City of Riverside Public Works Department

UPDATE OF THE INTEGRATED MASTER PLAN FOR THE WASTEWATER COLLECTION AND TREATMENT FACILITIES

VOL. 2 Basis of Planning

Chapter 1: Introduction
Chapter 2: Regulatory and Climate Change Considerations
Chapter 3: Population, Loading, and Flow Projections
Chapter 4: Basis of Cost Estimates
Chapter 5: Organizational Review

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Abbreviations

αF	alpha factor
µg/L	micrograms per liter
A/A Trunk Sewer	Acorn/Arlanza Trunk Sewer
AACE	Advancement of Cost Engineering
AADF	annual average daily flow
AAF	average annual flow
AB	Assembly Bill
ABS	Acrylonitrile-Butadiene-Styrene
ACI	American Concrete Institute
ACP	asbestos cement pipe
ACS	American Community Survey
ACT treatment train	Activated treatment train
ADC	alternative daily cover
ADEQ	Arizona Department of Environmental Quality
ADF	average daily flow
ADWF	average dry weather flow
AFY	acre-feet per year
APAD	acid-phase anaerobic digestion
AQMD	Air Quality Management District
AQMP	Air Quality Management Plan
ARB	California Air Resources Board
ARVs	air release valves
ASCE	American Society of Civil Engineers
AWT	Advanced Water Treatment
BACT	best available control technology
BCM	Best Available Control Measures for Fugitive Dust Sources
BFP	belt filter press
BMP	best management practices
BNR	Biological nutrient removal
BOD	biochemical oxygen demand
BOD_5	5-day biochemical oxygen demand
BPTC	Best Practicable Treatment or Control
Btu/lb	British thermal unit per pound
BWF	base wastewater flow
C	Celsius
$CaCO_3$	calcium carbonate
Carollo	Carollo Engineers, Inc.

CASA	California Association of Sanitation Agencies
CCB	chlorine contact basin
CCF	hundred cubic feet
CCI	Construction Cost Index
CCTV	Closed Circuit Television
CDFW	California Division of Fish and Wildlife
CDM	Camp Dresser & McKee, Inc.
CECs	Contaminants of Emerging Concern
CEQA	California Environmental Quality Act
CESA	California Endangered Species Act
cfd	cubic feet per day
cfm	cubic feet per minute
cfs	cubic feet per second
CIP	Capital Improvement Program
City	City of Riverside
CIWQS	California's Integrated Water Quality System
CMB	Combustion Sources
CMMS	Computerized Maintenance Management System
CNG	compressed natural gas
CO_2	carbon dioxide
COD	chemical oxygen demand
COS	cost-of-service
cP	centipoise
CSCI	California Stream Condition Index
CSD	Community Services Districts
CTS	Coatings and Solvents
cu ft	cubic feet
CWA	Clean Water Act
CWC	California Water Code
CWEA	California Water Environment Association
DAF	dissolved air flotation
DAFT	dissolved air flotation thickeners
days/week	days per week
DCR	demand-capacity ratio
DDW	California Division of Drinking Water
DG	digester gas
DIR	Department of Industrial Relations
DMR	discharge monitoring report
DU	dwelling unit

DWF	dry weather flow
EBRT	empty bed residence time
EC	Emerging Constituents
EDR	electro-dialysis reversal
EDU	equivalent dwelling units
EGM	Emission Growth Management
EIR	Environmental Impact Report
EnerTech	EnerTech Environmental California, LLC
ENR	Engineering News Record
EPA	Environmental Protection Agency
EQ	equalization
ESA	Endangered Species Act
F	Fahrenheit
FDA	Food & Drug Administration
Flo-Dar	Marsh-McBirney Flo-Dar™
FLX	Compliance Flexibility Program
FOG	fats, oils, and grease
fps	feet per second
ft	feet
FTE	Full Time Employee
FUG	Fugitive Emissions
FY	fiscal years
g	grams
gal	gallons
GBT	gravity belt thickeners
GHG	Greenhouse Gas
GIS	Geographic Information System
GL	General Ledger
gpcd	gallons per capita day
gpd	gallons per day
gpd/ac	gallons per day per acre
gpm	gallons per minute
gpm/sq ft	gallons per minute per square feet
GWI	groundwater infiltration
H_2S	hydrogen sulfide
HGL	hydraulic grade line
HID	High-Intensity Discharge
hp	horsepower
hr	hour

hrs/day	hours per day
HS^-	hydrogen sulfide ion
HVAC	heating, ventilation, and air conditioning
I/I	Infiltration/inflow
IEBL	Inland Empire Brine Line
IEUA	Inland Empire Utilities Agency
in.	inch
iPACS	Internet-based POTW Administration and Compliance System
IRWD	Irvine Ranch Water District
IT	Information Technology
IWWMP	Integrated Wastewater Master Plan
klb/d	thousand pounds per day
klbN/d	thousand pounds of nitrogen per day
KPI	Key Performance Indicator
kWh	kilowatt hour
lbs	pounds
lbs/cfd	pounds per cubic feet per day
lbs/ft^3	pounds per cubic feet
LF	linear feet
LIMS	Laboratory Information Management System
LM	Longitudinal Motion
LOTO	Lock Out / Tag Out
LRO	legally responsible official
Master Plan	Integrated Master Plan for the Wastewater Collection and Treatment Facilities
MBR	Membrane Bioreactor
MBR treatment train	Membrane Bioreactor treatment train
MCC	motor control center
MCS	Multiple Component Sources
MDD	maximum day demand
MDL	Method Detection Limits
MF	microfiltration
MFR	multi-family residential
MG	million gallons
mg-min/L	milligrams per minute per liter
mg/L	milligrams per liter
mgd	million gallons per day
mgN/L	milligrams of nitrogen per liter
min	minute

min/hr	minutes per hour
ML&C	mortar lined and coated
MLSS	mixed liquor suspended solids
mm	millimeter
MMBtu	million British thermal units
MMBtu/hr	million British thermal units per hour
MMRP	Measurement, Monitoring and Reporting Procedures
MOB	Mobile Source Programs
MP	Master Plan
MPN	most probable number
MRP	Monitoring and Reporting Program
msl	mean sea level
mV	millivolt
N/L	nitrogen per liter
N_2O	nitrous oxide
NACWA	National Association of Clean Water Agencies
$NaHSO_3$	sodium bisulfite
NaOCl	sodium hypochlorite
NASSCO	National Association of Sewer Service Companies
NEC	National Electric Code
NELAC	National Environmental Laboratory Accreditation Conference
NELAP	National Environmental Laboratory Accreditation Program
NFPA	National Fire Protection Association
NGO	Non-Governmental Organizations
NH_3-N	ammonia nitrogen
NOAA	National Oceanic and Atmospheric Association
NOI	notice of intent
NO_X	Nitrogen oxides
NPDES	National Pollutant Discharge Elimination System
NTU	nephelometric turbidity unit
O&M	Operations and Maintenance
OCSD	Orange County Sanitation District
OERP	Overflow Emergency Response Plan
OES	Office of Emergency Services
OJT	On-the-Job Training
ORP	Oxidation-Reduction Potential
P/L	phosphorus per liter
PACP	Pipeline Assessment Certification Program
PAYGO	Pay-As-You-Go

PDR	Preliminary Design Report
PEIR	Programmatic Environmental Impact Report
PFRP	Process to Further Reduce Pathogens
PLC	programmable logic controller
POTW	Publicly Operated Treatment Work
ppbv	parts per billion by volume
ppcd	pounds per capita per day
ppd	pounds per day
ppd/cu ft	pounds per day per cubic feet
ppd/sq ft	pounds per day per square feet
pph	pounds per hour
ppm	parts per million
psf	pounds per square foot
psi	pounds per square inch
PTZ	Pan-Tilt-Zoom
PVC	Polyvinyl Chloride
PWS	potable water salinity
PWWF	peak wet weather flow
QICS	Qualitative Intelligence and Communication System
R&R	rehabilitation and repair
RAS	return activated sludge
RCNLD	Replacement Cost New Less Depreciation
RCP	reinforced concrete pipe
RDII	Rain Derived Infiltration and Inflow
RDT	rotary drum thickeners
RECLAIM	Regional Clean Air Incentives Market
Regional Board	California Regional Water Quality Control Board
RG	rain gauge
RNG	renewable natural gas
RO	reverse osmosis
RPU	Riverside Public Utilities
RST	rotary screw thickeners
RTP	Regional Transportation Plan
RWQCB	Regional Water Quality Control Board
RWQCP	Regional Water Quality Control Plant
S_2^-	sulfide ion
SARDA	Santa Ana River Dischargers Association
SART	Santa Ana River Trail
SB	Senate Bill

sBOD	Soluble biochemical oxygen demand
SBT	sludge blending tank
SCADA	supervisory control and data acquisition
SCAG	Southern California Association of Governments
SCAP	Site Cleanup Subaccount Program
SCAQMD	South Coast Air Quality Management District
scfm	standard cubic feet per minute
sCOD	soluble chemical oxygen demand
SECAP	System Evaluation and Capacity Assurance Plan
SFR	single-family residential
SFY	square feet per year
SIU	Significant Industrial Users
SLCP	Short Lived Climate Pollutant
SLR	solids loading rate
SOC	Strengths, Opportunities, and Concerns
SOP	Standard Operating Procedures
SOR	surface overflow rate
South Star	South Star Engineering & Consulting, Inc.
SO_X	Sulphur oxides
sq mi	square mile
SQR	Structural Quick Rating
SRF	State Revolving Fund
SRT	solids retention time
SS	stainless steel
SSC	Sustainable Communities Strategy
SSMP	Sewer System Management Plan
SSO	Sanitary Sewer Overflows
State Water Board	California State Water Resources Board
SWMM	Storm Water Management Model
SWRCB	State Water Resources Control Board
TDS	total dissolved solids
TIN	total inorganic nitrogen
TKN	total Kjeldahl nitrogen
TL	
TM	Technical Memorandum
TMDL	total maximum daily load
TN	total nitrogen
TOC	total organic carbon
TP	total phosphorus

TS	total solids
TSS	total suspended solids
TST	Test for Significant Toxicity
URS	URS Corporations
USACE	United States Army Corps of Engineers
USBR	U.S. Department of the Interior Bureau of Reclamation
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey
UV/AOP	Ultraviolet/Advanced Oxidation Process
V&A	V&A Consulting Engineers
VCP	Vitrified Clay Pipe
VFA	volatile fatty acids
VFD	variable frequency drive
VSR	volatile solids reduction
VSS	volatile suspended solids
WaPUG	Wastewater Planning Users Group
WAS	waste activated sludge
WDR	Waste Discharge Requirements
WLAM	Waste Load Allocation Model
WMWD	Western Municipal Water District
WQMP	Water Quality Management Plan
WRCRWA	Western Riverside County Regional Wastewater Authority
wt	wet ton
WTPD	wet tons per day
WWTP	wastewater treatment plant
ZLD	Zero Liquid Discharge

City of Riverside Public Works Department

UPDATE OF THE INTEGRATED

MASTER PLAN FOR THE WASTEWATER COLLECTION AND TREATMENT FACILITIES

VOL. 2

CHAPTER 1

Basis of Planning

Introduction

Engineers...Working Wonders With Water®

City of Riverside Public Works Department

Update of the Integrated Master Plan for the Wastewater Collection and Treatment Facilities

VOLUME 2: BASIS OF PLANNING

CHAPTER 1: INTRODUCTION

FINAL | June 2019

City of Riverside Public Works Department
Update of the Integrated Master Plan for the Wastewater Collection and Treatment Facilities

VOLUME 2: BASIS OF PLANNING

CHAPTER 1: INTRODUCTION

Carollo Project No. 10495A00

Digitally signed by Graham J.G. Juby
Contact Info: Carollo Engineers, Inc.
Date: 2019.07.02 15:27:12-07'00'

REGISTERED PROFESSIONAL ENGINEER
GRAHAM J. G. JUBY
No. 67217
CIVIL
STATE OF CALIFORNIA

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Chapter 1

INTRODUCTION

1.1 Purpose

The purpose of the Basis of Planning Volume is to document the basic planning criteria used in the facility planning for the City's update of the Master Plan. This volume should be reviewed annually and updated as necessary. Revisions may be required to:

- Maintain permit compliance each cycle.
- Add additional capital improvement projects as needed.
- Update the rate structure as required.
- Reflect new operational modes.
- Address changes in influent flow quantities or characteristics.
- Adapt to changes in discharge requirements that could impact the level of treatment.
- Consider and implement new design philosophies.
- Manage any unforeseen circumstances.

Chapter 1 of the Basis of Planning Volume provides an introduction to the volume. It outlines the goals and objectives for the update of the Master Plan and presents the organizational structure of the update to the Master Plan Volumes.

1.2 Background

The City Wastewater Division is responsible for the collection and treatment of wastewater flows generated within the City and the service districts of Jurupa, Rubidoux, Edgemont, and the community of Highgrove. The City's collection system consists of over 800 miles of gravity sewers ranging from 6 to 48 inches in diameter, 414 miles of sewer laterals that are City owned, and 20 wastewater pump stations. The wastewater pump stations range in size from 100 gpm up to 2,000 gpm. Treatment is provided at the RWQCP, which provides preliminary, primary, secondary, and tertiary treatment for a hydraulic rated capacity of approximately 46 mgd ADWF. The loading capacity of the RWQCP will be discussed as part of the process design and reliability criteria in Volume 4, Chapter 3.

1.3 Goals and Objectives

The purpose of the update to the Master Plan is to evaluate the City's collection system and some of the RWQCP unit processes, make recommendations for future expansions and rehabilitation of the facilities, and develop the resultant CIP and rate structures to pay for the CIP. The CIP will be based on a 20 year planning period to the year 2037. The update of the Master Plan will incorporate the findings and recommendations of previous and ongoing plans and studies. More specific goals for the update to the Master Plan include:

- Analyze the collection system and RWQCP and develop an update to the Master Plan that:
  - Includes a CIP to serve the needs of both existing and future users (to 2037).

  - Complies with regulatory requirements.
  - Does not overburden rate payers.
  - Is equitable to the development community.
- Develop a proposed rate structure to fund the CIP by June of 2019 in preparation for the proposition 218 process.

1.4 Update of the Master Plan Organizational Structure

The update of the Master Plan is organized into 9 Volumes, as described in the table below.

Table 1.1 Update to the Master Plan Volumes

Volumes and Chapter Titles
Volume 1: Executive Summary
Volume 2: Basis of Planning
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Volume 5: Solids Treatment and Handling
Chapter 1: Existing Facilities Chapter 2: Summary of Planning Studies Chapter 3: Process Design and Reliability Criteria Chapter 4: Solids Production and Thickening Chapter 5: Solids Disposal

Table 1.1 Update to the Master Plan Volumes (continued)

Volumes and Chapter Titles
Volume 6: Regional Water Quality Control Plant Condition Assessment Results
Volume 7: Capital Improvement Plan and Implementation
Volume 8: Financial Plan and User Rates and Fees
Volume 9: Additional Special Collection System Studies
Chapter 1: Introduction Chapter 2: Sewers and Manholes in Close Proximity to Waters of US Chapter 3: SSO Reporting and Response Chapter 4: Laboratory Compliance Audit Chapter 5: Chemical Root Control SOP Chapter 6: SSMP Update

City of Riverside Public Works Department

UPDATE OF THE INTEGRATED

MASTER PLAN FOR THE WASTEWATER COLLECTION AND TREATMENT FACILITIES

VOL. 2

CHAPTER 2

Basis of Planning

Regulatory and Climate Change Considerations

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City of Riverside Public Works Department

Update of the Integrated Master Plan for the Wastewater Collection and Treatment Facilities

VOLUME 2: BASIS OF PLANNING

CHAPTER 2: REGULATORY AND CLIMATE CHANGE CONSIDERATIONS

FINAL | June 2019

City of Riverside Public Works Department
Update of the Integrated Master Plan for the Wastewater Collection and Treatment Facilities

VOLUME 2: BASIS OF PLANNING

CHAPTER 2: REGULATORY AND CLIMATE CHANGE CONSIDERATIONS

Carollo Project No. 10495A00

Digitally signed by Graham J.G. Juby
Contact Info: Carollo Engineers, Inc.
Date: 2019.06.24 16:01:21-07'00'

REGISTERED PROFESSIONAL ENGINEER
GRAHAM J. G. JUBY
No. 67217
CIVIL
STATE OF CALIFORNIA

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Chapter 2

REGULATORY AND CLIMATE CHANGE CONSIDERATIONS

2.1 Purpose

The City's update of the Master Plan will be used to guide the City's decisions regarding expansion and modernization of the wastewater collection and treatment facilities. In addition to estimating the additional treatment capacity required to service the needs of a growing population, the update to the Master Plan attempts to anticipate the level of treatment required by the effects of climate change and to comply with state and federal regulations now and in the future.

Current regulations are identified in the City's existing permits. The purpose of this Chapter is to assess how these permits are likely to change over the next 20 years, and how those changes will affect design, construction, operations, and maintenance decisions at the City's RWQCP. The focus of this assessment is on regulations relating to climate change, the City's NPDES, air quality permits, and biosolids disposal restrictions and regulations.

2.2 Engineering Perspective to Planning

The City has numerous aspects to consider when planning to meet future and potential regulatory requirements, including climate change, water quality, air quality, and solids disposal. From an engineering perspective, what types of infrastructure are required at the RWQCP and in the collection system for the City to remain in compliance over the 20-year planning horizon?

The function of the collection system is to convey wastewater to the RWQCP in a manner that avoids spills and produces the least amount of odor. For the collection system, hydraulic capacity, and the condition of the sewers and lift stations, are the key components of determining infrastructure needs that will prevent overloading and spills from the system. More intensive rainfall events due to climate change creates greater potential for I/I of storm water into the sewers. This has the potential to hydraulically overload the system and cause a spill elsewhere. This is one example of a consideration that has to be made in deciding on future infrastructure needs for the collection system.

The role of the RWQCP is to accept all flow from the collection system and then treat it in a cost efficient manner to a quality that meets the discharge permit. Much of the focus at the RWQCP is on meeting future air quality, effluent discharge quality, and biosolids disposal quality permits and regulations, as well as protecting the plant itself from flooding from the Santa Ana River and in-plant rain events. All this has to be considered while looking far enough into the future to avoid designing and constructing facilities that may become obsolete or ineffective should regulations change.

Once potential projects are identified for either the collection system or the RWQCP, these are prioritized and sometimes grouped to develop a logical approach to project implementation that fits within the financial means and rate structure of the City.

2.3 Summary

In 2007, the City Council adopted a "Sustainable and Resilient Riverside" policy committing to the City's Green Action Plan to go green in the areas of Energy, GHG Emissions, Waste, Urban Design, Urban Nature Transportation, and Water. In support of this initiative, the Public Works Department, Wastewater Division is committed to protecting natural resources, promoting environmental stewardship, and implementing sustainable operational practices through Renewable Resource projects and programs. Section 2.3 outlines the goals set forth by RWQCP in pursuit of this vision.

Environmental regulations are constantly evolving and, with limited exceptions, nearly always become more stringent, potentially requiring more advanced treatment to assure higher levels of water quality. Additional changes to the environment in response to climate change may also impact collection, treatment, and permit requirements. Because these regulations are often discussed for several years prior to being incorporated into permits, it is possible to anticipate some future requirements.

While the long-term impacts of climate change are still a topic of discussion among lawmakers and scientists around the globe, the USBR published a technical memorandum in August 2013 discussing the impact of climate change on the Santa Ana River Watershed (Appendix 2A). Additionally, the State of California published its fourth climate change assessment reports for Inland Deserts and Los Angeles in September 2018 discussing climate impacts in these two regions specifically. These reports are included in Appendix 2B and Appendix 2C, respectively.

Carollo contracted with Risk Sciences and Ramboll Environ, firms specializing in water quality and air quality standards regulations, respectively, and together with Carollo's in-house biosolids regulatory experts and Carollo process specialists, conducted a "brainstorming session" with City staff at Carollo's Orange County Office. The purpose of this session was to:

- Identify specific regulatory requirements likely to arise over the next 20 years.
- Determine how to address those requirements (whether through a regulatory compliance effort using City compliance staff or through infrastructure planning via the update to the Master Plan or other projects).
- Identify preliminary planning considerations for requirements that would be addressed through infrastructure needs in the update of the Master Plan.

The brainstorming session was successful in establishing a consensus about which new regulatory requirements should be considered in development of the update of the Master Plan. Results from the session were documented in a Conference Memorandum distributed to the participants on March 27, 2017 (Appendix 2D).

Following the brainstorming session, the discussions regarding applicable regulations were tabulated in a summary table as part of the development of this Chapter. Infrastructure in Table 2.1 is divided into three regulatory requirement areas: Water Quality, Air Quality, and Biosolids.

Table 2.1 Summary of Regulations and Discussions

Regulatory Requirement	Timing	Treatment Implications & Non-Structural Alternatives[1]	Infrastructure Needs for Planning Consideration[1]
Water Quality			
Mass limits	2018 Permit	Regulatory	None
Toxicity Testing	2018 Permit	Regulatory; may consider infrastructure due to possible disinfection change.	Ozonation or UV with peroxide
Pesticides	2018 Permit	Regulatory; may consider infrastructure due to possible disinfection change.	Ozonation or UV with peroxide
TDS (including Sodium and Chloride limits)	2023 Permit	Regulatory and Infrastructure	RO or converting disinfection to ozonation to reduce TDS
Nutrients	2023 Permit	Regulatory and Infrastructure	Aeration Basin Retrofits for nutrient (Nitrogen & Phosphorus) removal
Biocriteria	2023 Permit	Regulatory	None
CECs	2018/2023 Permit	Regulatory; may consider infrastructure due to possible disinfection change.	Ozonation or UV with peroxide
Disinfection	2018 Permit	Regulatory	Possible advanced treatment (RO)
Hydrologic Alteration	2023 Permit	Regulatory	None
Mercury	2018 Permit	Regulatory	None
Selenium	2018 Permit	Regulatory	None
Copper, Cadmium, Lead	2023 Permit	Regulatory	None
Aluminum	2023 Permit	Regulatory, but may also be impacted by nutrient management.	None
Pathogens	2023+ Permit	Regulatory	None
Dry Weather Diversion of Stormwater	2023 Permit	Regulatory and Infrastructure	Capacity analysis will determine if the RWQCP can accommodate dry weather storm flows
Air Quality			
SCAQMD 2016 AQMP: Convert fleet vehicles to CNG	March, 2017	Regulatory and potential Infrastructure	Fleet vehicle replacement considerations
MOB-07 and MOB-08: Convert fleet vehicles to CNG	MOB-07: N/A MOB-08: 2018	Regulatory and Infrastructure	Replace future fleet vehicles with cleaner alternatives

Table 2.1 Summary of Regulations and Discussions (continued)

Regulatory Requirement	Timing	Treatment Implications & Non-Structural Alternatives(1)	Infrastructure Needs for Planning Consideration(1)
Air Quality (continued)			
CMB-01: Transition to zero or near zero emission technology for stationary structures	Ongoing Requirement	Regulatory and Infrastructure	May need to replace diesel generators with alternative clean technologies; this may have more of an impact on lift station improvements.
CMB-03: Emission reduction for non-refinery flares	2018 adoption, 2022 implementation	Regulatory and Infrastructure	May need to consider beneficial reuse of gas; City flares meet current best available control technology standards
CMB-05: Further NO_x reductions from RECLAIM assessment	2018 adoption, 2022 implementation	Regulatory	May result in end of priority reserve, which would lead to higher new source implementation costs
BCM-10: Emission reduction from greenwaste composting	2022 adoption, 2031 implementation	Infrastructure	Co-digestion
SLCP Strategy: Co-digestion requirement/incentives	January 1, 2018	Regulatory and potential Infrastructure	Co-digestion and electricity generation using biogas
ARB 2030 Scoping Plan: Increase water sector efficiency, reduce GHGs, increased use of renewable energy	Beyond 2030	Regulatory and potential Infrastructure	Co-digestion and electricity generation using biogas
Biosolids			
Organics diversion/GHG reduction	Impact in the next 5 years	Infrastructure	Co-digestion and additional gas use options
ADC changes/Organics diversion	Impact in 5 to 10 years	Infrastructure	Rising costs for land application will make alternative disposal options more attractive
Limits on land application of Class B biosolids	Impact in 10 plus years	Regulatory and Infrastructure	Options for Class A treatment & disposal may be more attractive

Notes:

(1) The word "Regulatory" in the column fields refers to City staff following the development of the regulations and/or working with the regulators, either individually or in conjunction with discharger groups such as the Santa Ana River Discharger's Association, to help develop the regulations. Specifics on which discharger group the City should work with for each regulatory requirement are provided in the "Treatment Implications and Non-Structural Alternatives" or the "Planning Assumptions and Recommendations" subsection of each regulatory requirement that is described below (whichever is applicable). The word "infrastructure" in the column refers to addressing the regulation by planning for future infrastructure improvements as part of the update of the Master Plan. The infrastructure that will be considered for the update of the Master Plan for each regulation is listed in the "Infrastructure for Planning Consideration Column." More detail on the infrastructure is provided in the "Planning Assumptions and Recommendations" subsection for each regulation that is described below.

The rest of this Chapter provides more detail on the thought processes that went into the development of information in Table 2.1 for the three regulatory areas that are being addressed: water quality, air quality, and biosolids regulations, as well as climate change, which will be discussed following a summary of the City's Green Action Plan.

2.4 RWQCP Commitment to Sustainability and Green Action Plan

The RWQCP developed a series of goals based on four Resource areas: Recycled Water production and distribution, Organics Receiving and Treatment, Energy Production and independence, and Waste Management and reuse. From these four areas, eight goals were identified:

- Energy Independence: Produce 100 percent of the RWQCP electrical energy needs (Microgrid) and become a net exporter of energy to RPU.
- Renewable Energy and Waste Diversion Credits: Reduce air emissions and waste, produce energy and pursue all available programs to receive renewal energy and waste reduction credits maximizing the value of those credits to support City incentives.
- Infrastructure Capital Investment: Utilize private and public partnership opportunities, grant funding and Sewer Enterprise capital funding as the source to develop and implement projects.
- Organic and Green Waste Management: Partner with Solid Waste Division of Public Works to put in place refuse and organic service contracts that divert waste from going to landfills and bring waste to the RWQCP for bio-methane production and energy generation.
- Outside Partnerships: Pursue funding and research partnerships with industry, University of California Riverside, California Air Resources Board, non-profit organizations and other public agencies to improve and develop technology to maximize resource recovery.
- Project Delivery: Pursue private and public partnerships to enhance funding opportunities, provide community value, and project success.
- Products for Market: Produce products for the open market such as Class A biosolids for beneficial reuse, recycled water and renewable natural gas, as a potential revenue source for capital investment and to stabilize wastewater operation and maintenance expenses.
- Public Education and Outreach: Educate the public about the importance and value of resource recovery.

2.5 Climate Change

In 2013, USBR and SAWPA collaboratively prepared the *Climate Change Analysis for the Santa Ana River Watershed*, a report explaining the potential implications of climate change and how those implications might affect issues of importance to the Santa Ana River Watershed. The report was broken up into six Chapters:

- Chapter 1 provided an introduction to the project and study area along with a summary of any relevant studies conducted previously.
- Chapter 2 discussed the development of climate projections and hydrology models.
- Chapter 3 provided projections for water supply and demand.
- Chapter 4 discussed the potential impacts on key areas of importance in the region.
- Chapter 5 detailed a tool that was developed to evaluate demand management strategies along with a case study of potential adaptation strategies.
- Chapter 6 addressed uncertainties in the analysis.

In general, this study concluded that annual surface water and precipitation are likely to decrease over future periods, while temperatures rise. These effects will reduce groundwater availability over time. Additionally, findings indicated an increased risk of severe floods in the future.

Additional areas of inquiry included impacts to specific communities and regions, such as Lake Elsinore, Jeffrey Pine ecosystem, and Big Bear Mountain Resorts.

The USBR study and others like it formed the foundation of several other climate change documents in California, including a series produced by the State of California itself. The State of California produced its fourth climate change assessment report in September 2018. Two reports from that collection are included in Appendices 2C and 2D specifically relating to Inland Deserts and the Los Angeles region (including Riverside County). In general, the climate changes to be anticipated in this region include:

- Increases in minimum and maximum temperatures.
- Increase in the frequency and intensity of extreme events, such as drought, heat waves, storms, and precipitation amounts of single rainfall events.
- Spatial and temporal shifts in precipitation patterns.

Increased minimum and maximum temperatures could impact personnel and equipment needs whereas the other two items could impact how much and when the RWQCP could expect peak storm event flows. Unfortunately, there is not enough information provided on the state-level to indicate the exact impacts on the City.

In addition, the Santa Ana RWQCB is planning to modify the NPDES permit renewal process to require inclusion of a resilience/vulnerability assessment. The following documents may be required:

- A Climate Action Plan to address storm events and rising sea levels. To do this for a collection system and wastewater treatment plant, a vulnerability assessment would be conducted to identify and prioritize adaptation strategies, estimate the costs of each item, and provide an implementation plan.
- A revised Asset Management Plan to address climate resiliency. The City already has an asset management system in place. However, the adaptation strategies and prioritizations identified in the above study would be used to update the Asset Management Plan to ensure adaptation strategies are included and funded.

The specific impacts of climate change on the City require further evaluation, studies for which will likely be required by Santa Ana RWQCB during the next NPDES permit cycle. Until these studies are conducted, the impacts to the CIP cannot be determined. For the purposes of the Master Plan Update, it has been assumed that studies to a value of about $0.5 million would be carried out as a result of the future NPDES permitting process. This is expected to occur during the first five years of the new CIP. Since such studies would not be considered a CIP project, it was assumed that funding for such studies would be drawn from an account for specific capital engineering services.

2.6 Water Quality

2.6.1 Mass Based Limits

2.6.1.1 Regulatory Requirements and Timing

NPDES permits generally require mass-based effluent limits for certain parameters such as TSS, BOD, TDS, TIN, and ammonia (40 CFR 122.45[f]). Historically, the mass limits were computed by multiplying the concentration-based limits by the design flow of the treatment plant (40 CFR 122.45[l]). In May of 2016, EPA published a draft rule (81 FR 96, 31355) proposing that mass-limits

be computed based on the actual discharge flow expected during the term of the permit. This rule was expected to be finalized by mid-2017. Its status is uncertain under the new administration. The City's NPDES permit expires on October 31, 2018. At the time of completion of this update to the Master Plan, the NPDES permit is in the review process. If the new rule is finalized, mass-based limits will be computed using the maximum annual discharge expected to occur during the next permit term (2019-2024).

2.6.1.2 Treatment Implications and Non-Structural Alternatives

Since the City's treatment plant was recently expanded, the maximum expected flow will be some fraction of the current design capacity. There are no treatment implications for the next 6 to 7 years. However, as presently written, the rule may inadvertently impose a permanent cap on total mass that is substantially less than the design capacity. Federal anti-backsliding regulations preclude the Regional Board from reauthorizing an NPDES permit with effluent limits that are less stringent than the prior permit (40 CFR 122.45[l]). While this does not appear to be the intent of the new regulation, it may be the unanticipated result. The City should continue to work with state and national organizations (e.g., CASA and NACWA) to encourage EPA to clarify the proposed regulation in order to avoid this unintended consequence.

2.6.1.3 Planning Assumptions and Recommendations

If the new regulation is finalized, the City should make certain that the new permit, with the re-calculated mass-based limits, also contains a provision which will allow the Regional Board to raise those limits as influent flows increase provided that the concentration-based limit remains the same. For planning purposes, we have assumed the Regional Board will accept this approach and therefore no infrastructure changes/additions would be needed.

2.6.2 Toxicity Testing Requirements

2.6.2.1 Regulatory Requirements and Timing

In April of 2016, the State Water Board distributed a revised draft of its new toxicity control policy. This policy has been under development since 2010 and will probably be finalized by the end of 2017. As such, the new provisions will likely apply to the City when the NPDES permit is reauthorized in the fall of 2018. The most critical change is that the new policy presumes that all POTW discharges greater than 5 mgd always have a "reasonable potential" to cause or contribute to toxicity in the receiving stream. Therefore, the next permit will have an effluent limit for chronic toxicity. When the current (2013) permit was issued, the Regional Board found that the City did not have "reasonable potential" for toxicity and did not impose an effluent limit but did require the results of monthly toxicity tests to be monitored and reported. A test failure triggered additional monitoring/reporting but did not constitute a permit violation provided the City conducted the required Toxicity Identification Investigation. If the new policy is adopted, and the required effluent limit is imposed in the new permit, subsequent toxicity test failures will constitute discharge violations. In addition, the new policy requires bioassay laboratories to analyze toxicity test results using an entirely different statistical procedure called the TST. The new procedure reverses the traditional null hypothesis and presumes the effluent is toxic until proven otherwise. This new method is, by design, more sensitive and difficult to pass. Finally, the new policy requires dischargers to perform routine toxicity tests on three standard species (fish, invertebrate and plant) until such time that the Regional Board determines which species is "most sensitive" (i.e., most likely to fail) after which all subsequent testing will be done on just that one species. Prior

toxicity testing of the City's treated wastewater indicates that *Ceriodaphnia dubia* (a freshwater flea) is the most sensitive species. That is not likely to change if the City is required to repeat the multi-species evaluation.

2.6.2.2 Treatment Implications and Non-Structural Alternatives

Ceriodaphnia dubia reproduction is very sensitive to elevated chlorine or excessive dechlorination compounds. The City's current plan to reduce the disinfection residence time should decrease risk of toxicity test failure from either of these treatment chemicals. However, *Ceriodaphnia dubia* reproduction can also be adversely affected by ionic interference (elevated conductivity) and/or the presence of common household pesticides (e.g., pyrethroids) that the treatment plant is not designed to remove. The ionic interference problem may be addressed by using the EPA's recommended "Dual Control" test procedure. But, over time, increasing water conservation is likely to exacerbate salinity concentrations in the final effluent (see Section 2.3.3). Higher background levels of biological stress caused by ionic interference, coupled with occasional spikes in residual pesticides, increase the risk of toxicity test failures in the future. Eventually, it may be necessary to replace the current chlorine-based disinfection system with ozone which has been shown to be more effective at treating pesticides and other CECs, and does not leave a residual disinfectant after treatment. Although eliminating chlorination and dechlorination will also help reduce TDS, it may be necessary to desalinate some portion of the wastewater stream to reduce the risk of salinity-induced toxicity in the final effluent.

2.6.2.3 Planning Assumptions and Recommendations

In the near term, it would be prudent for the City to work closely with the Regional and State Water Board as the new toxicity control policy is being finalized. It is critically-important that the option to use EPA's "Dual Control" method be preserved and that the regulatory authorities understand how state-wide efforts to promote water conservation can inadvertently interfere with a WWTP's ability to consistently pass the reproduction endpoint in the C*eriodaphnia dubia* chronic toxicity test. The City should also work with state authorities to address pesticide toxicity by revising the registration requirements when such chemicals are approved for use and certified as "safe" for the environment. For planning purposes, we are assuming that the recent improvements to the City's disinfection system will be adequate to prevent toxicity during the next permit term (2018 to 2023). However, the City should plan to replace the disinfection system with ozone to prevent toxicity from other CECs in the next 10 years. In the interim, the City should continue to support the ongoing efforts of CASA and SCAP to revise the proposed Toxicity Policy before it becomes final.

2.6.3 Salinity Limits

2.6.3.1 Regulatory Requirements and Timing

The City is already required to comply with two salinity-related effluent limits. The first restricts the 12-month flow weighted running average TDS concentration to no more than 650 mg/L. The second requires that 12-month flow weighted running average TDS concentration in the final effluent be no more than 250 mg/L higher than that of the municipal water supply. Although the City has consistently complied with both limits in the past, it is becoming increasingly difficult. Prolonged periods of drought increase reliance on poorer quality (higher TDS) water supplies and water conservation is increasing the concentration of salt in raw sewage at the headworks of the treatment plant. Long-term water quality monitoring at Prado Dam indicates that salt

concentrations are rising and will soon exceed the applicable Basin Plan objectives for TDS, chloride and sodium. It is likely that Reach-3 of the Santa Ana River will be added to the 303(d) list of impaired waters, due to excess salinity, in 2022. This may result in a new, more stringent waste load allocation for all discharges to the river. In addition, in December of 2016, the EPA proposed a new method for developing water quality objectives for Conductivity. These methods may also lead to more restrictive water quality standards to protect salt-sensitive aquatic species living in the river. The most recent water quality assessment has already identified excess salinity as one of several pollutants that may be impairing benthic macroinvertebrate populations in the Santa Ana River. Any one of the preceding regulatory concerns may cause the City to consider additional local limits and/or advanced waste treatment (e.g., reverse osmosis) to reduce salt concentrations in the final effluent.

2.6.3.2 Treatment Implications and Non-Structural Alternatives

Provided that excess salinity does not cause or contribute to toxicity test failures (see Section 2.3.2, above), it is likely that the City will continue to comply with its current TDS-related effluent limits for the next NPDES permit cycle (2018 to 2023). However, if current trends continue, consistent compliance cannot be assured beyond that period. The most recent TDS projections by the City project that the City will exceed the 650 mg/L TDS limit in 2028. The City is already actively engaged in regional planning efforts to review and update the water quality objectives for TDS and other salt ions in the Basin Plan. This includes evaluation of longer-term averaging periods and the possibility of providing some adjustment for TDS increase caused by state-mandated conservation efforts. The City should also assess whether additional restrictions on in-home self-regenerating water softeners may be needed to better control sodium and chloride loads in residential sewage. It may be necessary to revise local limits to encourage some commercial/industrial sources with disproportionately high salt loads to implement additional pre-treatment or divert to the IEBL.

2.6.3.3 Planning Assumptions and Recommendations

For planning purposes, it is assumed that ongoing efforts to develop more appropriate permit averaging periods and manage salt loads from residential and commercial sources should be sufficient to assure compliance until 2028. However, the Regional Board is considering transitioning from a 12-month to a 10-year flow weighted running average for TDS. To support this transition, the City should continue to provide water quality data for the Long-Term TDS Trends Study presently being sponsored by the Southern California Salinity Coalition. Eventually, however, the City will have to desalinate some portion of the total waste stream in order to maintain consistent compliance with discharge limits or to be able to use recycled water for landscape irrigation or groundwater recharge in the service area. Planning for addition of a system to desalinate a portion of the waste stream will be conducted as part of Volume 4, Chapter 8, Advanced Water Treatment, of the update to the Master Plan. In the interim, the City should continue to actively participate in SAWPA's Basin Monitoring Program Task Force and closely scrutinize development of the updated Waste Load Allocation Model which will govern TDS limits in the discharge permit for the next 10 to 15 years.

2.6.4 Nutrient Limits

2.6.4.1 Regulatory Requirements and Timing

Numerous waterbodies throughout the state have already been deemed impaired due to elevated nutrient (nitrogen and phosphorus) concentrations. Until recently, these 303(d) listings were confined to lakes and reservoirs where high nutrient levels contribute to excess algae growth, low dissolved oxygen, and fish kills. Recently, however, EPA and other states have enacted more restrictive nutrient standards to protect aquatic organisms, particularly benthic macroinvertebrates. California initiated a similar effort (called "Numeric Nutrient Endpoints" or the Nutrient Policy) in 2010. Last year, California merged its program to develop a nutrient policy with its program to develop a method for measuring biological integrity (called CSCI). Some preliminary CSCI data suggests that the benthic macroinvertebrate community in Reach 3 of the Santa Ana River is impaired. Thus, there is reason to believe that more restrictive effluent limits for nitrogen and/or phosphorus may be required to prevent eutrophication in the still waters behind Prado Dam. However, this is not expected to occur for at least 10 years as it will take that long to finalize the policy, determine whether the river should be added to the 303(d) list and to develop a TMDL.

2.6.4.2 Treatment Implications and Non-Structural Alternatives

Riverside recently upgraded its wastewater treatment facility to comply with a TIN limit of 10 mg/L (expressed as a 12-month flow weighted running average concentration). No additional treatment is expected to be necessary to assure consistent compliance with the existing effluent limit of 10 mg/L while continuing to meet service demands associated with projected population growth. The City should continue to actively participate in SAWPA's Basin Monitoring Program Task Force and, in particular, carefully review the updated Waste Load Allocation Model which will govern TIN limits in the discharge permit for the next 10 to 15 years.

2.6.4.3 Planning Assumptions and Recommendations

The City should continue to monitor regulatory development of the CSCI and the related Numeric Nutrient Endpoints. Recent concerns regarding the potential adverse health effects of cyanotoxins produced by blue-green algae may accelerate implementation of new, more restrictive statewide policies governing the discharge of nitrogen and phosphorus in treated wastewater. This is especially true where recycled water provides significant recharge to groundwater that is later used as a source for municipal drinking water (e.g., the Chino-South and Orange County Groundwater Management Zones). In the longer term (i.e., 15 to 20 years), the City should plan that more restrictive nitrogen and phosphorus limits may be required because technology advances have "raised the bar" on what constitutes Best Practicable Treatment or Control. The City may need to upgrade its nutrient removal capability because other similarly-situated POTWs have already done so. Experience in other states and other regions of California indicate that regulatory authorities generally believe that WWTPs can reliably meet limits of 3.0 mg/L for Total Nitrogen and 1.0 mg/L for Total Phosphorus using currently available technology (see, for example, the effluent limits proscribed for Elsinore Valley Municipal Water District). More restrictive nutrient limits will be addressed as part of the capacity analysis in Volume 4, Chapter 3, Process Design and Reliability Criteria.

2.6.5 Chemicals of Emerging Concern

2.6.5.1 Regulatory Requirements and Timing

In 2013, the State Water Board amended the Recycled Water Policy (Res. No. 2013-0003) to require additional monitoring and reporting for certain CECs (17B-estradiol, caffeine, NDMA, Triclosan, Gemfibrozil, Iopromide, DEET and sucralose) in groundwater recharge projects that rely on recycled water. In 2014, the California Department of Health (now the DDW) finalized the Groundwater Replenishment Regulation (DPH-14-003E) which requires routine monitoring for a wide array of CECs that may occur in recycled water. The regulation requires that at least one chemical from each of nine distinct groups be analyzed to evaluate occurrence in municipal wastewater (see Table 2.2).

Table 2.2 CEC Monitoring in the Groundwater Replenishment Regulation (DPE-14-003E)

Group	Chemical Category	Examples of Chemicals in the Category
A	Hydroxy Aromatics	Acetaminophen, Benzyl salicylate, Bisphenol A, Estrone, Hexyl salicylate, Isobutylparaben, Methyl salicylate, Nonylphenol, Oxybenzone, Propylparaben, Salicylic acid, Triclosan, Clorfibric acid
B	Amino/Acylamino Aromatics	Sulfamethoxazole, Atorvastatin, Tricolcarban
C	Nonaromatic w/ Carbon Double Bonds	Acetyl cedrene, Carbamazepine, Codeine, Hexylcinnamealdehyde, Methyl ionone, OTNE, Simvastatin hydroxyl, Terpineol
D	Deprotonated Amines	Atenolol, Caffeine, Diclofenac, EDTA, Erythromycin-H_2O, Fluoxetine, Metoprolol, Nicotine, Norfluoxetine, Ofloxacin, Paraxanthine, Pentoxifylline, Trimethoprim
E	Alkoxy Polyaromatics	Naproxen, Propranolol
F	Alkoxy Aromatics	Gemfibrozin, Hydrocodone
G	Alkyl Aromatics	Benzophenone, Benzyl acetate, Bucinal, DEET, Dilantin, Dibutyl Phthalate, Diphenhydramine, Galazolide, Ibuprofen, Indolebutyric acid, Primadone, Tonalide
H	Saturated Aliphatics	Iopromide, Isobornyl acetate, Meprobamate, Methyl dihydrojasmonate
I	Nitro Aromatics	Musk ketone, Musk xylene

In both cases, these new monitoring requirements were generally imposed only on projects that intentionally recharged recycled water to groundwater; incidental recharges were not formally included. In 2017 through 2018, however, the State Water Board is expected to expand the current CEC monitoring program to include substances that may pose a hazard to aquatic organisms (Bifentrhin, Permethrin, Chlropyrifos, Estrone, Ibuprofen, Bisphenol A, 17-beta estradiol, Galaxolide, Diclofenac). The new monitoring requirements will apply to all treated wastewater discharged to surface waters not just intentional recharge projects.

2.6.5.2 Treatment Implications and Non-Structural Alternatives

Unless CECs cause or contribute to toxicity test failure, additional treatment will probably not be required to continue discharging treated effluent to the Santa Ana River. Previous voluntary monitoring projects showed that CEC concentrations were generally quite low in the City's treated wastewater. The City should continue to coordinate with SARDA, CASA and SCAP to review and

comment on any new CEC monitoring requirements that the State Board may add to the Recycled Water Policy. In addition, the City should participate in SAWPA's EC Task Force if and when that group resumes operations.

2.6.5.3 Planning Assumptions and Recommendations

The City should assume that additional routine water quality monitoring for CECs will be required when the NPDES permit is reauthorized in late 2018. The City should continue to work closely with SARDA and CASA to monitor new MS4 (stormwater) permitting requirements for common household pesticides currently under development at the State Water Board as these limits may be cross-applied to POTW permits despite claims to the contrary. If more restrictive effluent limits are imposed, then replacement of the existing chlorine disinfection system with ozone would provide some level of treatment to reduce CECs through oxidation (see Sections 2.3.2 and 2.3.6).

2.6.6 Disinfection Requirements

2.6.6.1 Regulatory Requirements and Timing

The City has been required to meet Title-22 disinfection requirements for nearly 30 years. However, Reach 3 of the Santa Ana River is on the 303(d) list due to excessive concentrations of pathogen indicator bacteria (*E. coli*) and the Regional Board adopted a TMDL in 2004. The Federal Department of Agriculture recently adopted new food safety regulations which limit the concentration of *E. coli* bacteria in recycled water used for crop irrigation. In general, the FDA standards are identical to those already imposed through the TMDL. The City is in full compliance with its permit limits for bacteria which are considerably more stringent than necessary to meet the waste load allocation for E. coli bacteria in the TMDL.

2.6.6.2 Treatment Implications and Non-Structural Alternatives

No new disinfection treatment will be required in order to continue discharging recycled water to the Santa Ana River for the next 5 to 10 years unless DDW expands the Groundwater Recharge Regulation to include incidental recharge with recycled water. It is likely that the City will be required to analyze samples of recycled water for *E. coli* bacteria when the NPDES permit is reauthorized in 2018.

2.6.6.3 Planning Assumptions and Recommendations

The DDW's Groundwater Recharge Regulation requires dischargers to demonstrate a 12-log reduction in viruses for recycled water projects. If the City has plans to begin using recycled water to deliberately recharge local aquifers, additional treatment will be necessary to make the required disinfection demonstration and to meet the DDW's more restrictive standards for TOC (TOC<0.5 mg/L), and other limits. Based on Inland Empire Utilities Agencies' experience, this may be able to be achieved through tertiary or equivalent treatment.

The MBR system will improve the efficiency of the disinfection process in two ways. First, the MBR treatment train (Plant 1) membranes produce an effluent with a lower turbidity than the media tertiary filters, which will reduce the chlorine demand of the effluent, making the chlorination more effective against target organisms. Secondly, the GE UF membrane will provide some "disinfection" due to the fact that the membranes prevent some bacteria, protozoa, and even some virus from entering the product stream. In other words the membrane will provide some log removal of bacteria, protozoa and virus. Although the DDW does not yet recognize and give credit for such log removal, because it is hard to measure, the MBR treatment train (Plant 1) membranes will result in a lower microbial constituent load getting to the CCBs; which will improve the

efficiency of the disinfection process. Nevertheless, until the permit if modified, the City will still be required to maintain the 450 CT approach.

Assuming that the biological process in both the MBR treatment train (Plant 1) and ACT treatment trains (Plant 2) is about the same (same SRT), then we would expect the TOC concentration in both effluents to be similar also. Due to the pore size of the GE MBR treatment train (Plant 1) membranes there may be some additional removal of large organic macromolecules, which would reduce the TOC concentration of that stream, but that impact should be relatively small. Overall, the TOC of both trains should be similar, but the MBR treatment plant (Plant 1) stream might have a slightly lower value. However, in the absence of pilot testing for actual TOC removals through the soil column, it is prudent for the City to plan for potential Reverse Osmosis treatment.

2.6.7 Hydraulic Flow Restrictions

2.6.7.1 Regulatory Requirements and Timing

In 2010, the Regional Board reauthorized the NPDES permit governing urban runoff in Riverside County and adopted new restrictions on the total amount of flow that can be discharged. These restrictions were imposed to reduce TSS associated with erosion and to prevent loss of instream habitat due to substrate scour during rain storms. During the recent 303(d) water quality assessment process, the Earth Law Center submitted significant written comments arguing that Reach 3 and Reach 4 of the Santa Ana River should also be deemed impaired due to insufficient flow during dry weather conditions. The cities of Colton and San Bernardino, joint operators of the RIX wastewater treatment facility, were recently sued for failing to discharge adequate flow to protect endangered species downstream of the RIX outfall. As a result, there is now considerable regulatory uncertainty about how much or how little wastewater the City will be allowed/required to discharge in the future.

2.6.7.2 Treatment Implications and Non-Structural Alternative

Apart from any water the City is obligated to discharge under the 1969 Judgment (15,000 AFY) and the subsequent entitlement that was approved by the State Water Board (additional 10,000 AFY), the City has long assumed it could use the remaining recycled water as it wished. That assumption is now being directly challenged by various NGOs seeking to ensure minimum stream flows in the Santa Ana River. Similar efforts have already been successful in the North Coast Region and in the San Diego Region. Should such initiatives be successful in the Santa Ana Region, it will severely restrict the City's ability to divert recycled water for landscape irrigation or groundwater recharge projects.

2.6.7.3 Planning Assumptions and Recommendations

In the forthcoming NPDES permit renewal, it would be prudent for the City to request explicit text be included to confirm that it has the right to withdraw and reuse any wastewater provided it meets the water quality requirements at the new point of discharge. Such reuse is consistent with goals established by the State Water Board in the Recycled Water Policy. In addition, since many of the hydraulic flow regulations seem to originate in stormwater permits, it would be wise for staff to increase communication and coordination between the City's wastewater and stormwater divisions.

2.6.8 Trace Metal Limits

2.6.8.1 Regulatory Requirements and Timing

In 2011, EPA added Reach 3 of the Santa Ana River to the 303(d) list due to elevated concentrations of copper and lead. EPA's decision was based on comparing total recoverable metal concentrations, measured in stormwater samples, to the dissolved metal objective. Although this flawed approach was opposed by both the Regional Board and the State Water Board, a TMDL must be developed by 2021 unless new data shows the river is actually meeting water quality standards. In April of 2018 the Santa Ana Regional Board voted to de-list Reach 3 for copper and lead. However, the State Board has over-ruled the Regional Board's decision and has not de-listed Reach 3 for copper and lead. If a TMDL is adopted, it would likely include a more restrictive waste load allocation that would result in more stringent effluent limits for cadmium, copper, and lead in the City's NPDES permit. EPA has also promulgated new water quality criteria for selenium and is working on a revised criteria for aluminum. In addition, the State Water Board is considering new water quality standards for mercury.

2.6.8.2 Treatment Implications and Non-Structural Alternatives

The City has been collecting additional water quality samples, above and below the wastewater outfall, for the last 6 years. The data shows that under normal dry weather conditions, the ambient concentration of dissolved metals consistently comply with the applicable water quality objective. The data has since been submitted to the Regional Board and the City has asked that Reach 3 of the Santa Ana River be removed from the 303(d) list for the aforementioned metals. The City has also been collecting and analyzing fish tissue samples for more than 20 years. Data from this tissue monitoring program shows that fish in the Santa Ana River consistently comply with the new requirements adopted by EPA and proposed by the State Water Board.

2.6.8.3 Planning Assumptions and Recommendations

For planning purposes, it is reasonable to assume that the Santa Ana River will be de-listed for metals before the Regional Board is required to develop a TMDL. Nevertheless, the City should continue collecting and analyzing samples to support such a determination. The City should continue supporting SARDA's long-term tissue sampling program to demonstrate compliance with the new water quality standards for mercury and selenium. It would also be wise for the City and SARDA to continue collecting habitat data and benthic macroinvertebrate data, as part of the same long-term sampling program, for use in evaluating the biological integrity of the Santa Ana River during future 303(d) water quality assessments.

2.6.9 Dry Weather Diversion of Stormwater

2.6.9.1 Regulatory Requirements and Timing

As noted earlier, the Regional Board has already adopted a TDML for *E. coli* bacteria in the middle Santa Ana River. Under the TMDL, urban runoff from the City is governed by a waste load allocation during dry weather conditions. Routine water quality monitoring shows that urban runoff is rarely able to meet the required bacteria standard.

2.6.9.2 Treatment Implications and Non-Structural Alternatives

At present, there does not appear to be any way to assure that urban runoff will consistently comply with the waste load allocation. Therefore, cities named in the TMDL (including Riverside) may look for ways to divert dry weather flows to the sanitary sewer system for further treatment.

A similar dry weather diversion program has been implemented successfully in Costa Mesa, for more than a decade, to address bacteria in the Greenville-Banning flood control channel. The dry weather diversion program was recently expanded by the City of Irvine to divert urban runoff away from Peters Canyon Wash and San Diego Creek in order to comply with a selenium TMDL established for Newport Bay.

2.6.9.3 Planning Assumptions and Recommendations

The City should determine if it has the capacity to accept diversion of dry weather urban runoff (principally return flows from excess irrigation) and whether such flows would present any new compliance problems for the wastewater treatment plant. Since the TDML deadline for compliance with the dry weather waste load allocation has already passed (December 2015), and the stormwater permits will soon be reauthorized, it is likely that the City will receive inquiries regarding diversion to sanitary sewers in the next 2 to 3 years. This is another area where the City would benefit from enhanced communication and coordination between the wastewater and stormwater divisions.

2.7 Air Quality

The RWQCP is located in Riverside County, which is within the jurisdiction of the SCAQMD. In addition, state policies and regulations from the ARB may also impact the RWQCP. As such, the following regulations were considered:

1. SCAQMD's 2016 Air Quality Management Plan (2016 AQMP).
2. The SLCP Strategy.
3. The ARB 2030 Scoping Plan.

2.7.1 SCAQMD – 2016 AQMP

The 2016 AQMP was approved by the SCAQMD on March 3, 2017. There are several measures included in the AQMP and the measures have various suggested adoption and implementation dates, as noted below. The Draft Final of the AQMP was completed in December of 2016 and multiple comment letters were submitted. There was an extensive public hearing in February of 2017, but the 2016 AQMP was approved, as mentioned, on March 3, 2017 by SCAQMD.

For reference, the various measures contained within the 2016 AQMP have been given designations to quickly identify the applicability to equipment types. The three-letter designation represents the abbreviation for a source category or specific program. The following provides a description of the abbreviations for each of the measures.

- CTS Coatings and Solvents.
- CMB Combustion Sources.
- FUG Fugitive Emissions.
- MCS Multiple Component Sources.
- BCM Best Available Control Measures for Fugitive Dust Sources.
- FLX Compliance Flexibility Program.
- EGM Emission Growth Management.
- MOB Mobile Source Programs.

2.7.1.1 AQMP Measures Regulatory Requirements and Timing

MOB-07: Accelerated Penetration of Partial Zero-Emission and Zero-Emission Light-Heavy- and Medium-Heavy-Duty Vehicles and MOB-08: Accelerated Retirement of Older On-Road Heavy-Duty Vehicles

MOB-07 focuses on accelerating advanced hybrid and zero-emission technologies for certain heavy-duty car classes. MOB-08 focuses on replacing heavy-duty vehicles with newer, and lower emitting, vehicles.

CMB-01: Transition to Zero and Near Zero Emission Technologies for Stationary Sources

CMB-01 describes the transition to zero and near-zero emission technologies for stationary sources. This measure specifically mentions that the biogas sector must decrease emissions either through incentive funding or regulatory enforcement. It also calls for the cleaning of biogas before use and for the replacement of emergency diesel engines with fuel cells and battery storage. Implementation of this section is ongoing.

CMB-03: Emission Reductions from Non-Refinery Flares

CMB-03 focuses on emission reductions from non-refinery flares, including flares at wastewater treatment facilities. The emission reductions would be achieved by requiring beneficial reuse of the digester gas or, if infeasible, disposal in a flare that meets current best available control technology standards. This measure includes certain considerations for the backup handling of gas. The transition to cleaner flares may be required by 2031. Note that the SCAP has requested a third party assessment regarding the cost-effectiveness and feasibility of technology for biogas control measures.

CMB-05: Further NO_x Reductions from RECLAIM Assessment

CMB-05 institutes the sunset of SCAQMD's RECLAIM program, to be replaced with command and control regulations. As part of this measure, the priority reserve currently available as part of RECLAIM may be eliminated. The new framework will likely be adopted in 2018 and implemented as soon as 2022.

BCM-10: Emission Reductions from Greenwaste Composting

BCM-10 requires the increased diversion of green waste from landfills to anaerobic digestion to decrease emissions from composting efforts. This will likely be adopted in 2022 and implemented in 2031.

2.7.1.2 Treatment Implications and Non-Structural Alternatives

The 2016 AQMP could impact the RWQCB by requiring the following:

- Lower emitting fleet vehicles.
- Beneficial use the digester gas, instead of flaring (or demonstrate that it isn't feasible).
- Replacement of diesel generators with alternative clean technologies.
- Additional digestion to handle organics diversion from solids waste.

The City should continue to actively participate with SCAP to help influence these regulations as they are developed.

2.7.1.3 Planning Assumptions and Recommendations

Based on the above described measures, it is recommended that the RWQCB take the following actions when making future planning decisions:

- As fleet vehicles need to be replaced, consider replacing retired vehicles with cleaner alternatives (e.g., CNG or near-zero emissions vehicles), if possible, which would be consistent with possible future regulatory efforts, if any, based on MOB-07 and MOB-08.
- When planning for future modifications to the RWQCB, consider beneficially using the digester gas. If the RWQCB shows that beneficially reusing the digester gas is infeasible, no further action may be necessary provided that the existing flaring system meets current best available control technology standards.
- When planning for future modifications to emergency engines and generators, diesel options may not be acceptable. CMB-01 should be carefully monitored to determine the applicability to lift stations and RWQCB facilities. Alternative clean technologies should be considered during CIP planning.
- Plan for a potential increase in compliance costs associated with new source review. This is due to elimination of the priority reserve as a result of CMB-05.
- Although the RWQCP is not part of RECLAIM, implications of CMB-05 and other future AQMD rulings make it necessary for the City to follow the development of these regulations very closely in order to ensure that access to priority reserve for future projects is not jeopardized.
- Plan for additional digestion capacity to handle organics diversion (discussed further in Section 2.7).

2.7.2 SLCP Strategy

2.7.2.1 Current Status of Plan

The final draft of ARB's SLCP Strategy was published in March 2017. The strategy focuses on short-lived climate pollutants (i.e., black carbon, methane, and fluorinated gases) as a way of achieving statewide GHG reduction goals. The SLCP notes that the wastewater sector contributed 4 percent of statewide methane emissions in 2013. As such, the SLCP includes measures to reduce emissions from the wastewater sector.

2.7.2.2 Applicable Elements

The SLCP Strategy includes measures to reduce emissions of the three SLCPs addressed in the document: black carbon, methane, and fluorinated gases. The proposed measures include a subset focused on reducing methane emissions from the wastewater sector.

Co-digestion of Waste

The SLCP Strategy includes the co-digestion of food-related waste streams at existing and new digester facilities, including wastewater treatment plants, by partnering with CalRecycle, The State Water Board, the RWQCB, and others. This action reduces methane emissions that would occur with food-waste decomposing in landfills and, with other actions discussed below, increases the potential methane that can be captured from anaerobic digesters and beneficially reused (see Section 2.4.1.1 item BCM-10).

Methane Capture and Reuse at Wastewater Treatment Facilities

This action focuses on incentivizing methane capture and the beneficial reuse of the captured methane at wastewater treatment facilities, through the production of on-site renewable electricity.

Additional Measures

There are additional programs and rules that may impact wastewater treatment facilities in the future, including the following:

- AB 1496: Methane Emissions – This bill is focused on identification of large methane "hot spot", and represents a joint venture by ARB and the Jet Propulsion Lab (JPL).[1]
- SB 1122: Renewable Bioenergy Projects – This bill will encourage electricity generation from biogas facilities.[2]
- AB 512: Local Government Renewable Energy Self-Generation Program – This bill expands eligibility of the existing tariff program to facilities that have a capacity of up to 5 MW of renewable generation.[3]
- Water Energy Grant Program – This program provides funds to implement water efficiency programs or GHG reduction projects by reducing water and energy use.[4]
- CalRecycle Waste Diversion Loans – This program provides funding for composting/anaerobic digestion infrastructure for waste diversion.[5]

2.7.2.3 Treatment Implications and Non-Structural Alternatives

The SLCP Strategy could impact the RWQCB by the following:

- Greater capacity and/or engineering needs required for anaerobic digestion and greater biogas production due to waste diversion.
- Potential incentives and funding programs.

The City should continue to actively participate with SCAP to help influence these regulations as they are developed.

2.7.2.4 Planning Assumptions and Recommendations

Based on the above described measures, there are no specific actions that are recommended for the RWQCB. During this update of the Master Plan effort, digester capacity should be reviewed to determine available co-digestion potential to accommodate food wastes. It may be advisable to plan for additional digester capacity to take advantage of available incentives. The RWQCB should

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[1] Assembly Bill 1496. Available at: http://leginfo.legislature.ca.gov/faces/billTextClient.xhtml?bill_id=201520160AB1496&search_keywords=California%23%23%23Air+Resources+Board%23%23%23null%23%23%23null%23%23%23null%23%23%23null%23%23%23null. Accessed April 2017.

[2] Senate Bill 1122. Available at: https://leginfo.legislature.ca.gov/faces/billTextClient.xhtml?bill_id=201120120SB1122. Accessed April 2017.

[3] Assembly Bill 512. Available at: http://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=201120120AB512. Accessed April 2017.

[4] Water-Energy Grant Program. Available at: http://www.water.ca.gov/waterenergygrant/. Accessed April 2017.

[5] CalRecycle. Greenhouse Gas Reduction Loan Program. Available at: http://www.calrecycle.ca.gov/Climate/GrantsLoans/GHGLoans/default.htm. Accessed April 2017.

continue to track the progress of these actions and consider possible funding opportunities when making future planning decisions.

2.7.3 ARB 2030 Scoping Plan

The ARB 2030 Scoping Plan is a proposed framework to achieve a 40-percent reduction of GHGs below 1990 levels by the year 2030. The primary sources of GHGs from the water sector are fossil-fuel based energy used to produce (e.g., pump, convey, and treat) water and for water end uses (e.g., heating). Note that wastewater treatment is identified as a source of N_2O but nothing in the Scoping Plan addresses N_2O emissions from this source. N_2O in a GHG that has a global warning potential that has been estimated to be almost 300 times that of CO_2.

2.7.3.1 Applicable Potential Actions

The Scoping Plan identifies two GHG reduction goals that are focused on the water sector:

- Develop and support programs and projects that increase water sector efficiency and reduce GHG emissions through reduced water and energy use.
- Increase the use of renewable energy to pump, convey, treat, and utilize water.

The Scoping Plan also identifies several supporting actions that may be relevant to the water sector:

- Adopt a long-term goal to reduce GHGs by 80 percent below 1990 levels by 2050.
- Move toward low carbon or net-zero carbon water management systems.
- Develop distributed energy using expanded and new programs.
- Encourage co-digestion and methane capture systems (in support of SLCP Strategy).

2.7.3.2 Treatment Implications and Non-Structural Alternatives

The 2030 Scoping Plan is currently a proposed framework with suggestion actions. Any regulations or programs will undergo their own legislative process. As such, any actions the Regional Board may consider are purely speculative based on the anticipated actions. The City should continue to actively participate with SCAP to help influence these regulations as they are developed.

2.7.3.3 Planning Assumptions and Recommendations

There are no specific recommendations based on the 2030 Scoping Plan because of the uncertainty of how and when the Plan may be applied. The City, potentially SCAP or statewide organizations, should track any related legislative or regulatory incentives to keep up to date with developments in this area.

2.8 Biosolids Management

According to the federal EPA, biosolids are "nutrient-rich organic materials resulting from the treatment of domestic sewage in a treatment facility. When treated and processed, these residuals can be recycled and applied as fertilizer to improve and maintain productive soils and stimulate plant growth." Previously in California, there were only a handful of counties in the state with restrictions in place against land application. However, by 2016, that trend reversed and land application, particularly in northern and central California has become highly regulated.

Currently, the City's biosolids disposal portfolio includes composting via Synagro, formerly Nursery Products, and land application in Arizona. However, as more restrictions against land

application of biosolids are put into place, this portfolio may need to be expanded to different markets in order to meet forecasted regulatory restrictions. The following sections discuss regulatory impacts that may drive the investigation into solids disposal technologies while Volume 5, Chapter 5, Solids Disposal Options, of this update to the Master Plan will detail disposal alternatives identified as a result of the regulatory considerations included below. The City should continue to actively participate with SCAP to help influence these regulations as they are developed.

2.8.1 Regulatory Requirements and Timing

There are multiple regulatory bodies imposing biosolids requirements with direct and indirect impacts for the RWQCP. Some are detailed below:

- AB 341, signed in 2012, requires mandatory commercial recycling with a goal of reducing, recycling, or composting 75 percent of all solid waste generated by 2020.
- AB 1826, signed in 2014, requires mandatory commercial organics recycling with phased diversion of organics from commercial and multi-family residential dwellings to recycling. This is not yet impacting single-family dwellings.
- AB 1594, signed in 2014, limits the use of green material used as ADC of landfills. This means that by 2020, green waste will no longer qualify for recycling diversion credit under AB 939. Green waste is typically mixed with biosolids for use as ADC to achieve the required moisture content. If green waste is no longer available to be used in landfills, biosolids disposal at landfills may also be limited because it is typically mixed with green waste when used as ADC.
- SB 605, signed in 2014, directs the ARB to develop the SLCP strategy (discussed as part of the air quality section above).
- SB 1383, signed in 2016, requires the ARB to begin SLCP plan implementation January 1, 2018. SB 1383 is also expected to have a final ruling by the end of 2018, regarding the implementation of the SLCP strategy. In this bill, 50 percent of organics relative to 2014 are to be diverted from landfills by 2020 and 75 percent of organics relative to 2014 are to be diverted by 2025.

Public opinion and ongoing court cases may also impact future limitations on land application. In general, the public is largely opposed to land application of biosolids, especially of Class B materials with increasing concerns on emerging contaminants. The Kern County decision still be determined may impact future local ordinances and restrictions on land application.

The recent past and future regulatory requirements described above could impact the RWQCP in three areas.

- Organics Diversion/ GHG Reduction - impacts expected in the next 5 years.
- Alternate Daily Cover/Organics Diversion - impacts expected in 5 to 10 years.
- Limits on Land Application of Biosolids - impacts expected in 10 plus years.

Further discussion of each of these three areas is presented below.

2.8.2 Organics Diversion and Greenhouse Gas Reduction Goals

2.8.2.1 Treatment Implications and Non-Structural Alternatives

Land application of solids is becoming increasingly restricted in California. For example, AB 341 and AB 1826 directly impact the quantity of solid waste that must be recycled. Taken in

combination with SB 1383, which diverts 50 percent of organics from landfills, and ARB 2030, which will accelerate the reduction of GHGs, there will be an increased push to co-digest high strength organics such as FOG, food waste, etc. In terms of treatment implications, excess digester capacity may need to be leveraged to meet these requirements, which also means incentives may be offered to facilitate necessary infrastructure modifications.

2.8.2.2 Planning Assumptions and Recommendations

The organics diversion and GHG reduction goals could impact the RWQCP in the next 5 years. They will result in increased pressure to accept external feedstocks and produce renewable fuels. Specifically, this will impact digester infrastructure and other solids processes. The City indicated an interest in promoting co-digestion of high strength solids as well as the beneficial use of the produced gas. For this update to the Master Plan, consideration should be given to necessary infrastructure changes that would be required to accommodate these goals. However, the scope of work of the update to the Master Plan does not include evaluating the impact of digestion and other solids processes at the RWQCP. The City has indicated that they are working with other parties to help address this deficiency.

2.8.3 Alternate Daily Cover Changes and Organics Diversion

2.8.3.1 Treatment Implications and Non-Structural Alternatives

AB 1594 and SB 1383 further limit ADC of landfills and thus biosolids, digestate, and sludge typically blended with green waste for ADC may no longer be permitted at landfills. However, the ARB aims to increase carbon sequestration and carbon content of soils and is interested in a "healthy soils initiative" that includes replacing carbon and nutrients with biosolids land application. This could help support biosolids land application.

2.8.3.2 Planning Assumptions and Recommendations

The future ADC limitations and organics diversion may result in increasing costs for solids management. For planning purposes, it is assumed that risings costs for land application will make alternative disposal options more attractive. Alternative biosolids management strategies will be evaluated as part of Volume 5, Chapter 5.

2.8.4 Limits on Land Application of Biosolids

2.8.4.1 Treatment Implications and Non-Structural Alternatives

The ADEQ does not consider changes on Arizona land application requirements to be very likely in the near future. It is probable that land application in Arizona can continue for quite some time. However, competition for land application in Arizona is driven by continuous local opposition to land application in California. In particular, failure of regional facilities such as EnerTech, difficult air permitting, and ADC limits in Northern California may drive up the cost of land application in Arizona as demand increases.

Disposal of biosolids at landfills or other sites is also becoming increasingly challenging due to permit or willingness limitations. In the long run, municipalities may be required to shift to Class A material for local end-use options. Depending on the end product, Class A material may require substantial marketing efforts to be able to sell the end product.

2.8.4.2 Planning Assumptions and Recommendations

The limitation on land application of biosolids may drive an industry shift towards Class A biosolids. The City should monitor discussions regarding the "healthy soils initiative" as it could prove to be a feasible avenue to aid continued Class B biosolids land application. In addition, these factors will be considered when the alternative biosolids disposal strategies are considered in Volume 5, Chapter 5.

Appendix 2A

CLIMATE CHANGE ANALYSIS FOR THE SANTA ANA RIVER WATERSHED

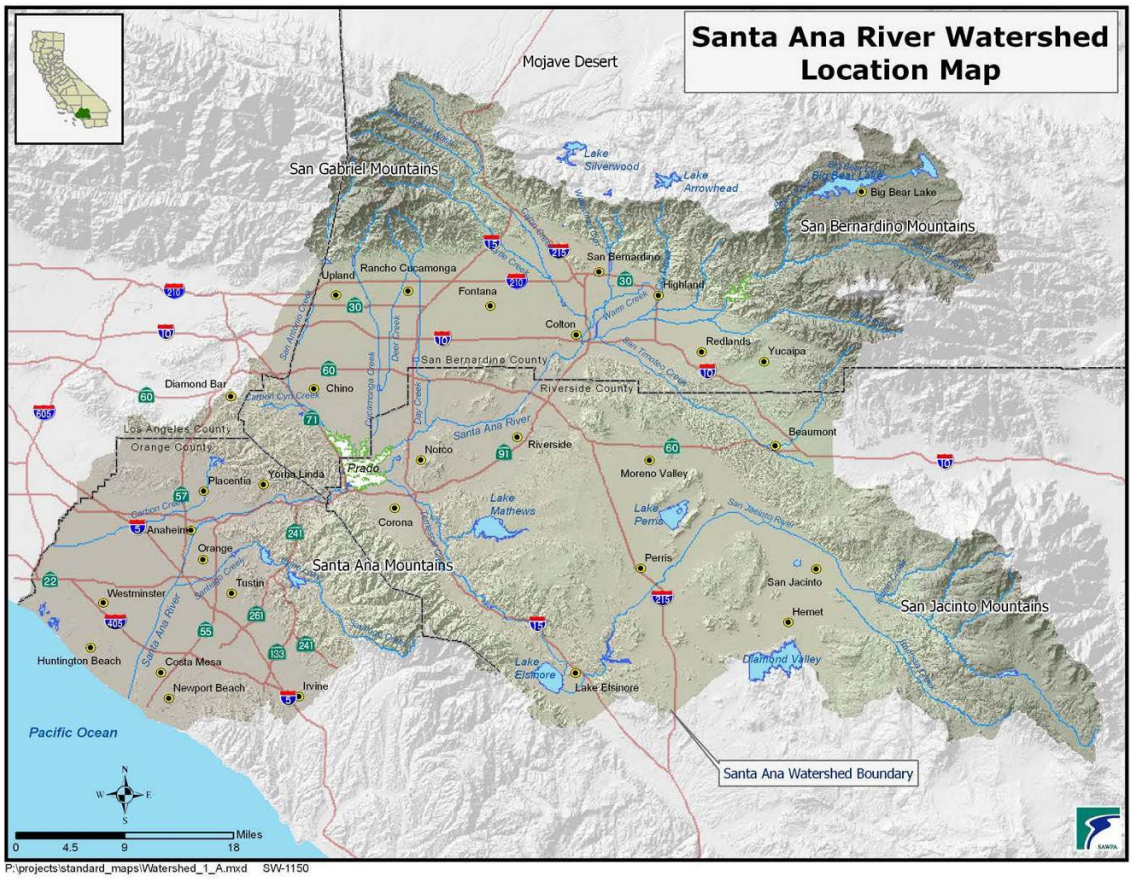
RECLAMATION

Managing Water in the West

Technical Memorandum No. 1

Climate Change Analysis for the Santa Ana River Watershed

Santa Ana Watershed Basin Study, California
Lower Colorado Region



U.S. Department of the Interior
Bureau of Reclamation

August 2013

Mission Statements

The mission of the Department of the Interior is to protect and provide access to our Nation's natural and cultural heritage and honor our trust responsibilities to Indian Tribes and our commitments to island communities.

The mission of the Bureau of Reclamation is to manage, develop, and protect water and related resources in an environmentally and economically sound manner in the interest of the American public.

BUREAU OF RECLAMATION
Water and Environmental Resources Division (86-68200)
Water Resources Planning and Operations Support Group (86-68210)
Technical Services Center, Denver, Colorado

Technical Memorandum No. 86-68210-2013-02

Climate Change Analysis for the Santa Ana River Watershed

Santa Ana Watershed Basin Study, California
Lower Colorado Region

Prepared by:

Kristine Blickenstaff, Hydraulic Engineer
Subhrendu Gangopadhyay, Hydrologic Engineer
Ian Ferguson, Hydrologic Engineer
Laura Condon, Hydrologic Engineer
Tom Pruitt, Civil Engineer

Peer reviewed by:

Marketa Elsner, Hydrologic Engineer

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Acronyms and Abbreviations

°C	degrees Celsius
°F	degrees Fahrenheit
%	percent
~	Approximately
AB 32	Assembly Bill 32
AMJJ	April - July
AR4	Fourth Assessment Report
BCSD	Bias Correction and Spatial Disaggregation or bias-corrected and spatially downscaled
CDF	Cumulative Distribution Function
CO_2e	Carbon Dioxide Equivalent
CMIP	Coupled Model Intercomparison Project (CMIP1, CMIP2, CMIP3, and CMIP5 are CMIP phases 1, 2, 3, and 5 respectively)
DCP	Downscaled Climate Projections
DEM	Digital Elevation Model
DJFM	December - March
DOE	U.S. Department of Energy
DWR	California Department of Water Resources
EMWD	Eastern Municipal Water District
EVMWD	Elsinore Valley Municipal Water District
FAQs	Frequently Asked Questions
GCM	General Circulation Model, or Global Climate Model

GHG	Greenhouse Gas
IEUA	Inland Empire Utilities Agency
IPCC	Intergovernmental Panel on Climate Change
IRWM	Integrated Regional Water Management
km	kilometer
LESJWA	Lake Elsinore and San Jacinto Watersheds Authority
LLNL	Lawrence Livermore National Laboratory
MAF	million acre-feet
MAFY	million acre feet per year
MGD	million gallons per day
MWDSC	The Metropolitan Water District of Southern California
NCAR	National Center for Atmospheric Research
OCWD	Orange County Water District
OWOW	One Water One Watershed
PCMDI	Program for Climate Model Diagnosis and Intercomparison
PET	Potential Evapotranspiration
QSA	Quantification Settlement Agreement
Reclamation	U.S. Department of the Interior, Bureau of Reclamation
SARP	Santa Ana River Mainstem Project
SARW	Santa Ana River Watershed
SAWPA	Santa Ana Watershed Project Authority
SBVMWD	San Bernardino Valley Municipal Water District

SECURE	Science and Engineering to Comprehensively Understand and Responsibly Enhance
SCAG	Southern California Association of Governments
SLR	Sea Level Rise
SWE	Snow Water Equivalent
USGCRP	U.S. Global Change Research Program
USGS	U.S. Geological Survey
VIC	Variable Infiltration Capacity hydrologic model
WaterSMART	WaterSMART (Sustain and Manage America's Resources for Tomorrow)
WCRP	World Climate Research Programme
WMWD	Western Municipal Water District
WRMS	Water Resources Management System

Executive Summary

The Santa Ana Watershed Basin Study (Basin Study) is a collaborative effort by the Santa Ana Watershed Project Authority (SAWPA) and the Bureau of Reclamation (Reclamation), authorized under the Sustain and Manage America's Resources for Tomorrow SECURE Water Act (Title IX, Subtitle F of Public Law 111-11). The study began in 2011 and was completed in the spring of 2013. The Basin Study complements SAWPA's Integrated Regional Water Management (IRWM) planning process, also known as the "One Water One Watershed" (OWOW) Plan, and refines the watershed's water projections, and identifies potential adaptation strategies, in light of projected effects of climate change. This climate change analysis for the Santa Ana River Watershed (SARW) is a contributing section to the Basin Study.

This report explains the methods used to develop an analysis of potential implications of the changing climate, and how those implications might affect issues of importance to the Santa Ana River Watershed. Chapter 1 provides an introduction to the project and the study area, along with a summary of relevant previous studies. The development of climate projections and hydrology models used can be found in Chapter 2. Chapter 3 provides projections for water supply and demand in the SARW. An impact analysis was conducted focusing on key areas of importance to the SARW, the results of which can be found in Chapter 4. A tool to evaluate demand management is presented in Chapter 5, along with a case study of potential adaptation strategies. Chapter 6 addresses uncertainties in climate change analysis.

In light of climate change, prolonged drought conditions, growth, and population projections, a strong concern exists to ensure there will be adequate water supplies to meet future water demand. The findings of this Basin Study will be used to update the OWOW Plan, evaluate the implications of climate change, assess increased energy demand, and ensure that future water quality and supply needs are met. Goals of the study include: incorporating existing regional and local planning studies within the watershed; sustaining the innovative "bottom up" approach to regional water resources management planning; ensuring an integrated, collaborative approach; using science and technology to assess climate change and greenhouse emissions effects; facilitating watershed adaptation planning; and expanding outreach to all major water uses and stakeholders.

Future water supply was analyzed for the Santa Ana River Watershed using the Variable Infiltration Capacity (VIC) hydrologic model (Liang et al., 1994; Liang et al., 1996; Nijssen et al., 1997) to project streamflow using 112 different projections of future climate. Projected climate variables, including daily precipitation, minimum temperature, maximum temperature, and wind speed,

came from the Bias Corrected and Spatially Downscaled Coupled Model Intercomparison Project Phase 3 (BCSD-CMIP3) archive. Historical VIC model simulations over the period 1950-1999 were conducted using historical meteorological forcings (factors affecting the climate of the earth that drive or "force" the climate to change) developed by Maurer et al., (2002), and subsequent extensions. The VIC hydrologic model solves the water balance for each of a series of 1/8° by 1/8° (~12km x 12 km) grid cells, which represent the watershed. Daily climate projections span the time period January 1, 1950 to December 31, 2099 and exist for each grid cell. Grid based outputs of daily runoff and baseflow generated by the VIC hydrologic model are routed to select sites throughout the watershed to produce daily streamflow projections. Through coordination with SAWPA and local water agencies, 36 key locations in the basin were determined, so that sub-basins could be delineated. Change factors were developed by calculating decade mean (reference decade – 1990s; three future decades – 2020s, 2050s, and 2070s) total precipitation and temperature, then calculating percent change, and finally calculating the median change for all the 112 projections. Final products include data sets at key locations for precipitation, temperature, evapotranspiration, April 1st Snow Water Equivalent (SWE), and streamflow.

These data sets were used to answer frequently asked questions regarding impacts of climate change on the Santa Ana River Watershed. The questions and key findings can be found below.

Will surface water supply decrease?

- Annual surface water is likely to decrease over future periods.
- Precipitation shows somewhat long term decreasing trends.
- Temperature will increase, which is likely to cause increased water demand and reservoir evaporation.
- April 1st SWE will decrease.

Will groundwater availability be reduced?

- Groundwater currently provides approximately 54% of total water supply in an average year, and groundwater use is projected to increase over the next 20 years.
- Projected decreases in precipitation and increases in temperature will decrease natural recharge throughout the basin.
- Management actions such as reducing municipal and industrial water demands or increasing trans-basin water imports and recharge will be required in order to maintain current groundwater levels.
- A basin-scale groundwater screening tool was developed to facilitate analysis of basin-scale effects of conservation, increasing imported supply, changing agricultural land use, and other factors on basin-scale groundwater conditions.

Is Lake Elsinore in danger of drying up?

- Lake Elsinore has less than a 10% chance of drying up (2000-2099).
- In the 2000-2049 period, Lake Elsinore has a greater than 75% chance of meeting the minimum elevation goal of 1,240 ft.
- In the future period 2050-2099, Lake Elsinore has less than a 50% chance of meeting the minimum elevation goal of 1,240 ft.
- There is less than a 25% chance that Lake Elsinore will drop below low lake levels (1,234 ft) in either period.
- The Elsinore Valley Municipal Water District (EVMWD) project does aid in stabilizing lake levels; however, for the period 2050-2099 additional measures will likely be required to help meet the minimum elevation goal of 1,240 ft.

Will the region continue to support an alpine climate and how will the Jeffrey Pine ecosystem be impacted?

- Warmer temperatures will likely cause Jeffrey pines to move to higher elevations and may decrease their total habitat.
- Forest health may also be influenced by changes in the magnitude and frequency of wildfires or infestations.
- Alpine ecosystems are vulnerable to climate change because they have little ability to expand to higher elevations.
- Across the State it is projected that alpine forests will decrease in area by 50-70% by 2100.

Will skiing at Big Bear Mountain Resorts be sustained?

- Simulations indicate significant decreases in April 1st snowpack that amplify throughout the 21st century.
- Warmer temperatures will also result in a delayed onset and shortened ski season.
- Lower elevations are most vulnerable to increasing temperatures.
- Both Big Bear Mountain Resorts lie below 3,000 m and are projected to experience declining snowpack that could exceed 70% by 2070.

How many additional days over 95°F are expected in Anaheim, Riverside and Big Bear City?

- All the climate projections demonstrate clear increasing temperature trends.
- Increasing temperatures will result in a greater number of days above 95°F in the future.

- The number of days above 95°F gets progressively larger for all cities advancing into the future.
- By 2070 it is projected that the number of days above 95°F will quadruple in Anaheim (4 to 16 days) and nearly double in Riverside (43 to 82 days). The number of days above 95°F at Big Bear City is projected to increase from 0 days historically to 4 days in 2070.

Will floods become more severe and threaten flood infrastructure?

- Simulations indicate a significant increase in flow for 200-year storm events in the future.
- The likelihood of experiencing what was historically a 200-year event will nearly double (i.e. the 200-year historical event is likely to be closer to a 100-year event in the future).
- Findings indicate an increased risk of severe floods in the future, though there is large variability between climate simulations.

How will climate change and sea level rise affect coastal communities and beaches?

- Climate change will contribute to global sea level rise (SLR) through melting of glaciers and ice caps and thermal expansion of ocean waters, both of which increase the volume of water in the oceans.
- Regional SLR may be higher or lower than global SLR due to effects of regional ocean and atmospheric circulation.
- Average sea levels along the Southern California coast are projected to rise by 5-24 inches by 2050 and 16-66 inches by 2100.
- SLR is likely to inundate beaches and coastal wetlands and may increase coastal erosion. Effects on local beaches depend on changes in coastal ocean currents and storm intensity, which are highly uncertain at this time.
- SLR will increase the area at risk of inundation due to a 100-year flood event.
- Existing barriers are sufficient to deter seawater intrusion at Talbert and Alamitos gaps under a 3-foot rise in sea levels. However, operation of barriers under SLR may be constrained by shallow groundwater concerns.

As climate science continues to evolve, periodic reanalysis and evaluation will be needed to inform the decision-making process.

1.0 Introduction

1.1 Purpose, Scope, and Objective of Study

The Santa Ana Watershed Basin Study (Basin Study) is a collaborative effort by the Santa Ana Watershed Project Authority (SAWPA) and the Bureau of Reclamation (Reclamation), authorized under the Sustain and Manage America's Resources for Tomorrow SECURE Water Act (Title IX, Subtitle F of Public Law 111-11). The study began in 2011 and was completed in the spring of 2013. The Basin Study complements SAWPA's Integrated Regional Water Management (IRWM) planning process, also known as their "One Water One Watershed" (OWOW) Plan, and refines the watershed's water projections, and identifies potential adaptation strategies, in light of projected effects of climate change. This climate change analysis for the Santa Ana River Watershed is a contributing section to the Basin Study.

SAWPA is a joint powers authority that represents five major water resource agencies. SAWPA's area includes over 350 water, wastewater and groundwater management, flood control, environmental, and other nongovernmental organizations. These entities work together collaboratively and focus on the region's OWOW Plan.

In light of climate change, prolonged drought conditions, growth, and population projections, a strong concern exists to ensure there will be adequate water supplies to meet future water demand. The findings of this Basin Study will be used to update the OWOW Plan, evaluate the implications of climate change, and ensure that future water quality and supply needs are met. Goals of the study include: incorporating existing regional and local planning studies within the watershed; sustaining the innovative "bottom up" approach to regional water resources management planning; ensuring an integrated, collaborative approach; using science and technology to assess climate change and greenhouse emissions affects; facilitating watershed adaptation planning; and expanding outreach to all major water uses and stakeholders.

1.1.1 Location and Description of Study Area

The Santa Ana River Watershed (also referred to as SARW, or 'Watershed') is home to over 6 million people, within an area of 2,650 square miles in southern California. The regional population is projected to grow to almost ten million within the next 50 years (U.S. Census Bureau, 2010). The watershed includes much of Orange County, the northwestern corner of Riverside County, the southwestern corner of the San Bernardino County, and small portions of Las Angeles County. The watershed is bounded on the south by the Santa Margarita watershed, on the east by the Salton Sea and Southern Mojave watersheds, and on the northwest by the Mojave and San Gabriel watersheds. SAWPA has five member agencies: Eastern Municipal Water District (EMWD), Inland Empire

Utilities Agency (IEUA), Orange County Water District (OCWD), San Bernardino Valley Municipal Water District (SBVMWD), and Western Municipal Water District (WMWD). shown below in Figure 1.

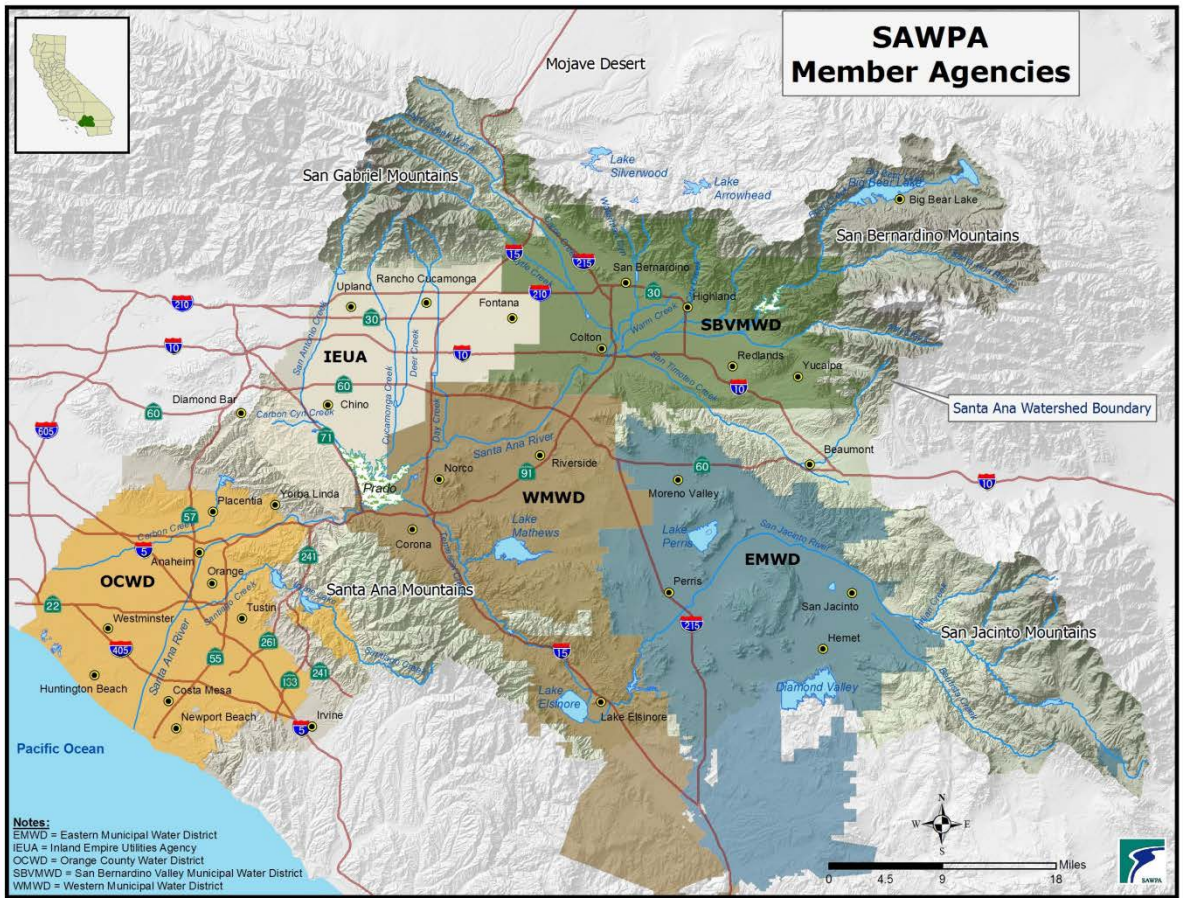


Figure 1: SAWPA member agencies

The climate and geography of the State of California present a unique challenge to the management and delivery of water. While most of the State's precipitation falls on the northern portion of the State, most of California's population resides in the semi-arid, southern portion of the State. Water is diverted, stored, and then transferred from the water-rich north to the more arid central and southern sections of the state through the California State Water Project (SWP), the Central Valley Project, and the Los Angeles Aqueduct. In addition to the projects that transport water from the north to the south, the southern coastal area relies on water imported through The Metropolitan Water District of Southern California's (Metropolitan) Colorado River Aqueduct. The Bureau of Reclamation and seven basin states manage the Colorado River system under the authority of the Secretary of the Interior and for the benefit of the seven basin states. Over-allocation of this resource, along with a U.S Supreme Court Decision (Arizona v. California, 1964) and population and economic growth, led to the recent California "4.4 Plan" and Quantification Settlement Agreement (QSA). The QSA

limits California's share of the Colorado River water supply to 4.4 million acre-feet (MAF). As a result of these actions, Metropolitan's supply from the Colorado River was significantly reduced, especially during extended dry periods. In the past, a buffer supply was developed by constructing new facilities, such as dams and/or aqueducts, to provide water supply for future growth. Today, the gap between supply and demand has closed and increasing emphasis is placed on conservation and development of local supplies. Building new facilities is costly and such projects face strict environmental review before they can be approved. This has caused California to seek more creative and sustainable solutions to water resource management.

1.2 Summary of Previous and Current Studies

A large body of research has been conducted over the past ten or more years on climate change and its potential impacts on the western United States. Most of this research has focused on large scale implications (for example, over the western United States), while providing limited regional scale information. The following section summarizes research that is relevant to the Watershed, and shows that although these results are applicable, additional research was required, through this Basin Study, to evaluate smaller scale, site specific, climate change impacts. For additional information on previous and current climate change studies, not directly related to the Watershed, please see Reclamation's Literature Synthesis on Climate Change Implications for Water and Environmental Resources (http://www.usbr.gov/research/docs/climatechangelitsynthesis.pdf).

1.2.1 Historical Trends

California's historical temperature has increased by about 1.7°F over the past 116 years (Moser et al., 2012), while showing declines in spring snowpack and a shift to earlier spring runoff (Knowles et al., 2007; Regonda et al., 2005; Peterson et al., 2008; Stewart et al., 2009). It is difficult to distinguish long-term climate change from natural climate variability, although many studies have tried to distinguish between the two (Bonfils et al., 2007; Cayan et al., 2001; Gershunov et al., 2009). It is likely that the historical temperature trends are due to a combination of anthropogenic climate change and natural climate variability (Reclamation, 2011k).

A study by Gershunov et al., (2012) shows that generally, there is a positive trend (1950-2010) in heat wave activity over the entire California region that is expressed most strongly and clearly in nighttime rather than daytime temperature extremes. This trend in nighttime heat wave activity has intensified markedly since the 1980s and especially since 2000. The two most recent nighttime heat waves were also strongly expressed in extreme daytime temperatures. Circulations associated with great regional heat waves advect hot air into the region. This air can be dry or moist, depending on whether a moisture source is available, causing heat waves to be expressed preferentially during day or night.

A remote moisture source centered within a marine region west of Baja California has been increasing in prominence because of gradual sea surface warming and a related increase in atmospheric humidity. Adding to the very strong synoptic dynamics during the 2006 heat wave were a prolonged stream of moisture from this southwestern source, and despite the heightened humidity, an environment in which afternoon convection was suppressed, keeping cloudiness low and daytime temperatures high.

Vermeera and Rahmstorf (2009) suggest a simple relationship linking global sea-level variations to temperature. This relationship is tested on synthetic data from a global climate model for the past millennium and the next century. When applied to observed data of sea level and temperature for 1880–2000, and taking into account known anthropogenic hydrologic contributions to sea level, the correlation explains 98% of the variance.

Trends in historical precipitation are more sporadic making it difficult to attribute them to climate change (Hoerling et al., 2010). A series of regression analyses, conducted by Dettinger and Cayan (1995), indicate that runoff timing responds equally to the observed decadal-scale trends in winter temperature and interannual temperature variations of the same magnitude, suggesting that the trend in temperature is sufficient to explain the increasingly early runoff. However, this trend is not immediately distinguishable from natural atmospheric variability.

A well-documented shift towards earlier runoff can be attributed, in part, to more precipitation falling as rain instead of snow (Regonda et al., 2005; Pierce et al., 2008; Das et al., 2009; Hidalgo et al., 2009; Lindquist et al., 2009). Knowles et al., (2007) showed a regional trend during the period 1949–2001 toward smaller ratios of winter-total snowfall water equivalent (SWE) to winter-total precipitation, with the most pronounced reductions occurring in the Sierra Nevada and the Pacific Northwest, with more varied changes (but still predominantly reductions) in the Rockies. The trends in this ratio correspond to shifts toward less SWE rather than to changes in overall precipitation, except in the Southern Rockies, where both snowfall and precipitation have increased. The trends toward reduced SWE are a response to warming across the region, with the most significant reductions occurring where winter-average wet-day minimum temperature changes have been less than +3°C over the course of the study period. The observed trends in hydroclimatology over the western United States will likely have significant impacts on water resources planning and management.

There have been preliminary efforts by agencies managing California's water resources to incorporate climate change research into their planning and management tools, including preliminary modeling studies of potential impacts of climate change to operations of the State Water Project and Central Valley Project, Delta water quality and water levels, flood forecasting and evapotranspiration rates (Anderson et al., 2008).

1.2.2 Climate Projections

The Intergovernmental Panel on Climate Change (IPCC) projections of future climate have been utilized in assessing climate over California. Projections indicate the rate of increase in global mean annual temperature nearly doubles before 2100, and that increases in summer temperatures are greater than winter (IPCC, 2007). There is less confidence in projections of future precipitation than temperature (Reclamation, 2011). However, precipitation projections show less snowfall and more rainfall, less snowpack development and earlier runoff, more intense and heavy rainfall interspersed with longer dry periods (Congressional Budget Office, 2009; Lundquist et al., 2009; Moser et al., 2009; Rauscher et a l2008; Maurer et al.,2007).

1.2.3 Hydrological Projections

The changing climate will likely result in lower stream flow, lower reservoir storage, and decreased water supply deliveries and reliability later in the 21st century throughout California (Vicuna and Dracup, 2007). Drought in the Southwest may no longer be driven by precipitation, but rather by temperature (Hoerling and Eischeid, 2007).

Two hydrologic impacts, in which there is high confidence, are increasing winter streamflow and decreasing late spring and summer flow (Maurer, 2007). There is also high confidence in reduced snowpack at the end of winter, and earlier arrival of the annual peak flow volume, which has important implications for California's water management. The shift to earlier peak streamflow timing, and the decline in end-of-winter snow pack, results in more extreme impacts under higher emissions scenarios in all cases. This indicates that future emissions scenarios play a significant role in the degree of impacts to water resources in California.

The potential effects of climate change on the hydrology and water resources of the Sacramento–San Joaquin River Basin were evaluated by Van Rheenen et al., (2004) using an ensemble of climate projections generated by the U.S. Department of Energy and National Center for Atmospheric Research Parallel Climate Model (DOE/NCAR PCM). From these global simulations, transient monthly temperature and precipitation sequences were statistically downscaled to produce continuous daily hydrologic model forcings, which drove a macro-scale hydrology model (VIC) of the Sacramento–San Joaquin River Basins at a 1/8° spatial resolution, and produced daily streamflow sequences for each climate projection. Each streamflow scenario was used in a water resources system model that simulated current and predicted future performance of the system. Results from the water resources system model indicated that achieving and maintaining status quo system performance in the future would be nearly impossible, given the altered hydrologic projections.

1.2.4 Climate Change Impacts

With respect to management, a number of studies have investigated the implications of climate change on water management in the region, suggesting management of reservoir systems will become more challenging (Vicuna and Dracup, 2007). The impacts are expected to be expensive, but not catastrophic for California (Harou et al., 2010).

Subtle changes in hydrology due to climate change can alter wetlands, resulting in a positive biotic feedback, contributing methane and carbon dioxide to the atmosphere (Burkett and Kusler, 2007). Policy options for minimizing the adverse impacts of climate change on wetland ecosystems include the reduction of current anthropogenic stresses, allowing for inland migration of coastal wetlands as sea-level rises, active management to preserve wetland hydrology, and a wide range of other management and restoration options.

Ficke et al. (2007) summarizes the general effects of climate change on freshwater systems to be increased water temperatures, decreased dissolved oxygen levels, and the increased toxicity of pollutants. Altered hydrologic regimes and increased groundwater temperatures could affect the quality of fish habitat. Eutrophication may be exacerbated and stratification will likely become more pronounced. Model predictions indicate that global climate change will continue even if greenhouse gas emissions decrease or cease. Therefore, proactive management strategies such as removing other stressors from natural systems will be necessary to sustain our freshwater fisheries.

Projected temperature and carbon dioxide increases may extend growing seasons, stimulate weed growth, increase pests, and may impact pollination (Baldocchi and Wong 2006). Stream temperatures in many areas are increasing due to increases in air temperature and reduced summer flows that make streams more sensitive to warmer air temperatures (Haak et al., 2010).

1.3 Identification of Interrelated Activities

1.3.1 Federal – WaterSMART

The WaterSMART Program, established by the Secretary of the Interior under Secretarial Order 3297, addresses an increasing set of water supply challenges, including chronic water supply shortages due to increased population growth, climate variability and change, and heightened competition for finite water supplies. The WaterSMART Program was developed as means of implementing the SECURE Water Act of 2009 (Public Law 111-11). The WaterSMART Program provides the scientific and financial tools and the collaborative environment needed to help balance water supply and demand through the efficient use of current supplies and the development of new supplies. Through WaterSMART, Reclamation is making use of the best available science in the assessments it conducts and the policies it employs. WaterSMART science has

and will continue to inform the real-time decisions of water managers who need reliable estimates of current conditions in the hydrologic cycle and projections of supply and demand in watersheds throughout the nation. Many examples of best available science are being developed through the WaterSMART Program. Much of that science can be accessed through the WaterSMART Clearinghouse, an online collaborative site where best practices and cost-effective technologies for water conservation and sustainable water strategies are shared with the public (http://www.doi.gov/watersmart/html/index.php).

1.3.2 State – Proposition 84 and IRWM

California's Safe Drinking Water, Water Quality and Supply, Flood Control, River and Coastal Protection Bond Act of 2006 (Prop 84) authorizes $5.388 billion in general obligation bonds to fund safe drinking water, water quality and supply, flood control, waterway and natural resource protection, water pollution and contamination control, state and local park improvements, public access to natural resources, and water conservation efforts.

Integrated Regional Water Management (IRWM) is a collaborative effort to manage all aspects of water resources in a region. IRWM crosses jurisdictional, watershed, and political boundaries; involves multiple agencies, stakeholders, individuals, and groups; and attempts to address the issues and differing perspectives of all the entities involved through mutually beneficial solutions. The California Department of Water Resources is currently working to ensure that IRWM planning is continued and expanded throughout the State; better align state and federal programs, polices, and regulations to support IRWM; identify stable and sufficient funding for IRWM; and further support regional water management groups.

1.3.3 Local – OWOW

The Santa Ana Watershed Project Authority is a planning and implementation agency that was formed in 1972 with the goal of building facilities to protect the water quality of the Watershed. Their planning efforts have expanded and, in 2006, SAWPA's One Water One Watershed (OWOW) plan was adopted. The OWOW plan is a comprehensive view of the watershed and water issues. The plan encompasses all sub-regions, political jurisdictions, water agencies and non-governmental stakeholders (private sector, environmental groups, and the public at large) in the watershed. All types of water (imported, local surface and groundwater, stormwater, and wastewater effluent) are viewed as components of a single water resource, inextricably linked to land use and habitat, and the plan tries to limit impacts of water use and climate change on natural hydrology.

2.0 Climate Projections and Hydrology Models

2.1 Climate Projections

Projected changes in climate (including both anthropogenic changes and natural variability), and their influence on streamflow and basin water supply, have been studied by several researchers in recent years, as described in Chapter 1. Future projections from global climate models (GCMs) indicate that the climate may exhibit trends and increased variability over the 21st century, beyond what has occurred historically. Downscaled GCM projections are one way to consider plausible future conditions.

Downscaled GCM projections are produced by internationally recognized climate modeling centers around the world and make use of greenhouse gas (GHG) emissions scenarios, which include assumptions of projected population growth and economic activity. GCM projections used in this study are spatially downscaled to 12 km grids to make them relevant for regional climate change impacts analysis. This process is illustrated in Figure 2. The downscaled GCM projections used in the Basin Study are based on the Coupled Model Intercomparison Project Phase 3 (CMIP3). These projections were the basis for analysis in the IPCC Fourth Assessment Report (IPCC, 2007).The emission scenarios used in the downscaled GCM projections based on CMIP3 are A2 (high), A1b (medium), and B1 (low), and reflect a range of future GHG emissions. The A2 scenario is representative of high population growth, slow economic development, and slow technological change. It is characterized by a continuously increasing rate of GHG emissions, and features the highest annual emissions rates of any scenario by the end of the 21st Century. The A1B scenario features a global population that peaks mid-century and rapid introduction of new and more efficient technologies balanced across both fossil- and non-fossil intensive energy sources. As a result, GHG emissions in the A1B scenario peak around mid-century. Last, the B1 scenario describes a world with rapid changes in economic structures toward a service and information economy. GHG emission rates in this scenario peak prior to mid-century and are generally the lowest of the scenarios.

Emission scenarios exist that have both higher and lower GHG emissions than those considered in this Basin Study (e.g. A1fi). However, the three scenarios included in the analysis span a wide range of projected GHG, and there are more GCM projections available based on these three emissions scenarios than any others.

This Study used the downscaled CMIP3 climate projections; however, new projections from the CMIP5 were recently published in May 2013. CMIP5 climate projections are based on emission scenarios referred to as representative concentration pathways (RCPs; Taylor, 2011). Even though CMIP5 projections are more current, it has not been determined that they are a more reliable source of climate projections compared to existing CMIP3 climate projections. At this time, CMIP5 projections should be considered an addition to (not a replacement for) the existing CMIP3 projections, unless the climate science community can offer an explanation as to why CMIP5 should be favored over CMIP3.

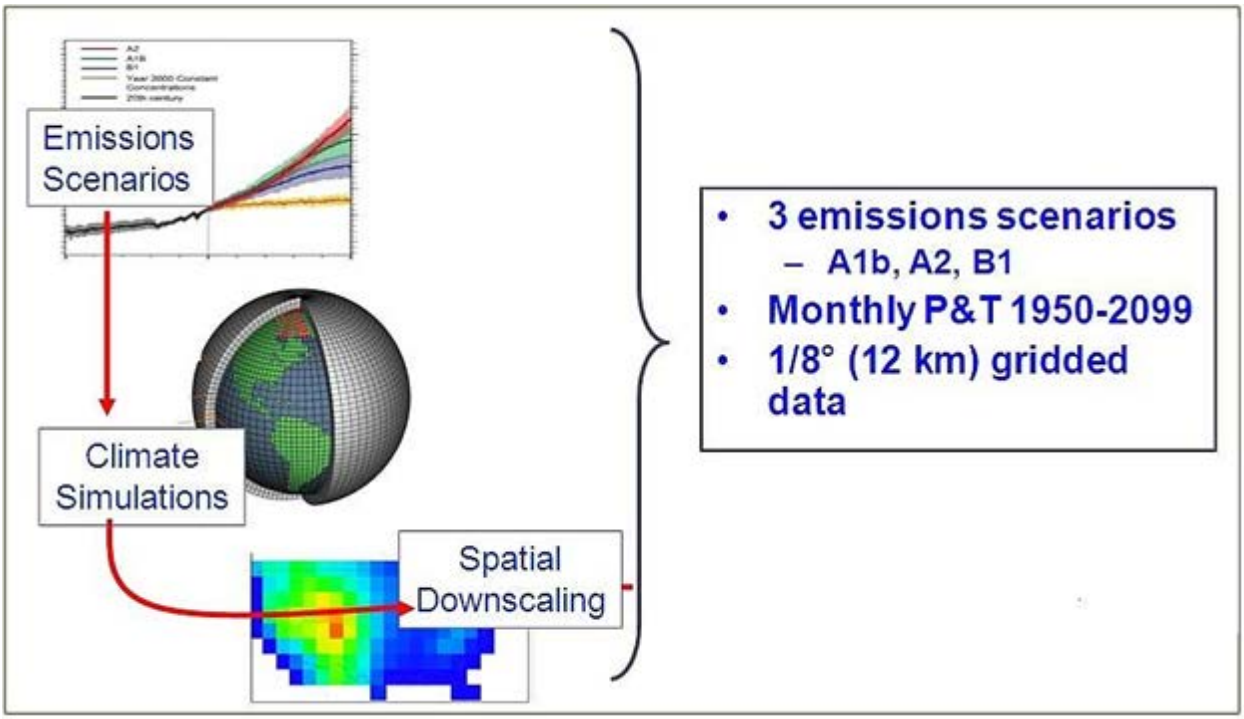


Figure 2: Downscaled GCM key elements figure

2.2 Hydrology Models for the Santa Ana River Watershed

2.2.1 Surface Water

Surface water hydrology projections for the Watershed were developed using the Variable Infiltration Capacity (VIC) model (Liang et al., 1994; Liang et al., 1996; Nijssen et al., 1997) as part of Reclamation's SECURE report on surface water hydrology projections (Reclamation, 2011).

The VIC model is a spatially distributed hydrology model that solves the water balance at each model grid cell. The model initially was designed as a land-surface model to be incorporated in a GCM so that land-surface processes could

be more accurately simulated. However, the model now is run almost exclusively as a stand-alone hydrology model (not integrated with a GCM) and has been widely used in climate change impact and hydrologic variability studies. For climate change impact studies, VIC is run in what is termed the water balance mode that is less computationally demanding than an alternative energy balance mode, in which a surface temperature that closes both the water and energy balances is solved for iteratively. A schematic of the VIC hydrology and energy balance model is given in Figure 3.

The VIC model may be implemented at any spatial resolution, adhering to a latitude-longitude grid. For this Basin Study, and for consistency with Reclamation's West-Wide Climate Risk Assessment, the model was implemented over the study area at 1/8° or ~12 km resolution. Physical characteristics of each cell are predefined within the study area to simulate runoff and other water/land/atmosphere interactions at each grid cell. The VIC hydrology model uses daily weather data (precipitation, maximum temperature, minimum temperature and wind) along with land cover, soils, and elevation information at 1/8° grid scale to simulate hydrologic processes.

VIC provides a wide array of hydrologic outputs, typically including runoff, snow-water equivalent and evapotranspiration, which are routinely analyzed to assess climate change impacts on watershed hydrology. Also, note that all these outputs are produced at the native VIC grid cell resolution of 1/8° or ~12 km. Analysis of these hydrologic variables for the watershed is described in Chapter 3.

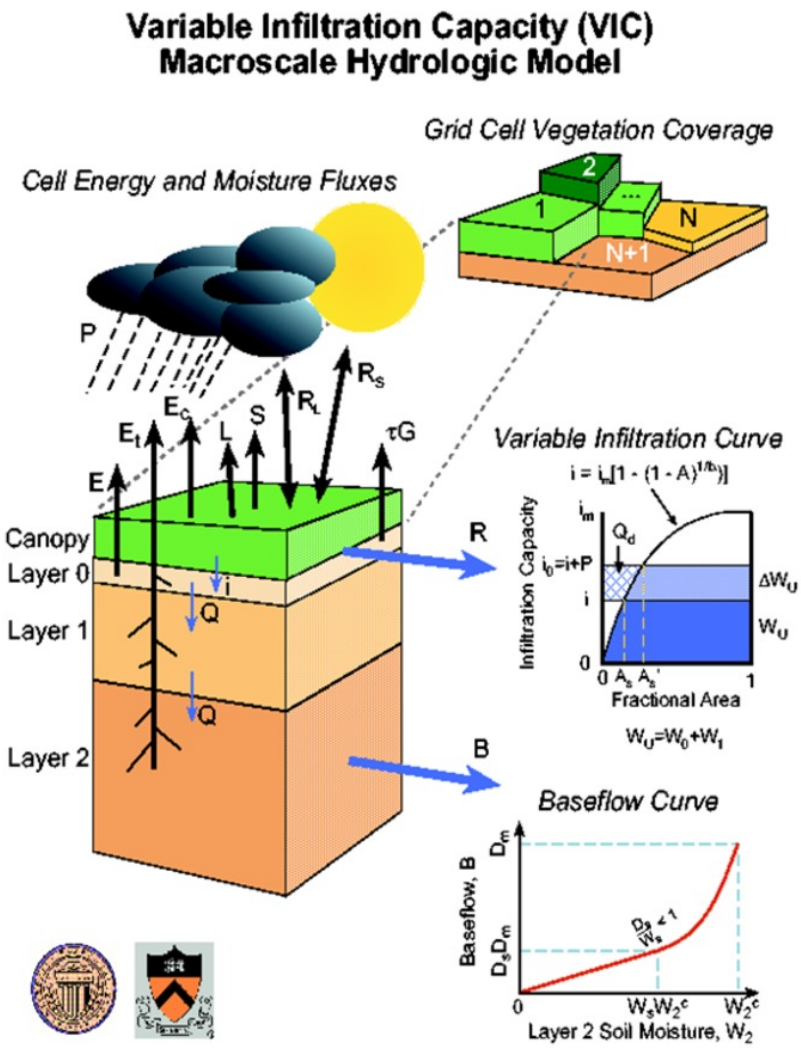


Figure 3: VIC macroscale hydrologic model

However, to analyze streamflow, gridded runoff was routed (Figure 4) to 36 gage locations (Table 1; Figure 5) within the Watershed using the Lohmann et al., (1998) routing model. Additional inputs to the routing model, developed for this Basin Study include, a routing network derived from 15 arc-second (~450 meters) Digital Elevation Model (DEM), flow accumulation, and flow direction data available from the United States Geological Survey (USGS) HydroSHEDS (hydrological data and maps based on Shuttle Elevation Derivatives at Multiple Scales) archive using ArcGIS™. The result of this approach is 112 unique sequences of natural flow under future climate projections. Further details on the development and choice of using the VIC model are available from Reclamation's West-Wide Climate Risk Assessments: Bias-Corrected and Spatially Downscaled Surface Water Projections (2011) report.

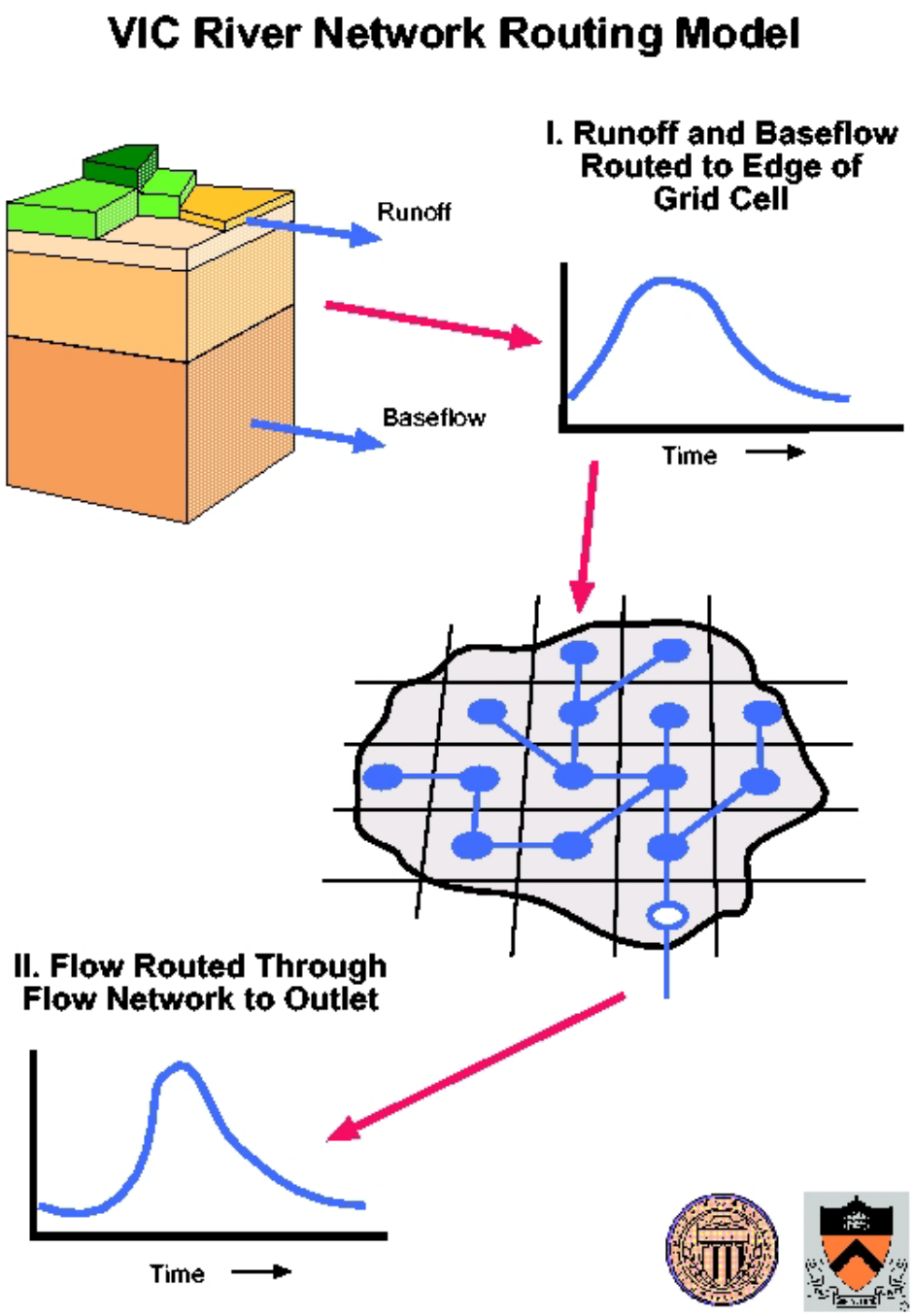


Figure 4: VIC routing model

Table 1: Routing locations in the Santa Ana River Watershed

ID	Latitude (decimal degree)	Longitude (decimal degree)	Site Description
1	33.675020160	-117.835611000	Peters Canyon Wash Tustin Gage
2	33.683909460	-117.745330710	Marshburn Channel Gage
3	33.681686820	-117.809499150	San Diego Creek Myford Rd Gage
4	33.725442191	-117.802408768	El Modina-Irvine Channel Gage
5	33.693809460	-117.823037908	Peters Canyon Wash Irvine Gage
6	33.672798000	-117.835888800	San Diego Creek Lane Rd Gage
7	33.655576290	-117.845611300	San Diego Creek Campus Dr Gage
8	33.885294816	-117.651816486	Santa Ana River Prado Dam Gage
9	33.872738742	-117.670852174	Santa Ana River County Line Gage
10	33.856404490	-117.790611220	Santa Ana River Imperial Highway Gage
11	33.855848910	-117.797555880	Santa Ana River AB SPRD Imperial Highway Gage
12	33.856404440	-117.800889300	Santa Ana River SPRD Imperial Highway Gage
13	33.888903530	-117.845335820	Carbon Creek Olinda Gage
14	33.889459080	-117.845335830	Carbon Creek Yorba Linda Gage
15	33.818812586	-117.873013779	Santa Ana River Ball Rd Gage
16	33.802238450	-117.878390750	Santa Ana River Katella Ave Gage
17	33.822794190	-117.776721310	Santiago Creek Villa Park Gage
18	33.822794190	-117.776721310	Santiago Creek Div Villa Park Gage
19	33.777261477	-117.878057039	Santiago Creek Santa Ana Gage
20	33.752045602	-117.906379262	Santa Ana River Santa Ana Gage
21	33.672033347	-117.943733939	Santa Ana River Adams St Gage
22	33.887792060	-117.926449600	Brea Channel Brea Dam Gage
23	33.873625670	-117.925893710	Brea Channel Fullerton Gage
24	33.895847650	-117.886170600	Fullteron Channel Fullerton Dam Gage
25	33.872875108	-117.902127395	Fullerton Channel Fullerton Gage
26	33.860696271	-117.929366516	Fullerton Channel Richman Ave Gage
27	33.810571570	-118.075342080	Coyote Creek Los Alamitos Gage
28	34.259256110	-117.330684440	Devils Canyon
29	33.968611110	-117.447500000	Santa Ana River AT Metropolitan Water District Crossing NR Arlington
30	34.064688346	-117.303911477	Santa Ana River AT E Street NR San Bernardino
31	33.889166670	-117.561944440	Temescal Creek AB Main Street AT Corona
32	33.982777780	-117.598611110	Cucamonga Creek NR Mira Loma
33	34.003888890	-117.726111110	Chino Creek AT Schaefer Avenue NR Chino
34	34.114206940	-117.096661940	Seven Oaks Dam Outlet
35	34.252500000	-117.525277780	Middle Fork Lytle Creek Gage
36	34.263888890	-117.401388890	Ridge Top Gage NR Devore

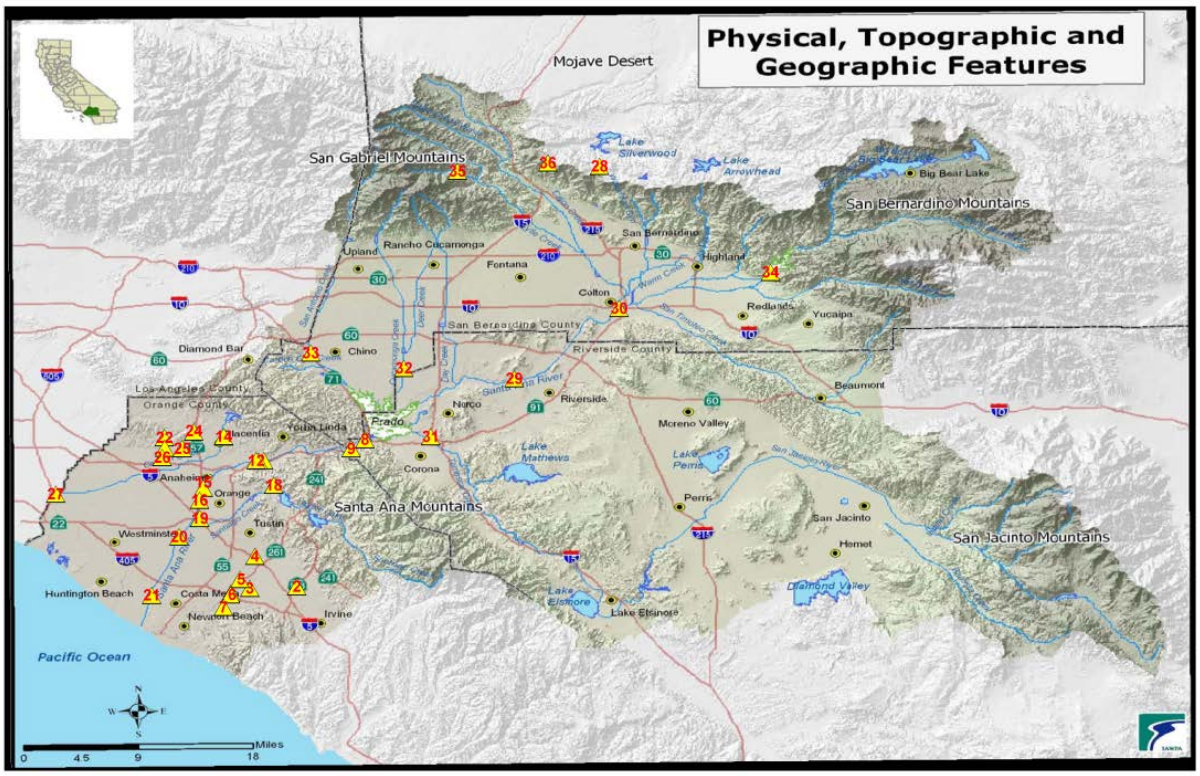


Figure 5: Distribution of routing locations

2.2.2 Groundwater

Changes in climate, population, land use, water management practices, and other natural and anthropogenic factors may affect the quantity and quality of future groundwater resources within the Watershed. Groundwater currently provides approximately 54% of total water supply in the watershed during an average year, and groundwater use is projected to increase over the next 20 years, according to the first OWOW plan (2010). The potential effects of natural and anthropogenic changes on future groundwater resources—including the potential effects of climate change—are therefore a critical component of water resources planning in the Watershed.

Changes in precipitation and temperature directly affect hydrologic processes at the land surface, including groundwater recharge. Changes in precipitation and temperature may also affect groundwater storage and discharge indirectly through changes in water demands. Accurately projecting the potential effects of climate change on groundwater resources within the Watershed, however, is a significant challenge due to the many local factors that govern groundwater recharge and use throughout the watershed. The Watershed encompasses 17 individual groundwater basins and sub-basins; however, only 4 have consistent historical data available, as shown in Figure 6 (California Department of Water Resources [DWR] Bulletin 118). Effects of changes in precipitation and temperature on

groundwater resources are likely to vary substantially between groundwater basins due to differences in local hydrologic, geologic, and topographic conditions, as well as differences in local water supplies, water demands, and water management practices between basins.

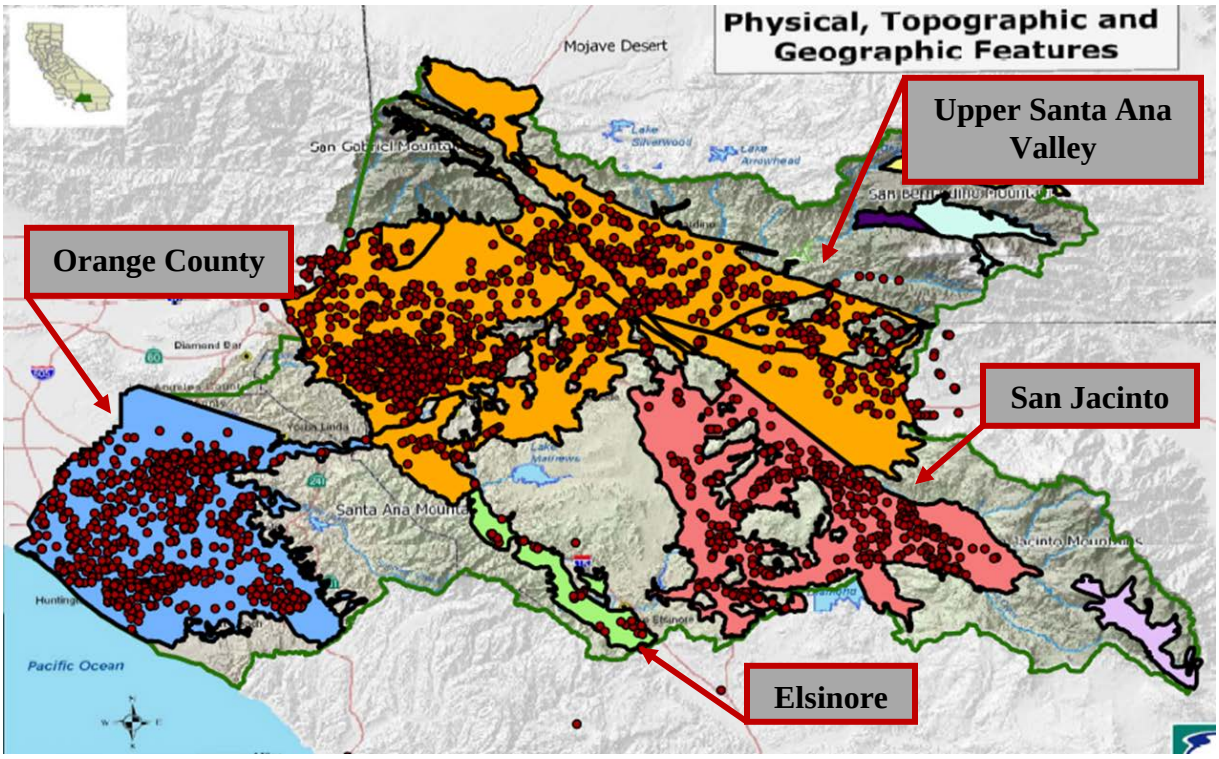


Figure 6: Groundwater basins and monitoring well locations (illustrated by red dots)

The effects of climate change on groundwater resources are commonly evaluated using a spatially distributed numerical model of the groundwater flow system in question, which may consist of a single aquifer or unit, multiple aquifers, or an entire groundwater basin or sub-basin. A numerical model of the groundwater flow system is constructed to represent the relevant physical properties of the system, including its geographic extent and orientation, the porosity and permeability of subsurface materials, and the location and extent of key features affecting groundwater flow such as faults, aquitards, and aquicludes. Historical inflows and outflows from the groundwater system are estimated from available data and formatted as model inputs, including spatially distributed recharge from precipitation, focused recharge from stream and canal seepage losses or deep percolation of irrigation water, groundwater abstraction by pumping, and other inflows and outflows. The model is then calibrated and verified with respect to available observations. A second set of groundwater inflows and outflows is then developed based on projected future climate conditions, and is again formatted as model inputs. Finally, the model is used to simulate groundwater flow and storage under historical and projected climate conditions and the resulting model

outputs are compared to evaluate the effects of climate change on groundwater resources.

The use of spatially-distributed numerical models to evaluate climate change impacts on groundwater is both data intensive and computationally intensive, and requires explicit representation of the many local factors that affect groundwater recharge and use. As a result, this approach generally bears a large cost and long timeline. Moreover, the use of spatially-distributed numerical models to evaluate climate change impacts on groundwater resources in the Watershed would require development of separate models for individual groundwater basins and sub-basins. The cost of such an analysis is therefore prohibitive at the watershed scale.

In order to evaluate basin-scale groundwater conditions in the Watershed under future climate, population, land use, and water management scenarios, a basin-scale groundwater screening tool was developed based on a simplified representation of individual groundwater basins. The groundwater screening tool estimates fluctuations in basin-scale groundwater levels in response to natural and anthropogenic drivers, including climate and hydrologic conditions, agricultural land use, municipal water demand, and trans-basin water imports. The tool allows users to quickly estimate basin-scale groundwater conditions under a broad range of future scenarios and provides insight into the primary factors driving basin-scale groundwater fluctuations.

A basin-scale groundwater screening tool was developed to facilitate evaluation of groundwater conditions within the Watershed under future climate, population, land use, and water management scenarios. The tool estimates fluctuations in average groundwater levels over a given groundwater basin, at a monthly time scale, in response to natural and anthropogenic drivers, including climate and hydrologic conditions, agricultural land use, municipal water demand, and trans-basin water imports. The tool allows users to quickly estimate changes in basin-average groundwater levels in response to projected changes in future climate, and provides insight into the primary factors driving basin-scale groundwater fluctuations.

In groundwater basins where groundwater is a primary source of water supply, fluctuations in basin-averaged groundwater level depend on both water availability and water demands. In general, higher than average water availability from precipitation, local streamflow, and imported water contributes to increased recharge and/or decreased groundwater pumping, resulting in rising groundwater levels. By contrast, higher than average water demands for municipal and agricultural uses and higher than average evaporative demand from native and landscaped vegetation contribute to decreased recharge and/or increased groundwater pumping, resulting in declining groundwater levels. In addition to supply and demand, large-scale management objectives in some groundwater basins such as pressurization of hydraulic barriers against sea water intrusion and

dewatering for hydraulic control of groundwater discharge may also affect basin-average groundwater levels.

The competing influences of water availability, water demand, and large-scale groundwater management objectives on basin-scale groundwater elevations are illustrated schematically in Figure 7, which forms the conceptual model for the basin-scale groundwater screening tool. This conceptual model considers fluctuations in basin-average groundwater elevations as a function of basin-scale drivers. As a result, use of the groundwater screening tool does not require detailed information regarding local hydrologic, geologic, climatic, and anthropogenic factors that may affect local groundwater fluctuations; however, it should be noted that as a result of this basin-scale approach, the groundwater screening tool is primarily applicable at the scale of individual groundwater basins or sub-basins, where the effects of local-scale conditions are largely averaged out and where subsurface inflows and outflows from surrounding areas are negligible.

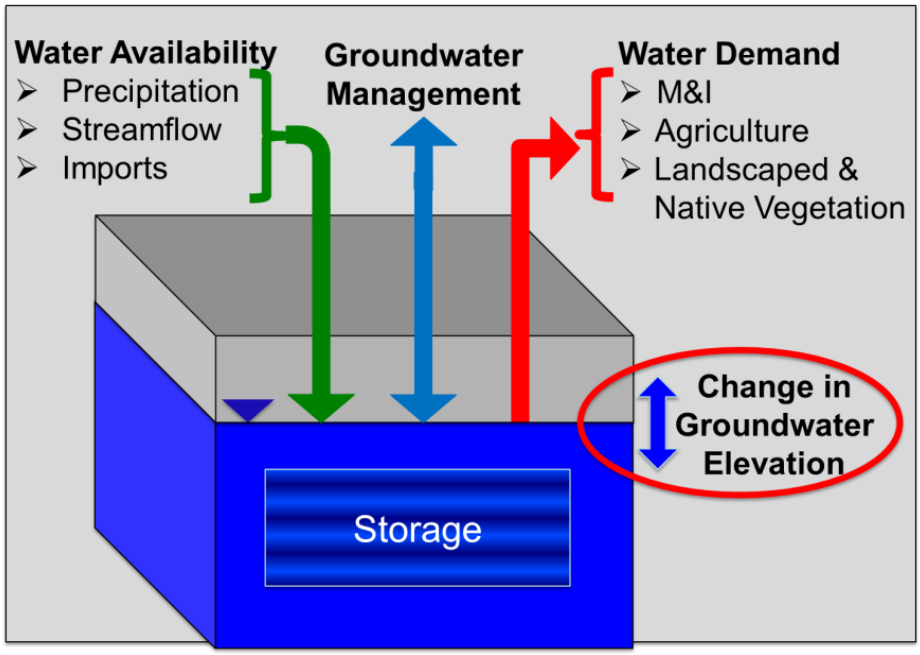


Figure 7: Conceptual model of basin-scale groundwater fluctuations used in developing the groundwater screening tool

In the basin-scale groundwater screening tool, fluctuations in groundwater elevation are estimated as a function of three inputs that characterize water availability (precipitation, local streamflow, and trans-basin imports), three inputs that characterize water demand (municipal and industrial demand, agricultural land use [irrigated acreage], and evaporative demand), and an optional exogenous input that represents groundwater management objectives that affect basin-scale groundwater levels. The functional relationship is implemented in the form of a multi-variate linear regression equation (Equation 1):

$$\frac{\Delta h}{\Delta t} = (C_1 \cdot P_t) + (C_2 \cdot E_t) + (C_3 \cdot Q_t) + (C_4 \cdot M_t) + (C_5 \cdot A_t) + (C_6 \cdot I_t) + (C_7 \cdot X_t) \text{.....} \quad \textbf{Eq. 1}$$

Where:

$\frac{\Delta h}{\Delta t}$ is the change in basin-averaged groundwater elevation (t is in months)

P_t is total precipitation over the groundwater basin

Q_t is streamflow at a representative location that reflects surface water availability in the basin

I_t is the volume of trans-basin water imports to the groundwater basin

M_t is municipal and industrial demand within the basin

E_t is evaporative demand from native and landscaped (non-agricultural) vegetation

A_t is agricultural water demand (applied water demand)

X_t is a timeseries of values representing the effect of a specific large-scale water management practice on groundwater levels within the basin

C_i are linear regression coefficients

Variables P_t, Q_t, and I_t represent the available water supplies within the groundwater basin during the given time period, whereas variables M_t, E_t, and A_t represent the primary water demands within the basin during the same period. Variable X_t is optional and can be used to reflect specific large-scale management activities that affect groundwater levels throughout the basin. Coefficients C_i are determined via linear regression (i.e., by fitting Equation 1 to historical observations). After the coefficient values have been determined, the groundwater screening tool uses Equation 1 to estimate future groundwater elevations under various future scenarios. For example, the tool can be used to estimate future groundwater elevations under climate change by modifying inputs P_t, Q_t, and E_t to reflect projected future climate conditions.

In addition to reduced data and computational requirements, implementation of the basin-scale conceptual model via linear regression provides broad flexibility in the development of inputs to the groundwater screening tool. The conceptual model represents the large-scale mass balance of groundwater in a given basin. However, accurate and comprehensive data for many of the inflow and outflow terms in the conceptual model are often unavailable for most groundwater basins.

For example, evaporative demand for native and landscaped vegetation generally is not readily available for most groundwater basins. The regression-based approach used here allows the user to substitute a related variable in place of the missing data. In the case of evaporative demand, the user may substitute temperature data for evaporative demand as temperature is strongly correlated with evaporative demand. As long as fluctuations in the substituted dataset (in this case temperature) are strongly correlated with fluctuations in the primary input variable (in this case evaporative demand), discrepancies in magnitudes of two variables are accounted for by the regression coefficient on this term.

Development of Groundwater Model Inputs

As detailed above, the groundwater screening tool estimates changes in basin-averaged groundwater levels over time as a function of seven natural and anthropogenic factors that govern groundwater recharge and discharge: precipitation, local streamflow, trans-basin water imports, municipal and industrial water demands, agricultural water demand, evaporative demand from native and landscaped vegetation (non-agricultural), and an optional exogenous input that represents groundwater management objectives that affect basin-scale groundwater levels. The regression-based approach used in the groundwater screening tool allows substitution of related datasets where accurate data for one or more model input is not available. This section summarizes the development of inputs to the groundwater screening tool for groundwater basins within the Watershed.

Historical Input Data (1990-2009)

Historical data were used to fit the regression coefficients in Equation 1 and to evaluate model performance over the historical period (1990-2009). For each groundwater basin, historical inputs are required for the six primary input variables to Equation 1. Additional inputs may be provided for the optional exogenous variable if desired. No exogenous inputs were developed for groundwater basins within the Watershed; however, exogenous inputs may be incorporated by water resources planners and decision makers in the watershed based on knowledge of management operations relevant to individual groundwater basins.

Groundwater Elevation (h_t)

The groundwater screening tool requires an input timeseries representative of historical monthly groundwater elevations within the basin for the period 1990-2009. For this study, a database of historical groundwater elevations from more than 4,000 monitoring wells within the Watershed was obtained from SAWPA. Monitoring well locations are shown in Figure 6. Well records were evaluated to determine the period of record, completeness of record, and occurrence of outlier or spurious values. Wells exhibiting records shorter than 10 consecutive years or exhibiting a high frequency of missing values were excluded from this analysis. For each well identified as having a sufficient period of record and sufficient sampling frequency, monthly mean groundwater elevations were calculated from the available instantaneous measurements. For months containing more than one

measurement, the monthly average was computed as the unweighted arithmetic average of the available measurements. For months with a single measurement, the single measurement was assumed to reflect average conditions during that month. It should be noted that individual outlier points were excluded from averaging; outliers likely reflect measurement errors, data transcription errors, or measurements taken during or after permeability testing was carried out (i.e., during or after a slug test or pump test). Lastly, monthly averages were linearly interpolated to develop a complete timeseries of monthly mean groundwater elevations over the period of record. Accuracy of monthly timeseries was evaluated by sub-sampling and cross-validation. Interpolated monthly timeseries were shown to accurately reflect raw measurements.

Monthly timeseries of basin-averaged groundwater elevations were then developed for each of the individual groundwater basins and sub-basins (defined by DWR) in the Watershed. Steps were required to avoid two sources of bias in calculating basin-average groundwater elevations: variations in the period of record between wells, and outlier wells that are not representative of large-scale groundwater fluctuations within a basin. These steps are described below.

Very few wells in the database used here exhibit complete monthly timeseries for the full historical period (1990-2009). As a result, simply taking the arithmetic average of well records over each groundwater basin results in a biased estimate of basin-average groundwater elevations. This bias occurs due to differences in the period of record of wells within a given basin: if the basin average for different months is based on a different sub-set of wells, and each well has a different mean groundwater elevation, then the resulting average reflects variations in the sub-set of well used. To minimize biases associated with varying record lengths, averaging was carried out based on monthly deviations rather than monthly groundwater elevations. This was done by computing monthly deviations (anomalies) for each record (i.e. for each well), where monthly deviations are calculated as the difference between the monthly mean value and the long-term average value for that month.

In addition to differences in record length, potential biases may occur in cases where individual well records reflect unique local conditions that are not broadly representative of groundwater fluctuations within the basin. This situation might occur when groundwater pumping throughout a basin is not driven primarily by municipal and industrial demand, but is driven by agricultural demand in one small area of the basin. Groundwater fluctuations in the agricultural portion of the basin are likely to exhibit substantially different behavior than groundwater fluctuations throughout the rest of the basin. In basins where a large number of monitoring wells are available, individual outliers have little effect on the basin-scale average and therefore do not need to be excluded from analysis. Where a small number of samples are available, however, individual outliers can disproportionately impact the basin average, resulting in potentially significant bias.

For this study, a correlation-based clustering procedure was developed to group wells into sub-sets exhibiting similar behavior. In basins and sub-basins where a large number of monitoring records were available, the majority of wells fell into a single cluster. For the purposes of this analysis, the largest cluster was assumed to reflect basin-average conditions, and basin-average groundwater elevations were calculated based on wells in this cluster. In basins and sub-basins where, only a small number of records were available, wells generally fell into a small number of similar size clusters. For the purposes of this analysis, these clusters were assumed to represent conditions in different portions of the basin where groundwater fluctuations were subject to different primary stressors. In these cases, averages were computed for each cluster and were evaluated separately. This report only presents results for basins where the majority of groundwater records fell into a single cluster.

Precipitation (P_t)

The groundwater screening tool requires an input timeseries that is representative of historical monthly precipitation over the groundwater basin for the period 1990-2009. Precipitation input may be basin-averaged monthly precipitation calculated from multiple gage records or from a gridded precipitation dataset. Alternatively, precipitation input may be derived from gage data at a single location or selected locations that represent key areas within the groundwater basin, such as areas of significant recharge or runoff. For this study, basin-average monthly precipitation was calculated for each groundwater basin based on the historical gridded daily precipitation dataset developed by Maurer et al. (2002), the same dataset used to derive the surface water projections. Area-weighted monthly total precipitation was computed for each basin based on groundwater basin polygons developed by DWR.

Evaporative Demand (E_t)

The groundwater screening tool requires an input timeseries that is representative of historical monthly evaporative demand from native and landscaped (non-agricultural) vegetation over the groundwater basin for the period 1990-2009. Because evaporative demand is generally not measured directly, monthly mean temperature or calculated monthly potential evapotranspiration (PET) may be used as surrogates for evaporative demand. For this study, basin-average monthly-mean temperature was calculated for each groundwater basin based on the historical gridded daily temperature dataset developed by Maurer et al. (2002), the same dataset used to derive the surface water hydrology projections. Area-weighted monthly-mean temperature was computed for each basin based on groundwater basin polygons developed by DWR.

Streamflow (Q_t)

The groundwater screening tool requires an input timeseries that is representative of historical monthly streamflow that contributed to water supply in the groundwater basin for the period 1990-2009. This streamflow excludes that

which is provided by trans-basin imported water. Locations selected for the streamflow inputs for the four basins can be seen in Figure 8; the latitude and longitude for each point can be found in Table 2. Locations were chosen to be representative of streamflow in the basin. The San Jacinto and Elsinore Basins are able to share a stream flow point because the point is representative of water leaving the San Jacinto Basin and water entering the Elsinore Basin. Streamflow input may be based on a single gage that is representative of natural streamflow conditions within the basin, or may be estimated natural flow in the absence of storage and trans-basin diversions (i.e., naturalized streamflow). For this study, simulated historical natural flow at a representative point was used for each basin, development of which is described in section 2.2.1.

Table 2: Streamflow locations for groundwater basins

Groundwater Basin	Latitude (decimal degree)	Longitude (decimal degree)
Orange County	33.85640444	-117.80088930
Upper Santa Ana Valley	33.88916667	-117.56194444
Elsinore/San Jacinto	33.66411200	-117.29397600

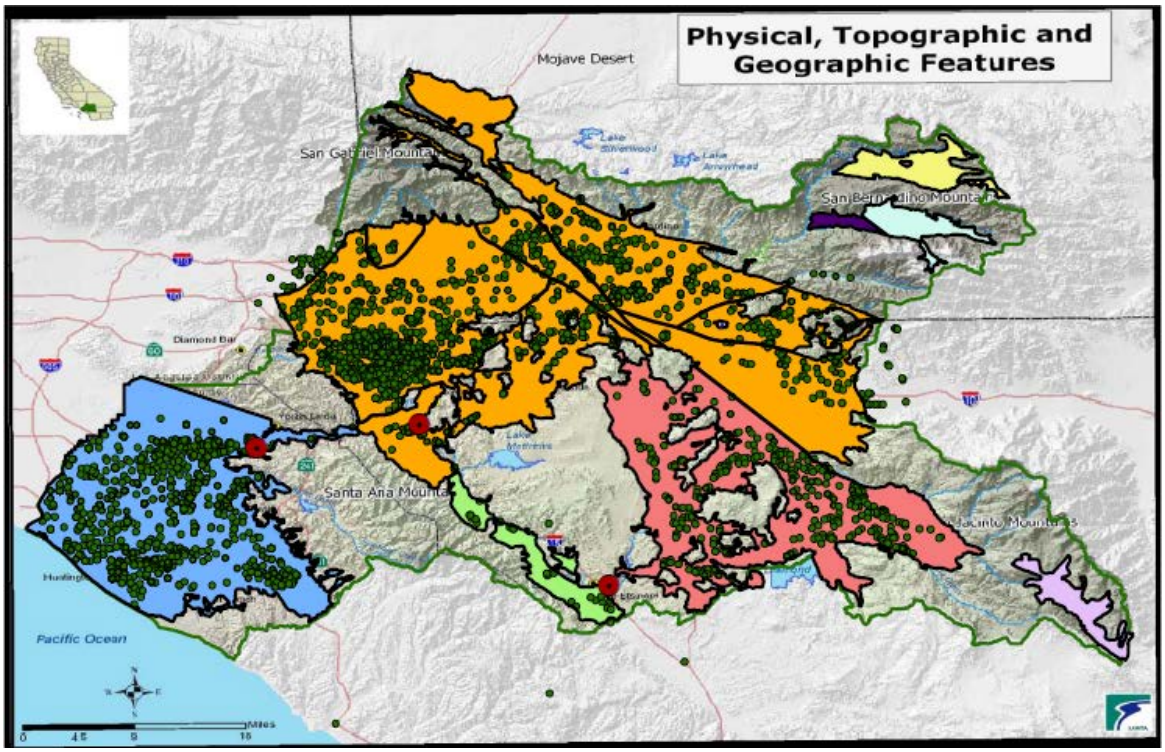


Figure 8: Locations for streamflow inputs (represented by red dots)

Municipal and Industrial Demand (M_t)

The groundwater screening tool requires an input timeseries that is representative of historical monthly municipal and industrial water demand within the groundwater basin for the period 1990-2009. Where municipal and industrial demand data are not directly available, demand may be estimated from available population and per capita water use data, interpolated as needed to obtain monthly data for the period 1990-2009. For this study, population within each groundwater basin was calculated from census tract data for years 1990, 2000, and 2010, and were interpolated to obtain monthly values. Data for annual per capita water use were obtained from urban water management plans for SAWPA member agencies and other water providers within each basin, and were similarly interpolated to obtain monthly values. Municipal and industrial demand was then estimated as the product of population and per capita use.

Agricultural Demand (A_t)

The groundwater screening tool requires an input timeseries that is representative of historical monthly agricultural water demand within the groundwater basin for the period 1990-2009. Accurate and consistent data on agricultural water use is not available for the groundwater basins within the Watershed. For this study, agricultural land area (irrigated acreage) was used as a surrogate for agricultural demand. For each groundwater basin, irrigated acreage was calculated from available land use datasets developed by the Southern California Association of Governments (SCAG). Available values were interpolated to obtain estimates of monthly values over the period 1990-2009. Where cropping patterns and irrigation practices are reasonably constant, agricultural acreage is strongly correlated with agricultural demand.

Trans-basin Imported Water (I_t)

The groundwater screening tool requires an input timeseries that is representative of historical monthly trans-basin water imported into the groundwater basin for the period 1990-2009. For this study, import data were obtained from SAWPA member agencies and associated, to the extent possible, with the corresponding groundwater basin. Initial analysis revealed that trans-basin imports are generally small compared to precipitation and natural streamflow for most groundwater basins in the watershed; as a result, uncertainties associated with the historical trans-basin import data used in this analysis is considered negligible.

Exogenous Variable (X_t)

The simplified approach used by the groundwater screening tool does not represent many of the complex and dynamic processes that may affect groundwater fluctuations within a given basin. For this purpose, the tool allows for an optional exogenous input, which provides the user an opportunity to account for a key driver that is not explicitly represented by the above inputs. Key drivers may include groundwater injection operations for a hydraulic barrier against sea water intrusion, dewatering for hydraulic control of groundwater

discharge, or other management objectives that affect groundwater levels. No exogenous variable was used in this study.

Projected (Future) Input Data (2010-2099)

The groundwater screening tool estimates future groundwater elevations over the period 2010-2099 based on input data reflecting projected water supply, water demand, and water management conditions over this period. Future inputs are required for each of the primary input variables to the screening tool. If an exogenous variable is used for the historical period, projected values of the same exogenous variable are required for the future period. As noted above, no exogenous inputs were developed for groundwater basins within the Watershed. It should also be noted that projected groundwater elevations are calculated by the screening tool; groundwater elevation is not an input for the future period.

Precipitation (P_t)

The groundwater screening tool allows users to provide up to 250 projections of future precipitation for a given basin. Consideration of multiple future projections provides insight into the range of future conditions corresponding to uncertainties in projected future climate. For this study, projected basin-average monthly precipitation for the period 2010-2099 was calculated based on an ensemble of 112 bias corrected and spatially disaggregated climate projections (see Section 2.2.1). For each projection, input timeseries were developed by calculating the area-weighted monthly total precipitation for groundwater basin polygons developed by DWR.

Evaporative Demand (E_t)

Similar to precipitation, the groundwater screening tool allows users to provide up to 250 projections of future evaporative demand for a given basin. For consistency with historical inputs, basin-average monthly-mean temperature was used to represent monthly evaporative demand over the future period. Projected basin-average monthly average temperature inputs were calculated for each groundwater basin based on an ensemble of 112 BCSD climate projections (see Section 2.2.1). For each projection, input timeseries were developed by calculating the area-weighted monthly average temperature for groundwater basin polygons developed by DWR.

Streamflow (Q_t)

Similar to precipitation and temperature, the groundwater screening tool allows users to provide up to 250 projections of streamflow for a given basin. For this study, projected natural flow at a representative point for the period 2010-2099 was used for each basin (see Section 2.2.1).

Municipal and Industrial Demand (M_t)

The groundwater screening tool requires a single timeseries input representing projected municipal and industrial demand for the future period. For the purposes of this study, it was assumed that future municipal and industrial demand will

remain at current levels. However, the tool allows water resources planners and decision makers to input alternative projections of future municipal and industrial demand based on various scenarios and planning objectives related to individual groundwater basins.

Agricultural Demand (A_t)

The groundwater screening tool requires a single timeseries input representing projected agricultural demand for the future period. For consistency with historical inputs, agricultural land area (irrigated acreage) was used to represent agricultural water demand in the future. For the purposes of this study, it was assumed that future agricultural land area will remain at current levels. However, the tool allows water resources planners and decision makers to input alternative projections of future agricultural demand based on various scenarios and planning objectives related to individual groundwater basins.

Trans-basin Imported Water (I_t)

The groundwater screening tool requires a single timeseries input representing projected trans-basin imported water for the future period. For the purposes of this study, it was assumed that future water imports will remain at the average historical level, calculated as the average over the period 1990-2009. However, the tool allows water resources planners and decision makers to input alternative projections of future water imports based on various scenarios and planning objectives related to individual groundwater basins.

Exogenous Variable (X_t)

As for the historical period, no exogenous variable was used in this study for the future period.

The methods described in this chapter were used to project hydroclimate conditions including surface water and groundwater supplies, which are presented in Chapter 3 along with projected demand.

3.0 Water Supply and Demand Projections

3.1 Water Supply

Future water supply projections were made using the CMIP3 projections and the VIC hydrology model. The CMIP3 archive provides a downscaled 12 kilometer resolution grid on a monthly time-series of precipitation and temperature from 1950-2099 for 112 climate projections.

3.1.1 Hydroclimate Projections

Timeseries Plots

This set includes projection specific annual timeseries plots for six hydroclimate indicator variables covering the period 1950–2099 (water years 1951-2099). The six variables are:

- Annual Total Precipitation
- Annual Mean Temperature
- April 1st Snow Water Equivalent
- Annual Runoff
- December–March Runoff
- April–July Runoff

The three variables—annual total precipitation, annual mean temperature, and April 1st SWE—vary spatially (at 1/8° or ~ 12-km-grid resolution) across the basins. To estimate total annual precipitation for the basin, basin-wide average precipitation (average across the grid cells in the basin) was first calculated for each month of the years 1950–2099. These basin average monthly precipitation values then were summed for each water year 1951-2099 to obtain the annual total precipitation.

To estimate basin mean temperature, average monthly temperature was calculated from all the grid cells in the basin for each month of the water years 1951–2099. These monthly temperatures for any given year next were averaged across the grid cells in the basin to estimate the basin-wide annual mean temperature.

SWE on April 1st of a given year is a widely used measure to assess snowpack and subsequent spring–summer runoff conditions in the snowmelt dominated basins of the western United States. SWE is one possible output from the VIC hydrology model. For each of the simulation water years, April 1st SWE was

saved from the simulations for each model grid cell in the basin. Gridded SWE on April 1st was averaged over all the grid cells for the given basin to calculate the basin-wide April 1st SWE for water years, 1950–2099.

Runoff for each of the 36 site locations (Table 1) was calculated for the annual timescale and for two seasonal timescales December–March (DJFM) total runoff depicting winter season runoff conditions and April–July (AMJJ) total runoff depicting spring–summer runoff conditions. For each of the simulation years 1950–2099, monthly runoff was aggregated on a water year basis to calculate water year specific total annual runoff, DJFM runoff, and AMJJ runoff.

The annual time series plots for the six hydrologic indicator variables for all 112 projections were calculated, and the results are presented to reflect ensemble central tendency and ensemble spread. The central tendency is measured using the ensemble median. The 5th and 95th percentiles from the 112 projections provide the lower and upper uncertainty bounds in the envelope of projections through time.

Figure 9 shows the projection ensemble for six hydroclimate indicators for the site Santa Ana River at Adams Street Gage (most downstream location): annual total precipitation (top left), annual mean temperature (top right), April 1st SWE (middle left), annual runoff (middle right), DJFM runoff season (bottom left), and AMJJ runoff season (bottom right). The heavy black line is the annual time series of 50th percentile values (i.e., ensemble-median). The shaded area is the annual time series of 5th to 95th percentiles.

The annual total precipitation over the basin shows a somewhat declining trend over the transient period going out to 2099. The uncertainty envelope does not appear to expand or contract over time. The mean annual temperature over the basin shows a monotonically increasing trend and a diverging uncertainty envelope over time. April 1st SWE also shows a decreasing trend. The annual runoff follows the long-term declining trend pattern similar to precipitation. The winter season DJFM runoff shows a declining trend, so does the AMJJ summer season runoff.

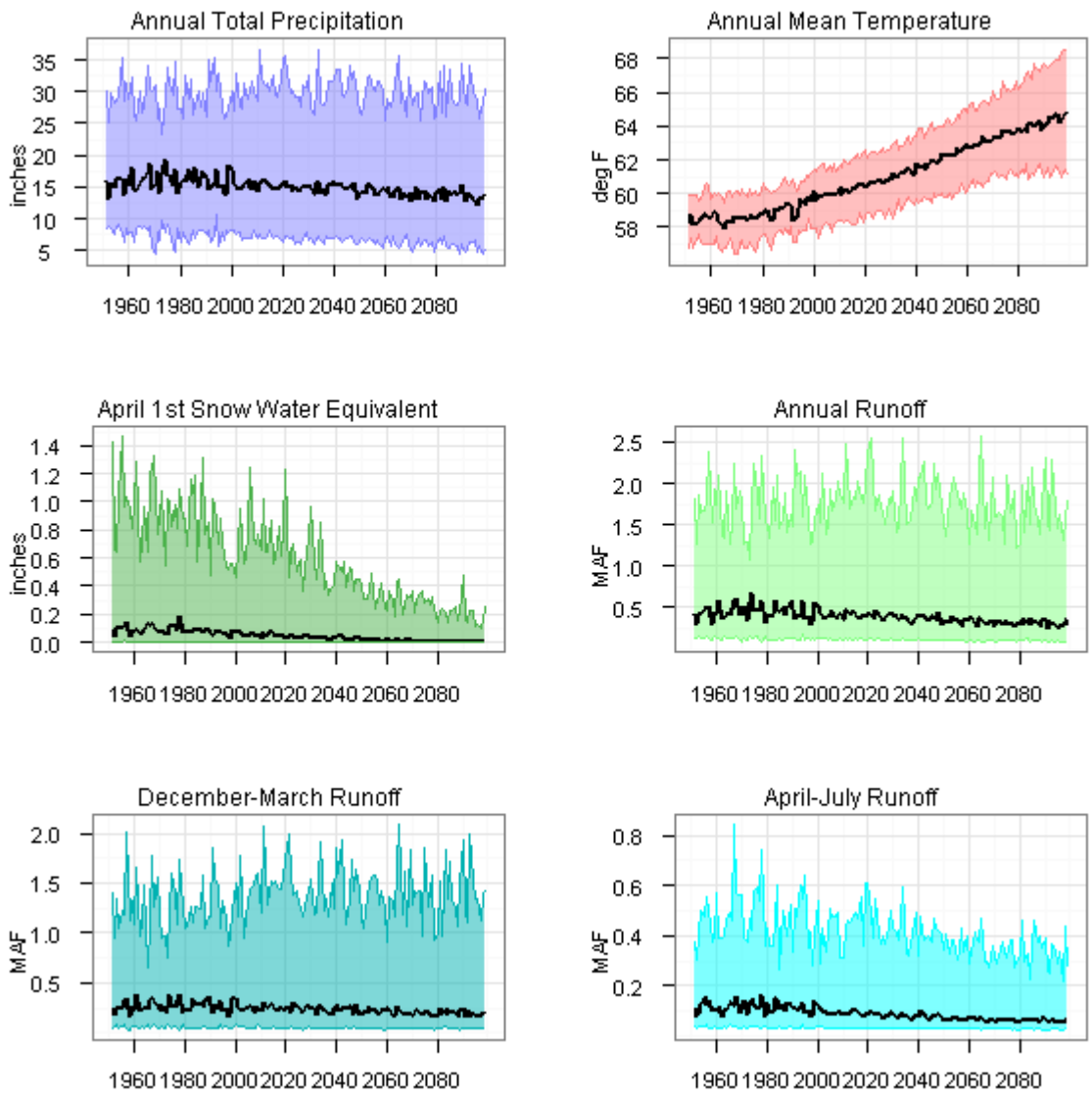


Figure 9: Projection ensemble for six hydroclimate indicators for the site Santa Ana River at Adams Street Gage

Spatial Plots

The next set of plots includes spatial plots of decade-mean precipitation, and temperature. These plots show the spatial distribution for the variables across the contributing basin. The spatial plots were developed on a water year basis for the reference decade of the 1990s (water years 1990–1999).

Spatial distribution of precipitation for the 1990s decade is presented as an ensemble median of the 112 projections. At each grid cell in the basin and for

each of the 112 projections, average total precipitation was calculated by averaging total precipitation from the 10 water years, 1990–1999. Next, for each grid cell, the ensemble median of the decade average total precipitation was calculated and used in developing the spatially varying precipitation plot.

Precipitation changes in each of the future decades – 2020s (represented by water years, 2020-2029), 2050s (represented by water years, 2050-2059), and 2070s (represented by water years, 2070-2079) – were calculated as follows. At each grid cell in the basin and for each of the 112 projections, average total precipitation was calculated by averaging total precipitation from the 10 water years in the respective future decades. Then, for a given projection and at a given grid cell, the percentage difference in average total precipitation between a given future decade and the reference 1990s decade was calculated. This percentage difference for a given cell was calculated only if the 1990's average total precipitation for that cell was greater than 0.01 millimeter. This step is necessary to threshold division by a small value, which would result in a numerically large change magnitude. Positive percentage change implies wetter conditions, while negative percentage change implies drier conditions from the 1990s reference decade.

After all projection-specific changes were calculated for a given future decade, the median change from the 112 projections was calculated. The median or 50th percentile change provides a measure of the central tendency of change in decade average total precipitation for a given future decade compared with the reference 1990s decade (Figure 10).

The 2020s decade shows some increase in the upper elevation parts of the watershed from the 1990s reference decade, but for the subsequent two decades – 2050s and 2070s – the precipitation shows consistent decline throughout the watershed.

The calculations for the spatial distribution of mean temperature are similar to the spatial distribution of precipitation calculation for the 1990s reference decade. The difference being, in case of temperature, mean annual temperature is first calculated from the 12 monthly values (in case of precipitation, it is the total precipitation) for each of the 10 water years, and subsequently, averaged to calculate the decade average mean annual temperature. The changes in mean annual temperature for the future decades are presented as magnitude changes and not as percentage change (as computed for precipitation). The median or 50th percentile change from the 112 projections represents the central tendency in decade-mean temperature distribution.

Figure 11 shows the spatial distribution of simulated decadal temperature. These results show that the watershed is expected to get hotter through the successive decades (2020s, 2050s and 2070s) compared with the 1990s reference decade.

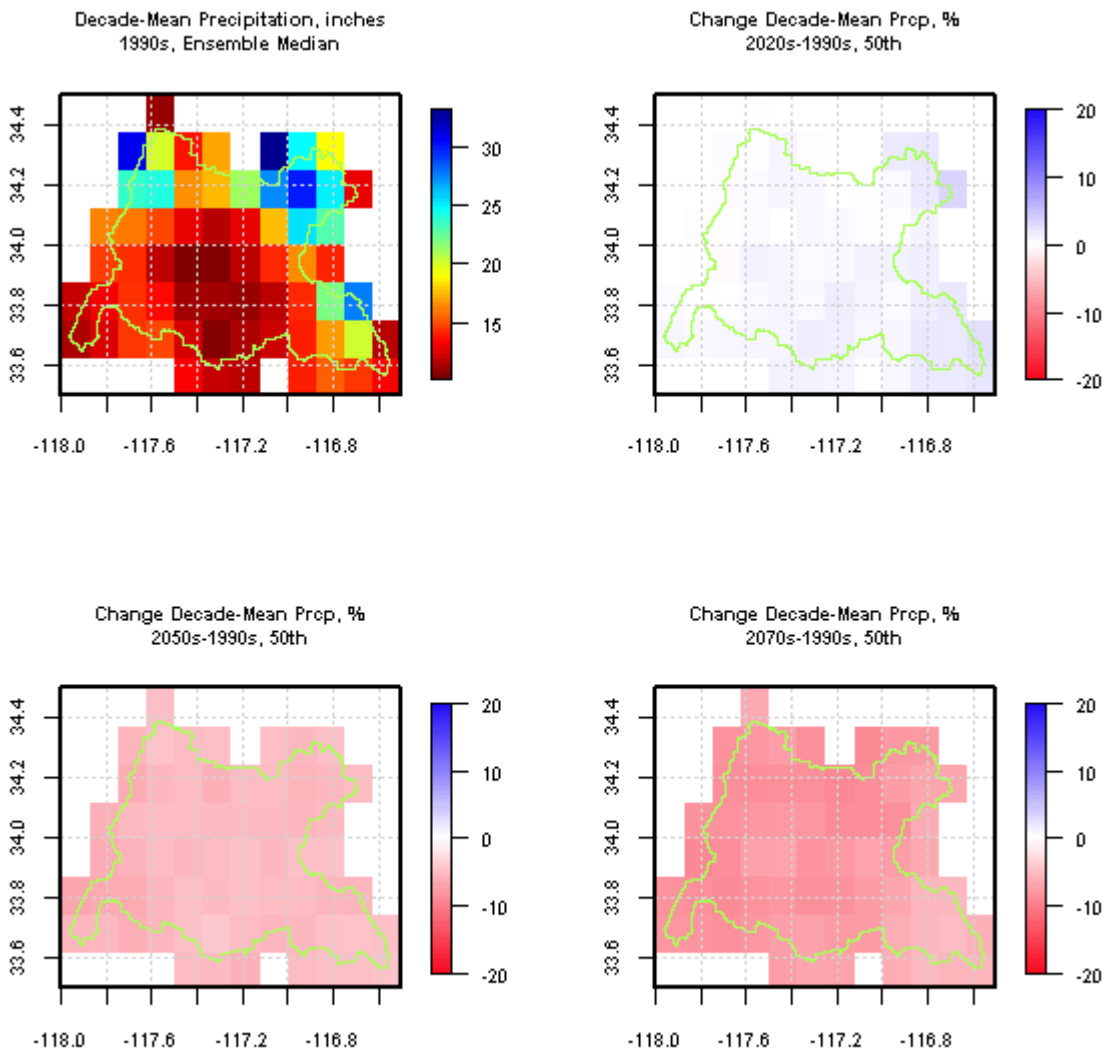


Figure 10: Spatial distribution of simulated decadal precipitation. The vertical axis represent latitude, the horizontal axis represent longitude

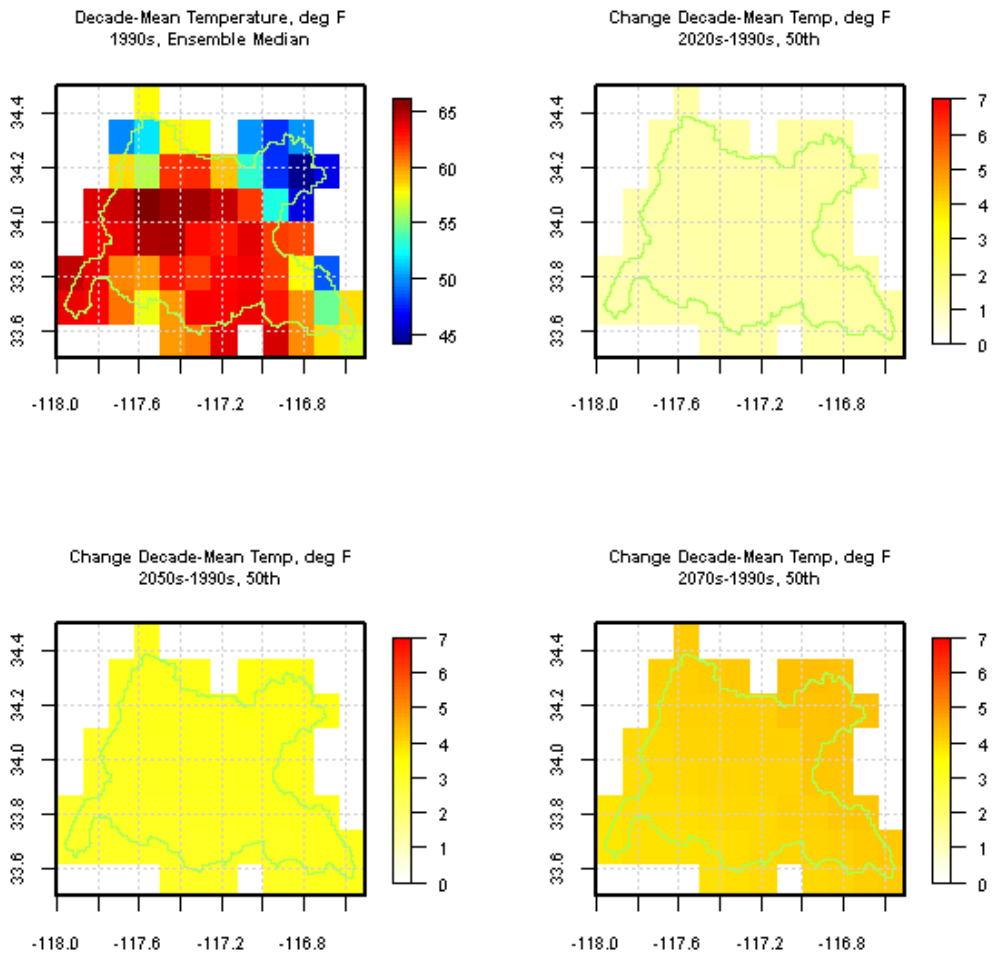


Figure 11: Spatial distribution of simulated decadal temperature. The vertical axis represent latitude, the horizontal axis represent longitude

3.1.2 Impacts on Runoff Annual and Seasonal Cycles

Similar to the calculations of precipitation and temperature changes, annual and seasonal runoff changes were calculated for all 36 sites listed in Table 1. Figure 12 shows mean annual and mean-seasonal runoff change for the site, Santa Ana River at Adams Street Gage (most downstream location). Changes in mean runoff (annual or seasonal) were calculated for the three future decades – 2020s, 2050s and 2070s – from the reference 1990s decade. For the 2050s and 2070s decade, there is a decline in the mean annual and seasonal runoff from the 1990s decade; for the 2020s decade the change in runoff is nominal. Similar change in runoff patterns was observed for all sites across the basin, as can be seen in Table 3.

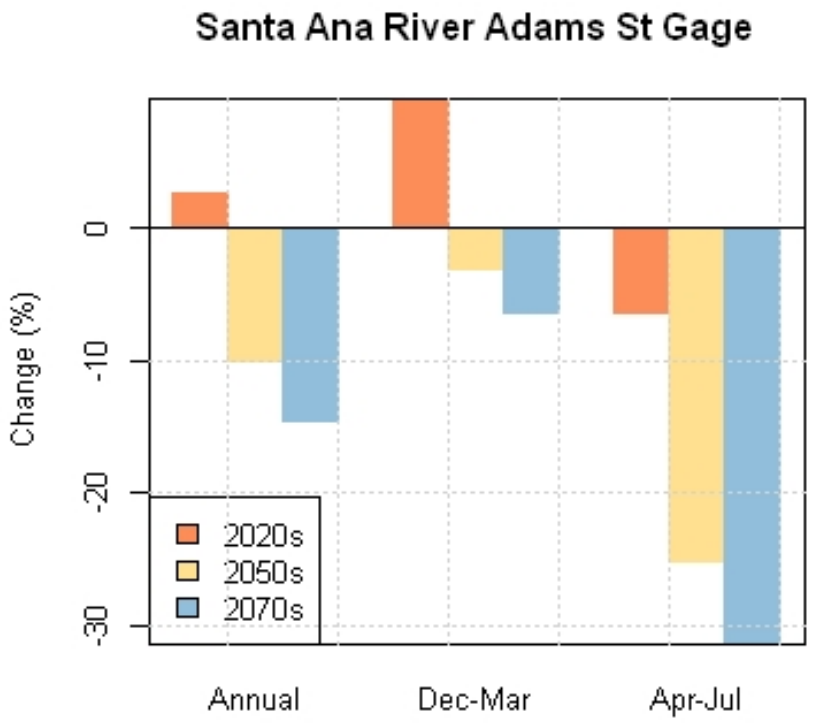


Figure 12: Simulated mean annual and mean-seasonal runoff change

Table 3: Percent change from 1990s for annual, DJFM, and AMJJ runoff

ID	Site Description	2020s			2050s			2070s		
		Annual Flow	DJFM	AMJJ	Annual Flow	DJFM	AMJJ	Annual Flow	DJFM	AMJJ
1	Peters Canyon Wash Tustin Gage	2.58	5.95	-6.08	-8.92	-1.19	-15.75	-11.82	-8.96	-19.06
2	Marshburn Channel Gage	5.10	6.76	-8.79	-6.41	-2.60	-21.70	-10.73	-8.12	-23.97
3	San Diego Creek Myford Rd Gage	4.40	6.98	-7.87	-8.36	-3.28	-18.67	-11.44	-7.34	-21.36
4	El Modina-Irvine Channel Gage	2.89	4.01	-3.50	-6.36	-3.54	-14.84	-9.05	-8.46	-15.37
5	Peters Canyon Wash Irvine Gage	2.59	5.98	-6.15	-8.86	-1.20	-15.77	-11.84	-8.98	-19.10
6	San Diego Creek Lane Rd Gage	2.58	5.93	-6.03	-8.95	-1.19	-15.73	-11.81	-8.95	-19.03
7	San Diego Creek Campus Dr Gage	4.37	6.48	-4.81	-7.74	-3.22	-13.80	-10.30	-8.42	-15.05
8	Santa Ana River Prado Dam Gage	2.71	9.76	-6.65	-10.69	-1.90	-26.04	-14.97	-7.19	-32.29
9	Santa Ana River County Line Gage	2.72	9.84	-6.66	-10.67	-2.20	-25.96	-14.95	-7.08	-32.24
10	Santa Ana River Imperial Highway Gage	2.69	9.87	-6.54	-10.57	-2.52	-25.88	-14.91	-6.92	-32.13
11	Santa Ana River AB SPRD Imperial Highway Gage	2.68	9.86	-6.54	-10.56	-2.53	-25.88	-14.91	-6.92	-32.13
12	Santa Ana River SPRD Imperial Highway Gage	2.68	9.86	-6.54	-10.56	-2.53	-25.88	-14.90	-6.92	-32.12
13	Carbon Creek Olinda Gage	3.06	6.96	-4.49	-3.09	-3.69	-17.86	-8.07	-6.58	-20.91
14	Carbon Creek Yorba Linda Gage	3.06	6.96	-4.49	-3.09	-3.69	-17.86	-8.07	-6.58	-20.91
15	Santa Ana River Ball Rd Gage	2.67	9.84	-6.53	-10.52	-2.60	-25.82	-14.88	-6.92	-32.07
16	Santa Ana River Katella Ave Gage	2.65	9.89	-6.55	-10.49	-2.83	-25.71	-14.85	-6.88	-32.01
17	Santiago Creek Villa Park Gage	2.90	8.35	-4.59	-5.09	-0.25	-18.15	-10.07	-7.81	-23.45
18	Santiago Creek Div Villa Park Gage	2.90	8.35	-4.59	-5.09	-0.25	-18.15	-10.07	-7.81	-23.45
19	Santiago Creek Santa Ana Gage	4.15	7.43	-5.11	-5.40	-1.30	-17.99	-10.42	-7.02	-20.97
20	Santa Ana River Santa Ana Gage	2.63	9.85	-6.39	-10.09	-3.01	-25.48	-14.69	-6.41	-31.70
21	Santa Ana River Adams St Gage	2.60	9.82	-6.35	-10.08	-3.01	-25.24	-14.61	-6.38	-31.39
22	Brea Channel Brea Dam Gage	1.99	5.34	-5.77	-3.37	-1.79	-19.51	-8.88	-7.33	-19.75
23	Brea Channel Fullerton Gage	1.73	4.97	-6.04	-3.54	-1.35	-19.91	-8.84	-7.45	-19.87
24	Fullteron Channel Fullerton Dam Gage	0.94	3.76	-5.87	-4.13	-1.47	-18.91	-8.98	-8.82	-18.91
25	Fullerton Channel Fullerton Gage	0.14	3.60	-5.68	-4.54	-3.08	-18.43	-9.14	-9.08	-16.44
26	Fullerton Channel Richman Ave Gage	2.15	4.95	-5.48	-4.55	-2.02	-17.80	-8.58	-7.34	-18.39
27	Coyote Creek Los Alamitos Gage	0.31	4.85	-4.60	-3.59	-3.16	-17.37	-9.54	-7.87	-16.51
28	Devils Canyon	2.94	5.12	-3.29	-13.23	-6.71	-22.69	-13.38	-10.72	-26.62
29	Santa Ana River AT MWD Crossing NR Arlington	2.73	10.54	-9.68	-11.36	-2.04	-30.55	-17.35	-7.84	-37.75
30	Santa Ana River AT E Street NR San Bernardino	3.03	10.66	-11.25	-10.86	-2.34	-31.89	-16.98	-7.35	-39.70
31	Temescal Creek AB Main Street AT Corona	5.50	9.02	-6.01	-7.65	-1.64	-18.68	-12.06	-5.03	-28.47
32	Cucamonga Creek NR Mira Loma	2.20	7.43	-3.35	-13.45	-8.76	-27.40	-17.51	-13.81	-33.20
33	Chino Creek AT Schaefer Avenue NR Chino	2.30	4.54	-3.62	-7.11	-2.05	-19.63	-11.19	-8.46	-19.83
34	Seven Oaks Dam Outlet	1.11	12.83	-19.49	-13.17	-4.07	-40.17	-19.29	-4.76	-48.65
35	Middle Fork Lytle Creek Gage	2.94	6.88	-9.22	-15.28	-8.14	-36.30	-21.35	-16.24	-40.80
36	Ridge Top Gage NR Devore	3.08	6.48	-6.72	-7.15	-1.54	-18.56	-6.26	-5.05	-21.65

3.1.3 Groundwater Impacts

The groundwater screening tool was applied to four groundwater basins (Orange County, Upper Santa Ana Valley, San Jacinto, and Elsinore) within the Watershed where sufficient data were available, including observed groundwater elevations, municipal and industrial demands, agricultural acreage, and trans-basin imported water.

Figure 13 illustrates observed and simulated monthly changes in groundwater elevation for the Orange County Coastal Plain groundwater basin for the period 1990-2009, as well as observed and simulated monthly basin-averaged groundwater elevations. Figure 13a shows that the groundwater screening tool realistically simulates the timing of month-to-month changes in groundwater elevation, but does not capture the peak magnitudes of drawdown and rise. Similarly, Figure 13c shows that the tool accurately simulates seasonal fluctuations in groundwater elevation as well as trends in groundwater elevation over the past two decades, but does not capture interannual variations in groundwater elevation, including the groundwater decline of the early 1990s and subsequent rebound during the late 1990s and early 2000s. Interannual fluctuations may be driven by local-scale non-linear processes that are not represented in the basin-scale screening tool, or by management objectives that are not included in this analysis. The correlation between simulated and observed changes in groundwater elevation is 0.618 (R^2 = 0.382), and correlation between simulated and observed groundwater elevation is 0.884 (R^2 = 0.782).

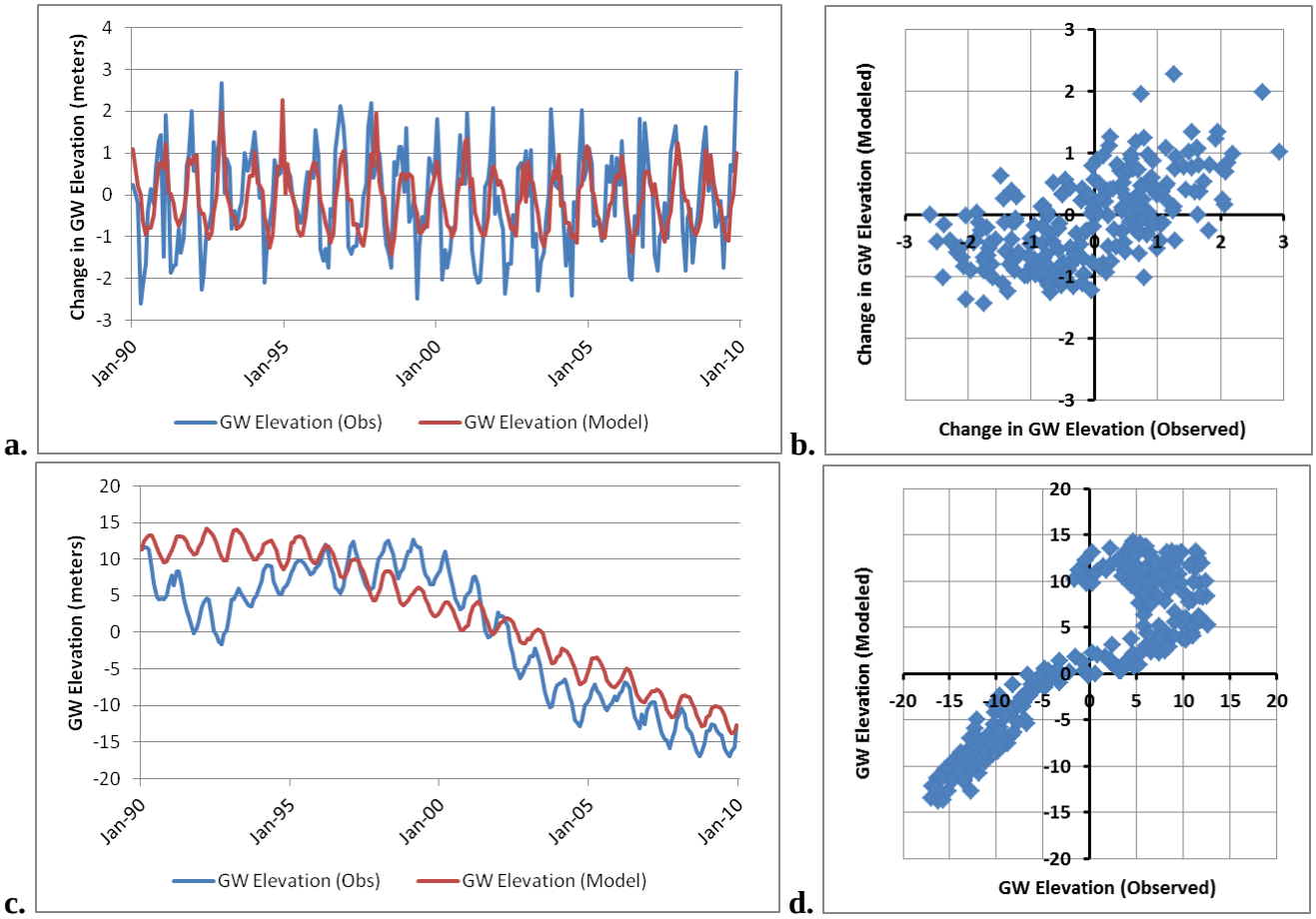


Figure 13: (a) Timeseries of observed and simulated fluctuations in monthly groundwater elevation for the period 1990-2009; (b) scatter plot of simulated monthly change in groundwater elevation as a function of observed change groundwater elevation; (c) Timeseries of observed and simulated monthly groundwater elevation for the period 1990-2009 (zero represents mean sea level); (d) scatter plot of simulated monthly groundwater elevation as a function of observed groundwater elevation (all plots are for Orange County groundwater basin)

Future groundwater availability in the Watershed will depend on future recharge from precipitation, stream seepage, and managed infiltration facilities, as well as future groundwater withdrawals to for municipal, industrial, and agricultural uses. Projected increases in temperature and decreases in precipitation will result in increased water demands and decreased groundwater recharge, respectively. Management actions will be required to protect groundwater resources under projected future climate conditions. Figure 14 illustrates the observed range of basin-averaged groundwater levels in the Orange County groundwater basin for 1990-2009, along with simulated groundwater levels under projected climate conditions. In the absence of groundwater management actions, groundwater levels are projected to decline significantly over the 21st century. It should be noted that projected declines are not constrained by the physical limits of the aquifer; for example, projected declines may exceed the actual amount of usable groundwater in the basin.

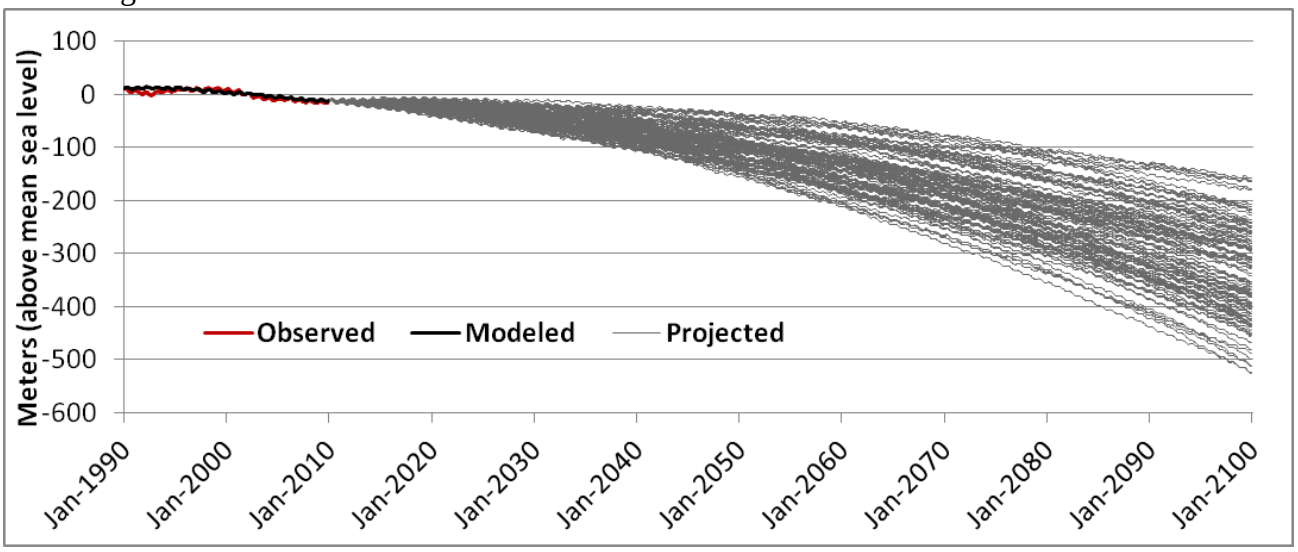


Figure 14: Projected groundwater elevations for Orange County for a no action scenario

The groundwater screening tool, developed by Reclamation for this Basin Study, can be used to evaluate potential deficiencies in future supplies and to develop sustainable management alternatives. As an example, potential actions to avoid projected water level declines in Orange County are listed below. Each alternative listed will protect against groundwater declines through 2060.

- Reduce M&I demand, gradual reduction of approx. 15% by 2020 (i.e., reduce per capita use from ~175 gallons per day in 2010 to ~150 gallons per day by 2020).
- Increase imports from the Colorado River Aqueduct and State Water Project gradually from ~30,000 acre-ft per year to ~105,000 acre-ft per

year (this may not be feasible due to cost, greenhouse gas emissions, or availability).

- Increase local water supplies by ~75,000 acre-ft per year through recycled water treatment capacity, development of seawater desalination capacity, and increase storm water capture efficiency.

Figures 15, 16, and 17 show the projected groundwater elevations for a no action scenario for the Upper Santa Ana Valley, San Jacinto, and Elsinore respectively. The groundwater screening tool can be used to develop and compare additional management alternatives in order to meet the projected growing demands that are discussed in the next section.

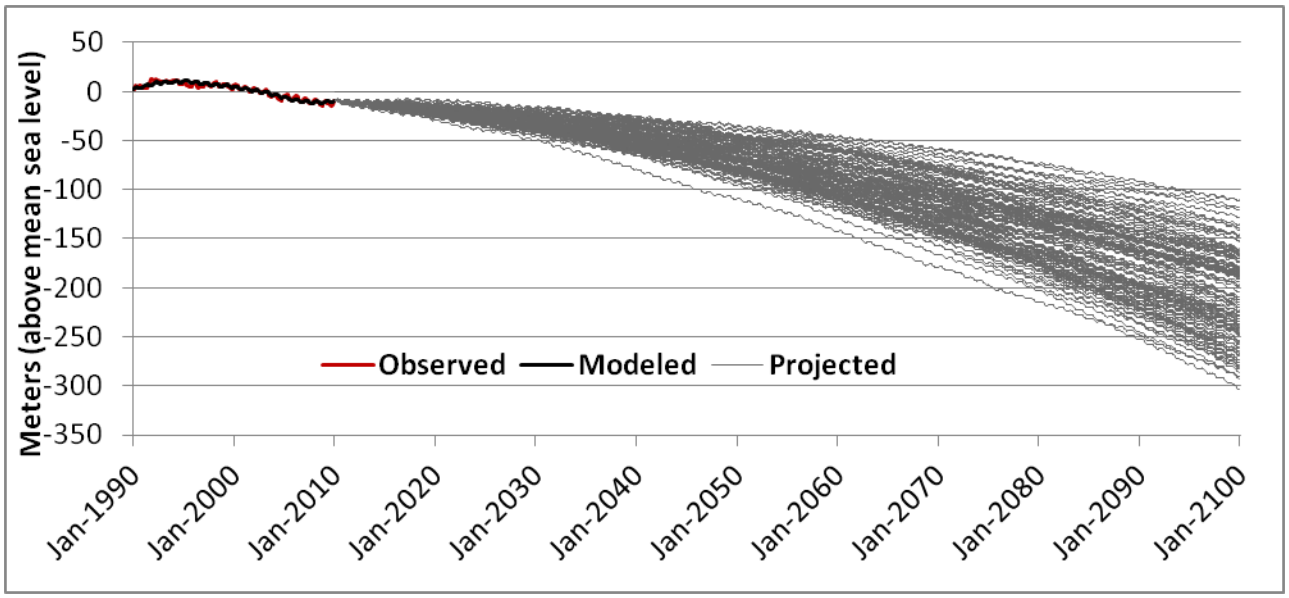


Figure 15: Projected groundwater elevations for Upper Santa Ana Valley for a no action scenario

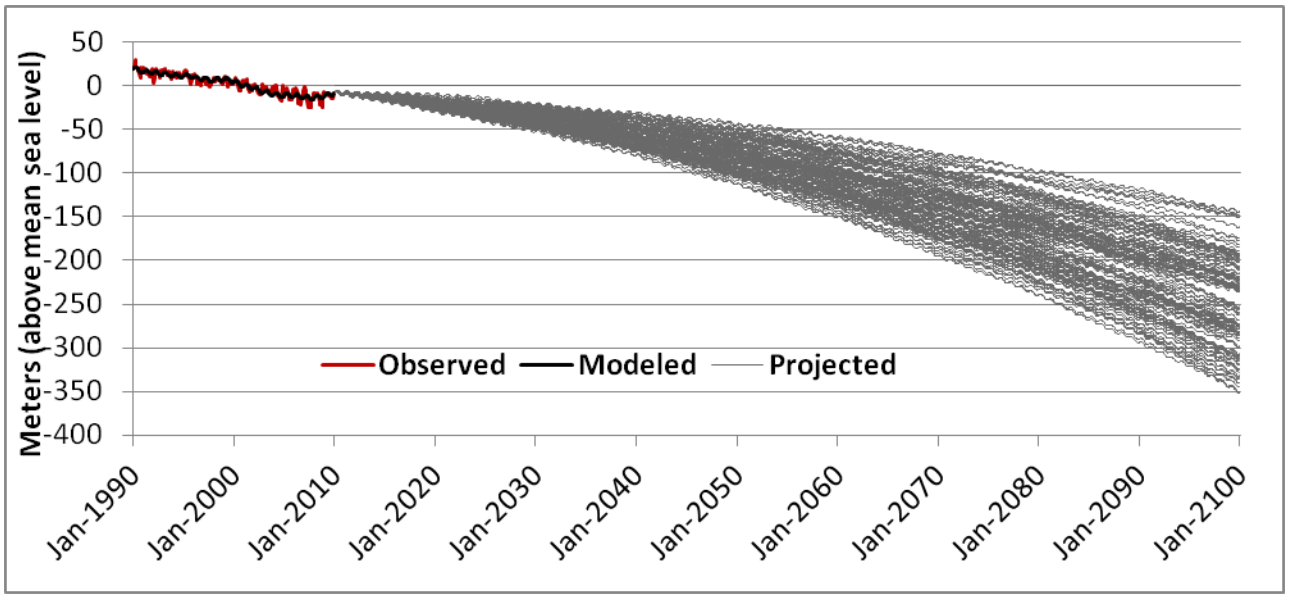


Figure 16: Projected groundwater elevations for San Jacinto for a no action scenario

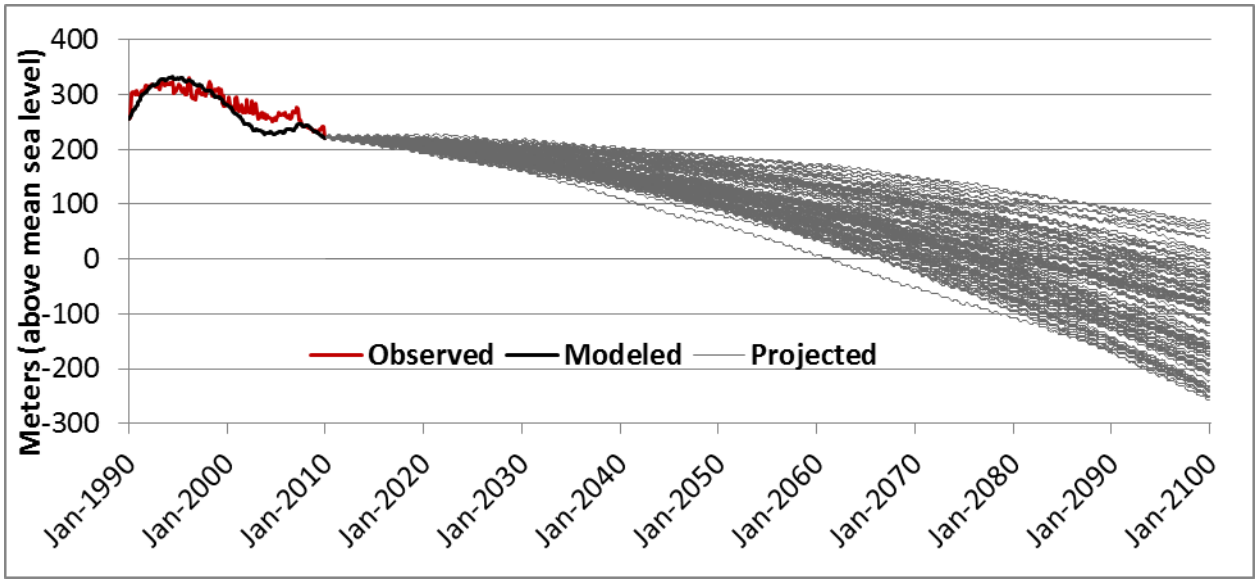


Figure 17: Projected groundwater elevations for Elsinore for a no action scenario

Note: The Elsinore groundwater basin projections, shown in Figure 17, are not as representative of what is actually happening in the basin as the other three basins. This is because the basin average groundwater timeseries is based on four wells, three of which are missing a fair amount of data, resulting in a poor model fit. More representative results could be obtained if a more complete input dataset were developed.

3.2 Water Demands

Many factors affect future water demands such as population growth, hydrologic conditions, public education, and economic conditions, among others. In 1990, 4.2 million people lived in the Watershed. In the 1990s, the population grew by 17.6%, and continued to grow to the present population of approximately 6.1 million, as shown in Figure 18. By 2050, the population is projected to reach 9.9 million (Santa Ana Integrated Watershed Plan, 2002).

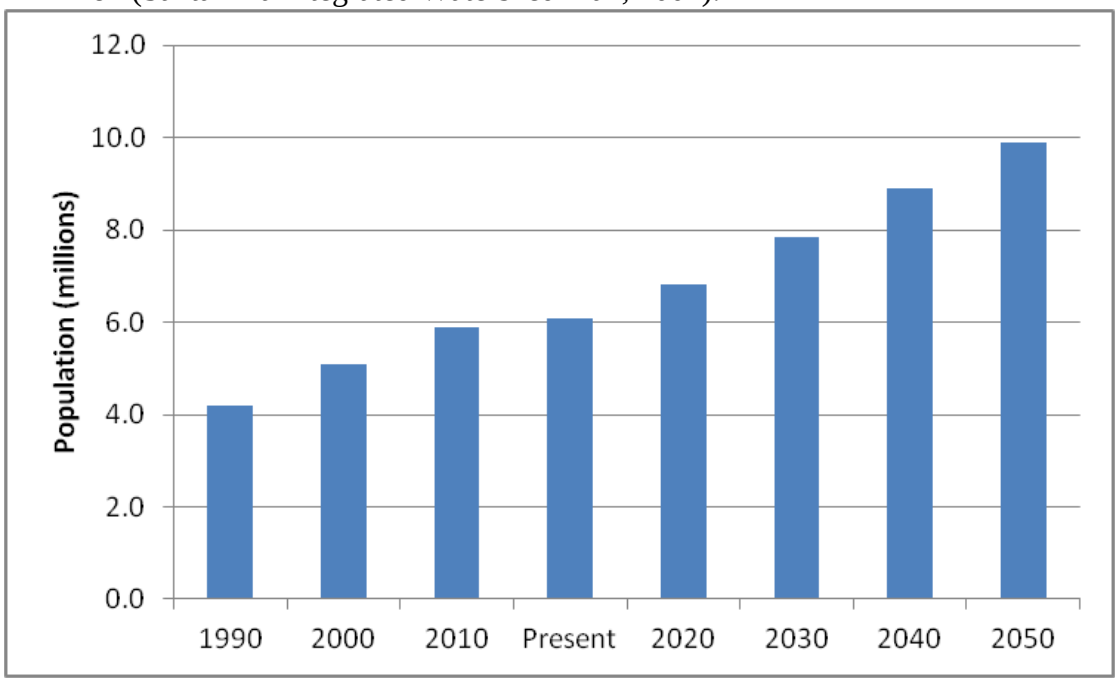


Figure 18: Population for the Santa Ana River Watershed

3.2.1 Water Demand Projections

Projected water demands out to 2050 were obtained from the various water resource plans for each of the individual member agencies. The projections, shown in Figure 19, include direct water demand for residential, municipal, commercial, and agricultural uses, but do not include recharge. Conservation is not taken into account in the projected demand. Aggressive conservation can drastically reduce the projected water demand, an example of which is shown in Chapter 5.

For the purpose of this study, the demand was calculated for the watershed, as a whole, every ten years from 1990-2050 (see Chapter 5 for a description of the tool used). The population projections from Figure 18 were used to determine the demand, and conservation was not taken into account. The results, found in Figure 20, are very similar (1% difference in 2050) to the demand projections calculated by the member agencies in Figure 16.

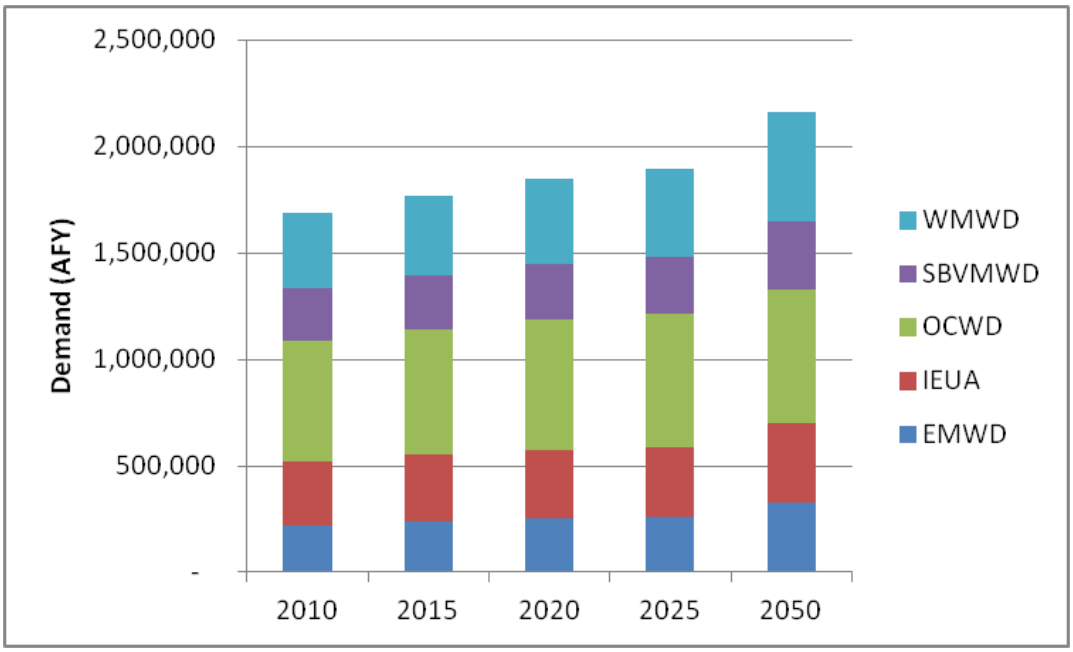


Figure 19: Water demand by member agency (Western Municipal Water District (WMWD); San Bernardino Valley Municipal Water District (SBVMWD); Orange County Water District (OCWD); Inland Empire Utilities Agency (IEUA); Eastern Municipal Water District (EMWD))

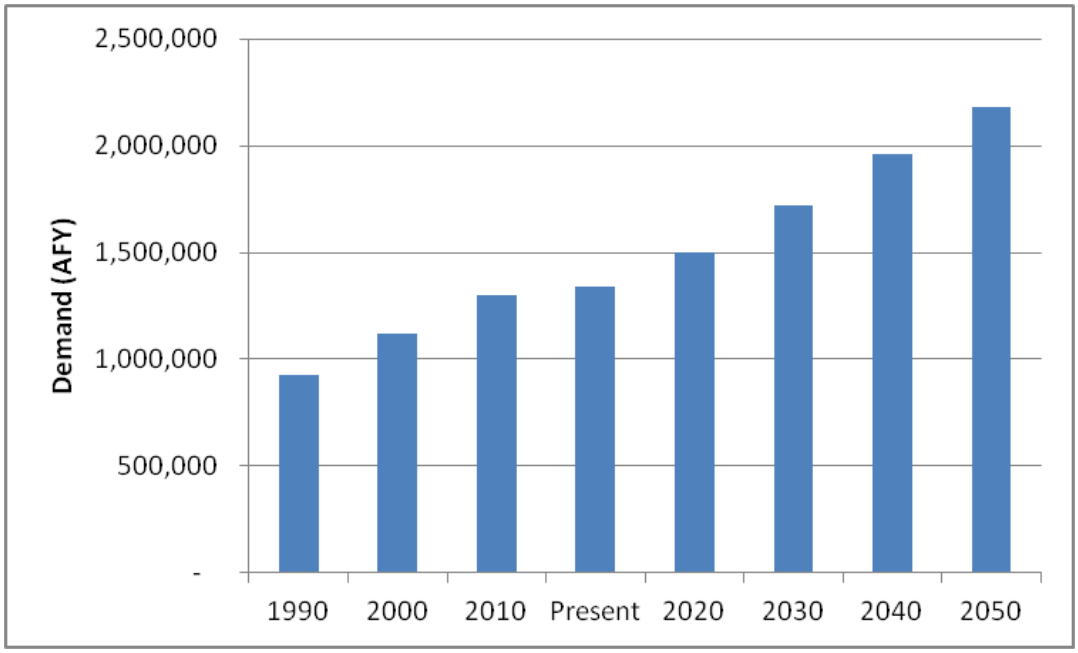


Figure 20: Santa Ana Watershed water demand calculated for this study

3.3 Supply and Demand Summary

Table 4 shows a summary of the project effects of climate change on a variety of hydroclimate metrics for three future periods (above the most downstream location, Adams St. Bridge). Table 5 shows a summary of projected water demands out to 2050.

Table 4: Summary of Effects of Climate Change on Supply

Hydroclimate Metric (change from 1990s)	2020s	2050s	2070s
Precipitation (%)	0.67	-5.41	-8.09
Mean Temperature (°F)	1.22	3.11	4.1
April 1st SWE (%)	-38.93	-80.4	-93.07
Annual Runoff (%)	2.6	-10.08	-14.61
Dec-Mar Runoff (%)	9.82	-3.01	-6.38
Apr-Jul Runoff (%)	-6.35	-25.24	-31.39

Table 5: Summary of Water Demand for the Santa Ana River Watershed

	1990	2000	2010	Present	2020	2030	2040	2050
Demand (MAFY)	**0.924**	**1.121**	**1.298**	**1.339**	**1.503**	**1.723**	**1.958**	**2.178**

Imported water for the SARW will also likely be affected by the changing climate. The 2011 SWP Reliability report projects a temperature increase of 1.3° to 4.0 °F by mid-century and 2.7° to 8.1° F by the end of the 21st century. It predicts that increased temperatures will lead to less snowfall at lower elevations and decreased snowpack. By mid-century they predict that Sierra Nevada snowpack will reduce by 25% to 40% of its historical average. Decreased snowpack is projected to be greater in the northern Sierra Nevada, closer to the origin of SWP water, than in the southern Sierra Nevada. Furthermore, an increase in “rain on snow” events may lead to earlier runoff. Given these changes, a water shortage worse than the 1977 drought could occur one out of every six to eight years by the middle of the 21st century and one out of every two to four years by the end of 21st century. Also, warmer temperatures might lead to increased demand. This factor, combined with declining flows, will likely lead to decreased carryover storage from year to year. Alternative water supply options such as recycled water, rainwater harvesting, and desalination may need to be relied upon in order to meet the continually growing demand.

4.0 Decision Support and Impact Assessment

The analyses presented in this chapter were performed using the climate and hydrological projections and models described in Chapter 3.

4.1 Impacts on Recreation in Lake Elsinore

4.1.1 Background

Lake Elsinore, shown in Figure 21, is southern California's largest natural lake and is situated at the bottom of the San Jacinto Watershed. Because Lake Elsinore is a terminal lake, historically fed only by rain and natural runoff, it has been impacted by low lake levels. As the climate continues to change it is likely that these impacts will become more severe. Lake Elsinore is used for recreation and is currently not considered a water supply source.

In 2005, Elsinore Valley Municipal Water District (EVMWD) began a two-year pilot project to introduce recycled water into Lake Elsinore to stabilize lake levels. Soon thereafter, a discharge permit was granted to EVMWD by the Santa Ana Regional Water Quality Control Board to allow recycled water to be delivered to the lake. In 2008, a 36-inch-diameter pipeline was constructed to deliver recycled water from EVMWD's Regional Wastewater Treatment Plant, funded by the State of California Proposition 40 Water Bond and the Lake Elsinore and San Jacinto Watersheds Authority. The project delivers approximately 5 million gallons per day (MGD) of recycled water to Lake Elsinore, and includes repair and retrofit of three local, shallow groundwater wells that deliver approximately 1 MGD. As part of the Basin Study, an analysis was done to determine if these measures would be enough to meet the minimum goal volume of 41,704 acre-ft (elevation 1,240 ft), avoid low lake levels (below 24,659 acre-ft, elevation 1,234 ft), and prevent the lake from drying up altogether (as occurred in the 1930s) under a changing climate.

Figure 21: Lake Elsinore and VIC model grid cell used to determine data for Lake Elsinore analysis

4.1.2 Methodology

Monthly streamflow and open water evaporation values from 1950-2099 were determined by using BCSD-CMIP3 climate projections and the VIC macro-scale hydrology model. Gridded daily meteorological forcings from Maurer et al., (2002) were used to simulate historical conditions from 1950-1999. The model accounted for the upstream contributing basin, the San Jacinto River subwatershed, feeding the inlet of Lake Elsinore, excluding the effect of any upstream regulation.

A mass balance analysis of Lake Elsinore was conducted, resulting in a natural volume, unregulated by upstream reservoirs. Change values were determined for each future period using modeled observed average annual volume applied to historic annual average volume. The operations of Canyon Lake, a reservoir upstream from Lake Elsinore, were not taken into account in this analysis.

4.1.3 Results

Figure 22 shows the distribution of projected average annual volume for two future periods, 2000-2049 and 2050-2099, based on 112 different climate change projections. The two future periods were also analyzed with the addition of the EVMWD project. For the 2000-2049 period there is greater than a 50% chance that the average annual lake level will meet the minimum goal; adding in the EVMWD project brings that likelihood up to above 75%. For the 2050-2099 period there is less than a 5% chance that the minimum goal will be met; adding the EVMWD project brings that likelihood to almost 50%. Both periods are likely to stay above low lake level, with the 2050-2099 period having less than a 10% chance of drying up completely.

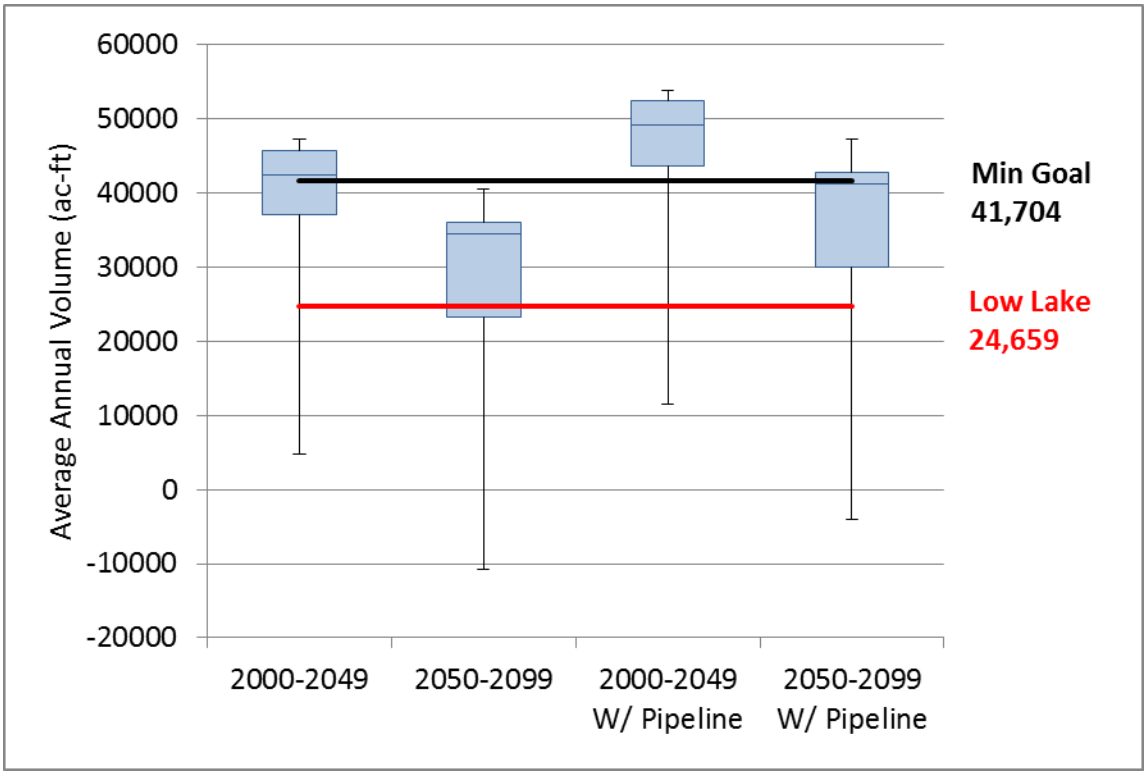


Figure 22: Projected average annual volumes for Lake Elsinore for two future periods, with and without EVMWD project

4.2 Alpine Climate Impacts

4.2.1 Background

An alpine climate is defined as the average weather for the region above the tree line. Climate change impacts could harm alpine recreation such as skiing. The Big Bear Mountain Resorts (Big Bear) are located in the San Bernardino Mountains within the SARW. They consist of two ski areas, Bear Mountain and Snow Summit, and provide nearly 750 skiable acres. They range in elevation from roughly 2,180 m to more than 2,600 m. Although Big Bear has the ability to cover 100% of its terrain with manmade snow using water from Big Bear Lake, there are still concerns about rising temperatures and decreased natural snowfall.

Member agencies of SAWPA extend to the San Bernardino Mountain, the San Gabriel Mountains, the San Jacinto Mountains and the Santa Ana Mountains. As such, potential climate change impacts to alpine ecosystems and recreational activities are an area of concern. In general, alpine ecosystems are characterized by cold temperatures and harsh growing conditions. One species of particular importance is the Jeffrey Pine. Jeffrey Pines are a coniferous species common to the area and extend through the Sierra Nevadas up to Oregon. They are a high altitude pine species that have the ability to grow in a diverse range of climates.

They can do well in harsh settings and infertile sites because they require a shorter growing season than some other species (Moore, 2006).

4.2.2 Methodology

Impacts to skiing near Big Bear Lake were analyzed by considering projected changes for April 1st SWE. April 1st SWE values from 1950 to 2099 were generated for 112 CMIP3 climate projections using the VIC model forced with downscaled (BCSD) climate variables. Each climate projection consists of 1/8° x 1/8° degree (~12 km x 12km) grid cell daily forcings. For this analysis, the locations of the Bear Mountain and Snow Summit ski areas were mapped to the single grid cell that contained them. Results shown in Section 4.2.3 summarize the median change (taken from the 112 projections) in April 1st SWE compared to the 1990s.

For comparison, results were also summarized from a study of climate change impacts in California by Hayhoe et al. (2004). They used climate forcing data generated with two GCMs of low (Parallel Climate Model, PCM) and medium (Hadley Center Climate Model version 3, HadCM3) sensitivity, forced using two emissions scenarios, one lower (B1) and one higher (A1fi). SWE results were generated using the VIC model forced with the BCSD temperature and precipitation. Results are provided in Section 4.2.3 on a statewide basis grouped by elevation.

Quantitative analysis of ecosystem impacts was not conducted as part of this work. Rather a literature review of existing climate change impact studies was conducted and the relevant findings are provided here.

4.2.3 Results

Recreation at Big Bear

It is likely that future snowpack at Big Bear will be significantly less than what is currently normal and accumulated snowpack will remain on the ground for a shorter season. Figures 23 and 24 illustrate future changes in April 1st SWE. Projected declines are between 30% and 40% by the 2020s, and are generally projected to be greater than 70% by the 2070s. These changes are largely a result of increased winter temperatures and potential declines in winter precipitation. Warmer temperatures will result in a delayed onset of the ski season, as well as earlier spring melting. Future precipitation is much more uncertain but many projections show decreased winter precipitation. Lower altitudes will likely be the most sensitive to increased temperature because small temperature changes can result in precipitation falling as rain rather than snow. Hayhoe et al. (2004) note that reductions in SWE are most pronounced below 3,000 m where roughly 80% of California's snowpack storage currently occurs. The Bear Mountain and Snow Summit ski areas both fall between roughly 2,100 and 2,600 m, making them vulnerable to increased temperatures.

While there is general consensus for a projected decrease in snowpack, it is also important to note that there is significant variability between climate projections. For example, the low sensitivity, low emissions scenario in Figure 24 projects only a 20% decrease in snowpack by 2070, while the other scenarios as well as the median, shown in Figure 23, project a greater than 70% decrease. Also, the grid resolution for both methodologies is 1/8° which is much larger than either ski area. As such, results include surrounding areas that are at lower elevations and beyond ski area itself. However, the overall findings in Figures 23 and 24 are consistent.

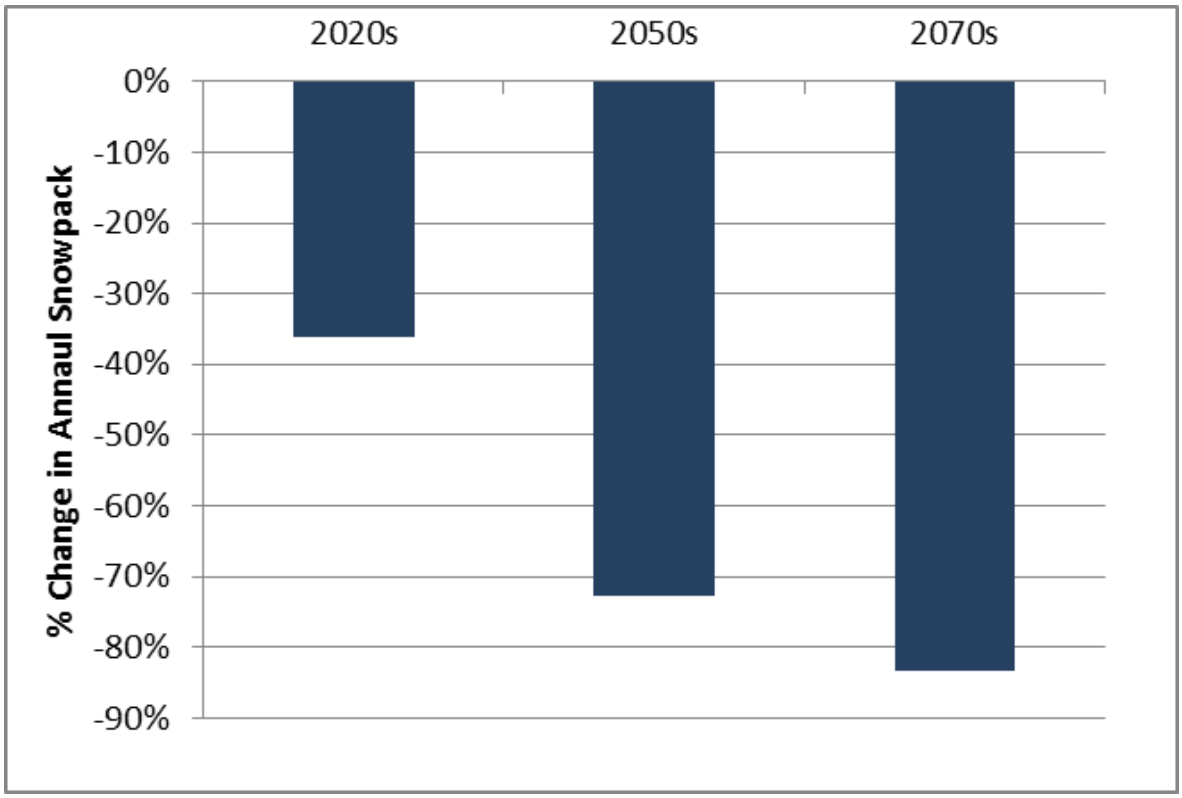


Figure 23: Median percent change (from 112 climate projections) in April 1st SWE for the grid cells containing the Bear Mountain and Snow Summit ski areas

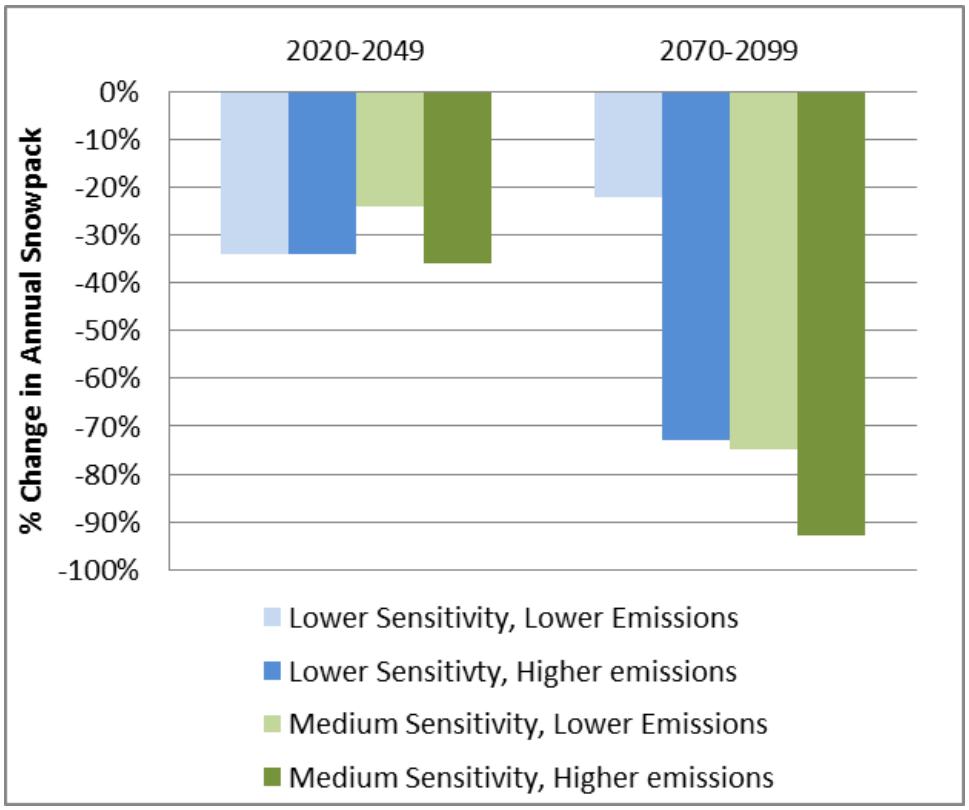


Figure 24: Percent change in April 1st SWE from Hayhoe et al. (2004) for areas of 2,000 to 3,000 m elevation

Jeffrey Pine Ecosystem

Predicting climate change impacts on ecosystems is very difficult because of the interconnections and dependencies among the large numbers of species present in any system. This is further complicated by uncertainty about future climate. For example, there is significant uncertainty about the role of increased carbon dioxide levels on forest productivity. In general, predictions about forest productivity are uncertain and will rely mainly on future precipitation. While there is variability among climate change scenarios, especially with respect to precipitation, all projections include increased temperature and increased levels of atmospheric carbon dioxide.

Based on projected climate, it is expected that warmer temperatures will cause trees to move northward and to higher elevations. Lenihan et al. (2008) project changes in total forest cover for the state of California will range from a 25% decrease to a 23% increase by 2100. Species with the smallest geographical and climate ranges are expected to be the most vulnerable to change because they will have limited ability to migrate. Alpine ecosystems are particularly vulnerable to increased temperatures because their habitat is already limited with little opportunities to shift to higher elevations. Lenihan et al. (2008) project that Alpine and subalpine forests will decrease in area by 50-70% by 2100, as shown in Figure 25.

Consistent with other tree species, it is likely that the Jeffery Pines (found at elevations of 2000-3100 m) will migrate to higher elevation and some lower elevation forest area will be lost. Several studies predict that warming temperatures will result in the displacement of evergreen conifer forests by mixed evergreen forests across California (Hayhoe et al., 2004; California, 2010). This trend is also shown by the decrease in conifer forests in Figure 25.

Figures 26 and 27 show projected change in viable Jeffery Pine habitat in southern California for three emissions scenarios looking out to 2030 and 2090, respectively (Crookston, 2009). The plots, generated using the Moscow Forestry Sciences Laboratory website http://forest.moscowfsl.wsu.edu/climate/species/speciesDist/Jeffrey-pine/, show significant decrease in viable Jeffery Pine habitat for many scenarios, and some of the most severe (e.g. A2 emission scenario) show no Jeffrey Pine habitat within the Watershed by 2090.

In addition to changes in forest area, warmer temperatures may also impact forest health. For example, extended droughts and earlier snowmelt could cause fire seasons to start earlier and last longer (California, 2010). Also, temperature increases may change the frequency and magnitude of infestations by pests, such as the pine beetle.

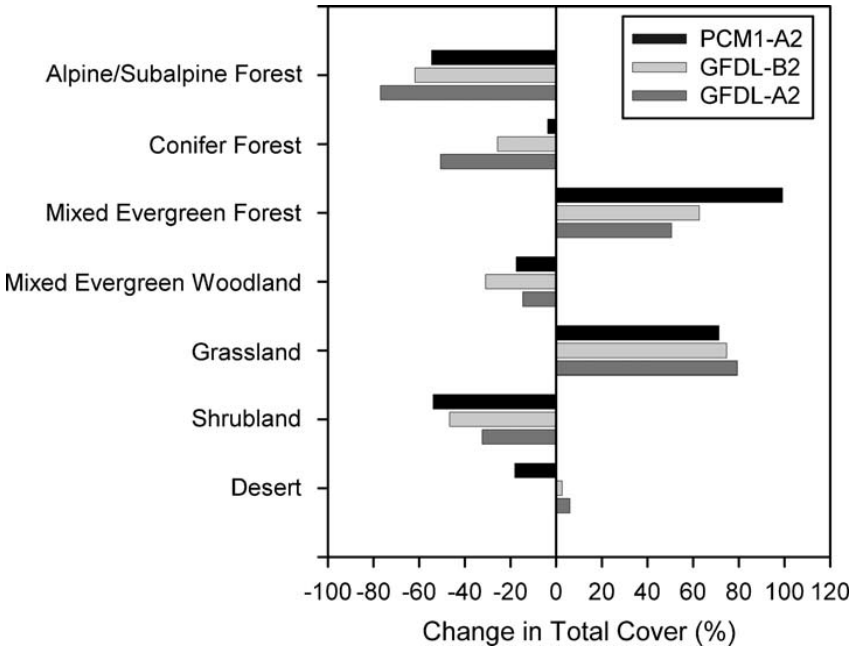


Figure 25: Fig. 4 from Lenihan et al., (2008). Percent change in total land cover for vegetation classes by 2100 for three climate change scenarios predicted using the MC1 Dynamic Vegetation Model

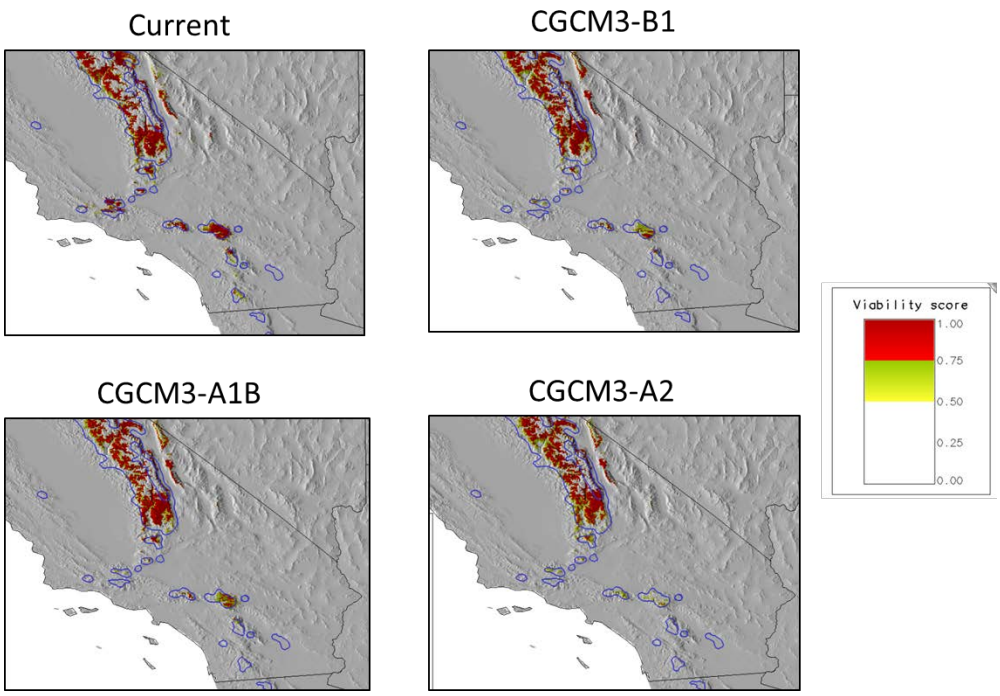


Figure 26: Viability scores for Jeffery Pine currently and for three future projections for 2030

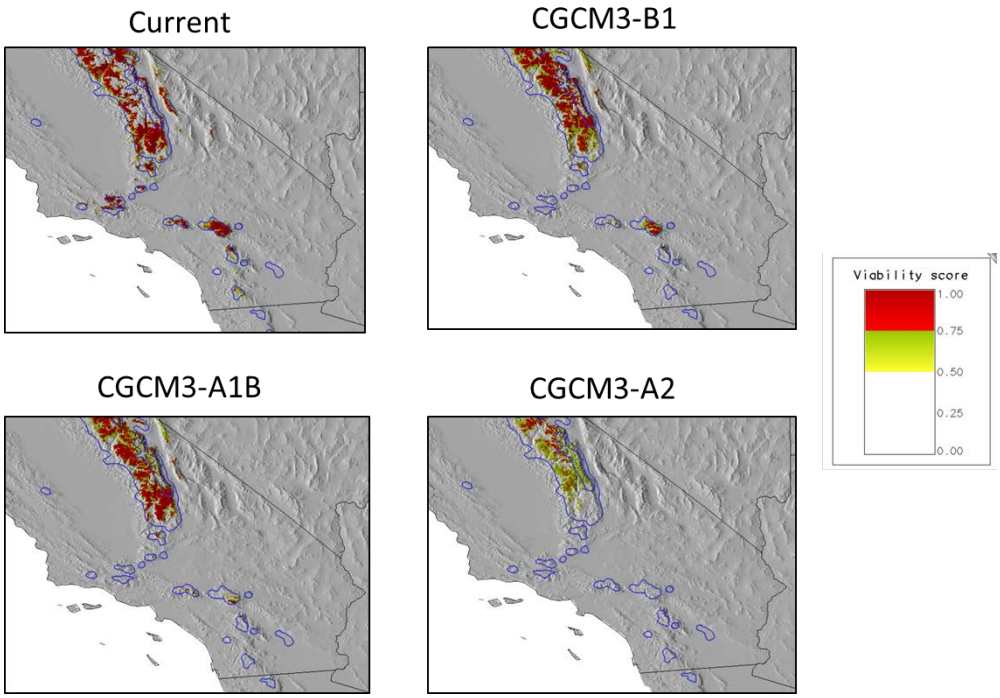


Figure 27: Viability scores for Jeffery Pine currently and for three future projections for 2090

Source: http://forest.moscowfsl.wsu.edu/climate/species/speciesDist/Jeffrey-pine/

4.3 Extreme Temperature Impacts

4.3.1 Background

There is no standard definition of an extreme heat event, commonly known as a "heat wave." It is most commonly defined as a period with more than three consecutive days of maximum temperatures at or above 90°F. However, temperature is only one component of heat, which also depends on humidity, wind speed and radiant load. Climate change is resulting in more frequent and severe heat waves (Dia, 2011). The increased heat could lead to additional air pollution in urban areas, bringing increased health risks.

In 2007, the IPCC concluded that "hot extremes" and "heat waves" are very likely (>90% probability of occurrence) to increase as our climate continues to change. This predicted temperature increase is particularly pronounced for night temperatures, resulting in reduced night-time relief from the heat. These changing weather conditions are a growing concern for individuals and communities in the Watershed.

4.3.2 Methodology

Daily maximum temperature values came from the BCSD-CMIP3 archive for 112 climate projections. Each projection has 1/8° x 1/8° (~12 km x 12 km) grid cell daily forcings that start on January 1, 1950 and run through December 31, 2099. For this analysis, the location of each city was matched to the single VIC grid cell that contains it. The data was analyzed and days with maximum temperatures over 95°F were considered to contribute to the results, found in Section 4.3.3, which summarize temperature trends for all 112 projections from 1950 to 2099 for the selected grid cell.

4.3.3 Results

Figure 28 shows the distribution of the annual number of days above 95°F from 1950-2099 for each of the cities (Anaheim, Riverside, and Big Bear City) for all 112 climate projections. As shown here, there is a clear, increasing trend in the number of days above 95°F for all three locations, with Riverside in the lead, followed by Anaheim. Big Bear City has the least number of days with a median of zero for all years prior to about 2030. The shaded area in Figure 28 shows the range of the 112 climate projections and demonstrates a large spread in projected results. Table 6 summarizes the median number of days above 95°F for each location for the historical time period (1951-1999) and three 30-year future time periods centered around 2020, 2050 and 2070. As shown in Table 6, the number of days increases for all stations advancing into the future. Changes are quite significant; for example, the median value for Anaheim quadrupled from 4 to 16 days between the historical time period and 2070. Similarly, the median value for Riverside nearly doubled between the historical time period and 2070 going from 43 to 82 days.

A study of warming trends in and around the city of Los Angeles also had similar findings (Hall et al., 2012). For this study they statistically and dynamically downscaled GCMs outputs for two emission scenarios ("Business as usual" RCP8.5 and "mitigation" RCP2.6) and compared results between a baseline period of 1981-2000 and future a future period from 2041-2060. Overall, they reported two to three times as many extreme days (i.e. greater than 95 °F) in coastal areas and within the Los Angeles Basin. Inland areas were noted to have three to five times the number of extremely hot days. Although the trends are the same, there are some differences between this report and the results presented in Table 6.

For example, in the Los Angeles study, they report that Riverside had a historical average of 9.6 day extreme heat days per year, while Table 6 reports 43 days. This difference is likely a result of differences in historical time periods (1981-2000 vs. 1950-1999), as well as differences in downscaling methodology. For example, the methodology used for this analysis did not include any bias correcting to match downscaled results to observed temperature gages. Similarly the future estimates provided in the Los Angeles report for Riverside range from 17 to 59 which is less than the 72 days reported in Table 6. Results for Big Bear are very similar between the reports because temperatures are much lower in Big Bear so the number of extreme days remains close to zero in all cases. However, in the Los Angeles report, they also repeated the extreme day analysis with locally derived temperature thresholds. For Big Bear, the local temperature threshold was set to 76.8 °F. Given this lower threshold, it was found that the number of extreme days increased from 7.3 days historically up to a range of 9 to 78 days by 2050. Anaheim was not covered in the Los Angeles report and so cannot be directly compared.

Table 6: Median annual number of days above 95°F for one historical (1951-1999), and three future (2005-2034, 2035-2064, 2055-2084) time periods

	Historical	2020	2050	2070
Anaheim	4	7	12	16
Riverside	43	58	72	82
Big Bear City	0	0	2	4

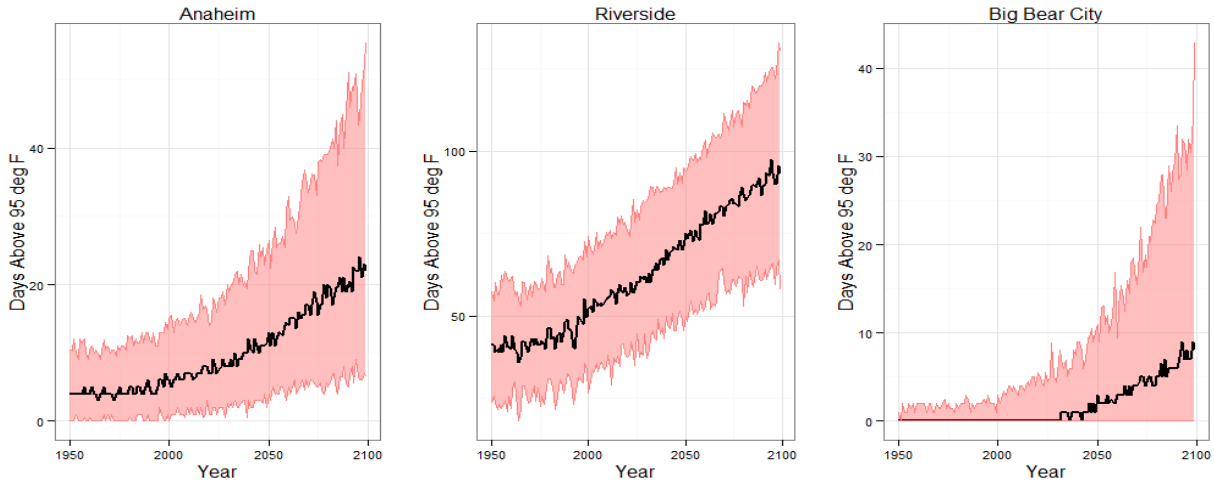


Figure 28: Projected annual number of days above 95°F. Solid black line is the median and the red shading denotes the 5th and 95th percentile bounds

4.4 Flood Impacts

4.4.1 Background

The Santa Ana River has a long history of flooding. In 1862, more than 30 days of rain resulted in flooding across California and destroyed the state capital (Hiltner, 2010). During this flood, it is estimated that the Santa Ana River flowed at roughly 320,000 cfs, about half the flow of the Mississippi River (Hiltner, 2010). Subsequently in 1916, flooding occurred along the Santa Ana River and Santiago Creek, washing out bridges and causing other damages (City of Santa Ana, 2006). In 1938 a flash flood inundated 68,400 acres, resulting in 19 fatalities and leaving 2,000 homeless (City of Santa Ana, 2006). This event led the U.S. Army Corps of Engineers to declare the Santa Ana River the biggest flood hazard west of the Mississippi (Hiltner, 2010). It also helped motivate the construction of Prado Dam and paved the way for a post-World War II construction boom that developed large agricultural areas (City of Santa Ana, 2006). Subsequently, another flood in 1969 caused extensive damage along tributaries. Most recently in 2005, an extended wet period put stress on Prado Dam. No flooding occurred, but the dam began to crack and downstream residents were temporarily evacuated.

As a result of historical floods, there have been a number of efforts to improve flood safety in the basin. In 1964, the Santa Ana River Mainstem Project (SARP) was initiated with a goal of providing flood protection to communities along 75 miles of the Santa Ana River in Orange, Riverside and San Bernardino counties. Today it provides increased flood protection to about 3.35 million people through improvement projects such as channel lining and dam construction (SARP, 2013). Although the flood control system has greatly improved safety, it's important to

note that increased development in the area has also increased impervious area and decreased the effectiveness of existing infrastructure.

Generally, the goal of flood frequency analysis is to determine the probability of occurrence for a range of flood values. Often this is expressed in terms of return periods (equal to the inverse of the threshold exceedance probability). If the probability of a given flood magnitude occurring in a given year is 1%, then the return interval is equal to 100-years (assuming every year is an independent sample from all years and that events are equally likely). There are two main approaches to flood frequency analysis. The extreme value approach uses historical flood data to generate a probability distribution that can be used to predict the flood magnitude for any number of return intervals. Alternatively, flood process can be modeled directly using physically-based hydrodynamic models driven by meteorological forcings. For this analysis we combine both approaches; first we simulate floods using a physically based hydrologic model, then we fit an extreme value distribution to the results.

Extreme value functions are designed to capture the distribution of extremes drawn from other distributions. Pearson Type III and Generalized Extreme Value (GEV) are two of the most commonly used distributions. The Gumbel and Weibul distributions are special cases of the GEV distribution that are commonly applied in hydrology. For this work we use the Log Pearson Type III distribution following the standard United States Government methodology presented in Bulletin 17B, “Guidelines for Determining Flood Flow Frequency” (Bulletin 17B, 1982).

Once an extreme value function has been chosen, the next task is to fit it to the observed data. There are three main approaches: plotting positions, method of moments, and maximum likelihood. Plotting positions is the simplest approach; it’s based on visualizing the observed data and fitting a distribution visually or by minimizing errors (e.g. using least squares fitting). Although this method is very straightforward, it is not very commonly used because it is problematic when dealing with limited data. Also, when using least squares to fit, the errors are minimized between sample values and distribution values, but the error that should in fact be considered is frequency not value (FEMA, 2007).

To improve upon this, the method of moments fits distributions using the various moments of the observed data (e.g. mean, variance, skew, kurtosis) rather than the values themselves. For example, one can simply compute sample moments and distribution moments and solve for distribution parameters. This approach can also be difficult, because simple moments may not exist for a given distribution and higher order moments may be limited by sample size (FEMA, 2007). Probability-weighted moments and linear moments (L-Moments) can address these issues (Hosking and Wallis, 1997). Finally, the maximum likelihood approach calculates the likelihood of a sample given the assumed distribution. Parameters are determined by trying to maximize the likelihood or often (log

likelihood) for a chosen distribution. Once again following the standard methodology recommended in Bulletin 17B, we will fit distributions using the methods of moments for this analysis.

Before applying flood frequency analysis, it is important to understand key underlying assumptions. All extreme value distributions assume that annual max floods are independent samples from a population. Also the distribution approach assumes point data. If data is available from multiple sites, regional frequency analysis can be used to improve parameter estimation. Finally, most extreme value approaches, including the methodology used here, assume that the distribution that is fit to the observed data remains stationary throughout time. This assumption can be problematic in the face of changing climate in which we might expect increased frequency of extreme events. To address this issue, a number of studies have explored the use of non-stationary extreme value distributions in which distribution parameters are allowed to vary as a function of covariates such as time, precipitation or temperature (Katz and Naveau, 2002; Graffis and Stedinger, 2007). For this study, we fit the traditional stationary models. However, we do account for climate change through the physical modeling step by applying non-stationary climate forcings to simulate future floods.

4.4.2 Methodology

As previously noted, for this analysis we used a combined physical and statistical modeling approach. First, floods are modeled using the VIC physical model forced with climate data from 112 climate simulations. Next, Log Pearson distributions are fit to the annual maximum flood values for each simulation for a range of historical and future time periods. We consider three locations along the Santa Ana: Prado Dam, Seven Oaks Dam, and the Adams Street gage near the river outlet. Three 30-year periods are considered centered around: 2020, 2050 and 2070. The historical period spans 50 years from 1950 to 1999.

Annual maximum one-day flood values are calculated from the VIC outputs for each of the 112 150-year simulations. Flood frequencies are estimated following the standard United States Government method outlined in Bulletin 17-B. For each analysis time period (one historical and three 30-year futures) and climate scenario, a Log Pearson III distribution is fit to the annual maximum values using the L-moments approach. Note that each time period is treated separately. For example, each future period will have 30 values with which to fit the distribution. Using the parameters for the Log-Pearson III distributions, the 200-year return period flow values are estimated for every climate simulation and analysis period. The 200-year storm was used in order to fill the requirements set forth in the California Department of Water Resources' Climate Change Handbook for Regional Water Planning (Appendix B). The distribution is also used to calculate the return period for the median historical 200-year flood for each climate simulation and future time period.

4.4.3 Results

Figures 29 through 31 show results for the three analysis locations: Prado Dam, Seven Oaks Dam, and the Adams Street gage. The boxplots on the left show the distribution of 200-year flood flows estimated using the distributions fit to the 112 scenarios for each time period. The boxplots on the right show the simulated return period of the historical median 200-year flood flow. Tables 7 and 8 summarize the data presented in the boxplots. Table 7 provides the median and interquartile range of 200-year flood flow values. Table 8 provides similar information for the future return periods of the historical median flood flows.

For all stations, there is a clear trend of increasing median 200-year flood flow for each subsequent future analysis period. However, there is also large variability in the future flood projections. Still, in all cases, the bottom of the historical interquartile range (designated by the shaded box) falls below the projected future interquartile range. As would be expected, this results in a decreased return interval for the median historical 200-year flood (as shown in the figures on the right). On average, projections indicate that what was historically the 200-year flood may be closer to a 70-year flood.

Comparing results from station to station, the trends are very similar, increasing flood volumes and decreasing return intervals. This trend is most pronounced for the Seven Oaks Dam site where there is a clear increasing trend in 200-year flood volumes and dramatic decrease in return periods. Seven Oaks Dam also shows a clear decrease in the upper interquartile range for return periods in later future periods.

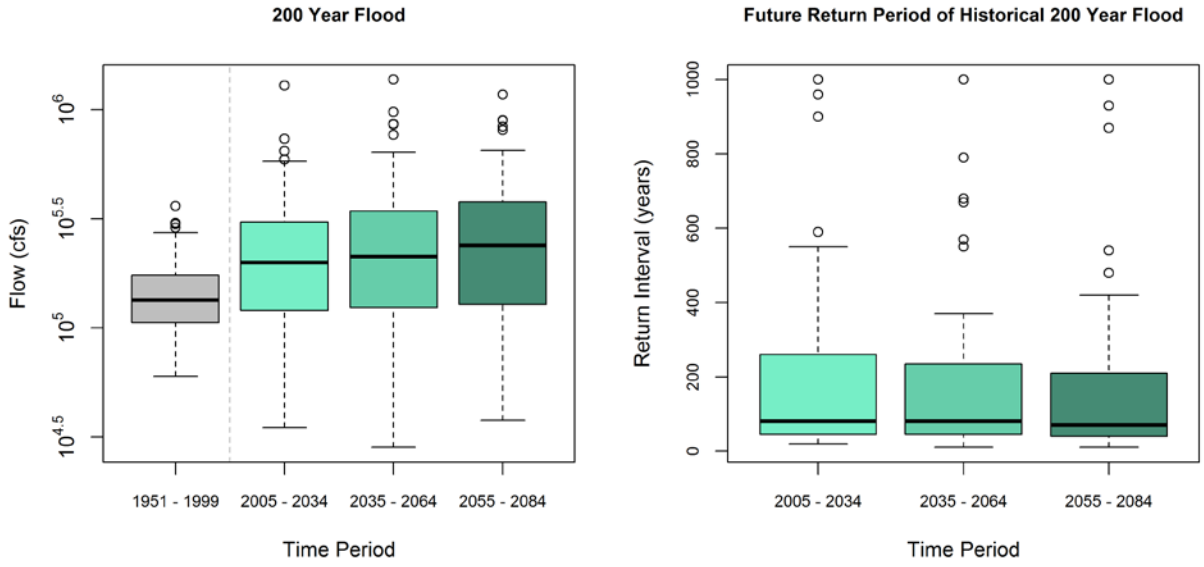


Figure 29: Station 8 Prado Dam - boxplots of 200-year flood volumes and future return periods for the median historical 200-year flood

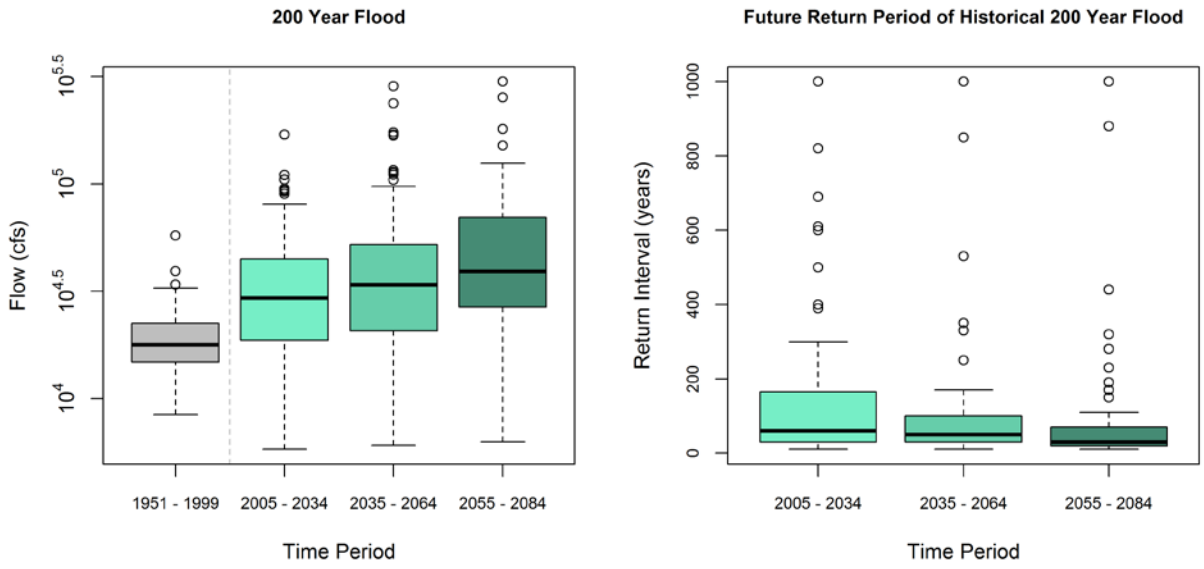


Figure 30: Station 34 Seven Oaks Dam - boxplots of 200-year flood volumes and future return periods for the median historical 200-year flood

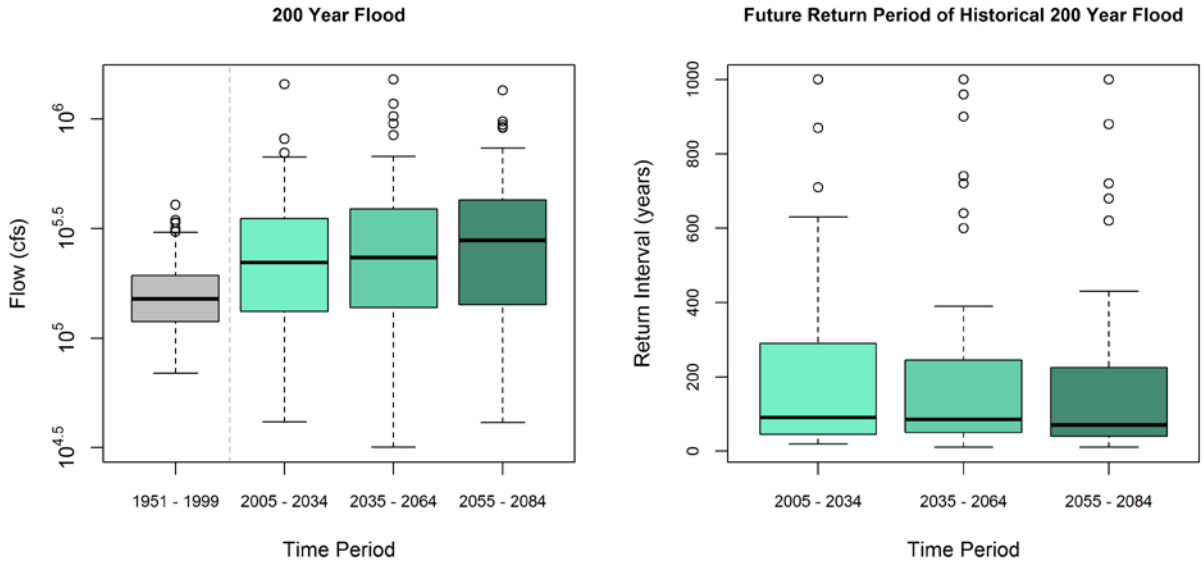


Figure 31: Station 21 Adams Street Gage - boxplots of 200-year flood volumes and future return periods for the median historical 200-year flood

Table 7: Summary of 200-year flood flows (cfs)

Station	Time Period	Percentile		
		25%	50%	75%
Prado Dam	Historical	106,289	134,170	174,018
	2020	120,616	199,623	302,401
	2050	124,369	212,392	335,621
	2070	129,706	239,359	377,660
Seven Oaks Dam	Historical	14,805	17,786	22,428
	2020	18,821	29,394	44,474
	2050	20,730	33,813	52,073
	2070	26,765	39,099	69,724
Adams Street Gage	Historical	119,084	151,084	192,357
	2020	132,923	221,375	347,943
	2050	137,749	232,974	385,438
	2070	142,980	279,004	424,881

Table 8: Summary of return periods, in years, for the median 200-year historical flood

Station	Time Period	Percentile		
		25%	50%	75%
Prado Dam	2020	48	80	260
	2050	48	80	233
	2070	40	70	205
Seven Oaks Dam	2020	30	60	163
	2050	30	50	100
	2070	20	30	70
Adam Street Gage	2020	48	90	285
	2050	50	85	243
	2070	40	70	223

Results from this analysis indicate increased risk of flooding in the future. This is demonstrated by increased 200-year flood magnitudes as well as decreased recurrence intervals for what was historically considered a 200-year flood. While these results show clear trends, it is also important to note that there is large variability between climate simulations. For the purposes of this analysis, it is assumed that all future scenarios are equally likely. Variability in the results reflects large underlying uncertainties with GCM outputs and downscaling methodologies. Additionally, the quality of results is necessarily limited by the ability of the VIC model to accurately generate flood flows from forcing data. While these constraints are acknowledged, it should be noted that this analysis follows standard methodologies and utilizes the best available input data.

4.5 Sea Level Rise Impacts

4.5.1 Background

Climate change will contribute to global sea level rise (SLR) through melting of glaciers and ice caps and thermal expansion of ocean waters, both of which increase the volume of water in the oceans. Regional SLR may be higher or lower than global SLR due to effects of regional ocean and atmospheric circulation.

California's 2,000 miles of coastline has experienced just under eight inches of sea level rise over the past decade (Cayan et al., 2009), a number that is likely to increase drastically as the climate continues to change. Critical infrastructure, such as roads, hospitals, schools, emergency facilities, wastewater treatment plants, power plants, and more will also be at increased risk of inundation, as are vast areas of wetlands and other natural ecosystems.

Flooding and erosion already pose a threat to communities along the California coast and there is compelling evidence that these risks will increase in the future. In areas where the coast erodes easily, sea level rise will likely accelerate shoreline recession due to erosion. Erosion of some barrier dunes may expose previously protected areas to flooding.

4.5.2 Methodology

Orange County Water District (OCWD) conducted a study to evaluate the potential effects of projected sea level rise on coastal Orange County groundwater conditions. Two locations were selected near the Talbert and Alamitos injection barriers, shown in Figure 32.

Projected sea level rise scenarios were developed by the California Climate Change Center (Cayan et al., 2009). For this analysis, the moderate projected sea level rise along the California coast was used. The projected time horizon or year is not critical for the model runs (described below), but rather just the sea level rise amount. Therefore, to bracket the entire range of projected moderate case sea

level rise values, OCWD chose to model a low end of 0.5 feet and an upper end of 3 feet. Separate model runs were conducted for these two sea level rise cases, both for the Talbert Barrier area using the basin model and for the Alamitos Barrier area using the Alamitos Barrier flow model.

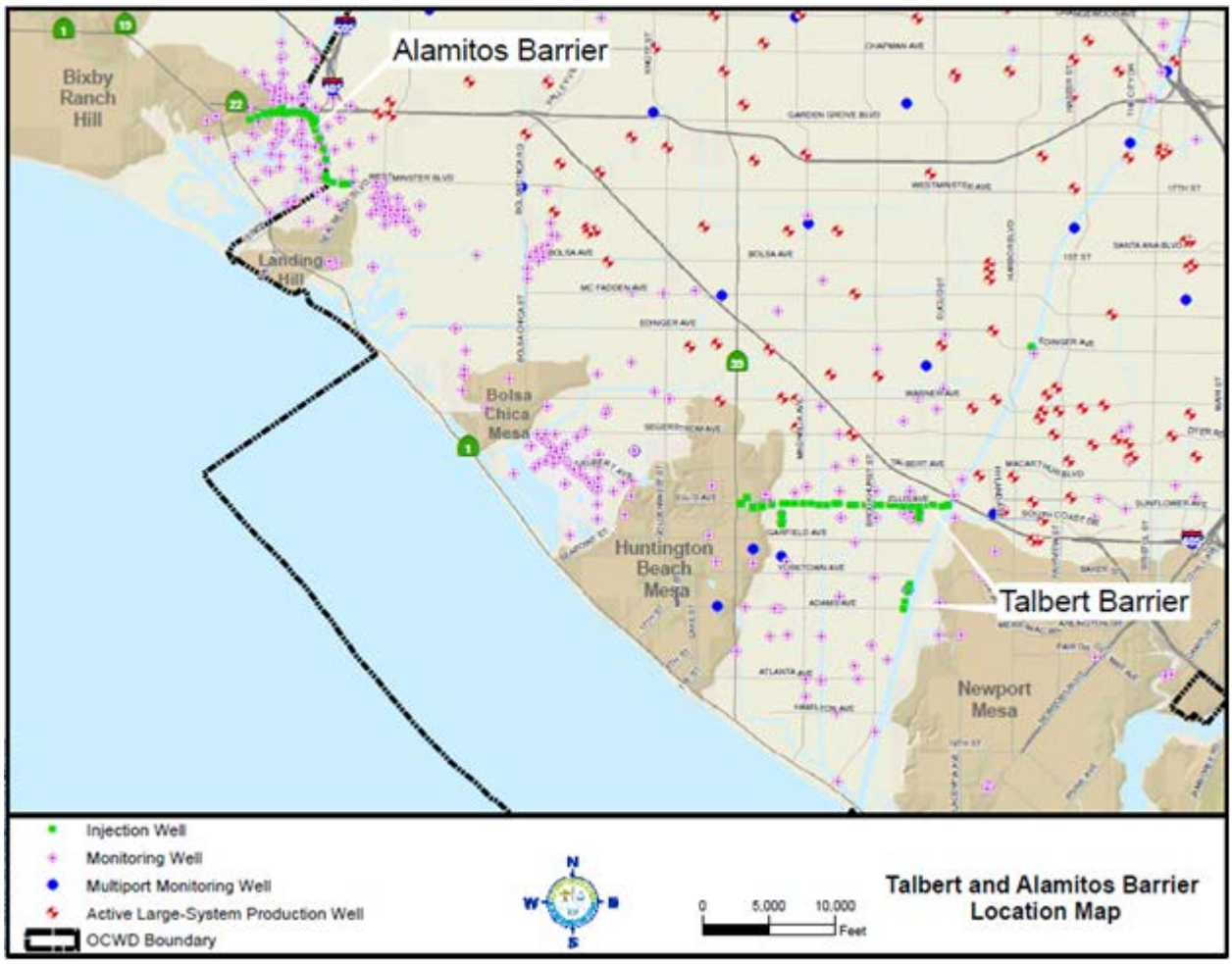


Figure 32: Locations selected for OCWD analysis

The model encompasses the entire basin and extends approximately three miles west into the Central Basin of Los Angeles County. The model grid cells are 500 by 500 feet and have vertical dimensions ranging from approximately 50 to 1,800 feet, depending on the thickness of each model layer at that grid cell location. The model accounts for time varying specified head boundaries, pumping rates, and recharge rates.

Model input data were obtained from well logs, aquifer pump tests, groundwater elevation measurements, hand-drawn contour maps, geologic cross sections, water budget spreadsheets, and other data stored in the OCWD Water Resources Management System (WRMS) database. The basin model was calibrated to transient conditions to achieve an acceptable match between simulated and actual observed conditions using monthly flow and water level data for the period 1990-1999.

4.5.3 Results

Increasing temperatures will melt ice sheets and glaciers and cause thermal expansion of ocean water, both of which will increase the volume of water in the oceans and thus contribute to global mean SLR. Regional SLR may be higher or lower than global mean SLR due to regional changes in atmospheric and ocean circulation patterns. Figure 33 shows the range of projected global mean SLR by 2100. Regional mean sea level along the Southern California coast is projected to rise by 40-300 mm (1.5-12 in) by 2030, 125-610mm (5-24 in) by 2050, and 405-1675 mm (16-66 in) by 2100.

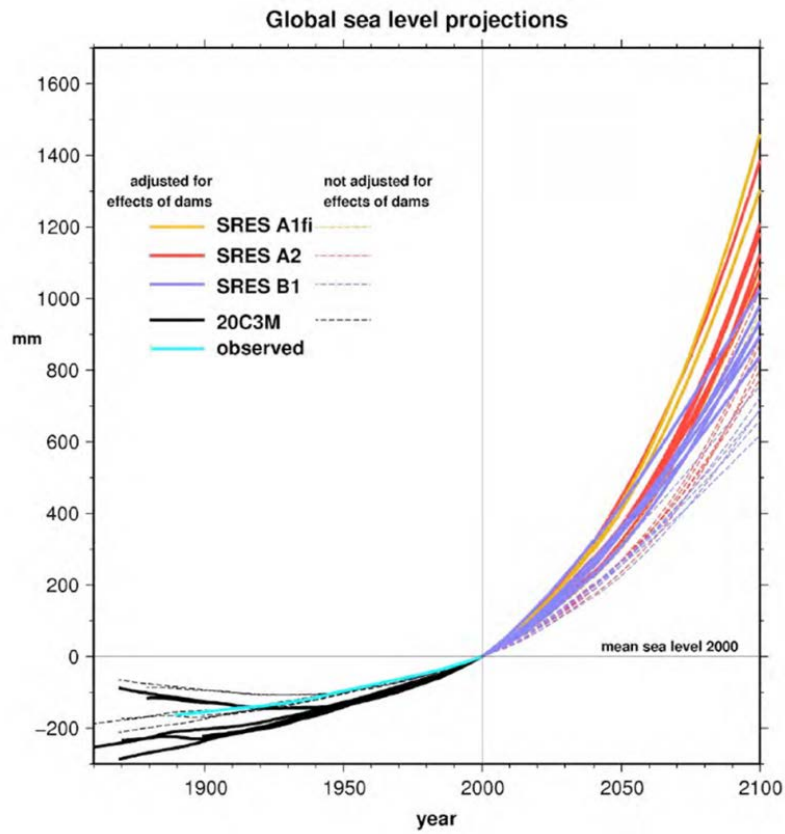
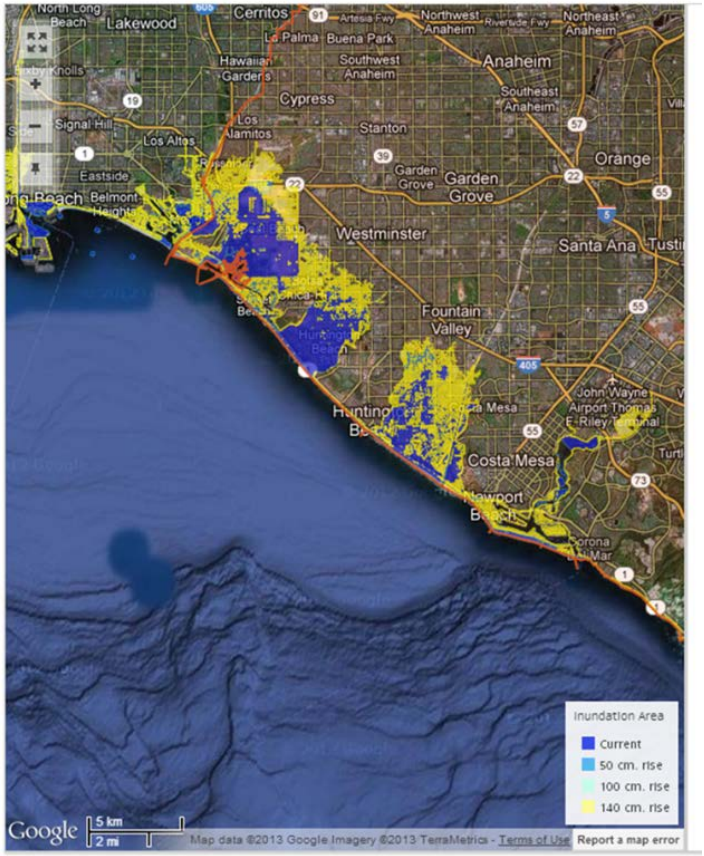


Figure 33: Projections of global mean sea level rise

Inundation due to SLR is likely to reduce the area of beaches and wetlands along the Southern California coast. In addition, SLR is likely to increase erosion of sea cliffs, bluffs, sand bars, dunes, and beaches along the California coast. However, the overall effects of climate change on local beaches will depend on changes in coastal ocean currents and storm intensities, which are less certain at this time. SLR is likely to increase the coastal area vulnerable to flooding during storm events. Figure 34 shows the areas of Orange County that are currently vulnerable to inundation due to a 100-year flood event (blue) and areas that will be vulnerable to inundation with a 1400 mm (55 in) rise in mean sea level (source: http://cal-adapt.org/sealevel/).

Detailed analysis carried out by Orange County Water District found that the Talbert Barrier would be effective at preventing seawater intrusions through the Tablert Gap under a 3-foot sea level rise. In the case of the Alamitos Barrier, seawater intrusion through the Alamitos Gap would likely be prevented once current plans to construct additional injection wells are implemented. At both barriers, however, shallow groundwater concerns could limit injection rates and thus reduce the effectiveness of barriers at preventing seawater intrusion under rising sea levels.



Source: http://cal-adapt.org/sealevel

Figure 34: Area at risk of inundation from 100-year flood event under current conditions (blue) and under 1400 mm sea level rise (yellow)

Average sea levels along the Southern California coast are projected to rise by 5 to 24 inches by 2050 and 16 to 66 inches by 2100. SLR is likely to inundate beaches and coastal wetlands and may increase coastal erosion. Effects on local beaches depend on changes in coastal ocean currents and storm intensity, which are highly uncertain at this time.

SLR will increase the area at risk of inundation due to a 100-year flood event. Existing barriers are sufficient to deter seawater intrusion at Talbert and Alamitos gaps under a 3-foot rise in sea levels. However, operation of barriers under SLR may be constrained by shallow groundwater concerns.

4.6 Decision Support and Impact Assessment Summary

A set of frequently asked questions (FAQs) were answered using the previous analyses. Those questions and the key findings are summarized below.

Will surface water supply decrease?

- Annual surface water is likely to decrease over future periods.
- Precipitation shows somewhat long-term decreasing trends.
- Temperature will increase, which is likely to cause increased water demand and reservoir evaporation.
- April 1st SWE will decrease.

Will groundwater availability be reduced?

- Groundwater currently provides approximately 54% of total water supply in an average year, and groundwater use is projected to increase over the next 20 years.
- Projected decreases in precipitation and increases in temperature will decrease natural recharge throughout the basin.
- Management actions such as reducing municipal and industrial water demands or increasing trans-basin water imports and recharge will be required in order to maintain current groundwater levels.
- A basin-scale groundwater screening tool was developed to facilitate analysis of basin-scale effects of conservation, increasing imported supply, changing agricultural land use, and other factors on basin-scale groundwater conditions.

Is Lake Elsinore in danger of drying up?

- Lake Elsinore has less than a 10% chance of drying up (2000-2099).
- In the 2000-2049 period, Lake Elsinore has a greater than 75% chance of meeting the minimum elevation goal of 1,240 ft.
- In the future period 2050-2099, Lake Elsinore has less than a 50% chance of meeting the minimum elevation goal of 1,240 ft.
- There is less than a 25% chance that Lake Elsinore will drop below low lake levels (1,234 ft) in either period.
- The Elsinore Valley Municipal Water District (EVMWD) project does aid in stabilizing lake levels; however, for the period 2050-2099 additional measures will likely be required to meet the minimum elevation goal of 1,240 ft.

Will the region continue to support an alpine climate and how will the Jeffrey Pine ecosystem be impacted?

- Warmer temperatures will likely cause Jeffrey pines to move to higher elevations and may decrease their total habitat.
- Forest health may also be influenced by changes in the magnitude and frequency of wildfires or infestations.
- Alpine ecosystems are vulnerable to climate change because they have little ability to expand to higher elevations.
- Across the State it is projected that alpine forests will decrease in area by 50-70% by 2100.

Will skiing at Big Bear Mountain Resorts be sustained?

- Simulations indicate significant decreases in April 1st snowpack that amplify throughout the 21st century.
- Warmer temperatures will also result in a delayed onset and shortened ski season.
- Lower elevations are most vulnerable to increasing temperatures.
- Both Big Bear Mountain Resorts lie below 3,000 m and are projected to experience declining snowpack that could exceed 70% by 2070.

How many additional days over 95°F are expected in Anaheim, Riverside and Big Bear City?

- All the climate projections demonstrate clear increasing temperature trends.
- Increasing temperatures will result in a greater number of days above 95°F in the future.
- The number of days above 95°F gets progressively larger for all cities advancing into the future.
- By 2070 it is projected that the number of days above 95°F will quadruple in Anaheim (4 to 16 days) and nearly double in Riverside (43 to 82 days). The number of days above 95°F at Big Bear City is projected to increase from 0 days historically to 4 days in 2070.

Will floods become more severe and threaten flood infrastructure?

- Simulations indicate a significant increase in flow for 200-year storm events in the future.
- The likelihood of experiencing what was historically a 200-year event will nearly double (i.e. the 200-year historical event is likely to be closer to a 100-year event in the future).
- Findings indicate an increased risk of severe floods in the future, though there is large variability between climate simulations.

How will climate change and sea level rise affect coastal communities and beaches?

- Climate change will contribute to global sea level rise (SLR) through melting of glaciers and ice caps and thermal expansion of ocean waters, both of which increase the volume of water in the oceans.
- Regional SLR may be higher or lower than global SLR due to effects of regional ocean and atmospheric circulation.
- Average sea levels along the Southern California coast are projected to rise by 5 to 24 inches by 2050 and 16 to 66 inches by 2100.
- SLR is likely to inundate beaches and coastal wetlands and may increase coastal erosion. Effects on local beaches depend on changes in coastal ocean currents and storm intensity, which are highly uncertain at this time.
- SLR will increase the area at risk of inundation due to a 100-year flood event.
- Existing barriers are sufficient to deter seawater intrusion at Talbert and Alamitos gaps under a 3-foot rise in sea levels. However, operation of barriers under SLR may be constrained by shallow groundwater concerns.

In order to adapt to the impacts of climate change described in this chapter, water managers need tools that enable them to make informed decisions. Reclamation has developed a tool, the Greenhouse Gas (GHG) Emissions Calculator, which can be used to inform adaptive strategies. This tool was used to conduct a demand management case study for Orange County. The tool and case study are presented in Chapter 5.

5.0 Demand Management to Inform Adaptive Strategies

5.1 Background

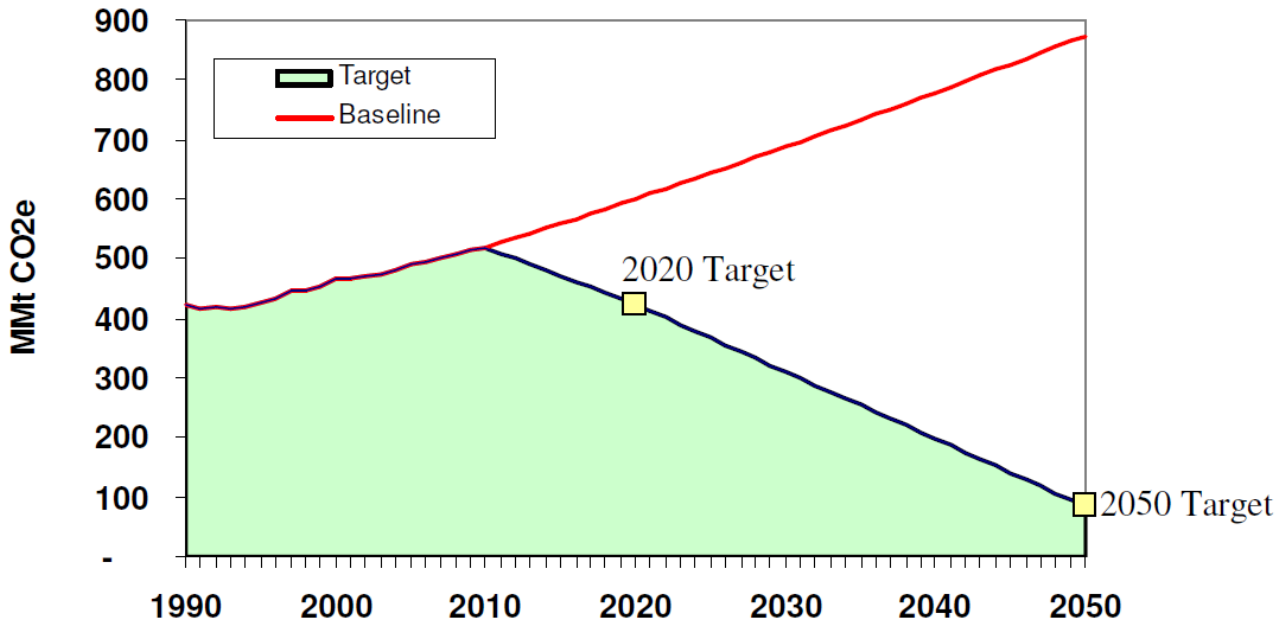
Water resource managers are currently being challenged to develop sustainable methods for adaptation and mitigation to climate change. Demands for treatment and transportation of water are increasing globally due to developments in industrial, agricultural and domestic water use, and water quality regulation (King and Webber, 2008). Large increases in energy use in the water sector are being driven by rising demand for food and bio-fuels, and their international trade, driving up irrigated cropland and cropping intensity (DOE, 2006). This estimate excludes the effects of climate change, which in many cases will put further pressure on water resources (IPCC, 2008). With increased irrigation, further development of ground water is highly likely. Declining ground water will compound energy use, as deeper wells require more carbon-intensive electric-driven pumps.

Growing populations are creating a higher water demand. In areas where water is already scarce, accelerated research will be required in order to develop sustainable mitigation and adaptation scenarios to climate change, while still meeting the demand. Consideration of alternative water supply systems, treatment technologies, or water allocation may have a tendency to overlook the carbon cost. This is particularly the case in the absence of regulatory pressure. The passing of California's Assembly Bill 32: The Global Warming Solutions Act (AB 32) is the first in a series of legislation forcing this issue to be addressed.

Climate change threatens California's natural environment, economic prosperity, public health, and quality of life (California Energy Commission, 2005; AB 32, 2006). Recognizing the need for action, California has put in place ambitious emission reduction goals in the form of AB 32. By requiring in law a reduction in GHG emissions, California has set the stage to transition to a sustainable, clean energy future, and put climate change mitigation on the national agenda, spurring action by many other states. AB 32 directly links anthropogenic GHG emissions and climate change, provides a timeline for statewide GHG emissions reduction, requires quantitative accounting of GHG emissions, and enforces disclosure of GHG emissions from ever major sector in the state.

AB 32 requires that every major sector in California reduce its GHG emissions to the 1990 levels by 2020, and to 80% below the 1990 levels by 2050, shown in Figure 35. These targets were developed from the levels of reduction climate

scientists agree is required to stabilize our climate (IPCC, 2008). The red line in Figure 35 represents the projected GHG emissions out to 2050, if no action is taken. In order to reach the GHG emissions target set by AB 32 for 2020, a reduction of approximately 30% is required from the no action scenario.



Source: http://ethree.com/documents/GHG6.10/CA_2050_GHG_Goals.pdf

Figure 35: AB 32 GHG Emission Reduction Targets

5.2 Methods

The methods used account for embodied energy and the subsequent GHG emissions of water consumption in a study area. Figure 36 illustrates the different energy consuming processes involved in the delivery and treatment of water. End-use of water is not considered in this analysis; for example, energy used for heating water in the home. The energy intensity of each of these processes, and the volume of water passing through each, will need to be known in order to accurately inventory emissions associated with water consumption. The degree to which each of the processes used to deliver water is identified, and the energy intensity of each of those processes is known, will define the accuracy of the methods for determining the GHG emissions from water consumption. Water conveyance can be the most impactful element in California. Communities in the south draw significant amounts of water from vast distances over elevated terrain.

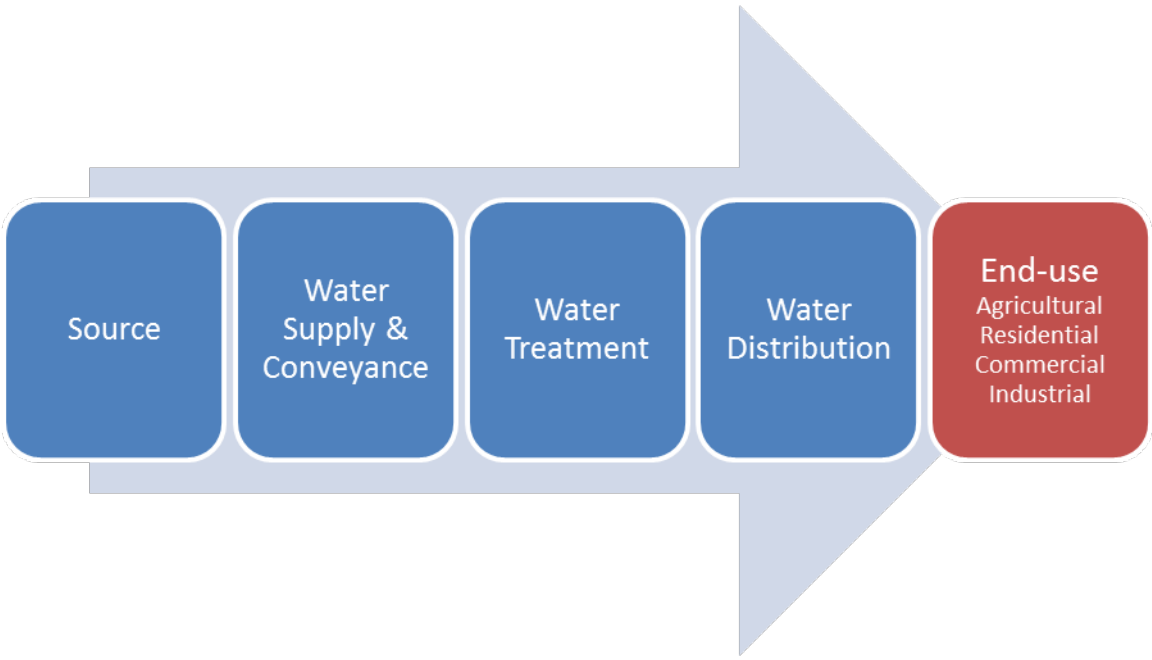


Figure 36: Energy Consuming Process in the Delivery and Treatment of Water (red not included in analysis)

Study area specific energy consumed per unit of water for each process of the water system is utilized. If site specific information is not available, southern California defaults are used. Default utility specific emission factors were obtained from the California Climate Action Registry Power/Utility Protocol reports. Annual average electricity emission factors came from the California Air Resources Board Greenhouse Gas Inventory (2007), and eGRID (2009).

Equation 2 depicts how total annual CO_2e emissions are calculated:

Annual CO_2e emissions = Extraction + Conveyance + Treatment + Distribution…….**Eq. 2**

Where:

Extraction =

$$\Sigma\,(\text{Source Percentage} * \text{Population} * \text{per capita Use} * \text{Process Energy Intensity}_{\text{GW Extraction}}) * \text{Energy Emissions Factor} * \text{Unit Conversions}$$

Conveyance =
$$\Sigma\left(\text{Source Percentage} * \text{Population} * \text{per capita Use} * \text{Process Energy Intensity}_{\text{Conveyance}}\right) * \text{Energy Emissions Factor} * \text{Unit Conversions}$$

Treatment =
$$\Sigma\left(\text{Source Percentage} * \text{Population} * \text{per capita Use} * \text{Process Energy Intensity}_{\text{Treatment}}\right) * \text{Energy Emissions Factor} * \text{Unit Conversions}$$

Distribution =
$$\Sigma\left(\text{Source Percentage} * \text{Population} * \text{per capita Use} * \text{Process Energy Intensity}_{\text{Distribution}}\right) * \text{Energy Emissions Factor} * \text{Unit Conversions}$$

A GHG Emissions Calculator was developed by Reclamation to allow users to implement this method in order to easily and quickly evaluate how their water management decisions affect their water demand, energy use, and GHG emissions. A full technical report on the GHG Emissions Calculator will be published by fall 2013.

5.3 Application

In February 2008, California Governor Schwarzenegger directed state agencies to develop a plan to reduce statewide per capita urban water use by 20% by the year 2020. The GHG Emissions Calculator was used to evaluate whether this conservation measure alone would be enough to meet AB 32 targets (shown in Figure 35) in Orange County. The results show that a 20% reduction by the year 2020 allows Orange County to meet the 2020 target (back to 1990 levels), but do not meet the 2050 target of 80% below 1990 levels, as shown in Figure 37.

A 20% reduction in per capita water use every 10 years from 2020 to 2050 was evaluated in the GHG Emissions Calculator. These additional conservation measures only reach 50% below the 1990 GHG emission levels, as shown in Figure 38. In order to reach the AB 32 2050 target of 80% below the 1990 levels of GHG emissions through conservation alone, a per capita water use reduction of an additional 10% each decade would need to be achieved, results of which are shown in Figure 39. This level of conservation, shown in Table 9, may not be feasible for the area. In Figure 40, the three conservation scenarios described above are compared to the no action scenario, a task easily accomplished by the GHG Emissions Calculator. The GHG Emissions Calculator can also be used to

evaluate additional measures to reduce GHG emissions including changes to water supply portfolio, graywater reuse, and rainwater harvesting among many others. It is likely that a combination of measures will be required to meet the GHG emission reduction targets laid out in AB 32.

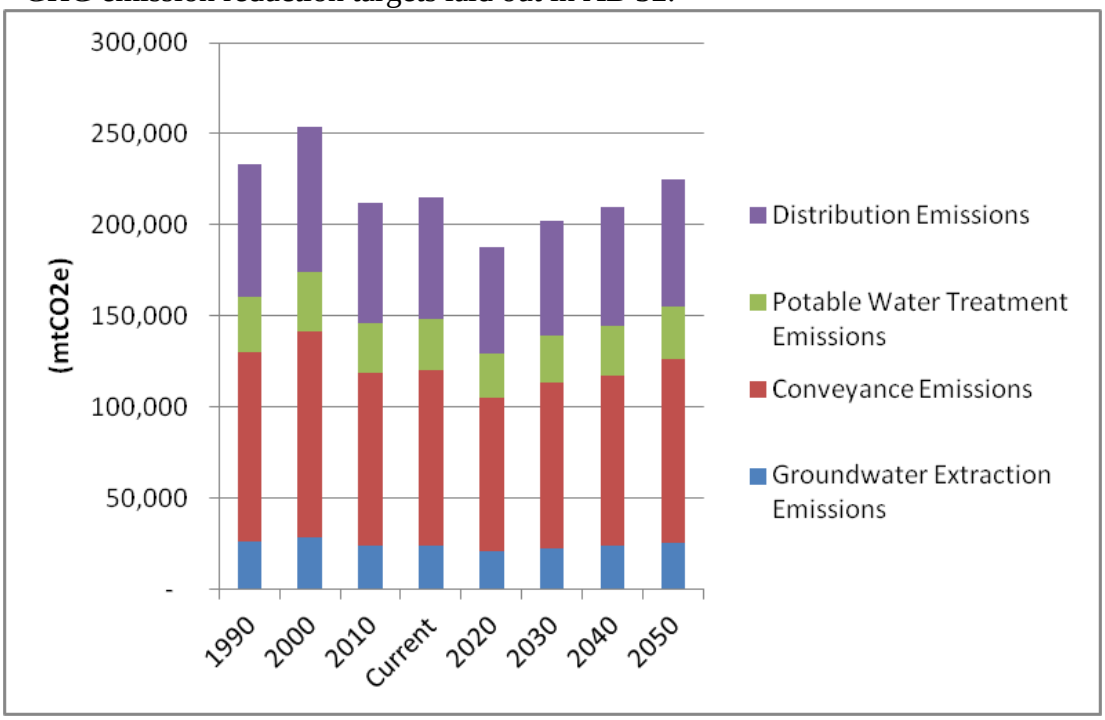


Figure 36: Conservation for Orange County to meet a 20% reduction in GHG emissions by 2020 (also referred to as 20x2020)

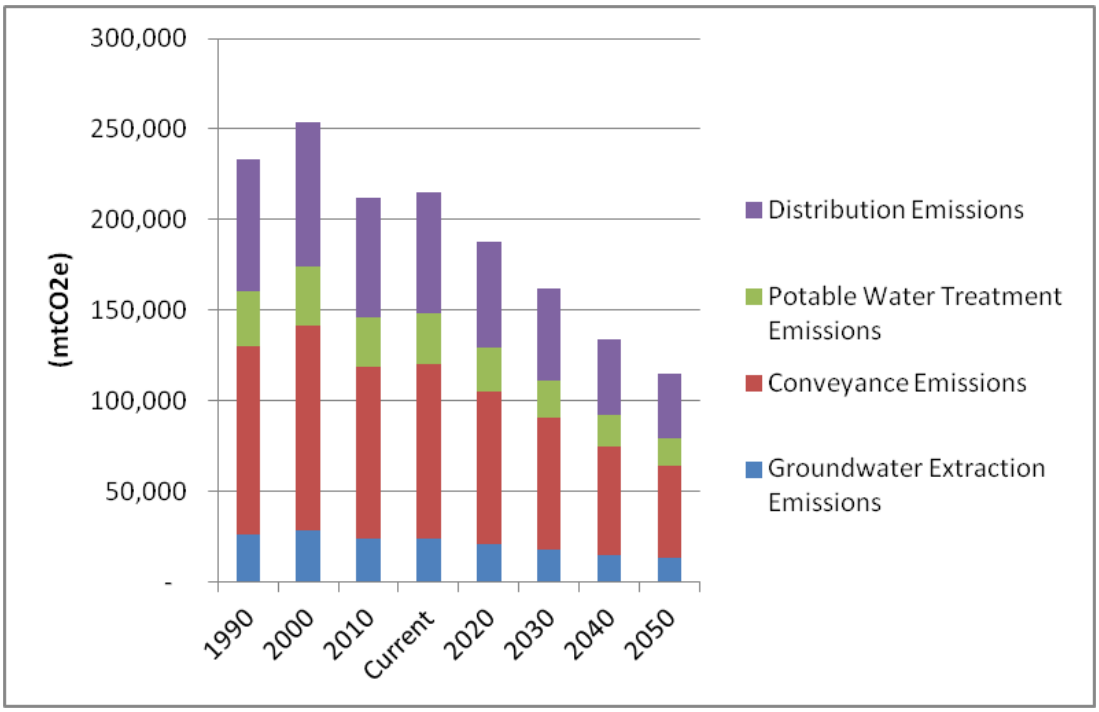


Figure 37: GHG emissions resulting from a 20% reduction in per capita water use every 10 years from 2020 to 2030 for Orange County

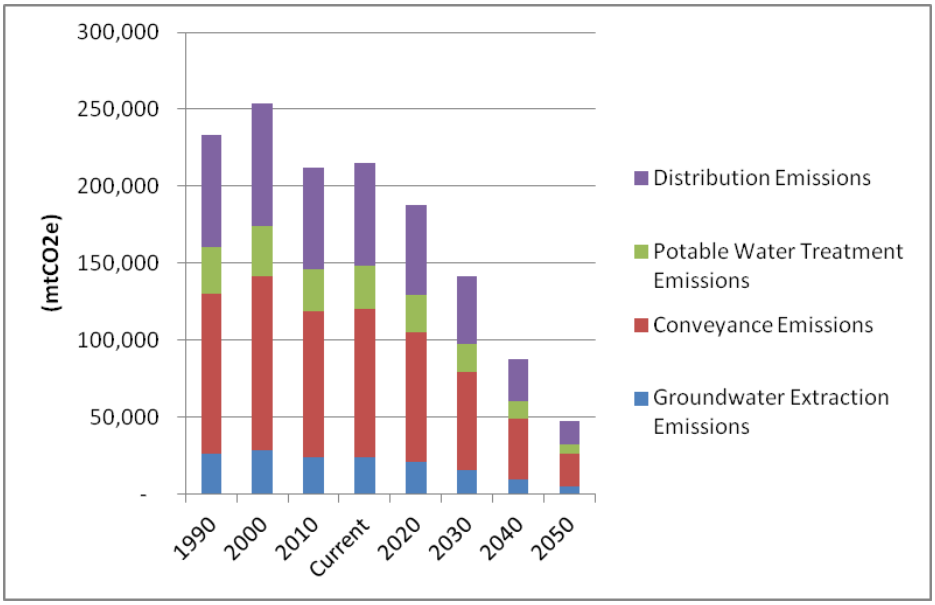


Figure 38: GHG emissions resulting from reductions in per capita water use shown in Table 9 for Orange County

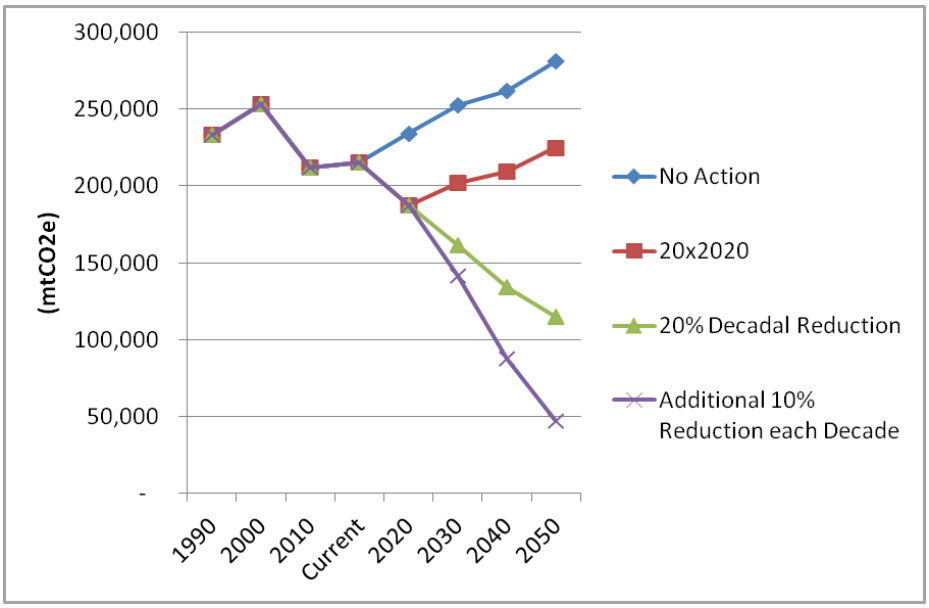


Figure 39: Comparison of GHG emissions resulting from conservation scenarios

Table 9: Conservation measures required to meet AB 32 2050 target

Historical and Projected Per Capita Water Use							
	1990	2000	2010	2020	2030	2040	2050
Per Capita Water Use (gpd)	240	221	175	140	98	59	29
Decadal Conservation Rate		-8%	-21%	-20%	-30%	-40%	-50%

6.0 Uncertainties

This analysis was designed to take advantage of best available datasets and modeling tools and to follow methodologies documented in peer-reviewed literature. However, there are a number of analytical uncertainties that are not reflected in study results, including uncertainties associated with the following analytical areas that can be grouped under two categories: climate projection information and assessing hydrologic impacts that inform many of the Basin Study FAQs.

6.1 Climate Projection Information

6.1.1 Global Climate Forcing

Although surface water hydrologic projections often consider future climate projections representing a range of future greenhouse emission paths, the uncertainties associated with these pathways are often not explored. Such uncertainties include those introduced by assumptions about technological and

economic developments, globally and regionally; how those assumptions translate into global energy use involving GHG emissions; and biogeochemical analysis to determine the fate of GHG emissions in the oceans, land, and atmosphere. Also, not all the uncertainties associated with climate forgings are associated with GHG assumptions. Considerable uncertainty remains associated with natural forcings, with the cooling influence of aerosols being regarded as the most uncertain on a global scale (e.g., figure SPM-2 in IPCC 2007).

6.1.2 Global Climate Simulations

While the activity presented in this report considers climate projections produced by state-of-the-art coupled ocean-atmosphere climate models, there are still uncertainties about the scientific understanding of physical processes that affect climate. For example, how to represent such processes in GCMs (e.g., atmospheric circulation, clouds, ocean circulation, deep ocean heat update, ice sheet dynamics, sea level, land cover effects from water cycle, vegetative, and other biological changes); and how to do so in a mathematically efficiently manner, given computational limitations. Still, these models have shown an ability to simulate the influence of increasing GHG emissions on global climate (IPCC 2007).

6.1.3 Climate Projection Bias Correction

Surface water hydrologic projections inherit GCM biases toward being too wet, too dry, too warm, or too cool. Such systematic biases in GCMs should be identified and accounted for through bias-correction of climate projections, prior to use in impacts studies. Bias correction of climate projections data affects results on incremental runoff and water supply response.

6.1.4 Climate Projection Spatial Downscaling

The Basin Study uses projections that have been spatially disaggregated on a monthly time step (following GCM bias correction on a monthly time step). Although this technique has been used to support numerous water resources impacts studies (e.g., Van Rheenan et al., 2004; Maurer, 2007; Anderson et al., 2008; Reclamation, 2008; Reclamation, 2010; Elsner et al., 2010), uncertainties remain about the limitations of empirical downscaling methodologies. One potential limitation relates to how empirical methodologies require historical reference information use on spatial climatic patterns at the downscaled spatial resolution. These finer-grid patterns are implicitly related to historical large-scale atmospheric circulation patterns, which presumably would change somewhat with global climate change. Application of the historical finer-grid spatial patterns to guide downscaling of future climate projections implies an assumption that the historical relationship between finer-grid surface climate patterns and large-scale atmospheric circulation is still valid under the future climate. In other words, the relationship is assumed to have statistical stationarity, meaning the joint probability distribution does not change when shifted in time or space. In actuality, it is possible that such stationarity will not hold at various space and time scales, over various locations, and for various climate variables. However,

the significance of potential non-stationarity in empirical downscaling methods, and the need to utilize alternative downscaling methodologies remains not well understood.

6.2 Assessing Hydrologic Impacts

6.2.1 Generating Weather Sequences Consistent with Climate Projections

The temporal disaggregation method developed first by Wood et al., (2002), was used in this Basin Study to translate monthly BCSD climate projections into daily VIC weather forcings. However, other techniques might have been considered. Choice of weather generation technique depends on aspects of climate change that are being targeted in a given study. Preference among available techniques remains to be established. Various characteristics, such as that the resampling approach, does not allow daily temperature ranges to vary from those selected with the sample, make the disaggregation approach unsuitable for studies focusing on potential changes in the diurnal range of temperature. In contrast, it may be sufficient for monthly time step hydrological assessments if the disaggregation is performed with thoughtful sampling constraints.

6.2.2 Natural Runoff Response

This Basin Study analyzes natural runoff response to changes in precipitation, temperature, and change in natural vegetation PET while holding other watershed features constant. Other watershed features might be expected to change as climate changes and affects runoff (e.g., vegetation affecting evapotranspiration and infiltration, etc.). On the matter of land cover response to climate change, the runoff models' calibrations would have to change if land cover changed, because the models were calibrated to represent the historical relationship between weather and runoff as mediated by historical land cover. Adjustment to watershed land cover and model parameterizations are difficult to consider due to lack of available information to guide such an adjustment. Eco-hydrological frameworks, perhaps involving dynamic vegetation response, may be suitable to represent such land surface changes for studies in which such sensitivities are important.

6.2.3 Hydrologic Modeling

The hydrology model used in the Basin Study excludes ground water interaction with surface water systems. The fate of precipitation is modeled as loss only to runoff and evapotranspiration; and loss of precipitation to deep percolation and return flows to stream channel networks are not considered in the VIC hydrology model. The groundwater impacts in the basin are simulated using a simplified tool.

6.2.4 Bias and Calibration

Where the VIC applications have been calibrated, they can reproduce historical natural streamflow with little bias. Where the VIC applications have not been

calibrated, they can exhibit significant bias. The location-specific implications of calibration, or lack thereof, on the conclusions of the study have not been quantified.

6.2.5 Time Resolution of the Applications

Simulations were conducted at daily time steps, while the applications were calibrated to reproduce monthly and annual runoff characteristics at a subset of locations in the basin. For this reason, users should cautiously interpret the daily hydrologic information coming from these simulations. The daily runoff information is physically consistent with assumed weather forcings and hydrologic model structure; however, there could be significant simulation biases at the submonthly level.

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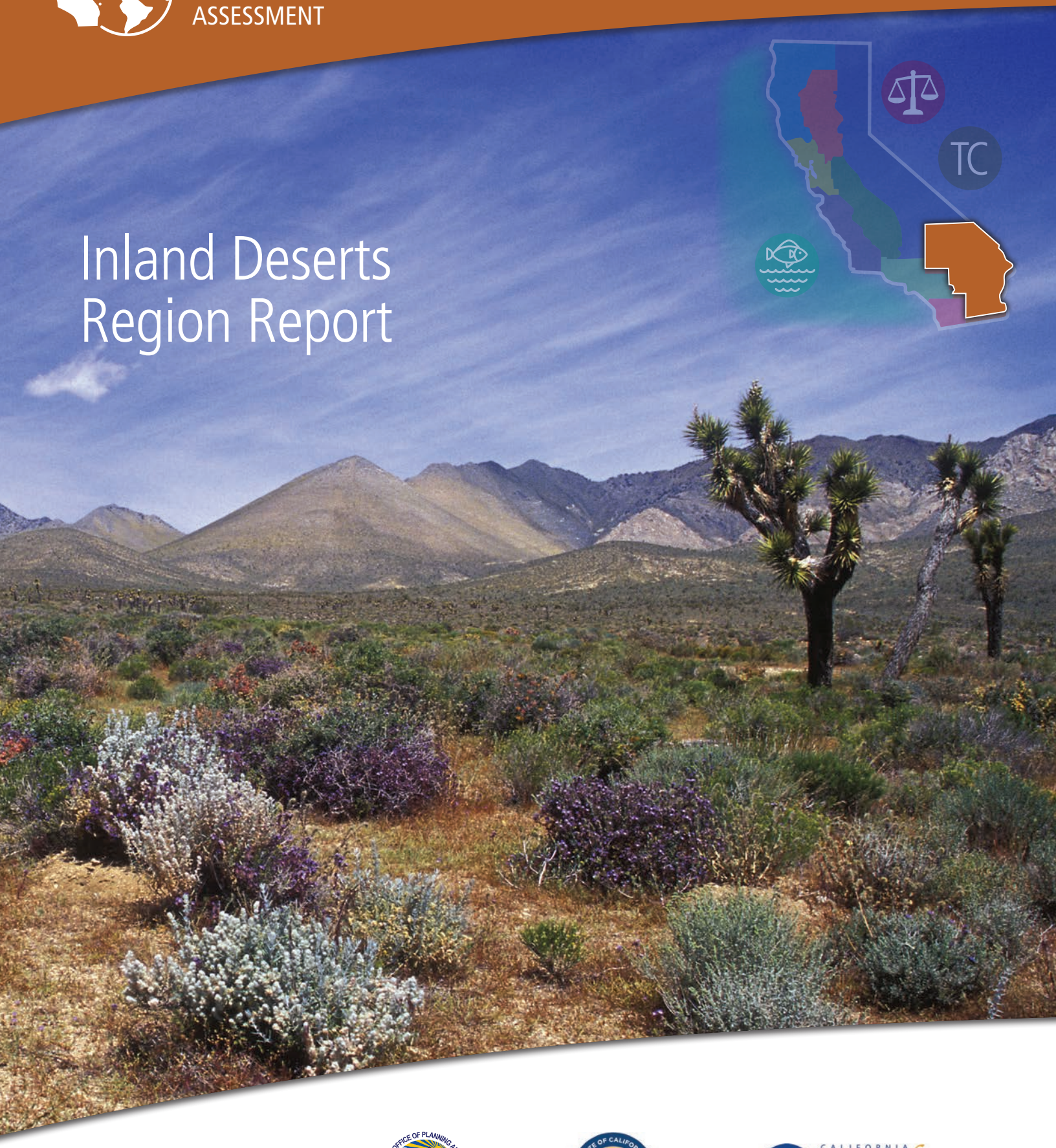
Appendix 2B

CALIFORNIA'S FOURTH CLIMATE CHANGE ASSESSMENT REPORT – INLAND DESERTS REGION

CALIFORNIA'S FOURTH
CLIMATE CHANGE
ASSESSMENT

Inland Deserts Region Report



Coordinating Agencies:

GOVERNOR'S OFFICE OF PLANNING AND RESEARCH · STATE OF CALIFORNIA

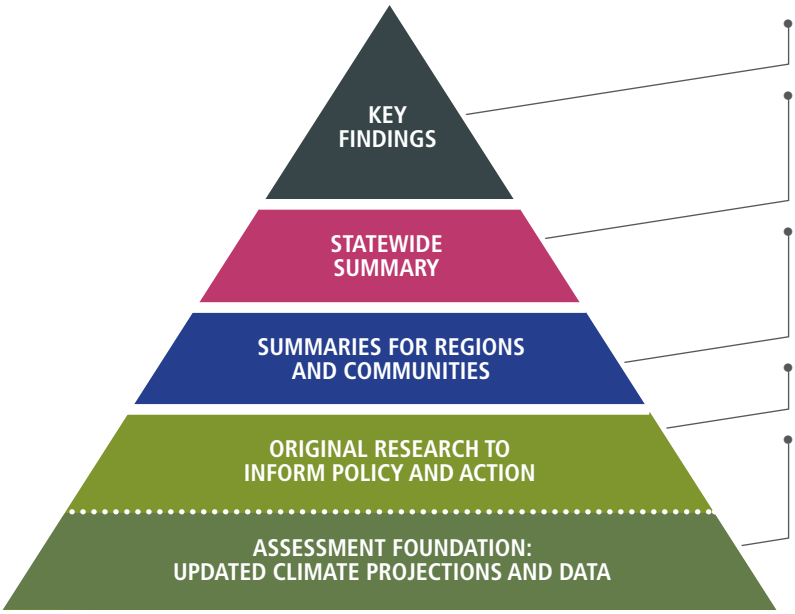
STATE OF CALIFORNIA · ENERGY COMMISSION

CALIFORNIA natural resources AGENCY

Introduction to California's Fourth Climate Change Assessment

California is a global leader in using, investing in, and advancing research to set proactive climate change policy, and its Climate Change Assessments provide the scientific foundation for understanding climate-related vulnerability at the local scale and informing resilience actions. The Climate Change Assessments directly inform State policies, plans, programs, and guidance to promote effective and integrated action to safeguard California from climate change.

California's Fourth Climate Change Assessment (Fourth Assessment) advances actionable science that serves the growing needs of state and local-level decision-makers from a variety of sectors. This cutting-edge research initiative is comprised of a wide-ranging body of technical reports, including rigorous, comprehensive climate change scenarios at a scale suitable for illuminating regional vulnerabilities and localized adaptation strategies in California; datasets and tools that improve integration of observed and projected knowledge about climate change into decision-making; and recommendations and information to directly inform vulnerability assessments and adaptation strategies for California's energy sector, water resources and management, oceans and coasts, forests, wildfires, agriculture, biodiversity and habitat, and public health. In addition, these technical reports have been distilled into summary reports and a brochure, allowing the public and decision-makers to easily access relevant findings from the Fourth Assessment.

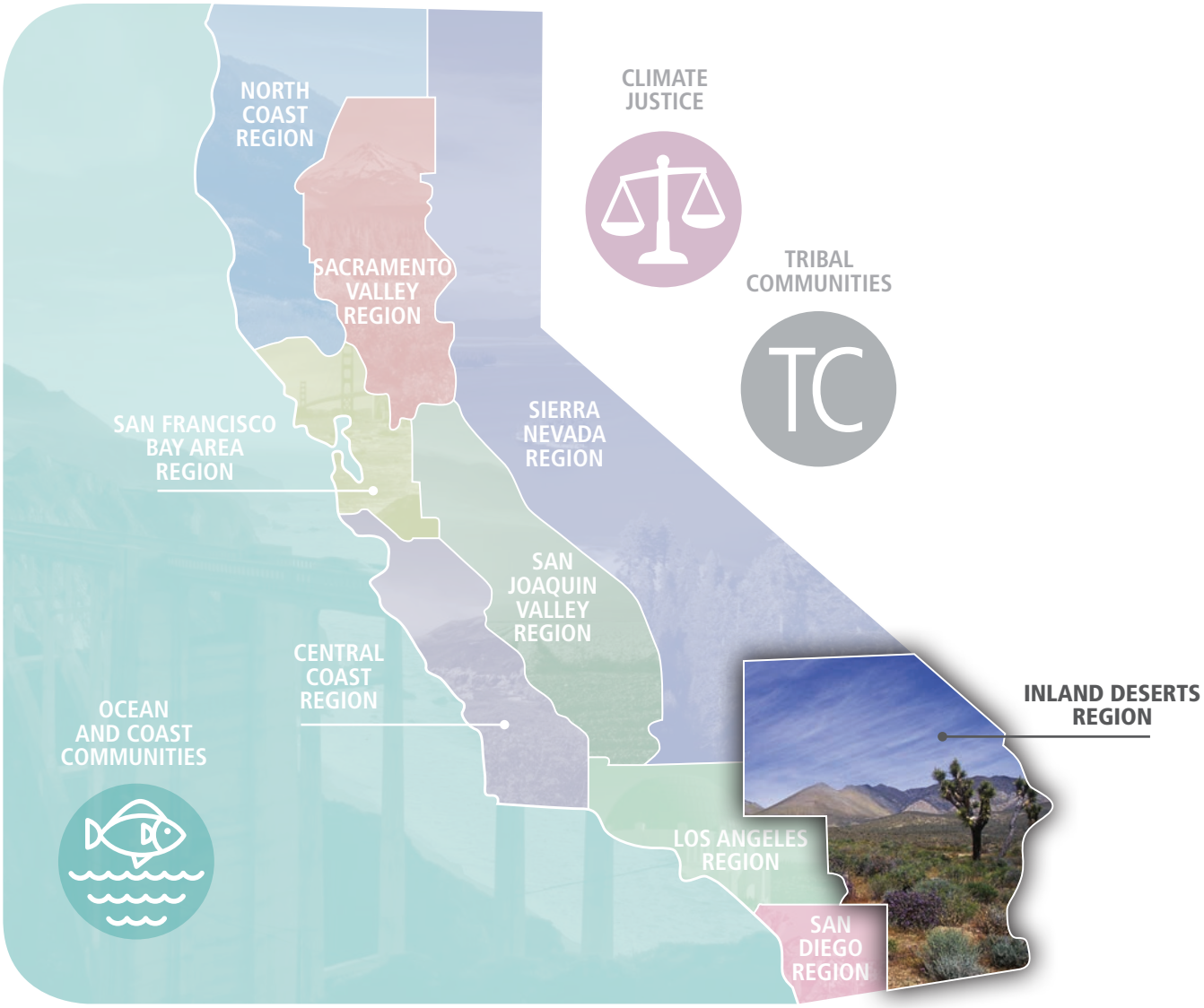


- A concise summary of the Fourth Assessment's most important findings and conclusions.
- An in-depth report on how California's people, built environment, and ecosystems will be impacted by climate change and how we can proactively adapt, based on the Fourth Assessment's findings.
- Reports summarizing Fourth Assessment findings to provide a state of the science for nine regions, the ocean and coast, tribal communities, and climate justice in California.
- Academic research that provides robust and detailed results on resilience and vulnerability to climate change.
- A shared foundation of updated climate change projections, data and ecosystem models developed for use by Assessment authors to permit cross-comparability of results and ensure the findings consider a robust range of future climate conditions. These data are available to the public via Cal-Adapt.org.

All research contributing to the Fourth Assessment was peer-reviewed to ensure scientific rigor as well as, where applicable, appropriate representation of the practitioners and stakeholders to whom each report applies.

For the full suite of Fourth Assessment research products, please visit: www.ClimateAssessment.ca.gov

Inland Deserts Region



The Inland Deserts Region Summary Report is part of a series of 12 assessments to support climate action by providing an overview of climate-related risks and adaptation strategies tailored to specific regions and themes. Produced as part of California's Fourth Climate Change Assessment as part of a pro bono initiative by leading climate experts, these summary reports translate the state of climate science into useful information for decision-makers and practitioners to catalyze action that will benefit regions, the ocean and coast, frontline communities, and tribal and indigenous communities.

The Inland Deserts Region Summary Report presents an overview of climate science, specific strategies to adapt to climate impacts, and key research gaps needed to spur additional progress on safeguarding the Inland Desert Region from climate change.

Inland Deserts Region Authors

COORDINATING LEAD AUTHOR

Francesca M. Hopkins,
UC Riverside

LEAD AUTHORS

Valerie Carranza,
UC Riverside

Hoori Ajami,
UC Riverside

Juliann Emmons Allison,
UC Riverside

Ray G. Anderson,
U.S. Department of Agriculture

Cameron W. Barrows,
UC Riverside

Matthew Barth,
UC Riverside

Darrel R. Jenerette,
UC Riverside

William C. Porter,
UC Riverside

Tom Rolinski,
U.S. Department of Agriculture Forest Service

Kurt Schwabe,
UC Riverside

Cindy Yáñez,
UC Riverside

Nanpeng Yu,
UC Riverside

Citation

Hopkins, Francesca. (University of California, Riverside). 2018. ***Inland Deserts Summary Report***. California's Fourth Climate Change Assessment. Publication number: SUM-CCCA4-2018-008.

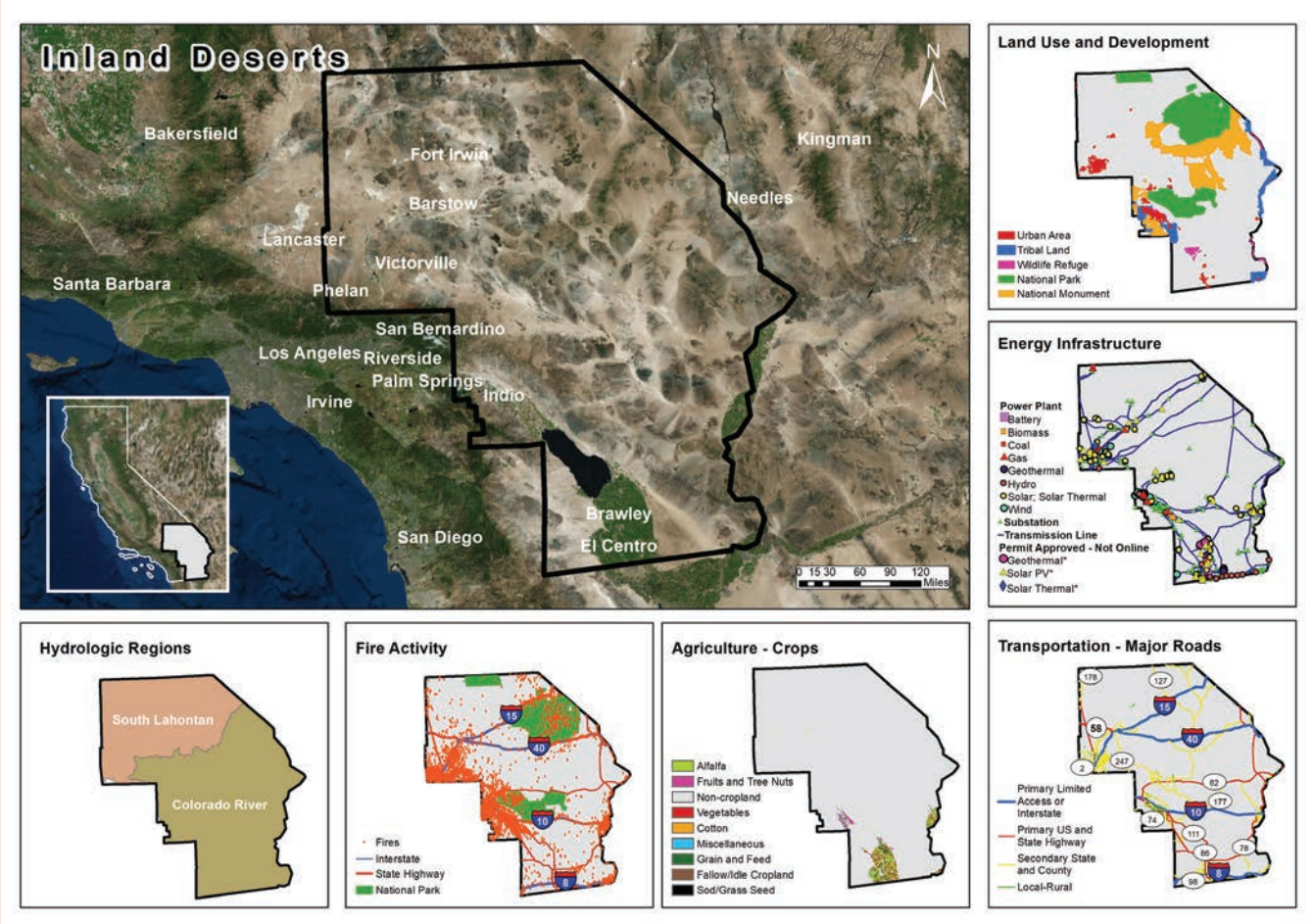
Disclaimer: This report summarizes recent climate research, including work sponsored by the California Natural Resources Agency and California Energy Commission. The information presented here does not necessarily represent the views of the coordinating agencies or the State of California.

Executive Summary

The Inland Deserts region is the hottest and driest region of California, with a desert climate that varies primarily due to elevation. The region's climate is becoming more extreme, with daily average high temperatures projected to increase by up to 8-14°F by the end of century. Rainfall rates are currently low (approximately 5 inches per year) and highly variable from year to year. This variability is projected to increase over the coming decades, with extreme drought and extreme wet events both becoming more common. In turn, increasing frequencies of these extreme events will increase the risk of flash flooding and wildfire, given the close relationship between precipitation variability and growth of invasive grasses that serve as the major fuel for wildfire in the region.

Physically, the region encompasses the Mojave and Sonoran deserts in the southeast corner of the state (Figure 1A). The domain includes all of Imperial County and the desert portions of Riverside and San Bernardino Counties. The region has about 1 million inhabitants, with 85% of those residing in urbanized areas including the Victor Valley in San Bernardino County (Victorville, Apple Valley, Hesperia), the Coachella Valley in Riverside County (Indio, Palm Springs, Palm Desert), and the El Centro Metropolitan Area in Imperial County (El Centro, Brawley, Calexico) [American Communities Survey estimated 2017 population]. In addition, the tribal lands of 12 different groups are contained in the region (Figure 1B). Future development will likely take place within and amongst these urbanized areas.

FIGURE 1



Satellite composite image of the Inland Deserts (A). Subplots B-G show geography and infrastructure in the region, including Land Use (B), Energy (C), Transportation (D), Agriculture (E), Fire Activity (F), and Watersheds (G).

Despite its sparse population, the region is important for protected lands, tourism, and agriculture. The region has the largest acreage of federally protected lands in the state (US BLM NLCS National Monuments and Conservation Areas)—7,448 square miles of National Parks and Monuments, including ecologically unique and sensitive ecosystems in Joshua Tree National Park and the Mojave Trails National Monument. It contains important wildlife refuges, including the Salton Sea. Biodiversity hotspots are found at high elevation, in oases, and sand dunes that provide a climatic refuge against extreme heat and aridity that characterizes sandy lowland areas (bajadas). These hotspots are threatened by climate change as well as other land-use pressures, and identifying and protecting appropriate climate refugia is likely to be the best strategy for conservation.

Tourism in the region derives from proximity to these protected lands and is a direct result of the region's climate. The Coachella Valley is a major tourist destination that developed in the 1950s as a warm-weather winter retreat for residents of cold, snowy climates. Tourism is the number one contributor to the Coachella Valley's economy. The close relationship between tourism and climate may make the region's economy uniquely vulnerable to the effects of climate change.

Crops cover 4% of land area in the region, primarily in the Imperial Valley (Figure 1E). While crop coverage may seem low in the region as a whole, it belies the importance of agriculture to the fully agrarian Imperial Valley, the Palo Verde Valley along the Colorado River, and the southeastern portion of the Coachella Valley adjacent to the Salton Sea. Agriculture is the primary economic driver of the Imperial and Palo Verde Valleys, and is second only to tourism in the Coachella Valley. Because its warm climate enables winter harvests, the Imperial Valley is a major source of winter fruits and vegetables for the U.S. and abroad. Other important crops include forage and fodder such as alfalfa and hay. Already at the high temperature limit for agriculture globally, climate change will bring additional heat stress to field crops, livestock, and the health of farm workers. Agriculture in the valleys is nearly completely irrigation dependent, and demand will likely increase with rising evapotranspiration rates under a warmer climate. Currently, the Imperial Valley has the highest per capita water consumption in the state due to its water-intensive agriculture, relatively low population, and senior water rights to the Colorado River. Potential climate-driven reductions to Colorado River flow and competing water needs in other regions pose another threat to agriculture.

Like much of California, many of the effects of climate change will be mediated through climate-driven stress to water supply and quality. Land use patterns in the region are highly dependent on water availability, and competing needs for water amongst urban development, agriculture, and natural ecosystems. High variability amongst climate model predictions of future rainfall rates make projections of future water availability highly uncertain; however, climate warming will dry soils and increase the risk of severe drought.

Much of the region is challenged by high poverty and unemployment rates and low educational attainment levels, making the residents more vulnerable to the effects of climate change. Imperial County has a poverty rate of 23%, making it the 5th highest poverty county in the state (CA Budget Project/US Census). Riverside and San Bernardino Counties also have poverty rates above the state average (15.6 and 17.6% respectively, vs. 14.7% statewide). The extreme heat projected for the region is likely to threaten this vulnerable population directly through heat-related illness, and indirectly through strain on infrastructure and via changing levels of air pollution and disease. Increasing climate extremes—extreme high temperatures, likelihood of flash flooding, and wildfire risk—will stress transportation and energy infrastructure currently in place, and will increase energy demand for cooling. Population

growth and urbanization in the region, expected to be higher here than for the state as a whole, is likely to exacerbate strains on infrastructure, land use, and water supply, and may increase wildland-urban interface areas that could potentially lead to more wildfire activity without careful planning that takes these issues into account.

In addition to climate-sensitive tourism and agriculture, other industries important to the region are based on the relatively inexpensive land costs compared to nearby coastal areas. These include real estate development and construction, renewable energy development, logistics and warehousing, and correctional facilities. Climate change mitigation policies implemented over the past decade have had a net positive economic impact on the region, mainly through construction of new renewable energy sources (Jones et al., 2017). These new renewable energy sources are a key part of attaining statewide greenhouse gas reduction goals while providing future energy supply. While beneficial for the economy and for greenhouse gas mitigation, development of renewable energy poses a threat to sensitive ecosystems that are contracting in size due to higher temperatures and more severe drought, and to competing land uses, including agriculture and recreation.

A major geographic feature of the region is the Salton Sea, the state's largest lake, which is maintained by inflows from agricultural runoff. Future environmental quality of the region is highly dependent on the fate of the Salton Sea, which is currently threatened by diminishing levels of inflows from agricultural runoff. As the Sea shrinks, the increasingly exposed playa (dry lakebed) is likely to become a major source of dust, polluting the air of the region and potentially of areas beyond. The region already suffers from high rates of childhood asthma and cardiovascular disease thought to be linked to dust emissions from the Sea (Imperial County Public Health, 2016), making increased playa dust emissions of particular concern in terms of human health and environmental justice. Climate change will exacerbate water supply and quality issues that hamper efforts to restore the Sea, and will place additional stress on environmental quality, habitat, and public health challenges related to the shrinking Sea.

A general summary of climate risks facing the California's Inland Deserts region include:

- Extremely high maximum temperatures are expected to occur in the Inland Deserts.
- The fate of the Salton Sea is a critical determinant of future environmental quality.
- Renewable energy development will have big impacts on the economy and infrastructure.
- Continuing current land use/development patterns (i.e., housing development in the region to compensate for lack of development on the coast) will require increased energy for cooling to compensate for a rise in extremely high temperatures.
- Higher temperatures will exacerbate water stress in an already very water-limited region.
- Changing water availability is a key determinant of the future for ecological and agricultural systems.
- Population in the Inland Deserts is highly vulnerable to the effects of climate change.
- Tourism is a major economic driver that is likely to be threatened by a changing climate.

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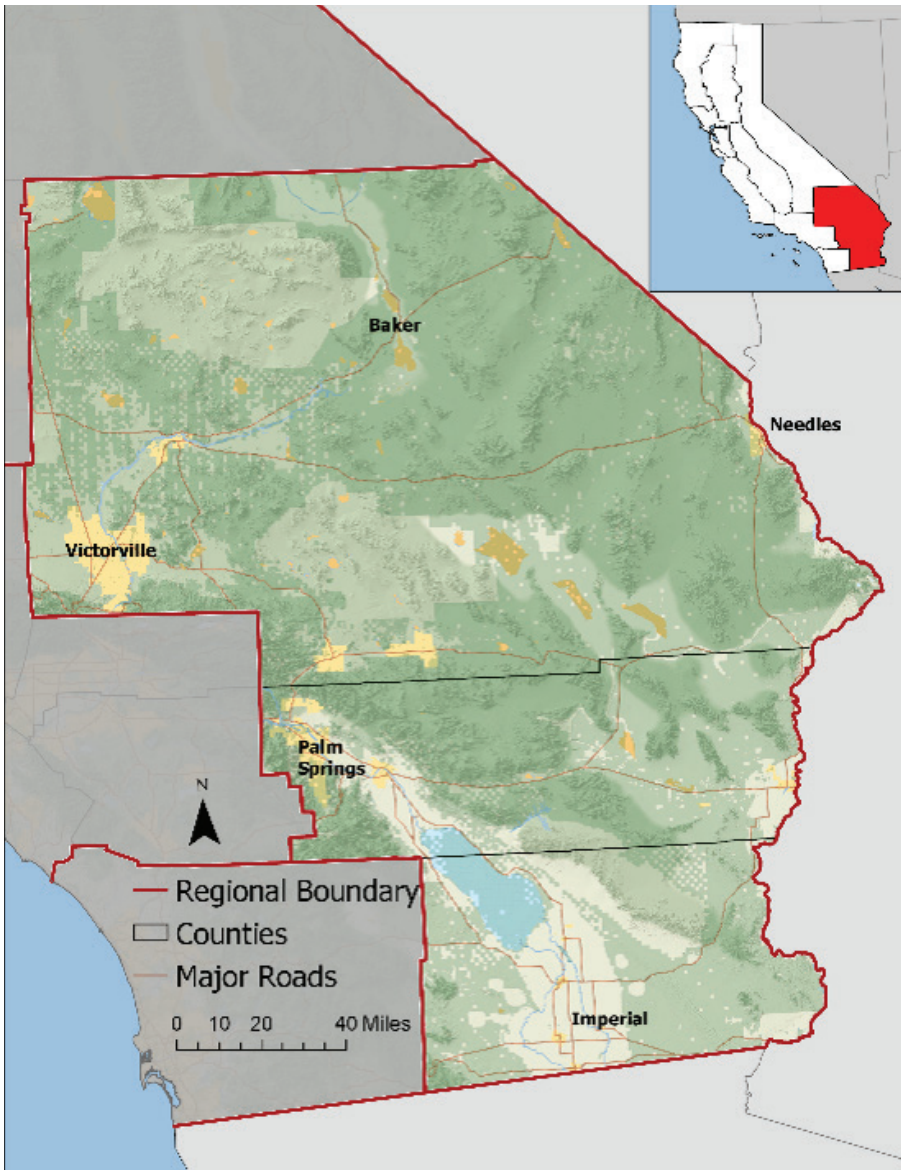
Introduction

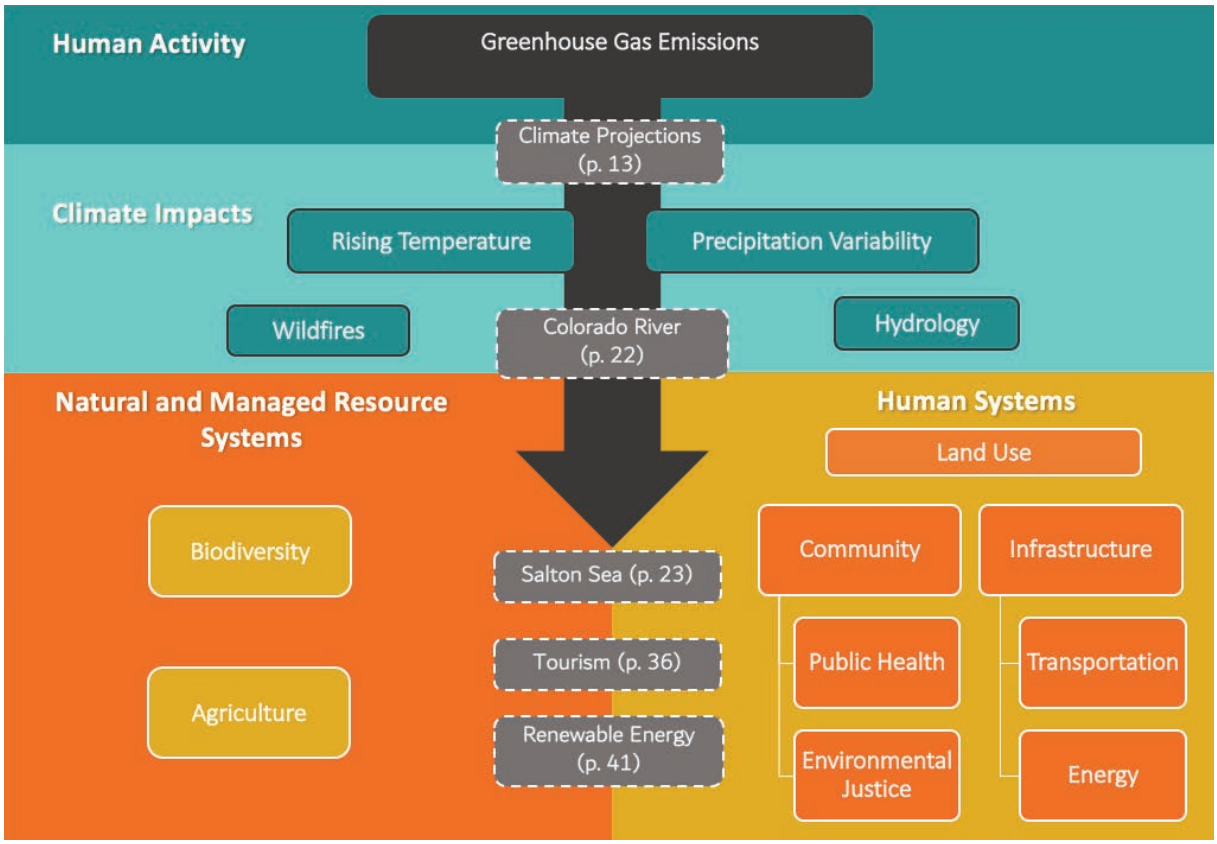
The Inland Deserts of California are comprised of the Mojave and Sonoran deserts in the southeast corner of California (Figure 2). The region includes all of Imperial County and the desert portions of Riverside and San Bernardino Counties. In this report, we summarize the major climate change risks for natural, managed, and human systems in the region, drawing on peer-reviewed literature, government reports, and other reports that contribute to California's Fourth Climate Change Assessment. In addition to synthesizing the state of knowledge, we identify adaptation options that can help lessen the impact of climate change in the region. The report is organized into 3 sections (Figure 3). Section 1 (Inland Deserts Physical Climate) describes the projected climate of the region to the end of the 21st century, along with direct impacts of climate on wildfires and hydrology of the Inland Deserts. Section 2 (Natural and Managed Resource Systems) addresses climate change effects on natural and managed resource systems, including biodiversity and agriculture. Section 3 (Human Systems) explores climate change effects on human systems, including land use decisions, risks to infrastructure, and the vulnerability of Inland Desert communities. Finally, section 4 (Research Needs) identifies knowledge gaps where future research can contribute an improved understanding of climate change impacts and adaptation strategies for Inland Deserts.

FIGURE 2



Inland Deserts. Source: Jim Thorne.

FIGURE 3

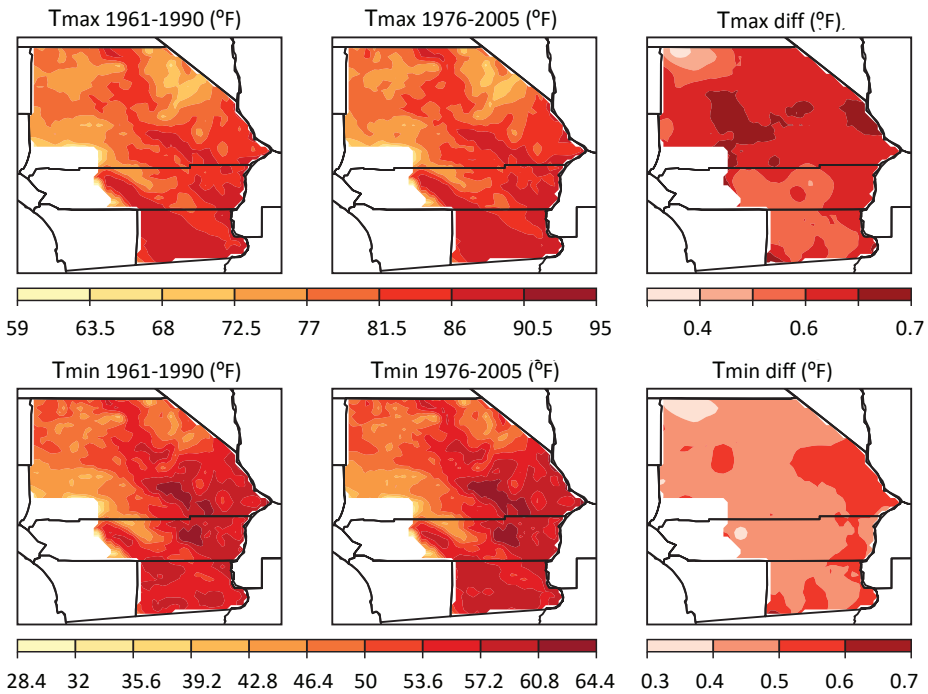


Greenhouse gases emitted by human activities have a direct effect on climate, including temperature and precipitation amounts and seasonality. In turn, these climatic drivers affect wildfires and hydrology, and indirectly impact natural and managed resource systems, and human systems including land use, community, and infrastructure.

Inland Deserts Physical Climate

In this section, we describe the direct impacts of climate change on temperature and precipitation projections in the Inland Deserts over the 21st century. These climate changes have important consequences for wildfire by changing the type, amount, and connectivity of vegetation that fuel fire intensity and spread. Climate change will also affect hydrology and water supplies in the region, which strongly depend on future precipitation amounts and variability. Of particular importance is how climate change will affect the flow of the Colorado River, which is the major water supply for most of the region.

FIGURE 4



Distribution and changes to daily temperature extremes in the Inland Deserts in the second half of the 20th century. Top panels: Average daily maximum temperature (°F), and bottom panels: average daily minimum temperature for 1961-1990 (left), 1976-2005 (middle) and difference between these periods (right). Source: Neil Berg, UCLA.

The Inland Deserts of California have an extremely warm and dry climate that is becoming even more extreme with climate change. Average high temperatures average 81°F across the region, with very hot, dry summers (average July highs 99°F-109°F) and warm, dry winters (average December lows 30-44°F). Rainfall averages just 5 inches per year, but annual totals are highly variable. Spatially, the climate varies primarily with elevation (Figure 4). The Mojave Desert is the relatively cooler high desert (Köppen Climate Class BWk: cold desert), while the Sonoran is the hotter low desert (Köppen Climate Class BWh: hot desert). Climate change has already increased temperatures in the region. Over the second half of the 20th century, daily maximum temperatures warmed by 0.4-0.7 °F, comparing 1976-2005 with 1961-1990 (Figure 4). It is extremely likely that increased levels of greenhouse gases in atmosphere due to human activities are responsible for warming over this period (IPCC, 2014).

Scientific Basis for Climate Change Projections

Greenhouse gases, such as carbon dioxide and methane, trap heat in Earth's atmosphere. Levels of these greenhouse gases have increased since the Industrial Revolution, and in particular since the 1950s, due to human activities such as fossil fuel burning. 21st century climate will depend on future emissions of greenhouse gases, which in turn depends on human decisions over the next several decades (IPCC, 2014).

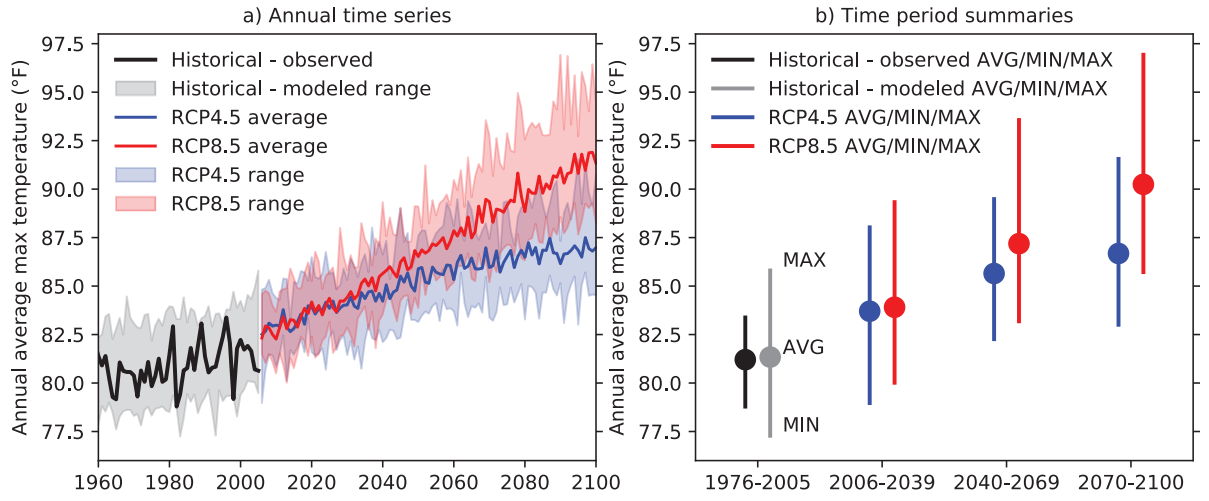
Predictions of future climate requires that future levels of greenhouse gases are estimated in a systematic way. Projections of future greenhouse gas emissions are called Representative Concentration Pathways (RCPs), and are based on future scenarios of global population, economics, energy and land use, technology, and policy (van Vuuren et al., 2011).

Climate projections given in this report are based on two RCPs: RCP 4.5, a moderate emissions pathway requiring greenhouse gas mitigation, and RCP 8.5, a "business-as-usual" scenario that extends current emission trends forward in time. These RCP emissions were used in 10 global climate models that best simulate aspects of California's climate to project climate conditions out to 2100 (Pierce et al., 2018). Projections of temperature and precipitation were downscaled to ~6 km (Pierce et al., 2014), and are presented here for the Inland Deserts. These data and accompanying visualizations are freely available at www.cal-adapt.org.

21st Century Climate Projections

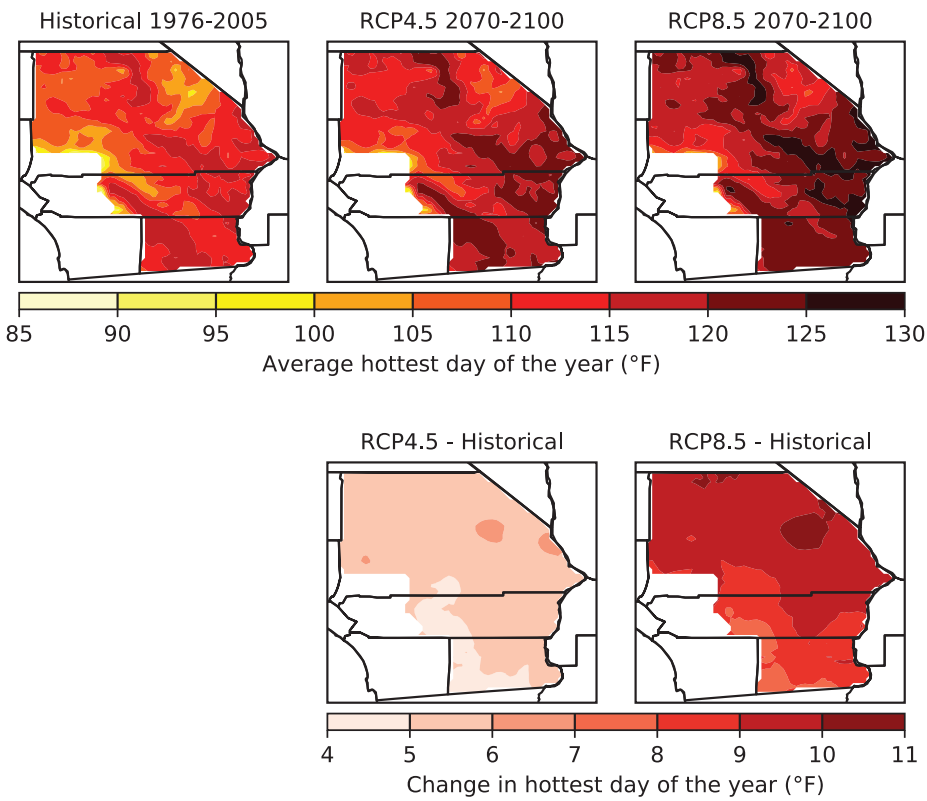
California's Inland Deserts are known for extreme heat, which will only become more extreme in the future. Daily maximum temperatures are projected to increase by +5-6°F for 2006-2039, by +6-10°F for 2040-2069, and +8-14°F for 2070-2100 on average for the region, with ranges depending on future greenhouse gas emissions (Figure 5). Historically, the hottest day of the year ranges from the high 90s (°F) at upper elevations to >115°F in eastern low desert regions. By the end of the 21st century, these hot extremes are projected to rise by at least +6°F, and up to +9°F on average, depending on future greenhouse gas emissions (RCP 4.5 and RCP 8.5, respectively; Figure 6). The region also has a high frequency of extremely hot days, defined as temperatures >95°F, averaging 90 per year in the Mojave, and 135 per year in Palm Springs during the 1981-2000 period (Sun et al., 2015). Climate change is expected to increase the frequency of >95°F days, with projection of up to 141 days in the Mojave, and 179 days—half the year—in Palm Springs by the end of the 21st Century under RCP 8.5 (Sun et al., 2015).

FIGURE 5



Historical (black) and projected annual average maximum temperature in the Inland Deserts for two emission scenarios (RCP 4.5: blue, RCP 8.5: red). Panel a: Annual Time Series: Solid lines show model averages, and shaded areas show modeled ranges. Panel b: Three decade summaries: Circle markers show model averages, and error bars show modeled ranges. Source: Neil Berg, UCLA.

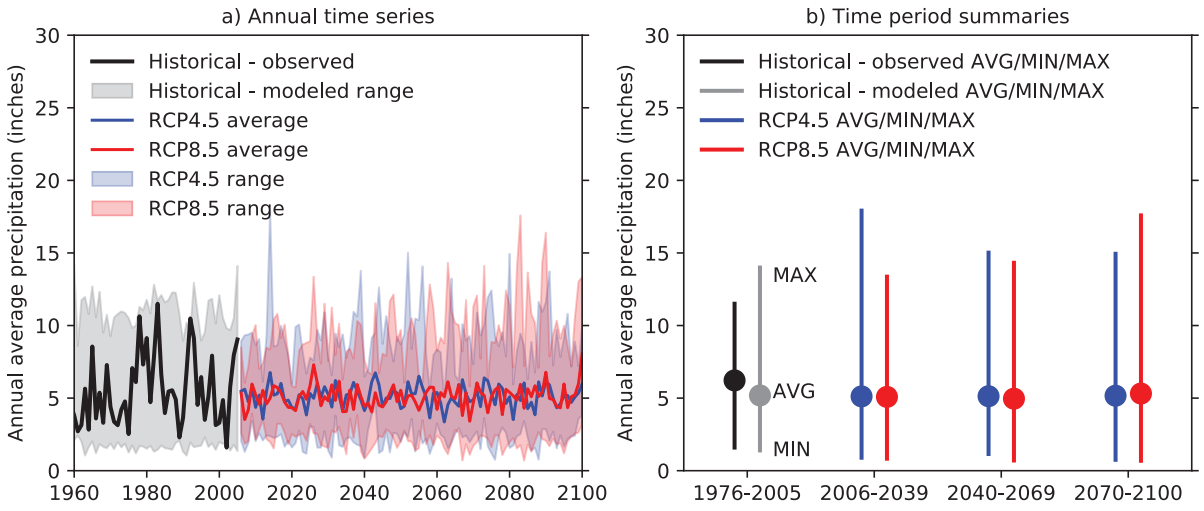
FIGURE 6



Average hottest day of the year (°F) across the Inland Deserts for historical observations (1976-2005) and modeled end of century (2070-2100) for RCP 4.5 and RCP 8.5 scenarios (top panels), and change in the temperature of the hottest day of the year at the end of century for RCP 4.5 and RCP 8.5 (bottom panels). Source: Neil Berg, UCLA

In addition to these hot extremes, low temperature extremes warmed over the 20th century by 0.3-0.6°F (1976-2005 period compared to 1961-1990; Figure 4). 21st century projections also show warming of daily minimum temperatures, albeit less than for daily high temperatures, ranging from +0-1°F for 2006-2039, +3-4°F for 2040-2069, and +4-7°F for 2070-2100 (Figure 5). This change is particularly relevant for high elevation areas that currently experience minimum temperatures below freezing (≤32°F). During 1981-2000, NOAA records indicate that Victorville (2,726' elevation) experienced 44 days a year of freezing temperature, but this number is projected to decline to 9 days per year midcentury, and to 2 days by the end of century (Sun et al., 2015).

FIGURE 7

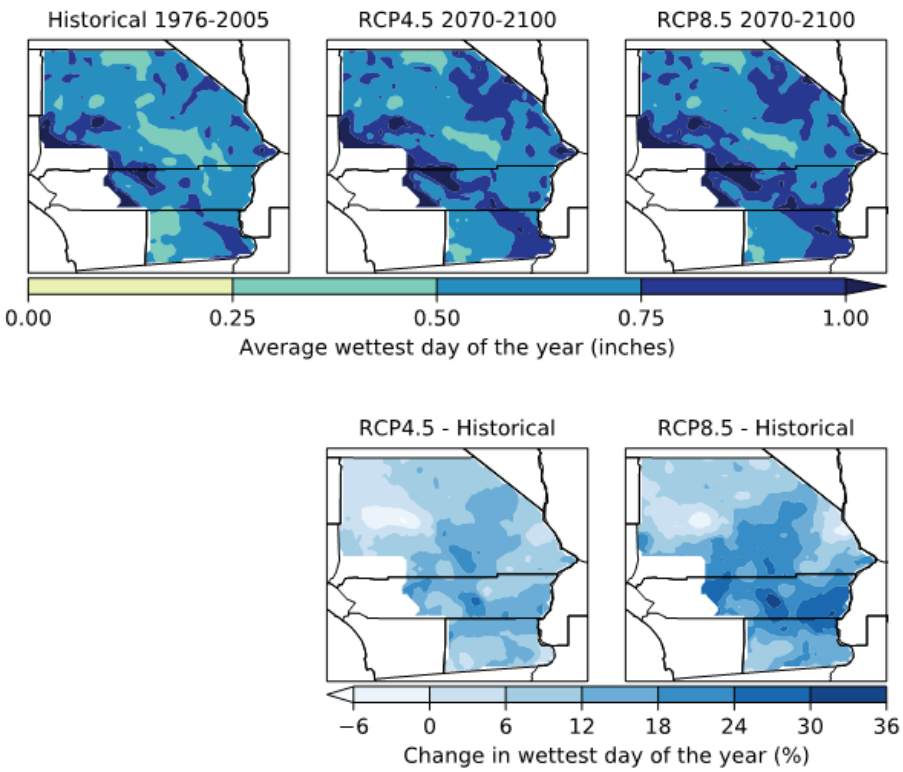


Historical (black) and projected annual average precipitation in the Inland Deserts for two different emission scenarios (RCP 4.5: blue, RCP 8.5: red). Panel a: Annual Time Series: Solid lines show model averages, and shaded areas show modeled ranges. Panel b: 3 decade summaries: Circle markers show model averages, and error bars show modeled ranges. Source: Neil Berg, UCLA.

Historically, precipitation in the region is highly variable, averaging around 5 inches per year, with rainfall some years as low as 1½ inches and as high as 10¾ inches over the 1950-2005 period (Figure 7). There is also large spatial variation in precipitation rates across the region driven by elevation and location, with averages ranging from 3 inches per year to roughly 8 inches per year (Figure 8). Projecting climate impacts on precipitation is highly uncertain in California, in particular for annual rainfall totals in the Inland Deserts (Allen and Luptowitz, 2017). For the suite of downscaled climate models used in this assessment, there is little projected change in average rainfall each year to the end of the 21st century (<10%), even under different emission scenarios (Figure 7). However, projections reveal an increase in inter-annual precipitation variability, with reductions in minimum annual precipitation of up to 50% and increases in maximum annual precipitation of 40-65% by the end of the 21st century (Figure 7).

Precipitation in the Inland Deserts occurs during two seasons. In the winter, large scale global circulations occasionally bring extratropical cyclones from the northern and eastern Pacific region. These storms are responsible for most of the annual rainfall across the desert region, with February typically being the wettest month. Winter precipitation increases with elevation and decreases going from north to south, and west to east. In the summer, global circulations reverse, allowing the North American Monsoon to periodically drift westward into this portion of the state (Hereford et al., 2006). Historically, summer monsoon precipitation falls primarily in July, August, and September (Tubbs, 1972). The monsoonal rains account for about 30% of precipitation over the eastern deserts, decreasing to around 15% in the western Mojave.

FIGURE 8



Average wettest day of the year (inches) across the Inland Deserts for historical observations (1976-2005) and modeled end of century (2070-2100) for RCP 4.5 and RCP 8.5 scenarios (top panels), and percent change in wettest day of the year at the end of century for RCP 4.5 and RCP 8.5 (bottom panels). Source: Neil Berg, UCLA.

These seasonal patterns of precipitation may also change with the climate. As winter and summer precipitation have different climatic drivers, current research suggests these phenomena will be affected differently by climate change. Winter precipitation (falling mainly in December, January, and February) is projected to increase over the region due to warming of the tropical Pacific according to roughly half of the current generation of climate models (Allen and Luptowitz, 2017). In contrast, summer monsoonal precipitation is thought to decrease by up to 40% (Pascale et al., 2017). While it is difficult to predict precipitation changes in the region, higher temperatures mean the atmosphere will be capable of carrying more water vapor, thus increasing evaporative demand on already scarce water supplies and decreasing soil moisture. High interannual and interdecadal variability along with the difficulty of simulating future sea surface temperatures pose challenges to precipitation simulations in current climate models (Pascale et al., 2017). Better prediction of precipitation trends and seasonality is an important area where future research is needed.

Over most of the region, the wettest day of the year is projected to increase by as much as 30% in some areas by 2100 (Figure 8). The combination of more intense rainfall events and drier soils in an already very dry region will increase the probability of flash floods. Dry soils are poor absorbers of rainfall, causing high runoff rates. Moreover, infrequent rainfall increases the possibility of debris flow of accumulated material such as dead vegetation and rocks during flash flood events (Reid et al., 1994). Because of the dry climate, infrastructure is generally not designed to handle large flows of water that may be generated in a flash flood event—for example, many roads cross dry creek beds without bridges—making intense rainfall events a large risk here than in wetter areas.

Projected Fire Activity through 2100

The combination of low annual precipitation amounts and high precipitation variability from year to year often results in discontinuous fuel beds (i.e. the horizontal and vertical spacing of fuels over a given area) across this portion of California. The Mojave Desert flora within these fuel beds is mainly comprised of annual grasses and shrubs such as manzanita, California buckwheat, and desert holly, while higher elevations are favorable habitats for juniper pine, sagebrush and some white fir. The Joshua tree is iconic and is a common flora across much of the Mojave, particularly over the southern Mojave (Figure 9). Various species of cacti are home to this portion of California but are more prevalent over the southeast portions of the Inland Deserts. Within the desert ecosystem, fuels have the most significant contribution to the overall fire regime (Brooks at el., 2004).

FIGURE 9

Joshua tree against a smoke plume from the 2015 Lake fire burning near Yucca Valley. The same region burned in 2006 during the Sawtooth Complex Fire. Source: Kurt Miller, Riverside Press-Enterprise/SCNG, https://www.pe.com/2015/06/25/pioneertown-desert-community-still-shaken-by-sawtooth-blaze-now-frets-over-lake-fire/

Consequently, fire activity is highly variable from year to year depending on the amount of loading, continuity, and vertical arrangement of the fuels that are present. A brief analysis was performed on historical fire data across the region that consisted of 9,784 records which spanned the years 1992 to 2015 (Short, 2017). Displaying the dataset graphically reveals that most of the fire activity is clustered around the national forests, in and near the more populated areas, and along major transportation corridors such as interstates and railroads (Figure 1F), illustrating that most of the fire activity in the region is human related. Specifically, 22% of the fires were caused by equipment use, 30% were attributed to miscellaneous causes, and 37% were related to various other causes, with only 10% started by lightning (Table 1). However, lightning played a disproportionately large role in the ignition of extremely large fires; it was cited as the cause for 40% of the fires that were 500 acres or more. While many incidents are covered at the initial attack stage, these larger fires require additional resources from outside the area, thus making them more costly to suppress.

TABLE 1. CAUSES OF FIRE IGNITIONS FOR 1992-2015.

Data from Short, 2017.

CAUSE	NUMBER	%
Miscellaneous	2,998	31%
Equipment Use	2,109	22%
Lightning	978	10%
Missing/Undefined	806	8%
Arson	743	8%
Children	562	6%
Smoking	516	5%
Debris Burning	477	5%
Campfire	419	4%
Railroad	64	1%
Fireworks	52	1%
Powerline	48	0%
Structure	12	0%

Perhaps the most significant meteorological effect of climate change would be the potential for a weaker North American Monsoon signal over the Desert Southwest (Pascale et al., 2017). Some climate models project lower precipitation amounts during the summer months in the coming decades. Since lightning is responsible for igniting nearly half the large fires that are listed in our database, a diminished monsoon influence would suggest potentially fewer starts due to lightning.

Projected warmer and periodically drier conditions during the next 80 years may increase the risk for more severe drought (Pierce et al., 2015). Although an increase in average temperatures will probably have little impact on fire activity, changes to the frequency, amount, and spatial distribution of annual precipitation could have dramatic effects on future amounts and types of desert vegetation. It has been suggested that the changing climate has fostered the advancing invasion of non-native grasses which has led to increased fire activity in recent years (Brooks and Matchett, 2006, Figure 10). However, the 1992-2015 record of fires in the region shows no distinct trend in large fires (>500 acres), which could imply that non-native grasses have limited influence on fire activity in this region. Despite a drier climate outlook for the remainder of this century, variability of precipitation from year to year will govern the length and severity of fire season through fuel loads.

FIGURE 10

The 2006 Sawtooth Fire as it moves through the desert landscape. Source: photo taken near Mocking Bird Ln, Morongo Valley by Taya Lynn Gray of the Desert Sun newspaper.

One major factor to consider when addressing the propagation of wildfire is wind. The Inland Deserts have a number of well-known high wind prone areas such as the San Gorgonio (Banning) Pass, which serves as the gateway to the Coachella Valley, and the Cajon Pass leading to the Victor Valley. Prevailing wind directions over these areas are generally from the west, except in the Colorado River Valley where the majority of wind comes from the south. Winds across these areas are strongest during the evening and overnight hours mainly from April through September (Fisk, 2008). The stronger winds that frequently occur in these areas play a vital role in the spread of wildfires, particularly in areas where vegetation is sparse. It is important to note in our discussion of wind that we are not referencing "Santa Ana Winds", which mainly affect the coastal and mountain areas of Southern California to the west of this region (Rolinski et al., 2016).

Speculation on how wind speed may be influenced by climate change is difficult to ascertain. Since the majority of these desert winds, particularly during the summer, are thermally driven, it is plausible that there would be an upward trend in velocity. The projection of higher temperatures would imply a stronger temperature gradient between the coast and the interior of California, which would subsequently enhance onshore flow during the afternoon and evening hours, especially over the western sections of the Inland Deserts. However, the current generation of climate models only projects subtle (5-10%) changes in wind speeds (Kulkarni & Huang, 2014). Future research is required to ascertain the effect of climate change on winds in the region.

As 60% of the cause of large fires are related to human activity, climate-driven changes in human population of the region, human behavior, and transportation infrastructure and activity are likely to have a large effect on future fire activity. How these various factors evolve in the coming years will dictate the kind of fire activity that occurs across this portion of the state. As an adaptation strategy, residents and visitors to the region need to be informed of the risk of human ignitions of wildfires despite the perception that deserts are not susceptible to fires. Further research that better elucidates the relationship between climate change and risk of ignition from human activity is needed.

The Colorado River: Key Water Resource for Development of Inland Deserts

The Colorado River is the lifeblood of agriculture and urban development in the Inland Deserts, supplying the vast majority of water resources to the Imperial, Coachella, and Palo Verde Valleys. Colorado River flows supply around 3.5 million acre-feet of water to the region, with drainage and runoff waters from agriculture feeding into and maintaining the Salton Sea. The Colorado River is also an important water resource for approximately 40 million people in six U.S. states in addition to California, and in Mexico. In most years, the entire flow of the river is consumed for human uses. Allocations of river water are governed by seniority of water rights, with California as a senior rights holder, and major agreements, including the 1922 Colorado River compact, the 1944 US-Mexico treaty, and amendments to both. However, these allocations were made based on high streamflow volumes during a historically wet period in the early 20th century, so river water has been over-allocated much of the time since. This shortfall has worsened with reduced streamflow during the 2000-2012 drought, the driest period in recorded history (U.S. Bureau of Reclamation, 2012), and will likely worsen with further 21st century climate change (Vano et al., 2012). Increasing evapotranspiration is projected to reduce Colorado River flows by 20-30% at mid-century, and 35-55% at end-century (Udall and Overpeck, 2017). As a result, less water will be available for human use across the entire Colorado River Basin. Furthermore, the amount of precipitation falling as snow in the region is projected to decline substantially, which impacts timing of streamflow, with implications for downstream users (Wi et al., 2012).

In addition to climate change pressures, increasing municipal use demands have already put additional pressure on irrigation districts to reduce agricultural water use. The 2003 Quantification Settlement Agreement identified a pathway for California to reduce its reliance on Colorado River water to its legal allocation, 4.4 million acre-feet, via water conservation and land fallowing schemes. These schemes transfer water from agricultural uses in the Inland Deserts to growing municipal populations in coastal Southern California served by the Metropolitan Water District and the San Diego County Water Authority. However, this "conserved" agricultural water reduces drainage inflows to the Salton Sea and, consequently, will cause significant ecosystem damages and health impacts to local communities due to a shrinking, increasingly saline Salton Sea. The potential political pressure for additional water use reduction in the Inland Deserts will likely depend on the magnitude of increased future demands elsewhere in the Colorado River basin and in coastal Southern California as well as the magnitude of future reductions in Colorado River flow.

The Salton Sea

The Salton Sea, located below sea level in Riverside and Imperial counties, is California's largest lake by surface area (> 340 square miles). It is ecologically important as a rest stop for millions of migratory birds along the Pacific Flyway, and a year-round habitat for several endangered and sensitive species, including the desert pupfish, Yuma clapper rail, and burrowing owl (Audubon California, 2016; U.S. Fish and Wildlife Services, 2011). Formed in its most recent state in the early 1900s due to a dam break along the Colorado River, this terminal lake was maintained by inflows consisting mostly of runoff emanating from irrigated farmland around the Sea. Since its formation, the Sea's water quality has been in a slow decline due to the accumulation of salts and pollutants. This decline accelerated in 2018 with cessation of water transfers to the Sea resulting from competing demands on water from the Colorado River. Agricultural runoff is also declining due to large transfers of Colorado River water from the Imperial Valley to urban users in coastal Southern California under the 2003 Quantification Settlement Agreement.

Reductions in agricultural runoff to the Salton Sea pose a hazard for public health and the region's economy, in addition to destroying the Sea's ecological benefits. As inflows are reduced, the shrinking Sea leaves exposed lakebed (playa) that is a source of airborne dust causing severe air quality impacts on the region (Frie et al., 2017). Increasing dust and potential toxic airborne emissions may lead to major environmental justice issues for the vulnerable population living nearby through increased asthma and respiratory illness. High levels of dust also threaten the region's economic drivers, tourism and development.

Over the next dozen years, inflow volumes will decrease by 40%, leaving 100 square miles of exposed playa, and increasing salinity by threefold (Cohen, 2014). Higher salinity levels threaten fish and birds that currently depend on the Salton Sea habitat. The estimated public damages of a continual decline of the Sea have been estimated at between $11 and $70 billion over the next 30 years (Cohen, 2014). These estimates cover impacts including increased respiratory illness associated with higher airborne particulates levels emitted from exposed playa, decreased property values, decreased recreation, and the loss of wildlife habitat. Climate change poses an additional threat not included in these assessments, including increasing evapotranspiration rates, and possible changes in agricultural water management inputs and Colorado River allocations to the region. Climate change will exacerbate stresses to the limited water supply feeding the Sea and may accelerate the pace of decline. Currently, there are no comprehensive restoration projects in place (Salton Sea Restoration Renewable Energy Initiative, 2015).

Hydrologic Assessment: Current Status and Future Challenges for Adaptation to Climate Change

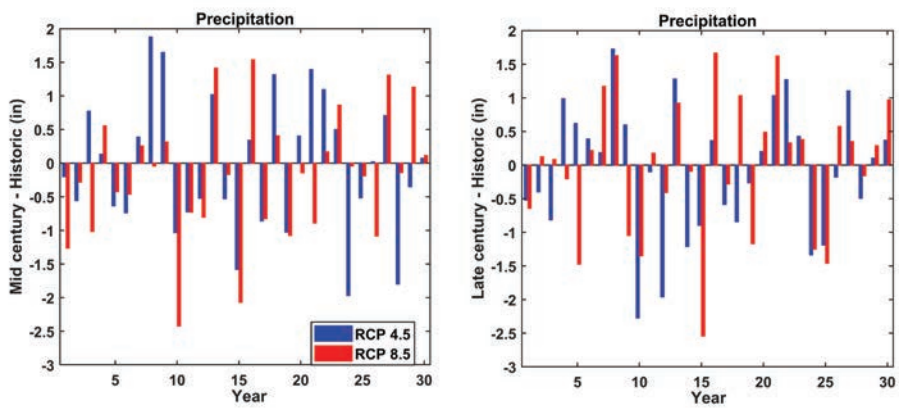
The Inland Deserts encompasses two main hydrologic regions of the state. These include the Colorado River hydrologic region and the southern portion of south Lahontan hydrologic region, with 92% and 39% of their areas located in this region respectively (Figure 1G). The Colorado River hydrologic region is the largest water user in California based on 1996-2005 data, at a rate of 379 gallons per capita per day. Surface water provides 91% of its water supply. Groundwater is the primary water supply in the south Lahontan hydrologic region, providing 66% of the region's water supply (California Department of Water Resources, 2013a).

The Colorado River Region has a subtropical desert climate. The northern part of this region includes Mojave Desert and San Bernardino and San Jacinto mountains with peaks higher than 10,000 ft above the sea level, as well as the Sonoran Desert. The Sonoran Desert is comprised of the Salton Sea, California's largest lake as measured in surface area, and significant irrigated land within the Imperial, Palo Verde, and Coachella Valleys (California Department of Water Resources, 2013b). Agriculture is the main land use in the Imperial Valley, and Colorado River water delivered through the All-American Canal is the main water source for this region. The Coachella Valley contains most of the urban areas within this region, and its main water source is Colorado River water transported by Coachella canals as well as groundwater. There are 64 groundwater basins in this region. According to the California State Groundwater Elevation Monitoring Program (CASGEM) basin prioritization, only the Indio and San Gorgonio Pass sub-basins of Coachella Groundwater Basin are classified as high priority basins, meaning that government and water agencies should reduce groundwater depletion in these sub-basins and determine sustainable pumping rates. Land subsidence has occurred in some areas as a result of high intensity pumping. Currently, water levels in the Salton Sea are primarily maintained by agricultural tailwater and runoff, with some contributions from urban wastewater flows. Salton Sea water levels are in decline due to water rights transfers away from the region (see Salton Sea sidebar) as well as below average precipitation in recent years and decreases in return flows from both local irrigated agriculture and surface flows from Mexico. As the Sea is a terminal lake, rising salinity levels are a significant concern.

The South Lahontan hydrologic region (Figure 1G) has an arid climate with mean annual precipitation of 8.2 inches (1981-2010). Surface water resources include ephemeral and intermittent streams and waterways that mostly flow during summer thunderstorms. The winter season is typically cool and dry. Groundwater resources for the South Lahontan hydrologic region are mainly supplied by the alluvial aquifers composed of sand and gravel or finer sediments. In areas near the mountains and foothills, fractured rock aquifers exist which typically have less capacity than the alluvial aquifers. The Los Angeles Aqueduct is the major water facility in this region (California Department of Water Resources, 2013c). The Mojave River watershed is one of the major watersheds of South Lahontan hydrologic region that is fully contained in the Inland Deserts domain. This watershed is amongst the most populated areas of the South Lahontan hydrologic region, with 66% of its water supplied by groundwater. This dependence on groundwater is expected to increase in the future as surface water supplies become limited due to recent and projected severe droughts. According to the CASGEM basin prioritization, the western portion of the Mojave River watershed is classified as a high priority basin. Lowering of groundwater levels in recent years has impacted important wetland and riparian communities in this region; efforts are underway to restore these important habitats (California Department of Water Resources, 2013c).

Future changes in water availability are assessed by comparing projected precipitation, surface runoff, and potential recharge with historic values. Historical annual precipitation from 1951-1980 is about 5 inches per year, with projections indicating a decline to 3.9 inches per year by the end of 21st century. While there are no significant differences between the projected 30-year mean annual precipitation and the historic period from the 10 global climate models (GCMs) considered to be most representative of the California climate (ACCESS1-0, CCSM4, CESM1-BGC, CMCC-CMS, CNRM-CM5, CanESM2, GFDL-CM3, HadGEM2-CC, HadGEM2-ES, MIROC5), there is a considerable year-to-year variability among the GCMs and RCP scenarios. Differences in the direction of precipitation changes relative to the historic period are strongly dependent on future emissions scenarios (RCPs; Figure 11). Projected mean annual precipitation from these 10 GCMs mostly representative of the California climate indicate that 50% of the years in the mid-century period (2035-2064) will be drier than historic conditions (1951-1980) based on the RCP4.5 simulations. However, RCP 8.5 simulations illustrate a drier mid-century and a wetter late century period relative to historic conditions. These variabilities among the GCMs ensemble averages complicate water resources planning.

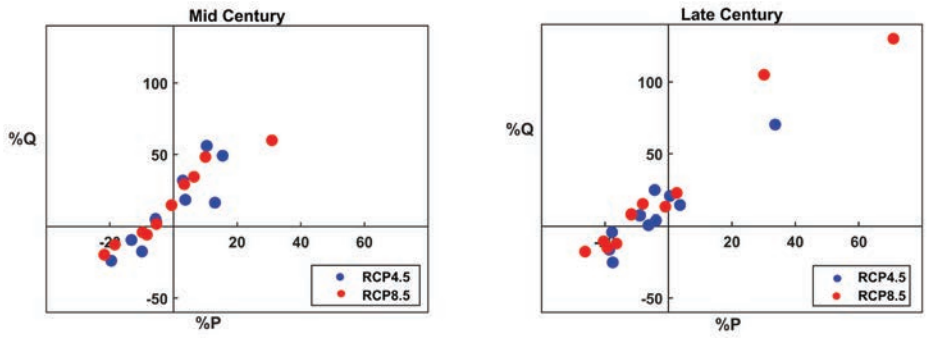
FIGURE 11



Relative annual differences between the ensemble annual mean precipitation from 10 GCMs and historic precipitation. The historic period corresponds to 1951-1980, the mid-century period to 2035-2064 and the late century period to 2070-2090.

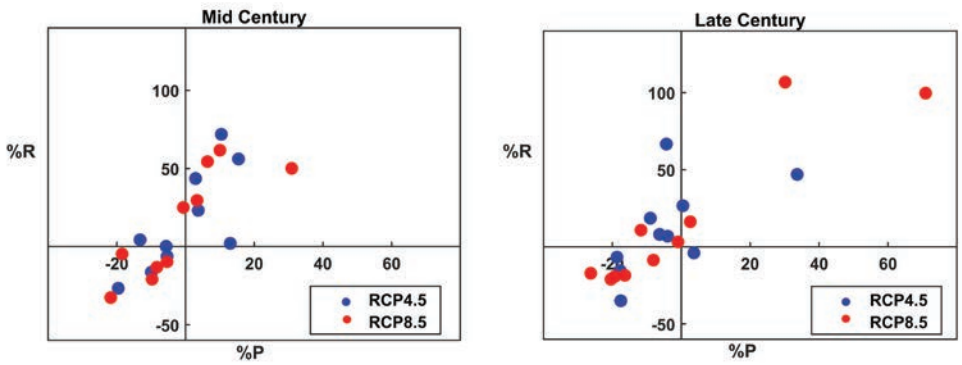
Variabilitiy in precipitation projections further translate to relative changes in surface runoff simulated by the Variable Infiltration Capacity (VIC) model, which has been widely used for climate change impact assessments. Previous investigations have shown that subsurface runoff simulations from VIC can be used as proxy for groundwater recharge (Niraula et al., 2017a). In the Inland Deserts, changes in 30-year mean annual surface runoff is linearly related to changes in precipitation amount relative to the historic period (Figure 12). While there is no clear consistency in the magnitude and direction of surface runoff among multiple GCMs at mid-century, almost all simulations converge to a drier than average surface runoff by end-century.

FIGURE 12



Percent changes in 30-year mean annual surface runoff (%Q) and precipitation (%P) from 10 GCMs relative to the historic condition. The historic period corresponds to 1951-1980; mid-century period to 2035-2064; and the late century period to 2070-2090.

FIGURE 13



Percent changes in 30-year mean annual recharge (%R) and precipitation (%P) from 10 GCMs relative to the historic condition. The historic period corresponds to 1951-1980, the mid-century period to 2035-2064 and the late century period to 2070-2090.

Subsurface runoff simulated by the VIC model was used as a proxy for potential recharge similar to the methods used by Niraula et al. (2017b). While changes in the 30-year mean annual recharge are mostly consistent with the projected changes in precipitation relative to the historic period, in some cases during the mid-century, increases in recharge were projected despite decreases in precipitation relative to the historic mean. There is more scatter in the relationship between 30-year mean recharge and precipitation compared to the relationship of surface runoff and precipitation (Figure 13). Future changes in the magnitude and direction of changes in runoff and recharge depend mostly on the precipitation rate, which is highly variable amongst GCMs (Figures 12, 13). Another source of uncertainty is related to the incomplete representation of land surfaces in the VIC model. It should be noted that these simulations only illustrate changes in surface runoff and potential recharge as a function of changes in precipitation and temperature. The role of human activities and how they change in response to future changes in the climate are not considered.

Various strategies have been implemented and are being considered as adaptation options for robust water resource management. The focus for water managers—both within the Inland Deserts and the state—will be to address future increases in water scarcity, which is defined as the degree to which demand exceeds supply. With respect to suplly management, the region is heavily reliant on imported water from the State Water Project and the Colorado River, but also on groundwater recharged from local sources and precipitation.

Since new freshwater supplies are unlikely to be appropriated on a permanent basis, the region must, and is, considering augmenting these current supplies through a number of avenues. To this end, the region is pursuing strategies such as recycling of treated municipal wastewater, capture and recycling stormwater, recharge and conjunctive use of ground water, desalinization of brackish groundwater, and the reuse of agricultural runoff.

In addition to these measures, water agencies within the region are increasing their cooperation to manage water more efficiently. As an example, a number of water agencies within the Inland Deserts have partnered in a joint project to manage their aquifers as a connected system in which dry year yields can be shared, and coordinated efforts have arisen to improve habitat for the Santa Ana Sucker fish species and to remove the invasive reed *Arundo donax* (SACCUP, 2017). Alternatively, the main wholesale water provider continues to develop long-term water sharing agreements with irrigation districts to ensure that water moves to its highest valued uses and to cover basic human needs during extreme droughts and periods of shortage (MWD, 2017).

On the demand side, the region has invested significantly in water conservation efforts. More effective water pricing structures, rebate programs for water conservation technologies, and education programs are part of the strategy to improve water use in the region. These strategies are particularly important given expected increases in the region's population. There is reason to believe significant gains in addressing water scarcity can be achieved by looking at the declining trend in per capita water use since the 1990s in the region. One area with significant possibilities for water savings is in urban outdoor conservation. More than 50% of the water used by households is for outdoor watering, with much of the indoor use already benefiting from decades of conservation efforts. In response, agencies are spending significant resources—time, money, personnel—to identify and encourage efforts by homeowners and business to reduce their outdoor water use.

Finally, the region is investing significantly in effective and efficient storage. While surface water storage will be limited in the region given lack of land for such purposes, groundwater storage and improved management will likely provide significant opportunities to the region to decouple water supply availability to yearly surface water deliveries. Future climate change impact assessment research in this region should implement integrated groundwater-land surface models to simulate dynamic feedback processes between land cover condition, groundwater flow, and surface runoff in response to changes in climate and changes in human water use.

Natural and Managed Resource Systems

In this section, we describe the effects of projected climate change on agriculture and ecosystems. Agriculture is the primary economic driver in the Imperial and Palo Verde Valleys, and is second only to tourism in the Coachella Valley. The region is a major source of winter fruits and vegetables. The region also has a large acreage of federally protected lands (U.S. Bureau of Land Management National Conservation Lands), including nearly 7500 square miles of National Parks and Monuments. This includes ecologically unique and sensitive ecosystems in Joshua Tree National Park and the Mojave Trails National Monument that are also tourist draws for the region. High biodiversity in the region is a product of localized refuges from climatic extremes that will likely contract as the climate warms. Both agriculture and natural systems are uniquely adapted to the already extreme climate of the Inland Deserts and serve as a model for how other regions of the state might respond to a warmer, drier climate.

Agriculture

The agricultural valleys of the Inland Deserts are some of the hottest agricultural regions in the world, with maximum summer temperatures that can reach 122°F. These extreme temperatures are project to increase by up to +8°F by the end of the century under RCP 8.5. The number of extreme heat days per year, with maximum temperature greater than 112°F, are predicted to increase from ~10 to more than 80. The major crops in the region are forage crops (alfalfa, Sudan grass, and Bermuda grass) and winter vegetable crops. Alfalfa, a crop with a C3 photosynthetic pathway, already shows heat stress and reduced yields during the warmest periods (Ottman and Mostafa, 2014). Less is known about the effect of extreme heat on other forage crops like Sudan and Bermuda grass, which use the C4 photosynthetic pathway. C4 crops also have a significant advantage in higher physiological water use efficiency. Recent studies of C4 energy crops show little evidence of reduced photosynthesis at the highest observed temperatures, thus biomass production could be maintained even as water stress increases (Oikawa et al., 2015). However, excessive temperatures can cause seed abortion of crops such as sorghum during the grain filling period (Nguyen et al., 2013). High temperatures can also substantially increase the risk of scalding in flood irrigated crops (Hutmacher et al., 2001).

Besides summer heat, the relatively minimal risk of winter frost in the region's agricultural valleys could diminish even further under climate change. Most of these valleys are currently in the US Department of Agriculture's plant hardiness zone of 10a or warmer (planthardiness.ars.usda.gov) which implies an extreme minimum temperature of 30°F or warmer. If the threat of frost were removed, crops that are highly intolerant of frost could become new candidate crops for cultivation in the Inland Deserts in winter.

Along with crops, another major face of agriculture is cattle production, both on grazing lands and in feedlots in the Palo Verde and Imperial Valleys. The feedlot cattle are often steers from dairy operations in California's Central Valley. Shade and sprinkling water to provide evaporative cooling are often used to successfully mitigate heat stress, but studies have shown contradictory impacts of sprinkling on animal weight gain and feed efficiency (Morrison et al., 1973; Correa-Calderón et al., 2010). Different cattle breeds have varying susceptibility to heat and ability to acclimatize, but commonly used dairy breeds (such as Holsteins) are recognized to be more heat-sensitive (Blackshaw & Blackshaw, 1994). Along with increases in temperature, potential increases in humidity may be important for cattle production as humidity increases mammal heat stress and reduces the effectiveness of evaporative cooling measures such as sprinkling. Besides animal health, potential impacts on farm workers needs to be considered for summer

workers. One mitigating factor in the Inland Deserts, unlike other parts of California, is that the main demand for farm labor occurs during the cooler winter vegetable season. Temperature changes may also exacerbate insect, weed, and other pest problems for humans, animals, and crops due to the potential for increased insect, pathogen, and weed growth under higher temperatures (Rosenzweig et al., 2001).

Agriculture is also vulnerable to increased stress to water supplies and extreme high temperatures under projected 21st century climate change. Agriculture in the region is nearly completely dependent on irrigation, primarily by water from the Colorado River. The Colorado is said to be the most litigated river on Earth, and much has been written about contested water rights for this overallocated resource that will only become more scarce and precious in the future. Inland Desert valleys are already one of the hottest agricultural regions in the world, and essentially serve as a model for what many other agricultural regions will face in the future with respect to heat tolerance and high salinity soils. Much research about temperature effects on agriculture has taken place here, but projected warming will take this region far past what it has experienced in the past.

Water for irrigation is critical to agriculture in the Inland Deserts, which have too little precipitation to support crops apart from marginal grazing lands. Precipitation in major agricultural valleys of the region is under 4 inches per year; climate change models under the RCP 8.5 scenario show wide relative variance in precipitation (0.5-8 inches/year), but all scenarios show that the major valleys retain their hyper-aridity (CalAdapt). The hydrologic scenarios show an increase in reference evapotranspiration, representing meteorological evaporative demand, of 2-4% by 2100 (CalAdapt). These increases in evapotranspiration will increase crop water demand, but this will depend on the type of crop grown. For some crops, such as alfalfa and winter vegetables, rising atmospheric carbon dioxide levels that cause climate change may also improve plant water use efficiency (Gago et al., 2014), but this is not relevant for the sorghum varieties that comprise most of the forage crops in the region since they have a C4 photosynthetic pathway.

The vast majority of irrigation water in the Inland Deserts comes from the over-allocated Colorado River, which is likely to see major streamflow reductions in the 21st century (see Colorado River sidebar). While irrigation districts that supply water to the region have some of the most senior water rights on the Colorado River (e.g., the Imperial Irrigation District, the Palo Verde Irrigation District, and the Coachella Valley Irrigation District), reduced streamflow may put additional pressure on these water suppliers to reduce their water use to alleviate shortfalls elsewhere in the Colorado River basin, especially if less than 7.5 million acre-feet are available for the US portion of the Colorado River Basin (MacDonnell et al., 1995). Efforts to reduce water use have already occurred, primarily with the Quantification Settlement Agreement that reduced Imperial Irrigation District use, regulated Coachella Irrigation District use, and implemented fallowing within the Palo Verde Irrigation District (Anderson, 2004; Hanak, 2003).

Along with the major agricultural valleys, there are smaller, isolated agricultural areas in the Inland Deserts, primarily in the alluvial regions of the Mojave Desert, that are irrigated primarily with groundwater. While small in area, they are isolated from other agricultural regions and can support cultivation of high-value, organic food crops (Jansen & Vellema, 2004). The water supplies for these isolated areas may be limited if climate change reduces the intensity and frequency of aquifer recharge during wet years. Besides reduced quantity, agricultural water quality may decrease under climate change as well. Water salinity is strongly and inversely correlated with stream flow in the Colorado River (Spahr, 2000). Irrigation districts in the region are in the downstream reaches of the Colorado, and thus experience higher salinity. As salinity of irrigation water rises, additional water will need to be leached through the soil profile to avoid deleterious yield losses (Grismer, 1990), which will reduce the water use efficiency of

agricultural systems in the region. Reuse of urban waste water that has higher salinity may also have an effect if that water is applied to agriculture (Glenn et al., 2009).

In addition to direct effects of climate on water supply, there are several non-climate issues that intersect with agricultural water use. These factors that may independently respond to climate change, indirectly affecting agriculture through changed water supply. First, urbanization of the agricultural valleys of the Inland Deserts competes with agriculture for both land and water. The populations in the Palo Verde, Coachella, and Imperial Valleys have increased by more than 20% per decade recently (US Census), and now exceed 600,000 people. The water needs of new urban development depends greatly on landscaping choices, and water used for indoor use can be reused for other purposes following secondary and tertiary treatment. Second, there is a potential for additional water transfers away from the region. Despite senior water rights of irrigation districts in the Inland Deserts for Colorado River water, serious shortages in the lower Colorado River Basin could cause some curtailment of current water allocations to the region during droughts or possibly the need to transfer water to urban water districts outside of the region. Finally, restoration of the Salton Sea could affect water availability for agriculture, depending on the desired physical and ecological condition of the Sea, which depends directly on the quantity and quality of water flowing in (Glenn et al., 1999; Kjelland & Swannack, 2018). If the Salton Sea continues to shrink, potential agricultural impacts include crop damage from dust storms from the exposed playa (Abuduwaili et al., 2015) and health impacts on cattle in feedlots close to the sea.

There are a number of adaptation options that can maintain agricultural productivity in the Inland Deserts in the face of reduced water supply and extreme heat expected with 21st century climate change. Drip irrigation, despite higher initial capital costs, can increase yields in forage crops compared to furrow or flood irrigation with the same evapotranspiration rates (Hutmacher et al., 1992). For vegetable and crops with sparser canopies, drip irrigation can reduce water losses by minimizing soil evaporation (Ayars et al., 2015). Deficit irrigation of alfalfa during summer can conserve water during periods of peak evaporative demand (Hanson et al., 2007), but may affect yields if not carefully implemented. While reduced yields are undesirable for farmers, alfalfa yields during extremely hot periods are already reduced by heat stress, and yields can recover quickly if the crop is well developed and the applied stress is not too severe. Conversion of forage crops from alfalfa to C4 pathway crops can result in increased water use efficiency and biomass production with similar evapotranspiration rates (Anderson, 2010).

Alternately, changing the planting date of crops might reduce water use by minimizing full canopy cover during periods of peak evaporative demand. For vegetable crops, the impact of changing crop season on agricultural markets needs to be considered. Crops that arrive earlier or later in the season may command lower prices due to competition from other regions. Switching to salt-tolerant crops that can be irrigated with drainage water or urban waste water is possible if water use regulations are appropriately modified and technical safeguards are in place to protect crop, soil, and human health (Rahman et al., 2016; Rhoades et al., 1988a; Rhoades et al., 1988b). However, market acceptance and crop quality of salt-tolerant crops is a substantial unknown. Changing crop timing is also likely to be of limited benefit for perennial crops including citrus, dates, and grapes.

While more efficient water use and water reuse are adaptation options, careful management of salinity of applied water is crucial for protecting soils and aquifer health in the Coachella and Palo Verde Valleys, as groundwater can be used in both of these regions (Harter, 2015). Moreover, improvements in irrigation and on-farm water use efficiency, both due to management changes and increased evaporative demand from climate change, will accelerate

the Salton Sea's decline, unless other mitigation water is provided, due to the increased salinity of drainage water entering the sea.

Further research is needed to project the impacts of higher temperatures on agriculture in the Inland Deserts. As the region already has some of the warmest climate agricultural systems in the world, there are no good analogues for potential changes under future climate scenarios. Research is needed on how current crops will fare under future climate, as resilience of crops and animal production systems to future temperatures is a key unknown. The tradeoffs between increasing evaporative demand and improved plant water use efficiency on controlling plant water consumption needs to be evaluated holistically. It is currently an open question as to whether breeding programs can help develop more heat-tolerant cultivars and whether there are cost-effective cooling strategies to help reduce stress and production losses in feedlot cattle. Along with heat-tolerance, new information on the impact of crop management practices and cultivars on water use is needed. Specifically, further research needs to examine how crop yields change with reduced amount and quality of irrigation water, how this varies over a season, and how much water can be saved by changing the timing of crop cycles.

More research is needed to better understand the risks of a changing water supply to the Inland Deserts in the 21st century. Projections of water supply require improved understanding of how external demands for Colorado River water will change, particularly with respect to pressure on Inland Desert irrigation districts to transfer water to coastal Southern California. Climate effects on water supply and quality must also be considered for better understanding of the requirements of restoration of the Salton Sea given that the amount and quality of agricultural drainage water will be altered by a changing climate and changing agricultural practices. Finally, work is needed on modeling and understanding different types of agricultural systems in the region that can maintain agricultural productivity (in terms of crop yield, quality, agricultural employment and revenues, etc.) while using less water.

Biodiversity and Ecosystems

Contrary to popular perception of deserts as a desolate wasteland, the deserts of southeastern California are in fact a biodiversity "hotspot" (Kraft et al., 2014). The California deserts comprise 28% of the state and include 37% of California's plant species (Figure 14). The rich biodiversity of these deserts is a product of both geography and topography; here, both the cooler Mojave Desert and the hotter low-elevation subset of the Sonoran Desert, the Colorado Desert, transition across a boundary extending from just north of Palm Springs and northeast to Needles. Additionally, the Baja California Peninsula bioregion extends into California along the Peninsular Mountain Range, through Anza Borrego State Park to its

FIGURE 14

Desert wildflowers.

northern terminus near Palm Springs. Each of these bioregions brings with it a characteristic flora and fauna. The Mojave Desert includes at least 1,409 plant species, 20 of which are endemic to that bioregion and 51 found nowhere else in California (Raven and Axelrod, 1977; Baldwin et al., 2002). The Colorado Desert includes at least 709 plant species; seven are endemic to this bioregion, with 100 species found nowhere else in California (Raven and Axelrod, 1977; Baldwin et al., 2002). These numbers are conservative—new varieties and species are being identified each year. Patterns of high biodiversity go beyond plants. A region that includes the northern part of the Peninsular Mountain range, the southwestern edge of the Mojave Desert, and the northwestern edge of the Colorado Desert, includes 33 species of native lizards, more than any similar sized area in all of North America [33 species] (Barrows et al., 2013).

The highway corridors of Interstate Highways 8, 10, 15 and 40 across the California deserts are often zones of low biodiversity, whereas the desert region's biodiversity is concentrated in the isolated mountain ranges ("sky islands") where somewhat cooler and relatively wetter climates occur (Kraft, 2014), at isolated springs, oases, and rare river courses (such as the Mojave and Amargosa Rivers), and on sand dunes. The two factors explaining these biodiversity hotspots are isolation and the occurrence of conditions that can buffer species from the harsh heat and aridity otherwise characterizing these deserts. Even sand dunes often hold more moisture than the surrounding coarser bajada sands. Unlike coarser sands or finer silts, aeolian sands absorb and hold onto rainfall for long periods at levels readily accessible to plant roots and burrowing mammals, lizards, snakes, and arthropods (Seely, 1991; Lei, 2004; Rosenthal et al., 2005). If species evolve adaptations to deal with the scouring, wind-blown sand that creates and maintains dunes, their populations can and do thrive there. Burrowing just a few tens of centimeters below the dune surface, creatures can enter a cooler zone of near-100% humidity and therefore survive through the summer droughts. Every dune system in the deserts of southeastern California includes plants, arthropods, and/or lizards that occur nowhere else in the world.

A warming and likely drier climate, with more intense and prolonged droughts, would clearly stress populations anywhere. For those species already near their presumed physiological limits living in deserts, there is reason for concern for common iconic desert species as well as for narrow endemic ones. Joshua Trees, *Yucca brevifolia*, are one such iconic, widespread Mojave Desert species (Figure 15). Using models to predict the future distribution of species under expected warmer conditions, Cole et al. (2011) concluded Joshua Trees in California and Arizona could likely be largely extinct by the end of this century due to the effects of modern climate change. Using comparable methods, but at a much finer scale and focusing on Joshua Tree National Park, models constructed by Barrows and Murphy-Mariscal (2012) similarly identified increasing levels of unsuitable habitat where

FIGURE 15

Joshua trees *(Yucca brevifolia)* are an iconic Mojave Desert species.

these trees currently occur. However, rather than extinction, the models also identified small areas of climate refugia (10% of their current distribution), where this species could continue to sustain populations in the Park. That more optimistic prediction has received support from on-the-ground measurements of patterns of seedling recruitment; recruitment is highest and most consistent in those same areas shown to be climate refugia in the models. In contrast, Joshua Tree seedling recruitment has been poor to non-existent for several decades in areas beyond these climate refugia. Outside of Joshua Tree National Park, high recruitment and expanding populations of Joshua trees at higher elevations and latitudes indicate distributional shifts consistent with a sensitivity to increasingly warmer and drier conditions.

Agassiz's desert tortoise, *Gopherus agassizii,* is yet another iconic and widespread species of the California Deserts (Figure 16). This region has many competing human land uses that can, at local scales, compromise and potentially cause local extinction of these federally threatened tortoises (Lovich and Bainbridge, 1999; Averill-Murray et al., 2012). However, risks associated with climate change extend beyond local scales, encompassing the entire range of this species. Modeling the response of this species to anticipated modern climate changes levels, Barrows (2011) identified a precipitous decline in suitable habitat if temperatures continue to increase and precipitation declines. Just 7% of the tortoise's current habitat would still be suitable within Joshua Tree National Park. That 7% represents potential climate refugia where the tortoises may still be able to sustain small populations. Using a similar modeling approach to predict tortoise impacts from climate change for the US Marine Corps Air and Ground Combat Center (MCAGCC) in Twentynine Palms, a region north of Joshua Tree National Park, a more optimistic 40% of suitable habitat would remain in climate refugia (Barrows et al., 2016). Validating these predictions with real on-the-ground data is more challenging for tortoises than for Joshua Trees, as young tortoises are notoriously difficult to find and therefore survey. Nevertheless, Lovich et al. (2014) reported a dramatic decline in tortoises within the National Park, a landscape protected from land uses that could otherwise cause tortoise declines. The tortoise decline occurred over the past two decades, a period associated with persistent drought and warming consistent that presage future climate conditions.

FIGURE 16

Agassiz's desert tortoise *(Gopherus agassizii).*

Joshua Trees and desert tortoises are presented here as examples because of their iconic nature and because of the detailed research done on these species. People will take notice if either are lost to extinction. However, for the vast

number of desert species, we lack such information. Almost certainly some will be more resilient to the effects of climate change, while other will be more sensitive (e.g., Wu et al., 2018). Identifying and protecting climate refugia may be the best opportunity to stem widespread climate-related extinctions in southeastern California's desert region. The climate buffering noted for sites that are desert biodiversity hotspots is an indication that they too are acting as climate refugia. High species richness and genetic diversity (Harrison and Noss, 2017) and endemism (Sandel et al., 2011) are characteristics of climate refugia, as are sustainable populations with on-going successful recruitment. However, modern climate change is just one of several threats they face; as such it is critical that within these potential refugia other anthropogenic stressors are eliminated or managed (i.e. Abella and Berry, 2016; Berry et al., 2014).

Pumping water from desert aquifers that may be supplying critical water to desert springs, oases, and rivers is an on-going concern. Without that water, the refugial capacity of these sites could dry up as well. Invasive plants represent another threat. To the extent that those weeds out compete and displace native plants, important food for vegetarian tortoises may be lost. Invasive plants also fuel wildfires in desert areas where the native desert plants, such as Joshua Trees, have little or no evolutionary history for adapting to fire, and so lack a capacity to survive intense fires. Invasive weeds and the fires they fuel are particularly problematic within the airflow corridors extending from the Los Angeles basin out onto the desert landscape. Those corridors carry nitrogen-laden smog, which then falls onto the desert soils, acting like a fertilizer that provides a competitive edge to non-native invasive grasses, to the detriment of the native flora (Rao et al., 2014). As anthropogenic stressors layer upon California's rich desert biodiversity, extinction risk is heightened. However, the benefits of identifying and protecting climate refugia can go beyond the reduction of climate effects; they represent relatively finite targets for focused management of weeds, fires, and water resources, thereby increasing the resiliency of the plants and animals therein.

Tourism in the Coachella Valley

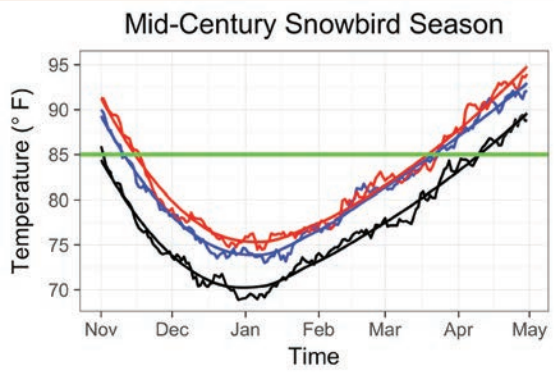
The Coachella Valley hosts thousands of out-of-state visitors every year. Tourism is the number one contributor to the local economy, generating 50,000 jobs and more than $6.4 billion annually. Climate change poses a threat to the tourism in the Coachella Valley as mild winter temperatures are expected to warm, and as the length of the mild temperature period contracts. The seasonal influx of visitors lasts typically during the time when the daily maximum temperature ranges 70-85°, roughly from November to May, with the season's peak in March. This period of visitors is often called the "Snowbird Season" because of the large number of visitors who come to escape cold and snowy winter climates in their hometowns.

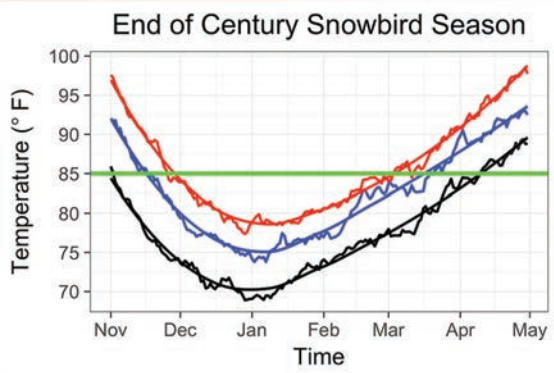
The Snowbird Season is an obvious economic driver, as employment and business revenue peak during this time. Jobs in tourism-related occupations such as accommodation, food services, waste management, arts, recreation, and entertainment decline significantly during the months outside of the Snowbird Season. These data show that tourism is the main driver for seasonal economic patterns in the Coachella Valley (CVEP, 2016).

This highly seasonal tourism may make the region economically vulnerable to climate change. With hotter winters to come, so-called "snowbirds" may be less inclined to visit the region due to both push and pull factors. That is, the Coachella Valley may be too hot for their liking or their hometowns may not be cold enough to make them want to leave. If temperature is a factor that tourists consider when they decide whether or not to visit the Coachella Valley, this could be a big blow to the local economy.

Climate projections from 4 models downscaled to the region suggests that the Snowbird Season, measured as number of days with high temperatures in the range of 70-85°, will be reduced from its historical length of ~5.5 months to around 4.5 months at mid-century, and to 3.5-4 months by the end of this century. By the end of the century, this represents a reduction of 25-33% in days with favorable temperatures for outdoor activities that are popular tourist attractions in the Coachella Valley, such as golf, tennis, and the Palm Springs Tramway.

Other main attractions in the Valley such as the Coachella Valley Music and Arts Festival, Stagecoach, The Palm Springs International Film Festival, and BNP Paribas Open attract many visitors annually. These major events will be affected by extreme heat, particularly since much of them take place outdoors. The venues will have to either shift their dates or provide more cooling infrastructure to accommodate their guests.





Historical and model projections of daily maximum temperature in Indio during Snowbird Season (Nov.-May) at mid- and end-century (historical: black, RCP 4.5: blue, RCP 8.5: red)

Human Systems

This section addresses the effects of climate change on human systems, encompassing land use, infrastructure, and human communities. The Inland Deserts have around 1 million inhabitants, with 85% living in urbanized areas including the Victor Valley in San Bernardino County (Victorville, Apple Valley, Hesperia), the Coachella Valley in Riverside County (Indio, Palm Springs, Palm Desert), and the El Centro Metropolitan Area in Imperial County (El Centro, Brawley, Calexico) [American Communities Survey estimated 2017 population]. Tribal lands of 12 different groups are contained in the region (Figure 1B). More information how already-occurring and projected climate change impacts disproportionately affect California's Tribal and Indigenous Communities may be found in the Fourth Assessment "Tribal and Indigenous Communities Summary Report"). In addition to agriculture, the major economic drivers are tourism; transportation, logistics, and warehousing; and real estate development, which includes housing and renewable energy. Land use is divided between natural and managed lands and those designated for the energy and transportation infrastructure that drive these industries. Use of land for renewable energy development is expected to grow in importance to meet California's climate change goals. Projected extremes in temperature and precipitation pose a threat to energy and transportation infrastructure, but these can be mitigated with careful planning. On the other hand, people and communities may be more vulnerable to climate change. Residents of the Inland Deserts are particularly vulnerable because of high poverty and unemployment rates, along with low educational attainment levels compared to state averages. The deterioration of the Salton Sea will additionally burden the population with worsening public health. Indeed, the fate of the Salton Sea will have a major negative impact on the region and will become a critical environmental justice issue for the State of California as a whole if it continues on its current trajectory of decline. A plan for the restoration of the Salton Sea is critically needed and will lessen the impact of many other climate-driven hardships that the region faces.

Land Use and Community Development

Land use decisions determine the impact of development on the environment, while in turn the environment shapes the type and form of development possible. Climate change affects land use both through changing patterns of development with the intent to minimize greenhouse gas emissions that cause climate change, and by directly altering the environment that shaped existing development patterns. Climate change affects not only public and private land use decisions, but is mediated by changing water availability and usage, and energy choices (Dale et al., 2011). In the Inland Deserts, water availability plays a fundamental role in determining the environment, society, and development. Climate change is likely to alter water availability in the region, with wide-ranging impacts on individuals and communities, industries and institutions, and entire ecosystems. Energy choices in the context of climate change, namely the drive toward emissions-reducing renewable energy sources, have become another fundamental driver of land use in the Inland Deserts.

Climate change is transforming land use priorities in the Inland Deserts under the California Renewables Portfolio Standard (RPS), which requires that 50% of electricity come from renewable sources by 2030 (Penn, 2017). The San Gorgonio Pass Wind Farm is California's third largest source of wind energy (Figure 17), with more than 2,000 turbines producing nearly 700 MW of power in 2015 (California Wind Energy Association, 2017). The Inland Deserts lead the state in solar power production and installation that includes investment in solar panel manufacturing and installation (Steinberg, 2014; Sullivan, 2017). In 2014, the Ivanpah Solar Electric Generating System in the Mojave Desert was the largest in the world, although that honor passed to India two years later (Al Jazeera, 2016). Renewable energy facilities as well as the land, roads, and transmission corridors necessary to transmit and distribute electricity constrain land use options and have important tradeoffs with natural environments.

FIGURE 17

Wind turbines near the San Gorgonio Pass

Yet the drive towards more renewable energy, as a response to California's climate change mitigation policy, can conflict with other land use goals, such as wildlife protection. Research addressing natural ecosystem impacts has suggested that future developments can and should be sited in more developed areas (Hernandez et al., 2015; Turney and Fthenakis, 2011). The Desert Renewable Energy Conservation Plan (https://www.drecp.org/), developed by a collaboration of state and federal agencies with the involvement of local stakeholders has the goal of conserving desert ecosystems in California while facilitating siting and permitting of renewable energy projects (see sidebar on Impact of Renewable Energy Development).

In addition to wildlife protection, development of land for renewable energy also competes with other uses of land such as for recreation and agriculture (Moore-O'Leary et al., 2017). Decisions to invest resources on energy production may reduce the money and space available to preserve open space, manage parks, and to invest in conventional and urban farm projects. In the Inland Deserts, only marginal or abandoned farm land in the Imperial Valley has been slated for utility-scale solar power development to date (Imperial County Planning & Development Services Department Cluster: Solar Power Project Draft Environmental Impact Report). Yet, as renewables become a larger fraction of California's energy portfolio, there is likely to be greater conflict on what might be considered less marginal land.

Increased adoption of renewable energy will help the region reduce its carbon footprint, albeit at some cost to future land use decisions and environmental services. In contrast, other land uses such as urbanization and agriculture are the most significant sources of climate change due to human activity, and account for the bulk of the region's greenhouse gas emissions (Kalnay and Cai, 2003, 2004; U.S. Environmental Protection Agency, 2015). Urban areas

account for as much as 80 percent of carbon emissions since 2008 (World Bank, 2018). In California, the majority of these emissions come from passenger vehicles. Since the mid-1980s, urbanization has surpassed land use for farming, grazing, and water resources in Inland Southern California (Chen et al., 2010). This urbanization trend is expected to continue, with state population projections showing future development around existing urban centers (Fourth California Climate Assessment Statewide Report, 2018).

Future land use planning of these expanding and developing urban centers will play a major role influencing the region's ability to reduce greenhouse gas emissions. These considerations are already included in California law, such as with the 2008's Sustainable Communities and Climate Protection Act (SB 375, 2008), which requires cities and counties to implement sustainable land use plans that reduce regional emissions from passenger vehicles in order to access statewide transportation funds. Specifically, each of California's Metropolitan Planning Organizations must develop and implement a Sustainable Communities Strategy as part of its Regional Transportation Plan. In the Inland Deserts, this role is played by the Southern California Association of Governments (SCAG). The region's current Regional Transportation Plan/Sustainable Communities Strategy, developed in cooperation with local governments, county transportation commissions, tribal governments, non-profit organizations, and businesses and local stakeholders throughout the six counties of Southern California, seeks to "[balance] future mobility and housing needs with economic, environmental and public health goals" (SCAG, 2016, Chapter 5). These land use strategies emphasize higher density, mixed-use, and transit-oriented development to encourage public and active transportation, which simultaneously reduce greenhouse emissions and increase physical activity and opportunities for social interactions (Maibach et al., 2008; Rissel, 2009). Improving access to efficient public transportation and other alternatives to automobile travel— both of which are targeted in the general as well as climate action plans of Inland Desert cities and the structure of subregional governments— is crticial to reducing greenhouse gas emissions throughout the Inland Deserts, and are also a means to improve public health (Ahern, 2011; Aylett, 2015; Carter et al., 2015; Flint, 2018).

The land use element of a general plan guides the physical development of city or sub-region, including greenhouse gas emissions associated with residential, retail, and industrial development. The land use elements designed to manage growth and development in the Inland Deserts emphasize transition to renewable energy, especially solar, urban infill where possible, improved access to effective public transit, reliance on drought-tolerant landscaping, and increased resilience to climate-related emergencies, including extended droughts and wildfires (Imperial County Planning and Development Services, 2015; Riverside County Planning Department, 2017). These plans do not identify the specific actions that counties, sub-regional governance organizations, or cities will take to adapt to climate change; those are made in Climate Action Plans.

Climate Action Plans specify the activities that a state, county, sub-regional organization, or city will undertake to reduce greenhouse gas emissions and otherwise adapt to a changing climate. In addition to the SCAG Regional Transportation Plan/Sustainable Communities Strategy, which anticipates significant declines in greenhouse gas emissions (SCAG, 2016), climate action plans developed by Riverside and San Bernardino counties and many of the region's cities detail strategies for reducing greenhouse gas emissions associated with energy production and use, waste water treatment and solid waste disposal, manufacturing, transportation, and agriculture (Riverside County, 2015; San Bernardino County, 2014; WRCOG, 2014). Overall, these documents support Smart Growth, a development approach that favors higher densities, mixed use buildings, and public transit to reduce sprawl, improve

environmental quality, and encourage community engagement. The success of these plans, which are consistent with California's SB 375 (Benfield, 2012) that directs governments to coordinate their investments in transportation, land use, and housing to minimize emissions and environmental impacts, are evident in the region's investment in solar energy, public and active transportation, and infill development rather than further expansion of housing into the Wildland-Urban Interface. Solar energy investment is expected to benefit the region's economy by supporting the region's energy independence, especially in the case of emergency, and generating jobs with middle class earnings potential (Jones et al., 2017).

A significant concern the region is confronting is development within the Wildland-Urban Interface, the zone where human development meets or intermixes with wildland fuel (Stein et al., 2018). Today, more than one-third of new development occurs in the Wildland-Urban Interface, with California leading the nation (U.S. Department of Agriculture-Forest Service, 2015). To address this issue, the region's smart growth strategies emphasize urban/suburban infill, a development strategy that limis opportunities for people to live in the Wildland-Urban Interface, thereby reducing the potential damages and risk surrounding wildfires. Regarding those who already live in areas vulnerable to wildfires, community participation, which the region has "in abundance," as noted in Guzman (2018), is central to best practices for managing the Wildland-Urban Interface and reducing the damages associated with wildfire (Lachapelle and McCool, 2012). "Best practices" in addressing wildlife in these vulnerable areas include incorporating defensible space around properities and emergency preparation, actions that are essential to mitigating property damage and loss of life that can be caused by wildfires. The success of these efforts to address wildfire risk, and more generally to promote sustainable development and to adapt to climate change depend on many factors, including community participation and awareness (perhaps facilitated through online and ad hoc dissemination strategies and education forums regarding best practices), quality data available that elected officials, policymakers, and community members can use to better inform their decisions, and the flexibility and capacity to develop and implement evidence-based strategies to increase climate resilience (Fisichelli et al., 2016; Hallegate, 2009; Hunt et al., 2011; Shulte and Miller, 2010). This challenge may be complicated by political as well public resistance to climate change adaptation strategies.

Of course, the ability of the community, agencies, and governments to make informed decisions, and implement scientifically sound climate action plans, depends critically on the quality of the data and science available, with recognition that there may be significant heterogeneity across cities or regions in how to best address climate change due to natural, social, economic, or demographic differences. Recent meta-analyses of local climate action plans and related subnational planning for climate change adaptation (see Moser and Ekstrom, 2010; Tang et al., 2010) suggest that there is considerable variation among climate action plans.

To best aid communities and decision makers in their efforts to continually update their climate action plans based on sound science, efforts and commitments are needed to develop consistent data sources and methods of analysis. Such efforts will facilitate both the comparison and assessment of climate change adaptation strategies, and perhaps increase regional coordination and cooperation. There has to be increased consideration (and science) into the effects of climate-induced heat waves, droughts and floods, and wildfires on natural ecosystems. The Inland Deserts region is vast, covering expansive deserts, uninhabited mountain ranges, rural settlements in the east, and both large and small agricultural areas. Most of the focus to date in the region has been on the impacts to plants and wildlife that might be impacted by renewable energy production and wildfire threats. While a focus on plants and wildlife should not wane,

Impact of Renewable Energy Development

The Inland Deserts are set to play a major role in California's energy future through development of new utility-scale renewable energy capacity that will supply California's energy needs while minimizing greenhouse gas emissions. The Inland Deserts have a strong competitive advantage for production of renewable energy because of abundant solar and wind resources, geothermal resources at the Salton Sea, proximity to demand centers and transmission infrastructure, and relatively inexpensive land available in large parcels (Jones et al., 2017; EES Consulting, 2013). Twenty-nine renewable energy projects (out of a statewide total of 150) have been granted permits in the region (CEC REAT Projections). Most of these projects are utility-scale solar energy systems, particularly those using solar photovoltaic panels mounted on steel and aluminum structures. In addition to reducing greenhouse gas emissions, solar energy improves air quality when it replaces fossil fuel burning. Carefully sited solar farms can reclaim degraded land, such as is taking place on abandoned farmland in the Imperial Valley (Imperial County Planning & Development Services Department Cluster: Solar Power Project Draft Environmental Impact Report: ftp://ftp.co.imperial.ca.us/icpds/eir/cluster-Isolar). Energy storage technologies can also support clean energy goals by reducing greenhouse gas emissions by delivering stored renewable energy, reducing demand for peak electrical generation from natural gas peaking plants, improving the reliability of the electrical transmission and distribution grid, and increasing the efficiency of existing infrastructure to meet energy system demands. In the Inland Deserts, operational energy storage systems are electrochemical (e.g., batteries) (California Energy Commission – Tracking Progress Report, http://www.energy.ca.gov/renewables/tracking_progress/documents/energy_storage.pdf). Imperial County, for example, is home to a 30-megawatt, 20-megawatt-hour lithium-ion battery energy storage system that helps the grid accommodate power from two large solar energy projects, SunPeak 2 and Midway III.

However, development of renewable energy, even on desert lands, involves trade-offs between ecological, political, and socioeconomic values (Moore-O'Leary et al., 2017). Specifically, avian mortality (birds and bats), death of insects, disruption to wildlife and habitat—such as that of the desert tortoise—are concerns due to large amount of land needed, dry cooling systems, effects due to other construction, operation and maintenance, proximity of power plants to protected areas including rare and endangered species habitat. In an effort consider these competing issues, the Desert Renewable Energy Conservation Plan (DRECP) was developed to ensure the conservation of desert ecosystems in light of renewable energy projects in California. This landscape-scale planning effort is a collaboration between the U.S. Bureau of Land Management, California Energy Commission, U.S. Fish and Wildlife Service, and California Department of Fish and Wildlife, with input from local stakeholders, that covers 22.5 million acres of California. A primary objective of the DRECP is to conserve sensitive desert resources by meeting climate adaptation requirements for desert wildlife and identifying sensitive ecosystems and species. For example, the DRECP streamlines the renewable energy permitting process by identifying lands closed to renewable energy, such as those designated as California Desert National Conservation Lands, Areas of Critical Environmental Concern, National Scenic and Historic Trail management corridors, and wildlife allocations. Specifically, in the Inland Deserts, the counties of Imperial, Riverside, and San Bernardino—along with the counties of Los Angeles and Inyo—were granted a Renewable Energy Conservation Planning Grant (RECPG) from the Energy Commission to effectively plan and promote renewable energy projects that align well with federal, state, and local renewable energy and conservation goals.

more research is needed on ways to mitigation and adapt to the health effects of climate change. Finally, there has to be increased development and dissemination of disaster-preparedness plans. Climate change adaptation planning emphasizes making transitions to renewable energy, public transit, etc. affordable at the expense of preparing the region for the real threat of drought, increased fresh food costs, wildfire, and deadly heat waves (Pierce et al., 2008; United States EPA, 2016). Failure to address these threats may be tied up in policymakers' reluctance to embrace climate science in a relatively conservative region. Yet disaster preparedness need not require accepting climate science; for example, measures can involve preparing for drought and wildfire as we do for earthquakes by improving infrastructure, limiting where people can live, preparation kits, and drills specific to the Inland Deserts region (Boulter et al., 2013; Lloyd et al., 2017).

Energy

Energy supply and demand in the Inland Deserts will be sensitive to rising temperatures projected with 21st century climate change, in addition to concurrent changes in population, technology, and policy. Climate change will affect energy supply because higher temperatures reduce production capability by decreasing capacity and efficiency of electricity production, transmission and distribution systems. At the same time, higher temperatures will increase electricity demand for air conditioning, which will become particularly necessary for human well-being in the Inland Deserts, a region of already extremely high temperatures. These effects are important considerations for energy development planning in the region.

Energy generation in the Inland Deserts is currently being transformed by a transition from fossil fuel to renewable energy sources required under the California Renewables Portfolio Standard (RPS). The RPS requires that 50% of retail electricity sales come from renewable sources by 2030 and is a major component of California's climate change mitigation strategy. Construction of new renewable energy generation infrastructure in the Inland Deserts— mainly solar photovoltaic (PV) and solar thermal systems— has already begun to replace natural gas power plants as the primary electricity source. Many new utility-scale renewable energy projects have come online since 2010, and more are proposed for the region, which will turn the region from a net electricity importer to an exporter, with a substantial positive effect on the region's economy (Jones et al., 2017). While likely to be effective at reducing greenhouse gas emissions from electricity generation, utility-scale renewable energy in the region could have cross-cutting, potentially negative, effects on some

TABLE 2.

PRIMARY ENERGY SOURCE (TOTAL ELECTRICITY CONSUMPTION*)	SOUTHERN CALIFORNIA EDISON (85,448 GWH)	IMPERIAL IRRIGATION DISTRICT (3,385 GWH)	OTHER ELECTRIC UTILITIES (424 GWH)
Coal	0%	14%	21%
Hydro	6%	4%	6%
Natural gas	19%	35%	1%
Nuclear	6%	3%	5%
Renewable	28%	28%	17%
Biomass & biowaste	1%	10%	0%
Geothermal	7%	3%	8%
Eligible hydroelectric	0%	8%	0%
Solar	10%	7%	1%
Wind	10%	0%	7%
Other	0%	0%	1%
Unspecified**	41%	16%	50%

Primary energy sources by utility provider in the Inland Deserts in 2016. Please note that the values for total electricity consumption and primary energy sources represent the entire region served by each individual electrical utility. The "Other Electric Utilities" refers to the City of Needles, City of Banning, Victorville Municipal Utility Services, Anza Electric Co-op, and Bear Valley Electric Service. (Source: California Energy Commission, Utility Annual Power Content Labels for 2016 (http://www.energy.ca.gov/pcl/labels/))

* Total electricity consumption data is for the year 2016 (Source: California Energy Commission, Electricity Consumption by Entity (http://www.ecdms.energy.ca.gov/elecbyutil.aspx))

** "Unspecified" sources of power refers to transactions of electricity that are not traceable to specific generation sources.

aspects of ecology and human systems in the Inland Deserts without careful planning to minimize and mitigate these effects (see sidebar "Impact of Renewable Energy Development").

Finally, the Inland Deserts region is likely to experience large increases in energy demand as the climate warms due to extreme high temperatures. Compared to the state as a whole, the region has higher than average transportation fuel use, and lower than average per capita income, meaning that it is more vulnerable to possible increases in the cost of energy (electricity and transportation fuel). Nevertheless, energy-related climate change mitigation policies have had a net positive impact on the economies of Riverside and San Bernardino Counties between 2010-2016, and the positive impact is expected to continue (Jones et al., 2017).

The major sources of electricity in the Inland Deserts are provided by Southern California Edison (SCE) and Imperial Irrigation District (IID) (Table 2). Meanwhile, five other electrical utilities serve the remainder of the region, including the City of Needles, City of Banning, Victorville Municipal Utility Services, Anza Electric Co-op, and Bear Valley Electric Service. The current electricity generation mix in the region is composed of both in-state and out-of-state electricity generated from fossil fuels and renewable sources of energy (Figure 1C). Most of the electricity in region is generated from fossil fuel combustion (coal and natural gas) and from unspecified sources of energy, which are transactions of electricity that are untraceable to specific sources. However, the largest providers of electricity (SCE and IID) in the region use close to 30% renewable energy (biomass/biowaste, geothermal, small hydroelectricity generation, solar, wind).

Southern California currently imports electricity from out of state via major transmission lines, most of which pass through the Inland Deserts region (Sathaye et al., 2012). A large fraction of this energy comes from coal, which California is eliminating from its energy supply mix as part of efforts to decrease greenhouse gas emissions (Mahone et al., 2018). Nevertheless, out of state imports of electricity and transmission through the region will likely still be necessary in the future with increasing utilization of renewable energy sources. Supplies of wind and other renewables from out of state are abundant at times when local solar power is insufficient and will be needed to overcome the mismatch in the timing of peak energy demand versus energy supplied from local renewable sources (CEC, 2017).

Currently, a total of 166 operating power plants exist in the Inland Deserts region and use a variety of energy sources to generate 8.6 gigawatts of power (https://cecgis-caenergy.opendata.arcgis.com/datasets/california-power-plant). Some of the power stations burn natural gas, while others use renewable energy sources, including solar, wind, biomass, hydropower, and geothermal energy (Figure 1C). In this region, there are six natural gas power plants (2709 MW). Approximately 95% of the power plants in this region are fueled by renewable sources, including 94 solar/solar thermal (4034 MW), 33 wind (943 MW), 1 biomass (54 MW), 10 hydropower (124 MW), and 20 geothermal power plants (718 MW). This shift toward renewables, driven by the RPS, has led to replacement of older fossil fuel power plants by new renewable sources (Jones et al., 2017). Of the 150 permitted renewable energy projects statewide, 29 of them are located in the Inland Deserts (https://cecgis-caenergy.opendata.arcgis.com/datasets/california-renewable-energy-action-team-reat-projects). These 29 plants, 90% fueled by solar energy and 10% by geothermal sources, are estimated to produce up to 2.4 gigawatts of energy.

Increasing temperatures will reduce the efficiency of energy generation by natural gas fired power plants and solar

photovoltaic systems. For a combined cycle natural gas fired power plants in the Inland Deserts, power output is reduced by 0.14-0.25% per °F above 96°F for wet and dry cooling systems, respectively (Maulbetsch and DiFilippo, 2006). For photovoltaic systems, voltage output is reduced linearly with temperature. Reductions have been reported as 0.21-0.25% per °F warming; however, the relationship between power loss and increased temperature will vary among systems depending on the material and other system properties (Fouad et al., 2017). In contrast, concentrated solar thermal systems, such as the Ivanpah Solar Power Facility (392 MW) located in the northeast corner of the Inland Deserts region, increase efficiency with rising ambient temperatures. Projecting the combined effects of warming and changes in radiation due to air pollution using CMIP5 models up to mid-century, Wild et al. (2017) found no net change in power output from concentrated solar in southern California.

In addition to electricity generation, the region has infrastructure for distribution and storage of electricity that will also be vulnerable to climate change. A little over 4,900 miles of transmission lines exist in the region (https://cecgis-caenergy.opendata.arcgis.com/datasets/california-electric-transmission-line). These transmission lines currently serve an important role transmitting imported electricity from out of state into the population centers of southern California. This will likely continue with further development of renewable energy in the Inland Deserts and out-of-state. Transmission lines are vulnerable to warming because high temperatures can damage lines, leading to capacity losses around 0.8% per °F of warming when conductor temperature rises above the design limit of 176°F (equivalent to an air temperature of 100°F) (Sathaye et al., 2012).

Electric substations then convert high voltage electricity to lower voltage that is suitable for homes and industrial purposes. There are 262 operational electric substations in the region, and three proposed substations (https://cecgis-caenergy.opendata.arcgis.com/datasets/california-electric-substation). Voltage transformers are a critical component vulnerable to climate change, since heat causes energy loss and increases the rate of transformer failure (Gao et al., 2017). Transformer capacity is sensitive to ambient temperature conditions at the time of peak load (Sathaye et al., 2012) and decreases roughly 0.4% for every 1°F increase of ambient temperature above 86°F (Li et al., 2005). Using climate model projections, Sathaye et al. (2012) project a 1.5-5% reduction in regional peak load capability by mid-century, and a 2-3% reduction by end of century.

As a whole, California's current residential electricity consumption is 2,333 kWh per capita. Meanwhile, the energy demand by residents of Inland Desert counties of Imperial, Riverside, and San Bernardino is 2,679 kWh per capita (http://ecdms.energy.ca.gov/elecbycounty.aspx). Both per capita and total electricity demand in the region are expected to increase with climate change and population growth. Population in Imperial, Riverside, and San Bernardino counties is projected to increase close to 70% by the year 2100 along with increased land use development (California Department of Finance, 2016). Per capita energy use will go up as increased penetration of residential air conditioning will play a vital role in ensuring the adaptation of the growing population in this region to a warming climate (Sailor & Pavlova, 2003; Auffhammer & Aroonruengsawat, 2011). By the end of the century, the non-coastal portions of Southern California are projected to experience the largest increases in household electricity demand in the state (Auffhammer, 2018). Parts of the Inland Deserts will require increases of up to 2.5 and 3.4% in electricity demand by mid-century, and 10.6 and 29% under RCP 4.5 and 8.5, respectively (Auffhammer, 2018).

Future research and adaptation planning is needed to address energy challenges due to 21st century climate change in four areas. First, as electricity generation transitions to renewable sources, a more nuanced analysis of the costs and benefits of different types of renewable energy sources under a warming climate is needed. Specifically, more

attention is needed to comparing trade-offs between distributed generation, such as rooftop solar and local storage, with utility-scale solar energy with traditional transmission and distribution pathways. Some of the negative effects of utility-scale renewable energy may be partially mitigated by the additional generation of distributed renewable energy. Second, better predictions of the impacts of climate change on energy supply and reliability are needed for this region in particular, with a focus on the electricity consumption of disadvantaged communities, and on vulnerability and resilience of current and proposed power system equipment to ensure a reliable supply given temperature projections. Furthermore, increased utilization of renewable energy will also require new research on coordinating the operations of distributed generation and solar and wind energy resources to deliver a steady energy supply, including microgrids and energy storage systems. Third, with the increasing adoption of smart sensor technology such as advanced metering infrastructure, big data analytics are critically needed to improve energy efficiency, reduce emissions, and enhance the security of the smart power grids under a changing climate. Last but not the least, there is an urgent need to study electric vehicle sharing and coordinated charging strategies to improve air quality and reduce transportation costs by leveraging the electric grid infrastructure.

FIGURE 18

Bridge washout along I-10 near Desert Center, July 2015.

Transportation

California has a large multi-modal transportation system, consisting of thousands of miles of roadways and railways, several seaports, airports and transit systems, as well as extensive biking and walking networks. This large transportation network is critical to millions of travelers and for the efficient movement of goods. The Inland Deserts region includes most of Caltrans District 8, the largest of 12 statewide Caltrans districts that covers approximately 28,650 square miles of land, and the Imperial County part of Caltrans District 11. Within District 8, there are four major interstates and 32 state routes totaling 7,200 lane miles.

In the last several years, the impacts of climate change on transportation has been a topic of high interest. In 2015, the Transportation Research Board (part of the National Academies, see www.trb.org) formed a Transportation Systems Resilience Section consisting of committees on infrastructure protection, business continuity and disaster logistics, and emergency evacuation research. There have been several specific workshops on these topics and a research roadmap is currently being developed. The impacts of climate change on transportation consist of three main areas: 1) impacts on transportation infrastructure; 2) impacts on travel behavior; and 3) impacts on goods movement and supply chain business continuity.

It is clear that transportation infrastructure such as roadways (highways, arterial roads, residential streets, etc.), bridge supports, railways, seaports, and airports are all potentially at increased risk due to severe storms, flash floods, higher temperatures, and increased wildfire risk (Radke et al., 2018). As an example, in July 2015 a bridge over a desert wash collapsed during a major flash flood near Desert Center (Figure 18). As a result, bridges like this are being rebuilt with deeper foundations, with the expectation that flash floods will increase in frequency due to climate change. Wildfires can also directly affect the transportation infrastructure, literally melting pavement and buckling concrete. Debris flows or mudslides can also wash out or damage transportation infrastructure.

Temperature extremes are also increasing within the Inland Deserts (see "Regional Climate Projections," Figures 4, 5). In general, these higher temperature extremes do not necessarily have a strong effect on transportation, except when temperatures are so high, that airplanes may be restricted on being able to take off and land. This is dependent on a number of factors, including airport altitude, runway length, type of aircraft and payload. As an example, many flights were cancelled at several southwest US airports during June 2017 when temperatures exceeded 119 °F (https://www.washingtonpost.com/news/capital-weather-gang/wp/2017/06/20/its-so-hot-in-phoenix-that-airplanes-cant-fly/?noredirect=on&utm_term=.63bea31f7125).

In addition to the direct effects on transportation infrastructure, extreme weather events can cause major disruptions in normal everyday travel. When parts of the transportation infrastructure fail, then typical travel routes for both passenger travel and goods movement may be affected. In recent years, the California Department of Transportation has set up Traffic Management Centers (TMCs) around the state to provide roadway information to the public; as an example, Caltrans District 8's TMC can be accessed at http://www.dot.ca.gov/dist8/tmc/. In addition to providing real-time information on lane- and road-closures, it also offers rerouting information, future conditions on the roadways, and other information. This allows travelers to choose different routes to avoid travel delays, congestion, and other related problems. In the extreme cases of a major disaster where evacuations are required, the TMC and related websites can also provide evacuation routes and related information. There are a variety of examples of the effectiveness of these TMCs over the last several years. A good example for the Inland Deserts region was the re-routing of traffic along the I-10 freeway during the bridge washout incident in July 2015 (Figure 18).

Beyond re-routing and evacuations that may be related to climate change and extreme weather events, it is unclear whether actual travel behavior changes due to higher temperature extremes. Most current vehicles have robust climate controls; therefore, there is little evidence that people change their travel behavior (e.g., deciding to make a trip, trip departure times, trip route) due to extreme heat. However, when the extreme heat is combined with traveling on roads with significant road grade, more vehicle breakdowns along the roadside have been recorded, potentially affecting traffic operations.

Transportation is often thought of as simply trips made by typical passenger vehicles. However, perhaps just as important is the goods movement system. Southern California is home to two major seaports (Port of Long Beach and Port of Los Angeles) that process approximately 43% of all the goods entering the United States. In addition to the ports, there is a sophisticated system of goods movement that include railyards, transfer stations, trucking fleets, rail systems, and distribution warehouses. All of these are vulnerable to transportation disruptions due to climate change and extreme weather events. Missed shipments can drastically affect material supply, the manufacturing process, and the distribution of the finished goods. Any disruption can have a deep effect on the economic vitality of the region and on the livelihood of many businesses (Radke et al., 2018). As a result, many companies are engaged now in resiliency planning and preparation to mitigate these potential effects due to transportation disruptions.

Inland Southern California plays an important role in the goods movement and supply chain business continuity. This region is home to a large and expanding number of warehouses and distribution centers, a critical link for goods movement and manufacturing. In addition to addressing re-routing issues described in the previous section made by trucks, companies are now eliminating "weak-links" in their transportation system, seeking out multiple modes of good movement and delivery.

There are a variety of actions that can and should take place in order to adapt to climate change and mitigate its impacts. In terms of transportation infrastructure, more resilient structures should be built, including bridges, ramps, and drainage systems. In many cases, actions are already being taken to fortify structures susceptible to flooding. For example, bridges such as the one along the I-10, described above, are being rebuilt with deeper and stronger footings. Use of materials with a higher heat tolerance should be considered during the next repaving cycles to increase resilience to extreme heat events. Barriers and diversions can be built along roads to protect critical locations from potential mudslides.

California has already set up effective traffic management centers to deal with strategy development and for disseminating information to travelers during infrastructure failures or disruptions. These traffic management centers should continue to embrace new techniques in "intelligent traffic management", including:

- Innovative monitoring solutions that use traffic and roadway sensing to improve situational awareness among travelers.
- Advanced traffic routing methods (e.g., distributed routing algorithms) that can be utilized during extreme weather events, which may result in isolated road closures all the way up to full blown evacuations.
- Innovative traffic control techniques that can potentially change traffic signal timing and ramp metering.

For goods movement and supply chain management, businesses should continue to identify risks and impacts associated with supply chain disruptions. Based on this assessment, action plans can be developed to minimize

these disruptions through redundant pathways. For Inland Southern California, the majority of the distribution warehouses were developed and located in an ad-hoc manner based on land prices and availability. It would be valuable for regional planners to now examine the warehousing and distribution system as a whole and identify weaknesses. Based on this analysis, specific roadway and management techniques could be developed to increase the resiliency of current goods movement system in the Inland Deserts.

There are a number of specific research needs and knowledge gaps, specifically on the relationship between climate change and transportation as a whole. Specific research questions include: 1) improving our understanding of the linkages between climate change events and traffic operations, where numerous "what-if" case studies can be carried out to determine how we can improve traffic operations to increase resiliency; 2) improving our understanding of the linkages between climate change events and travel behavior; to date, there are no solid studies showing how people change their travel habits based not just on disruptive weather events, but on extended extreme heat; this also pertains to goods movement; and 3) improving how transportation agencies (e.g. Caltrans District 8) interact with city traffic managers and private-sector entities during extreme weather events.

Public Health: Vulnerability and Adaptation Options

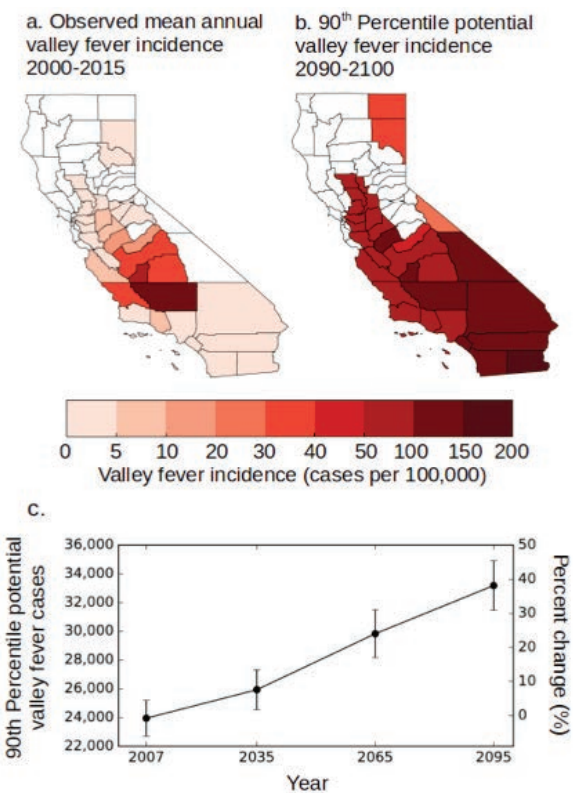
Within the Inland Deserts region, climate change is poised to increase multiple public health vulnerabilities by exacerbating environmental risks to health and well-being while also compromising the capacity to address risks. Direct effects of increasing temperatures within the region, already characterized by extreme heat, could include increased risk of rapid and lethal health consequences as well as chronic degradation in well-being (Kostas and Hajat, 2008). Indirectly, climate change is expected to interact with other global change drivers and exacerbate health vulnerabilities associated with air pollution and disease (Patz et al., 2005). Climate changes in the Inland Deserts may degrade or add strain to health-related infrastructure, including electricity, water delivery, and transportation. Spatial and demographic variability in climate-related health risks also have high potential for increasing environmental justice issues, with greater predicted warming impacts in low income and minority communities (Tayyebi and Jenerette, 2016). Differences in the availability of air conditioning and other mitigation measures can further exacerbate these differences in heat vulnerability among communities (Harlan et al., 2006; Jenerette et al., 2016). In preparing and adapting to future climate warming, a suite of uncertainties may lead to alternate public health futures. The fate of the Salton Sea in particular, which may be affected by climate change, could have a large effect on public health in the region.

Heat-related health impacts are associated with increases in both chronic and peak exposure to high temperatures (Basu, 2009; Ostro et al., 2011; Sherbakov et al., 2018). High temperatures can have extensive health impacts ranging from degraded quality of life to mortality (Kovats and Hajat, 2008). These negative health effects can result both from increased average temperatures and increased intensity and duration of acute heat waves. The projected increases in daytime high temperatures for the Inland Deserts are associated with increasing risk from a diverse set of respiratory and pulmonary health consequences, as well as the aggravation of other health conditions (Patz, 2007; McMicheal et al., 2007). The specific mechanisms linking high temperatures to the resulting health impacts are an active area of research, and translating outdoor meteorological conditions to physiological warming and health vulnerabilities is an ongoing research challenge (Hondula et al., 2014; Harlan et al., 2014).

In measuring environmental temperature and impacts to health, two metrics are commonly evaluated: air temperature and surface temperature. Air temperature is a widely used metric of environmental temperature representing conditions in shaded locations, and has been repeatedly found to influence human health through many heat-related illnesses (Kalkstein, 1991; Hondula and Barnett, 2014; Harlan et al., 2014). The influence of air temperature on heat-related illness is frequently related to elevated nighttime temperatures, as projected increases in minimum temperatures reduces a person's ability to recover during sleep from high daytime temperatures. A second temperature metric, surface temperature (frequently defined as land surface temperature) is measured as the emission of long-wave infrared radiation from a surface primarily viewed from thermal cameras or satellite platforms (Voogt and Oke, 2003). Surface temperatures have also been shown to directly correlate with heat-related health incidents (Laaidi et al., 2012; Vanos, 2015; Jenerette et al., 2016), and are more closely related to negative health outcomes than air temperature (Jenerette et al., 2016). These two metrics provide alternate windows into temperature-related health threat: air temperature is measured continuously but only from a limited number of locations, while surface temperature measure by satellite provide extensive spatial coverage but only limited timing of available temperature. Resolving the uncertainties in the drivers of spatial and temporal variation for both air temperature and land surface temperature will contribute to a more robust understanding of the drivers of climate change related heat impacts.

In addition to direct effects of warming on public health vulnerability, climate change in the Inland Deserts is also likely to exacerbate air quality-driven health impacts (Jacob and Winter, 2009). Increasing temperatures and more drought conditions may increase concentrations of ozone and particulates (West et al., 2016; West et al., 2017). Specifically, formation of ground-level ozone generally increases with temperature (Cardelino and Chamedies, 1990), so warming is expected to increase harmful surface ozone levels. Emissions of the ozone precursor NO_x from agricultural soils may also increase with higher temperatures, further enhancing ozone production (Oikawa et al., 2015). Climate change may also increase exposure to particulates resulting both from increased dust and fire. More severe and frequent drought and high temperature conditions could increase dust production from the extensive desert regions (Engelstaedter et al., 2006) as has been implicated for the Owens Lake region in southern California (Borlina and Renno, 2017). Increasing fire frequency can create recurring air quality degradation events leading to respiratory health effects and growing evidence of increased risks of all-cause mortality (Reid et al., 2016). Increased air emissions from an expanded playa of the Salton Sea may also add to these air quality problems.

FIGURE 19



Observed and projected increase in Valley Fever incidence by county for (a) 2000-2015, and (b) 2090-2100 under RCP 8.5. Source: Gorris, Zender et al., in prep

Simultaneous with increasing health risks associated with climate changes, the capacity to cope with risks may also be compromised. Public health infrastructure associated with both electricity and water distribution may be compromised by climate change effects on those systems. With increasing temperatures, electricity demands for cooling increase, which can increase the risk of blackouts (Gao et al., 2018). In turn, electricity failure during heat waves may lead to widespread heat-related health impacts. Water distribution may also be impacted by climate change. Warming can increase water demand and decrease water availability, stressing water distribution systems. Climate change may also increase risks from infectious disease in the Inland Deserts. Mosquito borne diseases are expected to increase in prevalence with climate change (Gould and Higgs, 2009). Coccidioidomycosis, the fungal pathogen responsible for Valley Fever, may also increase in response to climate change due to warming and more variable precipitation patterns (Gorris et al., 2018, Figure 19).

Across most of these health risks, the consequences of climate change-induced health vulnerability are poised to magnify environmental justice concerns (Harlan et al., 2006). The Inland Deserts already have large disparities in wealth and heat risk (Tayyebi and Jenerette et al., 2016). Urbanized regions include some highly affluent neighborhoods featuring extensive outdoor irrigation supporting lush vegetation and cooler microclimates. Other urbanized neighborhoods contain extensive poverty, with limited irrigation and vegetation. Within the agricultural regions that are home to very disadvantaged communities, exposure to health risks may be higher, given that most farm workers perform strenuous labor outside in high temperature conditions and may be exposed to higher levels of atmospheric pollutants from agricultural activities. The increased health risks from climate change may exacerbate these differences.

Several strategies may help the Inland Deserts adapt to climate change by mitigating these health vulnerabilities. The increased use of urban vegetation may provide a buffer against higher maximum temperatures through vegetation-derived cooling (Jenerette et al., 2016); however, this strategy generally requires sustained water inputs, which may also be at risk given increasing water shortage predicted for the region. Better planning for increased peak electricity use and water demand can increase resilience of critical public infrastructure to climate change. Resource conservation efforts may also limit potential increases in infrastructure demand. Strengthening social networks may also provide added coping capacity to reduce climate change related health impacts. Climate effects on air quality can be minimized by reducing ozone precursors, both from on-road and agricultural sources, and reducing wind-blown particulates in general throughout the region and specifically in response to the shrinking Salton Sea. In alleviating climate change impacts to health vulnerability in the Inland Deserts, multiple strategies will be needed to address the breadth potential health impacts.

Further research could reduce the uncertainty in the effectiveness of these public health adaptations. A crucial uncertainty is the fate of the Salton Sea – both in terms of the water quality and from increasingly exposed playa sediments. Degraded water quality in the remaining sea may lead to increased emissions of the toxic gas hydrogen sulfide (H_2S) due to mass fish mortality, leading to noxious odors throughout the region. Toxic pollutants in the Salton Sea sediments may have a large potential for emissions during high wind events. Outside of the Salton Sea, abandonment of agricultural lands may lead to dust emissions from soils contaminated with pesticides and other residues. These legacies of contamination need further study to characterize the distribution of contaminants and assess the potential health impacts. Changing vegetation cover in natural and managed lands due to changing water availability may also pose a stress that is not well understood. In the end, translating environmental health

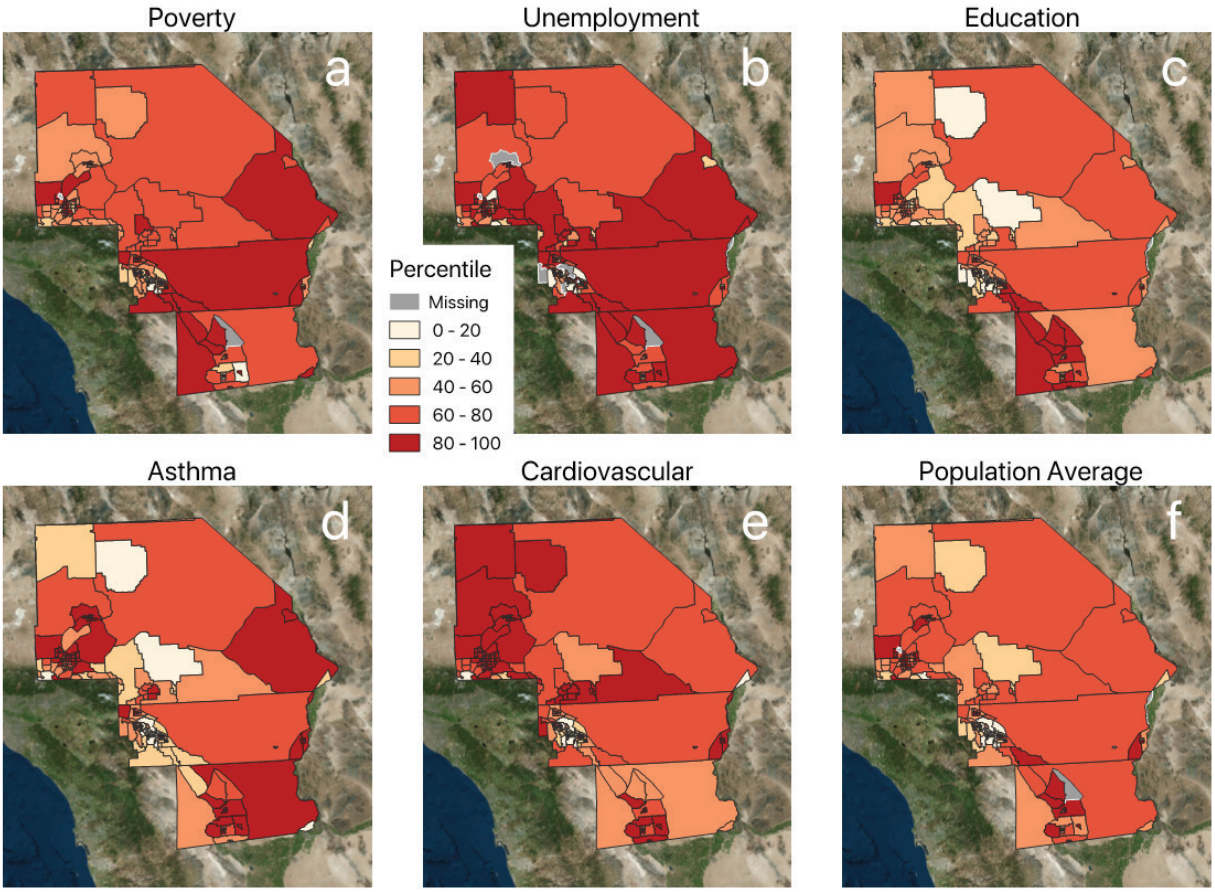
risks associated with climate change to specific health vulnerabilities has large uncertainties. With increased coping capacity and public infrastructure, some of the health risks can be mitigated. However, the implications of coping-based strategies will need foresight to avoid enhancing environmental injustice.

Environmental Justice

The impacts of environmental changes such as those expected with climate change in the Inland Deserts are not uniformly distributed across communities and population demographics. Health impacts associated with air pollution, for example, are typically most severe for specific at-risk populations, such as young children, senior citizens, and those already suffering from respiratory or cardiovascular disease. Many other factors can further influence the ability of any given group of people to successfully adapt to the local effects of environmental changes, including socio-economic status, mobility, employment opportunities, and language barriers. Collectively, analyzing and mitigating the disproportionate effects of climate change depending on these types of factors is an important environmental justice concern, and one that has been an increasingly highlighted policy priority within the state of California. For more information on Statewide environmental justice issues, please refer to the companion Fourth Assessment Climate Justice report (Climate Justice Summary Report 2018).

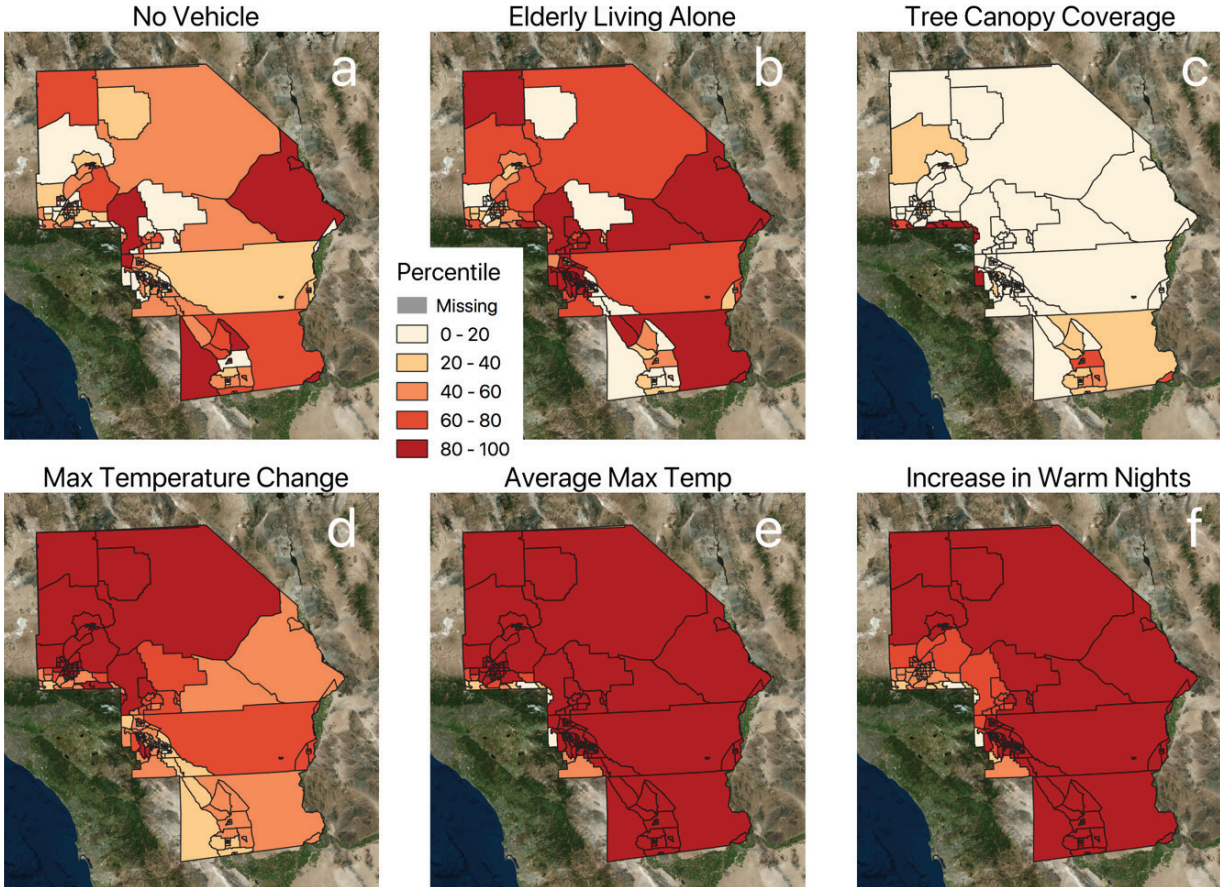
The Inland Deserts of California shows signs of disproportionate vulnerability to climate change through multiple demographic and environmental metrics currently in use. CalEnviroScreen, a data product of California's Office of Environmental Health Hazard Assessment (OEHHA), reveals a disproportionate number of census blocks in the Inland Desert region that rank in the upper quintiles for population vulnerability metrics such as poverty, unemployment, education, and existing incidence rates of asthma and cardiovascular disease (Figure 20). Combined, these metrics highlight some of the ways in which Inland Deserts residents in particular may struggle to respond to increasing challenges related to climate change relative to populations with greater resources and resilience. The Environmental Justice Screening Method, another tool used for the identification of at-risk communities on a regional scale, supports and extends the results of the CalEnviroScreen metrics, underscoring the importance of addressing resilience disparities within regional communities when planning for future environmental problems (Sadd et al., 2011). To estimate climate change vulnerability, the Environmental Justice Screening Method examines 7 indicators related to heat stress, including economic, social, and environmental factors (Figure 21). The resulting Climate Change Vulnerability metric reveals unique spatial patterns of climate-related risks: while metrics measuring current vulnerability to environmental health risks are concentrated almost entirely within the greater Los Angeles area of southern California, the climate-focused vulnerability metrics highlight the vulnerability of Inland Desert residents relative to those of more urban areas. In particular, Inland Deserts have some census tracts with a high proportion of the population with no vehicle, and who are elderly and living alone. There is also a low proportion of tree canopy that can provide a cooler microclimate in residential areas. Extending and responding to these and other risks associated with future climate change will require a careful examination of individual community resiliencies and vulnerabilities, enabling policies that can mitigate the disproportionate negative effects of climate change on at-risk groups.

FIGURE 20



Population vulnerability estimated by census-block quintile for poverty (a), unemployment (b), low educational attainment (c), asthma rates (d), cardiovascular disease rates (e), and population average risk (f). Source: CalEnviroScreen.

FIGURE 21



Climate change vulnerability estimated by census-block quintile for percent of households with no vehicle (a), population of elderly living alone (b), tree canopy coverage (c), changing in maximum monthly average temperature change from 2000s to 2050s (d), average maximum monthly temperature in 2050s (e), and increase in warm nights for 2000s to 2050s (f). Source: Environmental Justice Screening Method.

Research Needs

Because of the central role of water resources to the endurance of human and natural biological systems in the Inland Deserts, it is clear the uncertainty in the amount and seasonality of future precipitation complicates predictions about the future of the region. More robust climate model simulations of intra- and interannual precipitation would provide broad support for improved projections in other areas, since precipitation governs runoff and groundwater recharge rates, and development of fuel beds that control risk of severe wildfire. Another critical need for better understanding of future water resources is integration of surface and groundwater modeling, allowing simulations of the relationship between future climate, land cover, groundwater recharge, and surface runoff in response to climate change and human decisions.

Apart from physical drivers of water availability, there are also important questions about potential changes to water rights under climate change. For example, how would extreme reductions in Colorado River flows affect current water allocations? Similarly, the future of the Salton Sea is pivotal to the well-being of humans and ecosystems, but in the face of inaction, critical research questions remain. What kind of governance solution would it take to halt the shrinking of the Sea? What volume of fresh water is needed to maximize outcomes, and from where might this water come? How much will climate change exacerbate Salton Sea shrinkage rates? How severe are the public health risks from the Salton Sea within and beyond the region given different restoration scenarios?

The strength of the future economy of the Inland Deserts will likely depend on the development of robust renewable energy supplies that reduce greenhouse gases and air pollution. In order to realize this future while minimizing negative impact to other systems, research into the tradeoffs between distributed generation and utility-scale renewables that considers climate change effects on system infrastructure is needed. Development of smart sensor technology, microgrids, and efficient forms of energy storage will also be critical. Ideally, this will involve pilot demonstrations of these new technologies.

Continued strength of the tourism sector depends on a better understanding of the strength of the link between tourist decisions about where and when to travel to the Inland Deserts, and local climate conditions at their destination. Research on the link between travel behavior and temperature will also be useful for improved adaptation and resilience of the transportation sector.

More research is needed to identify community specific adaptation and mitigation strategies that are most appropriate for this region. Further research on the mechanisms of heat stress and its interactions with other health vulnerabilities may reveal new strategies to ameliorate the effects of extremely high temperatures on public health. How do spatial and temporal variability of air or land surface temperature affect the impact of heat on health, and can such information be used to mitigate this threat? Ways in which climate adaptation and mitigation strategies can be used in tandem to ameliorate current environmental justice issues and stresses should be explored, such as optimizing local climate in disadvantaged neighborhoods with combinations of solar panels and vegetation. Also, more research is needed to understand the future of urban development in the region given the expectation of extremely high temperatures in the region paired with climate impacts to other regions from which migrations to the Inland Deserts can be expected, such as loss of habitable land in coastal areas due to sea level rise.

Inland Desert valleys are already one of the hottest agricultural regions in the world, and essentially serve as a model for what many other agricultural regions will face in the future with respect to heat tolerance and high salinity soils. Much research about temperature effects on agriculture has taken place here, but projected warming will take

this region far past what it has experienced previously. More research about crop and animal response to higher temperatures, and ways to increase resilience is greatly needed. This may include research about the effectiveness of different cultivars, water application, crop planting cycles, and new models that better represent vegetation response to heat and elevated carbon dioxide levels.

While the climate refugia approach has been well studied for charismatic desert species such as the Joshua tree and the desert tortoise, such information is lacking for most desert species. Research to identify and protect refugia for a broader suite of endemic desert species could reveal the best adaptation options for these ecosystems as a whole.

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Appendix 2C

CALIFORNIA'S FOURTH CLIMATE CHANGE ASSESSMENT REPORT – LOS ANGELES REGION

CALIFORNIA'S FOURTH
CLIMATE CHANGE
ASSESSMENT

Los Angeles Region Report

Coordinating Agencies:

GOVERNOR'S OFFICE OF PLANNING AND RESEARCH · STATE OF CALIFORNIA ·

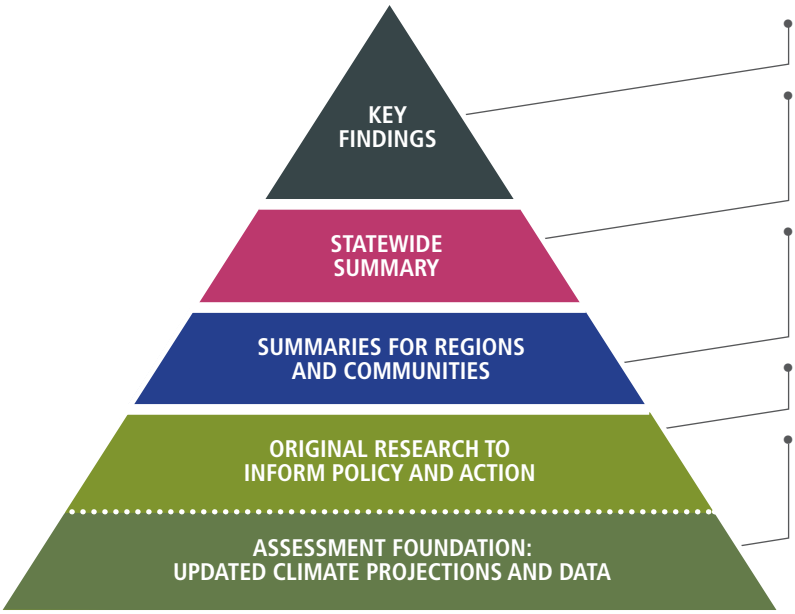
STATE OF CALIFORNIA ENERGY COMMISSION

CALIFORNIA natural resources AGENCY

Introduction to California's Fourth Climate Change Assessment

California is a global leader in using, investing in, and advancing research to set proactive climate change policy, and its Climate Change Assessments provide the scientific foundation for understanding climate-related vulnerability at the local scale and informing resilience actions. The Climate Change Assessments directly inform State policies, plans, programs, and guidance to promote effective and integrated action to safeguard California from climate change.

California's Fourth Climate Change Assessment (Fourth Assessment) advances actionable science that serves the growing needs of state and local-level decision-makers from a variety of sectors. This cutting-edge research initiative is comprised of a wide-ranging body of technical reports, including rigorous, comprehensive climate change scenarios at a scale suitable for illuminating regional vulnerabilities and localized adaptation strategies in California; datasets and tools that improve integration of observed and projected knowledge about climate change into decision-making; and recommendations and information to directly inform vulnerability assessments and adaptation strategies for California's energy sector, water resources and management, oceans and coasts, forests, wildfires, agriculture, biodiversity and habitat, and public health. In addition, these technical reports have been distilled into summary reports and a brochure, allowing the public and decision-makers to easily access relevant findings from the Fourth Assessment.

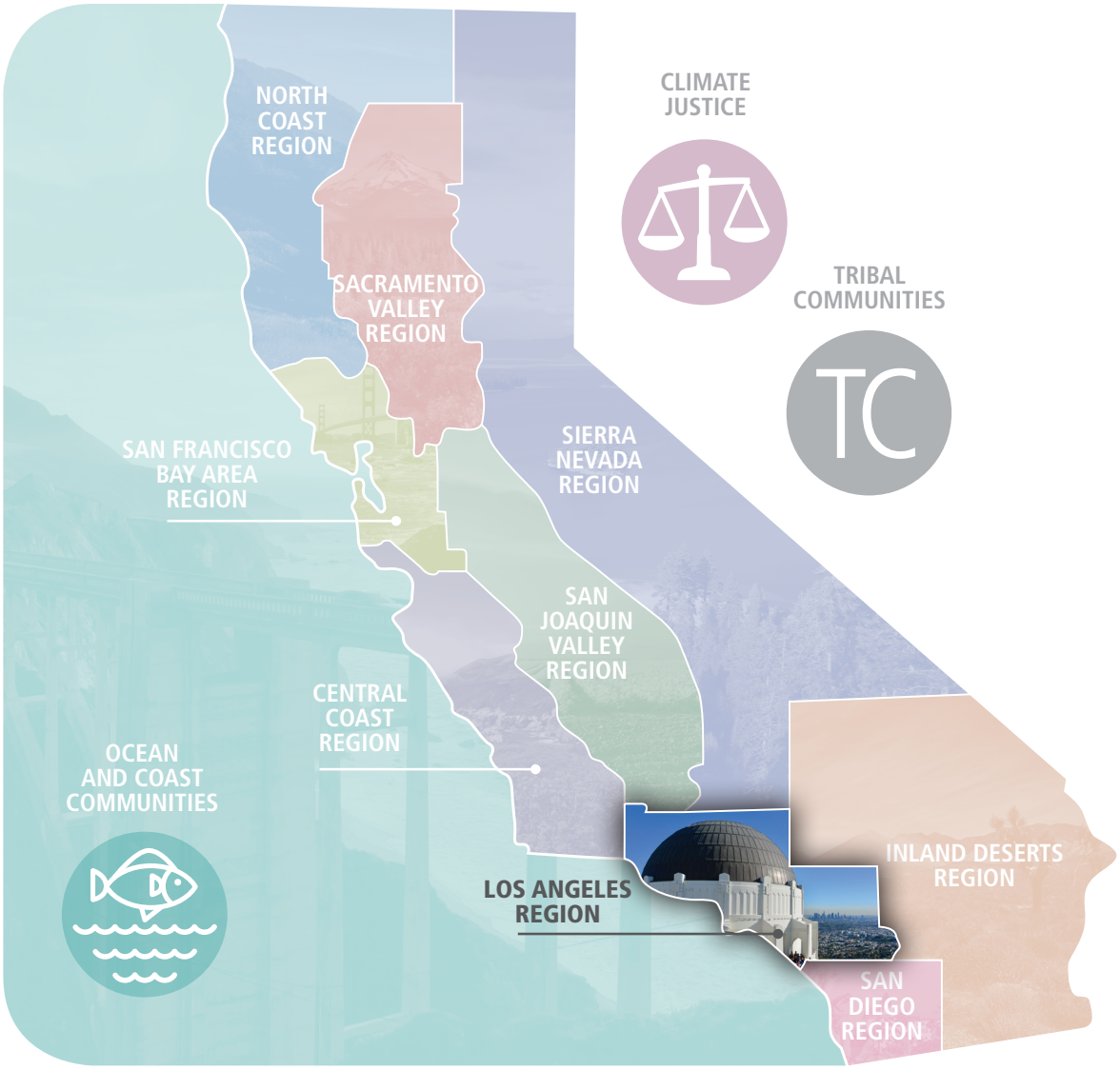


- A concise summary of the Fourth Assessment's most important findings and conclusions.
- An in-depth report on how California's people, built environment, and ecosystems will be impacted by climate change and how we can proactively adapt, based on the Fourth Assessment's findings.
- Reports summarizing Fourth Assessment findings to provide a state of the science for nine regions, the ocean and coast, tribal communities, and climate justice in California.
- Academic research that provides robust and detailed results on resilience and vulnerability to climate change.
- A shared foundation of updated climate change projections, data and ecosystem models developed for use by Assessment authors to permit cross-comparability of results and ensure the findings consider a robust range of future climate conditions. These data are available to the public via Cal-Adapt.org.

All research contributing to the Fourth Assessment was peer-reviewed to ensure scientific rigor as well as, where applicable, appropriate representation of the practitioners and stakeholders to whom each report applies.

For the full suite of Fourth Assessment research products, please visit: www.ClimateAssessment.ca.gov

Los Angeles Region



The Los Angeles Region Summary Report is part of a series of 12 assessments to support climate action by providing an overview of climate-related risks and adaptation strategies tailored to specific regions and themes. Produced as part of California's Fourth Climate Change Assessment as part of a pro bono initiative by leading climate experts, these summary reports translate the state of climate science into useful information for decision-makers and practitioners to catalyze action that will benefit regions, the ocean and coast, frontline communities, and tribal and indigenous communities.

The Los Angeles Region Summary Report presents an overview of climate science, specific strategies to adapt to climate impacts, and key research gaps needed to spur additional progress on safeguarding the Los Angeles Region from climate change.

Los Angeles Region Authors

COORDINATING LEAD AUTHOR

Alex Hall,
University of California, Los Angeles

LEAD AUTHORS

Neil Berg,
University of California, Los Angeles

Katharine Reich,
University of California, Los Angeles

CONTRIBUTING AUTHORS

Mike Antos
Santa Ana Watershed Project Authority

George Ban-Weiss
University of Southern California

Andre Biscaro
University of California, Davis

Sabrina Bornstein
City of Los Angeles

J. Mijin Cha
Occidental College

Oleg Daugovish
University of California Cooperative Extension, Ventura County

Ben Faber
University of California Cooperative Extension, Ventura County

Eric Fournier
University of California, Los Angeles

Timu Gallien
University of California, Los Angeles

Tom Gillespie
University of California, Los Angeles

Darren Haver
University of California Cooperative Extension, Orange County

Amber Kerr
University of California, Davis

Jaimee S. Lederman
University of California, Los Angeles

Caryn Mandelbaum
Environment Now

Martha Matsuoka
Occidental College

Juan Matute
University of California, Los Angeles

Fern Nueno
City of Long Beach

Jonathan Parfrey
Climate Resolve

Tapan Pathak
University of California, Merced

Stephanie Pincetl
University of California, Los Angeles

Erik Porse
University of California, Los Angeles

Elizabeth Rhoades
County of Los Angeles

James Sadd
Occidental College, and

Pablo Saide
University of California, Los Angeles

Jerry Schubel
Aquarium of the Pacific

Bhavna Shamasunder
Occidental College

Kristen Torres Pawling
County of Los Angeles

Alisa Williams
County of Los Angeles

STAKEHOLDER ADVISORY COMMITTEE

Marissa Aho
City of Los Angeles

Lee Alexanderson
Los Angeles County Department of Public Works

Fernando Cazares
Trust for Public Land

Juliette Finzi Hart
U.S. Geological Survey

Jason Greenspan
Southern California Association of Governments

Laurel Hunt
Los Angeles Regional Collaborative for Climate Action and Sustainability

Gregory Lopez
Leonardo DiCaprio Foundation

Tanya Peacock
Southern California Gas Company

ADDITIONAL REVIEW

Mark Gold
University of California, Los Angeles

CITATION: Hall, Alex, Neil Berg, Katharine Reich. (University of California, Los Angeles). 2018. ***Los Angeles Summary Report***. California's Fourth Climate Change Assessment. Publication number: SUM-CCCA4-2018-007.

Disclaimer: This report summarizes recent climate research, including work sponsored by the California Natural Resources Agency and California Energy Commission. The information presented here does not necessarily represent the views of the funding agencies or the State of California.

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Highlights

The Los Angeles (LA) region contains all of Ventura, LA, and Orange Counties, along with adjacent urbanized portions of San Bernardino and Riverside Counties. Topography in the region includes a large swath of coastal plains along the Pacific Ocean; the Santa Monica, San Gabriel, San Bernardino, Santa Ana, and San Jacinto Mountains; along with the western tip of the Mojave Desert in the Antelope Valley of northern LA County. Home to roughly 18 million people and growing, this region contains approximately half the population of California, and has a higher population than 45 other states. Countless ecosystems thrive throughout the region's coasts, mountains, and interior landscapes. The region also has immense economic value to California and the nation, including its entertainment and digital media industries, international trade through the Ports of LA and Long Beach, defense contracting, medicine, and a growing high-tech sector. Therefore, it is imperative to ensure that the human, economic, and natural systems across the LA region continue to thrive under a changing future climate.

Key projected climate changes include:

- Continued future warming over the LA region. Across the region, average maximum temperatures are projected to increase around 4-5 degrees F by the mid-century, and 5-8 degrees F by the late-century.
- Extreme temperatures are also expected to increase. The hottest day of the year may be up to 10 degrees F warmer for many locations across the LA region by the late-century under RCP8.5. The number of extremely hot days is also expected to increase across the region.
- Despite small changes in average precipitation, dry and wet extremes are both expected to increase. By the late-21st century, the wettest day of the year is expected to increase across most of the LA region, with some locations experiencing 25-30% increases under RCP8.5. Increased frequency and severity of atmospheric river events are also projected to occur for this region.
- Sea levels are projected to continue to rise in the future, but there is a large range based on emissions scenario and uncertainty in feedbacks in the climate system. Roughly 1-2 feet of sea level rise is projected by the mid-century, and the most extreme projections lead to 8-10 feet of sea level rise by the end of the century.
- Projections indicate that wildfire may increase over southern California, but there remains uncertainty in quantifying future changes of burned area over the LA region.

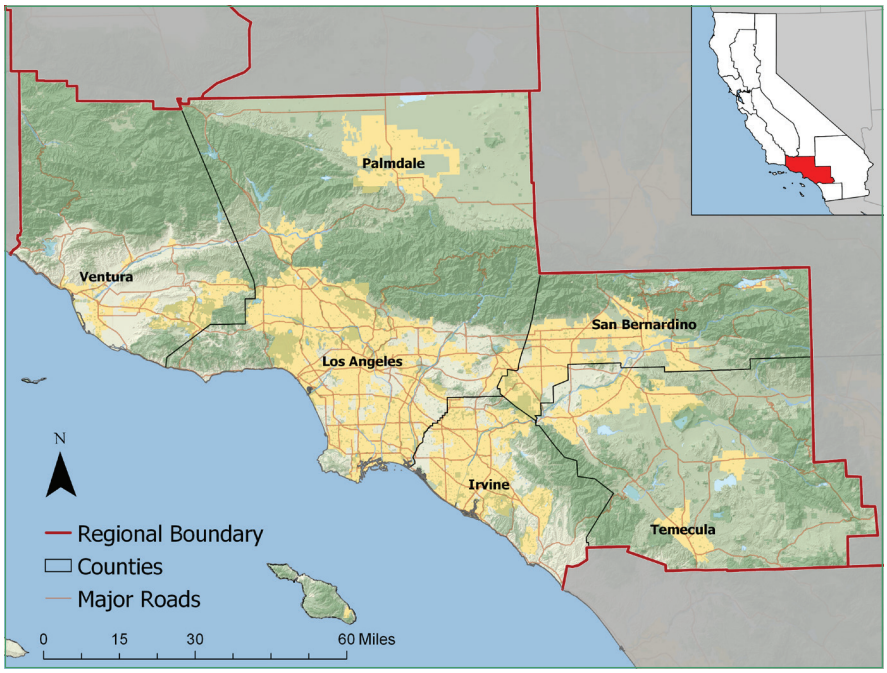
Introduction to the Region and Report

The Los Angeles (LA) region contains all of Ventura, LA, and Orange Counties, along with adjacent urbanized portions of San Bernardino and Riverside Counties (Figure 1). Topography in the region includes a large swath of coastal plains along the Pacific Ocean; the Santa Monica, San Gabriel, San Bernardino, Santa Ana, and San Jacinto Mountains; along with the western tip of the Mojave Desert in the Antelope Valley of northern LA County. Home to roughly 18 million people and growing, this region approximately contains half the population of California, and has a greater population than 45 other states. The region also has immense economic value to California and the nation, including its entertainment and digital media industries, international trade through the Ports of LA and Long Beach, defense contracting, medicine, and a growing high-tech sector.

The region is characterized by a Mediterranean climate with hot, dry summers and cool, wet winters. This famously pleasant climate influences all aspects of life in the LA region. Countless ecosystems thrive throughout the region's coasts, mountains, and interior landscapes. Substantial agricultural production occurs here, taking advantage of the bountiful sunshine and generally warm temperatures. Snow-based water from the Sierra Nevada (and Colorado Rockies) have, to date, largely satisfied the region's huge residential, industrial, agricultural, and ecological freshwater demands. A complex web of generation and transmission systems has also provided enough energy to power to the region's vast population. Cars, and especially solo driver traveling, remain the primary mode of transportation, leading to notoriously congested roadways with related problems of poor air quality blanketing the region.

Despite the region's overall prosperity, there remain significant environmental injustices. Large vulnerable communities, notably those that are economically disadvantaged – including racial and ethnic minorities, the elderly, and the homeless – are currently exposed to harmful environmental conditions. These include polluted air, water sources, and landscapes, in addition to heat stress.

FIGURE 1



Los Angeles region topography and boundary definition as a solid red line, which encompasses Los Angeles, Ventura, and Orange Counties, and adjacent urbanized portions of San Bernardino and Riverside Counties.

In fact, the region contains some of the most vulnerable neighborhoods in all of California, including much of East and South LA, Pomona, and Ontario. Future climate changes, especially increases in extreme heat, are expected to disproportionately burden low-income residents and communities of color across the region.

It is imperative to ensure that the human, economic, and natural systems across the LA region continue to thrive under a changing future climate. The LA Regional Collaborative for Climate Action and Sustainability (http://www.laregionalcollaborative.com/) and a handful of climate action plans within the region have already begun to organize and plan for these changes. Alongside these frameworks, this report summarizes the current understanding of projected local climate changes, and their impacts to public health, energy, transportation, land use, emergency management, vegetation and flora, oceans and coasts, agriculture, and water in the region. Examples of how the region has already adapted, or is planning to adapt, to new climate conditions are also included where available in certain sections of the report. They serve as clear examples that increasing the resiliency and sustainability of the LA region under a changing climate is a challenging yet achievable task. Overall, we intend for this report to serve as a summary of the latest science and impacts of regional climate change for stakeholders, policymakers, local officials, and others to consider in their decisions to help mitigate and adapt to these changes.

Regional Climate Science

In this section, we begin by briefly describing the climate and sea level projections developed for the Fourth Assessment that are examined for the LA region in this report. We then synthesize literature on observed changes and projected future changes to key aspects of the region's climate: temperature, precipitation, extreme storms, Santa Ana winds, sea level, wildfire, drought, clouds, humidity, and air quality.

Climate and Sea Level Rise Datasets

For the Fourth Assessment, Cayan et al. (2018) downscaled daily temperature and precipitation projections from 32 global climate models (GCMs) over California to a spatial resolution of 1/16° (around 6 km, or 3.7 miles) using a method called Localized Constructed Analogues (Pierce et al. 2014). 10 of the 32 downscaled GCMs were found to best simulate important aspects of California's climate and this subset of GCMs are used for analyses and figures in this report. The dataset includes a historical period of 1950-2005 and then two future projections spanning 2006-2100 based on two greenhouse gas emissions scenarios - Representative Concentration Pathways (RCP) 4.5 and 8.5. RCP4.5 represents a mitigation scenario where global CO2 emissions peak by 2040, while RCP8.5 represents a "business-as-usual" scenario where CO2 emissions continue to rise throughout the 21st century (van Vuuren et al. 2011). Public access to the downscaled data, along with mapping and other visualization tools, can be found at www.cal-adapt.org. Some caveats must be applied when interpreting the LOCA projections. The LOCA statistical downscaling procedure assumes persistence in the fundamental physics that drive spatial gradients across the region. Thus, future changes in sea breeze, clouds, and other local processes that could have important implications for spatial patterns of changes in temperature and precipitation are not captured in these projections.

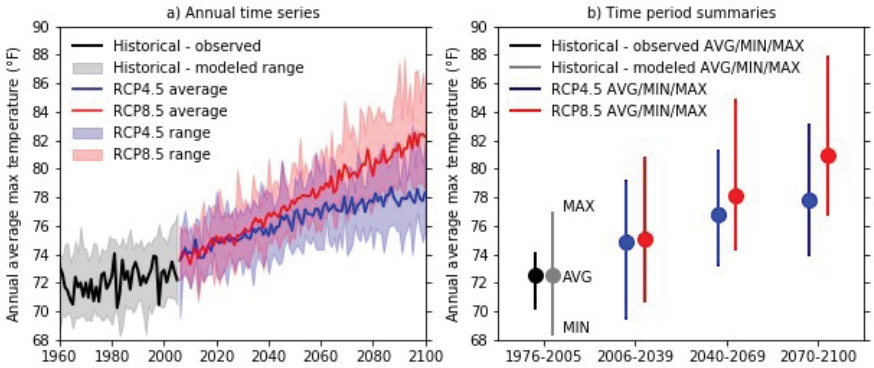
California-specific sea level rise projections were also developed for the Fourth Assessment (Cayan et al. 2018). Projections were generated under RCP4.5 and RCP8.5 scenarios using a probabilistic approach to estimate components that contribute to global and regional sea level rise, including possible contributions from Antarctica. Hourly sea level rise projections were also developed for selected coastal locations that include tides, regional and local weather influences, and short period Pacific climate fluctuations, along with the statewide sea level rise scenarios.

Temperature

Observations over the past century indicate that temperature has increased across southern California. Based on 1896-2015 temperature records for the California South Coast NOAA Climate Division, which encompasses the LA region, He and Gautam (2016) found significant trends in annual average, maximum, and minimum temperature around 0.16°C per decade. Every month has experienced significant positive trends in monthly average, maximum, and minimum temperature. Monthly average and minimum temperatures have increased the most in September and monthly maximum temperatures have increased the most in January, with each trend exceeding 0.2°C per decade. Recently, the California South Coast Climate Division has experienced sustained record warmth. The top 5 warmest years in terms of annual average temperature have all occurred since 2012: 2014 was the warmest, followed by 2015, 2017, 2016, and 2012 (data can be accessed at https://www.ncdc.noaa.gov/temp-and-precip/climatological-rankings/).

Warming is expected to increase across the LA region in the coming decades (Cayan et al. 2008; Horton et al. 2015; Swain et al. 2016; Maurer 2007; Hayhoe et al. 2004; Sun, Walton, and Hall 2015). Figure 2 shows projected changes in annual average daily maximum temperature using data sets developed for the Assessment. Figure 2a displays the annual averages for 1960-2005 using historical observations and model simulations, alongside 2006-2100 annual averages based on 10 downscaled GCM projections under RCP4.5 and 8.5. Figure 2b summarizes the continuous time series in Fig. 2a by noting the average annual-mean, along with the maximum and minimum annual-mean, across four time periods: 1976-2005 (historical), 2006-2039 (early-21st century), 2040-2069 (mid-21st century), and 2070-2100 (late 21st century). Projections are similar during the early-21st century regardless of emissions scenario. Only later in the 21st century do the projections diverge, as emissions continue to rise under RCP8.5, while they plateau in the mid-century under RCP4.5. Specifically, compared to the modeled historical annual average maximum temperature of 72.5°F, future model-average values are projected to increase to 74.8°F (model range of 69.5 - 79.1°F) by the early-21st century, 76.7°F (73.3 - 81.2°F) by the mid-21st century, and 77.8°F (74.0 - 83.1°F) by the late-21st century under RCP4.5 (blue dots and lines, Figure 2b). Corresponding model-average projections under RCP8.5 are 75.1°F (70.7 - 80.7°F) by the early-21st century, 78.2°F (74.4 - 84.8°F) by the mid-21st century, and 80.9°F (76.9 - 87.8°F) by the late-21st century (red dots and lines, Fig. 2b). Note that the data in Figure 2 combines inter-annual variability and model variability, resulting in apparent increases in future variability over the region.

FIGURE 2

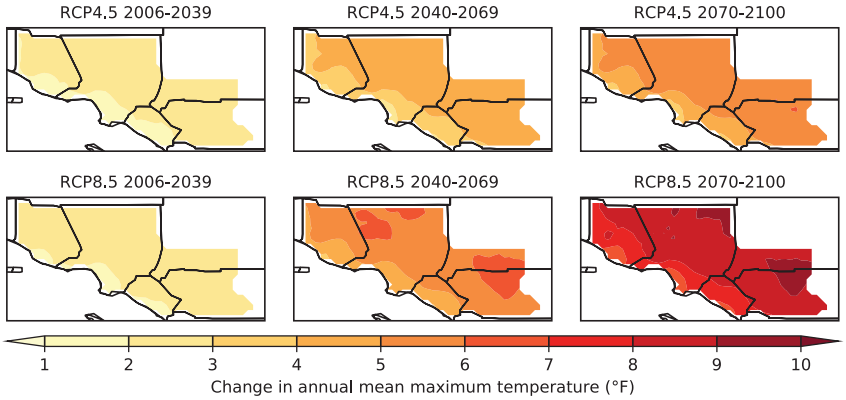


Historical-observed (black), historical-modeled (grey), and projected future (RCP4.5 - blue, RCP8.5 - red) annual average maximum temperature over the LA region. (a) Annual time series of data (future projections begin in 2006), with solid lines representing model-averages and shading representing model spread. (b) Summary of model-average (circles) and spread (vertical lines) across four time periods: 1976-2005 (historical), 2006-2039 (early-21st century), 2040-2069 (mid-21st century), and 2070-2100 (late-21st century). Unit is °F.

Clear spatial patterns are found in projected annual maximum temperature changes (Figure 3). Coastal regions in Ventura, LA, and Orange Counties are projected to experience relatively lower amounts of warming as the ocean provides a buffering effect to these areas. Interior regions are expected to experience the highest amounts of warming, up to 10°F in the late-21st century under RCP8.5. Projected annual temperature changes in Figures 2 and 3 are consistent with other recent studies. Using a different downscaling approach that examined changes across 35 GCMs, Sun et al. (2015) projected annual mean temperature changes over the greater LA region to be slightly over 2°C and 4°C by the mid- and end-of-century, respectively, under RCP8.5.

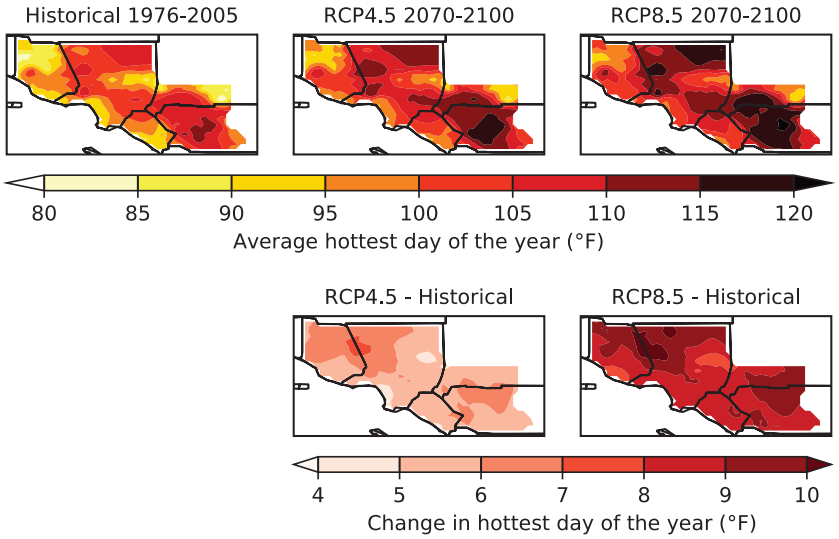
The intensity and frequency of extreme heat are also projected to increase over the LA region. The average hottest day of the year is expected to increase roughly 4-7°F under RCP4.5 and 7-10°F under RCP8.5 by the late-21st century (bottom row, Figure 4). Similar to the spatial pattern in annual max temperature changes, the largest changes in extremes are found in the interior of the region, and particularly the valleys, while the smallest changes are generally confined to coastal regions.

FIGURE 3



Spatial patterns of projected model-average change in annual mean maximum temperature under RCP4.5 and RCP8.5 for three time periods: 2006-2039 (early-21st century), 2040-2069 (mid-21st century), and 2070-2100 (late 21st-century). Unit is °F.

FIGURE 4



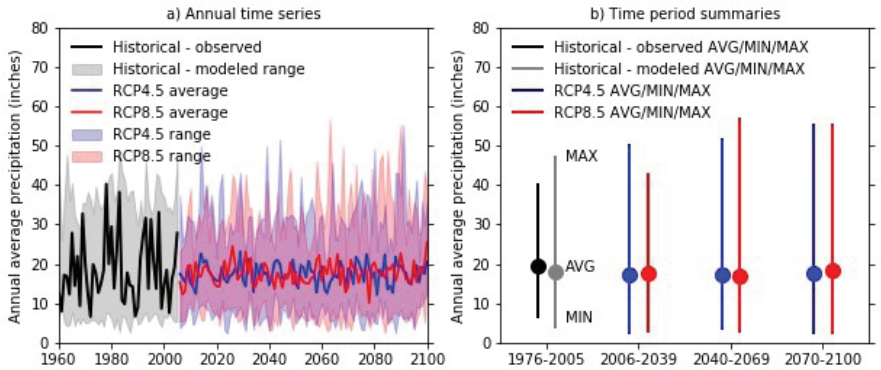
Top row: Average hottest day of the year in the historical (1976-2005) period, and in the late-21st century (2070-2100) under RCP4.5 and RCP8.5. Bottom row: change (late-21st century minus historical) in the hottest day of the year under RCP4.5 and RCP8.5. Unit is °F.

The number of extremely hot days is expected to increase in the future. For instance, LA International Airport (LAX) historically experiences less than 15 days per year with temperatures equal to or greater than 90°F (Cayan et al. 2018). By the end of the century under RCP8.5, LAX is projected to experience 50–90 such days per year (Pierce et al. 2018). Sun et al. (2015) similarly found that land locations are projected to experience 60–90 additional extremely hot days (greater than or equal to 95°F) per year by the end of the century, with the exception of the highest elevations and regions along the coast, where increases are only a few days.

Precipitation

Precipitation over the LA region is highly variable from year to year (black line in Figure 5a, Dettinger et al. 2011; Mitchell and Blier 1997) and only about five storms each year make up 50% of the annual precipitation total. Natural climate variability phenomena, such as the El Niño-Southern Oscillation, can influence the amount of precipitation that the region receives (Hoell et al. 2016), but there are no clear trends in historical precipitation for this region (Fig. 5a, He and Gautam 2016; Seager et al. 2014).

FIGURE 5

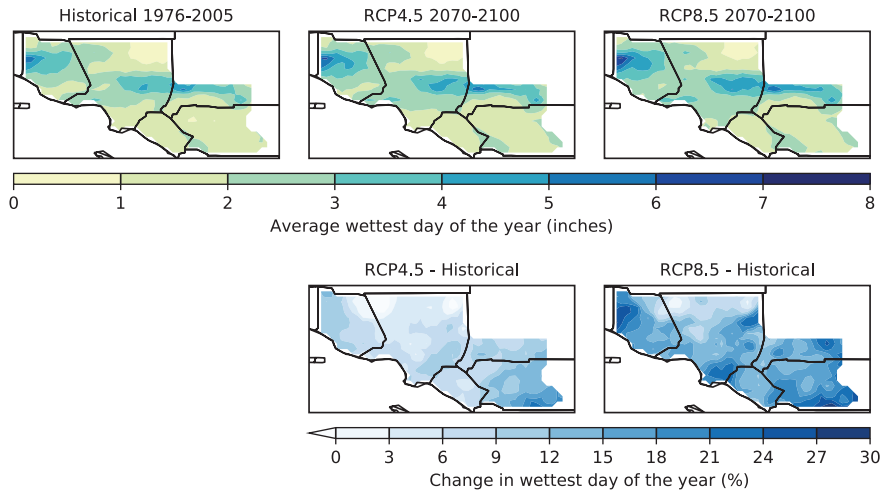


Historical observed (black), historical modeled (grey), and projected future (RCP4.5 - blue, RCP8.5 - red) annual average precipitation over the LA region. (a) Annual time series (historical: 1960-2005, RCP4.5/RCP8.5: 2006-2100), with solid lines representing model averages and shading representing spread across models. (b) Summary of model averages (circles) and spread (vertical lines) across four time periods: 1976-2005 (historical), 2006-2039 (early-21st century), 2040-2069 (mid-21st century), and 2070-2100 (late-21st century). Unit is inches.

Southern California lies between two large-scale zones of opposing projected precipitation change: general wetting in the northern mid-latitudes versus general drying in the southern sub-tropics (Guzman-Morales et al. 2016a; Hughes and Hall 2009a; Held and Soden 2006; Chou and David Neelin 2004; Trenberth 2011). Consequently, model projections disagree on the sign of future precipitation change over southern California, but generally project small mean changes (either positive or negative) compared to the region's large historical variability (Figure 6, Berg et al. 2015; Neelin et al. 2013; Pierce et al. 2012; Maurer 2007; Hayhoe et al. 2004).

Despite small changes in average precipitation, dry and wet extremes are both expected to increase in the future (Polade et al. 2014; Swain et al. 2018). By the late-21st century, the wettest day of the year is expected to increase across most of the LA region, with some locations experiencing 25-30% increases under RCP8.5 (Figure 6, lower panel). Extreme precipitation often arrives via "atmospheric rivers", and possible changes to these and other extreme storms are discussed further in the subsequent section. Extremely dry years are also projected to increase over southern California, potentially a doubling or more in frequency by the late-21st century (Swain et al. 2018).

FIGURE 6



Top row: Average wettest day of the year in the historical (1976-2005) period and in the late-21st century (2070-2100) under RCP4.5 and RCP8.5. Unit is inches. Bottom row: change (late-21st century minus historical) in the wettest day of the year under RCP4.5 and RCP8.5. Unit is percent.

Extreme Storms

Atmospheric rivers are regions of high water vapor transport from the tropics to the Pacific Coast of the U.S. that can produce intense topographic-induced precipitation along southern California mountain ranges (Neiman et al. 2008; J. Kim et al. 2012; Harris and Carvalho 2017; Guan et al. 2013; Payne and Magnusdottir 2014). Such events have helped pull the region out of droughts, although they are also responsible for devastating floods and mudslides (Ralph et al. 2006; Guan et al. 2013; M. D. Dettinger 2013). Between 1979-2013, 72 atmospheric rivers were identified as landfalling along the coast of southern California, approximately 2-3 events each year, though significant interannual variability exists. The frequency of atmospheric rivers over southern California has a potential connection to some natural climate variability patterns (Neiman et al. 2008; J. Kim et al. 2012; Harris and Carvalho 2017; Guan et al. 2013; Payne and Magnusdottir 2014).

Analysis of several previous-generation GCMs by (Dettinger 2011a) suggest that the frequency of atmospheric river events may increase in the future, and that the storms themselves will be associated with higher water vapor transport rates compared to historical conditions. Moreover, the peak season of atmospheric rivers may also lengthen, which could extend the flood-hazard season in California. The current generation of GCMs project a nearly 40% increase in precipitation during atmospheric river events over southern California by the late-21st century under RCP8.5. The number of atmospheric river events is also projected to increase in the future, possibly around a doubling of days by the end of the century (Warner et al. 2015; Hagos et al. 2016; Gao et al. 2015). Understanding future characteristics of atmospheric rivers, particularly over local spatial scales in California, remains an active area of research.

Santa Ana Winds

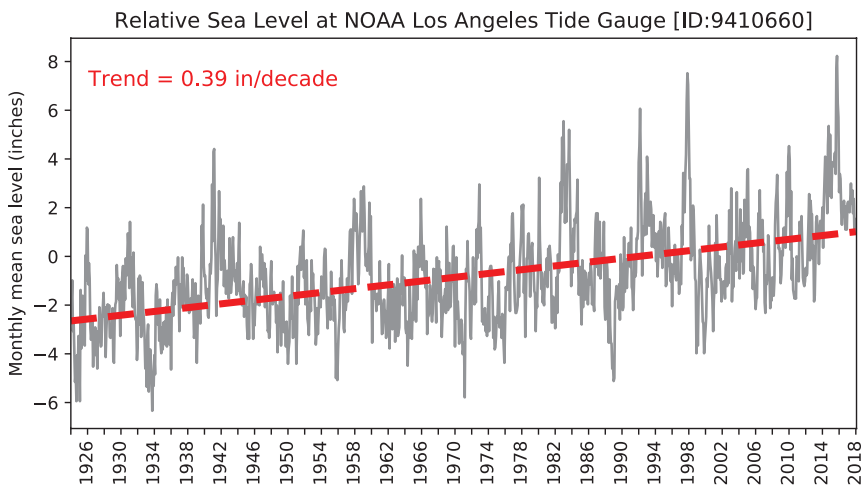
Characterized by strong northeasterly downslope and offshore flows, Santa Ana winds are a unique climatic feature during October to April in southern California. Very dry air associated with these winds can be catalysts for wildfire outbreaks in the region, notably the recent Thomas Fire in Ventura County in December 2017. Santa Ana winds tend to be most frequent in December, yet strongest in January (Guzman-Morales et al. 2016a; Hughes and Hall 2009a; Hughes, Hall, and Kim 2011a; Conil and Hall 2006). Significant interannual variability exists for these events, and there is evidence that their intensity may be connected with low-frequency climate variability patterns, such as the El Niño-Southern Oscillation and the Pacific Decadal Oscillation. However, no significant trends in intensity, duration, or frequency of Santa Ana winds have been detected during 1948-2010 (Guzman-Morales et al. 2016a; Hughes and Hall 2009a; Hughes et al. 2011a).

There is uncertainty in future changes to Santa Ana events. One study that examined two global climate models found an increase in future Santa Ana events, though others have found that the number of Santa Ana events may decrease around 20% in the future, as relatively greater warming over the interior land masses may weaken the ocean-to-desert temperature gradient that partly drives Santa Ana winds (Guzman-Morales et al. 2016b; Hughes and Hall 2009b; Hughes et al. 2011b; N. L. Miller and Schlegel 2006). Downscaling future wind fields and understanding their response to anthropogenic forcings remains a challenge and requires greater research going forward.

Sea Level Rise

Over the last century, ocean thermal expansion was the largest contributor to global mean sea level rise with secondary contributions from melting mountain glaciers and ice caps, and loss of ice sheets covering Greenland and Antarctica. Vertical land motion, along with changes in ocean and atmospheric phenomena, further influence local or relative sea level rise along the California coastline (Griggs et al. 2017). Figure 7 displays the observed record of monthly mean sea level at the NOAA LA gauge from 1924 through 2017. While substantial annual variability exists, a statistically significant ($p < 0.001$) linear trend of 0.39 inches per decade is found during this time period.

FIGURE 7



1924-2017 monthly mean sea level (with average seasonal cycle removed) for the NOAA Los Angeles tide gauge (grey line) and the long-term linear trend (red dashed line). Values are relative to the most recent Mean Sea Level datum established by CO-OPS. Data can be accessed at https://tidesandcurrents.noaa.gov/stationhome.html?id=9410660.

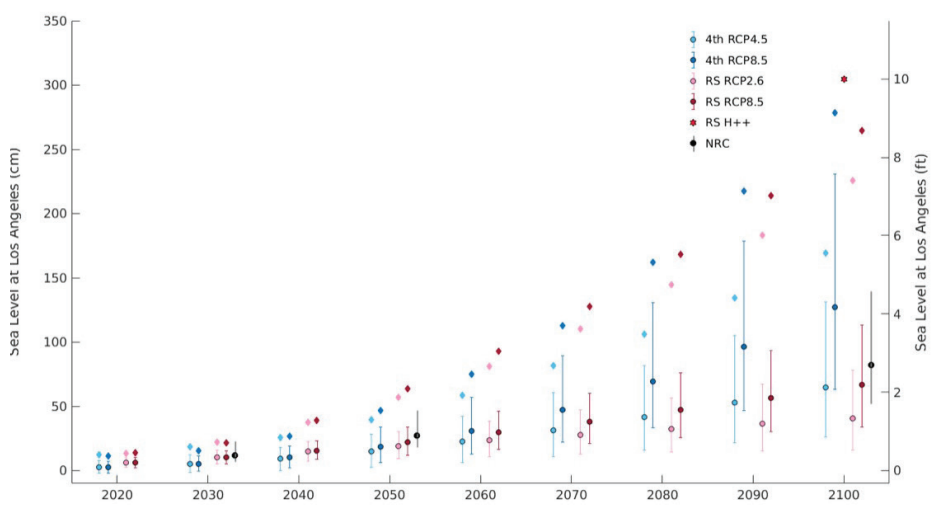
Sea levels are projected to rise in the future. The Fourth Assessment adopted probabilistic sea level rise projections following the method of Kopp et al. (2014) and incorporated new ice sheet dynamics for Antarctica, which include processes that could cause Antarctica to contribute significantly more to global sea level than previously thought (DeConto and Pollard 2016). Sea level rise projections developed for the Fourth Assessment include RCP4.5 and RCP8.5 emissions scenarios. The Rising Seas Report (Griggs et al. 2017), which is considered the state of the science for sea level rise in California, also produced sea level rise projections for the lowest scenario, RCP2.6, and includes an extreme sea level rise scenario called the H++.

Figure 8 displays sea levels for each decade remaining in the 21st century based on the probabilistic projections developed by the Fourth Assessment ("4th RCP4.5" [light blue lines] and "4th RCP8.5" [dark blue lines]), the Rising Seas projections ("RS RCP2.6 [pink lines], "RS RCP8.5" [dark red lines], and "RS H++" [red star in year 2100]). Uncertainty ranges are available for the Fourth Assessment RCP4.5 and 8.5 projections, along with the Rising Seas RCP2.6 and RCP8.5 projections. These uncertainty ranges are summarized by each dataset's 5th, 50th, 95th, and 99.9th percentiles. For additional reference, sea level rise projections and uncertainty for just the year 2100 according to the National Research Council are also shown (black dot and grey line in year 2100).

Focusing on the Assessment projections, differences between RCP4.5 and RCP8.5 begin to clearly emerge in the second half of the 21st century. Continued emissions and warmer future temperatures under RCP8.5 lead to drastically higher sea level rise projections compared to RCP4.5, especially by the end of the century. Specifically, the Fourth Assessment projects the 5th, 50th, and 95th percentiles of 2050 sea level rise to be 1.1, 5.9, and 11.1 inches under RCP4.5, with corresponding values of 2.3, 7.3, 13.3 inches under RCP8.5. By 2100, the 5th, 50th, and 95th values are 10.2, 25.4, and 51.7 inches under RCP4.5, and 24.8, 50.2, and 90.9 inches under RCP8.5. Differences between the Fourth Assessment and Rising Seas projections are also small until 2050. RCP8.5 projections by the Assessment are generally higher than corresponding projections by Rising Seas, and the ranges of projections for each dataset highlight that large uncertainty remains about how ice sheets and feedbacks in the climate system will respond to much warmer future temperatures.

Wide sandy beaches comprise much of the LA coastline. Therefore, in addition to sea level rise, the impacts of wave events from coastal storms is another important climate change consideration for this region. Recognizing the need to have projections of sea level rise in combination with coastal storms, the Fourth Assessment provided funding to complete the development of the USGS Coastal Storm Modeling System (CoSMos, O'Neill et al. 2018; Erikson et al. 2018) for the South Coast (Pt. Conception to the U.S./Mexico border). CoSMoS is a dynamic

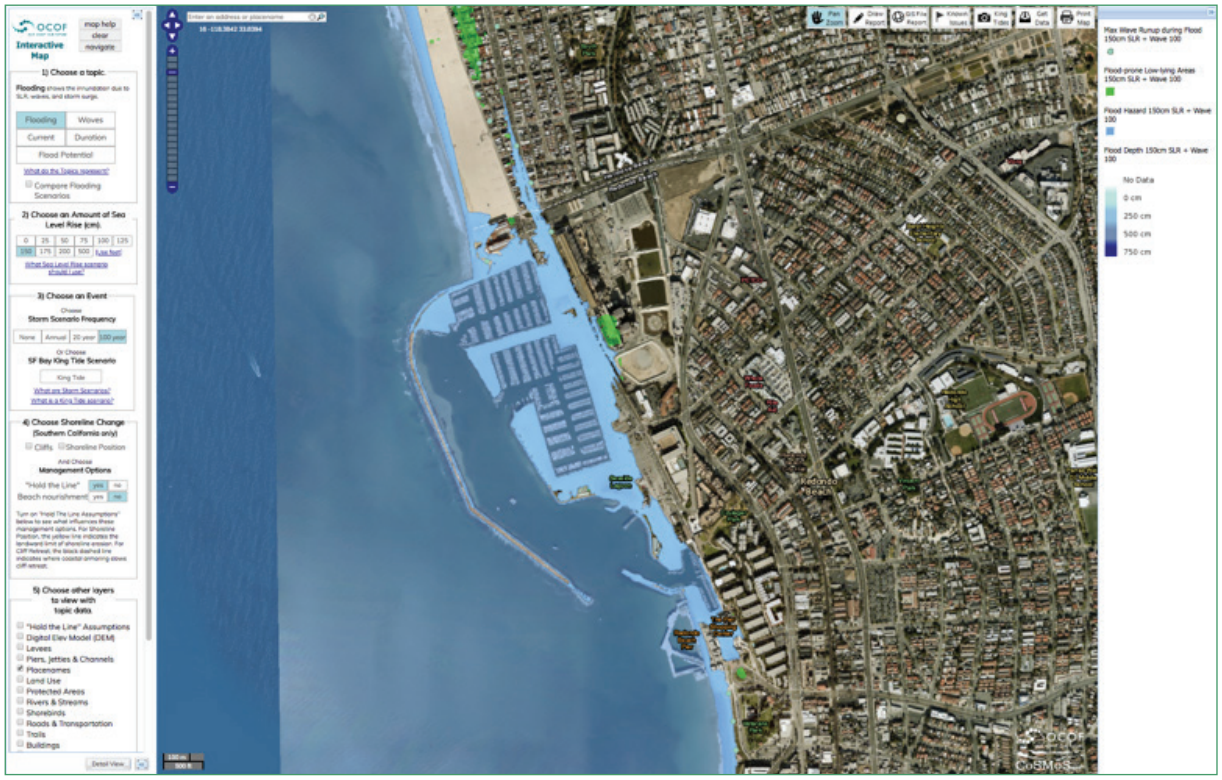
FIGURE 8



Los Angeles 21st-century sea level rise estimates for each decade based on: Fourth Assessment RCP4.5 (light blue) and RCP8.5 (dark blue), Rising Seas RCP2.6 (pink), Rising Seas RCP8.5 (dark red), and Rising Seas H++ in 2100 (red star). NRC is represented by the black dots and grey lines in 2100. Each decade's estimate is shown as a range from 5th to 95th with the circle representing the 50th percentile and diamond representing the 99.9th percentile. (Figure provided by Julie Kalansky.)

modeling approach that provides detailed predictions of coastal flooding due to both future sea level rise and storms integrated with long-term coastal evolution (i.e., beach changes and cliff/bluff retreat) over large geographic areas (hundreds of kilometers). CoSMoS models all the relevant physics of a coastal storm (e.g., tides, waves, and storm surge), which are then scaled down to local flood projections for use in community-level coastal planning and decision-making. Rather than relying on historic storm records, CoSMoS uses wind and pressure from global climate models to project coastal storms under changing climatic conditions during the 21st century. 40 different projections of sea level rise (0 - 2 meters and 5 meters at 0.25 m increments) and 4 storm scenarios (no storm, annual storm, 20-year return interval and 100-year return interval) are available for the LA region. One scenario is displayed in Figure 9, showing flooding for Redondo Beach based on projections of 4.9 ft (1.5 m) of sea level rise with a concurrent 100-year coastal storm.

FIGURE 9



Projections of 4.9 ft (1.5 m) of sea level rise with a concurrent 100-year coastal storm for Redondo Beach, CA. These data are publicly-available via the Our Coast, Our Future viewer, also funded by The Fourth Assessment.

Wildfire

Wildfire in southern California is influenced by a multitude of factors: a dry and warm Mediterranean climate with periodic episodes of Santa Ana winds and droughts, the type and spatial distribution of vegetation (along with dead/dry vegetation caused by pests), varying topography, large urban-wildland interfaces, past fire suppression attempts, and human activities (Jin et al. 2015; Dennison et al. 2014; Faivre et al. 2016; Moritz et al. 2010; Peterson et al. 2013; Parisien and Moritz 2009; Syphard et al. 2007). Nearly 80% of wildfires occur during the summer and fall, with a quarter of annual wildfires occurring during Santa Ana events. On average during 1959-2009, around 40 fires greater than 40 hectares occurred each year (average burned area of 53,300 hectares), though considerable year-to-year variability exists (Jin et al. 2014). Jin et al. (2014) found no significant historical trends in the number, size, or burned area of Santa Ana-driven fires, though the average size of summertime non-Santa Ana based fires significantly increased from approximately 1129 ha in the 1960s to 2121 ha in the 2000s. A significant increasing trend in the 90th percentile of fire size was also found during 1984–2011, though no trend in the number of large fires was detected (Jin et al. 2015; Dennison et al. 2014; Faivre et al. 2016).

Future projections by Jin et al. (2015) using statistical models indicate that southern California may experience a larger number of wildfires and burned area by the mid-21st century under RCP8.5. Overall burned area is projected to increase over 60% for Santa Ana-based fires and over 75% for non-Santa Ana fires. New wildfire projections were developed for the Assessment (Westerling et al. 2018) using different statistical models than those used by Jin et al. (2015), which also incorporated new datasets of future climate data and land use. Compared to the observed 1950-2009 historical average area burned of 53,300 hectares (Jin et al. 2015), the modeled 1976-2005 historical average area burned is roughly 16,000 hectares (Westerling et al. 2018). This discrepancy highlights that large uncertainties remain in current wildfire models, and is an area where further research is required. Based on the projections developed by Westerling et al. (2018), the annual burned area over the LA region may increase over 2000 hectares by the mid-21st century under RCP4.5 or RCP8.5 compared to simulated historical conditions. Similar, yet potentially slightly lower, increases are projected by the late-21st century, as continued warming (even with moderate precipitation increases) could lead to overall fuel declines necessary for wildfire.

Drought

Southern California is prone to periods of extremely dry conditions (MacDonald 2007; Woodhouse et al. 2010). The region recently experienced an exceptional drought during 2011-2015, with anthropogenic warming contributing to historically warm temperatures, dry soils, precipitation deficits, and low snowpack (Swain 2015; Mote et al. 2016; Margulis et al. 2016; Seager et al. 2015; AghaKouchak et al. 2014; Griffin and Anchukaitis 2014; Belmecheri et al. 2015). Anthropogenic warming has increased the probability that low-precipitation years coincide with warm years, increasing the current risk and severity of droughts and low snowpack in California (Diffenbaugh et al. 2015; Berg and Hall 2017; Williams et al. 2015). Atmospheric conditions conducive to California droughts, such as a persistent region of high pressure in the northeastern Pacific Ocean, may have also become more frequent in recent decades (Swain et al. 2016). GCMs project significantly drier soils in the future over the Southwest (including California), with more than an 80% chance of a multidecadal drought during 2050–2099 under RCP8.5 (Cook et al. 2015). Additional research is needed to better understand the prevalence and characteristics of future droughts on local scales in southern California.

Clouds

Low-elevation marine stratus and stratocumulus clouds are prevalent along the southern California coastline throughout the year and peak in the summer months, comprising more than 80% of all coastal clouds during the months of June through September (Iacobellis and Cayan 2013). These low clouds play an important role in the surface radiation balance and are a critical feature to certain marine ecosystems and vegetation types along the coast (Rastogi et al. 2016). The LA coast has experienced a 23% decline in stratus frequency since 1948, driven by a 63% reduction in fog frequency and potentially attributed to urban heat island effects of the region (Williams et al. 2015). Large uncertainty exists in future projections of low cloud changes, but there is emerging evidence from the GCMs that they will decline in the future (Klein et al. 2017). Further work is needed to reduce these uncertainties and improve low cloud projections along the southern California coastline.

Humidity

GCMs project a decline of relative humidity up to approximately 5% over southern California by the late-21st century under RCP8.5 (Sherwood and Fu 2014). A similar decline is found in the downscaled climate projections developed for the Fourth Assessment, with the largest changes occurring in the springtime (Cayan et al. 2018). This contradicts the finding of potentially fewer Santa Ana events in the future (p. 18), which would tend to increase relative humidity overall (as relative humidity dramatically drops during Santa Ana events (Guzman-Morales et al. 2016a). As such, there is a general lack of understanding behind the physical processes driving potential humidity changes, and more research of this aspect of climate change is needed.

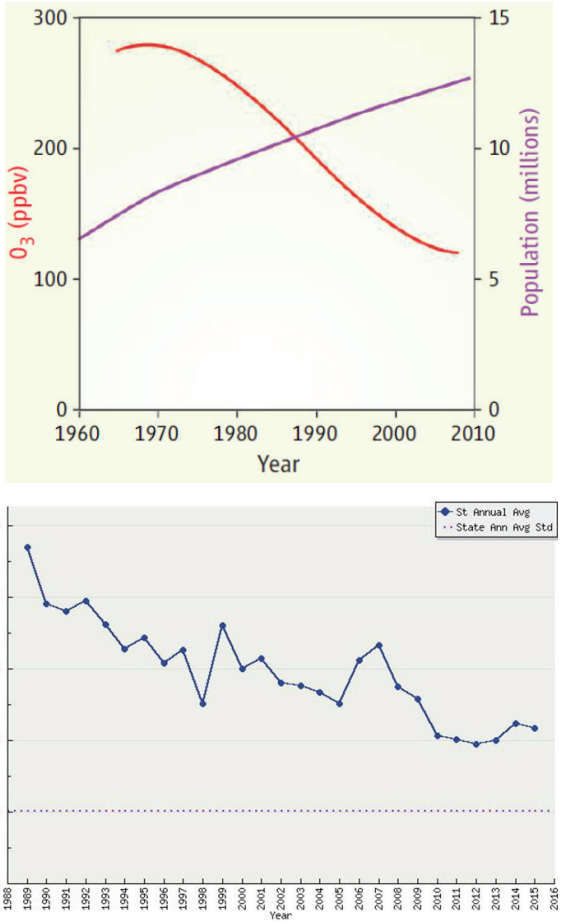
Air Quality

Despite a persistent growth in population, implemented reductions in emissions have significantly improved air quality in most metropolitan areas across the US, including LA (Figure 10). However, challenges remain as the LA basin is still the smoggiest region in the nation, creating large impacts on human health (Federico et al. 2017, Section 3.1).

Changes in meteorological conditions under climate change will affect future air quality. Regional stagnation conditions may occur more often in the future (Z. Zhao et al. 2011), which would increase pollutant concentrations (Jacob and Winner 2009). Hotter future temperatures (Section 2.2) will act to increase surface ozone concentrations both due to chemistry producing more ozone and higher rates of biogenic emissions, while increases of water vapor also influence chemistry by increasing ozone production in already polluted areas (Steiner et al. 2006). It's been estimated that ozone could increase up to 5-10 parts per billion (ppb) by 2050 in LA (Jacobson 2008; Pfister et al. 2014), and the number of days with ozone over 90 ppb could increase between 22-33 days (Abdullah Mahmud et al. 2008). While ozone may increase in the future, changes in particulate matter are less certain. Projected changes by 2050 are generally not statistically significant (Kleeman et al. 2012; A. Mahmud et al. 2010).

Assessments of future air quality also need to consider projected changes of emissions and long-range transport of pollutants. While some studies show that local anthropogenic emissions changes are expected to revert the expected ozone increase in LA (Pfister et al. 2014), others postulate that this might not happen under the planned emissions control program for ozone precursors (Rasmussen et al. 2013). Long range transport could also play a role in increased ozone concentrations in the future along the California coast (Steiner et al. 2006). While anthropogenic emission reductions due to climate change legislation are expected to reduce future particulate matter under multiple scenarios (Kleeman et al. 2012), an increase in wildfire activity is predicted to increase particulate matter in the region (Spracklen et al. 2009; Yue et al. 2013).

FIGURE 10



Top panel: Population and evolution of maximum ozone concentration in Los Angeles (Parrish and Zhu 2009). Bottom panel: PM10 (µg/m3) annual average in the South Coast Air Basin between 1988 and 2016 (www.arb.ca.gov/adam/trends/trends1.php).

Impacts on the Region

The previous section summarized the current scientific understanding about how the physical conditions in the LA region have already changed and how they are projected to change in the coming decades. Here, we discuss how a changing climate is expected to impact public health, energy, transportation, land use and community development, environmental justice, vegetation and flora, oceans and coasts, agriculture, and water across the region.

Human Systems

PUBLIC HEALTH

Climate change has been called "the biggest global health threat of the 21st century" (Costello et al. 2009). In the LA region, the health impacts of climate change are far-reaching, including direct and indirect impacts related to extreme heat, poor air quality, wildfires, infectious diseases, floods and mudslides, mental health concerns, and increasing disparities caused by disproportionate impacts to vulnerable populations. While some populations will be more severely affected than others, everyone in the LA region will be touched by these changes.

Extreme Heat

The number of extreme heat days in southern California is expected to increase considerably by the middle of the century as a result of climate change (pp. 11–12). Extreme heat is one of the most significant health impacts of climate change and already causes more deaths each year in the United States than floods, storms, and lightning combined (Berko et al. 2014). Exposure to extreme heat can cause direct heat-related illness (heat cramps, heat exhaustion, and heat stroke) and death, and can also exacerbate certain existing medical conditions. Heat waves are associated with increases in the number of people seeking emergency medical care for a variety of health conditions, though the magnitude of this effect depends on many factors, including geographic location, demographics, and availability of adaptive strategies such as air conditioning. During California's 2006 heat wave, there were 16,166 excess emergency department visits and 1,182 excess hospitalizations across the state, with increases in visits for kidney-related diseases, diabetes, and cardiovascular disease (Knowlton et al. 2009). Excess emergency department visits for respiratory illnesses were also found for certain regions, age groups, and racial/ethnic groups, although these effects were not significant statewide (Knowlton et al. 2009). Overall mortality also increased, with each 10°F increase in apparent temperature are associated with an estimated 9% increase in daily mortality (Ostro et al. 2009). Heat-related emergency department visits increased between 2005 and 2014 in LA County, though not steadily (California Office of Statewide Health Planning and Development 2017). Additionally, LA County may be one of the few locations in the United States that experiences heat-related mortality in the winter, possibly because winter temperatures have been known to exceed 90°F and can be unpredictable (Kalkstein et al. 2018).

Elements of the built environment contribute to heat-related health impacts. Specifically, high concentrations of impervious surfaces such as pavements and roofs and minimal tree canopy and green space create "urban heat islands" in heavily urbanized areas. Urban heat islands in non-tropical regions experience temperatures up to 5.4°F hotter than surrounding rural areas (Taha 2015a), an effect that increases in magnitude during heat waves (Zhao et al. 2018). The LA region experiences the largest urban heat island effect in the state (State of California n.d.). The urban

heat island effect means that populations in affected areas suffer from higher temperatures due simply to the built environment.

Extreme heat is also significant because of how it contributes to other climate impacts: extreme heat increases concentrations of ground-level ozone, contributing to poor air quality. Extreme heat and drought decrease soil moisture and increase plant mortality, factors that contribute to larger wildfires and poorer air quality. Plant die-offs also reduce available shade and evaporative cooling, raising surrounding temperatures and reducing the thermal comfort of pedestrians.

While all residents are affected to some extent by extreme heat, certain populations are more vulnerable to severe impacts. These include (a) low-income communities and communities of color, which often experience a greater urban heat island effect due to a lack of trees and other vegetation, and which have lower access to air conditioning (Reid et al. 2009a); (b) older adults, young children, people with chronic medical conditions, and people taking certain medications, who are physiologically vulnerable to the effects of heat (Kenny et al. 2010; Reid et al. 2009a; Tsuzuki-Hayakawa, Tochihara, and Ohnaka 1995); and (c) outdoor workers (Bethel and Harger 2014), people experiencing homelessness (Harlan et al. 2013), and others who spend a significant amount of time outside and are more exposed to extreme heat.

Unlike cities that have consistently experienced extreme heat in the past, the housing stock in LA is not designed for extreme heat. Approximately 51% of households in the LA-Long Beach area have central air conditioning (American Housing Survey 2015). While California code requires that landlords provide adequate heating facilities in homes, air conditioning is not a requirement. Moreover, the LA region's affordable housing crisis may prevent many renters from being able to move to air-conditioned homes where they would be less impacted by heat. Access to air-conditioned spaces may be additionally limited by factors such as mobility, vehicle ownership, perceptions of neighborhood safety, and distance to transit. These factors can prevent vulnerable populations from implementing adaptive and health protective strategies, such as getting to cooling centers or other air-conditioned locations.

Air Quality

The LA-Long Beach region already has some of the worst air quality in the country, ranking as the most polluted region in the United States for ozone and among the top 10 most polluted cities for year-round and short-term particle pollution (American Lung Association 2017). While air quality in the region has improved in recent decades, climate change threatens to reverse this trend. Higher future temperatures are likely to increase the production of ground-level ozone, a respiratory irritant that is a component of smog. Ground-level ozone is associated with various negative health outcomes, including reduced lung function, pneumonia, asthma, cardiovascular-related morbidity, and premature death (US EPA 2013). Simulations for the city of Upland, California project that median ozone concentration will increase by 27 ppb between 2011-2020 and 2091-2100 in the A2 climate scenario (Abdullah Mahmud et al. 2008). Ozone pollution may increase the most in places that already experience high levels (Jacobson 2008), suggesting that the LA region may see the greatest increases in ozone pollution in the country. Such increases would be expected to lead to corresponding increases in morbidity and mortality (Bell et al. 2004, 2007; Chang, Zhou, and Fuentes 2010; Ebi and McGregor 2008; Post et al. 2012).

Many of the same populations that are vulnerable to the effects of extreme heat are also vulnerable to the effects of poor air quality. These include the elderly; young children; people with existing respiratory and cardiovascular conditions such as asthma, chronic obstructive pulmonary disease, and heart disease; and low-income populations and communities of color. These populations are more likely to live in areas with worse air pollution, such as near freeways or industrial facilities, and in neighborhoods without the air filtering benefits of trees, and are also more likely to be exposed to indoor air pollutants from poor housing quality (Bell, Zanobetti, and Dominici 2014; Sacks et al. 2011).

Wildfires

The area burned by wildfires in southern California is projected to increase by the middle of the century (p. 18). Wildfires have various negative consequences for public health (Finlay et al. 2012), including, but not limited to: deaths and injuries; post-traumatic stress and depression due to deaths, injuries, loss of property, displacement, or other trauma (Marshall et al. 2007); and respiratory impacts due to poor air quality. Smoke from wildfires contains particulates and chemicals that are harmful to respiratory health. Consequently, wildfires are associated with increases in hospital admissions for asthma, acute bronchitis, chronic obstructive pulmonary disease, and pneumonia (Delfino et al. 2009; McDermott et al. 2005). An analysis of 11 wildfires in the Western United States between 2002 and 2013 found that air quality in urban areas 50-100 miles away from the fires was frequently 5-15 times worse than usual (Kenward et al. 2013). As with other climate impacts, wildfires often disproportionately impact vulnerable populations. For instance, low-income populations have fewer resources to recover from wildfires (Mazur et al. 2010) and are already more likely to suffer from respiratory illnesses that increase their vulnerability to poor air quality (Wolstein et al. 2010).

Infectious Diseases

VECTOR-BORNE DISEASES

Climate influences the population size, geographic distribution, and reproduction of vectors (rodents, mosquitoes, ticks, fleas, and others) that transmit diseases to humans (Gubler et al. 2001). The many factors that contribute to the incidence of vector-borne diseases—such as land use patterns and human behavior (Gubler et al. 2001)—present challenges in projecting their spread. However, current patterns provide some clues. For instance, reported cases of West Nile Virus increase during warm weather (Hahn et al. 2015). While incidence of West Nile Virus human cases and fatalities fluctuate greatly from year to year, 2017 showed the greatest number of human West Nile Virus deaths ever recorded in LACounty (LA County Department of Public Health 2017). Models for North America project increases in West Nile Virus infections in humans, caused by increasing temperatures and declines in rainfall (Harrigan et al. 2014).

In recent years, invasive *Aedes* mosquitoes (*Aedes albopictus* and to a lesser extent *Aedes aegyptii*) have appeared in LA County (California Department of Public Health 2018). These mosquitoes are known vectors for dengue fever, Zika virus, and chikungunya virus. While there have as yet been no known locally acquired human cases of these diseases, there remains the possibility of local transmission occurring as travelers return from affected regions.

VALLEY FEVER

Valley Fever is a noncontagious disease arising from a fungus endemic in soils in the Southwest, including parts of southern California. People are most likely to acquire Valley Fever in areas where the fungus spores become airborne and are inhaled during windy, dusty conditions (Schneider et al. 1997). Human cases of Valley Fever in LA County have increased steadily since 2009, with a 37% increase between 2015 and 2016 (Schwartz & Terashita 2017). Although the reasons for this increase are unclear, drought conditions exacerbated by climate change may contribute to higher dust levels, and consequently to increased risk for Valley Fever.

Floods and Mudslides

The projected increase in precipitation extremes, alone and in combination with the projected increase in wildfires, creates increased potential for floods, mudslides, and debris flows. Additionally, sea level rise increases the potential for flooding in coastal areas. Debris flows, such as those seen in Santa Barbara County in early 2018 (Livingston et al. 2018), can result from heavy rains preceded by wildfires that strip the land of vegetation. Flooding and mudslides have direct public health impacts such as deaths, injuries, and other trauma, and indirect impacts resulting from factors such as water contamination, damage to infrastructure, and mold contamination in homes following the subsidence of floodwaters (Riggs et al. 2008).

Mental Health

Climate change may impact mental health through various pathways, including but by no means limited to (a) increases in the frequency and severity of extreme weather events; (b) increasing economic instability; and (c) uncertainty about the future of the planet. Extreme weather events such as fires and floods can have acute mental health impacts. Clear links exist between extreme weather events and anxiety and depression (Kar and Bastia 2006), post-traumatic stress disorder (Neria, Nandi, and Galea 2008; Kar and Bastia 2006), and suicide (Krug et al. 1999).

Climate change can also precipitate chronic impacts. Climate change may negatively impact livelihoods, leading to mental health impacts such as chronic stress, depression, and suicide. Recent research linked high temperatures and associated reduced crop yields in India with nearly 60,000 suicides over a 30-year period (Carleton 2017). Links between drought and farmers' suicides have also been established elsewhere (Hanigan et al. 2012).

Additionally, people who are concerned about climate change may experience anxiety about the future of the planet. Some researchers and news media have termed this "ecoanxiety" (Albrecht 2011). Ecoanxiety can involve feelings of helplessness, as well as guilt over one's own contribution to greenhouse gas emissions (Moser 2013).

Disproportionately Impacted Populations and Increasing Disparities

Climate change disproportionately affects those with existing disadvantages. Low-income communities and communities of color often live in areas with conditions that expose them to more severe hazards, such as higher temperatures and worse air quality. These communities also have fewer financial resources to adapt to these hazards. For instance, low-income populations are already disproportionately burdened by energy bills (Drehobl & Ross 2016) and may reduce air conditioning usage out of concerns about cost. People with chronic medical conditions are often more physiologically susceptible to negative health impacts from extreme heat and poor air quality, and those with

mobility issues are particularly at risk. Many of the above risk factors are often present in older adults, who are more likely to have a limited income, chronic health conditions, and mobility limitations, and are more likely to experience social isolation. Also at heightened risk are people experiencing homelessness, who are most exposed to the hazards of extreme weather and experience barriers to seeking assistance. Likewise, undocumented immigrants and migrant workers often face poverty, linguistic isolation, political disenfranchisement, and fears of being apprehended by immigration officials when accessing government services, which present significant barriers to seeking resources to adapt to extreme weather and other climate impacts.

These disproportionate health impacts act on the social determinants of health (such as income) to further exacerbate existing disparities. For instance, increasingly poor air quality increases the number of impacted days—days in which people must restrict activity or miss work or school—exacerbating gaps in income and educational achievement. Climate effects can negatively impact agriculture, contributing to higher food prices (Chung et al. 2014) and further reducing access to affordable, healthy food options. These are only a few examples of how climate impacts further increase disparities. The Public Health Institute, a prominent California nonprofit focused on health and wellness, notes that "the disproportionate impacts of climate change on individuals with pre-existing conditions and on socially disadvantaged groups threaten to greatly exacerbate existing health and social inequities, globally and within the U.S." (Rudolph et al. 2015).

Recommendations

It is critical to implement strategies that protect the public from the health impacts of climate change by reducing greenhouse gas emissions and building resilience to climate impacts. Public health professionals are in a uniquely important position to deliver messages about climate change and strategies for addressing it, as health professionals remain highly trusted messengers (Maibach et al. 2015), and research shows that framing climate change in the context of health is the most effective way to elicit support for climate policies (Myers et al. 2012). Local health departments in particular engage directly with impacted communities and are on the front lines of protecting the public from the health impacts of climate change. With additional resources, local health departments can undertake activities such as expanding capacity to model and forecast health impacts and plan for those impacts;,tracking data on climate-related health indicators, improving preparedness and response plans for climate impacts, and training healthcare professionals on best practices for how to teach patients to protect themselves from climate impacts.

As the Lancet Commission on Health and Climate Change notes, climate change presents a "potentially catastrophic risk to human health" but "tackling climate change could be the greatest global health opportunity of the 21st century" (Watts et al. 2015). This is because the actions needed to counter climate impacts—those the Lancet Commission calls "no-regret" options—are exactly those that improve health outcomes and reduce inequities. For instance, using active and public transportation reduces greenhouse gas emissions and promotes public health through increasing physical activity and decreasing air pollution. Improving energy efficiency and transitioning to clean energy reduces air pollution. Changing patterns of food consumption—for example, eating less meat—reduces emissions associated with industrial livestock operations and reduces the risk of cardiovascular disease and other poor health outcomes. Urban heat island reduction—urban greening and transitioning to cool surfaces such as cool roofs and cool pavements—reduces emissions associated with air conditioning use and cools neighborhoods. As outlined in this section, climate change presents myriad threats and challenges. But it also presents opportunities

to implement "no-regret" options such as those listed here, that help to create healthier, more resilient, and more equitable communities.

EMERGENCY MANAGEMENT

LA County and the surrounding areas of southern California have already seen an increase in the frequency and intensity of emergencies exacerbated by climate change. The challenges brought on by climate change result in hardship for families, businesses, and local governments and demand an evolving response by government agencies tasked with protecting life and property. The research of the First, Second, and Third Assessments has already helped shape the County's preparedness for climate impacts to infrastructure, public health, and land use decisions, and ongoing research is essential for informing emergency response. As the municipal government for the more than one million residents of the unincorporated County area and as the provider of public safety services and coordinator of emergency response and recovery for nearly nine million more, the County of LA faces an acute urgency to adequately prepare and respond to the new normal of climate-related and climate-exacerbated emergencies.

Climate change will continue to compound the impact of future disasters in scope and severity. The County plays a planning, coordination, operational, training, and public education role in responding to emergencies. As defined by California State Code, the County of LA Office of Emergency Management (OEM) is the lead agency for the "Operational Area", which includes all of the independent cities and Special Districts in LA County. As the Operation Area Coordinator, LA employs a set of policies, procedures and practices to ensure an effective response to the most prevalent local emergencies driven by climate change – namely wildfires, mudslides in burn areas, drought, heat waves, vector-borne public health emergencies, sea level rise, and urban flooding. The LA County OEM works with County departments, cities, and partner agencies to increase the capability of the region to mitigate, prepare for, respond to, and recover from all hazards impacting the County, including those exacerbated by climate change.

OEM has already seen the direct impact of climate change in its operations. Increased staff hours have been spent on the consequences of climate change, as seen with the most recent drought, in which local water supplies were severely impacted. Specifically, in 2014, a northern LA County community in Bouquet Canyon faced a complete depletion of the local well field, requiring County response. The repercussions of climate change have triggered longer Emergency Operations Center activations and fire recovery efforts, including community outreach and Local Assistance Centers, as well as increased engagement with community partners and governmental agencies. Fire recovery efforts include post-fire hazard mitigation and cleanup. In addition, there has been a significant increase in pre-event planning and response and recovery actions for winter storms to mitigate and avoid the consequences of mud and debris flows on burn scars. OEM also monitors the response to the increase in frequency and severity of wildfires due to the drier conditions of hillside vegetation, and a considerable amount of time and effort is spent addressing the impacts of these events on vulnerable populations, such as children, the homeless, non-English speakers, and people with access and functional needs.

A yearly Threats and Hazards Identification and Risk Assessment is conducted to map out risks to the whole community, which includes individuals and families and those with disabilities and others with access and functional needs, businesses, faith-based and community organizations, nonprofit groups, schools and academia, media outlets, and all levels of government. This assessment includes climate change considerations regarding community

vulnerabilities and the necessary adjustments to current planning and response efforts due to climate change. For example, due to more extreme drought conditions and flooding, there may be a change to the availability of various foodstuffs or water when a disaster strikes. Planning efforts account for these potentialities in the event of a mass care incident where a disaster may impact distribution plans or the usual way of getting resources to a large number of people.

OEM develops specific plans often based on models for each of the areas within the County of LA impacted by specific disasters such as the coastal communities along the Pacific Ocean. Areas such as Marina Del Rey, Venice, Malibu, Redondo, San Pedro, and Wilmington are threatened by potential sea level rise due to climate change, and mitigation strategies are addressed and outlined within these planning documents. Emergency management will assign a greater focus on mitigation strategies and increase planning and response efforts to address these climate-related inevitabilities.

OEM also collaborates with partners on planning efforts and mitigation actions to promote community resiliency. For example, the Chief Executive Office's Office of Homeless Initiative, in partnership with OEM, designated County departments, and other agencies, have implemented an Augmented Winter Shelter Program (AWSP) as of 2015 to address increased rainfall and/or cold weather. The AWSP provides increased temporary shelter operations for individuals experiencing homelessness when adverse weather conditions meet an established threshold. Similarly, the Department of Public Health, in partnership with Workforce Development, Aging and Community Services, Parks and Recreation, and Internal Services, has established cooling centers that are open to the public during severe heat waves.

The pervasive nature of climate change impacts manifests in all types of County departments outside of core emergency response departments. The Department of Animal Care and Control has observed impacts of the increased incidence and intensity of wildfires on its emergency operations. The 2016 Sand Fire resulted in the largest animal evacuation and sheltering operation in the Department's history. Eight hundred domestic and barnyard animals were housed across five sheltering sites in partnership with three of the Department's thirteen mutual aid partners. Even prior to the Sand Fire, the Department made operational, community outreach, partnership, and leadership modifications to incorporate climate change risks. In an analysis of its preparedness, the Department found that to address climate emergencies, it will likely need to address the gap in the human resources needed to staff incidents with greater intensity to adequately maintain its existing operations.

The County also recognizes the unequal distribution of impact during emergencies. As described in other parts of this chapter, the social and physical impacts of climate change are not distributed equally. As the County develops a Countywide Sustainability Plan throughout 2018 and into 2019, it will further assess and plan for climate-related emergencies with a focus on equity. In January 2018, the County Chief Sustainability Office responded to a request from the Board of Supervisors to outline how the framework of the forthcoming Countywide Sustainability Plan incorporates climate impacts and extreme weather. All of the County departments responsible for emergency management are engaged in the process of developing the Countywide Sustainability Plan, which will articulate regional, long-term goals related to climate mitigation, adaptation, and resilience in a way that prioritizes actions to prevent climate-related emergencies.

CASE STUDY | LONG BEACH CLIMATE ACTION & ADAPTATION PLAN
Fern Nueno - City of Long Beach

The City of Long Beach began developing a Climate Action and Adaptation Plan (CAAP) in 2017 and anticipates that the CAAP will be completed in 2019. The CAAP is a coordinated, long-range planning effort to address climate change at a local level and promote a healthy and prosperous community. Through the CAAP, Long Beach will be able to meet regulations regarding greenhouse gas emissions, sea level rise, and the California Environmental Quality Act (CEQA). Other objectives for the CAAP include engaging a wide cross-section of the public in development of the plan with a focus on nontraditional outreach; building a shared commitment to greenhouse gas emissions reductions and adaptation measures across City departments, residents, scientific and educational institutions, and the business community; providing a publicly accessible and engaging method of monitoring and displaying progress of meeting CAAP goals; and improving economic opportunity and quality of life for residents.

The CAAP contains two related components: climate action and climate adaptation. Climate action (also known as climate change mitigation) refers to reducing impacts on the climate system by reducing future carbon emissions. Climate adaptation (also known as climate change resilience) refers to reducing the impacts of climate change by adjusting behaviors, systems, and/or infrastructure. The climate action component of the plan includes a greenhouse gas emissions inventory, forecast of projected emissions, emissions reduction targets, analysis of existing reduction efforts, development and implementation of strategies to reduce emissions, and regular monitoring of the plan. The emissions-generating sectors included in the plan are energy, transportation, wastewater, water, and solid waste. The climate adaptation component of the plan includes identification of climate change hazards, an inventory of City assets and operations, a vulnerability and risk assessment of identified assets and operations, development and implementation of measures to adapt to climate change hazards, and regular monitoring of the plan. The climate change hazards that have the potential to negatively impact Long Beach are sea level rise, extreme heat, precipitation, drought, and poor air quality. Long Beach is already seeing negative impacts of climate change and the CAAP will equip the City to effectively deal with the challenges of a changing future.

The robust and inclusive community engagement process will result in an innovative and actionable plan that reflects the Long Beach community. The process includes working groups with scientific experts, business representatives, and community stakeholders, in addition to open houses, online engagement, and other events for outreach to the general public. Outreach efforts focus on engaging with participants who are traditionally underrepresented in governmental decision making, and bringing together community organizations working towards environmental justice, environmental advocacy, and increasing youth participation. Long Beach is enthusiastic about the many benefits that will result from the CAAP.

ENVIRONMENTAL JUSTICE

This section provides a framework for understanding and assessing the unequal and disproportionate impacts of climate change in low-income communities of color in the region. The discussion below draws from the State policy framework of cumulative impacts to assess climate impacts, as well as a benefits and burdens framework to prioritize state actions to address the impacts of climate change in our most vulnerable communities. In earlier sections of this report, research shows that the effects of climate change – as well as approaches for mitigation and resiliency – disproportionately burden and/or diminish the impact of climate change on low-income communities of color leaving these communities vulnerable (English et al. 2016). A cumulative analysis framework considers environmental, social, and economic factors that can play a role in the unequal impacts of climate change and illustrates the limits of individual and group resilience, as well as the uneven ability at the community level to respond and adapt to impacts from climate change. More on the uneven ecological, social, and political impacts climate change is projected to have on California's vulnerable communities may be found in a companion Fourth Assessment piece (Climate Justice Summary Report 2018).

The concept of cumulative impacts is rooted in the history of disproportionately impacted communities organizing to reframe environmental conditions as everyday lived experiences. The environmental justice movement emerged in the 1980s, with its roots in the civil rights and indigenous peoples movements, and drew attention to the disparate placement of undesirable land uses (as well as unequal policy protections) in native, poor communities and communities of color.[1] Efforts by impacted communities to address regulatory inaction and unequal enforcement in communities with multiple polluting sources finally led the Environmental Protection Agency to recognize environmental justice in 1994 and set the federal standard for "the fair treatment and meaningful involvement of all people regardless of race, color, national origin, or income with respect to the development, implementation, and enforcement of environmental laws, regulations, and policies."

The knowledge and leadership by environmental justice organizations have since forged environmental justice policy at the state, regional, and local levels that sets the basis to address climate change impacts that disproportionately affect low-income communities of color. The environmental justice frameworks presented here make the necessary linkages among climate emissions, co-pollutants, and factors contributing to cumulative impacts and sets forth pathways for equitable policy development and implementation.

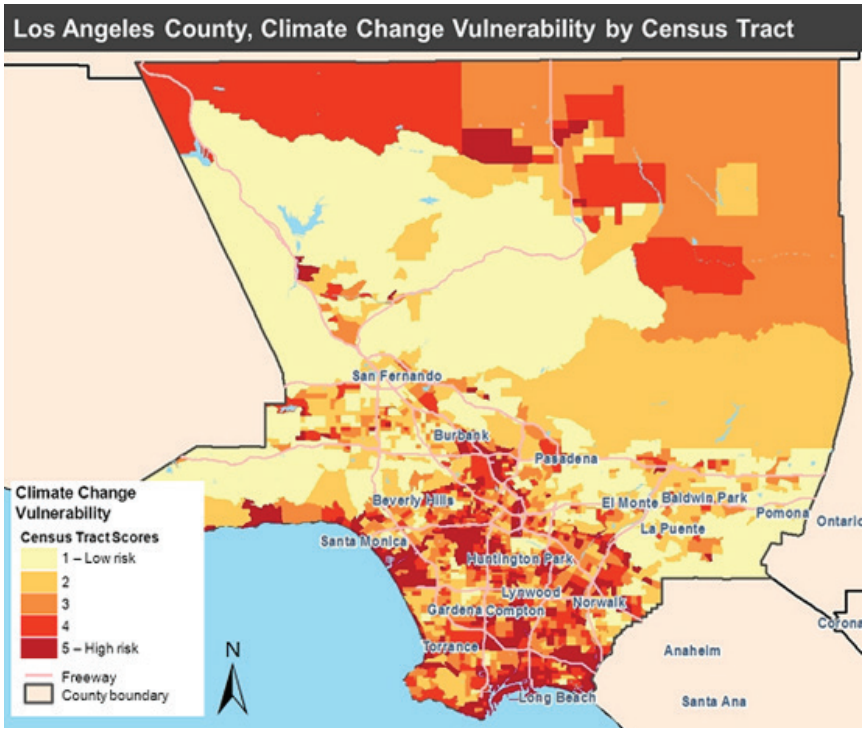
Cumulative Impacts Analysis to Guide Identification of Climate Vulnerable Communities

Cal/EPA's Interagency Working Group on Environmental Justice adopted a framework for identifying cumulatively impacted communities, an integral step to alleviating environmental injustice. The cumulative impacts approach has been operationalized by the CalEnviroscreen method to identify "environmental justice" neighborhoods characterized by multiple sources of environmental pollution and where the residential population is often vulnerable to the effects of this pollution through social vulnerabilities that can include factors such as poverty. The framework defines cumulative impact as "exposures, public health or environmental effects from the combined

1 More information about how already-occurring and projected climate change impacts disproportionately affect California's Tribal and Indigenous Communities – both in LA and across the State – may be found in the Fourth Assessment "Tribal and Indigenous Communities Summary Report."

emissions and discharges in a geographic area, including environmental pollution from all sources, whether single or multimedia, routinely, accidentally, or otherwise released. Impacts will take into account sensitive populations and socioeconomic factors, where applicable and to the extent data are available." (CalEPA Environmental Justice Update 2016) CalEnviroscreen aggregates these multiple, cumulative, and synergistic vulnerabilities to locate the most burdened communities statewide, and can thus be a valuable tool to help prioritize neighborhoods that may be most vulnerable to climate impacts. Through CalEnviroscreen v3.0 mapping, it is clear that environmental justice communities are exposed to a disproportionate share of environmental hazards in their neighborhoods. Worsened health outcomes related to environmental exposures can be compounded by various social determinants, including race, low socioeconomic status, linguistic isolation, and lower educational attainment. Screening approaches, such as CalEnviroScreen and the Environmental Justice Screening Method (Figure 11), identify several areas in the greater

FIGURE 11



Distribution of cumulative impact and vulnerability screening scores using the Environmental Justice Screening Method (Sadd et al. 2011) that includes a climate change impacts score. The impact is more concentrated in urban portions of the region. (Map from English, et.al, 2013: https://escholarship.org/uc/item/8h669570)

LA region as among the most vulnerable and impacted neighborhoods in California. These include Wilmington and Carson near the Port of LA, Pacoima and Sun Valley in the San Fernando Valley, communities surrounding downtown LA, such as East and South LA and Boyle Heights, and the inland valley communities of El Monte, Pomona, and Ontario.

Overlaid on this riskscape of pollution exposure and environmental injustice are the uneven impacts from climate change, often affecting these same communities. Environmental justice communities live closer to large greenhouse gas polluting facilities such as power plants and refineries (Cushing et al. 2016). Climate mitigation efforts typically target these greenhouse gases such as carbon dioxide and methane. However, these efforts typically don't address co-pollution from these facilities, such as particulate matter that can have significant adverse effects on health (Cushing et al. 2016). Preliminary analysis of California's cap-and-trade program shows that greenhouse gas emitting facilities tend to be located in communities with higher proportions of poor and residents of color (Cushing et al. 2016). While greenhouse gas emissions are not toxic, the copollutants that accompany greenhouse gas emissions, such as NOx, have significant negative health consequences and proximity to these facilities results in poorer health outcomes. Research by Shonkoff and others (2012) identifies a "climate gap" by documenting that negative impacts of climate change are concentrated in poor communities of color not only in California, but nationwide. Both biological and social factors can be used to predict vulnerability and death during heat waves (Reid et al. 2009a). Low-income communities and communities of color often experience a greater urban heat island effect due to a lack of trees and other vegetation and higher ratios of impervious surfaces, such as pavement and buildings, to tree canopy (Jesdale et al. 2013). Reduced access to air conditioning (Reid et al. 2009b) and disparity in heat-related mortality between blacks and whites may be explained by the prevalence of central AC in homes (Reid et al. 2009a). Sensitive populations such as the very young, elderly, and poor residents are most vulnerable to heat stress. Low income households may be less likely to have air conditioning and may also be less willing to use it to save electricity (English et al. 2007). While landlords are required to provide water and heat, they are not required to provide air conditioning or cooling systems. Residents seeking relief at local cooling centers may be limited by accessible transportation. Screening methods can incorporate a climate impact/vulnerability analytical framework to provide initial identification of areas that deserve further study to identify disparity in climate-related impacts, as well as inform decisions to concentrate resources to alleviate climate impacts most efficiently. The Environmental Justice Screening Method includes some climate vulnerability metrics, and similar variables could be incorporated into a version of CalEnviroscreen.

Benefits and Burdens

In addition to the Cumulative Impacts framework adopted into policy, a legal approach also frames actions for addressing environmental justice. As defined by California law, environmental justice requires "fair treatment of people of all races, cultures, and incomes with respect to the development, adoption, implementation, and enforcement of environmental laws, regulations, and policies" (Gov. Code, § 65040.12, subd. (e)). Fair treatment has been interpreted to mean that everyone should have access to the benefits of healthy environments and the burdens of pollution should not be borne disproportionately by sensitive populations or marginalized communities (State of California, Department of Justice 2012).

The benefits and burdens analysis studies who bears the burdens of environmental pollution and who is getting the benefit of a cleaner environment. Historically, communities of color and low-income communities have borne a disproportionate environmental burden, as detailed above. Wealthier communities, on the other hand, have more access to and live in healthier communities, and in turn benefit from a cleaner environment. In addition, polluting industries have benefited from fewer environmental regulations that decrease their operating costs while the health and environmental costs of the pollution are passed on to the public and environment.

When applied to climate change impacts and opportunities, the benefits and burdens framework protects sensitive and marginalized communities from higher rates of exposure to greenhouse gases and other harmful pollutants, and ensures they have access to the benefits and opportunities of climate policy. For example, in developing renewable energy projects, a benefits and burdens analysis would ensure that marginalized and sensitive communities did not bear the burden of fossil fuel operations while renewable energy deployment was accessible only to those that could afford it. This analysis would also require marginalized and sensitive communities equal access to renewable energy as other communities.

Community-Engagement and Participation in Climate-Based Decision-Making

Assessing cumulative impacts and evaluating benefits and burdens requires the inclusion of the knowledge and involvement of those bearing the burden of climate change. Building on research showing the positive role of community-engaged research, "citizen scientists" improve research outcomes (Balazs and Morello-Frosch 2013 Minkler and Wallerstein 2003; Corburn 2005) and research on the climate gap suggests that communities most impacted by changing climates can participate in identifying necessary protections in their neighborhoods (Shamasunder et al. 2018; Morello-Frosch et al. 2009; Corburn 2009). Indeed, the scientific enterprise has been improved by citizen science and community-based participatory research efforts that include lay and community knowledge alongside scientific evidence in crafting regulation.

Recommendations

State actions to address climate change must simultaneously address environmental injustices at state, regional, and local levels. The following recommendations address climate change as well as the factors contributing to the cumulative impacts of climate change in disadvantaged communities.

- Pursue stronger regulatory approaches that address greenhouse gas emissions as well as copollutants. State policies and approaches to address the "climate gap" have yet to address copollutants in environmentally disadvantaged communities. (Cushing et al. 2016). Environmental justice communities already burdened by air pollution, for example, live closer to large greenhouse gas polluting facilities such as power plants and refineries. Neighborhoods with GHG emitting facilities within 2.5 miles have a 22% higher proportion of residents of color and 21 percent higher proportion of residents living in poverty than places that are not within 2.5 miles of such a facility (Cushing et al. 2016).
- Place-based analysis and action at a census-tract scale are necessary to assess and prioritize environmental justice conditions and set goals that address localized impacts. Focusing only on regional targets and metrics misses the local-level impacts, such as in the case of the cap-and-trade program intended to reduce greenhouse gases regionally but which increased pollution and emissions in environmental justice communities (Cushing et al. 2016). Requiring emissions reductions among emitting facilities located in disadvantaged communities would address climate disparities and enhance environmental equity and health.
- Expand the scope and accessibility of research to measure and assess emissions and reductions. More research is necessary to understand the regional and localized impacts of climate change relative to cumulative impacts, as well as measure gains in emissions reductions and cobenefits in health and equity. Cushing et al. (2016) point specifically to the following:
    - Build better linkages between state facility-level databases on GHG and copollutant emissions.
    - Publicly release data on facility- and company-specific allowance allocations.
    - Track and make data available on facility- and company-specific allowance trading patterns.
- Recognize and develop mitigation and adaptation approaches that simultaneously address climate emissions, copollutants, and factors contributing to cumulative impacts facing the most vulnerable. The benefits-and-burdens framework establishes the framework for equity; approaches such as Just Transition (see Cha 2017) ensure that community-based organizations and labor unions are involved in defining goals and strategies. Steps include ensuring dedicated funding streams and a strong public sector role to prioritize equity in climate policy development and implementation (Cha 2017). Increasing the levels of Greenhouse Gas Reduction Funds to target disadvantaged communities identified by CalEnviro Screen has the potential to address cumulative impacts and advance equitable climate approaches. Currently, SB 535 requires a minimum of 25% of benefit disadvantaged communities and 10% funding projects located in these communities. More is needed to address the needs of the most vulnerable.

CASE STUDY | CITY OF LOS ANGELES CLIMATE RESILIENCE PLANNING

Sabrina Bornstein - City of LA

The City of LA is taking action to reduce the impact of future climate change, while also preparing for and adapting to the already changing environment. The Office of Mayor Eric Garcetti led stakeholder engagement processes to develop two key documents that address climate resilience: the *Sustainable City pLAn* and *Resilient Los Angeles*. The *Sustainable City pLAn* was released in April 2015 and set the course for a cleaner environment and a stronger economy, with a commitment to equity as its foundation. The *pLAn* is made up of short-term targets (by 2017) and long-term targets (by 2025 and 2035) across 14 categories that will advance environment, economy, and equity.

More recently, Angelenos came together to develop *Resilient Los Angeles*, a strategy released in March 2018 that leverages the city's strengths and advances new partnerships to address current and future challenges. This strategy focuses on five primary themes: Leadership and Engagement; Disaster Preparedness and Recovery; Economic Security; Climate Adaptation; and Infrastructure Modernization. Some of the key climate resilience targets include:

- Applying resilience criteria for projects that prioritize investments in capital planning and critical infrastructure;
- Developing and implementing urban heat island reduction plans and demonstration projects in the most vulnerable neighborhoods;
- Investing in green infrastructure and stormwater retention to increase the number of projects that capture water for reuse, improve water quality, and reduce flooding risk; and
- Modernizing the power grid to expand renewable energy to 65% of the power source by 2036 while deepening storage capacity and broadening emergency backup systems.

The City of LA is implementing a number of climate resilience initiatives. For example, the City is working to mitigate the urban heat island effect through a residential cool roof ordinance, providing a cool roof rebate, and piloting cool pavement projects. LA has also developed comprehensive solar incentive programs for residents and businesses and has the most installed solar power of any city in America, according to a report by the Environment California Research & Policy Center. The City has begun to pilot solar and battery storage sources at critical facilities, such as fire stations, so that, in the case of a grid outage, the battery and solar system will be able to keep critical equipment at the facility operational.

One of *Resilient Los Angeles*' 15 goals is to integrate resilience principles into government to prioritize the most vulnerable people, places, and systems. As one component of this goal, the City of LA will incorporate resilience as a guiding principle into the General Plan. The city is undertaking a comprehensive update to the General Plan. The General Plan update process will consider opportunities to incorporate climate adaptation, hazard mitigation and recovery, as well as efforts to increase equity and to leverage long-range capital planning for infrastructure investment. Combined, these efforts will address immediate needs while also developing a vision that ensures the city is resilient for future generations.

Economic Systems

ENERGY SYSTEM

Introduction

Energy system planning decisions must be made within the context of multiple sources of uncertainty, including economic growth, technological change, and global resource markets. Recently, the nature and extent of climate variability has emerged as among the most significant sources of uncertainty for regional energy system planners. This is because climate variables drive many heterogenous aspects of the supply and demand for energy services which can also result in cascading impacts to many other teleconnected sectors (Hart and Moser 2018). Conventional energy systems analysis and planning frameworks assume climate variables to be stationary. However, as the information in the "Regional Climate Science" section indicates, this assumption is no longer valid. Nonstationarity in southern California's regional climate dynamics is likely to influence the operations of the region's energy system in four fundamental ways:

1. Changes in the availability and/or accessibility of its primary energy resource endowments;
2. Changes in the operational modes and/or efficiency of its energy generation assets;
3. Changes in the capacity and/or reliability of its energy transmission and distribution infrastructure;
4. Changes in the timing and/or volume of its consumers' energy demand.

Resource Endowments

Primary energy resource endowments can refer to fossil fuels in place (stocks) or the renewability potential of renewable energy sources (flows). Fossil fuel stocks can be readily transported through space and stored over time, thus their availability is largely determined by the dynamics of global energy commodity markets. Alternatively, renewable energy flows cannot be as readily transferred across either space or time and their occurrence can be somewhat unpredictable. As a result, their immediate availability is determined by local climate conditions and other related geographic constraints. This fundamental difference between the two primary energy sources implies that flow-based renewable energy technologies must be supported by energy storage systems in various ways if they are to achieve performance parity with existing fossil fuel stock-based systems.

Southern California's energy system draws upon a diverse portfolio of primary energy resources as part of its supply side operations. The majority of the fossil energy resources consumed within southern California are sourced from a combination of out-of-state domestic and international producers. Alternatively, the majority of the region's renewable energy resource consumption consists of flows which have been captured within the state's local geographic boundaries.

Differences in the locality of procurement of renewable- versus fossil-based primary energy resources are caused by a number of factors. Renewable energy resources are predominately used for the generation of electricity which is ultimately delivered to end use consumers. As such the locality of the region's renewable energy resource procurement is primarily determined by the cost and technical difficulties associated with transporting electricity

over large distances. By comparison, fossil fuels-based primary energy sources are often delivered directly to end use consumers. Thus, the locality of the region's fossil fuel procurement is more significantly impacted by regulatory barriers which restrict regional production of local offshore oil and natural gas reserves for environmental and other reasons.

Table 1 summarizes the distribution of primary energy resources used to supply the average consumer serviced by the four largest electrical utilities operating within southern California as of 2016.

Anticipated future changes in regional climate variables ("Regional Climate Science" section) are likely to affect southern California's primary energy resource endowments in several ways. Some of these are exogenous to the operational management of the region's energy system and involve physical differences in the intensity and geographic distribution of renewable energy fluxes such as solar irradiance, surface winds, and surface water flows. Others are endogenous to the operations and management of the energy system and involve the implementation of energy policies, such as renewable portfolio standards, which can influence the dynamics of regional markets for primary energy resources and alter the economic viability of new and existing fossil energy resource reserves.

While southern California continues to consume a significant quantity of fossil fuels both for the generation of electricity and direct end-use in its homes and businesses, it does not produce significant quantities of these fossil energy resources itself. According to the Energy Information Administration, in 2016 California consumed a total of 2,113,847 million cubic feet (Mft^3) of natural gas statewide. However, during this same year its domestic production was only 205,024 Mft^3 (i.e. 9.7% of consumption, https://www.eia.gov/dnav/ng/ng_sum_lsum_dcu_SCA_m.htm). This reliance on out of state production can be a source of vulnerability if local storage assets or out-of-state suppliers become adversely impacted by climate change events.

TABLE 1

PRIMARY ENERGY SOURCE	SCE	SDG&E	LADWP	IID
Natural Gas	19%	42%	34%	35%
Coal	0%	0%	19%	14%
Renewable	28%	43%	29%	28%
Hydro	6%	0%	3%	4%
Nuclear	6%	0%	9%	3%
Other	0%	0%	0%	0%
Unspecified*	41%	15%	6%	16%

Primary Energy Sources** by Southern California Utility Provider

Utility Acronyms: SCE - Southern California Edison, SDG&E - San Diego Gas and Electric, LADWP - Los Angeles Department of Water and Power, IID - Imperial Irrigation District

* The category "unspecified sources of power" corresponds to electricity that has been obtained from transactions that are not traceable to specific generation sources.

** Many utility providers provide ratepayers with the option to purchase power that has been produced using a larger fraction of renewable energy resources than which is available in the default grid mix. For simplicity, the energy resource mixes of these optional programs have not been shown.

Source: California Energy Commission, Utility Annual Power Content Labels for 2016 (http://www.energy.ca.gov/pcl/labels/)

As an example of this vulnerability, in 2016 southern California experienced a four-month, 100,000 metric ton natural gas leak at the Aliso Canyon natural gas storage facility (Fairley 2016). During this period, the Aliso Canyon facility had to be temporarily closed for safety inspections and repairs. The loss of the facility's storage capacity was unable to be offset by short term increases in the volume of gas deliveries through the regional supply network. In response to this event, a combination of demand mitigation measures and emergency supply side procurement efforts had to be pursued in order to avoid large scale winter electricity blackouts, as electricity generators are among the first customers to be curtailed in the event of major natural gas supply shortages. This event exposed the limitations of the region's natural gas system to effectively respond to the prolonged disruption to a critical component of its seasonal energy storage infrastructure.

In terms of renewable energy flows, southern California's most significant primary energy resource endowment is its incident solar radiation. Virtually the entire southern California region experiences average daily solar irradiance intensities in excess of 6,000 Watt-hours per meter squared per day. This makes the region among the most attractive areas in the entire United States for the large-scale development of solar energy generation systems (Simons and McCabe 2005). The two other most significant renewable energy resource endowments possessed by southern California are its hydroelectric and wind power potentials. From year to year, the combined output of small and large hydropower generation station outputs can comprise between 5-15% of California's total in-state electricity production (Stoms et al. 2013). This significant interannual variability is largely driven by the increasing volatility in seasonal precipitation patterns, which can significantly alter the reservoir operations of hydro generators (Vicuna et al. 2007). Alternatively, the fraction of in-state electricity production coming from wind power has doubled from 3% to 6.8% from 2003 to 2017 (Stoms et al. 2013, AWEA 2018). Wind power resources in the high desert regions of southern California are among the most heavily developed anywhere in the world, with the region's five largest wind farms (Tule Wind Energy Project, Tehachapi Pass Wind Farm, San Gorgonia Pass Wind Farm, Ocotillo Wind Energy Project, and Alta Wind Energy Center) collectively comprising 3.3 gigawats of installed generating capacity.

There is a high degree of uncertainty in the forecasted changes in climate variables that are likely to impact southern California's renewable energy resource endowments. Reducing this uncertainty requires more detailed predictions of future cloud cover density, precipitation volumes, and surface wind intensities than the current generation of climate models can as yet accurately produce. More research is needed to determine the extent to which California's renewable energy resource endowments are likely to be impacted by anticipated changes in its regional climate system.

Generation Systems

As Table 1 indicates, natural gas is the dominant fossil based primary energy source used for electricity generation within southern California. According to CEC data, there are 683 natural gas fired thermal generating facilities currently operating within the state of California. Of these, 246 are located within the five counties encompassing the LA Region. Many of these local generator facilities are nearing the end of their design lifespans; with 53 of them having been in operation for 30 years or more. (CEC Online Generator Database, http://www.energy.ca.gov/almanac/electricity_data/web_qfer/Annual_Generation-Plant_Unit.php) The choice of when these assets are ultimately retired

and what types of systems are selected to replace them will both be significant factors in determining the rate of progress towards achieving the state's mandated renewable portfolio standard targets.

Natural gas-fired thermal generators use either water or air for the cooling of turbine exhaust gases. These cooling systems can be either active or passive and involve either once-through or recirculated flows. Most newer thermal generators tend to be air cooled, and those that are water cooled tend to use recirculating flows. In all cases, the lower the temperature of the ambient air or water source that is used for the cooling of these thermal generators, the higher their operational efficiencies. Forecasted temperature increases have the potential to reduce the capacity of California's existing fleet of thermal generators by as much as 25% (Sathaye et al. 2013). In 2010, the California State Water Resources Control Board approved a policy to progressively phase out the use of once-through cooling technologies at 19 coastal electricity generator stations within the state (http://www.energy.ca.gov/renewables/tracking_progress/documents/once_through_cooling.pdf). Ongoing efforts to comply with this policy will change the technological characteristics of the state's remaining fossil generator stations and thus their vulnerability to deleterious effects from anticipated regional climate changes (p. 9).

In 2005, a statewide assessment of technical solar photovoltaic (PV) generation potential conducted by the CEC identified LA County's total capacity potential for flat plate collector technologies as 662,486 MW with an expected daily power output of 3,912,346 megawatt-hours per day (Simons and McCabe 2005). Modeled future climate conditions within the region are likely to negatively impact this potential, as the power efficiency of flat plate solar collectors decreases with increases in ambient air temperatures (p. 9). Working in opposition to this trend, however, are the steady recent improvements in the performance capabilities of new generations of solar PV modules (Simons and McCabe 2005). More research is needed to accurately assess the net effect of climate warming on the future output potential of solar PV systems within southern California.

The impacts of climate change on wind resource availability are likely to be highly spatially variable, with some regions experiencing net increases in available wind energy resources and other undergoing net declines. A major issue in the design of individual wind turbines and collective wind farms is the characteristic range of wind loads at a given site, as these affect component performance and the service lifespan (Pryor and Barthelmie 2010). Sustained exposure to wind speeds considered extreme relative to the design criteria of an individual turbine can necessitate deactivation to protect the structural integrity of the turbine's blades and sensitive transmission components (Breslow and Sailor 2002). Should southern California experience increased future extreme wind weather events, the region's existing and potential future fleet of wind generators could potentially suffer from declining capacity factors and increased operations and management costs. More research is needed to ascertain the potential scale and extent of this problem.

Transmission and Distribution Systems

Within southern California, there are two energy transmission and distribution networks. The first conveys fossil-primary energy resource stocks through an integrated connected network of pipelines, shipping conveyances, and storage depots. The second conveys electrical energy through a tightly connected network of transmission lines, substations, and distribution circuits.

The climate change impacts which are most likely to directly impact fossil fuel distribution infrastructure, and in particular the subsurface pipeline systems used to transport natural gas, are elevated sea levels (p. 15) and corresponding increases in the future rates of coastal land subsidence. While these systemic vulnerabilities have been more extensively studied within California's Bay Delta Region, where their impacts are expected to be more acute, further study of these issues is necessary to understand the scope of their potential impacts within the southern California context (Shirzaei and Bürgmann 2018).

Compared to fossil fuel conveyance systems, existing infrastructure systems used for the transmission and distribution of electricity are likely to be far more sensitive to perturbation from future climate change impacts. Firstly, forecasted increases in air temperatures (p. 9) will impede the flow of electricity along overhead power lines. This impedance of flow results in the generation of significant quantities of heat which, if not as readily dissipated due to the higher ambient air temperatures, can eventually overload the thermal buffering capacity of system components and lead to cascading failures (Burillo et al 2018). Additionally, forecasted increases in the frequency and intensity of wildfires (p. 18) will increase the probability that transmission and distribution infrastructure components will be physically disturbed. These disturbances can result in widespread system outages due to the geographic remoteness of many key transmission system components. Finally, increases in the penetration of grid-tied renewable generation assets will create endogenous challenges around the need to store energy produced by intermittent sources as well as maintain its consistent quality in terms of voltage, frequency, and reactive power. These challenges will necessitate simultaneous investment in the modernization of electric power grid infrastructure components to support the increasingly bidirectional flow of power through the network.

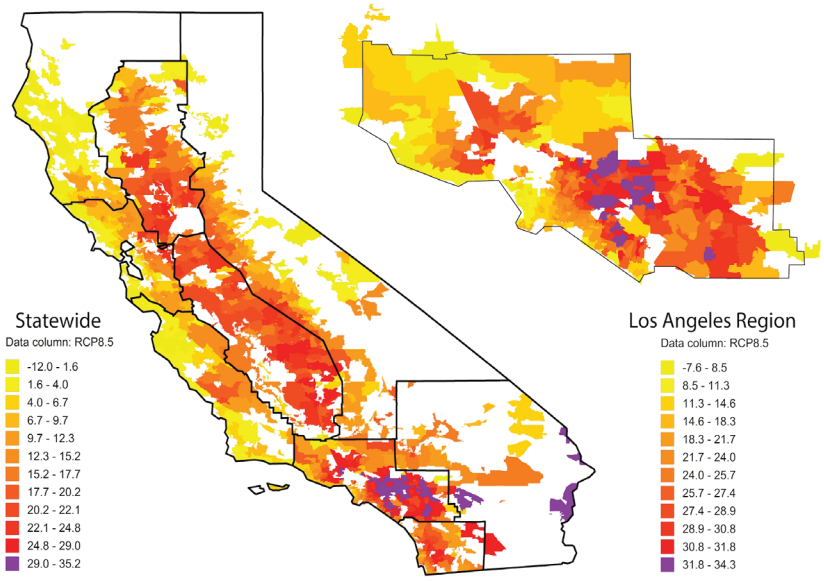
Consumer Demand

Based upon previous analyses of the sensitivity of the demand for natural gas to climate in the other U.S. states and elsewhere abroad, anticipated shifts towards higher average temperatures during typically cold seasons within southern California will likely lead to aggregate reductions in the demand for natural gas used for both space and water heating applications (Auffhammer and Mansur 2014; Sailor 1997). However, forecasted increases in the frequency and the intensity of extreme high temperature events (p. 9) will likely lead to more extensive air conditioning system usage during historically warm seasons. (Auffhammer and Aroonruengsawat 2011; Sailor 2003). Additionally, as the built environment expands to accommodate future population growth and is simultaneously redeveloped as part of natural turnover cycles, air conditioning penetration levels are also expected to increase.

Both of these trends point to a high likelihood of future increases in the magnitudes of peak electricity demands. This is especially true for the inland regions of southern California that are expected to receive the majority of the region's future population growth and also experience the most drastic increases in the number and intensity of extreme high heat days (Burillo et al. 2017a). Real world evidence supporting the validity of these conclusions has already begun to appear. For example, in 2015 the weather-adjusted system peak load within the LA Department of Water and Power service territory was 5,674 MW. On August 3, 2017, however, a new record peak load was established at 6,502 MW; an increase of 12% over a period of just two years.

Interactions between geographic distribution of population growth, urban development, and climate change impacts throughout southern California are likely to stress the region's energy system nonuniformly in both space and time (Burillo et al. 2017b; Baxter and Calandri 1992). The complex interdependencies between these various elements of the energy system will require the development of more integrated assessment techniques to deliver accurate quantitative forecasts of future energy demand (Chandramowli and Felder 2013; Ciscar and Dowling 2014).

FIGURE 12



Forecasted percentage increases in total annual electricity consumption by zip code by the year 2100 under RCP8.5 (Auffhammer 2018).

Figure 12 illustrates recent results on the scale and geographic distribution of expected percentage increases in annual electricity demand across California by zip code in the year 2100 under RCP8.5 (Auffhammer 2018). Overall increases in total annual electricity consumption among the state's coastal communities are anticipated to be more modest than those endured in inland areas due to the moderating influence of the ocean's thermal storage capacity. Statewide, the largest expected increases (+30-35%) are forecast to occur in inland portions of the LA region. These areas are likely to be subjected to the most significant future growth as well as in the frequency and intensity of climate change-induced high heat events (Auffhammer 2018). These are also areas already facing socio-economic challenges such as poverty, low levels of education, and aging housing and public infrastructure stock.

TRANSPORTATION

Climate change will have both direct and indirect effects on the transportation system in southern California. Direct effects include infrastructure damage, changes to vehicles, and system use. Indirect effects of climate impacts may change trade flows, land use patterns, transportation energy supply and demand, and the institutions, laws, and policies which shape the transportation system.

The Southern California Transportation System

In the National Climate Assessment, Schwartz et al. (2014) assess the transportation system's vulnerability to climate change through examination of its four components:

1. Fixed node infrastructure, such as ports, airports, and rail terminals;
2. Fixed route infrastructure, such as roads, bridges, pedestrian/ bicycle trails and lanes, locks, canals/channels, light rail, subways, freight and commuter railways, and pipelines;
3. Vehicles, such as cars, transit buses, and trucks; transit and railcars and locomotives; ships and barges; and aircraft (many privately owned); and
4. The people, institutions, laws, policies, and information systems that convert infrastructure and vehicles into working transportation networks.

Each of these system components has its own unique vulnerabilities.

Fixed Node Infrastructure

Nodes are concentrated infrastructure investments, typically at the interface of two or more transportation networks (e.g. ground transportation and aviation interface at airports). In southern California, key fixed nodes are commercial aviation airports, the Ports of LA and Long Beach, intermodal freight rail terminals, large warehousing complexes near the ports and in the Inland Empire, major transit stations in Downtown LA, transit maintenance and storage facilities, and major parking complexes in downtown LA and the Wilshire Corridor (Chester et al. 2015). The most vulnerable of these fixed nodes is the port complex, where sea level rise can affect not only inundation in low-lying areas but also the clearance between vessels and bridges. The Port of LA is planning investments to adapt to climate change (Sriver et al. 2018).

Fixed Route Infrastructure

Fixed routes link major nodes and distributed land uses. Routes are hierarchical: Some land uses are served by local streets or a rail spur, but most mid- and long-distance traffic volume is concentrated onto higher volume corridors: arterials, highways, and main rail lines.

CONCENTRATED VULNERABILITY TO CLIMATE IMPACTS

In southern California, key fixed routes are interstate highways and freeways, major arterials streets, freight rail, passenger transit commuter rail, bikeways, channels and shipping lanes, and links that connect with major fixed node infrastructure. The most vulnerable routes in the LA area are in coastal areas, which can be impacted by sea level

rise, and also in hillsides, which can be impacted by wildfires (p. 18), debris flows, and erosion from extreme weather events (p. 14).

A coastal 100-year flood event in southern California could damage 530 miles of roadway and rail trackage under current conditions, and 975 miles of roadway with 1.4 meters of sea level rise (see p. 15 for sea level projections). Radke et al. (2018) projects extreme flooding (flood depths exceeding 2 m, or 6.56 ft) to portions of the transportation fuel system located in Long Beach by the mid-21st century, which expands to larger spatial extents in the region by the late-21st century. Minor increases in the intensity of storms can significantly increase coastal erosion of both bluffs and beaches, damaging coastal transportation routes for multiple modes of travel (Hanak and Moreno 2012). Extreme rainfall events can inundate low-lying areas and subgrade infrastructure, such as roadway and rail tunnels. Swift-moving water due to extreme rainfall, inadequate culvert and other drainage capacity, or other causes can lead to washouts of road and rail beds or bridge support piers.

Key links to major fixed nodes that lack redundancy are also vulnerable, such as bridges into rail yards and causeways in the port complex. Cho et al. (2005) estimate the economic effects of a hypothetical tsunami closing the Ports of LA and Long Beach and freeway linkages for one year to be $21 billion in driver delays and $4.2-5 billion in freight delays. Since transportation systems are networks, some resilience is inherent in redundancy: if one segment of one route fails, users can route onto alternative facilities. Ganin et al (2017) found that LA is less prone than other U.S. cities to increases in traffic delay from random losses roadway segments.

BROADER CLIMATE IMPACTS

Expected temperature increases (p. 9) can impact the entirety of fixed route infrastructure. Extreme temperatures can increase risk of failure for transportation infrastructure not designed for high temperatures (Meyer, Amekudzi, and O'Har 2010). Extreme heat can lead to thermal expansion of rail trackage that results in warping or buckling (Smoyer-Tomic, Kuhn, and Hudson 2003), which can cause accidents or slowing or suspending of rail traffic.

There are also links between climate impacts to the transportation system and public health. Particulate matter (PM) from resuspended road dust is comparable to tailpipe emissions (Abu-Allaban et al. 2003). Frequent rain washings reduce the concentration of particulate matter from road dust for a period of up to 2 days after rainfall (Kuhns et al. 2003). In the absence of rainfall during prolonged periods of drought (p. 19), the region could experience increased concentrations of resuspended road particulates, which have adverse respiratory impacts (Tiitanen et al. 1999).

INTENSIFICATION OF CLIMATE IMPACTS

Fixed-route infrastructure in the LA region can act to intensify climate changes. Roadways and parking cover approximately 24% of the incorporated land area of LA County (Chester et al. 2015), and the ubiquity of paved surfaces in LA contributes to increased urban temperatures. Taleghani, Sailor, & Ban-Weiss (2016b), in a case study of El Monte, California, found that the presence of street-level vegetation reduces temperatures by an average of 0.15°C, and direct shade reduces mean temperature 7°C. Cool pavement infrastructure decreased radiant temperature and thermal discomfort in unshaded areas, but increased discomfort in shaded areas. Low-albedo pavement absorbs infrared radiation, contributing to the urban heat island effect (Taha 1997b). This effect can be mitigated by increasing tree cover (Taleghani, Sailor, and Ban-Weiss 2016b; Akbari, Pomerantz, and Taha

2001) and using high-albedo pavement surfaces (Hashem Akbari, Menon, and Rosenfeld 2009) which have been shown effective in LA (Santamouris 2013). Taha (1997b) calculated that cool pavements and roofs could decrease temperature in Downtown LA by 1.5°C. Non-permeable pavement and concrete surfaces also affect urban hydrology. The prevalence of impervious surfaces in the LA basin can also exacerbate extreme rain events. Urban watersheds in LA lose 90% of storm rainfall to runoff, increasing flood discharge rates and reducing stormwater retention (Sheng and Wilson 2009). Stormwater retention is necessary to recharge aquifers and preserve local water supply.

Vehicles

The third component of the transportation system is vehicles: cars, buses, trucks, railcars, locomotives, ships, and aircraft. In contrast with fixed nodes and routes, most vehicles are privately owned and maintained and have a replacement cycle of between 8 and 39 years (Federal Transit Administration 2016). A shorter replacement cycle means that vehicles are more adaptable than fixed infrastructure: New design requirements can be incorporated into the latest models and within 10 years, most vehicles in use will have the new capabilities. As an example, factory-installed air conditioning was present in 4.6% of all 1958 automobile models, 54% of all 1969 models, 72% of all 1980 models and 94% of all 1990 models (Bhatti 1999). The shorter replacement cycle and the fact that road transportation and petroleum refining emissions comprise 39% of statewide emissions (California Air Resources Board 2017) make transportation electrification an attractive policy option for greenhouse gas reductions (Yang et al. 2015). However, electrification of transportation will increase demand for electricity in California (J. H. Williams et al. 2012).

Operations

Operations of the transportation system include the people, institutions, laws, policies, and information systems that convert infrastructure and vehicles into working transportation networks (Schwartz et al. 2014).

EXTREME HEAT AND PEDESTRIANS

Average temperature increases (p. 9), particularly in the urban heat island, can affect the health, comfort, and behavior of pedestrians, cyclists, and passengers waiting for transit. Reducing exposure to transit users may prevent deaths in extreme heat events, a time when those without air conditioning must travel to a cooled facility (Shonkoff et al. 2011a). A study of officially designated cooling centers in LA found them inaccessible to large portions of the population (Fraser et al. 2016). Fraser and Chester (2017b) find that the heat-related exposures of walking to and waiting for transit vary between LA neighborhoods based on variations in local temperatures, transit service frequency, and the design of the street network. People using transit on the edges of the service network and those whose walking or biking journey to transit bus stops are located in urban heat islands will have the greatest exposure to heat-related impacts.

EXTREME HEAT AND AIRCRAFT REGULATIONS

Extreme heat affects not only the physics but the regulation of aircraft operations. Temperature is inversely proportional to air density, which provides lift. Takeoffs are limited by a combination of air density (a function of temperature and altitude), aircraft weight, and runway length. At high temperatures, aircraft must reduce weight in order to take-off at the same distance and may be grounded in extreme heat. Coffel and Horton (2014) studied

aircraft operations and runway lengths at four U.S. airports and predict that under RCP8.5, with existing aircraft, the number of takeoffs subject to weight restrictions would increase by 50-200%. Federal Aviation Administration regulations can also prevent aircraft from taking off under extreme temperatures. All aircraft must have maximum takeoff weight data, interpolated from actual test conditions, recorded in an Airplane Flight Manual for combinations of temperature, altitude and runway length (14 CFR § 121.173 (d)). U.S. Commercial Aircraft are restricted from taking off under conditions that are not in an Airplane Flight Manual (14 CFR § 121.189 (a)). Therefore, a manufacturer must test an aircraft at extreme temperatures to allow flight at those temperatures.

Cayan et al. (2018) predict that at the end of the century, under RCP8.5, LAX would experience 50-90 days per year with temperatures at or exceeding 90°F, versus 15 currently experienced. Further research is needed to examine these temperature impacts to airplane operations at southern California's five major airports.

INSTITUTIONAL RESPONSES TO CLIMATE CHANGE

The complicated and decentralized governance in the LA region limits the agility of governments and institutions to react to climate threats. Pincetl (2010a) found that initiatives to improve tree canopy cover in LA are challenged by the needs to engage and coordinate multiple public agencies and private stakeholders. Barbour and Deakin (2012) further note that California's strategy to encourage smart growth for adaptation and mitigation to climate change requires coordination by a regional agency to maximize the impact of local actions. Reviews of local climate action plans find that political will limited innovation, as cities often codified changes that market incentives supported (Bassett and Shandas 2010).

Schroeder and Bulkley (2009) found that the decentralization of transportation institutions in LA particularly hampered adaptation, compared to both water infrastructure under LADWP and centralized transportation governance in other states and countries. High reliance on local funding through ballot measures give transit agencies little freedom in changing future planned projects to adapt to climate impacts (Schroeder and Bulkeley 2009).

Indirect Effects from Climate Interventions

TRANSIT-ORIENTED DEVELOPMENT AS AN INTERVENTION

Transit-oriented development is a strategy to both mitigate and adapt to climate change. Transit oriented development can reduce greenhouse gas emissions from shorter trip distances and increased modal share of transportation options with lower greenhouse gas emissions per passenger mile traveled (Nahlik and Chester 2014a; Gallivan et al. 2011; D. Kim, Lee, and Choi 2015; Lund 2006; Gomez-Ibanez et al. 2009). Transit-oriented development also allows for the concentration of future development in areas forecast to have fewer climate change impacts (nearer to coast, away from wildlands) (Stone, Hess, and Frumkin 2010; S. R. Miller 2013; Hamin and Gurran 2009) and, by putting people in closer proximity to frequent transit and their destinations, less exposure to climate impacts for people who use transit, people who bicycle, and people who walk (Cervero and Sullivan 2011; Shonkoff et al. 2011b; 2017b, [c] 2017).

Chester et al. (2013) used life-cycle analysis of greenhouse gas emissions to find that a 20-30% shift of travelers from automobiles to transit is necessary to reduce greenhouse gas emissions. Nahlik and Chester (2014b) evaluated the life-cycle environmental impact of mixed-use infill development near accessible to new light rail and bus rapid transit

lines in LA over a 60-year forecast. They found that the potential commute mode shift to high quality transit due to transit-oriented development had the most positive environmental impact — greenhouse gas emissions reductions up to 470Gg CO2 per year, a potential 28-35% reduction of larger particle emissions that cause respiratory issues and smog, and overall energy use reduction from multi-unit development.

Glaeser and Kahn (2010) examined current land use patterns in large US cities and trends for future home construction, and found that new construction in denser areas results in comparatively lower energy use and GHG emissions from travel and home utility needs. They also found that the LA metropolitan area has one of the lowest marginal environmental costs of new development.

Boarnet et al. (2017) found that households within ½ mile of the new Expo line light rail in LA reduced vehicle carbon emissions by an average of 305% when the rail line opened. Another examined the variation in transit ridership patterns — and by extension emissions reduction potential—across different types of transit corridors in LA and found that the reduction in vehicle trips is greatest in rail transit corridors in which many stops have transit-oriented developments (Houston et al. 2014).

LAND USE AND COMMUNITY DEVELOPMENT

Overview

The LA region is characterized by a fragmented governmental system with 88 cities, county unincorporated areas, over 200 different water retailers, numerous electricity utilities, and more. Coordinating this large number of local governments for climate action and sustainability is a challenge as, aside from the Southern California Association of Governments (a largely voluntary organization with no regulatory authority), there are few overarching entities that can provide both leadership and regulatory guidance. The South Coast Air Quality Management District does have regulatory authority, but only over stationary sources of air pollution.

As land-use decisions are made incrementally by different local governments, the likelihood of increasing human impacts on local ecosystems and working lands increases, including exacerbating fire incidents, more water extraction, and more land transformation and impacts on ecosystems. These impacts go hand in hand with exposing more people to climate impacts in a feedback loop. These include land development in areas that will experience increased extreme high heat days, more fire incidents, and water uncertainty.

Urban Tree Canopy

Planting trees in cities has been seen as a means to reduce the urban heat island and cleaning the air of particulate matter pollution. Air pollution mitigation and carbon sequestration services have been shown to be minimal and the density and location of tree canopy along streets can cause air to be trapped and increase exposure of pedestrians to particulate matter (Pataki et al 2011 2013). The cooling capacity of trees has been shown to play an important role in remotely sensed land surface temperatures during the day and night, primarily via evapotranspiration and physical shading (Imhoff et al. 2010; Jenerette et al. 2015). However, the role of trees in reducing air temperature is less well understood and linkages between vegetation cover and reduction of air temperature are more variable than land surface temperature relationships. Reductions in air temperature vary in response to weather conditions and locations (Coseo and Larsen 2014; Shiflett et al. 2017; Wang et al. 2015). In addition, for trees to reduce energy

use they must be maintained to encourage their canopy cover. This often conflicts with other priorities such ease of maintenance (trees in LA city, for example, are on a 40 year pruning cycle), as well as unimpeded traffic flow. Thus, while a promising strategy, for trees to provide shading and cooling they must be cultivated for that end. Further, the magnitude of tree cooling depends on multiple factors, including local meteorological conditions, the extent of vegetation cover, and tree species composition, all of which impact rates of transpiration and latent heat flux (Pataki et al. 2011b). Water use by trees is another consideration in southern California cities and urban cooling by trees may be associated with land surface temperatures in contrast to reducing air temperature. There are techniques for watering trees, such as Tree Gators, but there is no entity that is in charge of systematic distribution of these items nor of ensuring they are well utilized. Trees in the urban environment are also poorly watered as they are often planted in lawns. When there are water use restrictions, trees suffer as their roots are shallow and they depend on surface irrigation rather than deep irrigation. This makes them more susceptible to disease as well. For trees to succeed in the region – one that was not originally forested other than in the mountainous areas and along the foothills – tree maintenance and cover will have to improve dramatically to have an impact in the region.

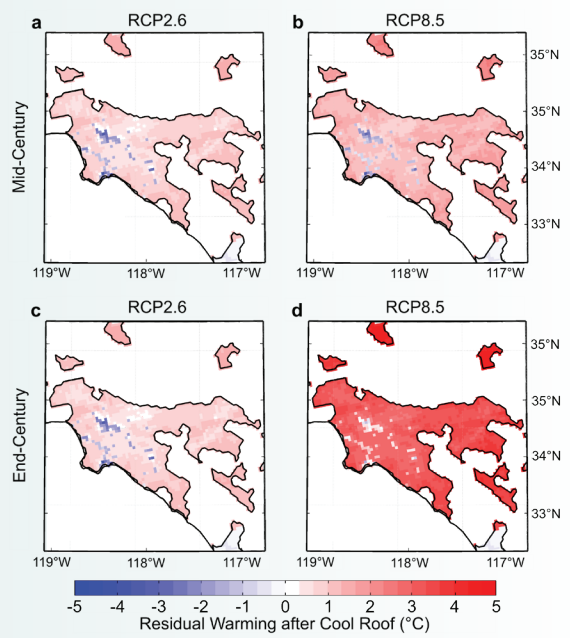
While trees reflect cultural desires (Muchnick 2007) an emphasis on trees for cooling may preclude exploration of other cooling strategies such as canopy structures and other built environment strategies. Finally, planting and maintaining trees is labor intensive and maintenance is required for trees to grow successfully. For example, watering depends on human labor if it is to be done correctly (that is, independently of sprinklers for lawns). Funding is rarely available for maintenance (Pincetl 2010b), though in the LA region there are active non-profit organizations that help communities plant trees. However, they do not provide any maintenance assistance. For services provided by trees to make a difference in the urban environment, they will need to be at scale and will require dedicated funding. Other strategies need to be implemented alongside planting trees, such as building shade structures and changing urban albedo.

CASE STUDY | ALBEDO MODIFICATION
George Ban-Weiss - USC Viterbi School of Engineering

In the face of urban warming due to the combined effects of urban heat islands and the local impacts of global climate change, local land cover choices can be used as strategies to reduce urban temperatures. Often referred to as "heat mitigation strategies," these can include two general categories: (1) use of materials that reflect increased amounts of sunlight and (2) increasing vegetation coverage. Increasing the reflectivity, or "albedo" (defined as the ratio of reflected to downwelling sunlight) of materials reduces their surface temperatures by decreasing sunlight absorption. Use of cool building envelope materials has the additional benefit that it can reduce heat transferred into the building and thus air conditioning energy use. While cool building envelope materials can lead to increases in heating energy use during wintertime, air conditioning energy saved outweighs this "heating penalty" in most climate zones (Levinson and Akbari 2009).

Past research has used numerical climate models to investigate regional temperature changes induced by hypothetical citywide adoption of cool roofs in southern California (Epstein et al. 2017; Taha 1997a; Taha, Konopacki, and Akbari 1998; Taha 2008b, [a] 2008, [b] 2015; Vahmani et al. 2016). Vahmani et al. (2016) found that cool roof adoption reduced the spatial average near-surface air temperatures in the afternoon by 0.9 °C. Nocturnal temperature reductions were smaller in magnitude at 0.5 °C. Cool roof adoption was also found to appreciably offset local warming by mid-century. However, end of century warming overwhelmed the cooling impacts of reflective roofs in most parts of southern California
(See Figure 13). This suggests that cool roofs can play a role in adapting to near-term climate change, but long-term regional climate stability can only be achieved through global scale reductions in greenhouse gas emissions. Highly efficient solar PV can also achieve "effective" albedos that are on par with residential cool roofs, and thus can both generate electricity and reduce urban warming relative to standard roofs (Vahmani et al. 2016).

FIGURE 13



Residual warming in southern California due to global climate change after adopting cool roofs. Values represent simulated changes (relative to current) in diurnal average near-surface air temperature at mid-century (2041-60) and end-century (2081-2100) due to the combined effects of global climate change and cool roof adoption. Simulations assume that cool roofs are adopted on all buildings, and results for both the RCP2.6 (a,c) and RCP 8.5 (b,d) scenario are shown. Figure from (Vahmani et al. 2016).

CASE STUDY | ALBEDO MODIFICATION
George Ban-Weiss - USC Viterbi School of Engineering - Continued

While cool roofs can reduce urban temperatures in LA, their effects on air pollution may be mixed, with both benefits (Epstein et al. 2017; Taha 1997a; Taha, Konopacki, and Akbari 1998; Taha 2008b, [a] 2008, [b] 2015) and penalties (Epstein et al. 2017).

Research on cool pavements and cool walls is not as far along as that of cool roofs. Some recent studies have investigated the effects of cool pavement adoption in California cities on lifecycle greenhouse gas emissions (Gilbert et al. 2017; Pomerantz, Rosado, and Levinson 2015), urban climate (Mohegh et al. 2017), and building energy use (Gilbert et al. 2017; Pomerantz, Rosado, and Levinson 2015). Mohegh et al. (2017) found that widespread cool pavement adoption in LA could lead to daily averaged near-surface air temperature reductions of 0.56°C. While cool pavements reduce air temperatures, they also can lead to increases in sunlight absorbed by pedestrians that has been reflected by the pavement, and thus may decrease human thermal comfort of pedestrians in some cases (Taleghani, Sailor, and Ban-Weiss 2016a). Only one study on climate impacts of cool wall adoption exists, suggesting that daily averaged canyon air temperature reductions attainable from cool walls are slightly lower (0.43°C) than those from cool roofs (0.48°C) given the same albedo increase (Zhang et al. 2018).

CASE STUDY | COOL ROOFS/COOL STREETS INITIATIVE

Lead Author: Jonathan Parfrey, Contributing authors: David Fink, Craig Tranby

The City of LA updated its building code in October 2014 to require "cool roofs" (materials that meet a minimal solar reflectance index value of 75 for low-slope roofs and 16 for steep-slope roofs) on all new and replaced residential roofs. Subsequently, 18,000 residential cool roofs have been installed, covering over 25 million square feet and saving over 3 million kilowatt-hours annually. The benefits of cool roofs include 1) energy and cost savings for residents, 2) reduced threat of heat-related illness in the home as well as in surrounding community, 3) reduced smog formation, 4) enhanced grid reliability as people use less power to cool during prolonged heat-waves, and 5) a reduction of the greenhouse effect by reducing energy production and by the high albedo roofs directly reflect solar radiation back into space. The cities of Pasadena and Santa Monica, as well as LA County (which sets a more rigorous solar reflectance standard), have recently enacted cool roof policies based on the LA City model.

Despite recent progress, challenges remain. Some people conceive of cool roofs as being made of white material exclusively. Not true. Cool roofs come in a wide spectrum of color. In fact, the Cool Roof Rating Council has evaluated over 3,000 roofing products. The City's building inspectors are stretched-thin and do not inspect every roofing operation. Moreover, most southern California cities have not yet adopted cool roof regulations, which slows regional adoption and allows old roofing materials to remain stocked in the region's warehouses.

Statewide, The California Energy Commission has been slow to promulgate new codes on cool roofs, or expand the small number of existing climate zones prescribing residential cool roofs.

Going beyond cool roofs, with assistance from Climate Resolve, the LA Bureau of Street Services created a "cool streets" pilot. Sixteen streets in various neighborhoods throughout the City are currently covered with a sealcoat, CoolSeal (https://www.coolrooftoolkit.org/), and the Bureau recently won a State grant to create a neighborhood-wide cool street project.

Public Transit Infrastructure During Extreme Heat

Transit design can mitigate human exposure to extreme heat (p. 44). Exposure to extreme heat can result in heat-related illnesses such as heat cramps, heat stroke, and heat exhaustion, and can also exacerbate pre-existing conditions. Further, extreme heat may discourage transit use altogether. Environmental exposure results from access and waiting. Transit users from areas with low residential density, limited high capacity roadways, and irregular street networks not located along direct paths between major activity centers, are likely to experience prolonged access and/or waiting times (Fraser and Chester 2017a). In LA, the majority of stops are exposed to the environment and waits can vary depending on the corridor. Average passenger waiting time is between 10 and 15 minutes. The placement of transit stops impacts how long passengers are exposed to the environment, and, coupled with walking, may leave them at risk for negative heat-related outcomes. Walking times can vary significantly by age and physical condition. They can increase by up to 30% for the slowest age group (Bohannon and Williams Andrews 2011). In LA, as in most places, riders in areas where residential density is low (with limited high capacity roadways and irregular street networks and not along direct paths between major activity centers) are likely to experience the greatest total exposure. These are also areas with lower demand (Cervero and Kockelman 1997; Chen, Gong, and Paaswell 2007). In southern California, these may correspond to some of the regions of highest heat gain going forward, such as northern LA County and some of the inland neighborhoods. Cooled waiting stations might provide mitigation in some parts of the county could alleviate some of the impacts of heat on transit riders. Further, in some areas, cooled transit vehicles also provide shelter for the most vulnerable.

Land Use in Wildfire Corridors

Growing urbanization across previously undeveloped areas near existing cities is diminishing the importance of climate in driving fire activity (Syphard et al. 2017). It is important to keep in mind that in southern California there are different types of vegetation, from forests (less than 10% of the vegetation) in the higher elevations of the National Forests to chaparral in the lower elevations. Much of the development pressure takes place in the chaparral-dominated regions. Although shrubland ecosystems are resilient to a wide range of fire regimes and intensities, increased fire can eliminate long-lived woody species that require fire free periods for successful maturity to reproductive age or that must resprout after fire from stored carbohydrates in woody root crowns. Putting homes in highly flammable watersheds expands the urban environment into wildland areas and therefore increases fire hazard because humans are a major source of fire ignitions (J. Keeley and Syphard 2016). This pressure can result in transformed adjacent landscapes. Further, humans can affect wildfire patterns in a unintended ways, including inhibiting prescribed burns due to concerns about air pollution and adjacency to homes (Brotons et al. 2013).

Building standards and fire breaks both contribute to mitigating property damage from fires (Syphard, Keeley, and Brennan 2011; Syphard, Brennan, and Keeley 2017). Between 2000 and 2017, large fires consumed around 3 million acres of southern California vegetation and burned numbers of structures. As land development pressure continues for development at the urban fringe, homes are increasingly in the line of fire. In California, there are nearly a million homes in suburbs adjacent to the wildlands and many of them are in areas with Very High Fire Hazard Severity (http://www.fire.ca.gov/fire_prevention/fire_prevention_wildland_zones_maps). Much of the undeveloped lands in southern California Counties are rated high severity, and yet are planned for more development (Pincetl et al 2008). This includes Tejon Ranch just north of Santa Clarita and the proposed Centennial project for 19,000 homes between

Gorman and Neenuch, among others. Strategies to curb such developments have been widely discussed for decades in California (Pincetl 2009, LARC Framework 2016), and include transfer of development rights and urban limit lines among others, but in a fragmented governmental system, the issues of assigning rights transfers, competition among jurisdictions and, little precedent make these approaches difficult to implement (Decker et al 2017).

Land development in wildland will incur increased fire, with or without increasing temperatures and changing climate. Mitigation can be practiced with better building practices (increasing both density and structural integrity), avoiding building in canyons where air flows can be intense, and with fire breaks as well, although such changes will only affect fire hazard marginally. More frequent fires at higher intensities due to lack of controlled and/or natural burns, will increase landscape transformation to likely more flammable vegetation.

Common wall and denser housing patterns are less energy intensive (Salat 2009; Salat et al. 2012; Burrillo et al. 2018). They also offer more potential for cooling if well-designed and laid out, ensuring that buildings themselves can offer shading and capture cooling breezes. Infill in existing urban areas, including densification of already built areas such as single-family zones through granny flats and enabling existing homes to be subdivided into multiple units, are ways to house many more people in current cities. Concentrating people in the urban core will reduce the need for building new infrastructure, enable better access to public transportation and put people in places where there is less exposure to wildfire, among other benefits.

Coastal Infrastructure and Land Use Along the Coast

Southern California is particularly vulnerable to sea level rise, especially in combination with wave events from coastal storms. Once-a-century water levels are expected to become an annual event (Tebaldi et al. 2012). Numerous transportation assets are located adjacent to sandy beaches which are vulnerable to erosion (LA, 2016). California beaches are a popular destination for both residents and tourists; Pendlelton et al. (2012) reported approximately 18 million annual visits in 2000. However, this is likely an underestimate. Venice Beach's iconic boardwalk alone hosts approximately 10 million visitors per year (LA Parks, 2018). Annual value for LA and Orange County beaches is estimated at ~$3B (Pendleton et al., 2012). King et al. (2011) studied sea level rise impacts on select California beaches and estimated annual benefits (against a year 2000 baseline) to be $491M and $1B at Zuma and Venice beaches. Financial exposure to the 100-year coastal flood is expected to double and quadruple by 2100 at Zuma and Venice, while sea level rise is expected to decrease benefits (recreation, habitat, spending, and tax revenue) by $100M and $89M in 2100, respectively (King et al., 2011).

Sea level rise will significantly impact roadways and water systems (wastewater, storm water, and potable water). Heberger et al. (2009) estimated 56 miles of LA County roadways are currently exposed to the 100-year coastal flood. Higher sea levels will shoal groundwater tables and increasingly interact with private wastewater treatment (septic systems) found in developed beaches such as Malibu (Hoover et al. 2017). Large scale sewage treatment plants such as Hyperion are not in near-term danger of inundation; however, reduced hydraulic gradients from increased coastal water levels may affect gravity-driven effluent discharge and require additional pumping operations. The Venice Storm Water Pumping Plant and Terminal Island Reclamation Plant are identified as highly sensitive to sea level rise (Grifman et al. 2013, 2016). Generally, storm water outlets to the ocean and bays will be impacted by higher water levels. In low lying areas (e.g., San Pedro, Long Beach), higher high-water levels will require tide valve closure to prevent tidal flooding. However, closed tide valves preclude urban drainage resulting in increasing freshwater

flooding of low-lying coastal communities because of the inability to operate the stormwater system during high tides. Over 57 km of potable water distribution pipes areas are vulnerable to sea level rise and erosion (Grifman et al. 2013, 2016).

LA and Long Beach port infrastructure is not considered particularly vulnerable to sea level rise because of relatively frequent infrastructure renewal (Grifman et al. 2013, 2016). However, increasing water levels will promote breakwater overtopping and subsequent damage. The breakwater protects all shoreward infrastructure from wave attack. Breakwater damage would increase both cliff and beach erosion, potentially compromising recreational, commercial, private, and transportation infrastructure adjacent to the ports of LA and Long Beach.

Natural and Managed Resource Systems

VEGETATION AND FLORA

California's Mediterranean ecosystem has been identified as one of the earth's "biodiversity hotspots," a region with exceptionally high levels of diversity and endemism that are under an exceptional degree of threat due to humans. The California Floristic Province has over 5500 native plant taxa; 40% of which are endemic or restricted to the Province (Myers et al. 2000). Though this ecosystem is home to a number of endemic flora and fauna species, it is also one of the most highly altered ecosystems on the planet (Newbold et al. 2016). The high degree of rapid urbanization along the southern California coastline has resulted in the loss of significant natural areas and increasing human impacts to the remaining natural systems (Klausmeyer and Shaw 2009; Underwood et al. 2009). Compounding factors of human population increases, urbanization, and agricultural expansion in southern California has forced natural areas into increasingly isolated and smaller geographic areas over the last 100 years (Jongsomjit et al. 2012; Soule et al. n.d.). This makes the remaining natural areas and current protected areas vulnerable to climate change (Klausmeyer and Rebecca Shaw 2009; Loarie et al. 2008).

Changing climate has impacted the distribution of biodiversity of southern California for thousands of years. Currently there is no question that temperatures will continue to increase in the region over the next 50 years (p. 9, Cook, Ault, and Smerdon 2015). Mean precipitation in the region has remained relatively stable over the past century. However, drought has intensified because it has become warmer during periods of precipitation deficit (p. 19, Diffenbaugh, Swain, and Touma 2015; Cayan et al. 2010; Cook, Ault, and Smerdon 2015). This could lead to significantly higher occurrences of extremely wet and extremely dry years, in spite of no change in mean precipitation (pp. 12-14). These changes in temperature and precipitation regimes will have a significant impact on the vegetation and flora in southern California.

Vegetation

Plant phenology is strongly controlled by climate and has become one of the most reliable bioindicators of ongoing climate change. There is also evidence that climate change has shifted plant phenology in California's Mediterranean region (Gordo and Sanz 2010). One of the known ecological responses to climate change is a shift in the local phenology of plants such as changes in the start and end of the growing season, duration of growing season, and maximum productivity (Parmesan and Yohe 2003). In particular, spring events, such as start of the growing season and blooming, are changing more than autumn events, as they are more sensitive to climate and are also undergoing the greatest alterations of climate relative to other seasons (Gordo and Sanz 2010).

In Mediterranean regions, changes in vegetation greenness (Normalized Difference Vegetation Index, NDVI) monitored from moderate spectral resolution spaceborne sensors make it possible to measure fine-scale changes in vegetation characteristics and changes in seasonality over time (Gillespie et al. 2018). NDVI represents photosynthetic activity and is associated with biomass, carbon sequestration, plant water stress, and biodiversity. It can be used to track the effects of climate change on natural ecosystem functioning, especially in protected areas which are less impacted by human activities (Pettorelli 2013). Results from southern California show that some vegetation types (e.g., chaparral and coastal sage scrub) have experienced declines in vegetation greenness over the last 17 years, especially during the summer with or without the impacts of fire (Gillespie et al. 2018). However, islands off the coast of southern California have remained relatively stable, possibly due to the maritime climate around the islands which may buffer some of the impacts of the regional climate change and drought (Gillespie et al. 2018).

Another important impact from climate change is that anthropogenic fires are hypothesized to be become more frequent in southern California as the climate warms (Section 2.7, J. E. Keeley, Fotheringham, and Baer-Keeley 2005). These fires are important episodic events, which are unpredictable in time and extent, and can result in rapid and dramatic vegetation change. Projections from extrapolations of observed sensitivity of fire characteristics to temperature and humidity anomalies predict a doubling of area burned by mid-century in southern California (Jin et al. 2015). There is also evidence that the fire season is getting longer in southern California (Jin et al. 2015). Increases in temperature and extremes in precipitation will continue to increase the chances of fire and transform the composition of the native vegetation in select regions. There is evidence that increased fire frequency has the potential for nonnatives to alter fuels in a way that further increases fire frequency, which further increases expansion of nonnative species (Keeley 2000). Short fire-return intervals of less than 10–15 years present an increasing threat to chaparral ecosystems by eliminating shrub regeneration and leading to nonnative annual grasslands (Rundel 2018). Increases in fire ignitions and the extent of grassland can lead to a positive feedback cycle in which grass promotes fire and shortens the fire-return interval, ultimately extirpating native shrub species that are not adapted to short fire intervals (Syphard, Brennan, and Keeley 2018). The recent fires in the San Gabriel and San Jacinto mountains have converted former pine forest areas to drier chaparral after the fire and these pine forests will probably not return to the drier slopes. Other relictual vegetation types that have been around since the last ice age, such as walnut forests in the lowlands and laurel forests on north-facing slopes, may not regrow after fire due to the current and future climate conditions.

Flora

The flora of California include 2,387 endemic plant taxa, and predicted climate change could drive dramatic range losses for as many as two-thirds of the endemic species that comprise over 25% of the state's flora (Loarie et al. 2008). Indeed, it has been projected that 66% of California's endemic species will experience >80% reductions in range size within a century due to anticipated climate change impacts (Loarie et al. 2008).

Modeling of the future distribution of endangered plants from southern California shows that the climatic niches of many species are clearly moving north (Kueppers et al. 2005; Riordan and Rundel 2009; Riordan et al. 2014). Using regional climate model output, Kueppers et al. (2005) found that potential ranges of two California endemic oaks, *Quercus douglasii* and *Quercus lobata*, may shrink considerably (59% and 54% of modern potential range sizes, respectively) and shift northward.

Based on regional climate change projections, almost half of protected land area currently containing these species is expected not to contain them under a future mid-range "business-as-usual" path of greenhouse gas emissions (Kueppers et al. 2005).

Species that occur in California's coastal sage scrub may also be significantly impacted by projected climate change impacts and anthropogenic land use change. Most coastal sage scrub species show potential northern habitat expansion and southern habitat contraction due to projected climate change (Riordan and Rundel 2009). High geographic overlap in habitat losses driven by projected climate change and projected land use in the southern California underscores the potential for compounding negative impacts of both drivers (Riordan and Rundel 2009). Limiting native habitat conversion may be a broadly beneficial strategy under climate change. Indeed, there will be a need to transplant some of these species to appropriate regions to maintain their range (Riordan et al. 2014). Protecting potential future refugia and facilitating species dispersal will be essential to maintain biodiversity in the face of climate change (Loarie et al. 2008).

OCEANS AND COASTS

Sea Level Rise and Coastal Flooding

The most dramatic effects of climate change on the ocean and coast of the greater LA region will be the result of sea level rise and coastal flooding. Ocean acidification will also take a toll. In addition to permanent inundation resulting from global sea level rise (p. 15), southern California will occasionally experience increased temporary short-term flooding, mostly during winter storms. When coupled with high tides and large waves, there may be substantial erosion and damage to coastal property, similar to what happened during the great storm of January 27, 1983. Even a moderate rise of sea level of 35 cm (less than 14 inches) relative to the year 2000, which could happen by the mid-21st century, would increase serious flooding risk to life and property 25-fold (Sweet 2017).

Effects on Beaches and Wetlands

A rising sea will accelerate coastal erosion, producing more sediment for beaches and wetlands, but both will almost certainly be compressed with a rising sea. Wetlands keep pace with a rising sea either by building vertically or by moving landward. The first requires an adequate supply of sediment; the second requires pathways unimpeded by infrastructure such as highways, railways, ports, airports, coastal parks, and buildings, and also requires land with appropriate low-lying elevation. The heavily urbanized character of southern California's coast and the relatively small sediment supply strongly suggest that we will lose a significant fraction of our wetlands over the next few decades unless there is intervention. This loss of wetlands will result in a loss of buffering capacity against coastal storms and erosion, loss of habitat, and loss of sequestered CO2. Wetlands are important spawning and nursery grounds for a number of species of fish and invertebrates, and also serve as resting areas for wildfowl migrating along the Pacific Flyway.

Doughty et al. (2017) found that under the 2050 maximum sea level rise scenario (Committee on Sea Level Rise in California, Oregon, and Washington et al. 2012), over the entire Southern California Bight, 12% of vegetated marsh and flats would be lost with an 0.6m rise, and that 48% would be lost under the 2100 maximum sea level rise scenario with a 1.6m rise, without intervention. Given recent higher estimates of sea level rise (p. 15), the projected losses of wetlands in this region could be even greater. Opportunities for intervention could not only reduce these losses, but potentially increase the area of wetlands within the region. They would require some combination of supplementing sediment sources, clearing pathways for migration of wetlands landward into areas of appropriate elevation, and modifying the geometry of the mouths of several of these systems.

An important paper by Thorne et al. (2018) analyzed the resilience and vulnerability of wetlands to sea level rise along the west coast of North America. Their analysis showed that for wetlands along the highly urbanized coast of much of southern California, under a high sea level rise scenario there would likely be a total loss of all marsh habitats by the end of the century without active intervention to allow migration or to supplement sediment supply. This will result in a loss of storm surge protection, wildlife habitat, and a net loss of important ecosystem services including long-term carbon storage. A number of species including the light footed Ridgway's rail and Belding's savannah sparrow face extirpation, and perhaps extinction. The increase in mudflat area will increase foraging habitat for shorebirds.

The sandy beaches along much of this segment of the California coastline provide the first line of defense against sea level rise and coastal storms. The landward translation of flooding from sea level rise and coastal wave events also leads to coincident bluff, cliff and beach erosion. In assessing the shoreline erosion for just the southern portion of the CoSMoS modeling (Santa Barbara to San Diego counties), initial analyses project that 1- 2 m of sea level rise by 2100 would result in an average beach loss of 26-41 m, completely eroding up to 67% of the South Coast beaches (Vitousek, Barnard, and Limber 2017). 19 – 30 m of bluff retreat are projected for 1 -2 m of sea level rise by 2100—an increase of 180% for the 2 m sea level rise scenario compared to the historical rates in southern California (Limber et al. 2018); an additional 17-36 m of storm-induced erosion is projected under the various sea level rise and storm scenarios.

The losses of beaches and wetlands will also take a toll on the recreational value of the region, particularly the loss of beaches.

The Ports of Long Beach and Los Angeles

Sea level rise also poses a threat to the nation's two largest container ports—the Port of Long Beach and the Port of LA. Both ports have major initiatives to reduce their greenhouse gas emissions and to develop adaptation plans. The Port of Long Beach has developed a Climate Change Adaptation and Coastal Resiliency Plan that is updated as new information becomes available. The Port of Long Beach is elevating piers and shore-based facilities in anticipation of a higher sea level. The movement of goods into and out of the two ports from the land side outside of port properties may also be subject to inundation and flooding.

Effects on Marine Life

Continued warming of the ocean will further stratify the water column the farther we go into the 21st century. This will reduce upwelling, decrease nutrient levels, and decrease primary productivity. The ocean will become more acidic with the continued transfer of CO2 from the atmosphere to the ocean, which will affect both natural populations of shellfish and shellfish mariculture operations (Ekstrom et al. 2015).

Effects of climate change on marine species and marine ecosystems are less well understood than effects on terrestrial species and ecosystems, but several trends are strongly suggested for this region. There will continue to be a poleward shift by many fish species to keep within their preferred temperature ranges. The probability is high that we will see more permanent resident extensions of subtropical fish into this region. There is a high likelihood of declining kelp forests due to rising ocean temperatures (Tegner et al. 1996; Reed et al. 2016). Evidence has shown that abalone populations are adversely affected by ocean warming: cool-water red abalone suffer stronger consequences in warm water compared to green abalone (Ekstrom et al. 2015; Vilchis et al. 2005).

Recruitment of fucoids (brown seaweed) and intertidal invertebrates in the littoral zone will probably decrease as a result of rising temperatures, causing desiccation of propagules and suppressing growth, leaving new recruits more susceptible to grazers (Hoegh-Guldberg and Bruno 2010).

Biodiversity will almost certainly decline well before the end of the century. Large (50-70%) declines of the communities associated with mussel beds are anticipated (Zippay and Helmuth 2012; Smith, Fong, and Ambrose 2006).

Over much of the past 50-60 years, the trend has been for a shoaling of low oxygen zones. If that trend continues, it will result in a loss of habitat for rockfish, one of the iconic fish species of this region (McClatchie et al. 2010). In a warm period from 1951-1993 zooplankton biomass in the Southern California Bight decreased by as much as 80% (Smith 1995). If this occurs, the seasonal populations of whales will probably move to other areas where food is more abundant. There is some evidence that algae responsible for harmful algal blooms are favored in a warmer ocean, indicating that they may increase in frequency and intensity in the region (Edwards et al. 2006; Peperzak 2003; Glibert et al. 2005). More on these and the other ecological, social, and political impacts climate change is projected to have on California's ocean and coast may be found in a companion Fourth Assessment piece (California's Ocean and Coast Summary Report 2018).

AGRICULTURE

Climate and Agriculture in the Los Angeles Region

Although the LA region is not primarily known for its agriculture, LA, Orange and Ventura Counties produces an annual agricultural output of $2.5 billion. Ventura County dominates the total ($2.2 billion), but with significant remaining contributions from Orange ($125 million) and LA ($193 million). Agricultural data are generally published at the county scale, so we do not present quantitative data on the fractions of San Bernardino and Riverside Counties that make up the remainder of the LA region, but the estimated regional boundaries include about $300 million of Riverside's $1.3 billion output.

The bulk of the value in the LA region is specialty crops, defined as fruit and nuts, fresh vegetables, and nursery products. Strawberries are the region's most valuable crop (Figure 14), with lemons, nursery plants, raspberries, celery, and avocados also figuring prominently (CDFA 2017). The complete list includes dozens of other fruits and vegetables, as well as some alfalfa hay, dairy, beef, and poultry. The region's Mediterranean climate and low annual rainfall (10"-20") makes irrigation essential for practically all commercial agriculture.

The climatic changes impacting agriculture in the LA region will be similar to those impacting the state as a whole: Increases in minimum and maximum temperatures (p. 9), increases in the frequency and intensity of extreme events, such as drought (p. 19), heat waves (p. 9), storms (p. 14), and precipitation amounts of single rainfall events (p. 12), and spatial and temporal shifts in precipitation patterns (p. 12). Of these, changes in average temperature are the most straightforward to predict and have received the most attention in the literature on agricultural impacts (Kerr et al. 2017), but changes in precipitation and extreme events may prove to be at least as consequential.

Potential Impacts of Climate Change on Crop Production Factors

WATER DEMAND AND AVAILABILITY

Like the rest of the state, the LA region is expected to face a challenging combination of decreased water supply and increased water demand (p. 61). Greater interannual variability of rainfall (Dettinger, Udall, and Georgakakos 2015) and sharp decreases in snowpack will create surface water limitations for the entire state. Although the effect of climate change on average precipitation in California is still unclear, more frequent occurrences of extreme events similar to the 2011-2016 drought could significantly decrease groundwater recharge, which is essential for the sustainability of agriculture in this region since the vast majority of water used in agriculture in the LA area is groundwater from local wells. Furthermore, higher temperatures mean that dry years will more quickly develop into severe drought conditions (Diffenbaugh, Swain, and Touma 2015). The South Coast's water demand is about 80% urban (Mount et al. 2014), and competition between water uses may increase in the future.

Concurrently, temperature increases will increase crop evapotranspiration and water demands. No studies could be found for the South Coast region, but studies for the Central Valley estimate a 4%-9% increase in crop water demand by 2100 (Purkey et al. 2007; Joyce et al. 2011). In southern California, increased frequency and duration of Santa Ana winds (easterly warm and dry winds) could require substantially more water to meet plant demands (p. 14). Since nearly all crops in this area are irrigated to meet demand, actual increases in water stress will be minimized to the extent possible. However, a variety of indirect impacts are likely:

- Increases in water costs will result in increased production costs, potentially causing producers to shift to less water-intensive crops (e.g., from avocados to grapes), fallow land, or (in the absence of adaptation options) leave agriculture altogether.
- Reduced rainfall and increased groundwater withdrawal may lead to more salinity buildup in topsoil and salt-water intrusion in wells, posing problems for the region's salt-sensitive crops such as strawberries and avocados. Or, if more irrigation water is applied to leach salts accumulated in topsoil, this will exacerbate the problem of increased water demand.
- Increases in extreme precipitation (greater amount and duration of single rainfall events) can adversely impact yield and quality, especially of the region's more delicate produce such as berries and vegetables, due to the extended exposure to saturated conditions.

PEST AND DISEASE PRESSURE

Higher temperatures can increase pest pressure; insects and mites reproduce at faster rates under warmer climate, resulting in crop production damages (Trumble and Butler 2008) and possibly increased pesticide use. New pests and diseases could also be introduced under future warmer temperatures. However, climate change may reduce pest populations if warmer temperatures exceed a pest's tolerance. For example, Persea mite pressure in California avocados can be reduced by several consecutive days of 100°F weather (Faber et al. 2016).

These dynamics are even harder to predict when multiple species are involved. For example, controlling spider mites in berry crops (Zalom et al., 2015) may become more challenging because the predatory mites such as Phytoseiulus persimilis (used as biocontrol) have lower optimum temperatures and higher humidity requirements than do the pest mites. Also unclear is how climate change may affect invasive disease vectors, such as the Asian citrus psyllid that spreads HLB bacteria or the polyphagous shot-hole borer that spreads Fusarium dieback affecting avocados. These vectors are already undergoing range expansion in southern California subsequent to their recent introductions in the region (2008 and 2003, respectively), and climate change may or may not exacerbate the spread.

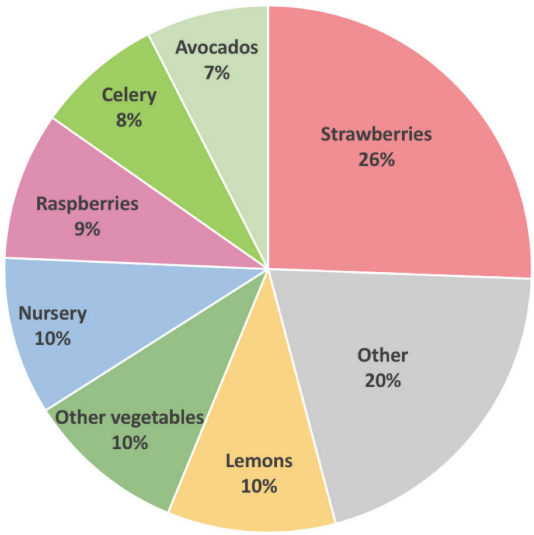
Many diseases affecting southern California crops are likely to increase with increasing temperatures. For example, Fusarium and Macrophomina fungal pathogens affecting strawberry and vegetable crops are particularly troublesome at soil temperatures above 70°F (Daugovish et al. 2016). Conversely, some diseases that thrive in cool, damp conditions, such as powdery mildew, may pose less of a threat in the future. A particular disease may respond not only to temperature but also to humidity, extreme events, and to the exact timing of these changes. In summary, though agriculture in the LA region will likely see shifts in pest and disease pressure, the outcome will greatly depend on the species under consideration.

TEMPERATURE STRESS AND PLANT PHENOLOGY SHIFTS

Whereas increased minimum temperatures pose a threat to California regions that grow fruit and nut trees requiring chill-hours, these crops are not widely grown in the LA area. Warmer minimum temperatures may actually have yield benefits for subtropical crops such as citrus and avocado (Lobell, Cahill, and Field 2007). Higher winter minimum temperatures may reduce freeze risk for subtropical crops, but no studies on this topic could be found for southern California.

However, increases in maximum temperatures in the LA region are likely to have distinct negative impacts on agriculture. Crop exposure to elevated temperature can accelerate crop growth and lead to earlier and often reduced yields (Lobell and Field 2011; Elias et al. 2017). Yield reduction may occur because plants close their stomata at temperatures above what is optimal for each crop. Vegetable crops, specifically grown in coastal areas in this region, are sensitive to extreme temperatures and can experience reduced yields with increases in maximum daily temperatures. Extreme heat events, or extended periods of warm day and night temperatures, can affect flower induction and decrease fruit yields of strawberries (Morton et al. 2017; Lobell and Field 2011) . This is particularly applicable to summer-planted strawberries that experience poor pollination when temperature reaches 80°F.

FIGURE 14



Top agricultural commodities (by value) in Ventura, Los Angeles, and Orange Counties combined. Total 2015 gross value for these counties was $2.52 billion. Data from CDFA (2017).

Finally, we note that changes in market window opportunities (anticipated or postponed) can significantly affect crop prices, and these economic effects may in some cases be of comparable importance to the biophysical effects of climate change. For example, climate change may allow higher yields earlier in the strawberry growing season when prices are at a premium. More research is needed on the economic aspects of crop phenology changes.

Adaptation Options and Research Needs

Based on recent literature summarizing climate adaptation options for US agriculture (Janoviak et al. 2016; Pathak et al. 2018), we highlight several strategies especially relevant to the LA region.

WATER AND SALINITY

- Further develop water-efficient technologies (such as microsprinklers, drip, and subsurface drip irrigation) and efficient irrigation scheduling for the region's crops, coupled with smart irrigation management systems.
- Promote on-farm water capture and storage, including rainwater collection, small dams, and groundwater recharge.
- Improve soil water-holding capacity and infiltration rates through organic matter addition.

- Refine and implement deficit irrigation strategies for citrus (Faber et al., 2015).
- Determine new approaches to avocado spacing, pruning, and plant growth regulators that can enhance avocado yields per unit of water (Rolshausen et al., 2016).
- Develop techniques for more efficient water use in nurseries, including water recycling.
- Prioritize plant breeding for improved water productivity and salt tolerance in sensitive crops, such as strawberries, raspberries, and avocados.
- Promote improved distribution and use of recycled water

PHENOLOGY AND TEMPERATURE:

- Revise planting, pruning, and harvest schedules to optimize use of a longer growing season.
- Deploy and further develop heat-tolerant varieties of sensitive crops such as strawberries.
- Use practical shade structures, surface mulch, and other cooling techniques.
- Use laboratory, field, and citizen-science studies to anticipate weather- and climate-related dynamics of major pests and diseases.
- Use UC IPM weather-based pest and disease models to reduce pest and disease impacts on crops and potentially reduce number of pesticide applications.
- Analyze economic feasibility of switching to less water intensive crops (e.g., avocados to grapes) or from cool- to warm-season vegetables (e.g., celery to peppers or cucumbers).

FIGURE 15

Strawberries are the highest-valued crop in the Los Angeles region, totaling $644 million in 2015. *(Photo by Amber Kerr.)*

WATER

Across southern California and its hundreds of water agencies, future climate impacts to water management operations are likely to occur at multiple geographic scales. This assessment focuses on the metropolitan LAregion and includes LA, Orange, Riverside, San Bernardino, and Ventura counties. First, within these areas, increases in mean surface temperatures will influence water needs that support aquatic habitat, irrigated landscapes, and protected areas, while sea level rise will threaten coastal areas. Second, far outside of the region in the distant watersheds that supply imported water, changes in precipitation and snowpack will affect historic expectations of water availability.

The structure of water management agencies across the region offers unique challenges and opportunities for confronting necessary management changes. Southern California has a diverse, hierarchical network of hundreds of water agencies. In LA County, for instance, there are more than 100 sizeable water supply agencies that acquire, treat, and distribute water throughout 88 cities and additional unincorporated areas, and the total number of community water systems in the county is over two hundred (Pincetl, Porse, and Cheng 2016; DeShazo and McCann 2015). Water importing agencies, primarily the large Metropolitan Water District of Southern California (MWD), built over time a system for acquiring water from northern California, the Sierra Nevada Mountains, and the Colorado River Basin (Erie and Brackman 2006). LA is situated within a hub of pipelines that move water over great distances in support of urban and agricultural needs (Hundley 2001).

Current scientific understanding, summarized below, illustrates the potential effects of climate change on water management in the LA metropolitan megaregion, along with possible options for adapting to expected variability of precipitation.

Within Los Angeles: Local Precipitation, Habitat, and Sea Level Rise

Inside the region's borders, climate change will likely alter precipitation, streamflows and aquatic habitat, coastal ecosystems, and security of access to water supply for some communities in LA and surrounding cities. In particular, more extreme rainfall events with increased intensity will likely affect local stormwater and water supply availability (Dettinger 2011b). Storms of greater intensity will make local stormwater capture and use more difficult, requiring larger surface storage and infiltration capacity to recharge groundwater basins (LA Basin Study). In addition, average total precipitation in southern California may reduce slightly (Allen and Luptowitz 2017). These two factors combine to challenge a system already seeking to increase capture and use of stormwater for recharging the regional groundwater basins that are critical for supply (Porse et al. 2015).

Urban ecosystems rely on water to supply aquatic habitat and landscapes. For aquatic habitat, the volume of urban streamflow will likely decrease, at least seasonally, due to reduced availability of imported water additions coupled with increased capture and use of in-basin runoff (Manago and Hogue 2017). Regional marshes and wetlands are particularly vulnerable to warming temperatures and sea level rise (Thorne et al. 2016). At the same time, stormwater pollutant loading is a complex process, correlated with the intensity, duration, and frequency of precipitation, land uses, and other factors (Stein et al 2007). Reducing untreated urban runoff through new stormwater control measures and source control actions such as street sweeping can improve water quality in local watersheds and coastal areas (Dwight et al. 2002; Dwight and Semenza 2006; Shuster et al. 2005; Lee et al. 2004).

Clean Water Act regulations have successfully reduced stormwater contaminant loading in southern California (Lyon and Stein 2009). Within cities, unique ecosystems exist that are highly influenced by human management and decisions (Pickett et al. 2001, 2011). Water conservation driven by reduced imported water availability, coupled with warmer surface air temperatures, will change urban landscapes as lawns reliant on seasonal irrigation are converted to low-water yards of mulch, rock, shrubs, and other ground cover (Pincetl et al., under review). Urban trees, which provide shade and contribute to reducing urban heat island effects, historically relied on significant irrigation but used much less water than turf (E. Litvak et al. 2017a; Elizaveta Litvak, Bijoor, and Pataki 2013; Pataki et al. 2011a). The effects of changing urban landscapes may increase local surface temperatures, but net trends are not clear. Low-water-use landscapes with less irrigation can cause warmer daytime temperatures due to reduced evapotranspiration, but model results show even larger cooling signals at night due from such landscapes to reductions in upward ground heat fluxes related to soil properties (Vahmani and Ban-Weiss 2016).

Finally, more extreme precipitation and increased intensity of rainfall would increase the risks and damages from urban floods. Coastal and inland southern California urban areas use a network of underground storm drains, natural and concrete channels, surface conveyance, and upstream flood control dams to reduce flood risks. The system arose after massive floods devastated LA in its early decades (Orsi 2004; Davis 1993; USGS 1970). Continued urbanization over time has increased flood risk (Sheng and Wilson 2008). Today, water quality regulations increasingly require on-site management of runoff from storms up to a key design storm from historic hydrology. While this assists in reducing runoff from smaller storms that can improve surface water quality, it does not address large-scale flooding that may result from more extreme rainfall events. Analysis from urban areas throughout the globe indicates the potential increased risks that may result from such changes (Willems et al. 2012; Zhou et al. 2013), serving as examples of peer-reviewed studies that can inform infrastructure planning in the LA region.

Beyond Los Angeles: Imported Water Availability

The LA region is intimately connected to other Western U.S. watersheds. Water supply agencies rely on imported water for a majority of regional water supply (Gold et al 2015; Porse et al. 2017). Three main water sources supply metropolitan LA water agencies: the California Aqueduct as part of the State Water Project, the Colorado River Aqueduct that supplies southern California's allocation of Colorado River water, and the LA Aqueduct that imports water from the Owens Valley. Imported sources comprise a majority of water demands. For instance, in LA County, imported sources meet 55-60% of annual urban water demands, with the remaining amount supplied by groundwater (35-40%) and recycled water for nonpotable uses such as irrigation. From 2000-2010, these water agencies received an annual average of 810,000 acre-ft from MWD's imported sources, through in recent years averaging closer to 700,000 acre-ft.

The entire American Southwest is expected to see increased drought and reduced availability of future water for agriculture and growth (MacDonald 2010). Such large-scale changes across a broad geography, which includes California, will pose unique risks for each of the massive infrastructure systems that import water to LA. The LA Aqueduct diverts alpine water from the Owens Valley and Mono Lake in the Eastern Sierra Nevada, which constitutes approximately a quarter of the supply for the City of LA, although little water has flowed from Mono Lake in the recent decade. Below the Owens Valley, the LA Aqueduct includes a series of reservoirs with limited storage capacity. In recent years, environmental restoration commitments by the LA Department of Water and Power

(LADWP) have reduced flows from the LA Aqueduct, whose costs and volumes fluctuate significantly across water years (LADWP 2015). Studies indicate that Eastern Sierra snowpack in the region may fluctuate towards wetter or drier conditions, but snowpack is expected to decrease. This increases spring runoff volumes and, without additional surface storage or groundwater recharge, reduces availability of imported water during the late summer and early fall months (Costa-Cabral et al. 2012; Musselman, Molotch, and Margulis 2017).

The State Water Project of California brings water from the northern and western Sierra Nevada mountains south through the Sacramento-San Joaquin Delta to urban and agricultural users in southern California. Historically, the State Water Project contributed the majority of water supply to MWD's sources (53% from 1976-2010). Numerous studies have documented the likely shifts in precipitation regimes that will result from climate change in California, including reductions in snowpack, advances in the timing of runoff leading to reduced seasonal capture and storage capacity, and hotter coastal and inland temperatures increasing demand (Anderson et al. 2007; Brekke et al. 2004; N. L. Miller, Bashford, and Strem 2003; Tanaka et al. 2006; Vicuna and Dracup 2007; Dracup and Vicuna 2005). Additionally, the system of reservoirs will face increasing operational risks in managing more extreme rainfall events and preventing floods (Brekke et al. 2009). Applying such projections in planning can be challenging, given long-term uncertainties and sunk costs in current infrastructure (Groves, Yates, and Tebaldi 2008). Given these long-term likelihoods, the reliability of water deliveries from northern California will likely stir significant continued political debate and uncertainties, especially regarding future management alternatives for critical habitat and conveyance areas of the California Delta (Madani and Lund 2010).

The Colorado River Basin supplies water to farms and cities for a region of the Southwest stretching from Colorado through Baja, Mexico. Through the Colorado River Compact of 1922 and agreement among the Lower Colorado River Basin states signed in 1928, California receives allocations of 4.4 million acre-feet per year. This is diverted through the Colorado River Aqueduct at the Arizona-California border, which was built by MWD and opened in 1939. Agricultural and urban growth throughout the region, along with contemporary understanding that the river's allocations are based on an historically wet-period, mean that coastal and inland southern California will likely face increasing variability of Colorado River Aqueduct supplies. Reservoirs are already lower, spurring recent efforts to renegotiate long-term allocations and drought restriction policies. Climate change will likely exacerbate these already-present shortages, with reduced precipitation leading to reductions in runoff of 10% or more (Hamlet and Lettenmaier 1999; Christensen and Lettenmaier 2006). Historically, the Colorado River Aqueduct has supplied MWD with 46% of its imported supplies, but continued growth in irrigated suburban development and agriculture will likely strain this water availability (MacDonald 2010).

Mitigation and Adaptation: Research and Assessments

Adapting the complex water management systems of LA, Orange, Ventura, and Riverside counties to adequately face evolving risks from climate change involves actions currently underway, as well as actions that must be undertaken in the future. Regional water managers must identify how to increase water conservation and promote reliability and resiliency of supplies.

For the goal of increasing conservation, outdoor water use is a key target. Residential lawns in particular constitute half of all urban water use throughout much of California, including the LA metropolitan area (Hanak and Davis 2006; Mini, Hogue, and Pincetl 2014a). Some coastal communities, notably areas with high-density

urban development and small yards, have much lower use, while other parts, especially inland areas and affluent neighborhoods with sizable well-irrigated yards, use more (Porse et al. 2017; Mini, Hogue, and Pincetl 2014c; Litvak et al. 2017a).

A key goal to address this opportunity involves better supporting public and community driven programs for replacing lawns (see the "Improved Landscaping Practices" sidebar for more information). Water supply portfolios much less dependent on imported water can still support urban life and trees, but converting to low-water landscapes is critical for progress (Porse et al. 2017).

CASE STUDY | IMPROVED LANDSCAPING PRACTICES
Stephanie Pincetl - UCLA IoES

In 2014, the Metropolitan Water District of Southern California (MWD) undertook an unprecedented investment to incentivize turf replacement throughout southern California in response to the state's serious drought. MWD devoted $350 million to the program, resulting in more than 46,000 rebate payments to remove 15.3 million square meters of turf.

Results from an MWD-commissioned study showed that program participation corresponded to wealthier socioeconomic neighborhoods, and the City of LA showed the highest numbers of program participants (more than 80% of program participants), likely due to the additional funding provided per square foot by the LA Department of Water and Power (Pincetl et al. 2017). Since outdoor landscaping accounts for over 50% of domestic water use, and residential water use is the highest proportion of overall water use in the region, reducing outdoor water use through turf replacement is the most effective way of reducing overall water use in the region (Mini, Hogue, and Pincetl 2014b). Litvak et al. (2017b) show that turf can be replaced with less water-intensive landscaping while maintaining tree canopy cover, although this will require shifting irrigation to more deliberately irrigating the trees themselves. This is important for ensuring the shading attributes of trees to cool the urban atmosphere are maintained. However, the longitudinal effects of short-term turf replacement incentives are unknown, and analysis to date has only encompassed examining changes in front yards (Pincetl et al. 2017).

Google Street View examination of a random sample of 1,000 front yard turf replacements showed several categories of plants, including shrubs, trees, succulents, perennial herbs, and grasses. Shrubby plants consisted in 14.6% of the new land cover and 9.6% of the front yard was covered by artificial turf. Woodchips, gravel dirt, and lawn were also found. Street View revealed a high diversity of plantings, but to understand how such turf replacement programs may affect urban landscaping and water use over the long term, longitudinal studies are needed, as well as backyard visits. Further, little to no work has been done on water-use reduction analysis that may result from the programs. Overall, MWD and other such entities will need to conduct assessments and evaluations to understand if, and how, such turf replacement programs affect urban landscapes and water use.

Developing more reliable water supplies involves enhancing capacity for alternative sources along with improving system performance. Many local water agencies in southern California are investing in local and alternative water supply resources, including groundwater, stormwater capture and reuse, and water recycling (Porse et al. 2017). The City of LA has outlined plans for integrating water management (*OneWater* strategy) and reducing purchased water imports to 50% of total supplies by 2025, which is a significant achievement for a city that relies on imported water for 90% of supplies (L.A. Office of the Mayor 2015). Other localities, too, are outlining integrated planning efforts, such as Santa Monica, which adopted a water neutrality ordinance and is undertaking sustainable groundwater management planning. Water districts in Orange County continue to operate and enhance water recycling and groundwater recharge facilities, which have buffered critical local groundwater basins for decades (Allen and Elser 1979; Mills 1998). Throughout the region, MWD is investigating the feasibility of a regional system for distributing recycled water from one or more of the region's existing large wastewater treatment plants, such as the LA County Joint Water Pollution Control Plant (MWD 2016). Finally, MWD has committed to funding a majority of the costs for the large new infrastructure project to build water supply conveyance tunnels in the Sacramento-San Joaquin Delta (*California WaterFix*), which would increase the system's operational reliability to climate-induced sea level rise at the intake valves in the northern Delta.

These alternatives all help diversify and reduce the dependence of agencies on a single supply such as imported water, while also making the system more resilient to water shortages in distant watersheds. Alternative actions and local sources can have additional habitat, energy, and water quality benefits (Spang, Holguin, and Loge 2018; Spang and Loge 2015; Mika et al. 2017). Given currently planned and discussed system improvements, it is unlikely the region would entirely wean off of imported water, but it could significantly reduce imports and even import water during only wetter years (Pincetl et al., under review). Moreover, the rising costs of imported water are making local and alternative sources more cost-effective (Porse, Mika, Litvak, et al. 2018).

CASE STUDY | MANAGING FOR SCARCITY TO WEATHER THE DROUGHT

Caryn Mandelbaum

The Inland Empire Utilities Agency (IEUA) water and energy optimization is a great example of climate resiliency in one of the hottest areas of southern California. The IEUA's service area covers 242 square miles where Riverside and San Bernardino Counties meet and where summer temperatures soar to over 110°F (43°C). The IEUA distributes imported and regionally-produced water and provides industrial/municipal wastewater collection and treatment services to more than 830,000 people throughout its nine member agencies.

How, you might ask, did they manage to have surplus water during the state's worst-ever drought? The short answer is they had been managing for scarcity for the past 20 years. Leadership had the foresight to establish a grant writing department that matched every dollar spent with grants for efficiency projects. They invested nearly $500 million in developing regional water supplies, including state-of-the-art recycled water and groundwater recharge facilities, water use efficiency programs, and infrastructure improvements that avoided leaks.

They also developed close ties with their customers through public affairs staff and communications campaigns. This allowed the water agencies to enforce water budgets for each ratepayer. The budget provided a specific monthly allowance of water, depending on the number of occupants and outdoor footprint. The outdoor space was measured aerially to the square foot. They learned about how their consumption patterns measured up to prior use and that of their neighbors. When customers exceeded their budget, they were penalized and provided with tools for conservation. Armed with information and tools, ratepayers were able to better control their water consumption.

Remarkably, while the IEUA developed surplus water during California's historic drought, they were also becoming one of the most energy-efficient utilities in the state. In 2010, the agency installed the world's largest fuel cell system powered by renewable biogas and reduced energy consumption by nearly 25% upgrading operations. In 2017, they launched an advanced energy storage system designed by Tesla that integrates solar, wind, biogas, and grid resources to optimize renewable generation, reduce demand, and lower energy costs. Together with dynamically controlling consumption, IEUA is on track to go gridless by 2020 with almost no capital investment by the Agency.

Finally, shifting water supply and management in metropolitan LA and surrounding cities to reduce reliance on imported water will have effects on the current governance system and likely requires governance innovations. For instance, in the absence of imported water, the networks of water agencies that interact to buy, sell, and distribute water would likely grow more decentralized. Wholesaler agencies and special districts will likely take on more responsibilities. The Water Replenishment District of Southern California, which began as an agency for managing water replenishment actions in the Central and West Coast Basins of LA, recently took on new duties as the groundwater master for these critical aquifers (Porse 2018, under review). Other agencies, such as the LA County Department of Public Works, have already taken emerging leadership roles to reoperate and expand existing systems for capturing and recharging more runoff (LACDPW 2016). But additional governance actions could increase regional capacity to respond to climate change uncertainties. For instance, reconsidering and reallocating the current system of groundwater pumping rights for LA County groundwater basins would provide additional flexibility to agencies for meeting demands and potentially offer critical new sources of water supply for agencies that have no pumping rights and are entirely reliant on imports (Porse, Mika, Williams, et al. 2018). In addition, changing financial and accounting schemes to reflect the life-cycle costs of water management, including acquisition, treatment, use, and disposal, can spur agencies to reconsider their current array of supply sources and give further reason for reaching out to agencies, including those from other sectors such as wastewater or water supply. To date, some of these agreements are taking place, but further opportunities exist and most regional management documentation still compare retail prices of current sources of water supply with long-term costs of new infrastructure without considering likely future increases to imports or all of the stages of water management. Comparative estimates of benefits and costs will change significantly with reduced imported water availability (Porse, Mika, Litvak, et al. 2018).

CASE STUDY | RIGHT-SIZING DECISION MAKING
Mike Antos, SAWPA

How we make decisions and administer the choices we make needs to be adapted with as much deliberation as any of the other sectors considered in this report. We speak of adaptation as being a local challenge, and inherent in that local scale is our existing local decision-making institutions (cities, counties). Climate adaptation challenges, however, will often resolve at scales which confound our local decision-making bodies, instead requiring regional decision-making processes that match the scale of the challenge.

The Santa Ana Watershed Project Authority (SAWPA) can be viewed as a model for this idea. Created in the late 1960's, it is a joint-powers agency whose members are Eastern Municipal Water District, Inland Empire Utilities Agency, Orange County Water District, San Bernardino Valley Municipal Water District, and Western Municipal Water District. SAWPA was created to protect and maintain water quality and quantity in the Santa Ana River in response to the challenges of salt accumulation due to increased imported water from the State Water Project, and increased development of first agriculture and now urban and suburban landscapes. SAWPA has authority to plan and implement projects across the entire Santa Ana River watershed and undertakes three primary roles in service to its mission. The first is the Inland Empire Brine Line, a separate and specialized wastewater discharge system that currently supports groundwater desalting and private industry salty discharges, removing about 500,000 pounds of salt per day from the watershed. Second, SAWPA facilitates multiple roundtable task forces and workgroups in support of multi-party regulatory compliance activity, or activity and research of broad interest within the watershed. Third, SAWPA is the watershed's approved regional water management group within California's Integrated Regional Water Management Program. The resulting One Water One Watershed (OWOW) Plan is written by stakeholders and governed by a steering committee of representatives from across the watershed. Implementing the OWOW Plan helps the entire watershed move towards sustainability.

The many local communities of the watershed benefit from the governance and management capacity achieved by the creation of SAWPA. The member agencies, each a special district water agency, together support the regional capacity SAWPA provides, both for their own benefit but also to the benefit of all in the watershed. SAWPA is a government entity that can plan and act at the watershed scale, and therefore is able to confront challenges that resolve at that same scale. The three lines of activity described above rely on authority at a regional scale to support collaborative and multi-party activity at that regional scale. SAWPA is an example of a governance adaptation to face the challenges of local- and regional-scale climate impacts.

Using SAWPA as a model, other legal partnerships or collaborative institutions can be formed to provide critical decision-making and project or program implementation in support of climate adaptation. Having this capacity is most critical when an adaptation effort is best resolved at a scale beyond that of existing local institutions. Collaborative institutions don't replace existing authority or autonomy; rather, they support and ease the shared activity at scales demanded by adaptation challenges. Integrated management requires specialized skills, authorities, and budgets, and having institutions that support effective integration and regionalization, when needed, will be an important mechanism for right-sizing our decision-making.

Conclusion

Climate change is expected to significantly impact the LA region. Warmer average and extreme temperatures, increased precipitation extremes, and rising sea levels are expected to occur. Future changes in Santa Ana winds, wildfire, coastal clouds, and air quality are less certain, but new integrated models and observational datasets are expected to advance our understanding of these aspects of climate change.

The LA region has already taken steps to prepare for a changing climate, but deeper understanding, smart planning, and ample financial and human resources will be needed to fully cope with these changes. Increased resources are needed for local health departments to model and respond to climate-related public health impacts and to train healthcare professionals on best practices for how to teach patients to protect themselves from climate impacts. Community vulnerabilities to climate change must be considered as local and regional agencies update emergency response plans and operations. Continued growth in renewable energy and investment in new energy infrastructure will be needed to handle projected increases in electricity consumption for many locations in the LA region. Reducing the region's carbon emissions and increasing mobility for its residents can be accomplished through targeted upgrades and new infrastructure to LA's transportation system. Planting trees can reduce the urban heat island and improve air quality for the region, but dedicated funding to increase the planting of new trees and maintenance of existing ones is needed to realize their full benefits. Longitudinal studies of changes in urban landscaping will need to be conducted to understand if, and how, turf replacement programs affect water use and other aspects in the region. Numerous ecosystems will be impacted by a range of climate changes, and refined projections of wildfire, in particular, and better integration of climate and species models will help inform how to best manage and preserve LA's magnificent ecological web. Advances in water-efficient irrigation systems, alongside shifts towards more water- and energy-sustainable farming practices, are needed to ensure that the region's profitable crops can thrive in a warmer future. Climate change will further complicate the challenging task of satisfying freshwater demands across the LA region. Improved integration of climate change into water management models, along with significant infrastructural investments to augment local water supplies and shifts, will help to maintain water resources for residential, commercial, and agricultural, and recreational purposes.

While models are a valuable tool for decision-making, the importance of building capacity within communities to engage in climate adaptation decisions cannot be overstated. Creating opportunities for robust stakeholder participation in planning processes and development decisions helps to raise awareness of climate impacts, builds a common understanding of key vulnerabilities, and allows local perceptions and preferences to guide the selection of adaptation strategies. Climate change is only one of many issues that threaten the health and prosperity of communities of the LA region, but as described above, it will affect nearly all aspects of life in the region, including ecosystems, the built environment, and public health. Therefore, greater effort should be invested in integrating climate change into existing planning and decision-making processes that traditionally have excluded climate change considerations. The more climate change is taken into account in long-term decisions, especially those regarding infrastructure and development projects, the better communities will be prepared to cope with climate change impacts in the future.

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Appendix 2D

CONFERENCE MEMORANDUM ON THE IMPACTS OF REGULATORY CHANGES TO THE RWQCP

CONFERENCE MEMORANDUM

Project:	Updated Integrated Master Plan for Wastewater Collection and Treatment Facilities	**Conf. Date:**	March 7, 2017
Client:	City of Riverside Public Works	**Issue Date:**	March 27, 2017
Location:	Riverside Water Quality Control Plant (RWQCP)	**Project No.:**	10495A.00
Purpose:	Regulatory Brainstorming Session		
Attendees:	**Riverside Public Works:** Craig Justice (CJ), Ed Filadelfia (EF), Robert Eland (RE), Gilbert Perez (GP) **Carollo:** Toby Weissert (TW), Graham Juby (GJGJ), Rajesh Doppalapudi (RBD), Rashi Gupta (RG), Brian Graham (BG), Nishel Ross (NR) **Other:** Tim Moore - Risk Sciences (TM), Julia Lester - Ramboll (JL), Dawn Chianese - Ramboll (DC)		
Distribution:	Attendees: Ernest Marquez (EM), Steve Walker (Carollo), Ron Appleton (Carollo), Alex Bugbee (Carollo), Tim Loper (Carollo), Ryan Orgill (Carollo), Khalil Kairouz (Carollo)		

Discussion:

This workshop included multiple presentations and involved an active discussion of potential and foreseeable regulations and the impacts therefrom as applicable to the RWCQP. The presentation slides and handouts presented at the workshop are attached and form the basis for the workshop discussion. Additional discussion not shown in the slides is presented in the body of these minutes. If this differs from your understanding, please notify us.

A summary table that shows the regulation discussed, the compliance strategy (regulatory or infrastructure), the potential infrastructure to address the regulation, and the potential implementation date is shown below. The table is also intended to summarize the decisions that were made about regulations in the workshop. A list of action items and the minutes that summarize the additional discussion follows the table.

Summary Table/Decisions:

Parameter or Regulation	Compliance Strategy	Infrastructure for Planning Consideration	Anticipated Execution/Impact Date
Water Quality			
Ammonia	Regulatory	N/A	2019 Permit
Toxicity Testing	Regulatory; may consider infrastructure due to possible disinfection change.	Ozonation or UV with peroxide	2019 Permit
Pesticides	Regulatory; may consider infrastructure due to possible disinfection change.	Ozonation or UV with peroxide	2019 Permit

Parameter or Regulation	Compliance Strategy	Infrastructure for Planning Consideration	Anticipated Execution/Impact Date
CECs	Regulatory; may consider infrastructure due to possible disinfection change.	Ozonation or UV with peroxide	2019/2024 Permit
Mercury	Regulatory	N/A	2019 Permit
Selenium	Regulatory	N/A	2019 Permit
TDS (including Sodium and Chloride limits)	Regulatory and Infrastructure	Reverse Osmosis or converting disinfection to ozonation could reduce TDS by 30 mg/L.	2024 Permit
Nutrients	Regulatory and Infrastructure	Aeration Basin Retrofits for nutrient removal	2024 Permit
Copper, Cadmium, Lead	Regulatory	N/A	2024 Permit
Aluminum	Regulatory, but may also be impacted by nutrient management.	N/A	2024 Permit
Biocriteria	Regulatory	N/A	2024 Permit
Hydrologic Alteration	Regulatory	N/A	2024 Permit
Pathogens	Regulatory	N/A	2024+ Permit
Mass limits	Regulatory	N/A	2019 Permit
Dry Weather Diversion of Stormwater	Regulatory and Infrastructure	Capacity analysis will determine if RWQCP can accommodate dry weather storm flows	2024 Permit
Air Quality			
ARB 2030 Scoping Plan	Regulatory and potential Infrastructure	Co-digestion and electricity generation using biogas	???
SLCP Strategy	Regulatory and potential Infrastructure	Co-digestion and electricity generation using biogas	January 1, 2018
SCAQMD 2016 AQMP	Regulatory and potential Infrastructure	Fleet vehicle replacement considerations	March 3, 2017
CMB-01	Regulatory and Infrastructure	Replace diesel generators with alternative clean technologies	Ongoing Requirement
CMB-03	Regulatory and Infrastructure	May need to consider beneficial reuse of gas;	2018 adoption, 2022 implementation

Parameter or Regulation	Compliance Strategy	Infrastructure for Planning Consideration	Anticipated Execution/Impact Date
		City flares meet current BACT standards	
CMB-05	Regulatory	May result in end of priority reserve, which would lead to higher new source implementation costs	2018 adoption, 2022 implementation
BCM-10	Infrastructure	Co-digestion	2022 adoption, 2031 implementation
Biosolids Handling			
Organics diversion/GHG reduction	Infrastructure	Co-digestion and additional gas use options	Impact in the next 5 years
ADC changes/Organics diversion	Infrastructure	Rising costs for land application will make alternative disposal options more attractive	Impact in 5 to 10 years
Limits on land application of Class B biosolids	Regulatory and Infrastructure	Options for Class A treatment & disposal may be more attractive	Impact in 10+ years

Action Items:

Item #	Task	Assigned to	Due Date	Status
3.1	Check with stormwater staff about the potential for dry weather flow diversion to the RWQCP.	CJ	3/31	

1) **Background and Introduction**:
   a) All attendees introduced themselves in a round-robin fashion briefly explaining their role on the project.
   b) Working off Attachment 1, TW Gave an overview of the project, concentrating on the project purpose and goals and then presenting the purpose of today's workshop.
      i) Project Purpose: The purpose of this project is to evaluate the City's collection system and some of the RWQCP unit processes in order to make recommendations for future expansions and rehabilitations of the facilities, and to develop the resultant capital improvement plan (CIP) and rate structures to pay for the CIP. The CIP will be based on a 20 year planning period to the year 2040. Regulatory brainstorming will be limited to the treatment plant only.
      ii) Project Goals:
         (1) Complete analyses of the collection system and RWQCP such that the City can:
            (a) Develop a CIP to serve the needs of both existing and future users
            (b) Complies with regulatory requirements
            (c) Does not overburden rate payers

(d) Is equitable to the development community.

(2) Complete the analyses and have the subsequent proposed rates ready to go through the proposition 218 process by June of 2018

iii) Purpose of Today's Workshop: The purpose of this workshop is to brainstorm future regulations including what regulations are predicted to be implemented and when they are forecasted to occur, decide upon a compliance strategy to be considered during master planning efforts, and to discuss alternative treatment scenarios and how they will be accounted for in the master plan.

2) **Water Quality Regulations:** TM began his discussion on water quality regulatory changes using Attachments 2, 3, and 4 throughout the portion of the workshop that he led. In general, TM emphasized that the process of identifying and setting numerical limits for contaminants has been changing during the last two years. Regulators are leaning towards reliance on the basin narrative ("Do no harm" type language) and peer-reviewed journals to streamline the determination of numerical limits without the typical public discussion/approval process. This change in methodology has significantly increased the list of regulatory challenges since the 2008 master plan.

a) Specific parameters are discussed below:

i) Ammonia (impacting the 2019 permit)

(1) The Regional Board has determined the new total ammonia concentration limit to be < 1.9 mg/L. EF indicated that due to historical ammonia data, this would not likely pose a challenge in the future except during a process upsets.

ii) Toxicity Testing (impacting the 2019 permit)

(1) Another change in regulatory methodology is the shift to presumed reasonable potential for all publically-owned treated works (POTW) discharges, because of the use of the Test of Significant Toxicity (TST) for toxicity compliance.

(a) This means regulatory agencies will assume POTW discharges are out-of-compliance until proven otherwise by a statistically-significant margin.

(b) Using TST, the City is 3 times more likely to fail because of false positives.

(c) Furthermore, once a sample indicates out-of-compliance, an accelerated sampling protocol involving bi-weekly sampling over a six-week period is put in place to determine if the out-of-compliance determination was legitimate or was a sampling error.

(d) If there is an out-of-compliance event occurring during accelerated sampling, a Toxicity Identification Evaluation (TIE) is required to identify the cause of the out-of-compliance events.

(2) This change in methodology poses a challenge for the City regarding the Ceriodaphnia dubia (C. dubia) chronic reproduction endpoint tests. C. dubia is extremely sensitive to high salt concentrations and as salinity concentrations in source waters continue to rise, C. dubia may show some signs of delayed reproduction resulting in test failures.

(3) Additional toxicity testing changes include the potential for acute & multi-species testing during the 2019 permit process and possibly a sediment toxicity test required during the 2024 permit process.

(4) In general, this means the RWQCP will need to be diligent in chlorination and dechlorination process control and consideration should be given to reduce pesticides, CEC's, and/or TDS concentrations as much as possible.

iii) Pesticides (impacting the 2019 permit)

(1) Pesticides including bifenthrin (pyrethroid pesticide) are extremely common in source waters and arguably detrimental to benthic organisms. Increasing pressures on multiple fronts are anticipated to limit discharge concentrations in the future, either specifically (<0.1 ug/L), or by way of a TOC concentration < 0.5 mg/L in recycled water.
(2) Future NPDES permits will likely require additional monitoring requirements for several pesticides.
(3) TM did indicate that any treatment process with ozonation should degrade these pesticides while chlorination does not.

iv) Constituents of Emerging Concern (CEC's) (impacting the 2019/2024 permit)
(1) Previous studies have been on human impacts, which have been shown to be nonexistent. Current studies are based on aquatic life and other environmental impacts, which will likely result in some type of monitoring in the next 5 years.
(2) Most CEC's can be measured under the umbrella of TOC and as such new Groundwater Replenishment Regulations from May 2014 require limits to the TOC concentrations.
(3) New monitoring requirements across 9 groups of CEC chemicals are required by the Groundwater Replenishment Regulations.
(4) The Regional Board is likely to adopt the Blue Ribbon Panel's recommendations for CEC monitoring in the Recycled Water Policy and may use the Blue Ribbon Panel's recommended thresholds to translate narrative water quality objectives (WQO's).
(5) The City should be vigilant in monitoring anticipated CEC's in anticipation of regulatory changes.
(6) Potential treatment for removal of CECs includes ozonation or a UV peroxide combination.

v) Mercury (impacting the 2019 permit)
(1) The State Board is developing a new mercury policy. This will include testing mercury concentrations in fish tissues based on subsistence consumption levels. The new policy may also require dual effluent limits (both fish tissue and water column concentrations).
(2) Fish in Reach-3 of the Santa Ana River have routinely met tissue targets for the last 22 years, but the City may not be able to consistently comply with an effluent limit of 12 ng/L (parts-per-trillion, PPT).
(3) EF indicated that incoming mercury is likely a source control issue. He also indicated that a lot of the mercury in the environment has been shown to be by air deposition from air pollution in Asia.

vi) Selenium (impacting the 2019 permit)
(1) Although research indicates that bird egg shell is a highly sensitive to selenium, no data has been collect to date. However, it is anticipated that areas known to be inhabited by endangered species such as the Least Bell's Vireo will require new testing standards for bird egg shell weakness.
(2) Attachment 2 page 3 shows numerical objectives for multiple parameters.

vii) TDS (impacting the 2024 permit)
(1) The City is currently on a slow upward trajectory to exceed their overall TDS limit (650 mg/L) sometime in the next 10 years if nothing is done. The City has a $100 million RO system planned in the current 10 year capital improvement plan (CIP) period. The hope is that evaluation during the master plan will be able to reduce this value. In addition, there are regulatory changes and other issues related to salinity that are occurring.
(a) Current TDS objectives are exceeded at Prado Dam and in the Chino South Groundwater Basin.
(b) EPA is proposing a method for developing conductivity standards to address salinity issues, instead of using TDS. In addition, the current (2017) 303(d) list alleges impairment to benthic organisms due to elevated salinity. These could lead to lower effective permit limits for salinity.

(c) Similar to the forecasted changes for toxicity testing, the new test procedures may mistake ionic interference for effluent toxicity.
(d) Overall, the long-term trend of rising TDS in the final effluent and the changes in test procedures may result in the erosion of the "compliance buffer" and thus increase the likelihood of increment-of-use effluent limit violations.
(e) Furthermore, it is likely that the 2022 303(d) list will reduce wastewater allocations for TDS in a new TMDL, which could cause restrictions that would limit the use of recycled water in some areas of the City.
(f) Sodium (impacting the 2024 permit)
  (i) For the first time, regulators are applying the secondary MCL's for drinking water to wastewater applications.
  (ii) In general, it is advisable to monitor/mitigate the use of chlorination/dechlorination which adds roughly 30 mg/L of sodium to plant effluent.
  (iii) EF indicated that once the new plant is operational, he intends to push the CCB's CT time to 90 minutes, which would significantly reduce the amount of chemical necessary in the chlorination/dechlorination process.
(g) Chloride (impacting the 2024 permit)
  (i) Similar to both TDS and Sodium, Chloride concentrations are exceeded at various locations and regulations applicable to the other two, would also be applicable to chloride.
  (ii) Expect more intensive antidegradation analysis in the next NPDES permit renewal possibly limiting chloride effluent concentrations to 140 mg/L.
  (iii) More restrictive local pre-treatment limits (especially on water softeners) is anticipated.

viii) Nutrients: Total Nitrogen and Total Phosphorus (impacting the 2024 permit)
(1) The State is developing a statewide Numeric Nutrient Endpoints (NNE) program, which has been combined with the Biocriteria Policy. Combining the efforts has likely delayed permit implementation until the next permit cycle for the City (2024). The 2024 permit would likely contain a reasonable time to meet compliance with the new limits (+/- 10 years). It is likely that the new effluent limits will be in the 1.0 to 3.0 mg/L range for total nitrogen and in the 0.1 to 1.0 mg/L range for total phosphorus.
(2) Nutrient concentrations are of concern due to their impact on recreation and drinking water supplies, specifically in relation to cyanotoxins released by blue-green algae.

ix) Copper, Cadmium, and Lead (impacting the 2024 permit)
(1) In addition to the information presented in Attachment 2, page 6, there is added emphasis on the importance of maintaining the site-specific translator factors between dissolved objectives and total recoverable limits. In order to validate these translators against future scrutiny, in-stream sampling (upstream, at the effluent, and downstream) should be continued. The sampling should include measurements of alkalinity, DOC, hardness, humic acid, etc.

x) Aluminum (impacting the 2024 permit)
(1) The current 303(d) list used the EPA's 1988 criteria to assess stream attainment and the EPA is in the process of developing a revised draft 304(a) criteria document for aluminum.
(2) Because alum and Al-polymers are commonly used to improve coagulation and flocculation, treatment options may be limited if phosphorus control becomes necessary.
(3) Related to this issue, new polymers should be tested for toxicity before they are used on site.

xi) Biocriteria: Richness, Abundance, and Community Structure for Benthic Macroinvertebrates (impacting the 2024 permit)

(1) The State is in the process of developing a policy to measure and protect "biological integrity." However, it is unlikely that the "correct" composition of benthic macroinvertebrates will be consistently present at the City's effluent site due to the poor habitat conditions.
(2) Long-term SARDA monitoring shows that biocriteria scores vary greatly from year to year (and often season to season) mostly due to poor stream habitat conditions.
(3) It is therefore recommended to increase the level of effort associated with SARDA's annual sampling effort to be able to satisfactorily demonstrate the change in local habitat conditions.
(4) SARDA completed a Use Attainability Analysis in the early 1990s. This study was a multi-million dollar effort that includes results that could be beneficial to positively support future regulatory development in the Santa Ana River Basin. The key will be to keep the study in the minds of the regional board staff as the staff transitions to younger people that were not part of the study.

xii) Hydrological Alteration of Receiving Water Habitat (impacting the 2024 permit)
(1) This relates to the existing and induced habitat conditions at the effluent location. Historically, flow restrictions focused only on storm water discharges, but increasingly, minimum flows have also been regulated due to induced habitats of threatened species.
(2) This may limit the ability for the City to implement future recycled water projects if organisms have come to rely on certain effluent flows.
(3) Currently, the City is required to discharge 25,000 acre-feet to the Santa Ana River annually. The City would like to reduce this amount so more water is available for recycled water use in the City.

xiii) Pathogens (impacting beyond the 2024 permit period)
(1) In addition to the information presented in Attachment 2, page 8, it is extremely important for the City to monitor *E. coli* concentrations in effluent streams. Regulators are in the process of changing pathogen regulatory compliance from coliform to E. coli.

xiv) Mass Limits
(1) EPA is proposing changing permit mass limit calculations from being based on design flows to being based on actual flows. This could cause anti backsliding to take effect when permits are renewed for higher flows.

xv) Dry Weather Storm Water Diversion
(1) Can the plant take on more storm water? Because of concerns about MS4 permittees struggling to meet stormwater effluent limits, it may come to that. CJ will talk to the stormwater group about this.

3) **Air Quality Regulations:** JL and DC began the discussion on air quality regulatory changes using Attachments 5. In general, JL emphasized that the acknowledgement of air toxic sensitivities is a huge risk and includes population groups such as homeless encampments. Similar to potential water quality regulations, the City should be watchful of air quality regulatory shifts. The regulations and programs presented in the workshop are discussed briefly below:

a) ARB 2030 Scoping Plan
i) This plan is still in draft form and as such has a high degree of uncertainty about it.
ii) The proposed framework aims to achieve a 40% reduction of greenhouse gases (GHGs) below the 1990 levels by the year 2030.
iii) The GHGs emissions from the water sector primary come from the fossil-fuel based energy used to produce (e.g. pump, convey, and treat) water and for water end uses (e.g. heating).
iv) It is important to note that while the scoping plan has identified wastewater treatment as a source of nitrous oxide (N_2O), there appears to be nothing in the plan to address N_2O emissions from this source. N_2O as a GHG source is 300 times more potent than CO_2.

v) In the water sector, the goals for GHG reduction include the following:
   (1) Development and support of programs and projects that increase water sector efficiency and reduce GHG emissions through reduced water and energy use, and
   (2) Increased use of renewable energy to pump, convey, treat, and utilize water.

vi) A long term goal identified in the scoping plan is to reduce GHG's by 80% below 1990 levels by 2050 and may move toward a low carbon or net-zero carbon water management system in the future.

vii) The scoping plan further describes supporting actions to achieve these goals including promoting the development of distributed energy using expanded and new programs and encouraging the use of co-digestion and methane capture systems (in support of the SLCP strategy discussed next). It should be noted that methane capture systems will be hard to implement because of the Rule 1110.2 regulations.

viii) The City should keep an eye on this plan and monitor the developing regulatory restrictions and implementation strategies.

ix) There was discussion regarding the creation/utilization of methane produced by wastewater operations within the City. CJ indicated that Riverside Public Utilities (RPU) are the power experts and if such an agreement was to be made, the goal would be to provide RPU with the methane and have them clean the gas and utilize it at a cost benefit to Public Works.

b) SLCP Strategy

i) This document is in "revised draft" status as of November 2016 and focuses on short-lived climate pollutants (i.e. methane, not carbon dioxide) as a way of achieving California's GHG reduction goals.

ii) Per the SLCP strategy, the wastewater sector comprised only 4% of the methane production in California in 2013. The dairy industry comprised 45% and the non-dairy livestock industry comprised 10%. Historically, the agricultural industry was largely ignored by regulators in part because mitigation and measurement were difficult to quantify.

iii) To reduce methane emissions, the goal is to divert organic wastes otherwise destined for landfills to plants with spare digestion capacity (co-digestion). In this vein, there is a partnership with CalRecycle and the State Water Resources Control Board (SWRCB) to support retrofit of existing facilities or installation of new facilities for co-digestion as well as other financial incentives.

iv) Additional funding opportunities include electricity generation from biogas facilities, local government renewable energy bill credit tariff, water energy grant programs, CalRecycle waste diversion loans, and Clean Water State Revolving fund loans.

v) As a sidebar, DC indicated that the AB32 lawsuit filed by the petroleum industries regarding the cap & trade is still in the courts. If the lawsuit is successful then the cap and trade program may go away. Removing this requirement could impact the priority reserve that is used by public agencies when they install new emission sources.

c) SCAQMD - 2016 AQMP:

i) The Air Quality Management Plan (AQMP) with amendments was adopted Friday, March 3rd, 2017.

ii) Most of the amendments focused on fleet vehicles. The idea is as vehicles are being phased out, they should be replaced with cleaner natural gas (CNG) vehicles (this includes current CNG vehicles being replaced with cleaner versions - near zero emissions). There are grant funding and other incentives available for heavy duty CNG vehicles. According to Ramboll, there is a low probability of this going forward.

iii) However, the City indicated the main hesitation with switching out heavy fleet vehicles (e.g., vactor trucks) to CNG is the available range and accessibility to fuel, particularly in the event of emergency circumstances (e.g., sewer main break).

iv) Other applicable control measures include SCAQMD rules. These are the most likely items from the AQMP to be adopted.
   (1) CMB-01 which describes the transition to zero and near zero emission technologies for stationary sources. This is an ongoing program.
      (a) Specifically, biogas sectors must decrease emissions which may come in the form of incentive funding or regulatory enforcement. Furthermore, biogas will be required to undergo cleaning processes.
      (b) Additionally there is or will be increasing pressures to move away from diesel back-up generators in lieu of fuel cells and battery storage, etc.
      (c) The Southern California Alliance of Publically Owned Treatment Works (SCAP) has commented on the proposal. In particular they are asking if incentive funding will be provided for implementation of this measure. They have also noted that biogas cleanup is not necessarily cost-effective. Finally, they have stated that facilities need reliable backup power during emergency situations, which is not currently provided by fuel cells or similar technology.
      (d) Orange County Sanitation District (OCSD) and Eastern Municipal Water District (EMWD) noted that the tri-generation project cited by SCAQMD is for demonstration purpose only and is not intended to assess cost-effectiveness.
   (2) CMB-03 focuses on emission reduction from non-refinery flares by requiring beneficial reuse of the gas or, if infeasible, disposal in a flare that meets current best available control technology (BACT) standards. This may be adopted in 2018 and implemented in 2020. The City may need to consider beneficial resuse, although their flares are new and meet the highest SCAQMD standard, if reuse is infeasible.
      (a) SCAP has requested a third party assessment regarding the cost-effectiveness and feasibility of technology for biogas control measures.
      (b) OCSD and EMWD have requested the wastewater sector be excluded from this control measure.
   (3) CMB-05 discusses further NO_x reductions from RECLAIM assessment. The RECLAIM program is sunsetting and will be replaced by command and control regulations in the future. This is a controversial matter with many public comments. This is scheduled for adoption in 2018 and implementation in 2022.
   (4) BCM-10 describes emission reductions from green-waste compositing facilities. This measure aims to increase diversion of green-waste to anaerobic digesters for co-digestion.
v) Slides 14 through 17 of Attachment 5 show applicable SCAQMD rules including relevance and impact to the City.
   (1) Rule 1402 could have an impact on plants if sensitive receptors like schools or other public facilities are located in close proximity to plants. This rule addresses cancer risk assessment.
vi) Slide 18 of Attachment 5 shows funding opportunities available.
vii) The remainder of Attachment 5 is a "read at your leisure" discussion to provide additional offline information about the SLCP strategy and SCAQMD rules.
viii) There do not appear to be any new odor regulations on the horizon.
ix) JL noted that use of ozone for treatment is not a concern for SCAQMD.

4) **Biosolids Regulations:** After a short pause, RG began the discussion regarding biosolids regulations. The presentation slides she used are provided in Attachment 6. Discussion items outside of the presentation slides are presented below.
   a) The City clarified that the current biosolids disposal portfolio includes composting, which is all sent to Nursery Products, and land application, which is sent to Arizona.
   b) Previously, there were only a handful of counties in the state with restrictions in place against land application. By 2016, that trend reversed and land application, particularly in northern and central California has become highly regulated.

c) There are multiple regulatory bodies imposing requirements with direct and indirect impacts. Some are detailed below:
   i) AB 341 signed in 2012 requires mandatory commercial recycling with a goal of reducing, recycling, or composting 75% of all solid waste generated by 2020.
   ii) AB 1826 signed in 2014 requires mandatory commercial organics recycling with phased diversion of organics from commercial and multi-family residential dwellings to recycling. This is not yet impacting single-family dwellings.
   iii) AB 1594 signed in 2014 limits the use of green material used as alternative daily cover (ADC) of landfills. What this means is that by 2020, green waste will no longer qualify for recycling diversion credit under AB 939. Green waste is typically mixed with biosolids for use as ADC to achieve required moisture content. If green waste is no longer available to be used in landfills, biosolids disposal at landfills may also be limited because it is typically mixed with green waste when used as ADC.
   iv) SB 605 signed in 2014 directs the Air Resources Board (ARB) to develop the SLCP strategy (briefly discussed as part of the air quality review above). SB 1383 signed in 2016 requires ARB to begin plan implementation January 1, 2018. The strategy targets short-lived climate pollutants such as black carbon, methane, ozone, and hydrofluorocarbons.
   v) SB 1383 regarding the implementation of the SLCP strategy is expected to have a final ruling by the end of 2018. In this bill, 50% of organics relative to 2014 are to be diverted from landfills by 2020 and 75% of organics relative to 2014 are to be diverted by 2025. The implications of this ruling are discussed below:
      (1) This ruling will drive high strength organics such as FOG, food waste, etc. to municipal treatment plants/digesters.
      (2) Biosolids, digestate, and sludges will be included in the organic waste and thus will not be allowed to be landfilled.
      (3) Within the industry, there are multiple questions regarding the 2014 baseline and how to handle/fund additional infrastructure needs and digestate production.

d) Solids management practices could be impacted by local and state changes. Land application of solids is becoming increasingly restricted in California. However the ARB aims to increase carbon sequestration and carbon content of soils and is interested in a "healthy soils initiative" that includes replacing carbon and nutrients with biosolids land application. This is definitely something that should be monitored as it could prove to be a feasible avenue of biosolids disposal.

e) In general, the public is largely opposed to land application, especially of Class B materials with increasing concern on emerging contaminants. The Kern County decision may impact future local ordinances and restrictions on land application.

f) In Arizona, AZDEQ does not consider changes to be very likely so it is probable that land application in Arizona can continue for quite some time.

g) Competition for land application in Arizona is driven by continuous local opposition to land application in California. In particular, failure of regional facilities such as EnerTech, difficult air permitting, and ADC limits in Northern California may drive up the cost of land application in Arizona as demand increases.

h) Disposal of biosolids at landfills or other sites is becoming increasing challenging due to permit or willingness limitations. In the long run, municipalities may be required to shift to Class A material for local end-use options. However, Class A material, depending on what the end product is, may require marketing to be able to sell the end product.

i) A summary of the timing of the recent/potential biosolids regulatory changes that are described above is presented below:
   i) Urgent (0 - 5 years): Organics diversion and GHG reduction goals and associated impacts which translates to increased pressure to accept external feedstocks and produce renewable fuels.

ii) Intermediate (5 - 10 years): Rising solids management costs due to changes for ADC/organics diversion/landfills.
iii) Long-Term (10+ years): Growing concerns/limitation on Class B land application may drive the shift toward Class A biosolids.
iv) The remainder of Attachment 6, starting at slide 22, was not presented and discussed.

5) **Compliance Strategies:** TM began discussing compliance strategies by asking EF, CJ, and GP for their philosophies on maintaining compliance.
   a) EF stated his preferred method was to be proactive in the regulatory development process using scientific analyses to ensure that new regulations were necessary before they were implemented. Since the scientific process takes time, this typically delays the implementation of new regulations, but it provides a regulation that is scientifically based. TM asked if he had been successful in applying this philosophy. EF said that this process was successful both with the City and with his previous work at an oil refinery. In particular, this process gives the City more time to find a workable solution. For example, during the development of the science, technology improvements often become available or someone else tests a solution which allows the City to climb on board after the techniques have been proven. This reduces the cost and risk to the City.
   b) EF commented that while other agencies seem to be reactive with regulatory adoptions, he prefers to be proactive using science to determine if the assumptions made by regulators are applicable.
   c) TM asked if the proactive legacy EF and others are setting will continue with younger generations. There seemed to be consensus that with the appropriate guidance and leadership, younger generations would come to follow the lead.
   d) TM then asked EF, CJ, and GP for their take on what is your reaction to the hypothetical future regulations discussed today?
      i) GP stated that predictive planning is a good practice that leads to good strategic planning. He sees this workshop as of tremendous value. That being said, he likes to look at technology, which means strategic planning needs to take into consideration changes in technology and how it will impact future planning efforts.
      ii) CJ has been working on branding the RWQCP as a resource recovery facility, but is very much aware of "rate payer fatigue." He knows that while developing the CIP we need to be careful about both overall cost and the technologies selected, and in general prefers tried-and-truth methods. Furthermore, on any technological shift, he indicated the need for strong collaboration and buy-in from member agencies. For energy and biosolids disposal issues, he likes the idea of 3rd party vendors that will operate the facilities (e.g., Lystek for biosolids).
   e) TM asked each of the three what was keeping them up at night in terms of compliance.
      i) CJ said TDS was first, with toxicity testing requirements as a close second. He wants to work with RPU to help fund the TDS removal project. He would also like to have more sustainable biosolids disposal options and avoid becoming a Title V facility.
      ii) EF said bio-integrity measures are worrisome because it may mean that the RWQCP is out of compliance due to forces beyond the control of the City. These are in addition to his concerns for TDS and toxicity testing.
   f) TM asked what CIP priorities specific to regulations would be for each member?
      i) GP stated co-digestion, digester gas to the adjacent gas pipeline, ozone disinfection, and transitioning the plant to a full MBR facility would be his priority project list.
      ii) CJ stated his priorities would be to get the water out of the river for recycled water purposes, before it becomes impossible to do so. He would also like to determine plant capacity, which is in question, due to water conservation. Next, he would like to address the following in priority order: TDS, gas reuse, conversion to full MBR facility or upgrading tertiary filters, disinfection, and biosolids disposal (which may move up on the priority list depending on economic drivers).
      iii) EF indicated that in addition to what his colleagues had stated, he would also like to be able to adjust the plan if changes occur.

g) TM concluded the meeting by selecting the compliance strategy for each parameter discussed. The table at the start of these minutes summarizes the strategies.

Prepared By:

Nishel Ross, P.E.

NR:nr

City of Riverside
Updated Integrated Master Plan for Wastewater Collection and Treatment Facilities Project

Internal Regulatory
Brainstorming Meeting

March 7, 2017

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Engineers...Working Wonders With Water®

Project Background

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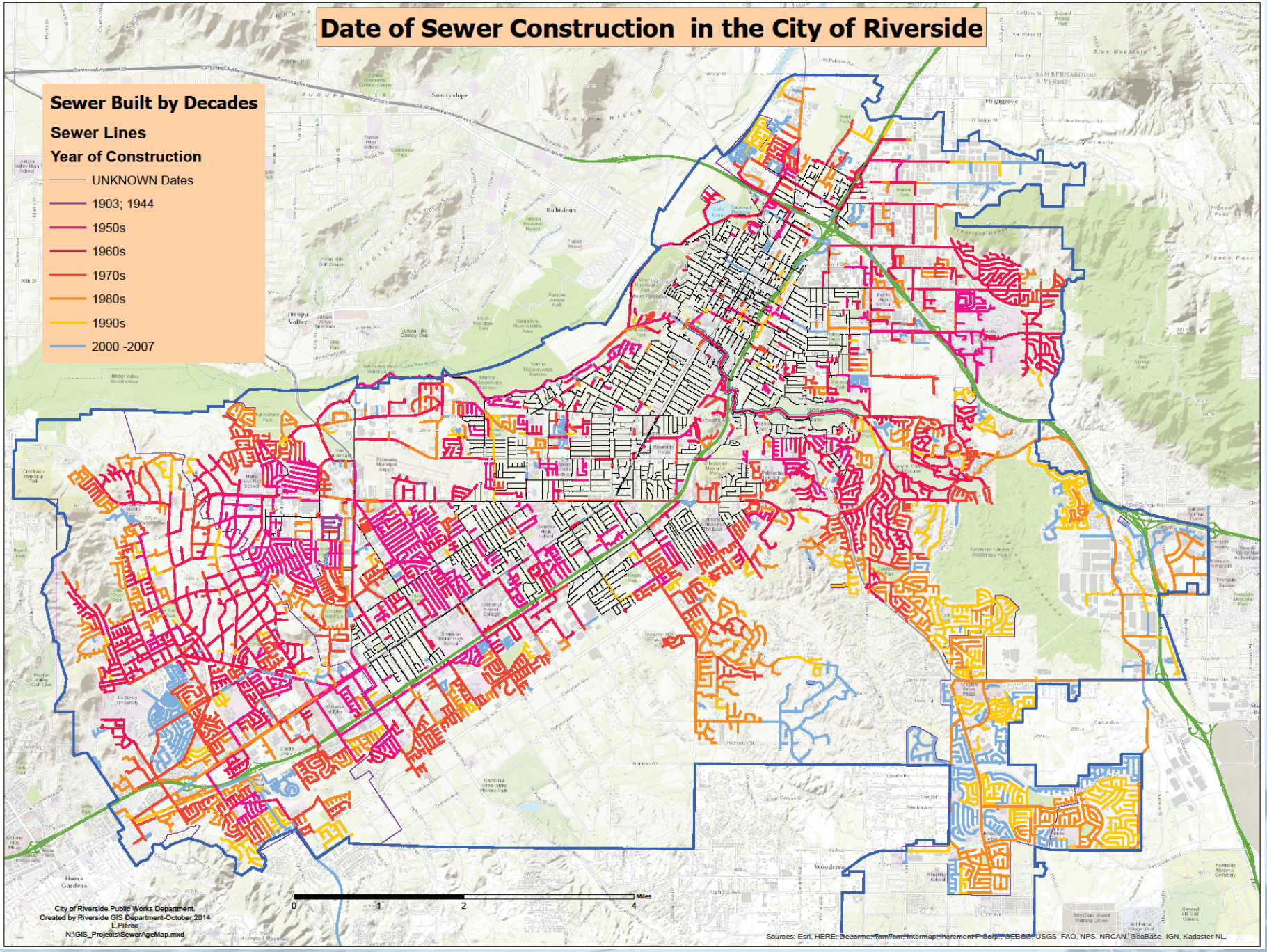
What is the Project Purpose?

- The purpose of the project is to
  - Evaluate the City's collection system and some of the RWQCP unit processes
  - Make recommendations for future expansions and rehabilitations of the facilities
  - Develop the resultant capital improvement plan (CIP) and rate structures to pay for the CIP. The CIP will be based on a 20 year planning period to the year 2040.

Project Overview



Project Overview

Project Goals

- Complete analyses of the collection system and RWQCP such that the City can:
  - Develop a CIP to serve the needs of both existing and future users
  - Complies with regulatory requirements
  - Does not overburden rate payers
  - Is equitable to the development community.
- Complete the analyses and have the subsequent proposed rates ready to go through the proposition 218 process by June of 2018

Project Goals

- Complete analyses of the collection system and RWQCP such that the City can:
  - Develop a CIP to serve the needs of both existing and future users
  - **Complies with regulatory requirements**
  - Does not overburden rate payers
  - Is equitable to the development community.
- Complete the analyses and have the subsequent proposed rates ready to go through the proposition 218 process by June of 2018

The Purpose of the Meeting is to:

- ✓ Brainstorm future regulations
  - ✓ What regulations will we need to prepare for from now until 2040 and decide the likelihood of the regulations occurring and when?
- ✓ Decide upon a compliance strategy
  - ✓ Do we address alternative treatment scenarios during the master plan or continue to work with regulators to influence the regulation?
- ✓ Decide upon which alternative treatment scenarios to address and how to account for them in the master plan analyses

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Agenda (see handout for details)

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Brainstorming Participants

- ✓City Staff
- ✓Water Quality – Tim Moore
- ✓Air Quality – Julia Lester and Dawn Chianese
- ✓Biosolids – Rashi Gupta
- ✓Treatment Scenarios – Brian Graham and rest of Carollo team

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Water Quality Brainstorming

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Air Quality Brainstorming

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Biosolids Brainstorming

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Develop Compliance Strategies

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Develop a List of Alternative Treatment Strategies

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Next Steps

- Summarize the findings of today's session in a Workshop on March 29

- Use the findings as we develop and evaluate RWQCP unit process alternatives

City of Riverside
Updated Integrated Master Plan for Wastewater Collection and Treatment Facilities Project

Internal Regulatory
Brainstorming Meeting

March 7, 2017

Engineers...Working Wonders With Water®

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1) **Ammonia** (2019 Permit)

A) Regulatory Drivers

i. EPA promulgated new 304(a) criteria in August of 2013
ii. Regional Board withdrew the current ammonia objectives from Basin Plan (Tables 4-2, 4-3 & 4-4)

B) Implications

i. Regional Board will use new 304(a) criteria to "translate" narrative objective into ammonia effluent limits
ii. Total ammonia concentrations must be <1.9 mg/L

2) **Toxicity Testing** (2019 Permit)

A) Regulatory Drivers

i. Reasonable Potential is now "presumed" for all POTW discharges
ii. Acute & multi-species test may be required (2019); sediment toxicity tests may be required in future (2024)
iii. SWRCB is finalizing new statewide Toxicity policy (in development since 2010)
iv. EPA published a new statistical analysis method (TST); already being implemented in other NPDES permits
v. In California, EPA has been objecting to NPDES permit renewals that lack numeric WET limits

B) Implications

i. TST is likely to increase the number of "false positives" (esp. for C. dubia chronic reproduction endpoint)
ii. Ionic interference may be mistaken for actual effluent toxicity
iii. Need additional replicates in routine monthly WET testing (double-edged sword)
iv. Expect more accelerated testing and Toxicity Identification Evaluations (TIE)
v. Extreme diligence in chlorination and dechlorination process control will be essential
vi. May necessitate advanced waste treatment to reduce pesticides, CEC's, or TDS

3) **Pesticides** (2019 Permit)

A) Regulatory Drivers

i. Current (2017) 303d assessment alleges impairment of benthic organisms may be due to bifenthrin (pyrethroid pesticide)
ii. Current (2017) 303d assessment uses LC-50 literature values to assess compliance with narrative objective (incl. sediment)
iii. SWRCB is developing statewide policy to control pesticide discharges from MS4 outfalls (Jan., 2017)
iv. High pesticide concentrations measured in middle Santa Ana River (SWRCB's long-term monitoring program)
v. Recycled Water Policy Blue Ribbon Panel recommended additional pesticide monitoring in discharges to freshwater
vi. New requirements in the Groundwater Replenishment Regulation (May, 2014)

B) Implications

i. Additional monitoring requirements for several pesticides are likely in the next NPDES permit
ii. Groundwater Recharge Regulation requires TOC concentration <0.5 mg/L in recycled water
iii. New effluent limits for pesticides are probable (similar to those imposed by other Reg. Boards)

4) **Constituents of Emerging Concern (CECs):** Pharmaceuticals, Hormones, Flame Retardants, Industrial Chemicals, etc. (2019/2024 Permit)

A) Regulatory Drivers

i. Total Organic Carbon limits in the new Groundwater Replenishment Regulation (May, 2014)
ii. New monitoring requirements for 9 groups of CEC chemical required by the Groundwater Replenishment Regulation
iii. SWRCB will soon adopt Blue Ribbon Panel's recommendations for CEC monitoring in the Recycled Water Policy

B) Implications

i. Blue Ribbon Panel's recommended thresholds likely to be used in future 303(d) assessments to translate narrative WQO's
ii. New requirements for "recharge projects" may be expanded to "incidental recharge" of recycled water

5) **Mercury** (2019 Permit)

A) Regulatory Drivers

i. SWRCB is proposing new fish tissue standards based on subsistence consumption levels
ii. New policy may require dual effluent limits (fish tissue and water column concentration)

B) Implications

i. Fish in Reach-3 of Santa Ana River have routinely met tissue targets for the last 22 years
ii. May not be able to consistently comply with an effluent limit of 12 nanograms-per-liter (parts-per-trillion)

6) **Selenium** (2019 Permit)

A) Regulatory Drivers

i. EPA finalized new 304(a) water quality in July, 2016 (recommended values for fish tissue, bird eggs and water column)
ii. EPA issued draft implementation guidance for selenium in Oct., 2016
iii. Endangered Species Act: Least Bell's Vireo habitat (new standard for bird egg shell will apply)

B) Implications

i. Chronic water column objective = 3.1 ug/L (lotic systems) and 1.5 ug/L (lentic systems) both as 30-day averages
ii. Fish tissue objective = 8.5 mg/kg/dw (whole body) and 11.3 mg/kg/dw (muscle filet only)
iii. Egg-Ovary objective = 15.1 mg/kg/dw
iv. SARDA sampling shows easy compliance with fish tissue objectives; egg shell concentrations are unknown (not measured)
v. EPA guidance says: water column objectives only apply if monitoring data from tissue/shell samples is not available

7) Total Dissolved Solids (2024 Permit)

A) Regulatory Drivers

i. Current TDS objective for SAR-Reach 3 (700 mg/L) is being exceeded at Prado Dam
ii. Current TDS objective for Chino-South GMZ (680 mg/L) is also being exceeded (>770 mg/L)
iii. City sought permit to use recycled water for landscape irrigation in areas w/ lower TDS objectives (Riverside-A GMZ)
iv. EPA is proposing a method for developing conductivity standards (12/23/16; comments due 4/24/17)
v. Current (2017) 303d assessment alleges impairment to benthic organisms due to elevated salinity
vi. New statistical test procedures (e.g. TST method, see below) may mistake ionic interference for effluent toxicity
vii. Current (2017) 303d assessment alleges impairment of GWR/MUN when TDS >500 mg/L (22 CCR §64449, SMCLs)

B) Implications

i. Long-term trend of rising TDS in final effluent (largely due to increased water conservation and water softeners)
ii. Compliance buffer is eroding = potential violations of the Increment-of-Use effluent limit in permit
iii. 303(d) listing likely (in 2022); wasteload allocation for TDS may be reduced in a new TMDL
iv. Restrictions on ability to use recycled water in some City service areas (ex. Riverside-A groundwater management zone)

8) Sodium (2024 Permit)

A) Regulatory Drivers

i. Current sodium objective for SAR-Reach 3 (110 mg/L) will soon be exceeded at Prado Dam
ii. EPA's proposed (5/18/16) revisions to NPDES permitting rules re: WQBEL's for antidegradation 40 CFR 131.12(b)

Implications

i. Current average sodium concentration in Riverside's effluent is approximately 110 mg/L
ii. More intensive Antidegradation Analysis in next NPDES permit renewal; Total Sodium limit of 110 mg/L is possible
iii. 303(d) listing likely (in 2022); new wasteload allocation for sodium may be required (by 2035)
iv. More restrictive local pre-treatment limits (esp. on water softeners)

9) Chloride (2024 Permit)

A) Regulatory Drivers

i. Current Chloride objective for SAR-Reach 3 (140 mg/L) is being exceeded at Prado Dam
ii. EPA is planning to promulgate a new 304(a) criteria for chloride(similar to Iowa's standards; hardness & sulfate based)
iii. Current (2017) 303d assessment alleges impairment of GWR/MUN when chloride >250 mg/L (22 CCR §64449, SMCLs)
iv. Current (2017) 303d assessment alleges impairment to benthic organisms due to chloride (no supporting data cited)
v. EPA's proposed (5/18/16) revisions to NPDES permitting rules re: antidegradation 40 CFR 131.12(b)

B) Implications

i. Current average chloride concentration in Riverside's effluent is approximately 130 mg/L
ii. More intensive Antidegradation Analysis in next NPDES permit renewal; Total Chloride limit of 140 mg/L is possible
iii. 303(d) listing likely (in 2022); new (lower) wasteload allocation for chloride may be required (by 2035)
iv. More restrictive local pre-treatment limits (esp. on water softeners)

10) Nutrients: Total Nitrogen and Total Phosphorus (2024 Permit)

A) Regulatory Drivers

i. SWRCB is developing statewide Numeric Nutrient Endpoints (NNE); now combined with state's Biocriteria Policy
ii. New EPA guidance w/ recommended framework for state nutrient reductions (Sept., 2016)
iii. Increasing concern over cyanotoxins released by blue-green algae (impact on recreation and drinking water supplies)
iv. Chino-South GMZ is exceeding the objective for nitrate (4.2 mg/L) by nearly 600%

B) Implications

i. NNE may recommend new water quality objectives of 1.0 - 3.0 mg/L for Total Nitrogen
ii. NNE may recommend new water quality objectives of 0.1 - 1.0 mg/L for Total Phosphorus
iii. May also implement new effluent limits by "translating" existing narrative objectives

11) Copper, Cadmium and Lead (2024 Permit)

A) Regulatory Drivers

i. California Toxics Rule Objectives
ii. EPA promulgated new 304(a) criteria for cadmium in April, 2016 (@ 275 mg/L hardness: CMC = 4.6 ug/L; CCC = 1.5 ug/L)
iii. EPA decision to add Reach 3 of the Santa Ana River to the 303(d) list in 2011; TMDL required by 2024
iv. EPA limited application of the site-specific translators used to translate dissolved objectives into total recoverable limits
v. In current (2017) 303d assessment, cadmium copper and lead exceedances were "linked" to benthic impairment in SAR-R3
vi. Recent drinking water problems in Flint increased public concern re: lead (MCLG = zero; Action Level = 15 ug/L Total Lead)

B) Implications

i. Riverside currently has “no reasonable potential” to exceed CTR objectives for WARM; Reach-3 is exempt from MUN
ii. May result in new wasteload allocation and more stringent effluent limits for cadmium, copper and lead
iii. Current site-specific translator, routinely used since 1994, may need to be re-validated
iv. Unlikely to comply with total recoverable effluent limits if translators are lost or reduced significantly
v. May need to develop site-specific water effect ratios (esp. for copper and lead)

12) Aluminum (2024 Permit)

A) Regulatory Drivers

i. Current 303d assessment used EPA's 1988 criteria document to assess stream attainment (CMC=750 ug/L, CCC=87 ug/L)
ii. EPA is developing a revised draft 304(a) criteria document for aluminum

B) Implications

i. Alum and Al-polymers are commonly used to improve coagulation and flocculation
ii. Effluent limits for aluminum may limit treatment options if phosphorus control becomes necessary

13) Biocriteria: Richness, Abundance and Community Structure for Benthic Macroinvertebrates (2024 Permit)

A) Regulatory Drivers

i. SWRCB is developing a statewide policy to measure and protect "biological integrity" (implements narrative standard)
ii. New (2015-16) California Stream Condition Index (CSCI) was applied in current (2017) 303d assessment
iii. Reg. Bd. initially proposed, then withdrew, a proposed 303d listing for benthic impairment in SAR-Reach 3 (Feb., 2017)
iv. In 303d assessment, any exceedance of any WQO is presumed to contribute to the observed benthic impairment

B) Implications

i. Long-term SARDA monitoring shows biocriteria scores vary greatly from year to year (mostly due to poor stream habitat)
ii. Likely to increase pressure for new effluent limits on pesticides, CECs, metals, nutrients, salinity, WET & hydrology
iii. Will need to (voluntarily) increase the level of effort associated with SARDA's annual sampling effort
iv. Annual biological monitoring above and below outfall will probably become mandatory (maybe 2019, definitely 2024
v. Will likely be used to justify more stringent effluent limits for pesticides, nutrients, TDS (incl. chloride, sodium)

14) Hydrologic Alteration of Receiving Water Habitat (2024 Permit)

A) Regulatory Drivers

i. Historically, flow restrictions have focused only on storm water discharges
ii. NGOs have filed ESA lawsuits against RIX for temporarily reducing effluent flows to SAR-Reach 3
iii. New EPA guidance published Dec., 2016

B) Implications

i. May be facing minimum or maximum flow requirements in future NPDES permits
ii. May establish water rights for aquatic organisms (similar to the El Dorado Irrigation District case)
iii. May limit ability to implement future recycled water projects

15) Pathogens (2024+ Permit)

A) Regulatory Drivers

i. Groundwater Recharge Regulation requires 12-log reduction for viruses in recycled water recharge projects
ii. EPA promulgated new 304(a) criteria for Pathogen Indicator Bacteria in November, 2013
iii. Regional Board adopted new water quality objectives for E. coli in April, 2012 (subsequently approved by SWRCB & EPA)
iv. Reach 3 of Santa Ana River is on 303(d) list for excessive concentrations of E. coli bacteria
v. Final TMDL compliance deadline for dry season was December 31, 2015; wet season is December 31, 2025.
vi. E. coli concentrations in Reach 3 of Santa Ana River routinely exceed E. coli objectives
vii. Sediment shown to be a significant source of bacteria in SAR-Reach 3
viii. Sediment shown to be a significant source of bacteria in Riverside's effluent channel
ix. USDA Salinity Laboratory in Riverside recently initiated study of Antibiotic Resistant Bacteria (ARB) in SAR-Reach 3

B) Implications

i. MS4 permittees have long alleged that "regrowth" is causing the exceedances of bacteria objectives
ii. Requirements for recycled water recharge projects may be expanded to encompass incidental recharge as well
iii. USDA's ARB study plan alleges that conventional disinfection is "not enough" and may make things worse in the long run
iv. E. coli monitoring may be added to 2019 permit

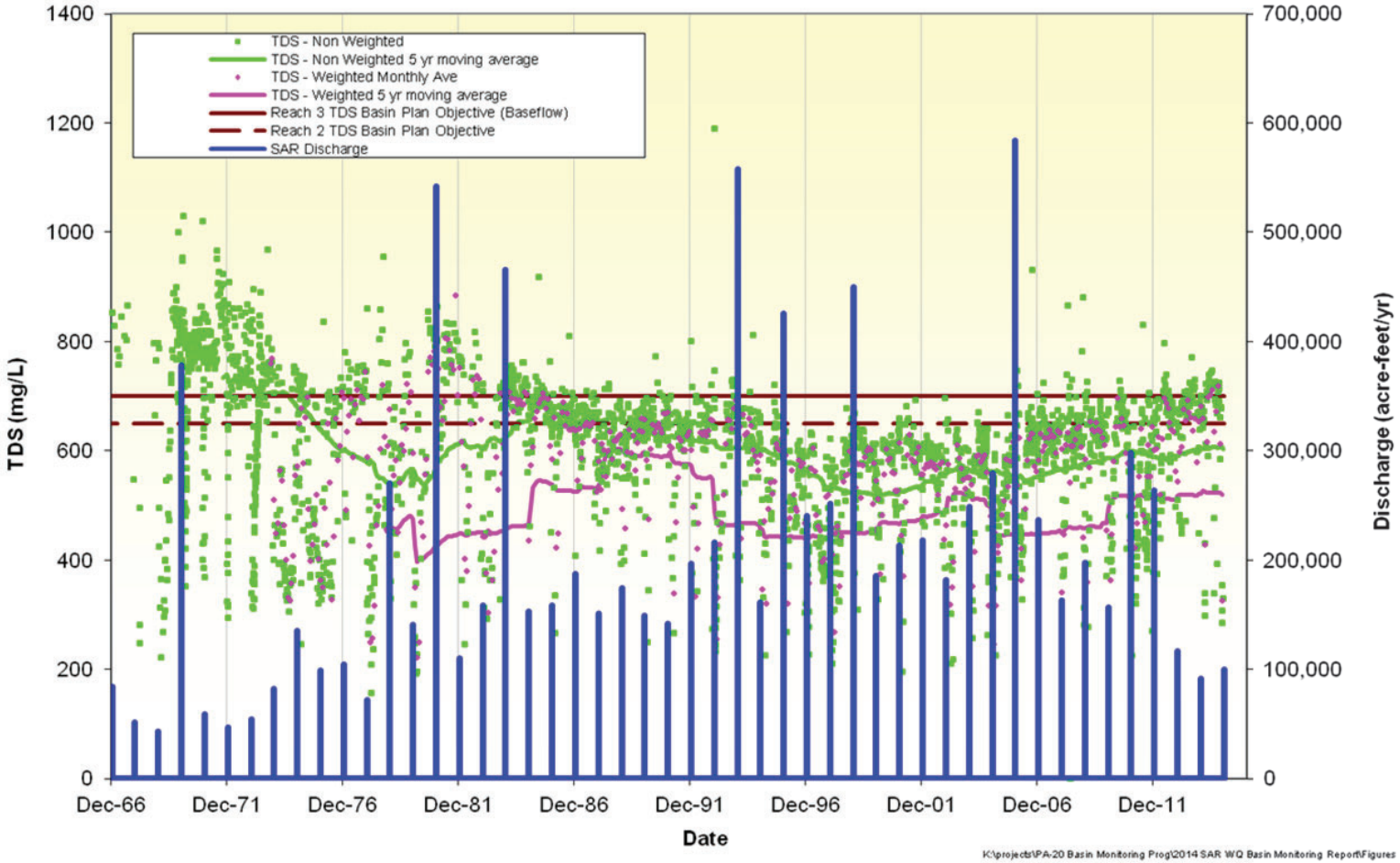
16) Other

A) EPA's Proposed (5/18/16) Revisions to NPDES Permitting Rules re: mass limits calculated based on design flow (2019 Permit)

B) Electronic Reporting Requirements in CIWQS & CEDEN (2019 Permit)

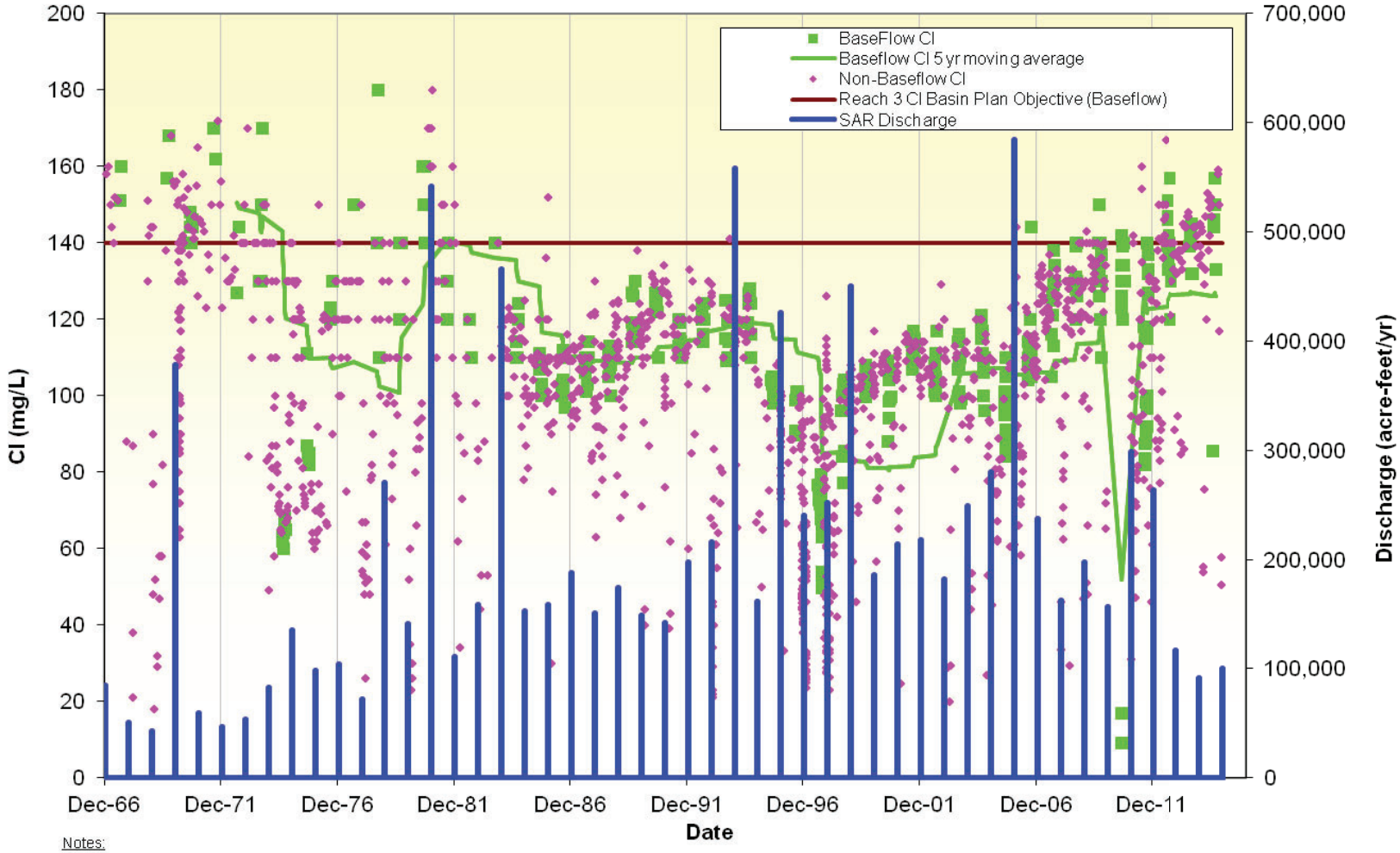
C) SWRCB's Proposed Climate Change Policy (2019 Permit)

Figure 3-1. Total Dissolved Solids (TDS) Below Prado Dam



Notes:
TDS Non-Weighted = TDS samples from RWQCB, USGS, HCMP, OCWD.
TDS Weighted = Monthly flow weighted TDS calculated from EC. Data prior to October 2003 from Watermaster; October 2003 to December 2004 from WeInc, 2005 to 2014 from SAWPA.

Figure 3-4. Chloride (Cl) Below Prado Dam



Notes:
Baseflow = Cl samples from RWQCB, USGS, HCMP, OCWD for August and September.
Non-Baseflow = Cl samples from RWQCB, USGS, HCMP, OCWD for all months except August and September.

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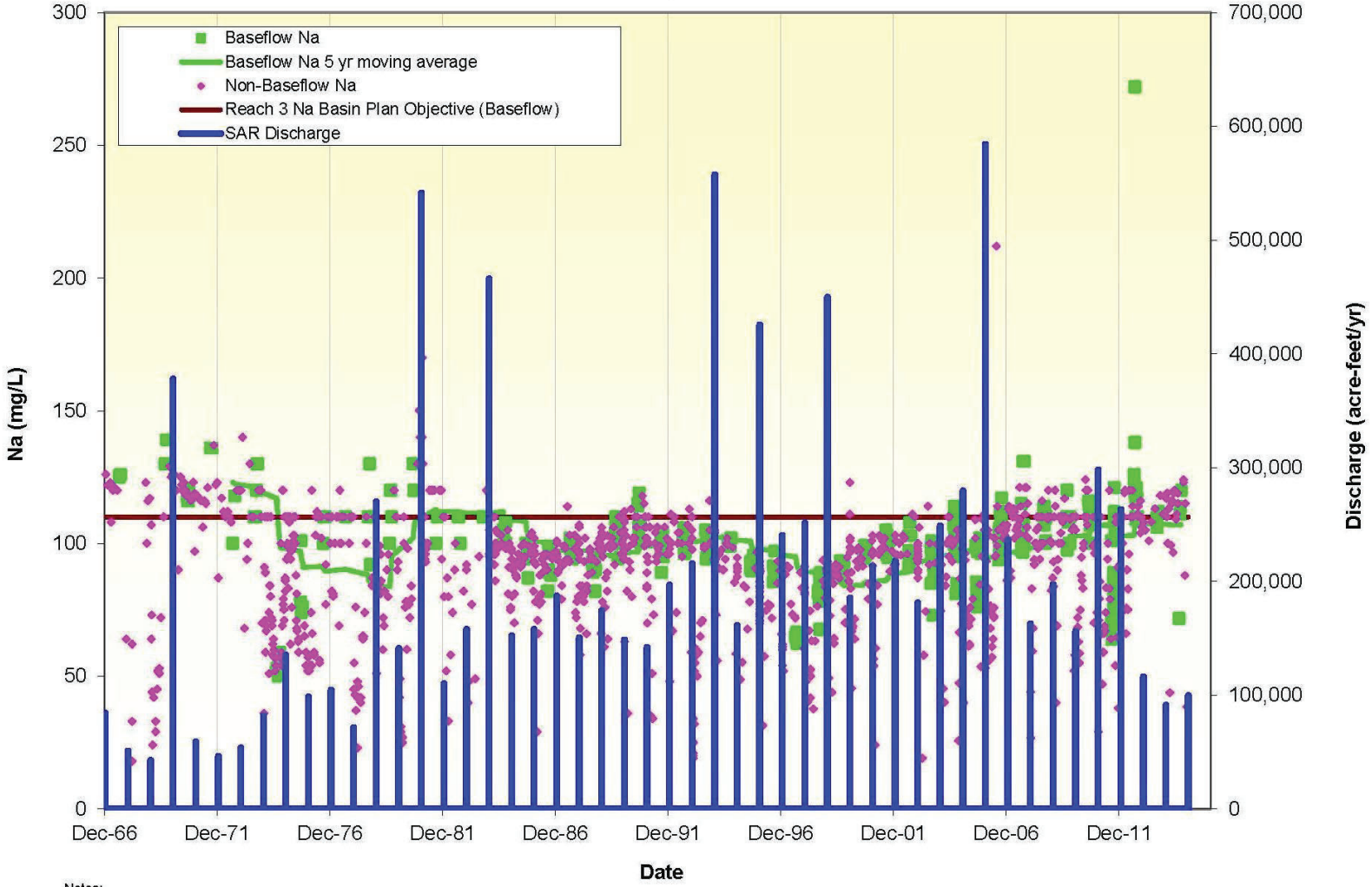
Figure 3-6. Sodium (Na) Below Prado Dam



Notes:
Baseflow = Na samples from RWQCB, USGS, HCMP, OCWD for August and September.
Non-Baseflow = Na samples from RWQCB, USGS, HCMP, OCWD for all months except August and September.

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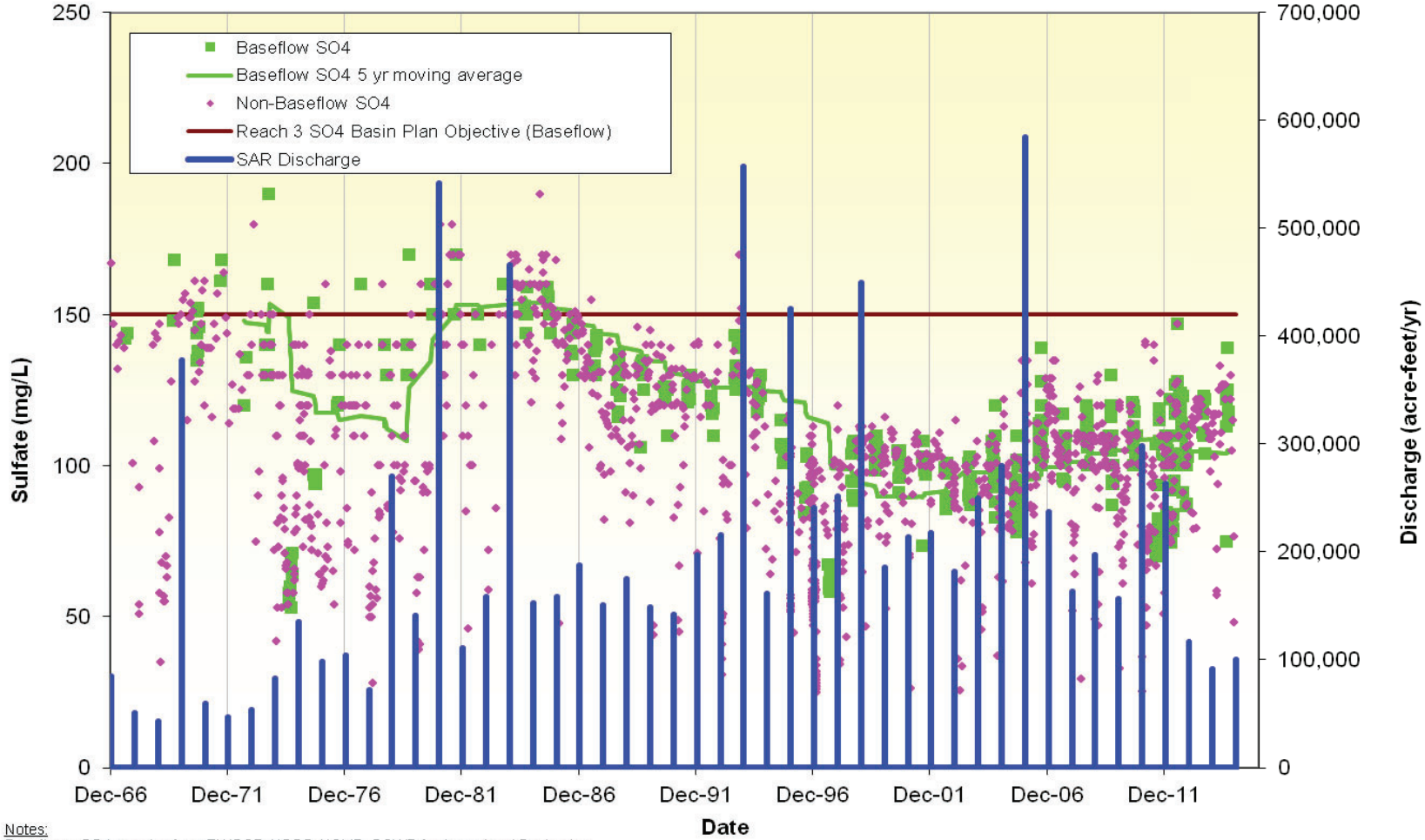
Figure 3-7. Sulfate (SO4) Below Prado Dam



Notes:
Baseflow = SO4 samples from RWQCB, USGS, HCMP, OCWD for August and September.
Non-Baseflow = SO4 samples from RWQCB, USGS, HCMP, OCWD for all months except August and September.

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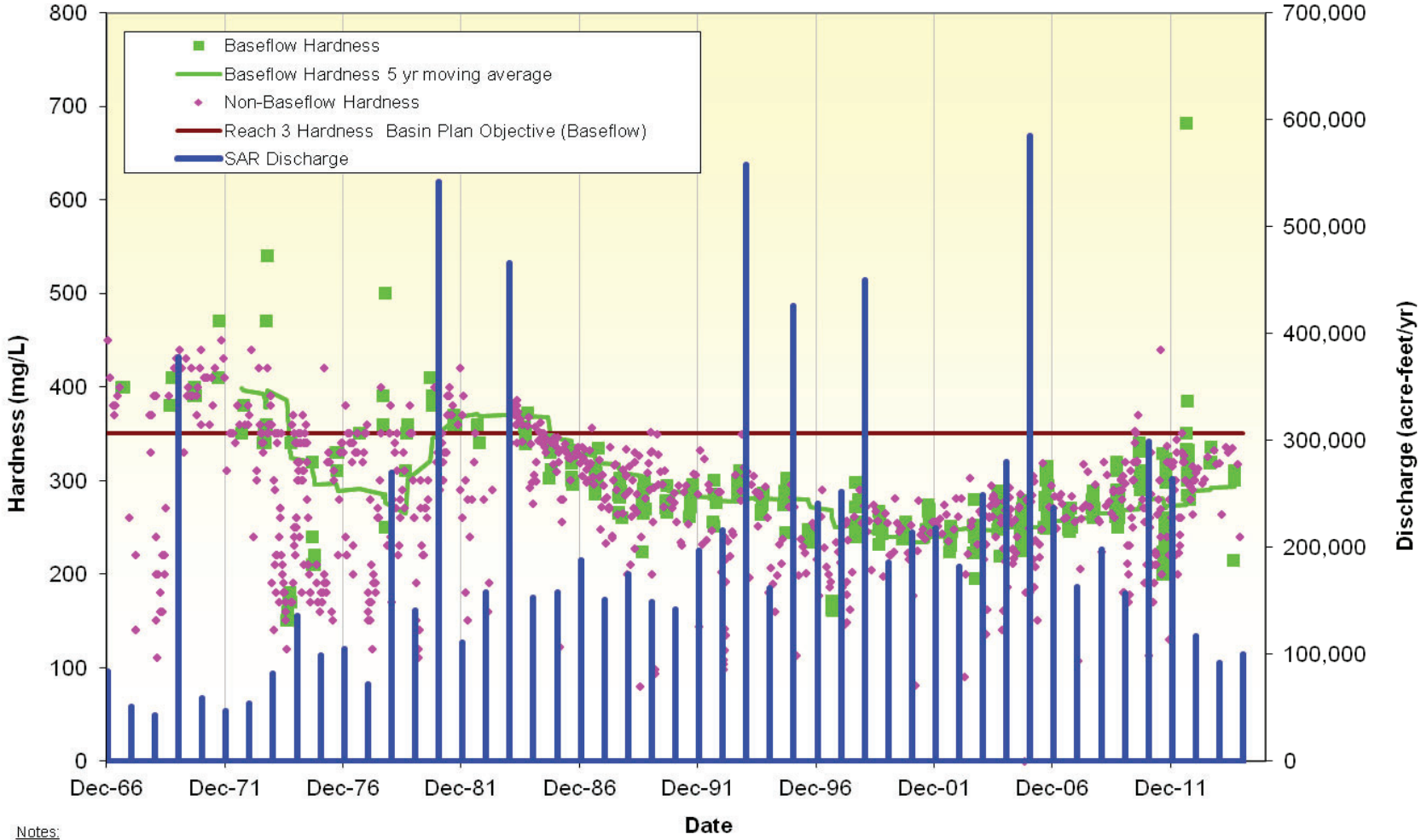
Figure 3-8. Total Hardness Below Prado Dam



Notes:
Baseflow = Hardness samples from RWQCB, USGS, HCMP, OCWD for August and September.
Non-Baseflow = Hardness samples from RWQCB, USGS, HCMP, OCWD for all months except August and September.

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Table 4-1 WATER QUALITY OBJECTIVES - Continued

INLAND SURFACE STREAMS	WATER QUALITY OBJECTIVES (mg/L)							Hydrologic Unit	
	Total Dissolved Solids	Hardness	Sodium	Chloride	Total Inorganic Nitrogen	Sulfate	Chemical Oxygen Demand	Primary	Secondary
UPPER SANTA ANA RIVER BASIN									
Santa Ana River									
Reach 3 – Prado Dam to Mission Blvd. in Riverside – Base Flow[2]	700	350	110	140	10[3]	150	30	801.21	801.27, 801.25
Reach 4 – Mission Blvd. in Riverside to San Jacinto Fault in San Bernardino	550	---	---	---	10	---	30	801.27	801.44
Reach 5 – San Jacinto Fault in San Bernardino to Seven Oaks Dam	300	190	30	20	5	60	25	801.52	801.57
Reach 6 – Seven Oaks Dam to Headwaters (see also Individual Tributary Streams)	200	100	30	10	1	20	5	801.72	
San Bernardino Mountain Streams									
Mill Creek Drainage:									
Mill Creek									
Reach 1 – Confluence with Santa Ana River to Bridge Crossing	200	100	30	10	1	20	5	801.58	
Reach 2 – Bridge Crossing Route 38 at Upper Powerhouse to Headwaters	110	100	25	5	1	15	5	801.58	

[2] Additional Objectives: Boron: 0.75 mg/l
[3] Total nitrogen, filtered sample

NOTE: This publication is meant to be an aid to the staff of the CDPH Drinking Water Program and cannot be relied upon by the regulated community as the State of California's representation of the law. The published codes are the only official representation of the law. Refer to the published codes—in this case, 17 CCR and 22 CCR—whenever specific citations are required. Statutes related to CDPH's drinking water-related activities are in the Health & Safety Code, the Water Code, and other codes.

Table 64449-B
Secondary Maximum Contaminant Levels
"Consumer Acceptance Contaminant Level Ranges"

	Maximum Contaminant Level Ranges		
Constituent, Units	*Recommended*	*Upper*	*Short Term*
Total Dissolved Solids, mg/L	500	1,000	1,500
or			
Specific Conductance, µS/cm	900	1,600	2,200
Chloride, mg/L	250	500	600
Sulfate, mg/L	250	500	600

(b) Each community water system shall monitor its groundwater sources or distribution system entry points representative of the effluent of source treatment every three years and its approved surface water sources or distribution system entry points representative of the effluent of source treatment annually for the following:

(1) Secondary MCLs listed in Tables 64449-A and 64449-B; and

(2) Bicarbonate, carbonate, and hydroxide alkalinity, calcium, magnesium, sodium, pH, and total hardness.

(c) If the level of any constituent in Table 64449-A exceeds an MCL, the community water system shall proceed as follows:

(1) If monitoring quarterly, determine compliance by a running annual average of four quarterly samples;

(2) If monitoring less than quarterly, initiate quarterly monitoring and determine compliance on the basis of an average of the initial sample and the next three consecutive quarterly samples collected;

(3) If a violation has occurred (average of four consecutive quarterly samples exceeds an MCL), inform the Department when reporting pursuant to Section 64469;

(4) After one year of quarterly monitoring during which all the results are below the MCL and the results do not indicate any trend toward exceeding the MCL, the system may request the Department to allow a reduced monitoring frequency.

(d) For the constituents shown on Table 64449-B, no fixed consumer acceptance contaminant level has been established.

(1) Constituent concentrations lower than the Recommended contaminant level are desirable for a higher degree of consumer acceptance.

(2) Constituent concentrations ranging to the Upper contaminant level are acceptable if it is neither reasonable nor feasible to provide more suitable waters.

NOTE: This publication is meant to be an aid to the staff of the CDPH Drinking Water Program and cannot be relied upon by the regulated community as the State of California's representation of the law. The published codes are the only official representation of the law. Refer to the published codes—in this case, 17 CCR and 22 CCR—whenever specific citations are required. Statutes related to CDPH's drinking water-related activities are in the Health & Safety Code, the Water Code, and other codes.

Article 14. Treatment Techniques

§64448. Treatment Technique Requirements.

(a) A public water system which uses acrylamide and/or epichlorohydrin in drinking water treatment shall certify annually in writing to the Department that the combination of dose and monomer does not exceed the following levels:

(1) Acrylamide: 0.05% monomer in polyacrylamide dosed at 1 mg/L, or equivalent.

(2) Epichlorohydrin: 0.01% residual of epichlorohydrin dosed at 20 mg/L, or equivalent.

Article 16. Secondary Drinking Water Standards

§64449. Secondary Maximum Contaminant Levels and Compliance.

(a) The secondary MCLs shown in Tables 64449-A and 64449-B shall not be exceeded in the water supplied to the public by community water systems.

Table 64449-A
Secondary Maximum Contaminant Levels
"Consumer Acceptance Contaminant Levels"

Constituents	*Maximum Contaminant Levels/Units*
Aluminum	0.2 mg/L
Color	15 Units
Copper	1.0 mg/L
Foaming Agents (MBAS)	0.5 mg/L
Iron	0.3 mg/L
Manganese	0.05 mg/L
Methyl-*tert*-butyl ether (MTBE)	0.005 mg/L
Odor—Threshold	3 Units
Silver	0.1 mg/L
Thiobencarb	0.001 mg/L
Turbidity	5 Units
Zinc	5.0 mg/L

demonstrated through Method A of ASTM International's method D4194-03 (2008) using the following substitute test conditions:

(A) tests are operated at a recovery of no less than 15 percent (15%);

(B) sodium chloride rejection is based on three or more successive measurements, after flushing and following at least 30 minutes of operation having demonstrated that rejection has stabilized;

(C) an influent pH no less than 6.5 and no greater than 8.0; and

(D) an influent sodium chloride concentration of no greater than 2,000 mg/L, to be verified prior to the start of testing; and

(2) during the first twenty weeks of full-scale operation the membrane produces a permeate with no more than five percent (5%) of the sample results having TOC concentrations greater than 0.25 mg/L, as verified through monitoring no less frequent than weekly.

(b) For the reverse osmosis treatment process, a project sponsor shall propose, for Department review and approval, on-going performance monitoring (e.g., conductivity or TOC) that indicates when the integrity of the process has been compromised. The proposal shall include at least one form of continuous monitoring, as well as the associated surrogate and/or operational parameter limits and alarm settings that indicate when the integrity has been compromised.

(c) To demonstrate a sufficient oxidation process has been designed for implementation, a project sponsor shall:

(1) Perform an occurrence study on the project's municipal wastewater to identify indicator compounds and select a total of at least nine indicator compounds, with at least one from each of the functional groups in subparagraphs (A) through (I) below. A project sponsor shall submit an occurrence study protocol, as well as the subsequent results and chosen indicator compounds, to the Department for review and approval.

(A) Hydroxy Aromatic

(B) Amino/Acylamino Aromatic

(C) Nonaromatic with carbon double bonds

(D) Deprotonated Amine

(E) Alkoxy Polyaromatic

(F) Alkoxy Aromatic

(G) Alkyl Aromatic

(H) Saturated Aliphatic

(I) Nitro Aromatic

(2) Utilize an oxidation process that achieves optimal removal of the indicator compounds selected in paragraph (1) such that removal is no less than;

(A) 0.5-log (69 percent) for each indicator compound representing the functional groups in paragraphs (1)(A) through (1)(G), and

(B) 0.3-log (50 percent) for each indicator compound representing the functional groups in paragraphs (1)(H) and (1)(I).

(3) Establish at least one surrogate or operational parameter that reflects the removal of at least five of the nine indicator compounds selected pursuant to paragraph (1) such that;

(A) at least one of the five indicator compounds represents at least one functional group in paragraphs (1)(A) through (1)(G),

(B) at least one of the five indicator compounds represents at least one functional group in paragraphs (1)(H) or (1)(I),

(C) at least one surrogate or operational parameter is capable of being monitored continuously, recorded, and have associated alarms, and

(D) a surrogate or operational parameter, including the parameter in subparagraph (C), is identified that indicates when the process may no longer meet the criteria established in paragraph (2).

(4) Conduct testing that includes confirmation of the findings of the occurrence study in paragraph (1) and provides evidence that the requirements of paragraphs (2) and (3) can be met with a full-scale oxidation process. The testing shall include challenge or spiking tests conducted to determine the removal differential under normal operating conditions utilizing, at minimum, the nine indicator compounds identified in paragraph (1). A project sponsor shall submit a testing protocol, as well as the subsequent results, to the Department for review and approval.

FAQ for Draft Regulations for Groundwater Replenishment with Recycled Water

Last Update: November 22, 2011

This page includes frequently asked questions (FAQ) for the CDPH Drinking Water Program's draft regulations for groundwater replenishment with recycled water. Such replenished groundwater will supplement drinking water supplies.

Portions of the draft regulations mention indicator compounds to evaluate the effectiveness of treatment processes.

* * * * * *

FAQ 1. Section 60320.118(f) of the November 21, 2011 draft regulations refers to indicator compounds for soil treatment process. What are examples of such indicator compounds?

Answer: The following are examples of chemicals that may be suitable as indicator compounds:

Acetaminophen
Atenolol
Atorvastatin (Lipitor)
Bisphenol A
Caffeine
DEET
Diclofenac
Dilantin
Erythromycin–H_2O
17β-Estradiol (E2)
Estriol (E3)
Estrone (E1)
Fluoxetine (Prozac)
Gemfibrozil
Hydrocodone (Vicodin)
Ibuprofen
Iopromide
Ketoprofen
Meprobamate
Metoprolol (Lopressor)
Naproxen
NDMA
Nonylphenol
Propranolol
Salicylic acid
Sulfamethoxazole
Triclosan
Trimethoprim

FAQ 2. Section 60320.201(c)(1) of the November 21, 2011 draft regulations refers to indicator compounds, at least one from each of nine functional groups, to demonstrate that a sufficient oxidation process has been designed for implementation. What are examples of such indicator compounds?

Answer: Examples of indicator compounds associated with each of the nine functional groups (A through I) mentioned in the regulations are presented below:

(A) Hydroxy Aromatic: Acetominophen, Benzyl salicylate, Bisphenol A, Estrone, Hexyl salicylate, Isobutylparaben, Methyl salicylate, Nonylphenol, Oxybenzone, Propylparaben, Salicylclic acid, Triclosan, Clorfibric Acid

(B) Amino/Acylamino Aromatic: Sulfamethoxazole, Atorvastatin, Triclocarban

(C) Nonaromatic with carbon double bonds: Acetyl cedrene, Carbamazepine, Codeine, Hexylcinnamaldehyde, Methyl ionine, OTNE, Simvastatin hydroxyl, Terpineol

(D) Deprotonated Amine: Atenolol, Caffeine, Diclofenac, EDTA, Erythromycin-H_2O, Fluoxetine, Metoprolol, Nicotine, Norfluoxetine, Ofloxacin, Paraxanthine, Pentoxifylline, Trimethoprim

(E) Alkoxy Polyaromatic: Naproxen, Propranolol

(F) Alkoxy Aromatic: Gemfibrozil, Hydrocodone

(G) Alkyl Aromatic: Benzophenone, Benzyl acetate, Bucinal, DEET, Dilantin, Dibutyl Phthalate, Diphenhydramine, Galazolide, Ibuprofen, Indolebutyric acid, Primidone, Tonalide

(H) Saturated Aliphatic: Iopromide, Isobornyl acetate, Meprobamate, Methyl dihydrojasmonate

(I) Nitro Aromatic: Musk ketone, musk xylene

* * * * * *

More Information

6.2. CEC Monitoring trigger quotients

6.2.1 Aqueous Exposure for Effluent-dominated Inland Waterway (Scenario 1)

Nine compounds exceeded thresholds for aqueous exposure to CECs in scenario 1 (Table 6.1). Current use pesticides had the highest MTQs with pyrethroids in the 50-200 range. While only two pyrethroids were evaluated in the current screening, the Panel notes that permethrin and bifenthrin were used as models, and it is likely that other pyrethroids of similar occurrence and potency would also present MTQ values exceeding unity. This also applies to diazinon, (like chlorpyrifos) an organophosphate insecticide. The steroid hormone 17-beta estradiol, the hormone degradate/metabolite estrone was also above unity as were the pharmaceuticals ibuprofen and diclofenac. The MTQs for the fragrance galaxolide (HHCB) and industrial plasticizer bisphenol A were also above one.

Table 6.1. CECs with Monitoring trigger quotients >1 for aqueous exposures in effluent dominated inland waterways (Scenario 1).

Compound	MEC (ng/L)	NOEC or PNEC (ng/L)	Safety Factor	Freshwater MTL (ng/L)	MTQ
Bifenthrin	85	4	10 [a]	0.4	210
Permethrin	46	10	10 [a]	1	46
Chlorpyrifos	190	50	10 [a]	5	38
Estrone	73	6	1	6	12
Ibuprofen	1000	1000	10[b]	100	10
Bisphenol A	520	60	1	60	8.7
17-beta estradiol	8.4	2	1	2	4.2
Galaxolide (HHCB)	2780	7000	10[b]	700	4.0
Diclofenac	230	1000	10[b]	100	2.3

[a]EDC mode of action not incorporated into PNEC or NOEC
[b]Unknown mode of action

6.2.2 Coastal Embayment (Scenario 2)

To estimate exposure, PECs were derived from MECs obtained in Scenario 1 with a 10-fold dilution to simulate embayment dilution. Table E.4 shows the relationships between measured values in San Francisco Bay and the PECs derived from dilution. The panel felt that since aqueous values from Scenario 1 were well characterized, it would be more consistent to use the diluted Scenario 1 values rather than measured values for a relatively few number of compounds in SF Bay receiving waters.

6.2.2.1 Aqueous Exposure

Seven compounds had MTQs greater than 1.0 for Scenario 2 (Table 6.2). Most of these also exceeded unity for Sceario 1 (Table 6.1) indicating a high priority for potential monitoring.

6.2.2.2 Sediment exposure

Data from a limited number of studies and for a handful of CECs were available for estuarine and marine sediments (see Table 5.4). Permethrin, bifenthrin and PBDE 47/99 were detected in estuarine sediments

6.4 Antibiotics

Assessment of potential bacterial effects was based on the range of MICs reported for each antibiotic. MICs are identified to develop dosing regimens for antibiotics. Ranges of MICs are often reported for individual antibiotics because some studies are conducted with naive strains (no resistant genes = most sensitive strains) while others use bacterial strains that have developed specific gene mutation based resistance (Most Resistant MIC). A highly resistant strain will have a higher MIC than a naïve strain. Antibiotics with at least 3 independent MICs (Most Resistant MIC, Most Sensitive MIC and an Intermediate MIC Values) were judged to have a complete data set and a safety factor of 100 was applied to the most sensitive MIC (NOEC from Section 4) to derive the MTL. This safety factor of 100 was applied to account for uncertainty associated with the use of indicator bacteria that are not aquatic/marine (safety factor = 10) and for the uncertainty of development of ABR from plasmids or other molecular constituents (safety factor = 10). For antibiotics with less than 3 independent MICs a Safety factor of 1000 (the safety factor of 100 mentioned above plus an additional safety factor of 10 to account for incomplete acute toxicity (MIC) data) was used to derive the MTLs discussed in Appendix D. NOECs were derived from most sensitive MICs (lowest concentration casuing toxicity) and were set at concentrations less than the most sensitive MIC value reported (see Section 4.3).

6.4.1 Aqueous Exposure for Effluent-dominated Inland Waterway (Scenario 1)

Monitoring trigger quotients for antibiotics/antibacterial agents in the effluent dominated inland waterway (Scenario 1) are listed in Table 6.6. One compound, triclosan, an antimicrobial agent, had an MTQ >1.

Table 6.6. Monitoring trigger quotient estimates for antibiotics/antibacterial agents in the effluent dominated inland waterway (Scenario 1).

Antibiotic	MEC (ng/L)	NOEC (ng/L)	Safety Factor	MTL (ng/L)	MTQ
Triclosan	510	25,000	100	250	2.0

6.4.2 Aqueous Exposure for Coastal Embayment (Scenario 2)

No antibiotics/antibacterial agents had an MTQ of greater than 1.0 in the coastal embayment likely due to the 10-fold dilution within the embayment Scenario 2.

6.4.3 Aqueous Exposure for Ocean Discharge of WWTP Effluent (Scenario 3)

No antibiotics/antibacterial agents had MTQs >1 for aqueous exposure in Scenario 3. In all cases, MTQs for antibiotics/antibacterial agents were reduced by an order of magnitude (factors of 19-90) or more (factors of 917-1000) at ocean outfalls when compared to Scenarios 1 and 2. This suggests that the risks for developing ABR is much lower in waters around marine outfalls than in effluent dominated inland and coastal embayment waters, due to the greater dilution of CEC sources in oceanic waters. These findings are consistent with results that illustrate the dilution effects of tidal range on the rate of antibiotic resistance as measured in other regions of the U.S. (Table 6.7).

Table 8.1. CECs recommended for initial monitoring (Phase 2) by scenario and environmental matrix (i.e., aqueous, sediment, tissue). M = include in monitoring program (discharges to E = embayments; F = freshwater, O = ocean waters; NA = not applicable. Monitoring Trigger Quotient values from Section 6 appear in parentheses.

Compound	Scenario 1 - Inland Waterbody Aqueous (Tables 6.1 & 6.6)	Scenario 2 - Embayment Aqueous (Table 6.2)	WWTP Effluent	FW Stream - Stormwater (Aqueous and Sediment)[a]	Scenario 2- Embayment Sediment (Table 6.3)	Scenario 3 - Marine Sediment (Table 6.4)	Tissue (Table 6.5)
Bis(2-ethylhexyl) phthalate	NA	NA	M-O	NA	NA	M(3.8)	NA
Bisphenol A	M(8.7)	M(2400)	M–E/F	M	NA	NA	NA
Bifenthrin	M(210)	M(750)	M-E/F	M	M(1500)	NA	NA
Butylbenzyl phthalate	NA	NA	M-O	NA	NA	M(16)	NA
Permethrin	M(46)	M(46)	M-E/F	M	M(2600)	NA	NA
Chlorpyrifos	M(38)	M(220)	M-E/F	M	NA	NA	NA
Estrone	M(12)	M(12)	M-E/F	M	NA	NA	NA
Ibuprofen	M(10)	NA	M-F	M	NA	NA	NA
17-beta estradiol	M(4.2)	M(4.2)	M-E/F	M	NA	NA	NA
Galaxolide (HHCB)	M(4.0)	M(4.0)	M-E/F	M	NA	NA	NA
Diclofenac	M(2.3)	NA	M-F	M	NA	NA	NA
p-Nonylphenol	NA	NA	M-O	NA	NA	M(30)	NA
PBDE -47 and 99	NA	NA	M-E/F/O	M	M(5700)	M(15)	M(850)
PFOS	NA	NA	M-E/F/O	M	M[b]	M[b]	M(1.8)
Triclosan	M(2.0)	NA	M-F	M	NA	NA	NA

[a] Addresses data gap on relative contributions of stormwater discharge and WWTP effluent (see Monitoring Question 4)

[b] Addresses route of exposure and data gap for estimation of BSAFs for tissue CECs (see Monitoring Question 5)

evaluations (TIEs) were recently conducted on sediment collected from the Alamo River site as part of routine SWAMP monitoring. The toxicity and chemistry results suggest that pyrethroid pesticides were contributing to the observed toxicity. Pyrethroid concentrations have generally been higher at the New River site, and a previous study identified cypermethrin as the cause of water column toxicity at this site (Phillips et al., 2007). Pyrethroids had a significant increase statewide, but only significantly increased at two individual sites. Both of these sites were located in Region 7. The Alamo River Outlet had a significant increase in total pyrethroids and the Coachella Valley Drain had a significant increase in bifenthrin. Significant decreases in DDT were observed at the New River, and a significant decrease in metals was observed at the Alamo River. The New River and Alamo River were both non-toxic in 2014, but exhibited high toxicity when tested at 15°C.

A recent collaboration between DPR and SWAMP showed that many of the agriculture sites in Region 7 are contaminated by mixtures of pyrethroid pesticides and toxic concentrations of chlorpyrifos. Samples from these sites were highly toxic to *H. azteca* in water exposures, and some were toxic to *C. dilutus*. Toxicity was driven by mixtures of chlorpyrifos and pyrethroids (Anderson et al. in preparation). All of the sites had detections of the neonicotinoid pesticide imidacloprid, in water. Two of these sites have been selected for continued water chemistry and toxicity monitoring as part of a collaboration between SPoT and DPR.

Station Code	Primary 5km Land Use	Years Sampled	Mean % Survival 2010-2014	Mean Total Concentration (ng/g) Pyrethroid	4 Metals (µg/g)	PBDE	PAH	DDT	PCB	% Fines	% TOC
719CVSCOT	Other	2008 2014	97	4.37	169	2.16	158	12.5	0	59.5	1.90
723ARGRB1	Other	2008 2014	68	7.77 ↑	96.6 ↓	0.070	16.8	25.3	0	69.4 ↓	2.63
723NROTWM	Agri.	2008 2014	67	17.4	96.8	1.84	19.5	27.2 ↓	0	73.9	1.62

Bold indicates sites that will be included in DPR surface water collaboration.

Region 8 – Santa Ana

Three of the four sites in the Santa Ana Region are classified as urban at the 5 km scale. The fourth site, San Jacinto Creek (802SJCREF), is one of the five SPoT reference sites, and was classified as other. No toxicity has been observed at San Jacinto Creek or at the Santa Ana River at Prado Basin (801SARVRx), but Chino Creek (801CCPT12) and San Diego Creek (801SDCxxx) continue to be significantly toxic in every sampling event. San Diego Creek has been highly toxic in five of seven sampling events, and Chino Creek was highly toxic in one of five events. The only significant trend observed in the chemistry data set was a decrease in PCB at the Santa Ana River. San Diego Creek and Chino Creek have some of the higher average total pyrethroid concentrations in the state. Non-toxic and moderately toxic sites are consistently toxic or highly toxic when tested at 15°C. Fipronil was measured at two sites and significantly increased at San Diego Creek (801SDCxxx).

Station Code	Primary 5km Land Use	Years Sampled		Mean % Survival 2010-2014	Mean Total Concentration (ng/g) Pyrethroid	Fipronil	4 Metals (µg/g)	PBDE	PAH	DDT	PCB	% Fines	% TOC
801CCPT12	Urban	2010	2014	54	105	0.839	228	23.5	410	2.37	0	51.0	3.47
801SARVRx	Urban	2008	2014	95	11.9		138	16.8	450	5.05	4.7 ↓	43.9	1.44
801SDCxxx	Urban	2008	2014	37	115	7.87	130	10.9	292	18.2	1.75	63.6	2.36
802SJCREF	Other	2008	2013	102	0.454		104	0.586	145	0.281	2.55	50.6	1.40

Region 9 – San Diego

All Region 9 sites are characterized as urban at the 5 km scale. Mostly moderate toxicity has been observed at San Juan Creek (901SJSJC9), Escondido Creek (904ESCOxx), San Dieguito River (905SDSDQ9), and Sweetwater River (909SWRWSx). San Juan Creek is also exhibiting a significant decrease in survival., The Tijuana River (911TJHRxx) has been highly toxic since 2008. This site also has the highest average concentration of total pyrethroids in the region, and has consistently been one of the most pyrethroid-contaminated sites in the state, based on SPoT monitoring. There were several increasing or decreasing trends in the region including increases in metals at San Diego River (907SDRWAR) and Sweetwater River, increasing PAHs at San Diego River, and a decrease in DDT at Santa Margarita River (902SSMR07). Fipronil concentrations tended to decrease between 2013 and 2014. Testing at 15°C consistently demonstrates significantly increased toxicity, indicating the contributing role of pyrethroids.

Station Code	Primary 5km Land Use	Years Sampled		Mean % Survival 2010-2014	Mean Total Concentration (ng/g) Pyrethroid	Fipronil	4 Metals (µg/g)	PBDE	PAH	DDT	PCB	% Fines	% TOC
901SJSJC9	Urban	2008	2014	76 ↓	32.5	3.44	121	12.4	327	7.23	0.985	71.0	2.11
902SSMR07	Urban	2008	2014	103	4.20		90.0	0.265	20.3	8.94 ↓	0.450	53.4	3.88
903SLRRBB	Urban	2011	2014	99	0.542		101			6.19	1.28	39.9	1.11
904ESCOxx	Urban	2008	2014	83	17.9	1.17	177	5.08	386	1.54	1.16	55.0	2.85
905SDSDQ9	Urban	2010	2014	80	0.466	0.126	109	0.610	54.2	0.278	0	54.7	1.57
906LPLPC6	Urban	2010	2014	90	172	7.46	257	27.8	392	0.122	1.02	69.5	3.11
907SDRWAR	Urban	2009	2014	91	81.1	13.6	401 ↑	38.2	2010 ↑	14.1	19.7	59.0	7.04
909SWRWSx	Urban	2011	2014	73	43.9	2.17	167 ↑	15.4	423	4.11	0	34.3	3.06
911TJHRxx	Urban	2008	2014	11	385	1.22	348	116	213	3.28	13.7	84.7	5.65

Bold indicates sites that will be included in DPR surface water collaboration.

3. Results

3.1 Fish Tissues

The following tissue samples were taken from the Santa Ana River in 2016: one crayfish (Cambaridae family), one Yellow Bullhead (*Ameiurus natalis*), and one composite sample of Western Mosquitofish (*Gambusia affinis*) each were collected from sites SAR 6 and SAR 8 (Table 1 and Appendix A). At Site SAR 12, one crayfish, one Largemouth Bass (*Micropterus salmoides*), and one composite sample of Western Mosquitofish were collected. One additional Western Mosquitofish for the composite sample was collected immediately outside of the reach at Site SAR 8, while all other fish in tissue samples were from within their respective sites.

Table 1: Tissue analysis (whole body) for total mercury, methylmercury, selenium, arsenic, and cadmium for organisms collected in the Santa Ana River, August 2016. CRAY = crayfish, LMB = Largemouth Bass, WMF = Western Mosquitofish, and YBH = Yellow Bullhead. ww = wet weight, and dw = dry weight.

Site/Organism (# in sample)	Weight (g)	Total Mercury (µg/g ww)	Methylmercury (µg/g ww)	Selenium (µg/g dw)	Arsenic (µg/g ww)	Cadmium (µg/g dw)
SAR 6						
CRAY (1)	>10	0.0101	0.0073	0.62	0.108	0.282
YBH (1)	45	0.0287	0.0388	1.10	0.010	0.030
WMF (17)	5.2	0.0242	0.0160	0.74	0.037	0.030
SAR 8						
CRAY (1)	>10	0.0102	0.0047	0.51	0.066	0.041
YBH (1)	6.8	0.0095	0.0071	1.62	0.028	0.051
WMF (5)	5.3	0.0421	0.0324	0.88	0.060	0.051
SAR 12						
CRAY (1)	>10	0.0069	0.0019	0.61	0.110	≤0.013
LMB (1)	4.8	0.0083	0.0081	0.67	0.016	≤0.013
WMF (12)	5.0	0.0217	0.0237	0.88	0.027	≤0.013

3.1.1 Mercury Results

In 2016, total mercury concentrations in the collected tissue samples ranged from 0.0069 µg/g wet weight (ww) at Site SAR 12 to 0.0421 µg/g ww in the Western Mosquitofish sample from Site SAR 8 (Table 1). Methylmercury concentrations ranged from 0.0019 µg/g ww in the crayfish sample from Site SAR 12 to 0.0388 µg/g ww in the Yellow Bullhead sample from Site SAR 6. These values are well below both the target concentration of 0.35 µg/g in the Mercury Monitoring Plan and the EPA human health criterion of 0.3 µg/g ww in fish tissue (EPA 2001). The percentage of mercury as methylmercury was variable and ranged from 28% in the crayfish sample from Site SAR 12 to 100% in the Western Mosquitofish sample from Site SAR 12 and the Yellow Bullhead sample from Site SAR 6.

Table 7: Benthic invertebrate abundance (#/m^2), number of taxa (including sweep data), and Shannon-Weaver diversity (H') on the Santa Ana River, 1991 and 1995-2016.

	SAR 6			SAR 8			SAR 12		
	#/m^2	Number of Taxa	H'	#/m^2	Number of Taxa	H'	#/m^2	Number of Taxa	H'
1991	39	17	1.99	34	19	0.91	6,688	13	1.90
1995	50	19	2.19	39	19	3.04	2,211	17	0.53
1996	155	34	3.01	36	20	2.10	3,524	30	2.51
1997	23	27	0.92	44	18	2.29	4,696	16	2.29
1998	2,295	34	2.88	9,840	15	1.77	1,238	18	2.93
1999	53	18	2.20	10	6	0.62	1,829	19	1.36
2000	22	9	0.73	38	20	2.35	459	14	1.09
2001	91	30	1.42	67	16	1.68	5,160	25	2.44
2002	131	18	2.32	85	15	2.90	7,024	26	2.59
2003	156	27	1.40	54	15	0.04	4,015	38	2.96
2004	641	31	2.15	112	29	1.51	11,332	29	1.72
2005	598	50	3.34	503	26	2.43	4,991	42	2.64
2006	26	25	0.73	88	32	2.75	3,084	17	2.70
2007	112	37	2.72	48	19	2.38	11,601	25	2.73
2008	69	35	1.10	37	25	1.46	12,941	33	2.76
2009	134	33	0.87	148	29	0.53	5,621	31	2.70
2010	15	32	1.53	48	24	2.06	4,049	30	2.34
2011	334	38	3.02	187	32	2.58	5,818	36	2.89
2012	93	21	2.08	204	13	1.51	10,634	35	2.52
2013	290	29	0.81	123	21	1.30	29,182	27	2.03
2014	173	48	3.26	91	30	2.62	1,433	37	2.95
2015	202	37	0.50	182	24	1.87	9,868	40	2.02
2016	3,298	37	3.15	193	26	2.15	7,453	24	2.54

RISK SCIENCES

Summary of EC Monitoring in City of Riverside's Final Effluent

Constituent *(ng/L)*	Type	2010	2011	2012	2013
Acetaminophen (Tylenol)	OTC Analgesic	11	<10	<10	NA
Bisphenol A	Industrial Plastics	10	<10	<10	NA
Caffeine	Food Additive	<10	<10	12	<10
Carbamazepine	Anti-Coagulant	220	230	100	NA
DEET	Insect Repellent	180	410	370	<10
Diuron	Herbicide	50	41	31	NA
17α Ethynylestradiol	Hormone	<10	<10	<10	NA
17β Estradiol	Hormone	NA	<10	<10	<1
Gemfibrozil	Anti-Cholesterol	<10	27	<10	12
Ibuprofen (Advil)	OTC Analgesic	12	14	<10	NA
Iopromide	Xray Contrast	NA	NA	860	320
Naproxen (Aleve)	OTC Analgesic	NA	NA	<10	NA
Sucralose	Artificial Sweetener	NA	NA	NA	56000
Sulfamethoxazole	Antibiotic	16	11	14	NA
TCEP	Flame Retardant	150	170	660	NA
Triclosan	Antiseptic	NA	<10	<10	<10

NA = "Not Analyzed"

RIVERSIDE WATER QUALITY CONTROL PLANT INTEGRATED MASTER PLAN UPDATE: AQ AND GHG REGULATORY FRAMEWORK

JULIA LESTER, PHD, CPP
DAWN CHIANESE, PHD

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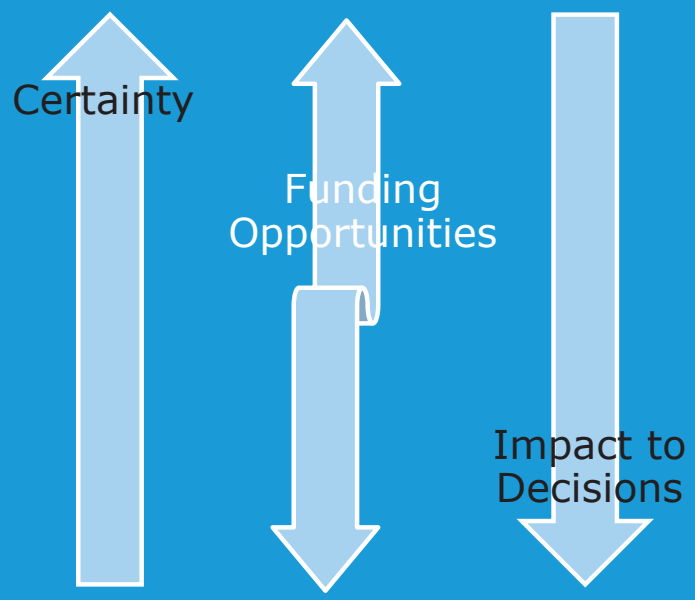
REGULATIONS AND PROGRAMS



Regulations and Programs

- SCAQMD Regulations – 2008 Master Plan
- SCAQMD Regulations – Existing and Proposed
- Air Quality Management Plan (AQMP)
- Short-Lived Climate Pollutant (SLCP) Strategy
- 2030 Scoping Plan
- Funding Opportunities

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Summary

Regulation / Programs	Details	Applicability	Certainty	Impact Decision Making	Funding Opportunities
SCAQMD Regulations – 2008 Master Plan	▪ Regulation II, Regulation IV, Regulation XI, Regulation XIII, Regulation IXV, Regulation XXX	TBD	√	TBD	TBD
SCAQMD Regulations – Existing and Proposed	▪ Regulation II, Regulation III, Regulation IV, Regulation XI, Regulation XIII, Regulation IV, Regulation XXII	TBD	√	TBD	TBD
2016 AQMP	▪ CMB-01: Transition to Zero & Near Zero Emission Technologies for Stationary Sources ▪ CMB-03: Emission Reductions from Non-Refinery Flares ▪ CMB-05: Further NOx Reductions from RECLAIM Assessment ▪ BCM-10: Emission Reductions from Greenwaste Composting	TBD	√	TBD	TBD
SLCP Strategy	▪ Divert organic waste to plants with spare capacity (co-digestion) ▪ Partner with CalRecycle and the SWRCB to support retrofit/purchase of new facilities for co-digestion ▪ Other financial incentives ▪ Additional programs that may affect sector	TBD	√	TBD	TBD
Scoping Plan	▪ Increase water sector efficiency and reduce GHGs ▪ Increase the use of renewable energy to pump, convey, treat, and utilize water	TBD	?	TBD	TBD

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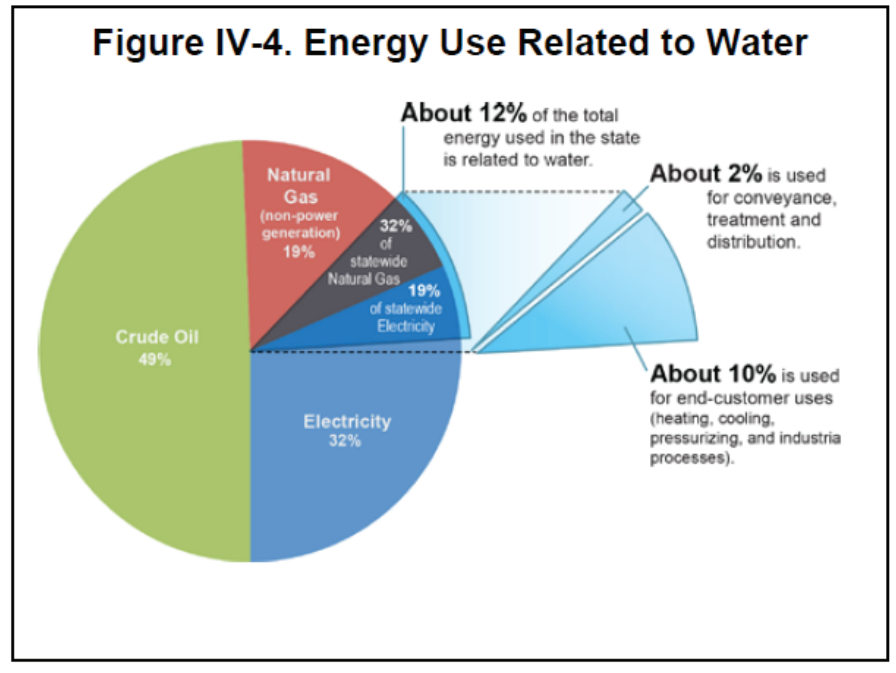
ARB – 2030 SCOPING PLAN



ARB PROPOSED SCOPING PLAN

Proposed framework to achieve 40% reduction below 1990 levels by the year 2030.

Primary source of GHGs from water sector = fossil-fuel based energy used to produce (e.g., pump, convey, and treat) water and for water end uses (e.g., heating)

Note that wastewater treatment identified as source of N_2O, but nothing in Scoping Plan to address N_2O emissions from this source

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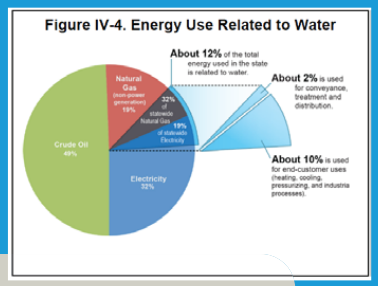
ARB – 2030 SCOPING PLAN



GHG REDUCTION GOALS IN WATER SECTOR

1. Develop and support programs and projects that increase water sector efficiency and reduce GHG emissions through reduced water and energy use.
2. Increase the use of renewable energy to pump, convey, treat, and utilize water

SUPPORTING ACTIONS THAT MAY BE RELEVANT TO WATER SECTOR

- Adopt a long-term goal to reduce GHGs by 80% below 1990 levels by 2050; move toward low carbon or net-zero carbon water management systems
- Develop distributed energy using expanded and new programs
- Encourage co-digestion and methane capture systems (in support of SLCP Strategy)

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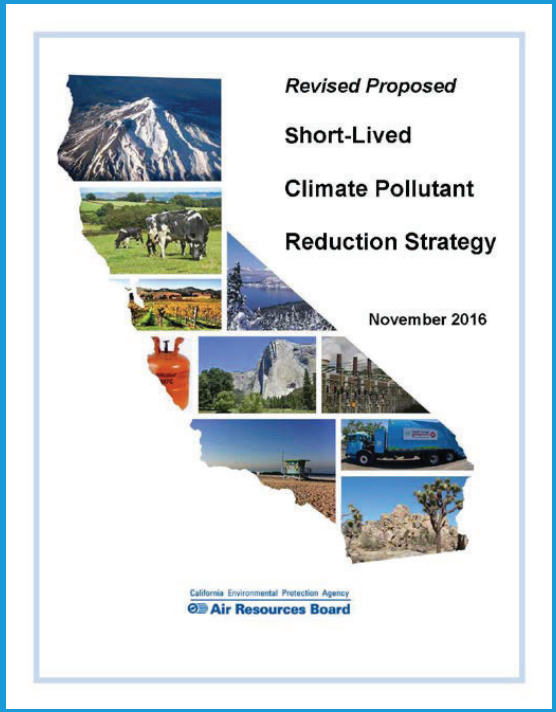
SLCP STRATEGY

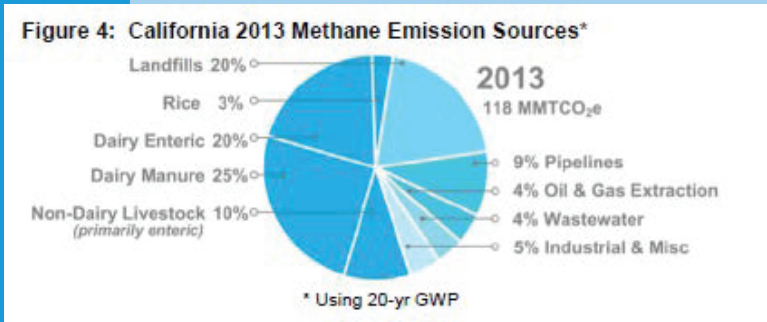


STATUS

Revised Draft November 2016

Strategy focuses on short-lived climate pollutants (i.e., CH_4; not CO_2) as a way of achieving CA's GHG reduction goals.

Methane from water treatment plants = 4%



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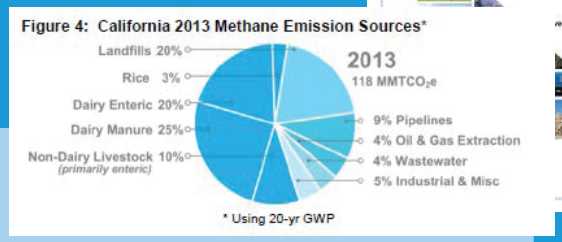
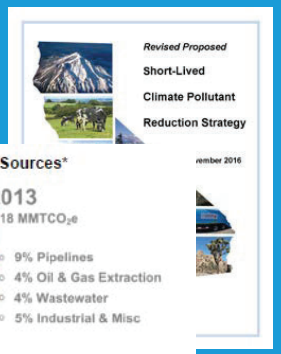
SLCP STRATEGY





STATUS

SLCP Goals

Reduce methane emissions associated with watewater

- Divert organic waste to plants with spare capacity (co-digestion)
- Partner with CalRecycle and the SWRCB to support retrofit/purchase of new facilities for co-digestion
- Other financial incentives

STATUS

Additional programs/rules

- Identification of large "hot spot" methane sources (ARB, JPL, AB 1496, Megacities Carbon Project)
- SLCP SB 1122 – Electricity generation from biogas facilities [$]
- Local Government Renewable Energy Bill Credit Tariff – Up to 5 MW of renewable generation [$]

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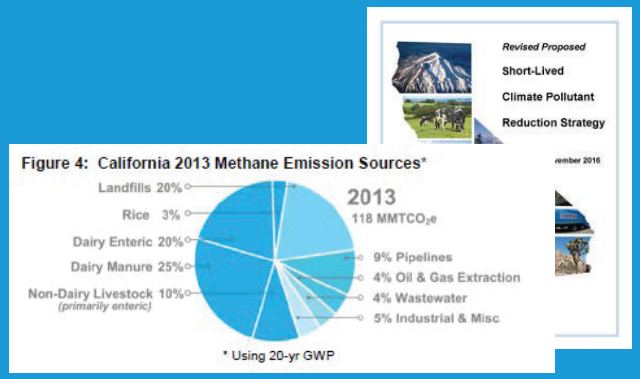
SLCP STRATEGY



STATUS

Additional programs/rules

- Water Energy Grant Program – Funds to implement water efficiency programs or GHG reduction projects [$]
- CalRecyle Waste Diversion Loans – Funding for composting/anaerobic digestion infrastructure for waste diversion [$]
- Clean Water State Revolving Fund – See list from Carollo [$]

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SCAQMD – 2016 AQMP

STATUS

Draft Final – December 2016

Multiple comment letters submitted

Extensive public hearing in February 2017

Adopted March 3, 2017 with amendments

- **Amendments focused on fleet vehicles (MOB-07, MOB-08) which may affect Plan**

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SCAQMD – 2016 AQMP

STATUS

Applicable Control Measures

CMB-01: Transition to Zero & Near Zero Emission Technologies for Stationary Sources

CMB-03: Emission Reductions from Non-Refinery Flares

CMB-05: Further NO_x Reductions from RECLAIM Assessment

BCM-10: Emission Reductions from Greenwaste Composting

AQMP CONTROL MEASURES

CMB-01: Transition to Zero & Near Zero Emission Technologies for Stationary Sources

Biogas sectors must decrease emissions (incentive funding or regulatory enforcement)

Cleaning of biogas

Use fuel cells, battery storage, etc. instead of emergency diesel engines

Timeframe: Ongoing

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SCAQMD – 2016 AQMP

AQMP CONTROL MEASURES

CMB-03: Emission Reductions from Non-Refinery Flares

Wastewater treatment facility flares included as possible source of reductions

Transition to cleaner flare may be required by 2031

Consideration may be made for backup handling of gas

Timeframe: 2018 (Adoption); 2022 (Implementation)

AQMP CONTROL MEASURES

CMB-05: Further NO_x Reductions from RECLAIM Assessment

Sunset of RECLAIM, for replacement by command and control regulatory future

Controversial with many comments

Timeframe: 2018 (Adoption); 2022 (Implementation)

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SCAQMD – 2016 AQMP

AQMP CONTROL MEASURES

BCM-10: Emission Reductions from Greenwaste Composting

Increased diversion of greenwaste to anaerobic digestion

Timeframe: 2022 (Adoption); 2031 (Implementation)

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SCAQMD – 2016 AQMP

AQMP COMMENTS

Southern California Alliance of Publicly Owned Treatment Works (SCAP)

CMB-01: Will incentive funding be provided for implementation? Biogas cleanup is not necessarily cost-effective. Facilities need reliable backup for emergency engines that is not currently provided by fuel cells etc.

CMB-03: Requests 3rd party assess the cost-effectiveness and feasibility of technology for biogas control measures.

AQMP COMMENTS

Orange County Sanitation District (OCSD) and Eastern Municipal Water District (EMWD)

CMB-01: Notes the tri-generation project cited by the SCAQMD is demonstration only and not intended to assess cost-effectiveness.

CMB-03: Requests that the wastewater sector be excluded from this control measure.

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SCAQMD RULES –APPLICABLE TO PREVIOUS PLAN

Rules – No Amendments Since 2008 Plan
201: Permit to Construct (12/3/2004)
203: Permit to Operate (12/3/2004)
402: Nuisance (5/7/1976)
1179: Publically Owned Treatment Works Operations (3/6/1992)
1303: Requirements (12/6/2002)
3001: Applicability (11/5/2010)
3004: Permit Types and Contents (12/12/1997)

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SCAQMD RULES –APPLICABLE TO PREVIOUS PLAN

Rules – Amended Since 2008 Plan
219: Equipment Exempt from Permitting (5/3/2013)
1110.2: Emissions from Gaseous and Liquid Fueled Engines (6/3/2016)
1302: Definitions (11/4/2016)
1401: New Source Review of Air Toxics (10/7/2016)

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SCAQMD RULES – EXISTING AND PROPOSED

Rule	Relevance	Impact to Facility
222: Filing Requirements for Sources Not Requiring Permit under Regulation II	Low	Medium
224: Incentives for Super Compliant Technologies (PAR)	Low	Medium
301: Permitting and Associated Fees	High	Low
403: Fugitive Dust	Medium	Low
464: Wastewater Separators	Minimal	Low
466: Pumps and Compressors	Low	Medium
1118.1: Non-refinery Flares	Medium	High
1146: NO_x from Boilers, Generators, and Heaters	Medium	Medium
1146.1: NO_x from Small Boilers, Generators, and Heaters	Medium	Medium

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SCAQMD RULES – EXISTING AND PROPOSED

Rule	Relevance	Impact to Facility
1146.2: NO_x from Large Water Heaters and Small Boilers and Heaters	Medium	Medium
1147: NO_x Reductions from Miscellaneous Sources	Low	Medium
1177: LPG Transfer and Dispensing	Minimal	Low
1304: BACT Exemptions	Medium	Medium
1402: Control of TACs from Existing Sources	High	High
1415: Refrigerant Emissions from Stationary AC	Low	Minimal
1415.1: Refrigerant Emissions from Stationary Refrigeration	Low	Minimal
1470: Stationary Diesel ICEs Requirements	Low	Low
1472: Stationary Emergency Standby Diesel-fuelled ICEs	Low	Low
2202: On-road Motor Vehicle Mitigation Options	Minimal	Low

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Funding Opportunities

	Opportunity
SLCP	• SB 1122 – Electricity generation from biogas facilities • Local Government Renewable Energy Bill Credit Tariff • Water Energy Grant Program (see GGRF) • CalRecyle Waste Diversion Loans (see GGRF) • Clean Water State Revolving Fund
ARB (GGRF)	• Water Energy Grant Program (see SLCP) • CalRecyle Waste Diversion Loans (see SLCP)

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Summary

Regulation / Programs	Details	Applicability	Certainty	Impact Decision Making	Funding Opportunities
SCAQMD Regulations – 2008 Master Plan	▪ Regulation II, Regulation IV, Regulation XI, Regulation XIII, Regulation IXV, Regulation XXX	√	√	√	
SCAQMD Regulations – Existing and Proposed	▪ Regulation II, Regulation III, Regulation IV, Regulation XI, Regulation XIII, Regulation IV, Regulation XXII	√	√	√	
2016 AQMP	▪ CMB-01: Transition to Zero & Near Zero Emission Technologies for Stationary Sources ▪ CMB-03: Emission Reductions from Non-Refinery Flares ▪ CMB-05: Further NOx Reductions from RECLAIM Assessment ▪ BCM-10: Emission Reductions from Greenwaste Composting	√	√	√	
SLCP Strategy (2016)	▪ Divert organic waste to plants with spare capacity (co-digestion) ▪ Partner with CalRecycle and the SWRCB to support retrofit/purchase of new facilities for co-digestion ▪ Other financial incentives ▪ Additional programs that may affect sector	√	√	√	√
Scoping Plan	▪ Increase water sector efficiency and reduce GHGs ▪ Increase the use of renewable energy to pump, convey, treat, and utilize water	√	?	√	√

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QUESTIONS?

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ADDITIONAL DETAIL

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SCAQMD RULES – EXISTING AND PROPOSED

Ranking	Relative Importance
Relevance to facility	
1	Definitely relevant to facility
2	Likely relevant to facility
3	May be relevant to facility, additional information is needed to confirm
4	Unlikely to impact facility, additional information is needed to confirm
Impact on decision-making	
A	Likely impact on future decisions
B	Possible impact on future decisions
C	No impact on future decisions

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SCAQMD RULES – EXISTING AND PROPOSED

Rule	Ranking
Regulation II – Permits	
222: Filing Requirements for Sources Not Requiring Permit under Regulation II (5/3/2013)	3B
224: Incentives for Super Compliant Technologies (PAR)	3B
Regulation III – Fees	
301: Permitting and Associated Fees (7/1/2016)	1C
Regulation IV – Prohibitions	
403: Fugitive Dust (6/3/2005)	2C
464: Wastewater Separators (12/7/1990)	4C
466: Pumps and Compressors (10/7/1983)	3B

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SCAQMD RULES – EXISTING AND PROPOSED

Rule	Ranking
Regulation XI – Source Specific Standards	
1118.1: Control of Emissions from Non-refinery Flares (11/2017)	2A
1146: Emissions of Oxides of Nitrogen from Boilers, Generators, and Heaters (11/1/2013)	2B
1146.1: Emissions of Oxides of Nitrogen from Small Boilers, Generators, and Heaters (11/1/2013)	2B
1146.2: Emissions of Oxides of Nitrogen from Large Water Heaters and Small Boilers and Heaters (5/5/2006)	2B
1147: NO_x Reductions from Miscellaneous Sources (9/9/2011)	4B
1177: LPG Transfer and Dispensing (6/1/2012)	3C

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SCAQMD RULES – EXISTING AND PROPOSED

Rule	Ranking
Regulation XIII – New Source Review	
1304: BACT Exemptions (6/14/1996)	2B
Regulation XIV – Toxics and Other Non-Criteria Pollutants	
1402: Control of TACs from Existing Sources (10/7/2016)	1B
1415: Reduction of Refrigerant Emissions from Stationary AC Systems (12/3/2010)	3C
1415.1: Reduction of Refrigerant Emissions from Stationary Refrigeration Systems (12/3/2010)	3C
1470: Requirements for Stationary Diesel Internal Combustion and Other Compression Ignition Engines (5/4/2012)	3B
1472: Requirements for Facilities with Stationary Emergency Standby Diesel-fuelled ICEs (3/7/2008)	3B

SCAQMD RULES – EXISTING AND PROPOSED

Rule	Ranking
Regulation XXII – Mobile Source Emissions Mitigation Program	
2202: On-road Motor Vehicle Mitigation Options (6/6/2014)	4C

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Biosolids Regulations

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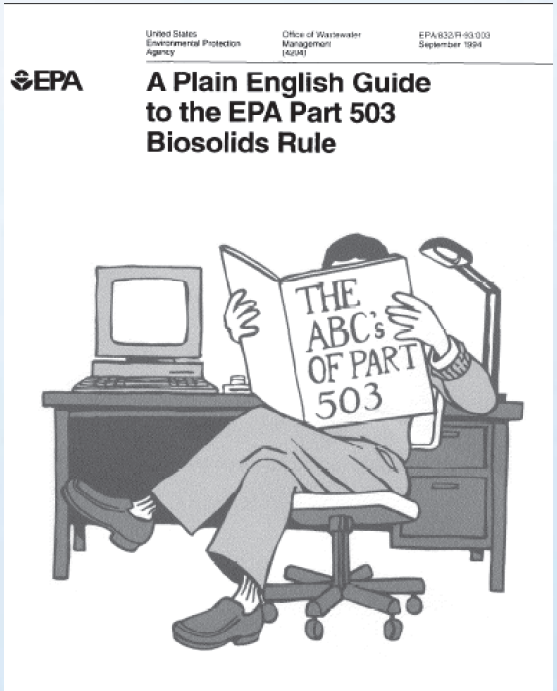
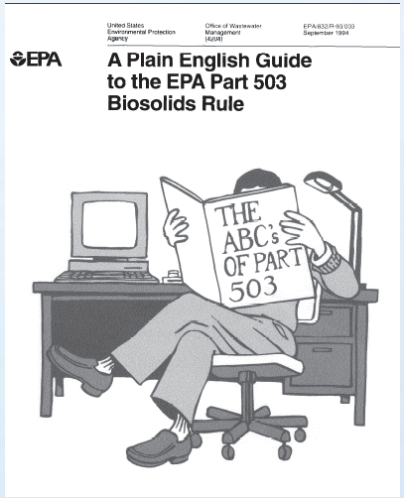

United States Environmental Protection Agency
Office of Wastewater Management (4204)
EPA/832/R-93-003 September 1994

EPA

A Plain English Guide to the EPA Part 503 Biosolids Rule

TRADITIONAL/HISTORIC SOLIDS REGULATIONS

Major Components of Part 503



- Use or disposal of sewage sludge
  - General Provisions
  - Land Application
  - Surface Disposal
  - Pathogens and Vector Attraction Reduction
  - Incineration

For Land Application and Surface Disposal…

- Part 503 Establishes:
  - Pollutant Concentration Limitations (7 metals, arsenic, selenium)
  - Operational Standards for Pathogen and Vector Attraction Reduction
  - Management Practices
  - Monitoring, Reporting, Recordkeeping Requirements
- Different “classes” of biosolids have different requirements

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Applicable State Regulations

- State Regulations
  - California:
    - SWRCB Order No. 2004-0012-DWQ ("**General Order**")
    - NPDES (Regional Boards)
  - Arizona:
    - Department of Environmental Quality – AAC Title 18 Chapter 9 Article 10
    - Pollutant Discharge Elimination System (AZPDES)

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Which regulations govern?

- Basically all of them
  - Majority of regulatory requirements are in Part 503
  - State regulations follow Part 503 with additional requirements
  - Local ordinances and regulations sometimes add further restrictions and requirements

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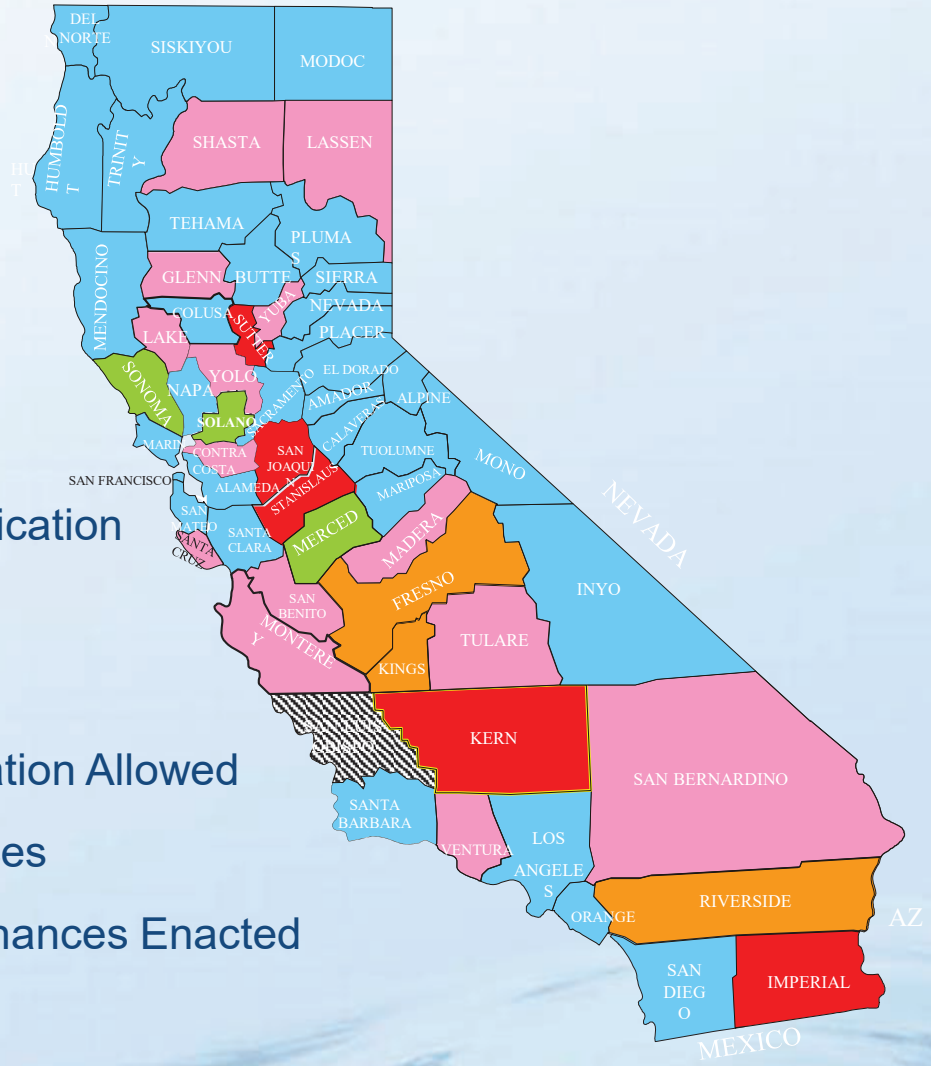
Biosolids Land Application in California - Old

Status of County Ordinances

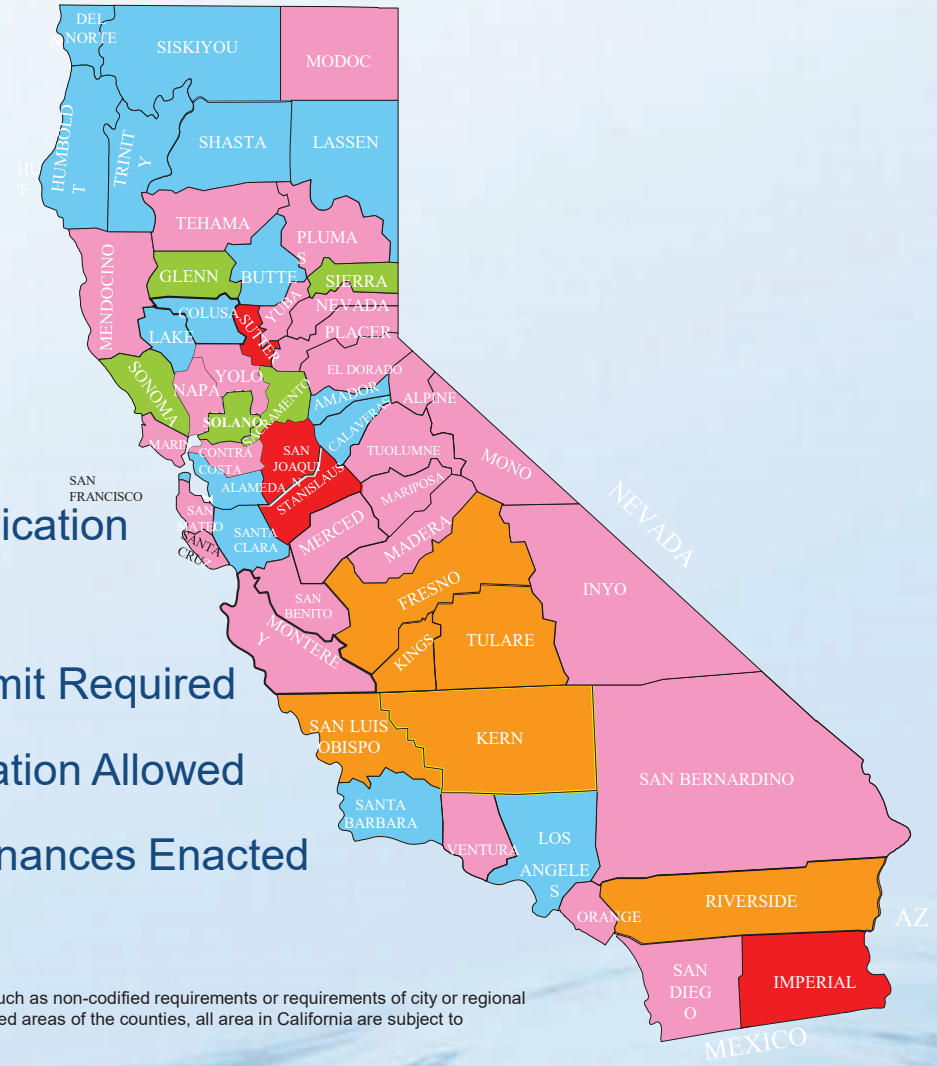
- Ban on All Land Application
- Practical Ban
- Ban on Class B
- Class B Land Application Allowed
- Developing Ordinances
- No Regulations/Ordinances Enacted



Biosolids Land Application in California - 2016

County Ordinance Requirements and Biosolids Bans

- Ban on All Land Application
- Ban on Class B
- Conditional Use Permit Required
- Class B Land Application Allowed
- No Regulations/Ordinances Enacted



This map is based on a search of online available Codes and may have missed County other requirements such as non-codified requirements or requirements of city or regional agencies. This map presents findings for individual county requirements and deals only with the unincorporated areas of the counties, all area in California are subject to California and Federal biosolids regulations.

RECENT AND POTENTIAL FUTURE REGULATORY CHANGES

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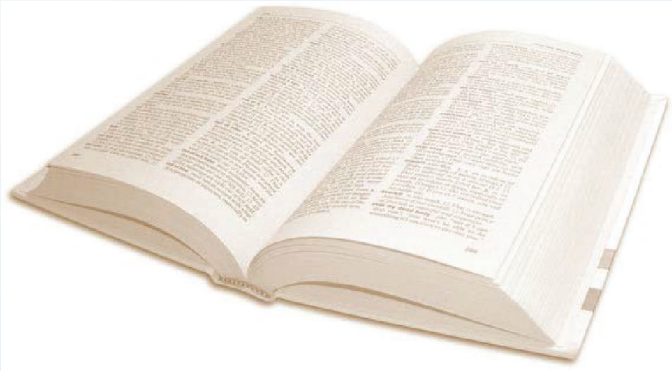
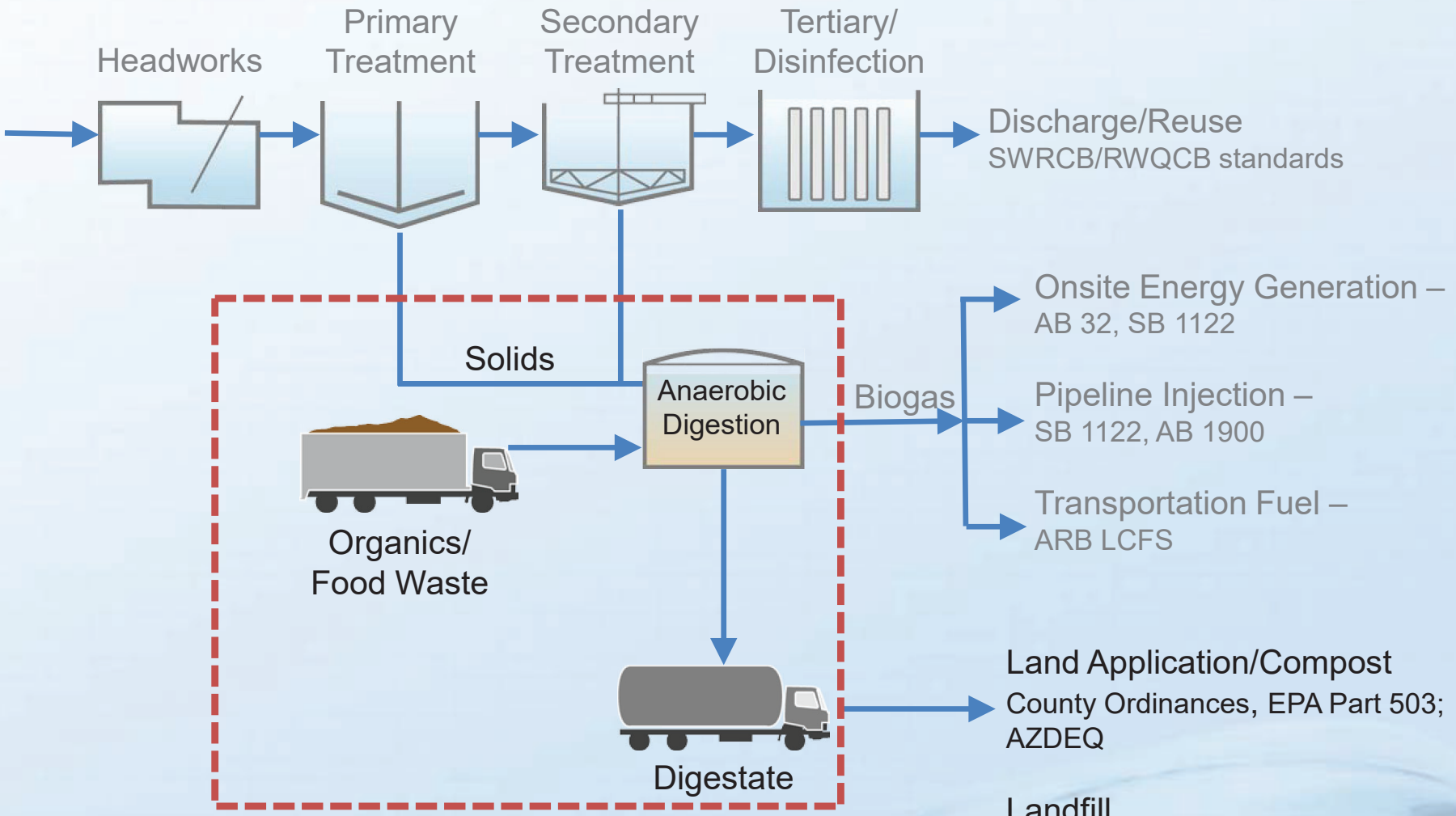
Lexicon



- AB = Assembly Bill
- ADC = Alternative Daily Cover
- ARB = Air Resources Board
- GHG = Greenhouse Gas
- POTW = Publicly Owned Treatment Works
- SB = Senate Bill
- SLCP = Short Lived Climate Pollutants

Multiple regulatory bodies imposing requirements with direct and indirect impacts



Land Application/Compost
County Ordinances, EPA Part 503; AZDEQ

Landfill
AB 341, AB 1826, SB 605, SB 1383, CalRecycle standards

Alternative Daily Cover
AB 1594

Regulations recently promulgated or under consideration

- AB 341 – Mandatory Commercial Recycling
  - Signed in 2012
  - Goal of 75% of all solid waste generated (including organic waste) be source reduced, recycled, or composted by 2020
- AB 1826 – Mandatory Commercial Organics Recycling (MORe)
  - Signed in 2014
  - Phased diversion of organics from commercial and multifamily residential dwellings to recycling

Regulations recently promulgated or under consideration

- AB 1594 – Green Material Used as Alternative Daily Cover (ADC)
  - Signed in 2014
  - As of 2020, green waste no longer qualifies for recycling diversion credit under AB 939
  - Green waste typically mixed with biosolids for use as ADC to achieve required moisture content
  - Without green waste, landfills may not accept biosolids for ADC

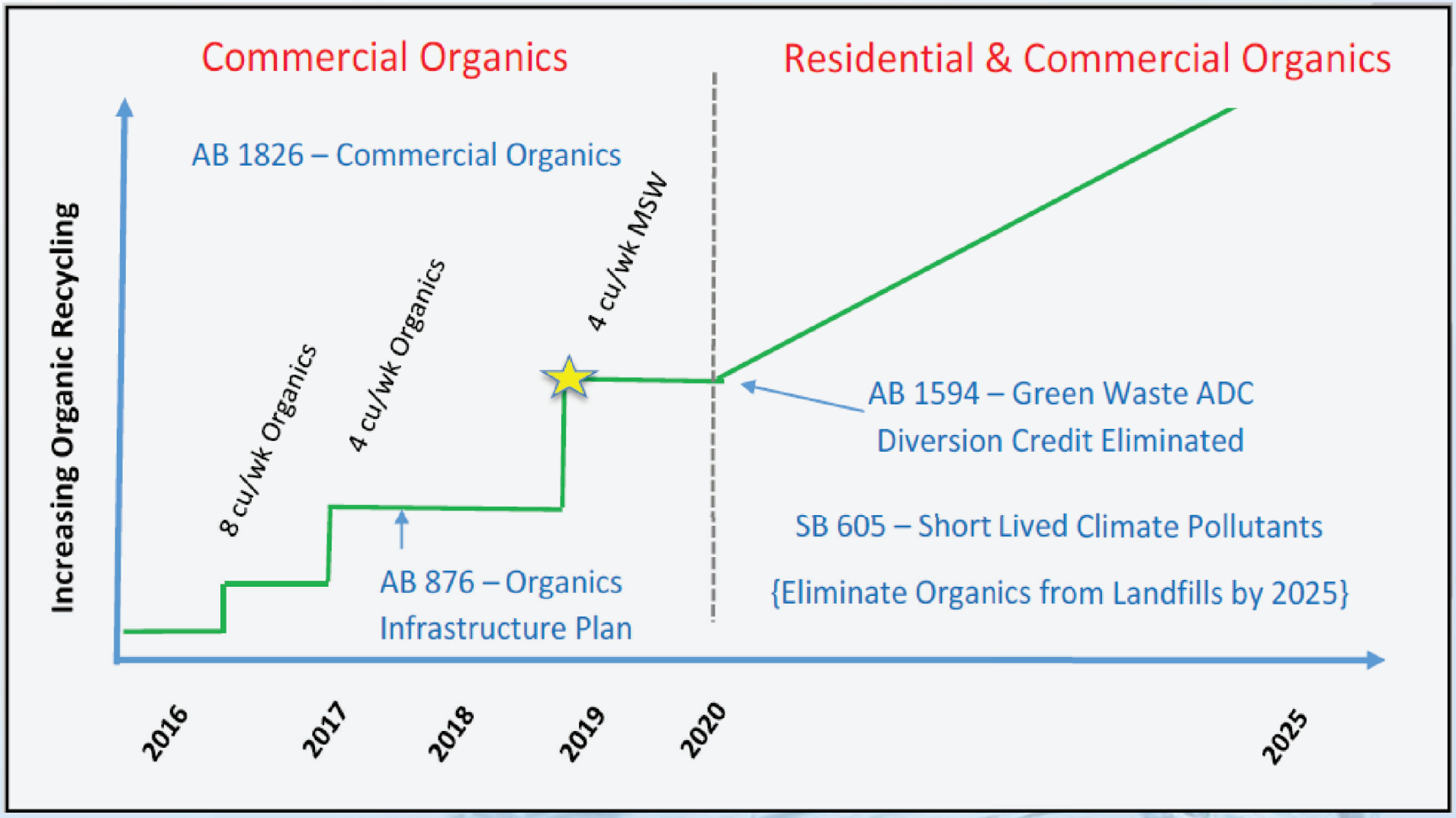
Regulations recently promulgated or under consideration

- SB 605 – Short-lived Climate Pollutant Strategy
  - Signed in 2014
  - Directs ARB to develop SLCP strategy
  - With SB 1383 (signed in 2016), requires ARB to begin plan implementation by Jan. 1, 2018
  - SLCPs:
    - Black carbon
    - Methane
    - Ozone
    - Hydrofluorocarbons
  - Long-lived CP: Carbon dioxide

Regulations recently promulgated or under consideration

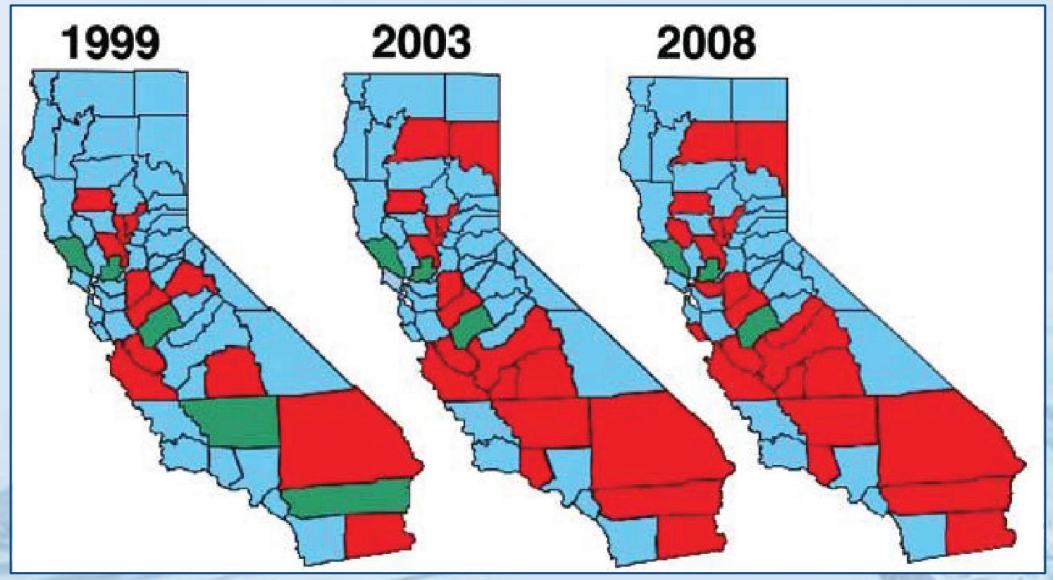
- SB 1383 – SLCP Reduction Strategy Implementation
  - Final rule expected by end of 2018
  - Divert 50% of organics from landfills by 2020 and 75% of organics by 2025 (relative to 2014)
  - Will drive high strength wastes (FOG, food waste, etc.) to municipal treatment plants/digesters
  - “biosolids, digestate, and sludges” currently included as organic waste
  - Questions on 2014 baseline and how to handle/fund additional infrastructure needs and digestate production

Regulations recently promulgated or under consideration



Current solids management practices could be impacted by local and state changes

- Land application of solids becoming increasingly restricted in CA, however:
  - ARB wants to increase carbon sequestration and carbon content of soils in CA
  - Interest in a “healthy soils initiative” that includes replacing carbon and nutrients with biosolids land application



Current solids management practices could be impacted by local and state changes

- Further local ordinances and restrictions on land application possible, but Kern decision may impact
  - General public opposition, especially to Class B
  - Concern about emerging contaminants
  - California
    - Kern County as an example – long-term fight
    - Continuous political pressure to restrict in certain areas
  - Arizona:
    - Changes unlikely from AZDEQ perspective
    - Individual counties along California border have implemented restrictions in past, later struck down

Current solids management practices could be impacted by local and state changes

- Competition for land application in Arizona driven by:
  - Continuous local opposition
  - Failure of regional facilities like EnerTech
  - Difficult air permitting
  - ADC limits for NorCal
- In long-term, may drive costs for land application in Arizona higher
  - Recent costs have been steady or declining, possibly because of fuel prices

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Current solids management practices could be impacted by local and state changes

- Use of biosolids as ADC at landfills in danger
  - Organics diversion
  - Increasing public opposition
  - Concern about VOC emissions from landfills
- Limited landfills/sites permitted or willing to accept biosolids
- Long term – may require shift to Class A for local end-use option
  - Class A material could require marketing to build and maintain acceptance

Summary of recent/potential regulatory changes

- Urgent (0-5 years): Organics diversion/GHG reduction goals and associated impacts
  - Pressure to accept external feedstocks and produce renewable fuels
- Immediate (5-10 years): Rising solids management costs due to changes for ADC/organics diversion/landfills
- Long-term (10+ years): Concerns/limitations on Class B land application may drive push to Class A

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ADDRESSING OR MITIGATING REGULATORY CHANGES

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Organics diversion and potential changes to solids disposal/use options are driving trends in local area

- Studying and/or implementing digestion of high strength wastes (FOG, food waste, etc.)
- Working through CASA/SCAP to
  - Maintain flexibility in regulatory organics diversion language and provide incentives/funding for required changes at plants
  - Track local ordinances and educate elected officials to avoid prohibitions and impractical ordinances

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Organics diversion and potential changes to solids disposal/use options are driving trends in local area

- Agencies seeking to:
  - Reduce disposal costs
  - Minimize risks
  - Improve sustainability
  - Increase diversification of management options
    - Various technologies
    - Multiple hauling contracts
    - <u>Backup plans</u>

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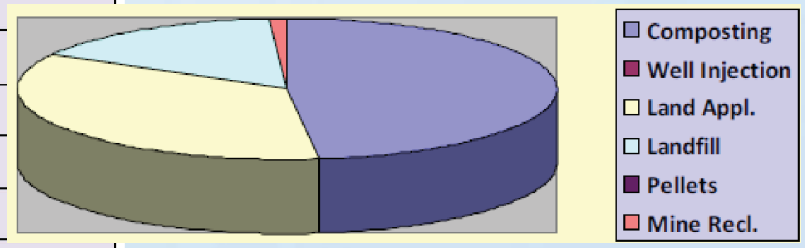
Local challenges identified by local agencies (SCAP, 2016)

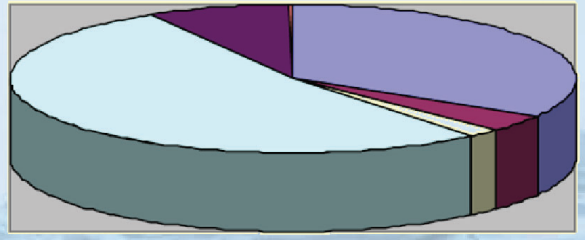
Agencies Main Challenges	Reported in 2010	Reported in 2012	Reported in 2014 *	Reported in 2016
Rising Costs	13	10	17	11
Public Perception/Relations	3	5	12	2
Finding Low Cost Local Mgnt Options	3	4	16	9
Space for Drying Operations	3	1	12	2
Regulatory Restrictions	3	3	14	4
Securing Long Term Disposal Options	3	8	19	8
Wet Weather Drying Operations	3	3	12	2

SoCal solids management has been changing recently (SCAP, 2016)

- Composting/landfilling increased
  - Composting has shifted up and down since 2010
  - Landfilling had been decreasing until 2015/2016
- Land application decreased after significant increases from 2010-2014

Biosolids Management Options (by Volume)	2015/16	2014
Composting	48%	32%
Land Application	35%	51%
Landfill	16%	12%
Mine Reclamation	1%	0%
Biofuel	0%	0%
Pellets/Fertilizer	< 0%	2%
Deep Well Injection	< 0%	3%





Biosolids Management Options (*by volume*)	2014	2012	2010
Land Application	51%	41%	28%
Composting	32%	44%	39%
Landfill	8%	2%	15%
Daily Landfill Cover	4%	9%	7%
Deep Well Injection	3%	3%	2%
Pellets	2%	>1%	0%

Current solids management costs in SoCal (SCAP, 2016)

- Average Costs
  - Composting: $54.59/WT
  - Landfill: $55.66/WT
  - Deep Well Injection: $41.69/WT
  - Land Application: $49.79/WT
  - Mine Reclamation: $48.00/WT

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Solids management in SoCal (SCAP, 2016)

- City of Riverside
  - ~41,000 WT/year
  - Class B
    - Land Application in AZ (12,345 WT; 225 miles; $40/WT)
    - Composting in AZ (16,302 WT; 80 miles; $40/WT)
  - Sub-Class B: Composting in AZ (12,345 WT; 80 miles; $45/WT)
  - Historically accepted FOG, new station constructed in expansion
  - Considering accepting food waste

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Solids management in SoCal (SCAP, 2016)

- IEUA
  - Composting
    - IERCA (116,000 WT)
    - Nursery Products (880 WT)
  - Dedicated food waste digestion operated by others
  - Considering additional FOG/food waste acceptance

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Solids management in SoCal (SCAP, 2016)

- OCSD (447,000 WT/year)
  - Land Application in AZ (~48%)
  - Composting (three locations; ~47%)
  - Landfill (~5%)
  - Considering supercritical water oxidation (SCFI) full scale pilot
  - Likely constructing TPAD, capable of future Class A
  - FOG accepted at head of plant; considering food waste

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Solids management in SoCal (SCAP, 2016)

- LACSD (397,500 WT/year)
  - Land Application in AZ (~11%)
  - Composting in CA (multiple vendors; ~72%)
  - Landfill, Direct Burial (~17%)
  - 10-Year contract with KORE Infrastructure (no longer valid)
  - Purchased single ThermaFlite dryer – operational
  - Food waste digestion pilot operational for several years – up to 60 WT/day

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Solids management in SoCal (SCAP, 2016)

- City of LA (254,000 WT/year)
  - Land Application in AZ (~9%)
  - Land Application in CA (~77%)
  - Composting (~10%)
  - Deep well injection (~4%)
  - Use thermophilic digestion to produce Class A at Hyperion
  - Considering acceptance of food waste slurry through sewers (because they cannot accept trucks)

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OPTIONS FOR RIVERSIDE

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Organics diversion goals could impact what goes in and out of a plant

- Impacts:
  - Interest and pressure to accept organics
  - Increased load on digestion systems and ancillary systems
  - Increased O&M
  - Increased solids production and pressure on disposal/end-use options
  - Increased potential for renewable gas production/beneficial use
  - Generates a lot of questions, including: Where's the $?

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Implementation of large scale co-digestion must consider many issues

- Study first:
  - Capacity of digestion, gas utilization, feedstock receiving systems
  - Capital cost of infrastructure and ongoing O&M costs
  - Contracts/feedstock supply
    - Quantity, schedule, quality, provisions for abnormal conditions
  - Labor needs
  - Site constraints, truck traffic
  - Odors
- Depending on study, decide whether to implement/expand

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Options for Riverside solids management

- Continue land application/compost in Arizona
  - Negotiate long-term contracts
  - Costs may be higher than in the past
- Consider adding contract with Nursery Products composting facility in Hinkley, CA for diversity
- Partner with regional agencies (IEUA/LACSD, IRWD, Encina)
- Consider cutting edge processes (SCFI, Genifuel) to convert biosolids
- Plan for “Class A” biosolids in future
  - High capital costs, economic feasibility dependent on agency disposal costs

CLASS A OPTIONS

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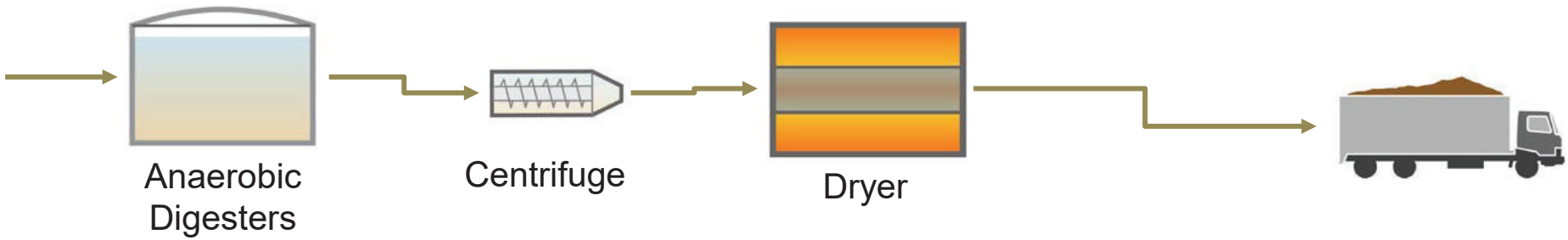
Criteria to Consider for Class A

- Cost effectively achieve Class A
  - Capital costs
  - Hauling costs
  - Power costs
  - Chemical costs
- Produce product that is marketable
- Minimize site impacts
  - New Equipment, Storage, Infrastructure
- Compatibility with codigestion

Class A Processes

- Thermal Drying
- Thermal Hydrolysis (Cambi, Exlysis, Biothelyis)
- Low Temp Thermal Hydrolysis (Lystek)
- Temperature Phased Digestion (TPAD) *(may not be practical for Riverside)*
- Composting *(may not be practical for Riverside)*
- Pasteurization *(may not be practical for Riverside)*
- Class A Screwpress (FKC) *(may not be practical for Riverside)*

Thermal Drying



Key Parameters:

- Low (190 to 285 deg F) or High Temp (500 deg F+)
- 90% solids after dryer
- Need high solids feed to minimize water/evaporation needs and operating costs

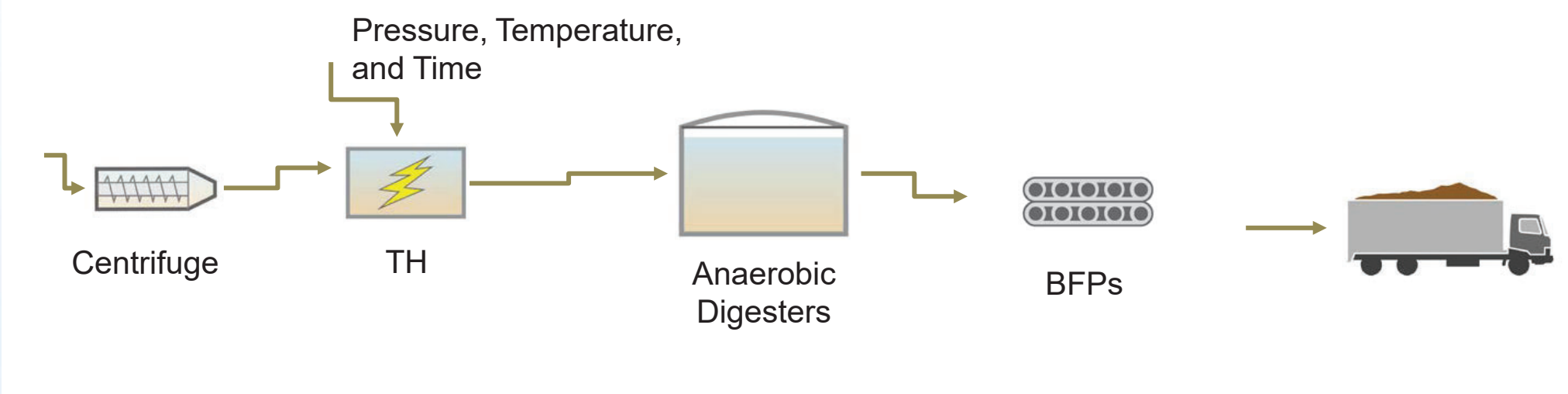
Thermal Drying

Thermal Drying Final Product

Thermal Drying

ADVANTAGES	DISADVANTAGES
• Lowest volume of solids • Marketable product • Relatively simple	• Capital Costs • Complexity • Emissions/Permitting • Energy Usage • Site requirements • Odors • Marketing required

Thermal Hydrolysis (TH)



Key Parameters:

- Increase digester feed solids to 8-12%
- VSR of approx. 60%
- BFP solids up to 30%
- Energy neutral?

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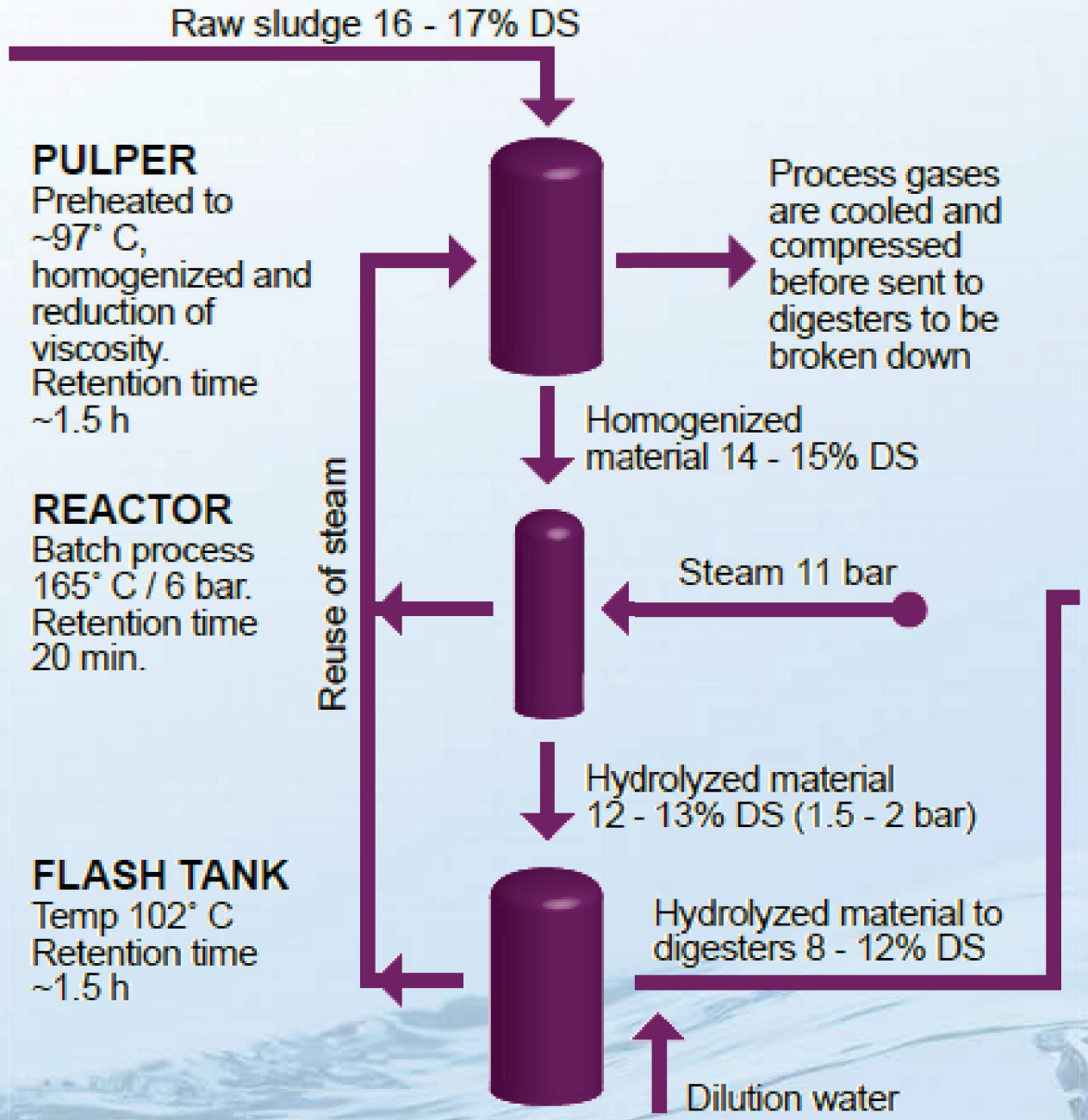
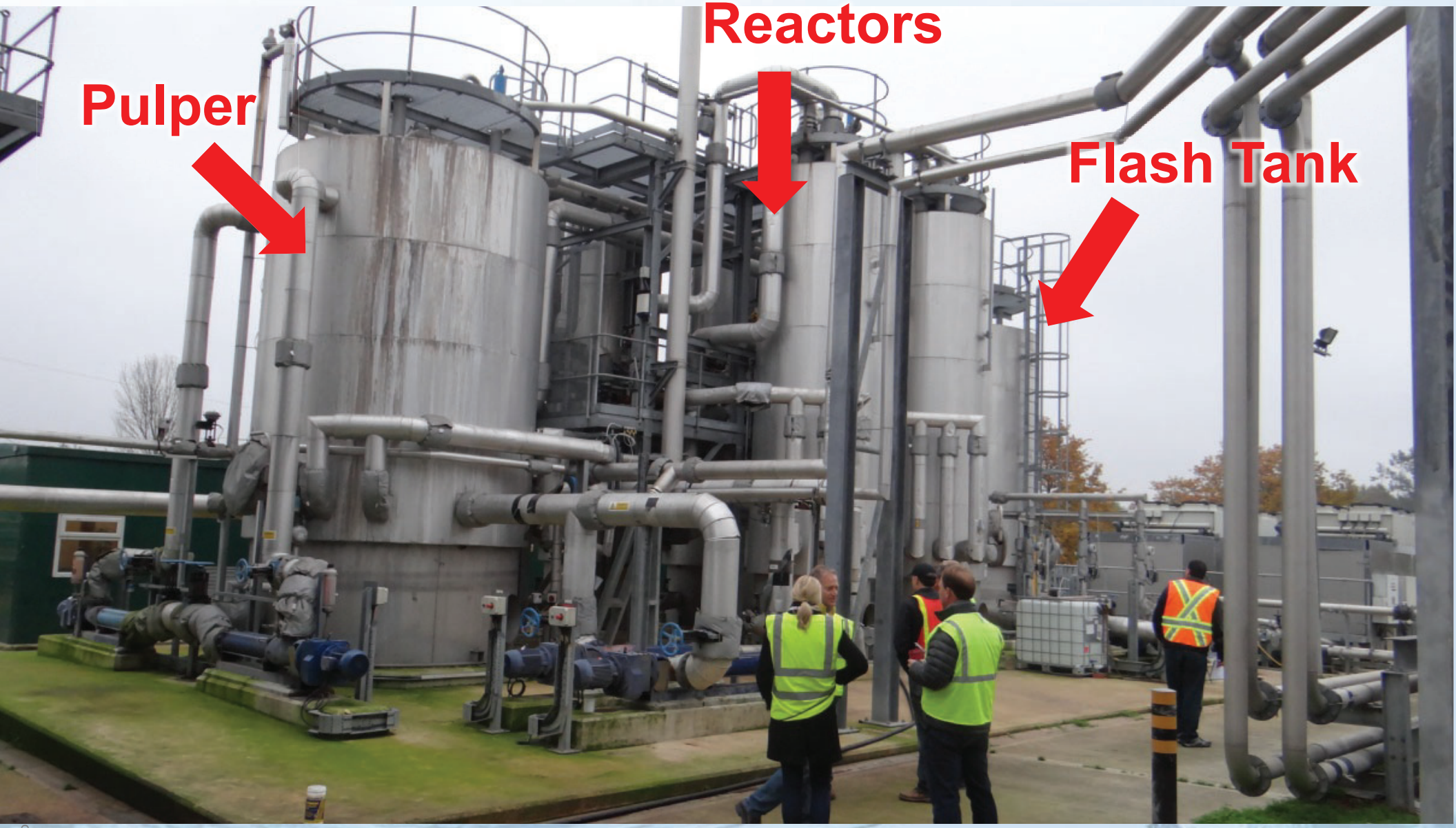
Cambi Thermal Hydrolysis (TH)



Cambi TH: 126,000 lb/d TH Plant



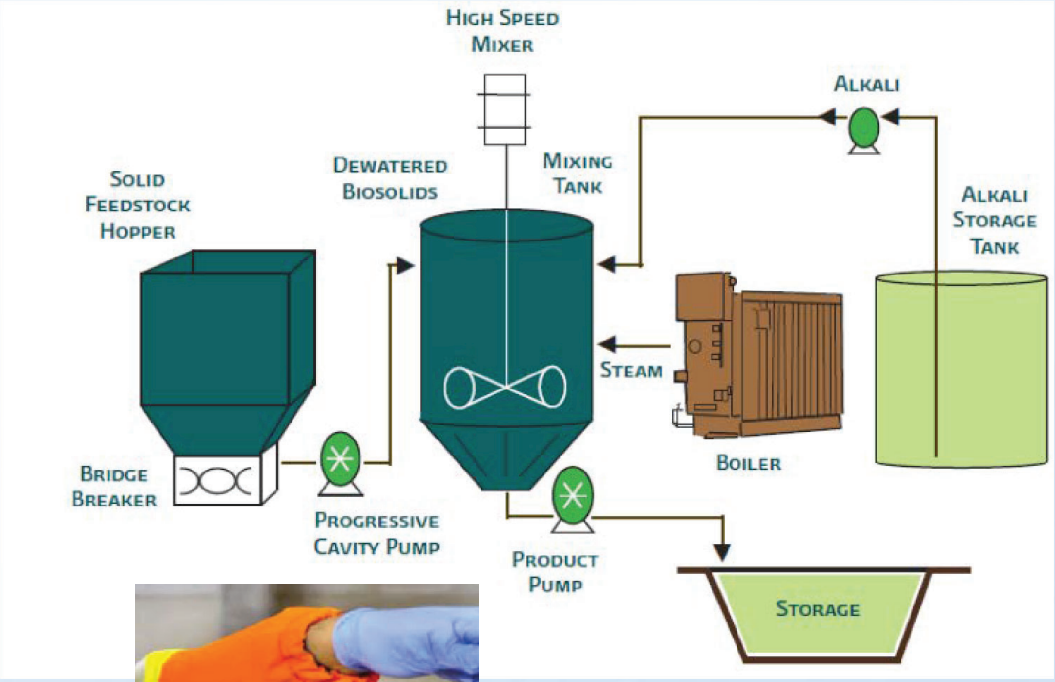
Conventional Digestion with TH

ADVANTAGES	DISADVANTAGES	
• Solids Reduction	• Capital Cost	• Energy Usage
• Dewaterability	• Sidestream	• Thickening
• Digestion tank volume	• U.S. Installations	• Complexity
• No pathogen regrowth	• Odor control	• Cooling steps
• Biosolids Volume	• Tea-colored recycle stream	
• Biogas Production	• Steam and pressure	

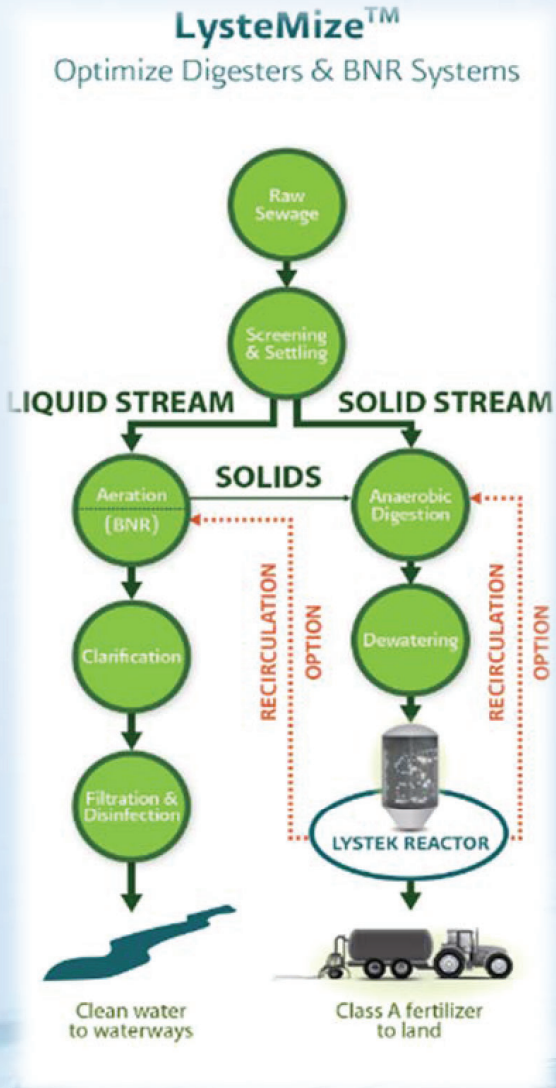
Low Temperature Thermal Hydrolysis (Lystek)

Key Parameters:

- 12-16% feed solids preferred
- 158-175°F for 30 min with low pressure/low temp steam
- pH 9.5 – 10 through addition of alkali
- Odor control
- Final product: Liquid fertilizer with TS 14-19%



Low Temperature Thermal Hydrolysis (Lystek)



Low Temperature Thermal Hydrolysis (Lystek)

- Installations
  - Fairfield, CA in operation now (since 3rd Qtr 2016)
  - 6 installations in Canada
- Partner with agencies to create regional solutions
- Accept material, convert it, deliver to market
- Lystek finds and maintains market/customers for product

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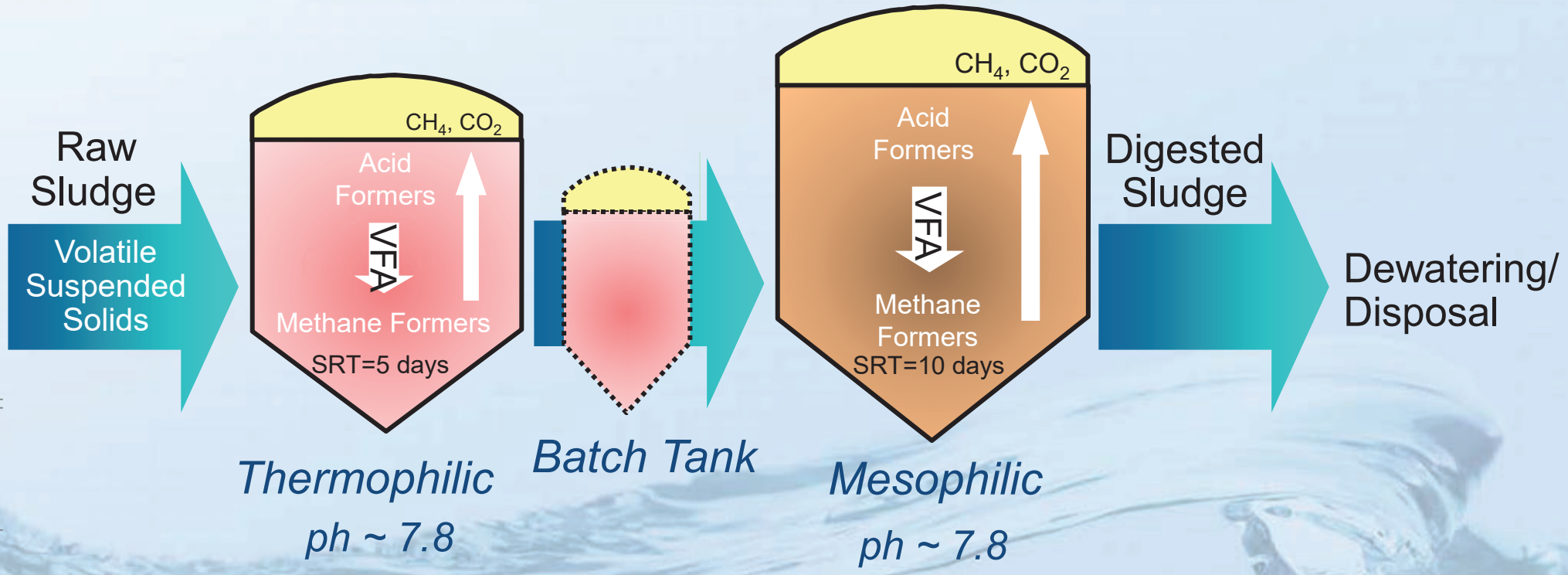
Low Temperature Thermal Hydrolysis (Lystek)

ADVANTAGES	DISADVANTAGES
• Relatively low energy, pressure, temperature • End product classified as a fertilizer, not biosolids • Lystek typically handles final market	• Limited installations • New technology • Risk for company – longevity, financial, etc.

Temperature Phased Anaerobic Digestion TPAD (Potentially Class A)

- Thermophilic phase increases hydrolysis/digestion rates
- Mesophilic phase reduces VFAs/odors
- Batch tank required for Class A



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Temperature Phased Anaerobic Digestion TPAD (Potentially Class A)

- Sturgeon Bay, Janesville, Waupun (WI)
- Western Lake Superior Sanitary District, Duluth (MN)
- Waterloo (IA)
- Under design/construction: San Jose (CA)
- Planned: OCSD (CA)

Shorter SRTs to achieve same or more VSR than conventional, fewer odors than thermophilic only

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Advanced digestion processes operate with higher loading rates/shorter SRTs

Configuration	SRT per Tank (days)	Combined SRT (days)	Temperature	VS Loading Rate (lb/cfd)	Biosolids Quality
Conventional	20	20	M	0.08 to 0.15	Class B
Thermophilic	15+	15+	T	0.3	Class A
Staged Thermophilic	17/2	19	T	0.3	Class A
TPAD	5/10	15	T/M	0.3	Class A

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Thermophilic digestion processes can produce Class A quality if Part 503 requirements are met

Configuration	SRT per Tank (days)	Combined SRT (days)	Temperature	VS Loading Rate (lb/cfd)	Biosolids Quality
Conventional	20	20	M	0.15	Class B
Thermophilic	15+	15+	T	0.3	Class A
Staged Thermophilic	17/2	19	T	0.3	Class A
TPAD	5/10	15	T/M	0.3	Class A

Temperature Phased Anaerobic Digestion TPAD (Potentially Class A)

ADVANTAGES	DISADVANTAGES
• High VS loading rate • Higher VSR at short SRTs • Better hydrolysis of biological sludge • Reduced solids to dewatering • Lower odors than thermophilic • Class A with batch tank	• Requires larger heat exchangers/heating system (more energy) • First phase highly susceptible to temperature changes • Poor dewaterability? • High ammonia in thermo phase sludge • Struvite/vivianite formation • Moisture content in biogas • Parallel feed requires complex controls/valves • Higher O&M

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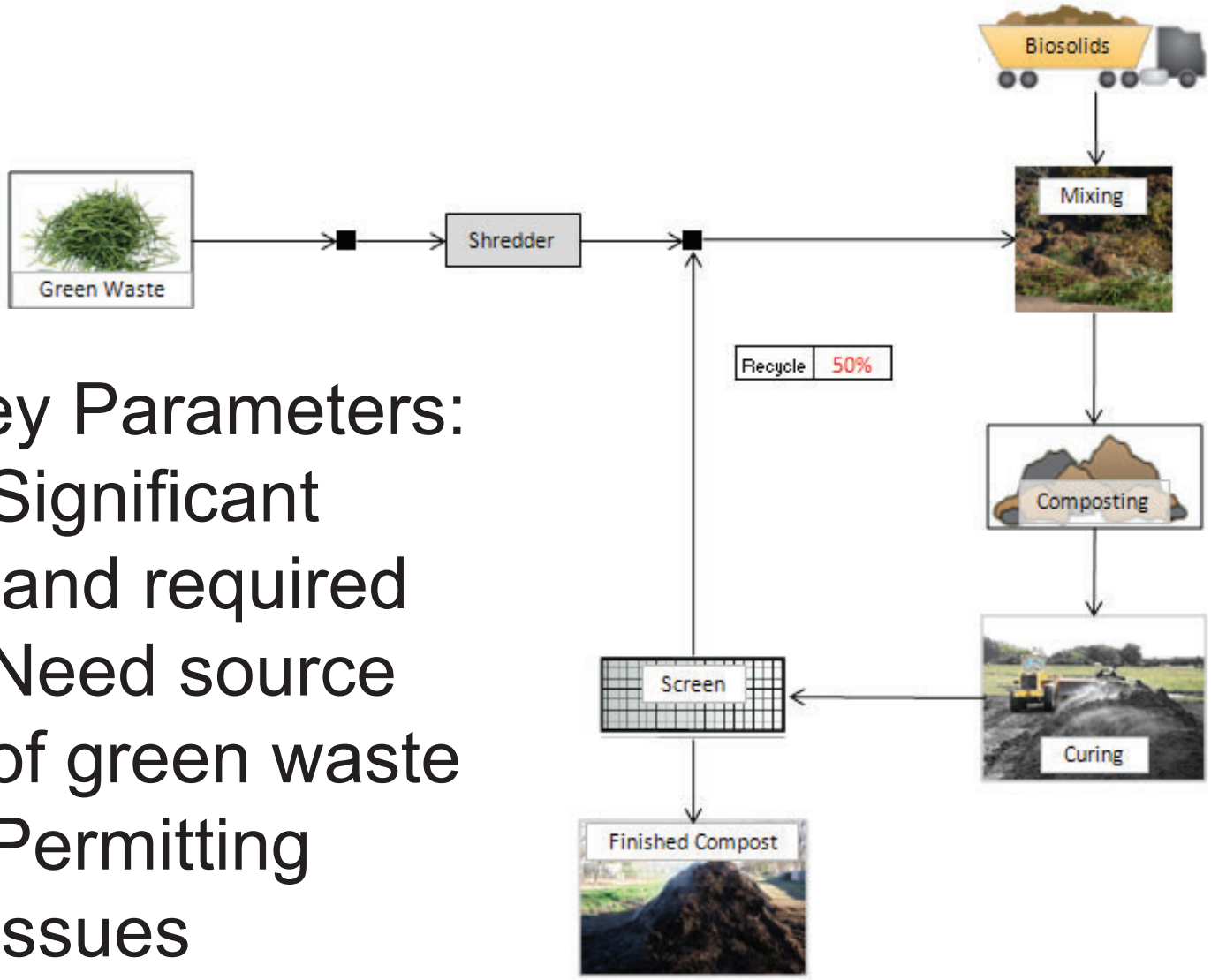
Composting



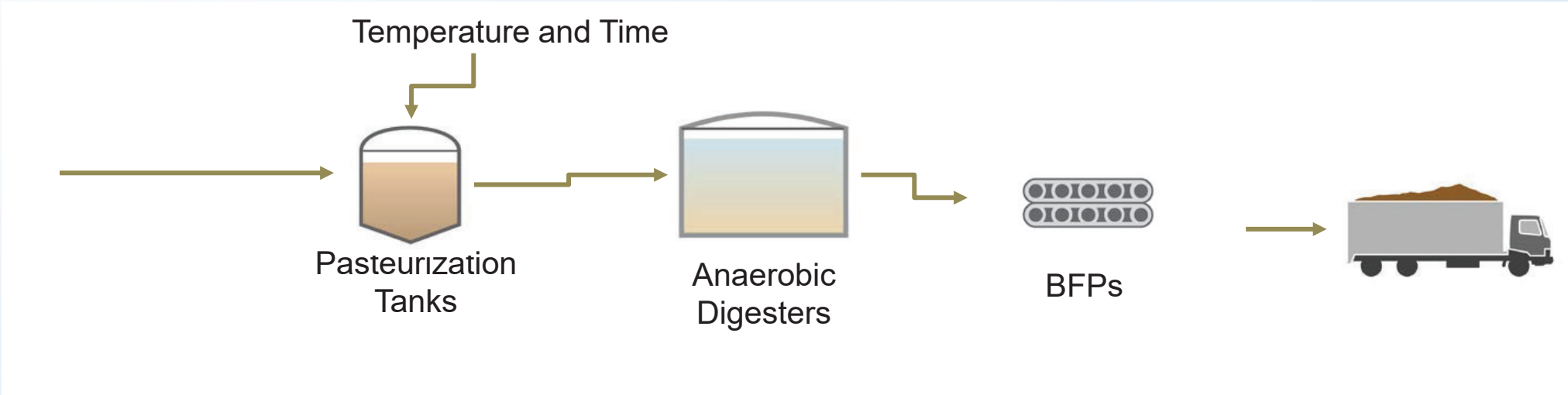
Key Parameters:

- Significant land required
- Need source of green waste
- Permitting issues

Composting

ADVANTAGES	DISADVANTAGES
• Low Energy • Marketable product • Relatively simple	• Site Requirements • Permitting/Emissions • Odor concerns • Public opposition (NIMBY)

Pasteurization



Key Parameters:

- 160°F for 30 min
- No other process benefits (i.e. VSR, VSL, Dewaterability)
- Potential pathogen regrowth concerns

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U.S. Installations of Pasteurization

- Veolia:
  - Alexandria, VA
  - Carmel, IN
- Ashbrook
  - Tulsa, OK (shutdown)
- GE Water
  - Rexburg, ID (under construction)

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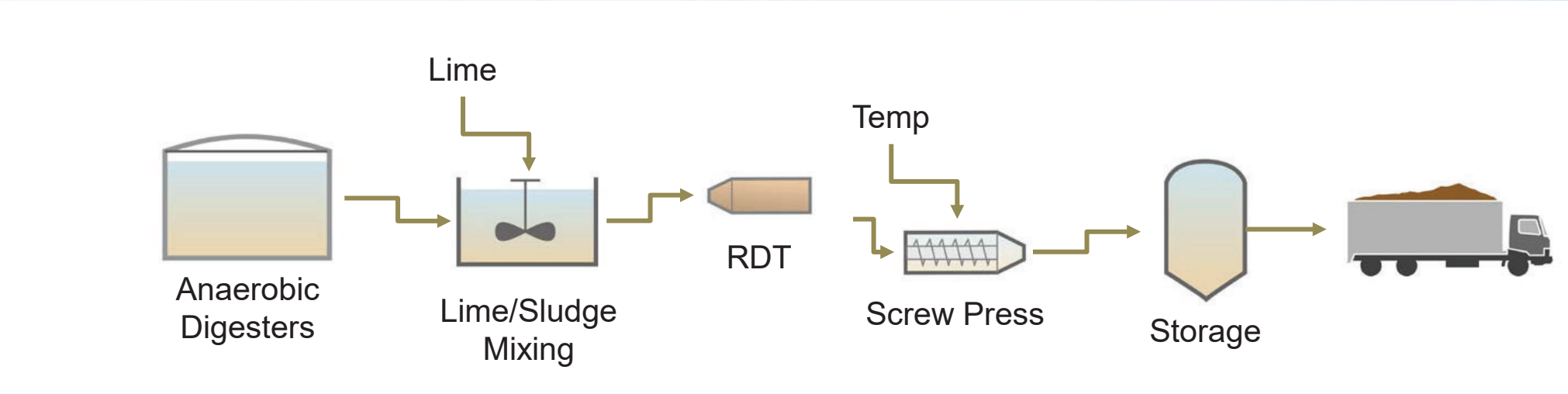
Conventional Digestion with Pasteurization

ADVANTAGES	DISADVANTAGES
• Simpler than TH • Lower equipment costs than TH	• Potential pathogen regrowth • Odors • Energy Usage • No other process benefits

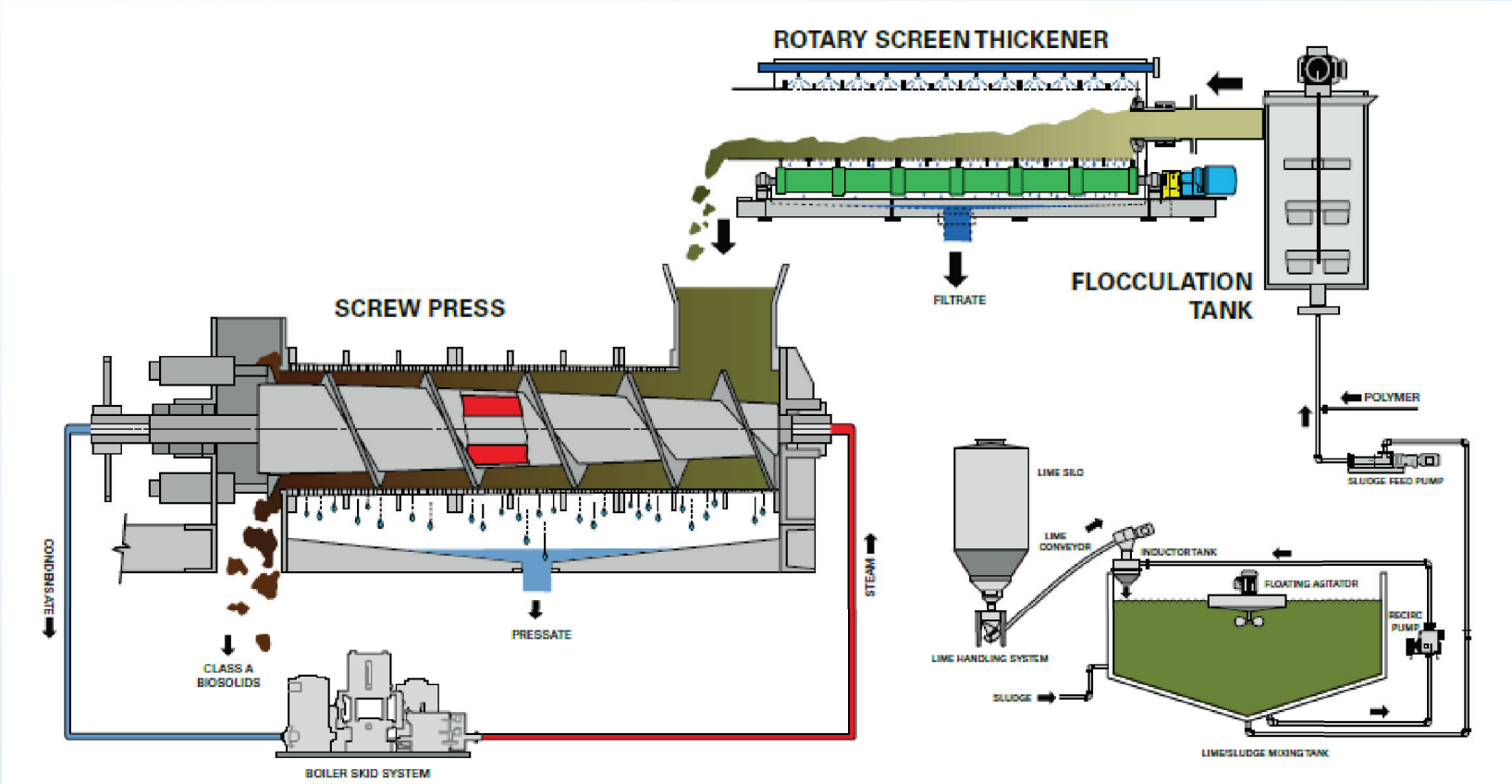
Class A Compatible Screwpress



Key Parameters:

- Approximately 600 lbs lime/DT solids
- 160°F for 20 min
- 30% solids from the screw press
- 24 hours of storage of final product at pH 11.5

Class A Compatible Screw Press (FKC)



ADVANTAGES	DISADVANTAGES
• Relatively low energy use	• Cake storage • Biosolids volume • Steam • Single supplier • Limited installations

ADDITIONAL INFO: CLASS A REQUIREMENTS

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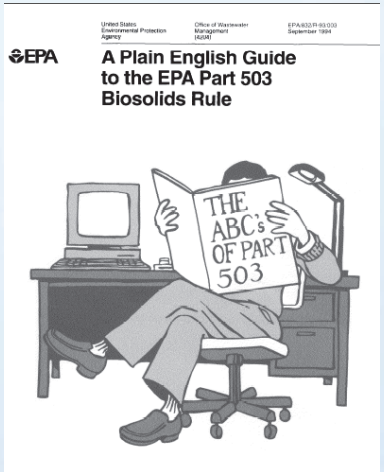
“Class A”



- Exceptional Quality (EQ) Biosolids
  - Low Pollutant Concentrations
  - Class A Pathogen Reduction
  - 1 of 8 Vector Attraction Reduction Options
- Biosolids meeting EQ standards can be applied in bulk or can be sold/given away in bags
  - Fewest limitations
- Informally, “Class A” if above criteria are met

Class A Biosolids

- Class A can be achieved through:
  - One of six pathogen reduction alternatives
  - Pathogen density levels at time of use or preparation for sale/give-away:
    - Fecal coliform < 1,000 MPN/g TS

      OR
    - Salmonella < 3 MPN/4 g TS
- One of eight vector attraction reduction alternatives
- Pathogen reduction prior to or at same time as most vector attraction reduction options

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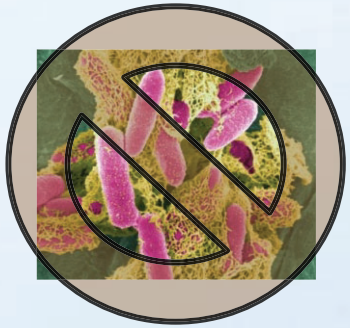
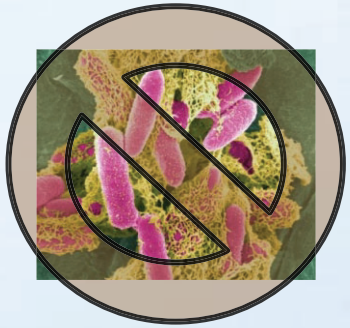
Class A Biosolids – Pathogen Reduction Alternatives



1. Thermally Treated Biosolids (Time/Temp)
   - Four time/temperature regimes based on percent solids and time that biosolids are heated
2. High pH/High Temp/Air Dry
3. Other Known Process and Measurement of Helminth Ova, Enteric Viruses
4. Unknown Process and Pathogen Testing at Time of Use/Disposal
5. Process to <u>Further</u> Reduce Pathogens (PFRP)
6. Process Equivalent to PFRP

Class A Biosolids - Processes to Further Reduce Pathogens (PFRP)



- Composting
- Heat Drying
- Heat Treatment
- Thermophilic Aerobic Digestion
- Beta Ray Irradiation
- Gamma Ray Irradiation
- Pasteurization

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Class A Biosolids – Vector Attraction Reduction Options

1. Minimum 38% reduction in volatile solids content
2. Addt'l digestion of anaerobically digested
3. Addt'l digestion of aerobically digested
4. Specific O2 uptake rate for aerobically digested
5. Aerobic processes at greater than 40°C
6. Addition of alkaline material
7. Moisture reduction of stabilized biosolids
8. Moisture reduction of unstabilized biosolids

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City of Riverside Public Works Department

UPDATE OF THE INTEGRATED

MASTER PLAN FOR THE WASTEWATER COLLECTION AND TREATMENT FACILITIES

VOL. 2

CHAPTER 3

Basis of Planning

Population, Loading, and Flow Projections

carollo

Engineers...Working Wonders With Water®

City of Riverside Public Works Department

Update of the Integrated Master Plan for the Wastewater Collection and Treatment Facilities

VOLUME 2: BASIS OF PLANNING

CHAPTER 3: POPULATION, LOADING, AND FLOW PROJECTIONS

FINAL | June 2019

City of Riverside Public Works Department
Update of the Integrated Master Plan for the Wastewater Collection and Treatment Facilities

VOLUME 2: BASIS OF PLANNING

CHAPTER 3: POPULATION, LOADING, AND FLOW PROJECTIONS

Carollo Project No. 10495A00

Digitally signed by Graham J.G. Juby
Contact Info: Carollo Engineers, Inc.
Date: 2019.08.24 16:00:14-07'00'

REGISTERED PROFESSIONAL ENGINEER
GRAHAM J. G. JUBY
No. 67217
CIVIL
STATE OF CALIFORNIA

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Chapter 3

POPULATION, LOADING, AND FLOW PROJECTIONS

3.1 Purpose

The purpose of this chapter is to present population projections developed by others and to use these projections to develop projected influent wastewater flow quantities and characteristics through the year 2037 for the RWQCP. The flow quantities and characteristics projections will be used as a basis for the design criteria in this update of the Master Plan.

3.2 Background

The City service area consists of five sewer basins: Arlanza, Northside, Phoenix, Spruce, and Tequesquite. The collection system conveys wastewater flows through these basins to the RWQCP through four major trunk sewers: Acorn/Arlanza, Santa Ana Trunk Sewerline (Riverside/Hillside), Jurupa, and Rubidoux. The Jurupa and Rubidoux trunk sewers convey flows from the Jurupa and Rubidoux CSDs to the RWQCP headworks. However, the Edgemont CSD and the Highgrove Community, which have individual agreements with the City, route wastewater flows through the City's collection system to the RWQCP, through the Santa Ana Trunk Sewerline (Riverside/Hillside). All of the CSDs are contractually entitled to their respective wastewater treatment and conveyance (where applicable) capacities under their prescribed fees and agreements. Furthermore, the City has an agreement with WMWD to allow diversion of 0.5 mgd of wastewater to the March Air Reserve Base Wastewater Treatment Plant. The City maintains a business relationship with the CSDs and WMWD through documented agreements and contracts that are updated periodically. The City and the CSDs also meet annually to review historical and projected plant flows and loads, O&M costs, and capital expenditures.

A major effort in the planning and development of facility expansions is the estimation of flow and loading projections, which is based on population projections. However, historical and projected population data are not available for the CSDs. In addition, the Highgrove community is an unincorporated area in Riverside County with predominately septic tank sewage handling. Beginning in 2014, the County has required residents to convert to the sanitary sewer system. This community represents a small subset of the population and portions of the community may already be included in the City's service area map. Furthermore, influent flow or loading data from the Highgrove community is not available. Based on 2013/14 projections, the total flow in 2017 is likely to be 0.2 mgd or less.

3.2.1 Master Plan Basis

Traditionally, flow projections would serve as the basis for the evaluation of the hydraulic capacity at each facility. However, conservation efforts in Southern California have resulted in increased wastewater concentrations while flow remained about the same or in some cases decreased in spite of a steady population increase. Increased concentrations adversely affect the treatment capacity of some processes such as secondary treatment and solids handling. As a result, flow projections alone are no longer adequate in determining needed expansions. For this update of the Master Plan, loading projections for COD, TSS, and NH_3-N were also considered.

3.2.2 Assumptions

For the purposes of this update to the Master Plan, the following assumptions were made to account for unknown information:

1. The historical and projected population of the Highgrove community was assumed to be included in the City's historic and projected population.
2. Edgemont and Highgrove were assumed to have similar wastewater quality characteristics as the City. After reviewing sampling data from January to September, 2017, Edgemont's influent concentrations were not significantly different from the City's wastewater quality characteristics. The City's COD and TSS concentrations were higher on average than the recorded samples meaning that the above assumption would result in a more conservative estimate.
3. Population, flow, and loading trends and projections were evaluated exclusively for the City, including the Highgrove community. The CSDs' (Jurupa, Rubidoux, and Edgemont) contribution to projected flow and loading was evaluated and added separately.
4. Where COD data is lacking while BOD data is available, COD was calculated based on historical COD to BOD ratios. COD is a useful parameter, particularly in process modeling; supplementing missing COD data through the use of a COD/BOD ratio is the only application of this ratio in this update to the Master Plan.
5. Flow and loading projections were based on the 5-year-average of the historical per-capita characteristics multiplied by the projected population data.

3.3 Population

This section summarizes the City's historic and projected collection system service area population. Some portions of the existing City limits are not currently sewered. Additionally, the City provides sewer services to the Jurupa CSD, the Rubidoux CSD, the Edgemont CSD, and the Highgrove area. The population projections in this section include sewered areas within the City limits only, including the Highgrove area. Population projections for the Jurupa, Rubidoux, and Edgemont CSDs were not developed, as flow estimates for these areas were documented in separate planning documents for each agency and are considered separately.

3.3.1 Historic Population

Historic population estimates for the City service area (and the Highgrove area) were developed based on 2010 census block data for the year 2010, as well as the ACS census block data estimates for the years 2011 through 2016. The population estimates summarized by basin in Table 3.1 were developed using GIS data, clipped to the current sewer service area boundaries. As shown in Table 3.1, the estimated total City population for the year 2016 was approximately 310,190.

Table 3.1 Historic Population by Sewer Basin

Basin	Service Area Population						
	2010	2011	2012	2013	2014	2015	2016
Arlanza	129,315	131,365	133,414	135,464	135,596	135,817	137,101
Northside	13,648	13,997	14,346	14,695	15,155	14,886	15,027
Phoenix	53,622	53,896	54,169	54,443	55,595	56,344	56,877
Spruce	31,284	30,168	29,052	27,936	28,023	29,224	29,500
Tequesquite	69,741	69,067	68,394	67,721	69,467	71,013	71,685
Total	**297,610**	**298,493**	**299,376**	**300,259**	**303,837**	**307,284**	**310,190**

Notes:
(1) Source: 2010 US Census Block Data (GIS Shape File).
(2) Source: American Community Survey (ACS) census block data estimates (GIS Shape File).
(3) Estimates include the City service area and the Highgrove area, but do not include the Jurupa, Rubidoux, or Edgemont CSDs.

3.3.2 Projected Population

Population projections were developed through the year 2037 (the planning horizon for this update to the Master Plan). These projections were developed based on GIS data provided by the SCAG for the 2016-2040 RTP / SSC Report, clipped to the City's service area boundary and limited by build-out projections discussed in Section 3.5.6 below. Table 3.2 summarizes the population projections by basin. Although the SCAG projections for the City's service area population (excluding Jurupa, Rubidoux, and Edgemont CSDs) predict a population increase to approximately 390,200 people by the year 2037, land use classifications and wastewater flow projections (discussed in Section 3.5.6) indicate build-out will occur in 2032 and will limit population growth to approximately 379,300 people in the year 2032 and beyond. This represents a 22-percent increase above the 2016 service area population.

Table 3.2 Projected Population by Sewer Basin

Basin	Service Area Population				
	2020	2025	2030	2032	2037
Arlanza	147,300	154,200	161,100	163,900	163,900
Northside	18,800	19,700	206,00	20,900	20,900
Phoenix	63,000	66,000	68,900	70,100	70,100
Spruce	34,600	36,100	37,700	38,400	38,400
Tequesquite	77,300	80,900	84,600	86,000	86,000
Total	**340,900**	**356,900**	**372,900**	**379,300**	**379,300**

Notes:
(1) Source: Southern California Association of Governments (SCAG) for the 2016-2040 Regional Transportation Plan (RTP)/Sustainable Communities Strategy (SSC) Report (GIS Shape File).
(2) Estimates include the City service area and the Highgrove area, but do not include the Jurupa, Rubidoux, or Edgemont CSDs.

3.4 Service Area Land Use

The City provides wastewater collection service to residents, businesses, and other institutions within its City limits. Table 3.3 provides the acreage totals by land use classification within the City limits. The City currently provides sewer service to approximately 29,949 developed acres.

Table 3.3 Existing Service Area Land Use

Land Use Type	Existing Acreage					
	Arlanza	Phoenix	Northside	Spruce	Tequesquite	Total
Agricultural/Rural Residential	364	125	0	0	0	489
Hillside Residential	233	729	82	28	531	1,603
Semi Rural Residential	1,053	0	1	0	59	1,113
Very Low Density Residential	43	720	12	0	225	1,000
Low Density Residential	125	457	0	0	1,556	2,137
Medium Density Residential	4,382	2,388	466	676	1972	9,886
Medium High Density Residential	205	59	38	25	202	528
High Density Residential	271	77	0	200	250	797
Very High Density Residential	52	26	0	0	10	88
Commercial	432	254	8	41	500	1,234
Commercial Regional Center	101	101	0	0	23	225
Office	56	122	5	27	13	223
Business/Office Park	872	181	930	240	941	3,164
Industrial	17	61	220	122	56	476
Downtown Specific Plan	0	0	16	41	346	403
Mixed Use - Neighborhood	0	45	0	0	18	63
Mixed Use - Urban	114	9	0	105	0	229
Mixed Use - Village	312	48	0	7	10	378
Public Park	128	315	268	16	690	1,417
Private Recreation	53	87	133	0	295	568
Open Space/Natural Resources	41	145	126	0	100	411
Public Facilities/Institutions	1,025	531	34	726	1,048	3,364
CBU Specific Plan	142	0	0	0	0	142
Unknown	0	1	3	3	3	10
Total	**10,019**	**6,482**	**2,342**	**2,258**	**8,848**	**29,949**

Notes:
(1) Estimates include the City service area and the Highgrove area, but do not include the Jurupa, Rubidoux, or Edgemont CSDs.

The largest land use category is residential (rural density, low density, medium density, medium-high density, and high density), which accounts for approximately 59 percent of the total current City limit acreage.

Table 3.4 summarizes the amount of additional land within the current service area that could develop within the service area. In total, an additional 18,178 acres of land would be added to the collection system service area. Figure 3.1 shows the service area land use.

Table 3.4 Additional Developable Land within the City Service Area

Land Use Type	Vacant Land and Unconnected Parcel Acreage
Agricultural/Rural Residential	4,669
Hillside Residential	4,078
Semi Rural Residential	152
Very Low Density Residential	2,145
Low Density Residential	136
Medium Density Residential	1,134
Medium High Density Residential	153
High Density Residential	52
Very High Density Residential	2
Commercial	188
Commercial Regional Center	3
Office	71
Business/Office Park	850
Industrial	184
Downtown Specific Plan	31
Mixed Use - Neighborhood	7
Mixed Use - Urban	5
Mixed Use - Village	39
Agricultural	746
Public Park	1,964
Private Recreation	245
Open Space/Natural Resources	781
Public Facilities/Institutions	481
Total	**18,178**

Notes:
(1) Estimates include the City service area and the Highgrove area, but do not include the Jurupa, Rubidoux, or Edgemont CSDs.

3.5 Wastewater Flows

This section summarizes the existing and projected wastewater flows for the City wastewater collection system. Historical wastewater flows, as well as flow data obtained as part of a temporary flow monitoring program are also presented. Finally, future wastewater flow projections are presented.

3.5.1 Wastewater Flow Components

This section describes and provides definitions of commonly used terminology in the wastewater collection system analysis and evaluations conducted as part of this project. Wastewater flows vary according to the season. DWF or base flow is flow generated by routine water usage in the residential, commercial, and industrial sectors of the collection system.

The other component of DWF is the contribution of dry weather GWI into the collection system. Dry weather GWI will enter the sewer system when the relative depth of the groundwater table is higher than the depth of the pipeline and when the susceptibility of the sanitary sewer pipe allows infiltration through defects such as cracks, misaligned joints, and broken pipelines.

WWF includes storm water inflow, trench infiltration, and GWI. The storm water inflow and trench infiltration comprise the WWF component termed I/I. The response in the sewer system to rainfall is seen immediately (as with inflow) or within hours after the storm (as with infiltration).

- **Base Wastewater Flow.** The BWF is the flow generated by the City's customers independent of wet weather influences. BWF is estimated by measuring flows during dry weather conditions. The flow has a diurnal pattern that varies depending on the type of use. Commercial and industrial patterns, though they vary depending on the type of use, typically have more consistent higher flows during business hours and lower flows at night. Furthermore, the diurnal flow pattern experienced during a weekend may vary from the diurnal flow experienced during a weekday.
- **Average Annual Flow.** The AAF is the average flow that occurs on a daily basis throughout the year, including both periods of dry and wet weather conditions.
- **Average Dry Weather Flow.** The ADWF is the average flow that occurs on a daily basis during the dry weather season. The ADWF includes the BWF generated by the City's residential, commercial, and industrial users, plus the dry weather GWI component.
- **Peak Wet Weather Flow.** PWWF is the highest observed flow that occurs following a design storm event. Wet weather I/I causes flows in the collection system to increase. PWWF is typically used for designing sewers, lift stations, and some unit processes in a treatment plant. Therefore, the PWWF and the "Design Flow" are synonymous and will be used interchangeably throughout this report.
- **Groundwater Infiltration.** GWI is the result of extraneous water entering the sewer system through defects in pipes and manholes. GWI is related to the condition of the sewer pipes, manholes, and groundwater levels. GWI may occur throughout the year, although rates are typically higher in the late winter and early spring. Dry weather GWI (or base infiltration) cannot easily be separated from BWF by flow measurement techniques. Therefore, dry weather GWI is typically grouped with BWF.
- **Infiltration and Inflow.** Infiltration is defined as storm water flows that enter the sewer system by percolating through the soil and then through defects in pipelines, manholes, and joints. Examples of infiltration entry points are cracks in pipelines, misaligned joints, and root penetration. Inflow is defined as storm water that enters the sewer system via storm drain cross connections, leaky manhole covers, or cleanouts. Examples of inflow entry points are roof drain and downspout connections, leaky manhole covers, and illegal storm drain connections.

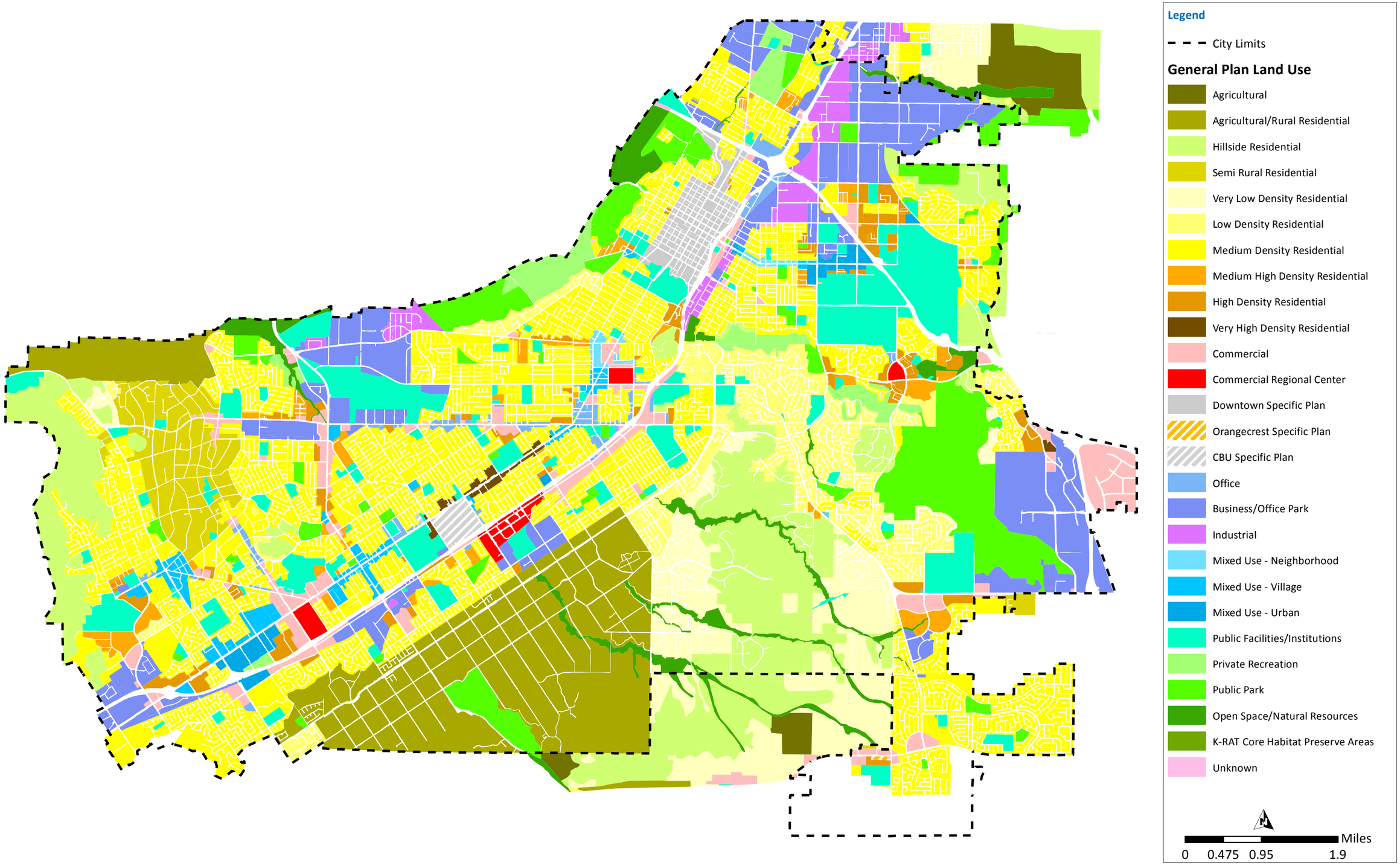


Figure 3.1 Service Area Land Use

3.5.2 Historic Flows

Before discussing existing and future flows that were developed for this update to the Master Plan, it is important to first take a look at historical flows and trends over the last several years. The City provided historical influent flow data at the RWQCP for the period of 2011 through 2016.

The monthly average and daily peak flow per month at the RWQCP are summarized in Table 3.5. As shown in Table 3.5, the AAF at the RWQCP has decreased since 2011 from 27.5 mgd to 20.0 mgd (excluding flows from Jurupa, Rubidoux, and Edgemont CSDs).

Table 3.5 Historic Flow at the RWQCP

Year	Population	AAF at the RWQCP(1)	Per-Capita Flow (gpcd)
2011	298,493	27.54	92
2012	299,376	24.92	83
2013	300,259	23.37	78
2014	303,837	23.55	77
2015	307,284	20.69	67
2016	310,190	20.01	65

Notes:
(1) Estimates include the City service area and the Highgrove area, but do not include the Jurupa, Rubidoux, or Edgemont CSDs.

3.5.3 Per-Capita Wastewater Flow

Table 3.5 summarizes the historical per-capita wastewater generation within the City service area. As shown in Table 3.5, the City's per-capita wastewater flow has steadily been decreasing since 2011, from 92 gpcd to 65 gpcd in 2016. The reduction in per-capita flow can be attributed to increased conservation by the City customers, as well as additional conservation associated with recent drought conditions.

For planning purposes, it was assumed that a per-capita flow of 77 gpcd would be used for future flow projections. The reason for this is that the 2015 and 2016 per-capita flows may be artificially low due to state mandated water conservation. Therefore, the City may see a rebound in the per-capita wastewater flow as drought conditions continue to ease.

3.5.4 Results of the Flow Monitoring Study

A flow monitoring study was conducted between January 25 and March 8, 2017, as part of this update to the Master Plan effort. Sixty temporary flow meters were placed throughout the collection system. The flow monitoring program did not capture flows from the Jurupa or Rubidoux CSDs. Although the results will be discussed in detail in Volume 3, Chapter 3, it is important to note that the measured ADWF was approximately 24 mgd. Table 3.1 indicates a total population in 2016 of 310,190 people. This translates to a per-capita wastewater flow factor of 77 gpcd during the flow monitoring program.

3.5.5 Wastewater Flow Factors

In order to develop wastewater flow projections and allocate future flows to the collection system, relationships between land use and wastewater generation were developed. These relationships, called wastewater flow factors, are established based on the average wastewater flow generated for each existing land use type. The land use flow factors were established to project the estimated average dry weather flow through build-out of the City's service area.

Average wastewater flow coefficients are rates, usually expressed in gpd/ac, applied to land use acreage to calculate the average flow generated from a particular land use. A flow factor was developed for each land use classification. The flow factor provides a means to transform a land use category from acreage into wastewater flow. The resulting flow can be used to estimate the ADWF associated with development of existing vacant land areas. Wastewater flow factors for residential areas can range between 200 to 5,000 gpd/ac, and commercial and industrial areas might range from 500 to 2,500 gpd/ac. Land uses designated as open space and agriculture were assumed to generate negligible amounts of sewage flow.

The flow factors were developed using the following procedure:

- Average flows for each sewer basin were derived from the flow monitoring data (described in detail in Volume 3, Chapter 3 of this update of the Master Plan). These average flows formed the calibration goals for each sewer basin.
- Using GIS, the acres for each land use type contained in each basin were calculated.
- Preliminary flow factors for each land use type were estimated based on values that are typical for the approximate number of dwelling units per acre and the typical number of people per dwelling unit for each land use type.
- The flow factors for each sewer basin were then adjusted up or down (balanced) so that the calculated average flows from each tributary area match what was measured during the flow monitoring period within a 4-percent tolerance.
- Once the flow factors for each basin were balanced, the weighted average of the coefficients for each land use type was calculated based on the acreage contribution from each basin.

The calibrated wastewater flow factors developed for this update of the Master Plan range from 50 gpd/ac to 4,300 gpd/ac, and are summarized in Table 3.6.

3.5.6 Build-Out Determination

Build-out wastewater flow projections were determined by applying the calibrated wastewater flow factors to the additional developable land and vacant parcels within the City service area. Table 3.6 summarizes the projected wastewater flow at build-out of the City service area (excluding Jurupa, Rubidoux, and Edgemont CSDs, but including the Highgrove area). As shown in Table 3.6, it is estimated that the City's service area could generate a total flow of approximately 29 mgd. The flow monitoring study used to calibrate the wastewater flow factors resulted in a per-capita generation rate of 77 gpcd. Applying this generation rate to the population projections indicates that build-out occurs in 2032.

Table 3.6 Wastewater Flow Factors

Land Use Type	Developable Vacant or Not Connected (acres)	Wastewater Flow Factor (gpd/ac)	Projected Average Flow Increase (mgd)
Agricultural/Rural Residential	4,669	60	0.280
Hillside Residential	4,078	130	0.530
Semi Rural Residential	152	350	0.053
Very Low Density Residential	2,145	350	0.751
Low Density Residential	136	640	0.087
Medium Density Residential	1,134	1,000	1.134
Medium High Density Residential	153	1,700	0.260
High Density Residential	52	2,800	0.146
Very High Density Residential	2	4,000	0.010
Commercial	188	710	0.134
Commercial Regional Center	3	640	0.002
Office	71	640	0.045
Business/Office Park	850	680	0.578
Industrial	184	670	0.123
Downtown Specific Plan	31	1,000	0.031
Orangecrest Specific Plan	7	1,000	0.007
Mixed Use - Neighborhood	5	1,100	0.006
Mixed Use - Urban	39	3,200	0.125
Mixed Use - Village	63	4,300	0.269
Agricultural	746	60	0.045
Public Park	1,964	50	0.098
Private Recreation	245	100	0.024
Open Space/Natural Resources	781	0	0.000
Public Facilities/Institutions	481	530	0.255
Total Flow Increase	**18,178**	--	**4.992**
		Existing Average Daily Flow (mgd)	**24.00**
		Total Build-Out Average Daily Flow (mgd)	**29.00**

3.5.7 Wastewater Flow Projections

Historical per-capita generation rates indicate a range between 65 and 92 gpcd. As previously stated, this update of the Master Plan will use 77 gpcd for future flow projections purposes. However, the 2016 per-capita flow rate of 65 gpcd is also included as a minimum anticipated ADWF flow. Figure 3.2 shows the projected wastewater flows through the year 2037 including the impact of build-out on population and flow. Population projections shown on Figure 3.2 are limited to the City service area and the Highgrove Community (not including the other CSDs), and are based on SCAG data. The population is limited to the build-out population occurring in 2032.

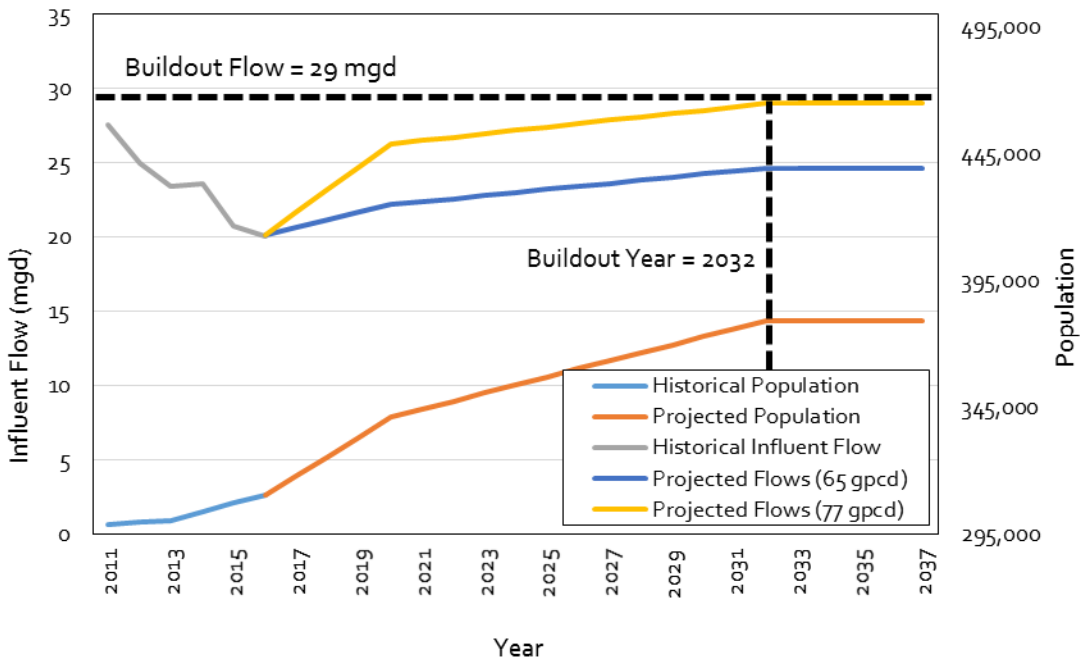


Figure 3.2 Projected Wastewater Flow

3.5.8 Contributing Agency Flows

Based on Jurupa's current purchase agreements, Jurupa has a 4.0 mgd allocation limit until 2030 when the limit increases to 5.0 mgd. Rubidoux is limited to 3.055 mgd and Edgemont is limited to 0.89 mgd. Highgrove is not a full CSD at the time of this update of the Master Plan and therefore does not have a hard allocation limit at this time.

Wastewater flow projections for the Jurupa, Rubidoux, and Edgemont CSDs were documented in separate planning documents for each agency. Table 3.7 summarizes the flow projections through 2037 for each of the CSDs.

Table 3.7 Contributing Agency Flow Projections

Agency	Projected Flows Through 2037 (mgd)
Jurupa(1)	4.90
Rubidoux(2)	4.00
Edgemont(3)(4)	1.07
Total	**9.97**

Notes:
(1) Source: 2004 Master Sewer Plan (Albert A. Webb Associates).
(2) Source: 2015 Rubidoux Wastewater Facilities Master Plan (Krieger & Stewart).
(3) Source: 2008 Master Sewer System Evaluation Plan (Albert A. Webb Associates).
(4) Total build-out flows are estimated to be 1.32 mgd. Based on growth projections (Albert A. Webb Associates), build-out is expected to occur beyond the 2037 planning period.

The Jurupa CSD last completed a Master Plan in 2004, but has produced multiple addenda, the latest of which was issued in 2010, providing updates as needed. This Master Plan was prepared based on the Jurupa 2004 Master Sewer Plan (Albert A. Webb Associates) and appropriate updates from the addenda. The 2004 Master Sewer Plan (Albert A. Webb Associates) estimated population projections based on SCAG data indicating an average growth rate of 4 percent, which is

consistent with actual development projections. The flow projections for the Jurupa CSD reflect this growth rate of 4 percent, capped at 4.9 mgd in line with the purchase agreement. The Jurupa CSD has decided to cap wastewater flows at 4.9 mgd to maintain the 5 mgd allocation agreement. Any excess flows will likely be routed to the WRCRWA facilities. Figure 3.3 shows the historical and projected wastewater flows for the Jurupa CSD. Based on a 4-percent growth rate, they are expected to reach their 4.0 mgd allocation limit by 2022. Based on the current purchase agreement, Jurupa will be expected to pay surcharge fees for flows in excess of 4.0 mgd between 2022 and 2030. As stated above, Jurupa will send flows in excess of 4.9 mgd to the WRCRWA plant, so the flow projection line on Figure 3.3 does not exceed 5.0 mgd during the planning period.

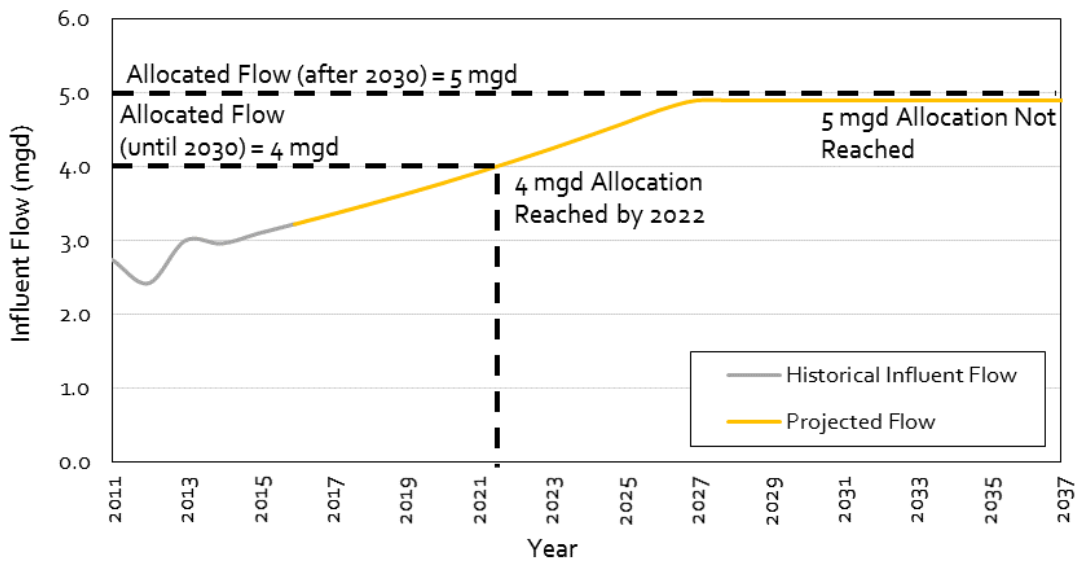


Figure 3.3 Projected Wastewater Flow (Jurupa)

The latest population and flow projections, again based on SCAG data, for the Rubidoux CSD were presented in the 2015 Rubidoux CSD Wastewater Facilities Master Plan (Krieger & Stewart). Figure 3.4 shows the historical and projected population and wastewater flows for the Rubidoux CSD. The 2015 Rubidoux CSD Wastewater Facilities Master Plan projected wastewater flows to increase at a rate of 0.8 mgd per year between 2010 and 2035. This would have resulted in a flow of 2.8 mgd in 2020 and 4.0 mgd in 2035. However, the actual average annual wastewater flow from Rubidoux to the RWQCP was only 2.0 mgd by the end of 2016, which is approximately 0.5 mgd lower than projected in the Rubidoux Master Plan. In order to maintain the 2020 flow projection of 2.8 mgd in 2020, the portion of the flow projection line on Figure 3.4, between 2016 and 2020, is therefore steeper than the portion of the line between 2020 and 2035. Additionally, the projected build-out flow for the Rubidoux CSD is estimated to be 4.0 mgd as demonstrated by the flat-line slope occurring after 2035. The Rubidoux CSD has a total wastewater flow allocation of 3.055 mgd. Based on the most recent flow projections, the Rubidoux CSD is expected to reach this allocation at year 2023.

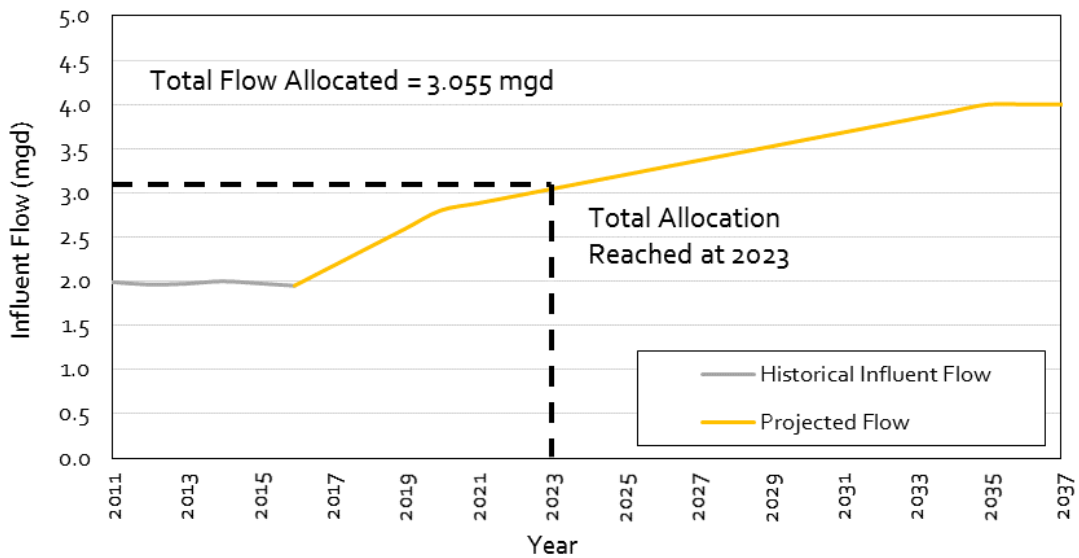


Figure 3.4 Projected Wastewater Flow (Rubidoux)

The estimated build-out wastewater influent flow for the Edgemont CSD is 1.32 mgd (Albert A. Webb Associates). The total allocation limit for the Edgemont CSD is 0.89 mgd. The projected wastewater flow was based on population growth rates provided in the 2016-2040 Regional Transportation Plan/Sustainable Communities Strategy Report (SCAG). Figure 3.5 shows the projected wastewater flows for the Edgemont CSD. The average influent flow for 2016 was 0.52 mgd. Based on the projected growth rate, the Edgemont CSD is expected to reach their allocation limit between 2031 and 2032. The Edgemont CSD is not expected to reach ultimate build-out (1.32 mgd) by 2037.

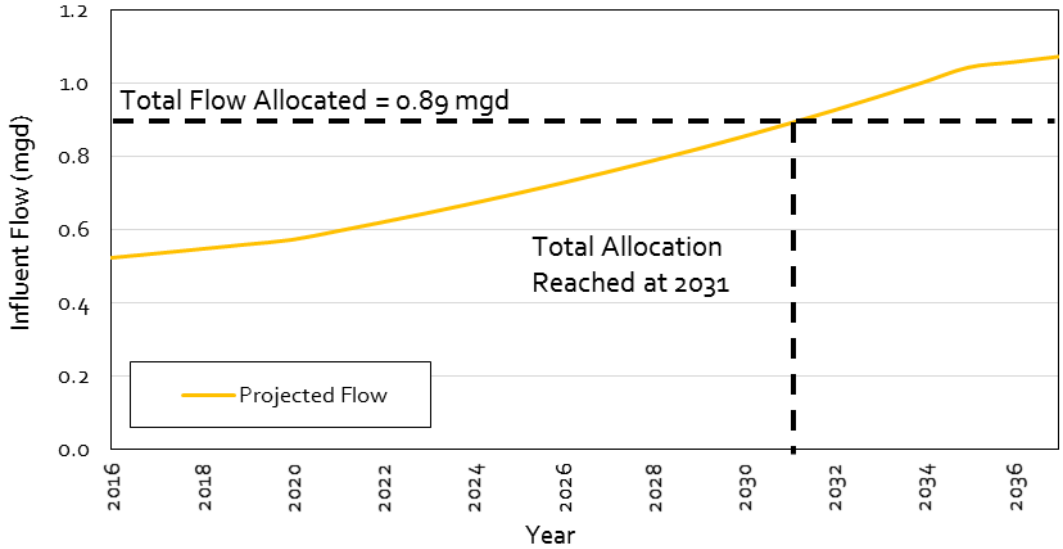


Figure 3.5 Projected Wastewater Flow (Edgemont)

3.5.9 Total Flows

The total projected wastewater flows through 2037, including the City of Riverside and the Jurupa, Rubidoux, and Edgemont CSDs is estimated to be 38.97 mgd. The total projected wastewater flows are summarized in Table 3.8.

Table 3.8 Contributing Agency Flow Projections

Agency	Projected Flow Through 2037 (mgd)
City of Riverside	29.00
Jurupa(1)	4.90
Rubidoux(2)	4.00
Edgemont(3)(4)	1.07
Total	**38.97**

Notes:
(1) Source: 2004 Master Sewer Plan (Albert A. Webb Associates).
(2) Source: 2015 Rubidoux CSD Wastewater Facilities Master Plan (Krieger & Stewart).
(3) Source: 2008 Master Sewer System Evaluation Plan (Albert A. Webb Associates).
(4) Total build-out flows are estimated to be 1.32 mgd. Based on growth projections (Albert A. Webb Associates), build-out is expected to occur beyond the 2037 planning period.

3.6 Wastewater Loads

This section summarizes the existing and projected wastewater loads for the RWQCP. Historical wastewater loads were analyzed for the City service area and the Jurupa/Rubidoux CSDs separately.

3.6.1 COD/BOD Ratio

BOD is the amount of dissolved oxygen needed by organisms to decompose organic material in wastewater. Chemical oxygen demand is the amount of dissolved oxygen needed to oxidize soluble and particulate organic material in wastewater. The procedure to measure BOD concentrations is an arduous task with several disadvantages. The most significant disadvantage for operational control and monitoring is the fact that the test must incubate for 5 days before the analysis can be run. COD, however, can be measured in real-time through in-line analyzers or in batches, in a lab, quickly and comparatively easily. Furthermore, COD allows for a conservative evaluation of wastewater characteristics by providing a metric of the amount of dissolved oxygen required in a biological system.

COD concentration typically correlates to BOD concentration fairly well. The ratio of COD to BOD is a useful metric, particularly in modeling plant performance. COD and BOD data collected between October 2013 and April 2017 were evaluated and the average COD/BOD ratio was determined to be 2.12.

For this update to the Master Plan, the COD/BOD ratio was used to estimate the COD concentration when plant measured COD data was unavailable. Additional uses of RWQCP COD and BOD concentration data are described in Volume 4, Chapter 3, Process Design and Reliability Criteria. It should be noted, however, that the RWQCP is obligated to measure and track BOD concentrations by the discharge permit and has no such obligation for COD.

3.6.2 Historic Loading Characteristics

To establish a trend in recent loading rates, BOD, COD, TSS, and NH_3-N loading characteristics were analyzed since 2012. During this time, loading rates have fluctuated for each parameter repeatedly. The annual average loading for each of the three parameters were calculated and are summarized in Table 3.9. Additionally, Table 3.9 shows the historic annual average population and the per-capita loading for each of the four parameters. Figure 3.6 through Figure 3.9 show the per-capita loading characteristics for the City Service Area.

Table 3.9 Historical Loading Isolated to the City Service Area[(1)(2)(3)]

Year	Population	BOD (ppd)	COD (ppd)	TSS (ppd)	NH_3-N (ppd)	BOD (ppdc)	COD (ppdc)	TSS (ppdc)	NH_3-N (ppdc)
2012	299,376	64,500	136,800	60,300		0.215	0.457	0.201	
2013	300,259	61,200	129,700	56,000	5,390	0.204	0.432	0.187	0.018
2014	303,837	66,600	140,300	59,200	5,740	0.219	0.462	0.195	0.019
2015	307,284	64,500	132,700	56,100	5,300	0.210	0.432	0.183	0.017
2016	310,190	62,600	136,700	55,700	4,900	0.202	0.441	0.180	0.016
			Historical Annual Average			**0.210**	**0.445**	**0.189**	**0.017**

Notes:
(1) Assume the Highgrove Community population is included in the City Service Area population projections; based on the 2013/14 projections, the total flow this year is likely 0.2 mgd or less.
(2) Assume Edgemont and Highgrove have similar water quality characteristics to that of the City of Riverside.
(3) City ONLY influent COD data from 1/1/2011 to 10/13/2013 is calculated based on the City ONLY BOD data multiplied by an average COD/BOD ratio between 10/14/2013 to 4/30/2017 of 2.12.

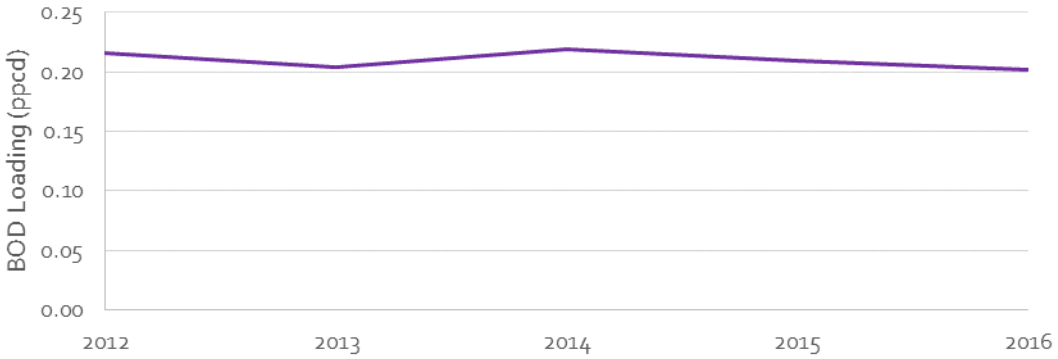


Figure 3.6 Historical Per-Capita BOD Loading for the City Service Area

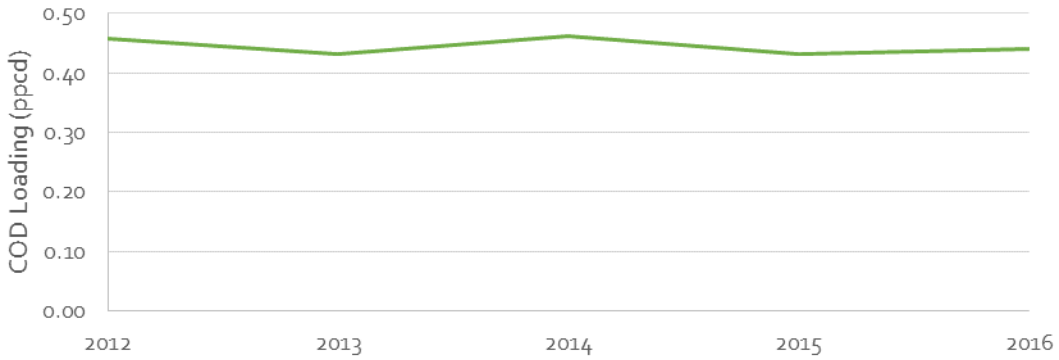


Figure 3.7 Historical Per-Capita COD Loading for the City Service Area

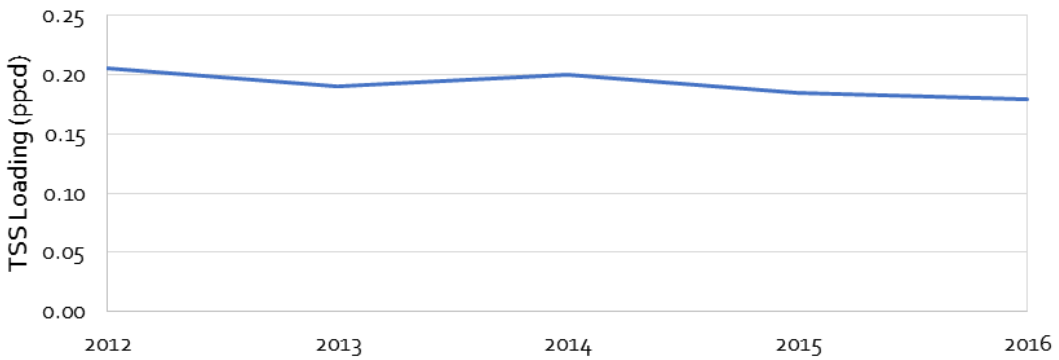


Figure 3.8 Historical Per-Capita TSS Loading for the City Service Area

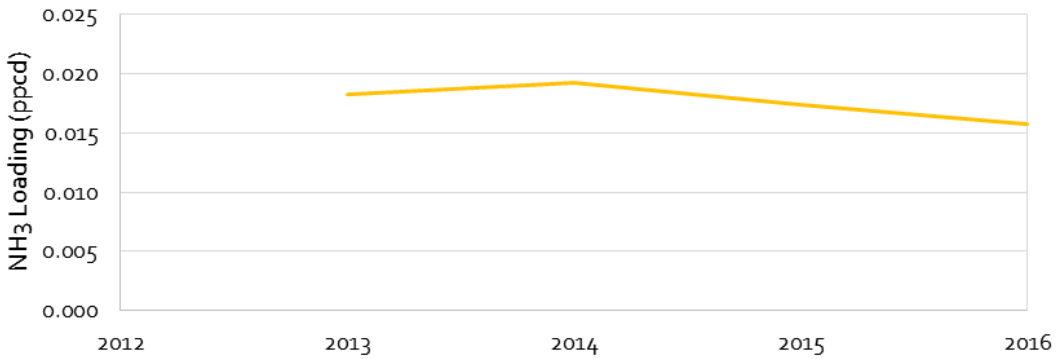


Figure 3.9 Historical Per-Capita Ammonia Loading for the City Service Area

3.6.3 Contributing Agency Loads

Similar to the City loading characteristics presented in the section above, BOD, COD, TSS, and NH_3-N concentrations were analyzed since 2012 for the Jurupa and Rubidoux CSDs. During this time, both CSDs showed a generally increasing trend in all parameters. The annual average loading for each of the four parameters were calculated and are summarized in Table 3.10.

However, only limited data was available to characterize the historic flow and loading for both Edgemont and Highgrove. Sampling data from two locations within the Edgemont service area, during a nine-month-period between January and September, 2017, show similar wastewater quality characteristics between Edgemont and the City. Edgemont's average BOD concentration during the nine-month-period is slightly higher than the City's 5-year annual average, but the small sample size makes this difference statistically insignificant. Additionally, Edgemont's COD and TSS average concentrations during the nine-month-period are lower than the City's 5-year annual averages. Therefore, it is assumed that the wastewater characteristics for Edgemont are similar to the City. Finally, due to limited population and flow data related to the Edgemont community, it is assumed to contribute 0.52 mgd annually. This coupled with the City's wastewater characteristics, results in a BOD contribution of 1,700 ppd, a COD contribution of 3,600 ppd, a TSS contribution of 1,500 ppd, and an ammonia concentration of 130 ppd. Figure 3.11 through Figure 3.13 show the combined annual average loading characteristics for Jurupa and Rubidoux. Finally, Table 3.11 shows the total historical loading for the City and CSDs using the above stated assumptions.

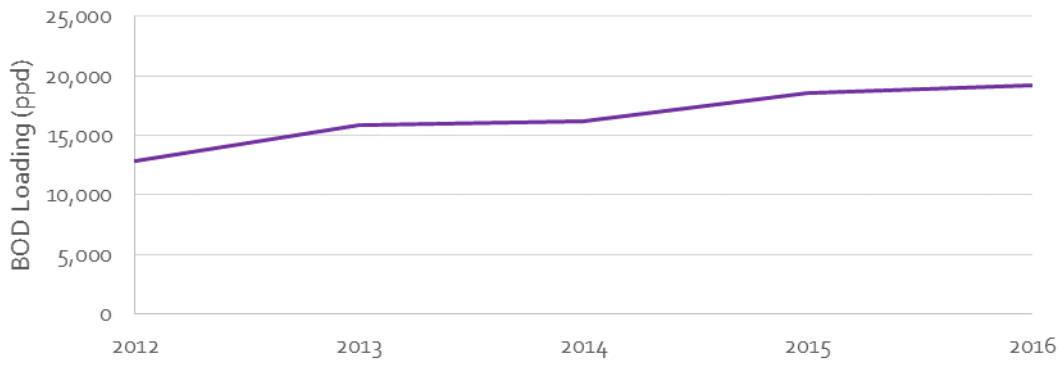


Figure 3.10 Combined Historical BOD Loading for Jurupa and Rubidoux

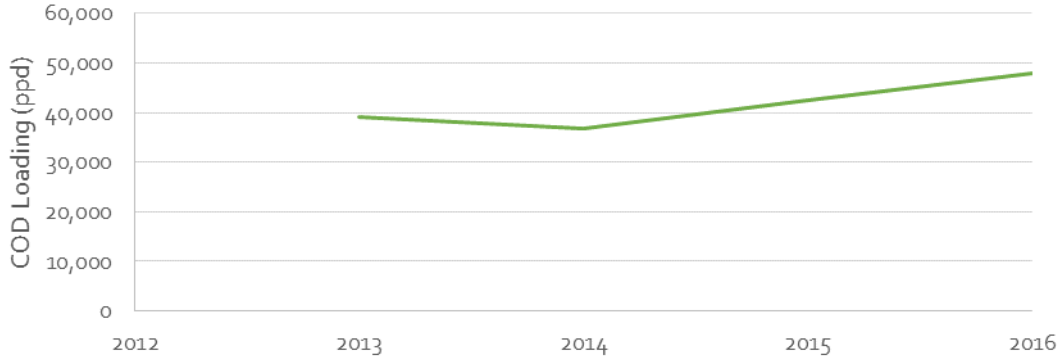


Figure 3.11 Combined Historical COD Loading for Jurupa and Rubidoux

Table 3.10 Historical Loading (ppd) for Jurupa and Rubidoux

Year	Jurupa CSD				Rubidoux CSD				Total CSD Contributions(1)(2)			
	BOD	COD	TSS	NH_3-N	BOD	COD	TSS	NH_3-N	BOD	COD	TSS	NH_3-N
2012	5,800		5,600		7,000		5,700		14,500		12,800	
2013	7,200	16,200	7,200	713	8,700	23,000	7,200	771	17,600	42,800	15,900	1,610
2014	7,100	16,000	7,100	780	9,100	20,900	7,300	785	17,900	40,500	15,900	1,700
2015	8,100	17,600	8,000	843	10,500	24,800	8,200	834	20,300	46,000	17,700	1,810
2016	7,800	18,800	7,800	913	11,400	29,100	9,000	844	20,900	51,500	18,300	1,890

Notes:
(1) Assume Edgemont has similar water quality characteristics to that of the City of Riverside.
(2) Assume Edgemont contributes 0.52 mgd, 1,700 ppd BOD, 3,600 ppd COD, 1,500 ppd TSS, and 130 ppd Ammonia historically.

Table 3.11 Combined Historical Loading (ppd) for the City and CSD's

Year	Combined Influent Historical Loading			
	BOD	COD	TSS	NH_3-N
2012	79,000		73,100	
2013	78,800	172,500	71,900	7,000
2014	84,500	180,800	75,100	7,440
2015	84,800	178,700	73,800	7,110
2016	83,500	188,200	74,000	6,790

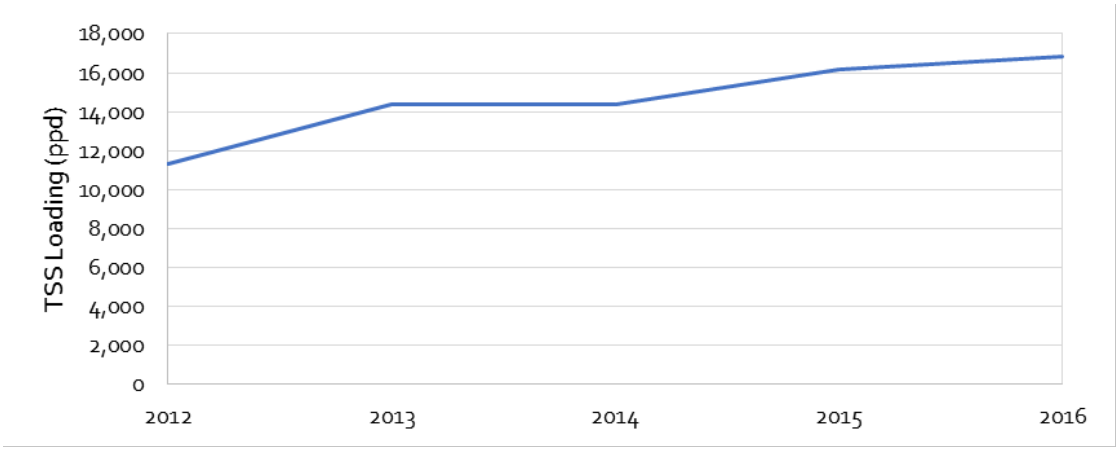


Figure 3.12 Combined Historical TSS Loading for Jurupa and Rubidoux

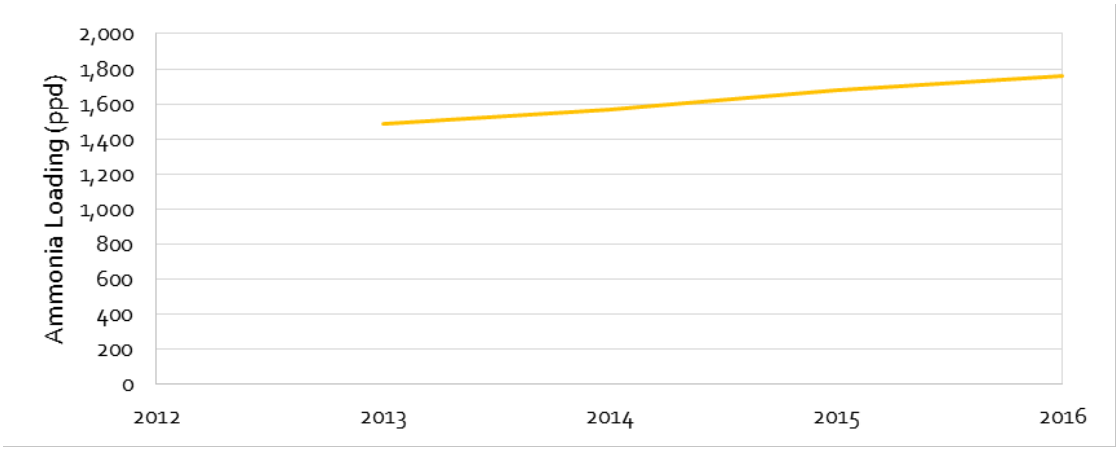


Figure 3.13 Combined Historical Ammonia Loading for Jurupa and Rubidoux CSD

3.7 Loading Projections

For this update of the Master Plan, loading projections are based on population projections for the City service area (the City and Highgrove Community). Using the average per-capita loading for BOD, COD, TSS, and NH_3-N presented in Table 3.9, loading conditions were projected through the year 2037, summarized in Table 3.12.

Table 3.12 Projected Loading Characteristics for the City Service Area

Year	BOD (ppd)	COD (ppd)	TSS (ppd)	NH_3-N (ppd)
2016	62,600	136,700	55,700	4,900
2017	66,800	141,400	60,100	5,550
2020	71,600	151,600	64,400	5,960
2025	75,000	158,700	67,400	6,240
2030	78,300	165,800	70,500	6,520
2032	79,700	168,700	71,700	6,630
2037	79,700	168,700	71,700	6,630

3.7.1 Contributing Agency Loads

Historical and projected population numbers could not be determined for the CSDs because the CSDs service area GIS data was not available. Historical populations from census information could not be determined without the service area GIS information. As a result, the loading projections for Jurupa and Rubidoux were determined using the annual average flow and loading in 2016 and projected CSD flow contribution in 2037 of 9.97 mgd presented above. As loading data for Edgemont was not available, it is assumed that the City and Edgemont will have similar loading characteristics. Table 3.13 shows the estimated loading contributions through 2037 for all CSDs. Additionally, Appendix 3A provides summary tables for Jurupa and Rubidoux as well as loading projections with trigger points at 75 percent of the agreed loading capacity.

Table 3.13 Projected Loading Characteristics for the CSDs

Year	BOD (ppd)	COD (ppd)	TSS (ppd)	NH_3-N (ppd)
2016	20,900	51,500	18,300	1,890
2017	22,230	54,760	19,460	2,010
2020	26,260	64,670	22,990	2,380
2025	31,210	76,840	27,320	2,830
2030	34,420	84,720	30,130	3,130
2032	36,590	90,070	32,030	3,330
2037	36,700	90,340	32,130	3,340

3.8 Basis of Design

The flow and loading projections developed in this chapter will be used in Volume 3, Chapter 3, and Volume 4, Chapter 3 as the basis for collection system and unit process capacity determinations. Table 3.14 summarizes the projections, capacity, and trigger point (75 percent of treatment capacity) for each constituent. Figure 3.14 through Figure 3.18 show the combined total projected flow, BOD, COD, TSS, and NH_3-N loading characteristics.

Table 3.14 Combined Total Projected Loading Characteristics

Year	Flow (mgd)	BOD (ppd)	COD (ppd)	TSS (ppd)	NH_3-N (ppd)
2016	25.9	83,500	188,200	74,000	6,790
2017	27.7	89,030	196,160	79,560	7,560
2020	33.4	97,860	216,270	87,390	8,340
2025	35.9	106,210	235,540	94,720	9,070
2030	37.9	112,720	250,520	100,630	9,650
2032	38.9	116,290	258,770	103,730	9,960
2037	39.0	116,400	259,040	103,830	9,970
Treatment Capacity(1)	**43.5**	**133,900**	**269,900**	**123,700**	**11,600**
75% Capacity	**32.6**	**100,425**	**202,425**	**92,775**	**8,700**
75% Capacity Trigger Year	**July 2019**	**July 2021**	**December 2017**	**July 2023**	**July 2022**

Notes:

(1) Treatment capacity is shown for reference. For a full description of the evaluation used to determine this capacity, see Volume 4, Chapter 3, Process Design and Reliability Criteria, of this update to the Master Plan.

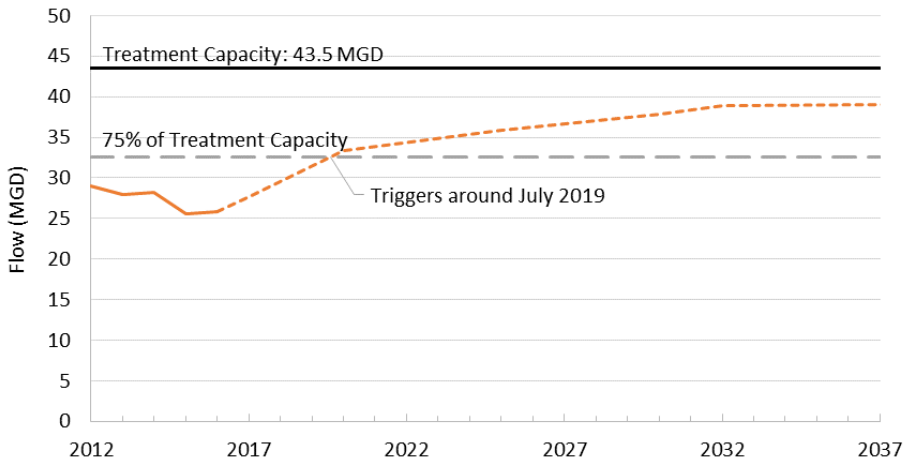


Figure 3.14 Combined Total Projected Flow

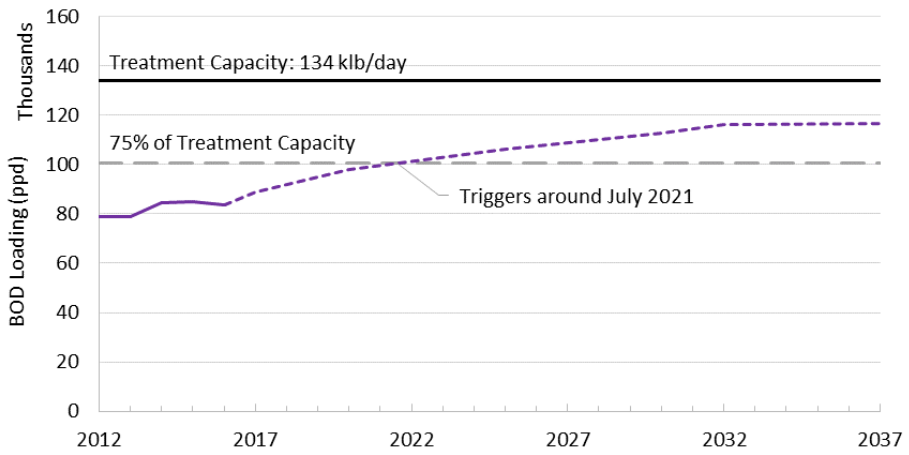


Figure 3.15 Combined Total Projected BOD

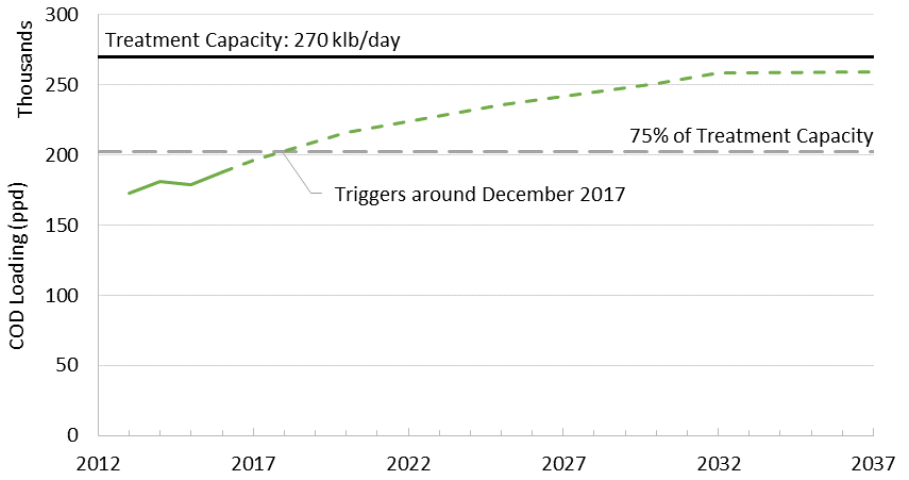


Figure 3.16 Combined Total Projected COD

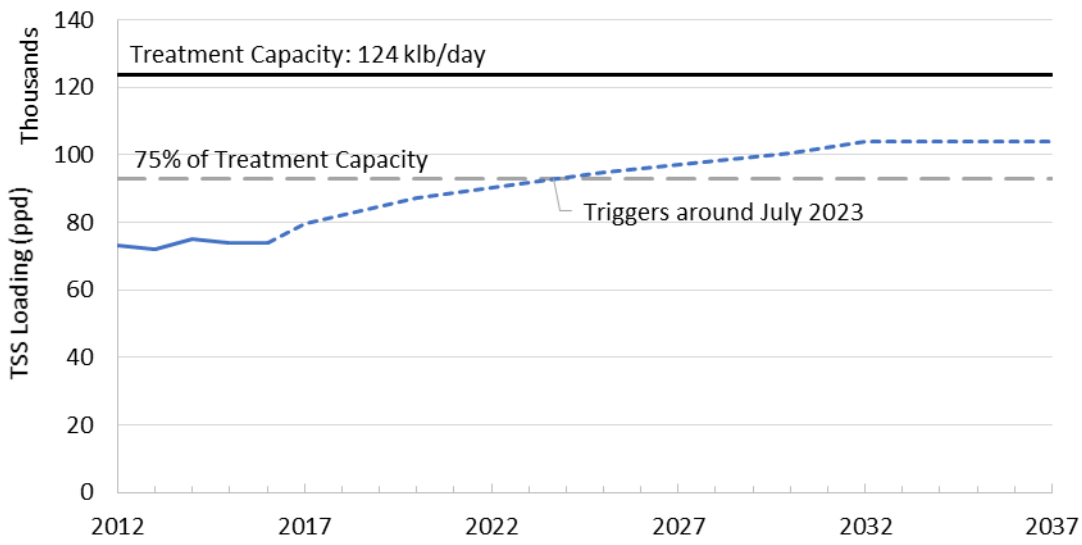


Figure 3.17 Combined Total Projected TSS

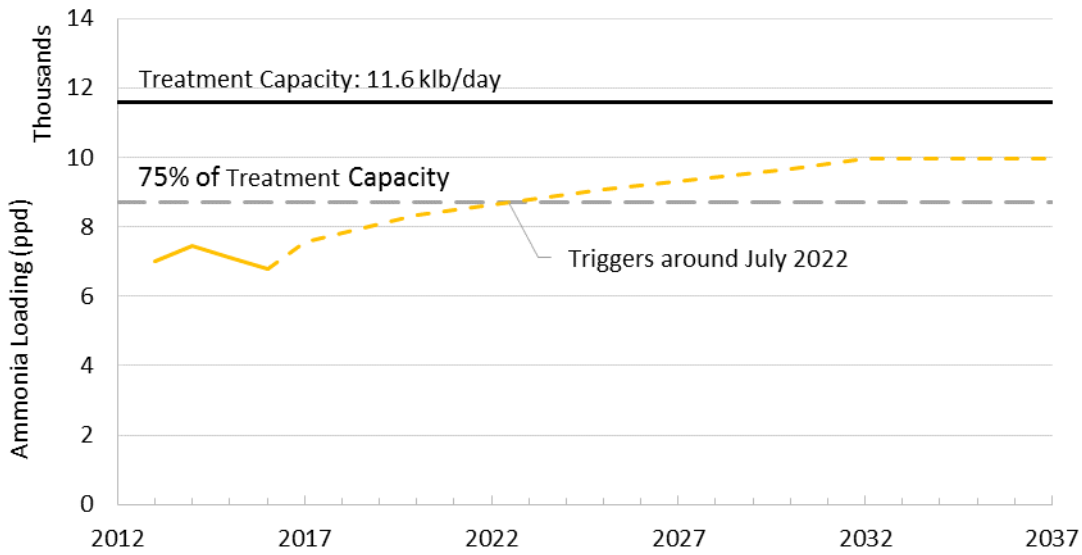


Figure 3.18 Combined Total Projected Ammonia

Appendix 3A

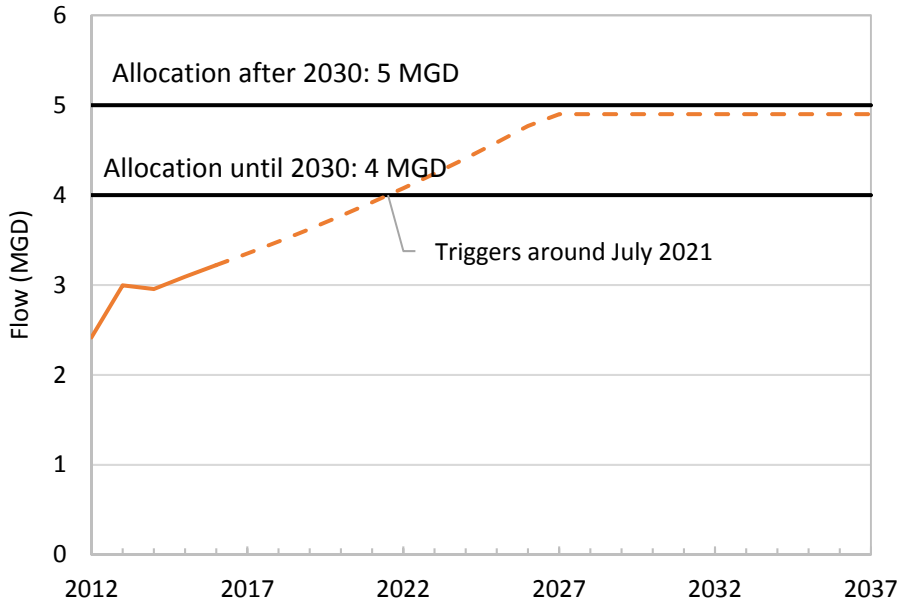
CSD HISTORICAL AND PROJECTED FLOW AND LOADING

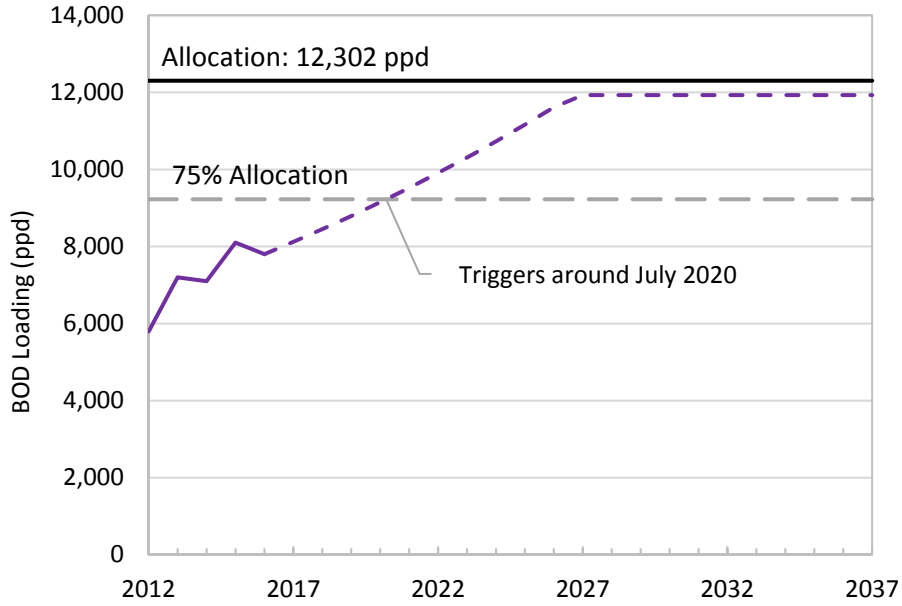
Jurupa

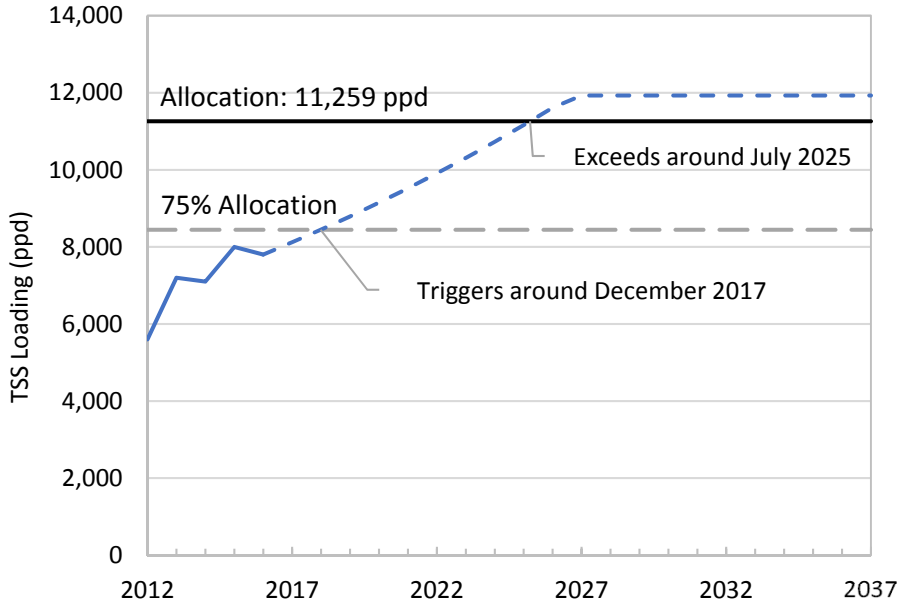
Year	Influent Flow (mgd)	BOD (ppd)	COD (ppd)	TSS (ppd)	NH_3 (ppd)	TDS (ppd)
2012	2.42	5,800		5,600		12,600
2013	3.00	7,200	16,200	7,200	713	15,800
2014	2.96	7,100	16,000	7,100	780	14,200
2015	3.09	8,100	17,600	8,000	843	16,600
2016	3.22	7,800	18,800	7,800	913	17,800
2017	3.35	8,120	19,560	8,120	950	18,520
2018	3.48	8,450	20,350	8,450	990	19,270
2019	3.62	8,790	21,170	8,790	1,030	20,050
2020	3.77	9,150	22,020	9,150	1,080	20,860
2021	3.92	9,520	22,910	9,520	1,130	21,700
2022	4.08	9,910	23,830	9,910	1,180	22,570
2023	4.24	10,310	24,790	10,310	1,230	23,480
2024	4.41	10,730	25,790	10,730	1,280	24,420
2025	4.59	11,160	26,830	11,160	1,340	25,400
2026	4.77	11,610	27,910	11,610	1,400	26,420
2027	4.90	11,930	28,680	11,930	1,440	27,150
2028	4.90	11,930	28,680	11,930	1,440	27,150
2029	4.90	11,930	28,680	11,930	1,440	27,150
2030	4.90	11,930	28,680	11,930	1,440	27,150
2031	4.90	11,930	28,680	11,930	1,440	27,150
2032	4.90	11,930	28,680	11,930	1,440	27,150
2033	4.90	11,930	28,680	11,930	1,440	27,150
2034	4.90	11,930	28,680	11,930	1,440	27,150
2035	4.90	11,930	28,680	11,930	1,440	27,150
2036	4.90	11,930	28,680	11,930	1,440	27,150
2037	4.90	11,930	28,680	11,930	1,440	27,150

	Capacity	75% Capacity	Triggers	Exceeds
Flow until 2030, mgd	4		2022	
Flow after 2030, mgd	5	3.75		
BOD, ppd	12,302	9,227	2020	
TSS, ppd	11,259	8,444	2018	2025
Ammonia, ppd	1,168	876	2015	2022
TDS, ppd	27,105	20,329	2019	

Jurupa


Flow (MGD)
Allocation after 2030: 5 MGD
Allocation until 2030: 4 MGD
Triggers around July 2021
0
1
2
3
4
5
6
2012
2017
2022
2027
2032
2037


BOD Loading (ppd)
Allocation: 12,302 ppd
75% Allocation
Triggers around July 2020
0
2,000
4,000
6,000
8,000
10,000
12,000
14,000
2012
2017
2022
2027
2032
2037


TSS Loading (ppd)
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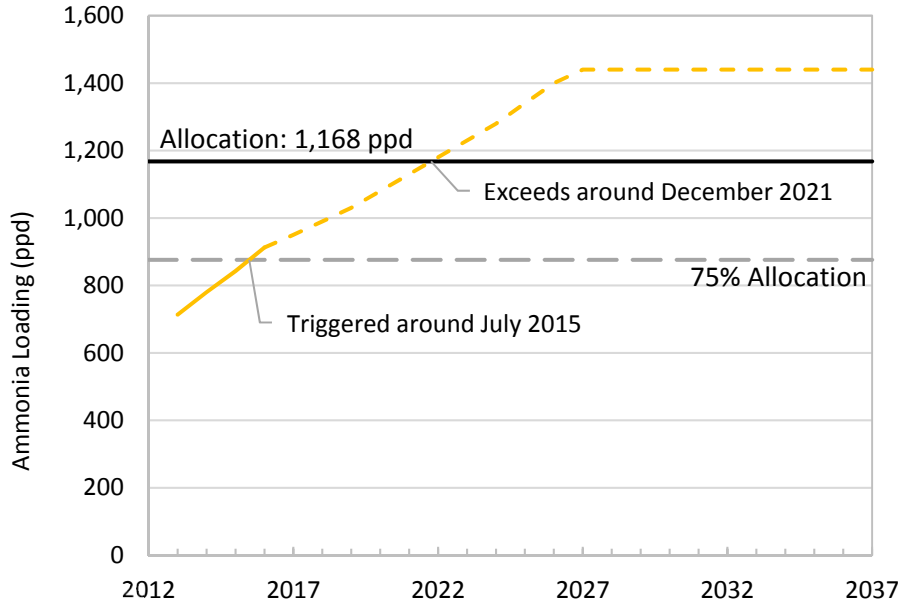
Exceeds around July 2025
75% Allocation
Triggers around December 2017
0
2,000
4,000
6,000
8,000
10,000
12,000
14,000
2012
2017
2022
2027
2032
2037

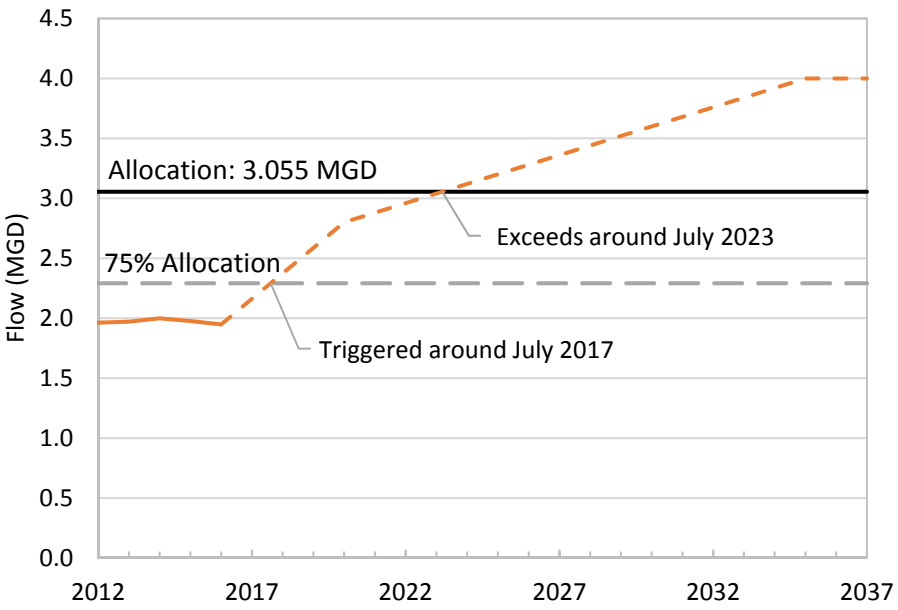

Ammonia Loading (ppd)
Allocation: 1,168 ppd
Exceeds around December 2021
75% Allocation
Triggered around July 2015
0
200
400
600
800
1,000
1,200
1,400
1,600
2012
2017
2022
2027
2032
2037

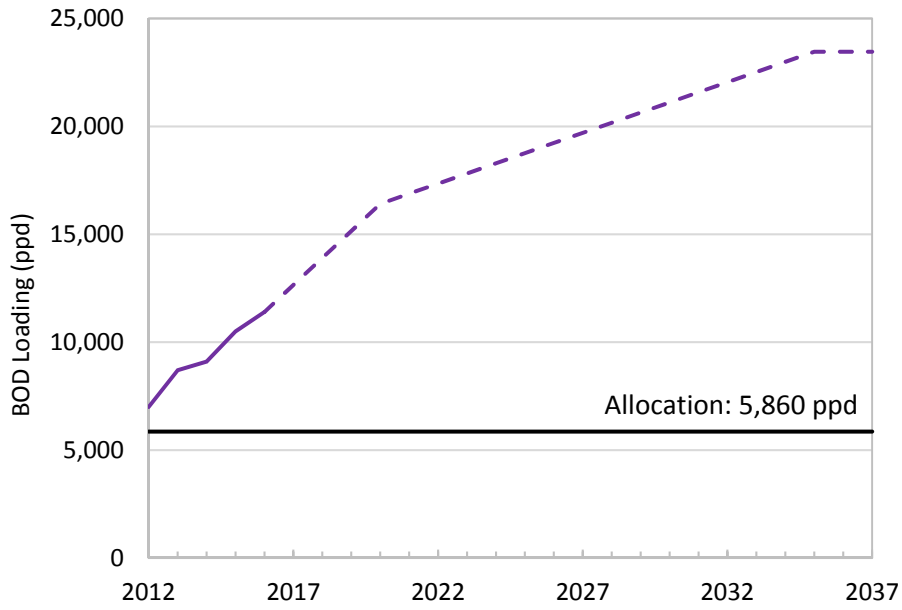
Rubidoux

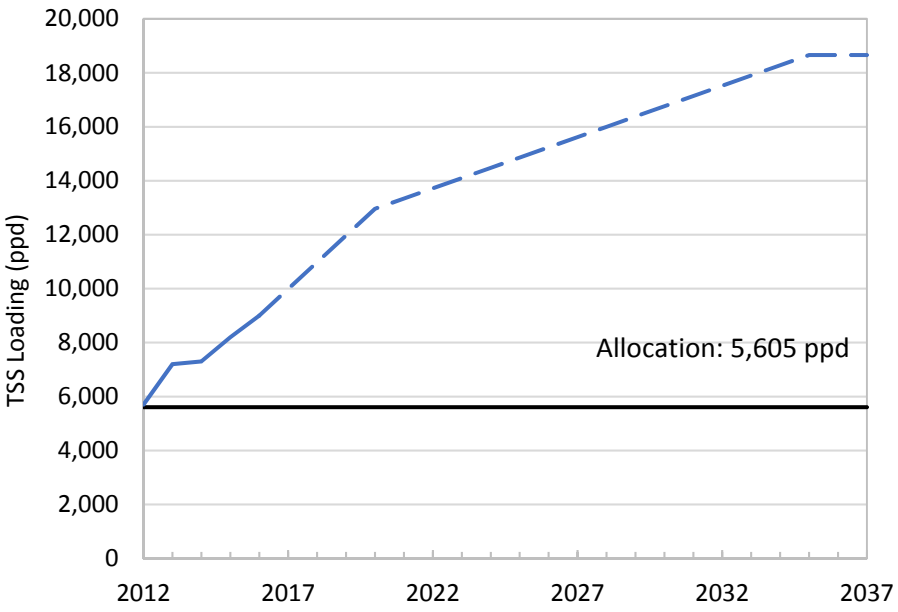
Year	Influent Flow (mgd)	BOD (ppd)	COD (ppd)	TSS (ppd)	NH_3 (ppd)	TDS (ppd)
2012	1.96	7,000		5,700		12,200
2013	1.97	8,700	23,000	7,200	771	14,700
2014	2.00	9,100	20,900	7,300	785	14,200
2015	1.98	10,500	24,800	8,200	834	15,400
2016	1.95	11,400	29,100	9,000	844	16,600
2017	2.16	12,650	32,280	9,990	940	18,410
2018	2.37	13,900	35,460	10,980	1,040	20,220
2019	2.59	15,150	38,640	11,970	1,140	22,030
2020	2.80	16,410	41,830	12,960	1,240	23,850
2021	2.88	16,880	43,030	13,340	1,280	24,540
2022	2.96	17,350	44,230	13,720	1,320	25,230
2023	3.04	17,820	45,430	14,100	1,360	25,920
2024	3.12	18,290	46,630	14,480	1,400	26,610
2025	3.20	18,760	47,830	14,860	1,440	27,300
2026	3.28	19,230	49,030	15,240	1,480	27,990
2027	3.36	19,700	50,230	15,620	1,520	28,680
2028	3.44	20,170	51,430	16,000	1,560	29,370
2029	3.52	20,640	52,630	16,380	1,600	30,060
2030	3.60	21,110	53,830	16,760	1,640	30,750
2031	3.68	21,580	55,030	17,140	1,680	31,440
2032	3.76	22,050	56,230	17,520	1,720	32,130
2033	3.84	22,520	57,430	17,900	1,760	32,820
2034	3.92	22,990	58,630	18,280	1,800	33,510
2035	4.00	23,460	59,830	18,660	1,840	34,200
2036	4.00	23,460	59,830	18,660	1,840	34,200
2037	4.00	23,460	59,830	18,660	1,840	34,200

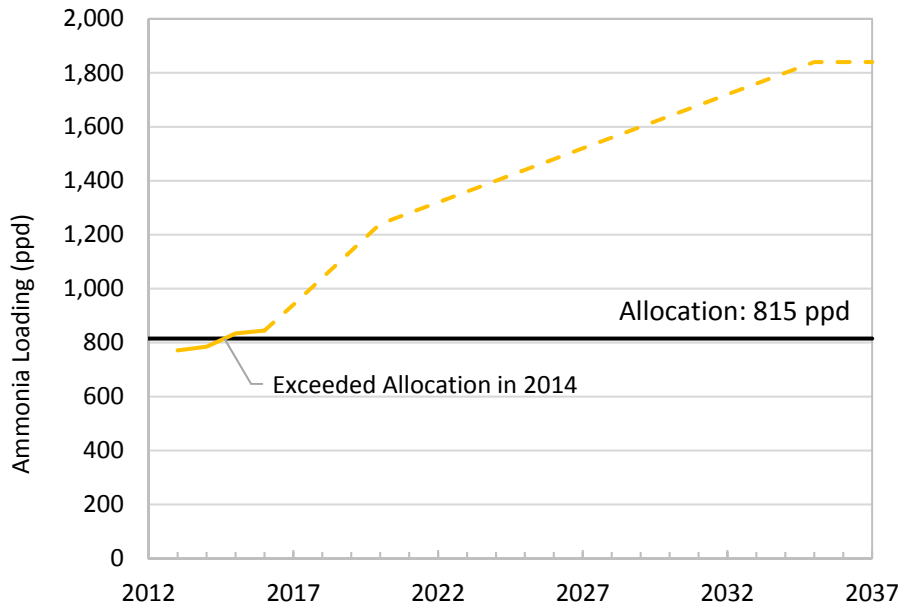
	Capacity	75% Capacity	Triggers	Exceeds
Flow, mgd	3.055	2.29	2018	2023
BOD, ppd	5,860	4,395		Pre-2012
TSS, ppd	5,605	4,204		Pre-2013
Ammonia, ppd	815	611		2015
TDS, ppd	16,561	12,421	2012	2016

Rubidoux


Flow (MGD)
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
2012
2017
2022
2027
2032
2037
Allocation: 3.055 MGD
75% Allocation
Exceeds around July 2023
Triggered around July 2017


BOD Loading (ppd)
25,000
20,000
15,000
10,000
5,000
0
2012
2017
2022
2027
2032
2037
Allocation: 5,860 ppd


TSS Loading (ppd)
20,000
18,000
16,000
14,000
12,000
10,000
8,000
6,000
4,000
2,000
0
2012
2017
2022
2027
2032
2037
Allocation: 5,605 ppd


Ammonia Loading (ppd)
2,000
1,800
1,600
1,400
1,200
1,000
800
600
400
200
0
2012
2017
2022
2027
2032
2037
Allocation: 815 ppd
Exceeded Allocation in 2014

Appendix 3B

REFERENCED DOCUMENTS

1. 2004 Master Sewer Plan for Jurupa Community Services District
2. 2004 Eastvale Master Sewer Plan Update for Jurupa Community Services District
3. 2004 Eastvale Master Sewer Plan Update Addendum No. 1 for Jurupa Community Services District
4. 2007 Master Sewer Plan Addendum for Jurupa Community Services District
5. 2009 Master Sewer Plan Addendum No. 2 for Jurupa Community Services District
6. 2009 Master Sewer Plan Addendum No. 2 Supplemental Information for Jurupa Community Services District
7. 2010 Master Sewer Plan Addendum No. 2 for Jurupa Community Services District
8. 2015 Rubidoux Community Services District Wastewater Facilities Master Plan
9. 2008 Edgemont Community Services District Master Sewer System Evaluation Plan

Appendix 3B.1

2004 MASTER SEWER PLAN FOR JURUPA COMMUNITY SERVICES DISTRICT

MASTER SEWER PLAN

Prepared for:

Jurupa
COMMUNITY SERVICES DISTRICT

September, 2004

ALBERT A. WEBB ASSOCIATES
ENGINEERING CONSULTANTS

jurupa
COMMUNITY SERVICES DISTRICT

MASTER SEWER PLAN

September, 2004

REGISTERED PROFESSIONAL ENGINEER
WALLACE H. FRANZ
No. 26979
Exp. 3-31-05
CIVIL
STATE OF CALIFORNIA

Prepared by
Albert A. Webb Associates

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SECTION 1 - INTRODUCTION

The following document is an update of the December, 1983 Wastewater Management Plan for the Jurupa Community Services District (District) which is located in Western Riverside County (Figures 1-1 and 1-2). The District provides sewer service to approximately 26,000 acres within its boundaries. The JCSD also provides water within its boundaries to all parcels except for a few that are on private wells.

Previous to 1986, the District encompassed approximately 18,000 acres. In October of 1986, the District approached the Riverside County Local Agency Formation Commission ("LAFCO") regarding a proposal to annex approximately 7,200 acres to the District. The annexation of the area which is commonly referred to as the "Eastvale Area" was approved by LAFCO in August of 1987. As shown on Figure 1-2, the area that was annexed is bounded on the south by the Santa Ana River, north by the Riverside/San Bernardino County boundary, east by Hamner Avenue and west by Hellman Avenue.

Prior to the annexation of the Eastvale Area, the District's boundary encompassed approximately 18,000 acres. Therefore, the annexation of the Eastvale Area resulted in a significant (40 percent) increase in the District service area. At the present time, the Eastvale Area land use is the fastest developing area in the District. The Eastvale area has a separate Master Sewer Plan that was developed in 1999. Due to the explosive growth in the area, this separate document was recently amended in February of 2004.

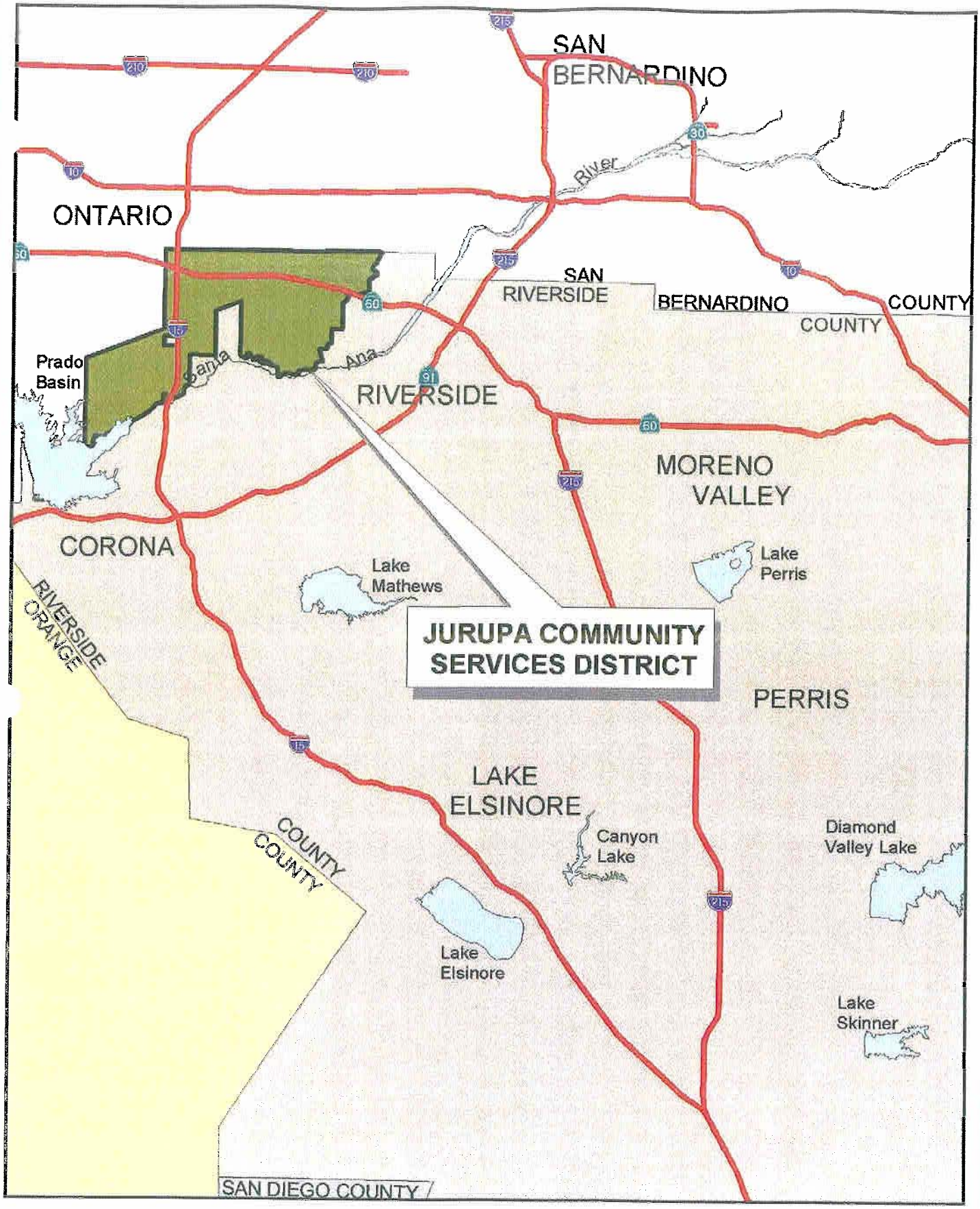
Purpose

The purpose of the Master Sewer Plan is to provide the District with a planning document that will outline a program to provide for the construction of "backbone" trunk sewer facilities for areas within the District, excluding the Eastvale Area, which is previously indicated under separate cover.

SCOPE OF REPORT

In order to accomplish the objectives of this report, the scope of the study includes the following:

1. Research and data collection;
2. Review of existing and projected study area characteristics;
3. Development of design criteria and basis of cost estimates;
4. Evaluation of existing facilities;
5. Determination of projected wastewater flows;
6. Hydraulic analysis of existing system;
7. Hydraulic analysis of design year system;
8. Development of capital improvements required and estimated costs associated therewith.

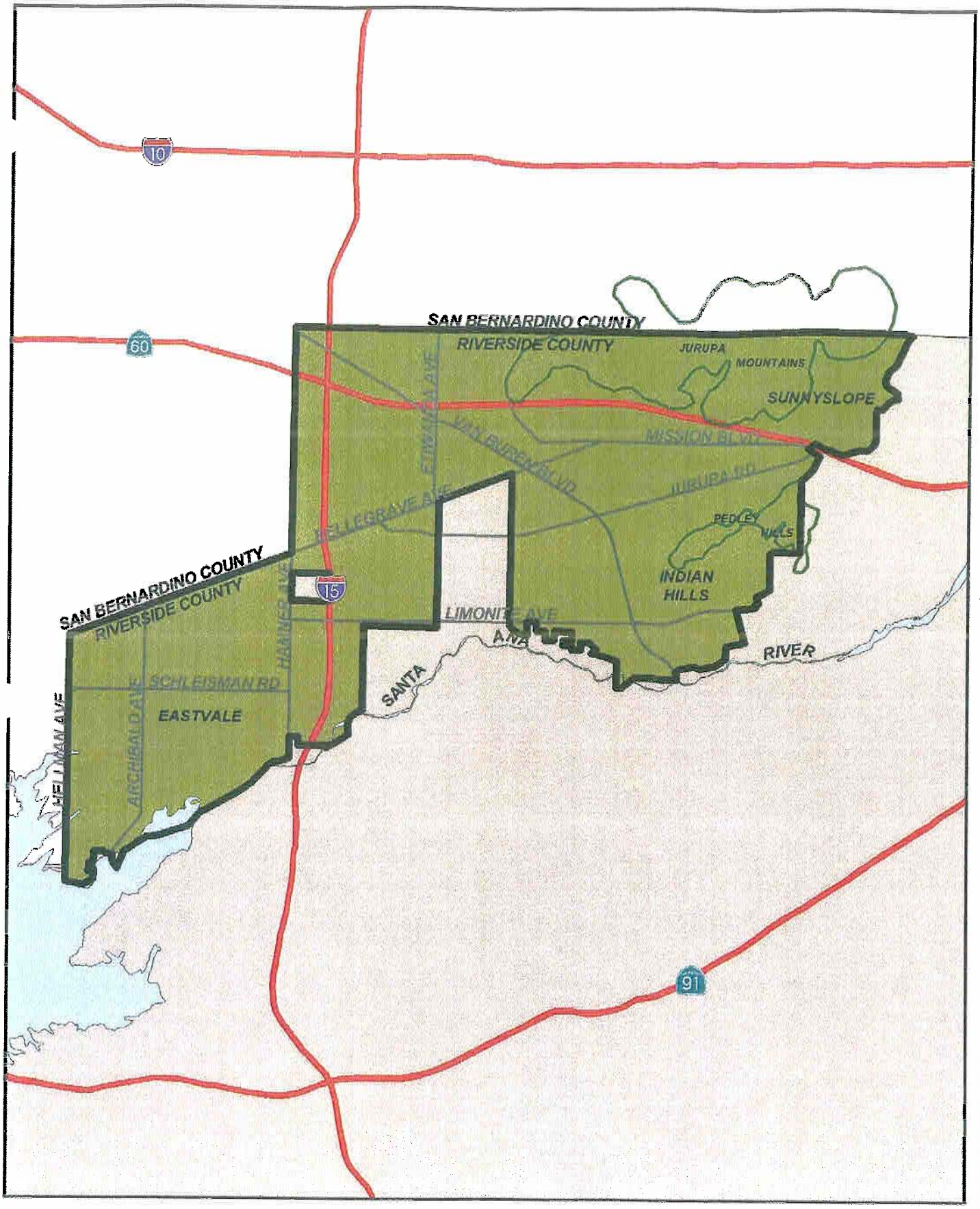


Not to Scale

ALBERT A WEBB ASSOCIATES ENGINEERING CONSULTANTS

Figure 1-1

Regional Location Map



Not to Scale

ALBERT A WEBB ASSOCIATES ENGINEERING CONSULTANTS

Figure 1-2

JCSD Boundary Map

ACKNOWLEDGEMENTS

Albert A. Webb Associates acknowledges with thanks the information and advice provided by various individuals during the preparation of this report. In particular, they are:

JURUPA COMMUNITY SERVICES DISTRICT

Board of Directors

Ken McLaughlin, President
Jack Smith, Vice-President
Paul Hamrick, Director
James Huber, Director
Curtis Hummel, Director

District Staff

Carole A. McGreevy, General Manager
Tom O'Neill, Senior Project Manager
Cheryl Russell, Administrative Manager/Deputy General Manager
Dan Ducasse, Safety Manager

Personnel

Albert A. Webb Associates formed a planning team consisting of its own planning and design engineers to prepare this report.

This report was prepared by:

Sam I. Gershon, P.E., Senior Vice President / Principal-in-Charge
Wallace H. Franz, P.E., Vice-President / Project Manager
Sinnaro Yos, P.E., Engineer
Kris Danielson, Associate Engineer
Brian Camp, GIS Specialist
Kelly Ganzer, Word Processing

SECTION 2 - EXISTING AND PROJECTED LAND USE AND POPULATION GROWTH

The purpose of this section is to provide background information on the area and population characteristics of Jurupa Community Services District.

STUDY AREA BOUNDARIES AND COMPOSITION

Jurupa Community Services District is located in western Riverside County (Figures 1-1 and 1-2) and encompasses approximately 26,000 acres of land. The District is bounded by the San Bernardino / Riverside County line to the north and west, the Santa Ana River to the south, and Pedley Hills to the east (Figure 1-2). JCSD serves the communities of Glen Avon, Mira Loma, Sunnyslope, Indian Hills, Sky County, Pedley, and Eastvale.

The District has a variety of topographic features associated with it, with elevations ranging from 560 feet to 2,230 feet. Within the District's service area are the Jurupa Mountains, which are located in the northern portion of the District, and the Pedley Hills, which are located in the eastern portion of the District. The balance of the service area consists of alluvial plains, which slope southwesterly to the Santa Ana River. More than 80 percent of the District is comprised of land with a natural slope of less than 12 percent; the remainder is divided between the categories of 12-25 percent and above 25 percent.

EASTVALE AREA ANNEXATION INTO THE DISTRICT'S SERVICE AREA

The Eastvale Area was annexed into the Jurupa Community Services District (JCSD) in 1987, though its wastewater collection system operates independently from the rest of the District. For additional information such as hydraulic analysis and modeling data, refer to the Jurupa Community Services District, Eastvale Master Sewer Plan, May 1999 and the Eastvale Master Sewer Plan Update (February, 2004).

EXISTING LAND USE ANALYSIS

Plate 1 provides an aerial view of the District. There are dense (mostly ½ acre lots) residential developments in the central, eastern, and southeastern regions, in the areas of I-15 Corridor, Sky Country, Sunnyslope, and Indian Hills. The area north of Galena Street and between Etiwanda Avenue and Hamner Avenue is heavily occupied by industrial warehouses. These areas are serviced by facilities financed by Community Facilities District (CFD) No. 1. The Eastvale area (west of Hamner Avenue) mainly consists of agricultural lands and residential developments. The Eastvale Area is quickly converting from an agricultural area (mostly dairies) to residential (4 EDU's per acre). There are open space and/or conservation areas in the northeastern portion of the District, as well as the southern region, near the Santa Ana River.

PROJECTED LAND USE ANALYSIS

Plate 2, which is based on the RCIP for the Jurupa and Eastvale Land Use Plan, depicts the different land uses for ultimate buildout conditions. It is noted that ultimate buildout conditions yields ultimate wastewater flows, which will be discussed in later sections. Table 2-1 tabulates the projected land uses within these areas.

The "original" JCSD Service Area (prior to annexation of the Eastvale Area)

The projected land use for this area is based on the April, 2001 Preliminary Riverside County Integrated Project (RCIP) Jurupa Area Land Use Plan and the existing and proposed land use within the Sky Country Development. The District will remain predominantly residential, with mixed land uses scattered throughout.

The Eastvale Area (annexed into JCSD in 1987)

The projected land use for this area is based on the April, 2001 Preliminary Riverside County Integrated Project (RCIP) Eastvale Area Land Use Plan, as well as tentative tract maps and the I-15 Corridor Specific Plan.

Table 2-1. Jurupa Community Services District Land Use Summary

Land Use Characteristics	Original JCSD Service Area (Acres)	Eastvale Area (Acres)	Total (Acres)
Residential			
Rural Res. (Less then 0.2 DU per AC	8	0	**8**
Very Low Density (0.4 to 2 DU per AC)	5,378	203	**5,581**
SP125-W (2 DU per AC)	0	940	**940**
Low Density (2 to 5 DU per AC)	1,398	2,491	**3,889**
Medium Density (5 to 8 DU per AC)	404	78	**482**
Med. to High Density (8 to 14 DU per AC)	31	0	**31**
High Density (14 to 20 DU per AC)	18	0	**18**
Proposed Developments	0	2,527	**2,527**
Commercial			
Retail	869	361	**1,230**
Office	0	0	**0**
Community Centers	46	153	**199**
Industrial			
Light Industrial	2,970	364	**3,334**
Heavy Industrial	337	0	**337**
Business Park	1712	81	**1,793**
Public Facilities	144	0	**144**
Open Space			
Conservation	75	0	**75**
Conservation Habitat	30	0	**30**
Recreation	351	141	**492**
Rural	34	76	**110**
Water	83	0	**83**
Mineral Resources	150	0	**150**
Areas Outside Wastewater Tributary Boundaries	2,356	1,435	**3,791**
Agricultural	10	0	**10**
Highway	486	0	**486**
Totals:	**16,890**	**8,850**	**25,740**

The area breakdown in Appendix A is based on tributary drainage areas and will be combined with wastewater generation factors in later sections to determine the ultimate buildout of the District. It is noted that the District's Service Area line goes beyond the tributary boundaries to a certain extent. In most cases the tributary boundary lines match the District Service Area lines, though there are some exceptions (Plate 3). The areas located in the northeast section of the District are bounded by the Jurupa Mountains. The tributary boundary lines were delineated to exclude a significant portion of this mountainous area because of the improbable likelihood of development. Another location of this type of exclusionary delineation would be located in the southwest portion of the Eastvale Area. In this area, the District is bounded by the Santa Ana River Flood Plain. The same philosophy was utilized in delineating the tributary boundaries in this area as well. As with the Jurupa Mountains in the north, the District's Service Area line is located beyond the tributary delineation into the Santa Ana Flood Plain. The land use areas not located with in the tributary boundary consist of conservation, conservation habitat, open space (mineral, recreational, rural and flood zone).

POPULATION PROJECTIONS AND GROWTH RATE

According to the Southern California Association of Governments (SCAG), the population within the District was approximately 57,000 as of 2000. The total population for the District, as projected by SCAG, will reach nearly 137,000 by 2025 (Table 2-2). This is an average growth rate of about 4 percent per year.

Table 2-2. Jurupa Community Services District Population Projection (including Eastvale) [1]

Year	Total Population
2000	57,163
2005	70,155
2010	84,840
2015	98,145
2020	116,995
2025	136,681

[1] Javier Minjares, Southern California Association of Governments, February 7, 2002.

The information provided on the RCIP of Jurupa and Eastvale Area Land Use Plans were utilized in developing Table 2-1 and Appendix A. Based on these plans, the total projected number of dwelling units or households for buildout conditions is 42,680 EDU's[1]. This value can be utilized to determine the total buildout population for the District. The buildout population can be calculated by utilizing a value of capita per EDU multiplied by the total EDU. To determine population projections for the District, an average number of capita per household must be applied. The preliminary RCIP County of Riverside General Plan for Western Riverside County uses a factor of 3.01 capita per household (Appendix B) while the 2000 U.S. Census Bureau Data for Riverside County utilizes 2.98 capita per household (Appendix C). When reviewing the U.S. Census Bureau Data per Census Tract within the JCSD Service Area, this value ranges from 3.38 to 4.06 capita per household (Appendix D) for areas within the District. Applying these factors yields the following results:

Standard	Capita per Household	Total Projected EDU's	Total Projected Population
Western Riverside County	3.01	42,680	128,467
2000 U.S. Census Per Average Census Tract	3.72	42,680	158,770
2000 U.S. Census Bureau Data Per County	2.98	42,680	127,186

The following is a summary of buildout population:

SCAG 2025 Population Prediction at 4% Annual Growth Rate:	136,681
RCIP for Western Riverside County at 3.01 Capita/EDU:	128,467
2000 U.S. Census Data per Tract at 3.72 Capita/EDU:	158,770
2000 U.S. Census Data per County at 2.98 Capita/EDU:	127,186
Average of the Above Buildout Population Projections:	137,776

There is an approximate 20% differential between the highest and lowest projections with an average population projection of 137,776. This differential is acceptable considering that fluctuations in growth may occur in the projected period. Figure 2-1 depicts the projected growth rate presented in Table 2-2 by SCAG. Also plotted on Figure 2-1 are the projected buildout populations as presented above. In review of this figure as well as the data presented in this section, the population growth rate of an annual 4% is acceptable to be utilized for planning purposes.

[1]This number does not include any equivalent dwelling units that may occur in the potential CFD land conversion area shown on Plate 3.

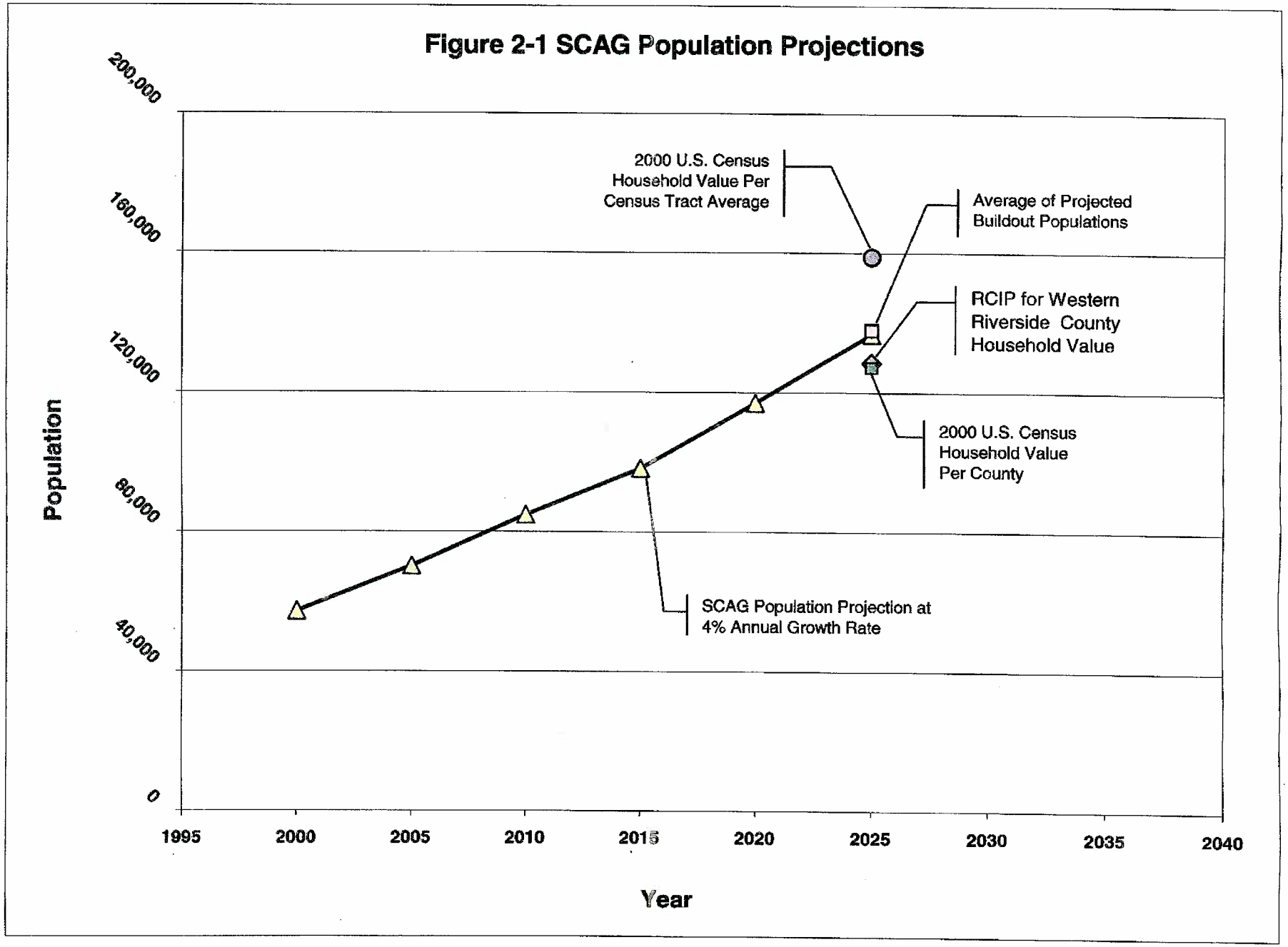


Figure 2-1 SCAG Population Projections
Population
200,000
160,000
120,000
80,000
40,000
0
1995
2000
2005
2010
2015
2020
2025
2030
2035
2040
Year
2000 U.S. Census Household Value Per Census Tract Average
Average of Projected Buildout Populations
RCIP for Western Riverside County Household Value
2000 U.S. Census Household Value Per County
SCAG Population Projection at 4% Annual Growth Rate

SECTION 3 - ANALYSIS CRITERIA

The following section discusses criteria used to evaluate the District's wastewater system. Specifically, the evaluation included the following:

- Projected Wastewater Flow;
- Facility Design;
- Preliminary Sewer Layout and Service Area;
- Cost Estimation;
- Alternative Evaluation.

PROJECTED WASTEWATER FLOW

This section describes the criteria used to project the quantity of wastewater flow to the District's facilities. As a result, the size of the pipelines and lift stations, along with treatment plant capacity, will be determined.

Consideration was given to both dry weather and wet weather flows in order to design the proposed trunk sewer system. Since most of the sewers in the study area will lie above the groundwater table, infiltration during dry weather periods is assumed to be negligible. However, wet weather infiltration plus direct storm inflow must be added to dry weather flows to obtain the total wet weather flow. Wet weather flows determine the hydraulic capacity of pipelines and other facilities such as lift stations and inlet and outlet structures. There are infiltration problems in several areas within the District. These will be discussed in more detail in a following section.

This section defines the elements considered in formulating the projected flows that will be associated with the tributary sewage flow areas and land use. Six elements of wastewater flow are examined: dry weather flows, infiltration/inflow, wet weather flows, wastewater generation, peak flow factors, and large point sources and related peaking factors.

Domestic Sewage

The domestic wastewater generation factor was developed based on actual flows experienced at Plant 1 (Regional Wastewater Pump Station) and Plant 2 (Indian Hills Wastewater Reclamation Plant) (Plate 3). Flow records from these locations were collected (Appendix E). The wastewater flow readings were evaluated in conjunction with the number of equivalent dwelling units (edu) that are tributary to each plant. The wastewater at Plant 1 averaged 3.23 mgd during 2001, collecting from 8,549 edus. Therefore, the Plant 1 tributary area averages nearly 380 gpd/edu. The wastewater at Indian Hills averaged 0.49 mgd during 2001, collecting from 2,459 edus. Therefore, the Plant 2 tributary area averages about 200 gpd/edu. As can be seen, this is a wide range of wastewater generation from the different areas that have been analyzed. The weighted average between Plant 1 and Plant 2 amounts to nearly 340 gpd/edu. However, the 340 gpd/edu includes commercial and industrial flows. Therefore, this report will use the current adopted District standard domestic wastewater generation factor of 280 gpd/edu.

Commercial/Industrial Sewage

A detailed analysis of several commercial and industrial areas within the District was conducted, particularly in the region north of Bellegrave Avenue, between Hamner Avenue and Etiwanda Avenue (C.F.D. No. 1). The analysis indicates that there is a wide range of wastewater generation factors. For example, the Price Costco development (one of the lower wastewater generators) produces less than 300 gpd/ac as opposed to the Metal Container Corporation development that can produce as high as 5,480 gpd/ac. The generation factor adopted by the District and utilized in this report is 2,000 gpd/ac.

Miscellaneous Land Use Sewage

Due to the variety of public facilities, such as post offices, fire stations, parks, etc., this report assumes a wastewater generation of 1,000 gpd/ac for public uses.

A brief study was conducted to determine the wastewater generation factor for schools. Based on data collected from the District, it was found that Jurupa Valley High School averaged about 0.035 mgd in domestic water usage during 2001. It is presumed that the majority of this water drains into the sewer system; therefore, it can be estimated that the average daily sewer flow is about 0.035 mgd. With approximately 2,750 students, this averages to be about 13 gpd/student.

This result was compared to data from "Wastewater Engineering Disposal Treatment" by Metcalf & Eddy, Inc., which recommends different wastewater generation factors dependent upon the grade level of schools. These factors are as follows: 10 gpd/student for elementary schools, 15 gpd/student for middle schools, and 25 gpd/student for high schools.[1] Based on this information, the 2,750 student population would theoretically generate an average of nearly 0.069 mgd. Because this approach anticipates more conservative estimated flows, this report will utilize these wastewater generation factors as described.

Dry Weather Flows

Dry weather sewage flows generated within the study area include domestic, commercial, and industrial wastes. The majority of the sewers in the study area are located above two major flood elevations: Santa Ana River 100-year flood elevation (elevation varies along the river) and the proposed Prado Dam flood inundation elevation (566'). Since the proposed pipelines will lie above the groundwater table, infiltration during dry weather periods has been assumed to be negligible.

Infiltration/Inflow

In order to design pipeline improvements, it is necessary to establish values for the peak flows, which also entails an allowance for infiltration/inflow. A starting point in developing this allowance for a sewer agency normally begins with a review of recorded data. Review of District flow records for Plant 1 (Regional Wastewater Pump Station) and Plant 2 (Indian Hills Wastewater Reclamation Plant) are provided in Appendix E. A review of flow data during inclement weather was then made to determine the extent of infiltration/inflow. As can be seen on the flow charts for both plants (Appendix F), there are definite peaks of inflow that distinguish direct stormwater inflow.

As previously mentioned, Plant 1 averages 3.23 mgd. The storm events in the month of February 2001 generated the maximum wastewater flow for the year. Plant 1 received as high as 4.71 mgd, 1.48 mgd higher than average. About 9,274 acres are tributary to Plant 1, which implies a maximum infiltration allowance of 160 gpd/ac under these conditions. The flow records to Plant 2 vary from a monthly average daily flow of 0.21 mgd in February, 2001 to 0.69 mgd in August, 2001 (Appendix E). Due to the large variance in flows to Plant 2, a separate infiltration/inflow estimate was not made. The study will utilize 160 gpd/ac for infiltration/inflow allowance for sewers tributary to Plant 1 and Plant 2.

Infiltration problems are being controlled to a certain extent with new developments in pipe jointing techniques. However, proper inspection during the construction phase is a key element in reducing infiltration. Current infiltration specifications are generally in the range of 50-200 gal/in/dia/mile of sewer pipe per day[1].

Storm inflow can be controlled with proper storm drainage in all areas, as they are sewered. Additionally, a continuous program for detecting and eliminating sources of inflow such as flooded manhole covers and roof drain or catch basin connections is a must.

In areas of new construction, this study uses and infiltration/inflow allowance of 50 gpd/ac. The basis of this allowance is shown in Appendix G.

Wet Weather Flow

As previously discussed, wet weather flow must be used to determine the maximum hydraulic loading on pipelines and various appurtenances. Since sewer lines are not anticipated to lie below the groundwater table, dry weather infiltration is considered to be negligible. However, wet weather infiltration plus direct storm inflow must be added to the dry weather flows to obtain the total wet weather flow. Direct storm inflow is distinguished from wet weather infiltration by the rapidity with which inflow begins and ends after a period of rainfall. Infiltration, on the other hand, may persist for an extended period after the cessation of rainfall.

This study uses the previously described dry weather flow and infiltration allowances to determine the total wet weather flow.

Wastewater Generation Factors

A summary of the wastewater generation factors utilized in the report is provided in Table 3-1.

[1] "Gravity Sanitary Sewer Design and Construction," American Society of Civil Engineers, 1982, Manual and Reports of Engineering Practice No. 60.

Table 3-1 – Summary of Wastewater Generation Factors

Land Use	Wastewater Generation Factor
Residential Wastewater	280 gpd/edu
Commercial/Industrial	2,000 gpd/acre
Public Uses (excluding schools)	1,000 gpd/acre
Elementary Schools	10 gpd/student
Middle Schools	15 gpd/student
High Schools	25 gpd/student
Infiltration/Inflow (existing development areas[1])	160 gpd/acre
Infiltration/Inflow (current and future development areas)	50 gpd/acre

Wastewater Peak Factors

The flow used for the design capacity for sewers and sewage lift stations is the "computed peak flow," or facility "design flow," which is determined on the basis of projected land use area, the unit wastewater generation factor assigned to the particular land use designation, and a peak factor to account for the diurnal flow rate variations.

The District currently utilizes the following equation to obtain peak flows:

$Q_{PK} = 2.5\ Q_{ADF}^{(0.91)}$, where

Q_{PK} = peak flow, in mgd
Q_{ADF} = average daily flow, in mgd

A review of recorded District data (Appendix E) indicates Plant 1 currently has an average daily flow of approximately 3.23 mgd. The flow charts provided in Appendix F indicate that the wastewater peak flows can exceed the capacity of the flow meter (5,000 gpm, or 7.2 mgd), especially during wet weather flow. Consequently, the wastewater peak flow varies from 5.0 mgd to over 7.2 mgd, with actual peak factors calculating to be about 1.5 to over 2.2 (Appendix H).

Large Point Sources and Peaking Factors

This section would normally identify large wastewater sources and/or sources which have extra-ordinary flow or peaking factors. Interviews with District staff have indicated there is currently one large point source of wastewater in the District. Metal Container Corporation, located at Etiwanda Avenue and Philadelphia Avenue, generates about 0.15 mgd into District's sewer system.

[1]Areas in which the sewer system was constructed more than 10± years ago.

The Chino 2 Desalter and the Ion Exchange Plant are two proposed facilities that could potentially have significant impact as large point sources in the future. The Desalter (18-mgd RO plant and Ion Exchange Facility) is proposed to generate 3.46 mgd of brine. The capacity Ion Exchange Plant (12.7 mgd), under ultimate conditions, will generate 0.59 mgd of brine. Both of these facilities will be located south of State Highway 60. The Chino 2 Desalter will be located just west of Etiwanda Avenue and the Ion Exchange Plant to the east of Etiwanda Avenue (Plate 3).

The computer modeling process will input these large point sources as separate flows.

Facility Design

Wastewater system design criteria basically falls into one of three wastewater facility components: (1) transport facilities; (2) treatment facilities; and (3) effluent disposal facilities. The following discusses each one of these three components. It should be noted that the majority of the following criteria are from the Jurupa Community Services District's Standards Manual dated July, 2001.

Transport Facilities

Collection sewers in this report are considered to be pipes less than 10 inches in diameter. These pipes should be designed under peak conditions to be flowing at one-half full. Collection sewers are typically designed to flow one-half full for maintenance purposes and since collection pipelines serve smaller areas, they can experience high peak factors. Collection sewer diameters are determined by means of Manning's formula, using a roughness coefficient (n) of 0.013.

Trunk and Interceptor Sewers

Trunk sewers in this report are considered to be pipes 10 inches and larger in diameter. The capacity to be provided in each section of a trunk sewer is based on the peak rate of flow calculated for the area tributary to that section. For each area this rate is the summation of peak domestic, commercial, and industrial rates plus storm water inflow which is known as the "peak wet weather flow" or "design flow."

A summary of design criteria for gravity flow sewer pipelines is as follows:

Trunk sewer lines are sized on the principle of conducting wastewater at a minimum velocity of 2 ft/sec when flowing with a maximum depth to diameter ratio (D/d) of 0.75, and are sized to carry peak flows without surcharge. A mean roughness coefficient (n) of 0.013 is used for new pipe sizing. A safety factor should be included in the design of all gravity flow pipelines to account for errors due to the variability of the initial approximation of flow and partial clogging of the sewer. The method of accounting for the inherent variables is to limit the depth of flow. Table 3-2 shows the design depth of flow ratio.

Table 3-2 – Maximum Depth of Flow to Pipeline Diameter Rates

Pipe Diameter (In Inches)	Ratio of Depth of Sewage Flow to Diameter of Sewer
8	0.50
10 and greater	0.75

Since low velocities in the sewers will cause deposition of solids and result in sulfide problems, minimum slopes should be set to maintain a flow velocity of not less than 2 feet per second during maximum flows. Table 3-3 provides a list of the minimum allowable slopes.

Table 3-3 – Minimum Pipeline Slope Criteria

Pipe Diameter (In Inches)	Minimum Slope (Feet/100 Feet)
8	0.40
10	0.32
12	0.24
15	0.16
18	0.14
21	0.12
24	0.10
27	0.08
30 and larger	0.07

When possible, the pipelines should be designed to flow by gravity. Sewage pump stations should be installed only when existing topography prevents gravity flow or to avoid excessive trench depths.

Manholes shall be located at all junctions, all changes in grade, all changes in direction, and all changes in pipe size. Where the distance between manholes required for the foregoing reasons exceeds 350 feet, good judgment should be used in placing intermediate manholes at points of probable sewer intersections, or lacking other criteria, at approximately equal intervals. In general, the maximum of 350 feet should be observed.

Manhole diameters are determined based upon pipeline diameters as shown on Table 3-4.

Table 3-4 – Minimum Manhole Diameter Summary

Largest Pipe Diameter	Minimum Manhole Diameter
8" – 12"	48"
15" – 30"	60"
36" – 42"	72"*
48" – 72"	County Sanitation District of Los Angeles County Standard Manhole, Type "B"

*72" manhole diameter will be the minimum used at all junction locations.

Vitrified clay pipe (VCP) material, unless otherwise indicated, is assumed to be used in future construction for purposes of comparative cost evaluation. However, final recommendation of any specific sewer pipe material will be made at the time of final design.

In addition to the above mentioned manhole design criteria, the following design parameters shall also be used in the final design process.

- Manholes will be constructed of precast reinforced concrete rises and top sections in compliance with ASTM C478. Additionally, there may exist the possibility of using watertight manhole covers.
- Manholes in pipelines where hydrogen sulfide may be problematic should be lined with PVC lining to minimize chemical deterioration. Manhole bases should be lined with PVC lining or a special protective coating.
- All manholes deeper than 25 feet, plus or minus, may require safety platforms installed.
- Where future sewerlines will likely be connected into the trunk sewer manholes, an appropriately sized stub will need to be installed.

Initially, some of the new trunk sewers or interceptors may not have sufficient velocity (greater than 2 fps) to prevent deposition of solids. These lines may require special preventive maintenance or other control procedures for the first few years to minimize the formation of hydrogen sulfide gases, which could damage the sewer system.

In general, large trunk and interceptor sewers should be designed for long-term requirements. Gravity flow pipelines should be designed with the latest pipe materials, providing rubber or plastic ring joints to assure permanent water tightness. Final recommendation of any specific sewer pipe material, however, will be made at the time of final design.

Inverted Siphons

The purpose of an inverted siphon is to carry the flow under an obstruction such as a stream or depressed highway and to regain as much elevation as possible after the obstruction has been passed. Self-cleaning velocities (2 to 3 fps) should be obtained at least once a day, even during the

early years of operation. To insure adequate minimum velocities, it may be necessary to use multiple diameter pipelines. Flow in these lines can be regulated by control structures such as overflow weirs. Inverted siphons may require cleaning more often than gravity sewers.

A conservative Hazen-Williams roughness coefficient (C) of 100 (equivalent to Manning's n of between 0.014 and 0.018) should be used to calculate head loss. Material that would be considered for siphons include VCP and lined ductile iron pipe. Final selection of pipe materials would be made during the detailed design phase.

Force Mains

Force mains are designed to flow full with minimum velocities required to prevent deposition of suspended solids. Velocities normally fall within a range of from 3 to 5 fps. A velocity of 2 fps is considered to be sufficient to prevent settling of solids, but velocities of between 2.5 and 3 fps are required to re-suspend those which already have accumulated in the force main. If flushing velocities are attained once or twice a day, excessive deposits are not likely to occur.

Material that would be considered for force mains are polyvinyl chloride (PVC) and mortar-lined ductile iron pipe. Final selection of pipe materials would be made during the detailed design phase. Diameters are calculated using the Hazen-Williams formula with a roughness coefficient (C) of 110.

Sewage Pump Stations

Small sewage pump stations should have two pumping units, with each unit sized to pump the peak design flow. One pumping unit operates during each pumping cycle with the other acting as standby. These units alternate in operation so that equal wear can occur. Typically, the pumping units are a submersible design with the units placed in a manhole or precast vault structure.

Intermediate sized sewage pump stations should be planned to have three units of usually equal size. One or two units can operate during a pumping cycle with the third unit acting as a standby in case one of the primary units fails. Two pumping units operating at the same time should be sized to handle the peak design flow. Intermediate sized sewage lift stations can have submersible pumping units or be of a wet well / dry well design.

Large sewage pump stations should be designed so ready expansion can occur when necessary. Thus, mechanical equipment may be installed at various stages of development. Large sewage pump stations typically provide for complete separation of wet and dry wells with easy access to both.

In all cases, standby drives or power units should be provided in cases where bypassing cannot be allowed around the sewage pump station.

Wastewater Treatment Plants

The primary considerations in the design of a wastewater treatment plant are the required capacity and the degree of treatment. Plant capacity is usually expressed in terms of average dry weather flow. Degree of treatment is based on requirements established in the waste discharge permit issued by the California Regional Water Quality Control Board. Plants are designed with sufficient capacity to handle peak organic, as well as peak hydraulic loads and are planned for enlargement to handle future increases.

The District owns one wastewater treatment plant, the Indian Hills Wastewater Reclamation Plant. It currently treats only the sewage generated within the Indian Hills area of the District. There are no plans of expanding this plant in the future. Therefore, criteria are not provided with regards to treatment plant design. Furthermore, because of its specialized nature, treatment plant design criteria is not typically addressed in the scope of master sewer plan. Though owned by JCSD, the Indian Hills Wastewater Reclamation Plant is currently operated by the City of Riverside.

The balance of the wastewater generated within the District is disbursed to treatment facilities operated by other agencies. The Santa Ana Regional Interceptor (SARI) line, which collects from residential, commercial and industrial areas in the District, discharges to the treatment facilities of Orange County Sanitation District. The remaining wastewater is pumped to a treatment plant owned and operated by the City of Riverside.

Effluent Disposal Systems

In general, effluent disposal can be accomplished with one of four methods. These are: (1) disposal into a body of water or drainage area; (2) irrigation; (3) percolation ponds; and (4) industrial reuse. For any alternative involved, the effluent quality and consequently, the degree of treatment required must comply with the regulations and objectives of the applicable local, state, and federal agencies. The four disposal methods are discussed below.

Disposal into a Body of Water or Drainage Area

Wastewater discharge requirements are extremely important with this method of disposal. Based on the discharge requirements, an advanced treatment process, such as demineralization, may be required. However, based on a higher quality water supply, it is not anticipated that it would be necessary to provide demineralization facilities. It is anticipated that the mineral quality of the effluent from industrial facilities will be controlled in order to meet the anticipated Waste Discharge Requirements.

Irrigation

This method consists of using the effluent as an irrigation source for different crops. Using the Blaney-Criddle formula and an irrigation efficiency value, the water use (acre feet/acre/year) of the crop can be calculated. Using this figure, the amount of land necessary for this disposal method (including landscape irrigation) can be determined.

Percolation Ponds

The size of percolation ponds is determined by the average daily flow and the rate at which reclaimed water is expected to percolate into the ground. An extensive and thorough site investigation to insure that favorable conditions exist should be conducted prior to the final site selection. Year-round operation of percolation ponds is possible in the Southern California area; however, proper operation of the facilities requires that a period of basin drying be permitted intermittently to maintain aerobic conditions in the basins. This reduces clogging of pores in the soils and restores the infiltration/percolation capacity of the basins. The operations cycle normally used includes two weeks of inundation followed by an 8 to 10-day dry period in summer and 20 days in winter. Basin bottoms are assumed to be bare soil.

Industrial Reuse

Industrial reuse realizes benefits such as water conservation, since the effluent could be used where only potable water is normally provided. Uses such as cooling water supply, hydraulic conveyance, gravel washing, fire protection, and a process water supply are potential applications. This type of effluent disposal method may not present itself until it is known what type of industry will develop. In addition, industrial use would require the installation of a separate waste-water distribution system. The cost of such a distribution system could be prohibitive. This alternative is feasible if one industrial user near the proposed reclamation plant had a need for the effluent.

Effluent Reclamation Potential

Evaluation of project alternatives must include the development and consideration of possible methods offering reclamation and reuse of plant effluent. The State Board requires reclamation and reuse of treated wastewater where such use is shown to be a cost-effective long range solution to the total needs of the area.

A review of the study area characteristics indicates the following potential beneficial uses of reclaimed wastewater:

1) Groundwater recharge
2) Landscape irrigation
3) Stream flow augmentation
4) Recreational impoundments
5) Agricultural irrigation
6) Industrial reuse

A detailed analysis of effluent reclamation potential and related planning activities are beyond the scope of this report.

Preliminary Sewer Layout and Service Area

In order to determine preliminary sewer pipeline layouts and service areas, tributary wastewater flow areas had to be developed. The tributary sewage flow areas (service areas) shown on Plate 3 were developed based on two criteria:

1. First, in undeveloped regions, tributary sewage flow areas were determined from Riverside County Flood Control Topographic Maps (1 inch equals 200 feet). Only generalized tributary areas could be determined due to the accuracy of the maps. The exact drainage boundaries may vary when future engineering plans are developed. Therefore, in the undeveloped areas, the wastewater was assumed to flow based on the natural drainage patterns of the existing topography.
2. In the developed areas of the study area, the tributary sewage flow areas were based on the layout of the existing collection system. These areas are also approximate since many areas adjacent to the existing sewer lines may be able to drain differently than originally assumed.

To permit an analysis of the finances necessary to construct new sewers, preliminary layouts or designs of the proposed facilities were made for each service area. Many factors may change with a

more focused design engineering report. Therefore, it is expected that relocation and/or resizing of some of the facilities may be required at a later date as a result of detailed engineering analysis during the preparation of construction drawings and specifications.

Based upon the locations of the existing sewer lines, capital improvement projects proposed by the District, and the tributary topographical areas previously discussed, the study area was divided into 86 sewer service areas. These service areas are shown on Plate 3.

COST ESTIMATION

Proper and consistent cost estimation is essential in determining the feasibility of a proposed project. Construction costs for all plans are based upon preliminary layouts of proposed facilities. For estimating purposes, the prices of comparative work were obtained from a variety of available sources of current information such as recent project bid data, literature publications, telephone and personal contacts with manufacturers and suppliers of equipment. It should be noted that the unit prices applied to sewer pipelines in the estimates take into account the costs of A.C. pavement removal, disposal, replacement, and cap where these lines occur in paved roads and clearing, grubbing and 12'-wide access road, construction costs where these lines occur outside of paved streets.

In reviewing the cost estimates presented herein for the proposed projects, it is essential to realize that changes in estimates during final design will alter the totals to some degree. Furthermore, future changes in the cost of material, labor, and equipment certainly will cause comparable changes in the cost summarized herein. Some of the specific cost- estimating factors are discussed in the following subsections. The cost data presented are comprised of two primary components: (1) estimated construction costs, and (2) estimated project costs (incidental costs).

Estimated Construction Costs

The basic estimated construction costs apply to preliminary design and layout of major facilities required for the proposed facilities. In such layouts, detailed construction drawings and specifications are not required. Instead, reasonably close approximations of the size, location, route and cost of the various facilities were developed in sufficient detail to permit cost estimates to be made. Estimated construction costs were based upon what one might expect of a "low bid" price to construct the required improvements.

Estimated Project Costs

In addition to construction costs (commonly referred to as "hard costs"), incidental costs (commonly referred to as "incidental" or "soft costs"), which are necessary during the planning, design, and construction of the project, must be included to obtain an overall or total project cost. The total project cost consists of construction costs, construction contingencies, design engineering, surveying and mapping, geotechnical, legal and administration, inspection, environmental documentation (excluding an EIR and/or EIS) assessment engineering and finance. The total project cost in this report has been determined to be 1.4 times the estimated construction cost plus land acquisition costs. This additional 40% consists of 15% for contingencies, 15% for engineering fees, and 10% for other costs. It should be noted that the total project cost includes public right-of-

way (R-O-W) portions only (i.e., sewer main to R-O-W line). In areas where existing unsewered structures are to be served, additional on-site costs will be incurred. These private property costs (i.e., abandonment of septic system and construction of the lateral from the R-O-W line to the structure) are not included in the cost estimates provided herein. Private property costs are typically estimated to be $1,500-$2,500 per parcel. Additionally, district sewer connection charges, which are currently at $3,000/EDU, are not included.

Construction Contingencies

A contingency allowance is made for uncertainties associated with preliminary design. Such factors as differences in final lengths and exact topography associated with the pipelines, unknown underground substructures, and changes made during construction, are a few of the many items which may increase contract costs and for which some allowance must be made in preliminary design estimates.

Cost Index and Price Escalation

Construction costs can be expected to undergo long-term changes in keeping with corresponding changes in the national economy. The best available barometer of these changes is the Engineering News-Record Construction Cost Index (ENR-CCI), which is computed from prices of construction materials and labor. For purposes of this report, cost data are based on an ENR-CCI Los Angeles of 7857 (August, 2004). By reference to the ENR-CCI at any future date, the estimated construction costs included herein can be adjusted to match the current costs at that future date. This allows the estimated costs to be updated to the time when actual construction is undertaken.

Engineering Costs

The cost of engineering services for major construction projects may include special investigations, pre-design reports, surveys, foundation explorations, location of interfering utilities, detailed design, preparation of contract drawings and specifications, construction inspection, materials testing, and final inspection of the completed work. Depending on the size and type of the project, the total engineering costs may range from 7 to 20 percent of the contract cost. The lower percentage applies to large projects and to those which do not require a large amount of preliminary investigation. The higher percentage applies to smaller projects or to those which require a relatively large amount of preliminary work.

Legal and Administrative Costs

Legal costs would include items such as assistance in R-O-W acquisition, specification review, construction contract review and approval, coordination during construction, etc. Administrative costs would be those associated with contract administration, progress payments to the Contractor, change orders, notice of completion, etc. Finally, it should be noted that assessment engineering and financing costs are not included in these costs. Assessment engineering and financing costs are those associated with securing funds to pay for the proposed improvements and determination of equitable method(s) of sharing the costs (i.e., costs to benefits). Environmental documentation includes those basic services necessary to obtain environmental clearance to perform the

construction. However, extensive environmental services such as those that would be necessary for an environmental impact report and/or environmental impact statement are not included.

ALTERNATIVE EVALUATION

The following criteria were utilized to evaluate the proposed system alternatives.

Economic Analysis

This review determines which proposed alternatives are the most economical in the long run. This is done in order to recognize the time value of money. Analysis of construction costs only does not always indicate the most economical alternative, due to annual costs (such as operation and maintenance) associated with it. These annual costs, along with the timing of major capital expenditures, must be evaluated to obtain the most economical solution.

Environmental Impacts

The environmental impacts taken into consideration are generally classified into two categories; primary and secondary impacts. Primary impacts encompass those effects which directly relate to the construction and operation of the proposed treatment work. Examples of such impacts include the destruction or damage of archaeological sites or sensitive ecosystems, the displacement of human activity or the pollution of air, water, or land resources. Secondary impacts cover those indirect changes in the environment induced by the project. An example of this type of impact is altering of a sensitive ecosystem due to population growth induced to some degree by the availability of wastewater treatment facilities to handle additional loads, and hence, additional population. A detailed environmental impact report is beyond the scope of this study. However, a cursory look at environmental characteristics involved in the proposed alternatives can be an important evaluation criteria.

Social Impacts

Again, a detailed analysis of this kind is beyond the scope of this study. However, since some improvements may have more adverse social impacts than the others, a cursory look at these impacts should be made. Social impacts include population, economics, public services, energy, and health hazards.

Reliability

The relative degree of assurance of expected project performance depends upon the reliability of the components of the improvements. In general, improvements consisting of fewer and less complex components are more reliable. Each of the wastewater management improvements consists of some of the following components: collection and conveyance facilities, pumping stations, treatment plants and disposal facilities. Performance of conveyance facilities, pumping stations, and percolation ponds, where proposed, are generally quite reliable.

Even the simplest treatment process is likely to have periodic mechanical or process failures. Plants providing the lowest degree of treatment can be expected to perform to their design capability more reliably and consistently than those achieving higher degrees of treatment. However, this advantage becomes relatively small in a large treatment plant where duplication of equipment and competence of operation virtually assure proper performance of even the more sophisticated processes. In

smaller communities, through, it is essential to provide reliable facilities that require a minimum degree of operator expertise and attention. Necessary duplicate supplies of energy and certain treatment process units are provided to assure reliable performance to the maximum extent possible, while maintaining cost effectiveness of the improvement.

Flexibility

Wastewater management plans must be able to adapt to uncertainties in the future. Therefore, the improvement's flexibility becomes an important consideration. Flexibility basically relates to four factors: ease of expansion, ability to meet changes in treatment requirements, ability to meet changes in wastewater characteristics, and changes that may be required in the degree of treatment brought about by improved technology.

Program Acceptability and Feasibility

Implementation feasibility normally relates to the acceptance of the public and the administrative staff to proceed with the project. Generally, this major constraint relates to the availability of sufficient funding needed to actually make the project realistic to the community and to assure that the project is indeed implementable and not simply idealistic.

Specific factors relating to acceptability and feasibility are: (1) amount of land acquisition (both gross acreage and individual easement acquisition); (2) public acceptability; and (3) are there benefits to outside concerns? These specific factors are discussed below.

Land Acquisition

The assumption made here is that the greater amount of land acquisition involved, the greater the chances of having land acquisition problems.

Public Acceptability

The public's reaction to the various alternatives is difficult to assess. Though the public's general attitude can be expected to be diverse, wastewater projects are typically controversial and public reaction is not always rational. Therefore, this category is an important consideration.

Benefits to Outside Concerns

Generally, a project that will benefit a greater number of people will be viewed more positively than one which has limited benefits. For this reason, this category is an evaluation criteria.

Compatibility with Local Planning Goals and Objectives

A project of this nature will involve various governmental agencies. Some of these include the Riverside County Public Works Department, Planning Department, and Flood Control, as well as the State and Riverside County Health Departments and the California Regional Water Quality Control Board. Many of these agencies have goals and objectives for the study area. Therefore, improvement compatibility with these goals is an objective in an evaluation criteria.

SECTION 4 - PROJECTED WASTEWATER FLOWS

This section summarizes the projected wastewater flows in the study area. The flows are calculated based on 86 tributary sewage areas delineated for a more detailed analysis. Plate 3 shows the boundaries of each sewer service area within the District.

TRIBUTARY SEWAGE FLOW AREAS

The tributary sewage flow areas are shown on Plate 3. These areas are divided into four main regions, one for each centralized location where wastewater flows converge:

(1) Indian Hills Water Reclamation Facility, Plant 2 (area shown in purple)
(2) Eastvale Area (area shown in pink)
(3) Community Facilities District (CFD) No. 1 (area shown in grey)
(4) Regional Wastewater Pump Station, Plant 1 (area shown in yellow)

The tributary areas were categorized with an alphabetic lettered prefix. The prefix "E" indicates areas that are in the Eastvale area and "J" indicates all other areas in JCSD.

TOTAL DESIGN FLOWS

In order to design the ultimate sewage system for the District, sewage flow was calculated from each tributary area based on the RCIP Jurupa Area Land Use Plan and the RCIP Eastvale Area Land Use Plan. Appropriate wastewater generation factors, developed in Section 3, were applied to calculate projected flows for each land use, developed in Section 2, for each tributary sewage area within the District.

The details of each tributary area summarized in Appendix A was combined with the wastewater generation factors discussed in Section 3 to determine the total buildout flows for the District. Appendix I is a spreadsheet that was developed to compile and tabulate the different types of land use in acreages and wastewater generation factors. Each row within this spreadsheet represents a tributary sewer drainage area. Each drainage area is broken up into the corresponding land use designations. The areas are multiplied with the corresponding wastewater generation factors to provide for flow values. The values are added up at the end of each row to totalize the flow generated in that tributary area. The summation of the total flows from each tributary area is required to determine the total design flow for the entire District.

Wastewater generation factors were discussed in detail in Section 3. Each type of land use was provided with a designated flow value per acre. For the residential aspect of this analysis, it was required to determine an equivalent number of dwelling units (EDU's) per tributary area before applying these factors.

A review of existing and future schools was conducted to determine the wastewater contribution to the District. Student body population was utilized and incorporated into the spreadsheet in conjunction with the corresponding wastewater generation factors. A review of the school locations in conjunction with Plate 2 was conducted to determine the type of land use the school is situated upon. The total developed acreage utilized by a particular school was deducted from the land use where it was located. For example, the Stone Avenue Elementary School is located within the land use area zoned "Very Low Density Residential". This school utilizes approximately 9.7 acres of this land use. The total area of this land use is approximately 418.1 acres, therefore, to properly account for wastewater generated by the Stone Avenue Elementary School, 9.7 acres was deducted from 418.1 acres thus yielding 408.4 acres. The wastewater generated by the school shall be the number of students attending that school (657 students) multiplied by the corresponding wastewater generation factor of 10 gpd per student (Elementary Schools, Refer to Section 3) thus yielding a total of 6,570 gpd. All schools located within the District boundaries are shown on Plate 4.

A review of the Indian Hills Area was conducted to survey the extent of development within this area. It appears that portions of the area are utilized as golf courses or have hilly terrain. These conditions limit the amount of development in the Indian Hills Area. The April, 2001 Preliminary Riverside County Integrated Project (RCIP) Jurupa Area Land Use Plan will not be utilized in estimating the projected number of residential dwelling units because areas zoned residential may not be developable due to existing site characteristics such as hilly terrain. Estimating the total number of residential dwelling units requires a review of existing and future lots as indicated in the current Riverside County land use database. In addition a review of the existing terrain was conducted to estimate future lots not show in the database (Plate 5). In contrast, areas zoned commercial or industrial will be based on the RCIP and quantified on a per acre basis. It is noted that the area zoned "heavy industrial" per the RCIP Land Use Plan (Plate 2) within Tributary No. J18 is not tributary to the Clay Street Sewer Lift Station (L-7). This area is tributary to the Clay and Van Buren Sewer Lift Station (L-11) which pumps sewer flow directly to the existing 18-inch Regional Forcemain (Plate 5). Wastewater generated within this area does not directly contribute to the wastewater influent flow to the Indian Hills WRF. Table 4-1 tabulates the number of projected residential dwelling units and the acreage of commercial and industrial areas per tributary area for the Indian Hills Area

Table 4-1. Indian Hills Projected Land Use Tributary to Indian Hills WRF Only

Tributary Drainage Areas	No. Of Residential Dwelling Units	Commercial/ Industrial Areas	Schools (No. Of Students)
J16	923	0.2 Acres	0
J17B	811	8.5 Acres	0
J18	744	155.9 Acres	851

The amount of average daily flow projected for each tributary sewage area is tabulated. These projected wastewater flow quantities are used in proceeding sections of this report to determine: (1) whether the existing system is capable of handling the future growth within the sewer service areas;

(2) the diameters and locations of pipelines necessary to convey the projected "buildout" wastewater flows; and (3) to estimate the wastewater treatment capacity for "buildout" conditions.

Table 4-2 summarizes the projected buildout average daily flows within the District (refer to Appendix I for a detailed breakdown of this table). The total projected average daily flow for the District is nearly 22.8 mgd, with about 8 mgd generated from the Eastvale area. These flow values will be utilized in the modeling process for the design of a trunk sewer system to convey the ultimate flow conditions. It is noted that point sources such as the Chino 2 Desalter, the Ion Exchange Plant and Metal Container Corporation were not a part of this spreadsheet but will be incorporated into the model.

Table 4-2. Projected "Buildout" Average Daily Flows For Ultimate Trunk Sewer Design

Tributary Drainage Areas	Residential Average Daily Flow (GPD) (1)	Commercial/Industrial (2) Average Daily Flow (GPD)	Schools Average Daily Flow (GPD)	Total Average Daily Flow (GPD)
JCSD Areas (J1 – J15B, J17A & J19 – J23, J25)	4,415,880	3,404,422	238,625	8,058,927
Indian Hills Area (J16, J17B & J18)	693,840	329,218	8,510	1,031,568
Lower Portion of Tributary Area No. J18	0	153,800	0	153,800
CFD Area No. 1 (J24, J26 – J30)	32,200	5,353,412	0	5,385,612
Eastvale Areas (E1 – E50)	6,254,680	1,594,344	134,800	7,983,824
Total	**11,396,600**	**10,835,196**	**381,935**	**22,613,731**

(1) A wastewater generation factor for residential dwelling units of 280 gpd/EDU was utilized for projecting flows for ultimate trunk sewer design.

(2) Commercial and industrial wastewater generation based on factors set forth in Section 3.

CALIBRATION OF SPREADSHEET

As previously discussed, the buildout flows were developed utilizing a spreadsheet in conjunction with various wastewater generation factors. It is important to benchmark this spreadsheet against existing data to determine its validity. A review of actual flow data, as discussed in Section 3, was conducted to assist in the calibration methodology.

Indian Hills Water Reclamation Facility (Plant 2)

Much of the wastewater processed at the facility is utilized for irrigation of the Indian Hills Golf Course. Irrigation requirements increase during the warmer months while wastewater generated in areas tributary to this facility generally remains the same. To supplement this demand, the District

diverts some flow out of the Regional Force Main (flows that are tributary to Plant 1) for treatment at the Indian Hills Water Reclamation Facility (WRF). This diversion of wastewater flow can be observed in Appendix E of this report. Average daily flow data from the year 2001 was utilized for this observation. For the months of December to April, the plant observed flows ranging from 0.21 to 0.42 mgd. For the months of May to November, the plant observed flows ranging from 0.53 to 0.69 mgd. With these fluctuations, flow information obtained from the Indian Hills WRF cannot be used for benchmarking.

Eastvale Area

Flow information within the Eastvale area is currently being investigated. Under ultimate buildout conditions, this area will be mostly residential developments. Flow data taken at Archibald/Chandler Sewer Lift Station will be reviewed in conjunction with water usage of the homes that are tributary to this lift station. Other sewer lift stations in the Eastvale area will be evaluated in the same fashion as additional information becomes available. The analysis and results will be discussed in the Eastvale Master Sewer Plan Update Letter.

Community Facilities District (CFD) No. 1

A review was conducted to determine the actual wastewater generation factor for industrial/ commercial facilities within the CFD Area No. 1. Information such as 2002 flow data and current parcel maps were reviewed to determine the quantities of flow within the respective trunk sewers and total developed areas.

Wastewater generated within the CFD Area No. 1 is intercepted by a series of trunk sewer systems (Plate 6):

- Etiwanda Avenue Trunk Sewer
- Wineville Road Trunk Sewer
- Hamner Avenue Trunk Sewer

Individual contributors, such as Metal Container Corporation can generation as much as 5,480 gpd/AC. It is noted that this is the highest wastewater generation factor located within District Boundaries. A review of the parcels developed by Metal Container Corporation reveals that this company is utilizing approximately 27 acres. To determine the current average wastewater generation factor tributary to the Etiwanda Avenue Trunk Sewer, the developed parcel areas as well as the wastewater generated by this company must be deducted from the total. The total developed parcels tributary to this trunk sewer is 1,059 acres (Appendix J). Deducting Metal Container's portion (27 acres) leaves 1,032 acres. The total average daily wastewater generated by Metal Container can be determined by multiplying its gross developed area (27 acres) by the generation factor (5,480 gpd/AC) to yield 147,960 gpd. Deducting this value from the total wastewater flow (268,504 gpd) yields 120,544 gpd. Therefore, the wastewater generation factor for areas tributary to

the Etiwanda Avenue Trunk Sewer excluding contributions from Metal Container Corporation is 117 gpd/AC.

A review of 2002 flow data and currently developed parcels was conducted to estimate the average daily flow tributary to each of the trunk systems. Table 4-3 tabulates the results of this review:

Table 4-3. Wastewater Flow Per Trunk Tributary Area

Trunk Sewer Systems	Average Daily Flow (gpd)	Total Developed Parcels (Acres)	Average Wastewater Flow Per Acre Per Trunk Sewer System
Etiwanda Avenue (1)	268,504	1,059	254 gpd/AC
Etiwanda Avenue (2)	147,960	1,032	117 gpd/AC
Wineville Road	26,174	490	53 gpd/AC
Hamner Avenue	45,461	404	113 gpd/AC

(1) With wastewater contributions from Metal Container Corporation

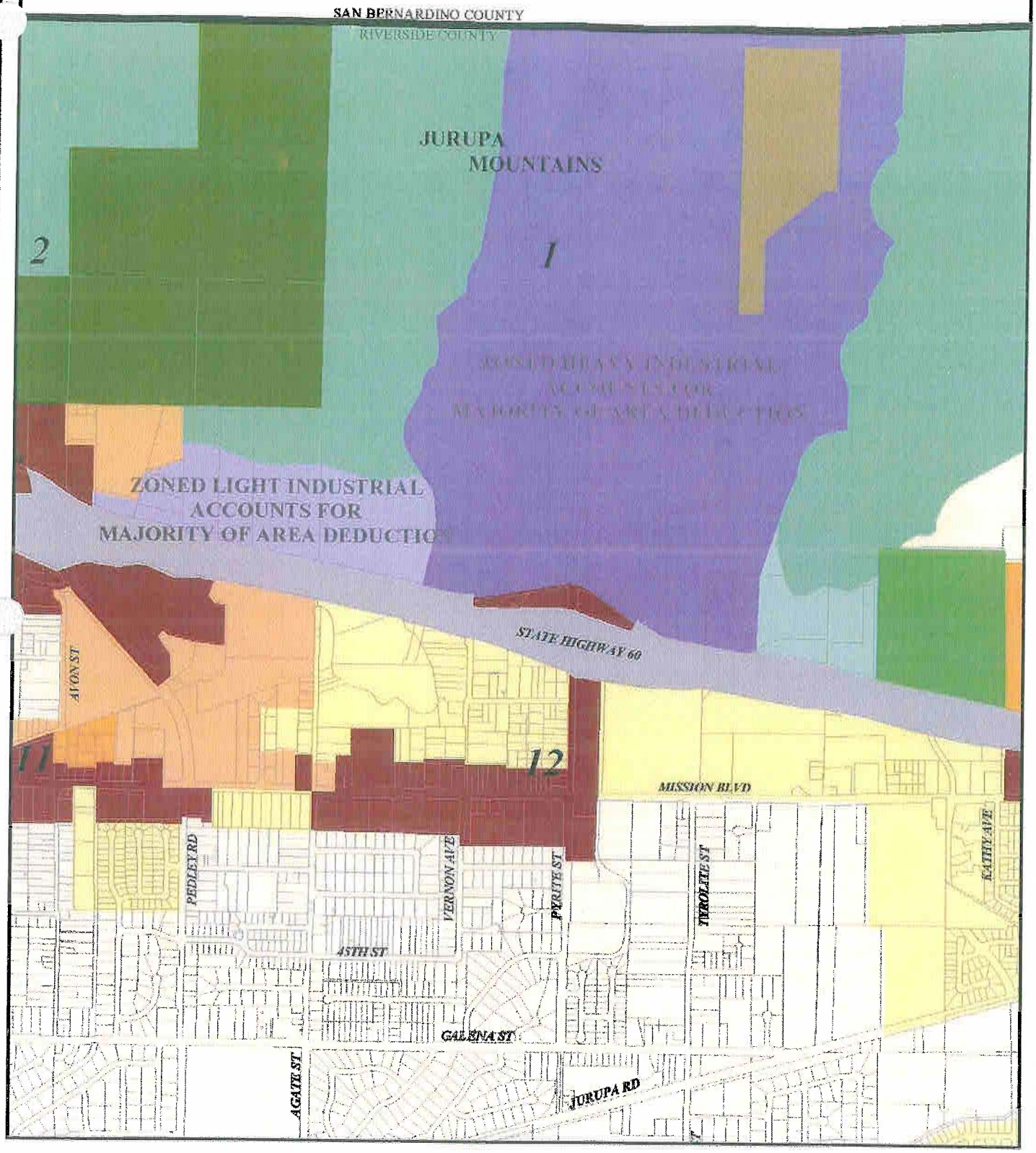
(2) With out wastewater contributions from Metal Container Corporation

The total wastewater flow generated from January to October of 2002 by this area is 103,670,700 gallons. The total number of days for this time period is 304 days. The data results in a generation factor of approximately 341,022 gallons per day (gpd) for the entire developed CFD Area No. 1. The total developed acreage for this area is 1,955 acres (Plate 6); therefore, the average daily wastewater flow generated per acre is 175 gpd/acre (refer to Appendix J for a detailed breakdown for all items per this discussion).

Development in the CFD Area No. 1 has included predominately large warehouses and storage facilities. While utilizing significant portions of property, wastewater generated in these types of facilities are minimal. For planning purposes, the wastewater generation factor of 500 gpd/acre for commercial and industrial facilities will be utilized for projecting "Buildout" Average Daily Flow for wastewater treatment capacity. In addition to determine treatment capacity, this factor will be utilized in the spreadsheet calibration for areas tributary to Plant 1. All other wastewater generation factors such as residential, as set forth in Section 3 will remain the same.

Projected Commercial/Industrial Areas to Tributary Plant 1

A review of the old JCSD areas (areas tributary to Plant 1) was conducted to survey the extent of commercial and industrial development within these areas. It appears that the portion of area above State Highway 60 have substantially hilly terrain. These conditions limit the amount of commercial and industrial development in these areas. In addition to this evaluation, a review of the April, 2001 Preliminary Riverside County Integrated Project (RCIP) Jurupa Area Land Use Plan was conducted. This revealed that a large portion of an area zoned heavy and light industrial above State Highway 60 was located within the "hilly terrain" area (Figure 4-1). This area may not be developable due to these existing site characteristics, therefore it is highly unlikely that these areas will generate wastewater flows.



Not to Scale

ALBERT A WEBB ASSOCIATES ENGINEERING CONSULTANTS

Figure 4-1

Commercial & Industrial Areas above State Highway 60

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The areas below State Highway 60 were evaluated as well. It appeared that portions of the areas zoned commercial and industrial consisted of roads and streets. Also, there were areas that were not developable due to existing site conditions. These areas were approximated and deducted from the total amount.

A total of approximately 500 acres will be deducted from commercial and industrial wastewater generation when determining the ultimate wastewater treatment plant capacity.

Current Areas Tributary to Regional Wastewater Pump Station (Plant 1)

As indicated in Appendix E, flow from Plant 1 had monthly averages ranging from 3.06 to 3.37 mgd with an annual average of 3.23 mgd. There is a 4% to 5% differential between the high, low and the average. Flow measurements are measured by a "mag meter" located just upstream of the Regional Wastewater Pump Station's wet well. Due to the consistent database and ideal flow measurement location, flow data collected at Plant 1 is the best source of information to use for benchmarking. The average daily flow indicated below will be utilized as the benchmark value by which the results from the spreadsheet will be compared. In addition, this value will be defined as the "Actual" Average Flow.

Location	Average Daily Flow	Year
Regional Wastewater Pump Station (Plant 1)	3.23 mgd	2001

The Regional Wastewater Pump Station (Plant 1) currently pumps flow from drainage areas J1 through J23, J25 and E1. Drainage area J25 discharges into the Sky Country Development area and not the Etiwanda Trunk Sewer. Drainage area E1, also known as the Sky Country Development currently contributes to wastewater at Plant 1. Drainage areas J16, J17B and J18 are tributary to the Indian Hills Water Reclamation Facility (Plant 2). Areas J24, J26 through J30 are tributary to the Community Facilities District (CFD) No. 1 which discharges into the S.A.R.I. Line at various locations.

A review of the current development in the drainage areas tributary to Plant 1 was required to determine the current "estimated" average flow. Current data such as existing lots and building locations were required to examine land use areas in its current state. One method was to locate the parcels with a structure within its boundaries. This was accomplished by utilizing G.I.S. mapping software with the Riverside County database. The parcels that contained structures within the parcels' boundaries were shaded a different color from the parcels that were vacant (Plate 7). This method provided for a general overview to the District's current land utilization.

To provide for a higher degree of accuracy, current aerial mapping of the District was reviewed. This will facilitate a graphical observation, thus obtaining area values, in terms of acres, to be utilized in the spreadsheet. A CAD software in conjunction with current aerial mapping was utilized to determine the area value. A function of the CAD software allows for the polygon trace of developed areas within the respective tributary drainage areas (Plate 8). The polygons contain area properties which can be viewed by the software. The spreadsheet utilized in this calibration is similar to the spreadsheet used to determine the "Buildout" Average Daily Flows (Appendix I) but revised to evaluate areas tributary only to Plant 1 (Appendix K).

In contrast to the "Buildout" areas values, the "Current" area values inputted into the spreadsheet were substantially smaller. One such example of this reduction is the observations made in the polygon trace of Tributary Area J13 (Plate 8):

Tributary Drainage Area J13	Residential (Acres)	Commercial/Industrial (Acres)
Buildout	81.2	194.0
Current	34.0	17.8

Applying the District Standard wastewater generation factors to the respective area yields the following results (Appendix K):

Tributary Drainage Area J13	Residential (GPD)	Commercial/Industrial (GPD)*
Buildout	45,360	92,210
Current	19,040	6,505

*Utilizing 500 gpd/AC for commercial/industrial areas.

Several tributary drainage areas were polygon traced to determine the current area land uses. Only flows within the Plant 1 Tributary Area boundaries were traced (Plate 8 and Appendix K). The summation of flows from areas E1, J1 through J23, and J25 were required to determine the flow tributary to Plant 1. In order to properly evaluate these values, a comparison between the actual field data is important. The following summarizes the "Actual" and "Estimated" average daily flow to Plant 1:

Location	"Actual" Average Flow	"Estimated" Average Flow
Plant 1	3.23 MGD	3.25 MGD

Some factors can be attributed to the differences in the values. As previously discussed, an aerial photo of the District was examined to assist in determining the type and size of building located in the tributary wastewater drainage areas. This was done with CAD software using polygons lines to estimate the locations of the developed areas. The polygon trace was performed with visual inspection of building locations from aerial photos along with the land use and parcel with structures value map per designated tributary wastewater drainage area. The polygon tracing was performed by the visual inspection of these maps.

Other factors that can be attributed to these differences are the wastewater generation factors. The wastewater generation factors are assigned based on the land use criteria. These factors are generalized and serve as a method of predicting how much wastewater is generated per land use criteria as described Section 3.

The "Actual" average flow is close to the majority of the "Estimated" average flow, therefore the spreadsheet and methodologies as well as the wastewater generation factors utilized are valid methods and tools in determining average daily flows for this study.

PROJECTED BUILDOUT FLOWS FOR SEWER TREATMENT CAPACITY

Applying the "actual" wastewater generation factors for commercial and industrial areas (per the CFD No. 1 discussion) to the "buildout" spreadsheet provided a more realistic depiction of average daily flows within the District. In addition to the "CFD No. 1" discussion, the commercial and industrial area deduction was applied to this spreadsheet in accordance to the "Commercial/ Industrial Areas Tributary to Plant 1" discussion. Table 4-4 summarizes the projected buildout average daily flows within the District (refer to Appendix L for a detailed breakdown of this table). The total projected flow for the District is nearly 14.8 mgd, with about 6.9 mgd generated from the Eastvale area. In contrast to the "design" spreadsheet, which will be used for sizing sewers for ultimate conditions, this spreadsheet will be utilized to determine "ultimate" treatment plant capacity and pumping facilities.

Table 4-4. Projected "Buildout" Average Daily Flows For Ultimate Wastewater Treatment Plant Capacity

Tributary Drainage Areas	Residential Average Daily Flow (GPD)	Commercial/Industrial (1) Average Daily Flow (GPD)	Schools Average Daily Flow (GPD)	Total Average Daily Flow (GPD)
JCSD Areas (J1 – J15B, J17A & J19 – J23)	4,415,880	675,732 (2)	169,875	5,261,487
Indian Hills Area (J16, J17B & J18)	495,600 (3)	82,305	8,510	586,415
Lower Portion of Tributary Area No. J18	0	38,450	0	38,450
CFD Area No. 1 (J24, J26 – J30)	32,200	1,917,350 (4)	0	1,949,550
Eastvale Areas (E1 – E50 & J25)	6,254,680	478,600	203,550	6,936,830
Total	**11,198,360**	**3,192,437**	**381,935**	**14,772,732**

(1) Commercial and industrial wastewater generation factor based on 500 gpd/AC.

(2) Area deduction of approximately 500 acres for commercial and industrial areas located above and some portion of areas below State Highway 60 of areas tributary to Plant 1.

(3) A wastewater generation factor for residential dwelling units of 200 gpd/EDU was utilized for projecting flows for ultimate treatment plant capacity for the Indian Hills Area only (refer to Section 3). A factor of 280 gpd/EDU was utilized for all other residential areas.

(4) If the CFD No. 1 continue to generate a wastewater capacity of 175 gpd/AC then the projected wastewater flow will yield 692,773 gpd.

POINT SOURCE ANALYSIS

As previously discussed, point source wastewater generation will be incorporated into the sewer model to determine ultimate flows to design the ultimate trunk sewer system. However, discussions on how point sources will affect the "ultimate" wastewater treatment plant capacity were not conducted. It is noted that the three point sources are located within the CFD Area No. 1 tributary

areas, therefore will only be affecting wastewater discharge into the existing Santa Ana River Interceptor (SARI). The following tabulates the point sources discharging into the SARI Line:

- Chino Two Desalter (Reverse Osmosis Portion) 3.00 mgd [1]
- Chino Two Desalter (Ion Exchange Portion) 0.46 mgd [2]
- Ion Exchange Plant 0.59 mgd [3]
- Metal Container Corporation + 0.15 mgd
- Total Point Source Discharge 4.20 mgd

(1) Flow projection from Mary Hambel, RBF Engineering, March 23, 2003 (based on 18 mgd plant buildout and average brine waste of 2.2 mgd w/ worst case of 3.0 mgd). It is the responsibility of the CDA to acquire SARI Capacity for this flow.

(2) Flow projection from Mary Hambel, RBF Engineering, March 23, 2003 (based on 18 mgd plant buildout and average brine waste of 0.36 mgd w/ 0.1 mgd from wash down and sampling water). It is the responsibility of the CDA to acquire SARI Capacity for this flow.

(3) Flow projection from April 2001 Feasibility Study for Nitrate Removal for JCSD by Boyle Eng. in association w/ Albert A. Webb Associates. Projection based on 12.7 MGD production with well water nitrate inflow of 140 mg/L.

These point sources will utilize approximately 60 acres total. In order to incorporate these point sources, area deductions from the spreadsheet utilized in developing Table 4-4 is required. A spreadsheet analysis on this matter was conducted (refer to Appendix M) to evaluate how the introduction of these point sources will have an effect on the projected wastewater discharged into the SARI Line. Table 4-5 tabulates the results of this analysis.

Table 4-5. Point Source Analysis of CFD No. 1

Wastewater Generation Factors	Wastewater Generated in CFD Area No. 1 [1]	Additional Point Sources Flows [2]	Projected Wastewater Discharge to the SARI Line [3]
Utilizing 175 gpd/AC	0.69 mgd	4.20 mgd	4.89 mgd
Utilizing 500 gpd/AC	1.92 mgd	4.20 mgd	6.12 mgd

(1) This flow value excludes approximately 60 acres of commercial and industrial area within the CFD Area No 1.

(2) This is the summation of all point sources.

(3) The discharge values projected in this table reflects wastewater generated within the CFD Area No. 1 only.

The values tabulated in Tables 4-4 should be utilized in conjunction with the values tabulated in Table 4-5 in determining wastewater treatment capacity as well as SARI Line discharge capacity.

INDIAN HILLS AREA CONVEYANCE SYSTEMS

Sewer lift stations and forcemains constitute the majority of wastewater conveyance directly to Plant 2. Table 4-6 tabulates the Indian Hills Area lift station and forcemains with the corresponding tributary areas (refer to Plate 5 for all pressure system locations).

Table 4-6. Indian Hills Area Conveyance Systems

Conveyance System	Tributary Areas
Clay Street Sewer Lift Station and Forcemain (L-7)	J18 (upper portion)
Lakeside Sewer Lift Station and Forcemain (L-8)	J17B
Clay and Van Buren Sewer Lift Station and Forcemain (L-11)	J18 (lower portion)

As previously discussed, the lower portions of Tributary Area No. J18 is tributary to the Clay and Van Buren Sewer Lift Station (L-11). This lift station pumps sewer flow directly to the Regional Forcemain via a 6-inch forcemain, therefore, wastewater generated within this area does not contribute to the influent flow at Plant 2. In contrast, wastewater generated within Tributary Areas No. J16 and J17B discharges directly into Plant 2 via a 12-inch gravity sewer main and the Lakeside Sewer Lift Station (L-8) and forcemain respectively.

The upper portion of Tributary Area No. J18 is tributary to the Clay Street Sewer Lift Station (L-7). During normal Plant 2 operations, this lift station pumps wastewater flow via a 10-inch forcemain north on Clay Street to discharge into the plant on Limonite Avenue. As previously discussed, a portion of the wastewater flow in the Regional Forcemain may be diverted to Plant 2 when irrigation requirements of the Indian Hills Golf Course increase. This diversion is accomplished by various valve settings at the Clay Street Lift Station and a 10-inch forcemain connection between the Regional Forcemain and the lift station's wet well (Plate 11).

During a Plant 2 shutdown, wastewater generated in Tributary Area No. J18 is not pumped to Plant 2 but diverted directly or indirectly to the Regional Forcemain. The District has two options in flow diversion. The first option is to cease operations of the Clay Street Lift Station and allow the wet well to fill up to the 12-inch wet well overflow. This overflow connection discharges into a manhole adjacent to the wet well which is collected by an 8-inch gravity sewer (Plate 11) that discharges into the Clay and Van Buren Sewer Lift Station (L-11). The second option requires the Clay Street Lift Station to be in operations mode with various valve settings to bypass the 10-inch forcemain on Clay Street and discharge directly into the Regional Forcemain via a 10-inch bypass connection and the 10-inch forcemain connection to the Regional Forcemain (Plate 11). It is noted that this is the same connection that allows the District to divert a portion of the Regional Forcemain flow to the Indian Hills WRF.

As previously discussed, wastewater influent to Plant 2 may be diverted to the Jurupa Trunk Sewer via the 15-inch overflow gravity main during plant shutdown. It is noted that pumping wastewater from Tributary Area No. J18 to discharge into this overflow main is economically inefficient and will over burden the pumps at the Regional Sewer Lift Station (Plant 1). Diverting flow directly into the Regional Forcemain, as described above is a viable solution and is currently in practice by the District. Based on these findings, wastewater generation factors for Tributary Area No. J18 will not be inputted into model and will not contribute to wastewater flows within the Indian Hills WRF Overflow Line.

SECTION 5 - EXISTING FACILITIES

Jurupa Community Services District has over 3,000 sewer pipelines within the jurisdiction. With the exception of the recent developments in the Eastvale area, the majority of the District consists of sewers that are at least 20 years old. The sewer systems are generally capable of providing service to the community at the present time, though there are areas in need of improvements. These will be discussed in this section.

TRUNK/INTERCEPTOR SYSTEM

Trunk and interceptor pipes are those having a diameter of 10 inches or greater. The District has over 20 miles of pipeline which fall into this classification. Review of the December 1983 Wastewater Management Plan for JCSD indicated the District has identified the following trunk lines with in the system:

1. Jurupa Trunk System
2. Glen Avon Trunk System
3. Bain Trunk System
4. Sky County Trunk System
5. Pedley Trunk System
6. Indian Hills Overflow Line (Indian Hills W.R.F. Area)
7. C.F.D. No. 1

Jurupa Trunk System

The Jurupa Trunk System (Plate 10) serves the largest area in the District and is the backbone for the majority of the system. The line begins in Armstrong Road with 10-inch diameter pipe and then travels in a southwest direction along Jurupa Road to Van Buren Boulevard. The line then parallels Van Buren Boulevard in a southward direction to a large natural drainage swale (Pyrite Creek) which it parallels in a southwest direction until it reaches the Regional Wastewater Pump Station located on Limonite Avenue. The pipe diameter is 21-inch by this point.

Glen Avon Trunk System

The Glen Avon Trunk System (Plate 10) serves the Glen Avon Area of the District. The line begins in Granite Hill Road adjacent to Campbell Street with a 10-inch diameter pipe. It then travels southward to the intersection of Bellegrave Avenue at Bly Channel and then south to Galena. It travels east on Galena to Felspar where then it runs south and discharges into the Jurupa Trunk Line (Point A, Plate 10). The pipe diameter is 15-inch by this point.

Bain Trunk System

The Bain Trunk System (Plate 10) begins at the southern portion of the County Village Development as a 15-inch diameter pipe. It runs south on Bain Street to Van Buren Boulevard where the diameter increases to 18-inch. The pipe then travels southwards, parallel to Bain Street and discharges into the Jurupa Trunk Line (Point C, Plate 10) near the Regional Wastewater Pump Station located on Limonite Avenue. The pipe diameter is 18-inch by this point.

Sky County Trunk System

The trunk sewer serves the Sky Country Development located in the southwestern portion of the district east of the Eastvale Area. The sewer begins with a 12-inch and 15-inch pipeline that runs parallel to and on each side of the Day Creek Channel (Plate 10). The line then travels southeast to a lift station located on Limonite west of Etiwanda. The lift station than pumps the wastewater through a 10-inch forcemain located on Limonite to the Regional Wastewater Pump Station (Plant 1). The Sky Country Trunk System, though a part of the District's service area, will not be modeled in this report since it was previously analyzed in the Eastvale Master Sewer Plan.

Pedley Trunk System

The Pedley Trunk System (Plate 10) serves the Pedley area. The line begins at the intersection of Limonite Way and Baldwin Avenue as an 8-inch line. It then turns south on Morton Avenue and then west onto 63rd Street. The line transitions to a 10-inch diameter and travels north on Corey Street. The line then increases to 12-inch diameter and travels briefly eastward back on Limonite Avenue and north on Felspar Street where it discharges into the Jurupa Trunk Line (Point B, Plate 10).

Indian Hills Overflow Line

The Indian Hills Water Reclamation Facility (W.R.F.) is located in the southeastern portion of the District. This facility serves the Indian Hills Area. Effluent from this facility is typically used for landscape irrigation for the Indian Hills Golf Course. The facility is equipped with an alternative flow bypass. In the event of a facility shutdown or if the facility is over burdened, influent to the facility may be diverted to the Jurupa Trunk System via an overflow gravity line (Plate 10). The overflow manhole is located at the intersection of Clay Street and Limonite Avenue. At this point the line is 12-inch in diameter and travels in a southwest direction along Limonite Way. At Baldwin Avenue, it travels south for a short distance and then to Pedley Road in a northwest direction and back onto Limonite Avenue in a westward direction. The line then travels north on Pedley Road by which time it is 15-inch in diameter. Next the line travels westward on 60th Street and north on Hudson Street where it discharges it to the Pedley Trunk Line (Point D, Plate 10).

Community Facilities District No. 1

In addition to the annexation of the Eastvale Area into the District's service area since the 1983 Master Sewer Plan was completed, a Community Facilities District (No. 1) was formed for an industrial area located in the northwest portion of the District (Plate 1). CFD improvements included additional trunk and collection systems in the area. These trunk systems are connected to the Santa Ana Regional Interceptor. The CFD trunk systems include the Hammer Avenue Trunk, Wineville Road Trunk and the Etiwanda Avenue Trunk. The majority of the wastewater generated in these systems are from industrial and commercial customers. These systems were added to the District's service area within the last 10 years.

Observed Trunk System Problems

For the most part, there are few current problems with the existing trunk systems. However, overall, the system has not changed from the originally constructed system facilities. As such, as growth

increases flow to the system, additional capital improvements will be required. Two of the more immediate problems are discussed as follows.

A portion of the Jurupa Trunk Sewer is currently a 21-inch diameter that traverses along Pyrite Creek (Plate 11). This trunk sewer services a large portion of the District. During periods of rain this trunk sewer surcharges due to the pipeline's location within the creek bed and storm water inflow due to old pipe joint technology. The area of particular concern is the pipeline segment from Jurupa Road to Limonite Avenue. There is a need for this sewerline to be realigned and upsized. Presently, there is a State Revolving Fund (SRF) project report being prepared that will address the improvement of this trunk sewer.

The second more immediate problem concerns the 15-inch diameter trunk sewers on Felspar Street, between Galena Road and Jurupa Road, and on Jurupa Road, from Felspar Street to Agate Street (Plate 11). These sewer lines collect from areas north of the 21-inch diameter trunk in Pyrite Creek, including the Glen Avon and Sunnyslope areas. The wastewater flow is approaching the capability of these pipelines based upon current flow monitoring measurements. Therefore, it is anticipated that upgrades in this area will be necessary in the near future.

COLLECTION SYSTEM

Collection pipes are those having a diameter of 8 inches or less. The District has over 80 miles of pipeline which are categorized as such.

Many of the older collection pipes have been constructed at grades less than the current minimum standard. At low flows, velocities may not be high enough to prevent deposition of solids, hence creating operation and maintenance problems. Since the pipes are at less than minimum grades, they can become surcharged during peak flows more quickly than if they were designed to meet current minimum standards.

There are sewer collection pipes in the Glen Avon area that have been damaged or broken by ingrown roots of Eucalyptus trees. There are also pipes that contain grease deposits in this area. The 8-inch sewerline in Bellegrave Avenue, which collects from the Glen Avon area, has been observed to surcharge at times.

The District is currently reviewing these sewerlines which are operational problems. Upon completion of the District review and evaluation of these pipelines, a project list will be compiled which will serve as the basis for a sewerline rehabilitation program.

PRESSURE SYSTEMS – SEWAGE LIFT STATIONS AND FORCEMAINS

The majority of the District's sewerage is collected and transmitted by gravity flow. For situations where gravity flow was unattainable, pressure systems were utilized. Table 5-2 summarizes these facilities:

Table 5-1. Summary of Sewage Lift Stations

Sewer Lift Station Name	District L.S. No.	No. of Pumps	Manufacturer of Pump	HP	ForceMain Dia. (inches)	Type of Use
Archibald/Chandler	--	2	Essco	75	12	Interim
Clay	L-7	2	Fairbanks Morse	25	10	Permanent
Clay and Van Buren	L-11	2	Wemco	25	8	Permanent
Emergency Bypass	At Plant 1	3	Wemco	30	18	Permanent
Florine	L-3	2	Wemco	5	4	Permanent
Forecast	--	2	Essco	10	6	Interim
44th St	--	2	Reliance	1.5	--	Permanent
Hammer Ave	--	2	Essco	25	10	Interim
Lakeside	L-8	2	Wemco	5	6	Permanent
Regional	Plant 1	3	Aurora	150	18	Permanent
Sky Country 1	L-2	3	Pacific	20	10	Permanent
Sky Country 2	L-5	2	Wemco	5	6	Permanent
Sky Country 3	L-10	2	Wemco	7½	6	Permanent
Sunnyslope (33rd St)	L-1	2	Wemco	10	6	Permanent

Archibald/Chandler Sewer Lift Station

The Archibald/Chandler Street Sewage Lift Station is located at the intersection of Archibald Avenue and Chandler Street on the north side of Chandler (Plate 11). The station pumps flow through a 12-inch diameter forcemain north on Archibald Avenue for approximately 5,400 feet where it discharges into the S.A.R.I. Line at the intersection of Schleisman Road and Archibald Avenue. This lift station is utilized on an interim basis as the collection point of sewerage from the Chandler Street portion of the Eastvale Sewer System.

Clay Sewer Lift Station

The Clay Street Sewer Lift Station is located on Clay Street between Haven View Drive and General Drive (Plate 11). The station pumps flow through a 10-inch diameter forcemain north on Clay Street for approximately 3,800 feet where it discharges into the Indian Hills Water Reclamation Facility (W.R.F.). This facility also has the capability to pump a portion of the flow from the 18-inch Regional Forcemain to the Indian Hill W.R.F.

Clay and Van Buren Sewer Lift Station

The Clay and Van Buren Boulevard Sewer Lift Station is located at the intersection of Clay Street and Van Buren Boulevard on the north corner of Clay Street (Plate 11). This station pumps flow through an 8-inch diameter forcemain northeast on Clay Street then north for approximately 940 feet where it discharges into the 18-inch Regional Forcemain.

Florine Sewer Lift Station

The Florine Avenue Sewer Lift Station is located at the southern portion of Florine Avenue (Plate 11). This station pumps flow through a 4-inch diameter forcemain north on Florine Avenue for approximately 730 feet where it discharges into a 6-inch diameter forcemain from the Sunnyslope Sewer Lift Station.

Forecast Sewer Lift Station

The Forecast Sewer Lift Station is located at the northeast corner of the intersection 58th Street and Westchester Way (Plate 11). This station pumps flow through a 6-inch diameter forcemain east on 58th Street then south on Hamner Avenue for approximate total of 3,000 feet where it discharges into the S.A.R.I. Line. This lift station is utilized on an interim basis as the collection point of sewerage from this area of the Eastvale Sewer System.

Emergency Bypass (Bypass) Lift Station at the Regional Lift Station (Plant 1)

The Emergency Bypass Lift Station is located approximately 30 feet north of the Plant 1 (Plate 11). This pump station is utilized as a bypass lift station to divert sewer flow to two storage ponds. This station pumps flow through an 18-inch diameter forcemain south for approximately 300 feet to discharge into the ponds. During emergency events such as Plant 1 failure or shutdown or a substantial wet weather event, a diversion manhole located upstream of the Plant 1 wet well surcharges and flows are diverted to the Bypass Lift Station wet well. Once operational conditions at Plant 1 are restored or wet weather conditions have passed, the sewer stored in the ponds is allowed to gravity flow back into Plant 1.

44th Street Sewer Lift Station

The 44th Street sewer lift station is located approximately 400 feet west of the intersection of Felspar Street and 44th Street (Plate 11). The purpose of this lift station is to pump sewer flow from the lowest point of a collection system to an adjacent manhole. Flow is pumped through a 4 inch diameter for approximately 10 feet to an adjacent sewer manhole location east of the lift station on 44th Street.

Hamner Sewer Lift Station

The Hamner Avenue Sewer Lift Station is located at the intersection of North Road and Hamner Avenue on the north side of North Road (Plate 11). This station pumps flow through a 10-inch diameter forcemain north on Hamner Avenue for approximately 2,300 feet to the intersection of Schleisman Road and Hamner Avenue where it discharges into the S.A.R.I. Line. This lift station is

utilized on an interim basis as the collection point of sewerage from this of the Eastvale Sewer System.

Lakeside Sewer Lift Station

The Lakeside Sewer Lift Station is located at the intersection of Clay Street and Limonite Avenue (Plate 11). This station pumps flow through a 6-inch diameter forcemain east on Limonite Avenue for approximately 900 feet where it discharges into the Indian Hills W.R.F.

Regional Sewer Lift Station (Plant 1)

The Regional Sewer Lift Station is located southwest of the Bain Street and Limonite Avenue intersection (Plate 11). This station pumps flow through an 18-inch diameter forcemain east for approximately 16,000 feet to a siphon that crosses the Santa Ana River to discharge into the City of Riverside Wastewater Treatment Plant. This lift station is the collection point for the majority of the District's sewerage including the Sky Country Development Area while excluding the Eastvale Area.

Sky Country 1 Sewer Lift Station

The Sky Country 1 Sewer Lift Station is located just south of Sky Country Drive between Sunny Circle and Moon Place east of the Day Creek Channel (Plate 11). This station pumps flow through a 10-inch diameter forcemain east for approximately 6,400 feet to a 15-inch gravity sewer west of the Regional Sewer Lift Station. This station is the collection point for sewerage generated within the Sky Country Development Area.

Sky Country 2 Sewer Lift Station

The Sky Country 2 Sewer Lift Station is located on Rigel Way between Lucretia Avenue and Puente Way east of the Day Creek Channel (Plate 11). This station pumps flow through a 6-inch diameter forcemain south for approximately 800 feet to a 15-inch gravity sewer main located just north of the Lucretia Avenue and Rigel Way intersection.

Sky Country 3 Sewer Lift Station

The Sky Country 3 Sewer Lift Station is located on Limonite Avenue just south of the Del Sur Drive west of the Day Creek Channel. (Plate 11). This station pumps flow through an 8-inch diameter forcemain east across the Day Creek Channel for approximately 840 feet to a 15-inch gravity sewer located at the intersection of Lucretia Avenue and Sky Country Drive.

Sunnyslope (33rd Street) Sewer Lift Station

The Sunnyslope (33rd Street) Sewer Lift Station is located southeast of 33rd Street (Plate 11). This station pumps flow through a 6-inch diameter forcemain northeast on 33rd Street, southwest on Florine Avenue then northeast on 34th Street for approximately 2,200 feet to a 6-inch gravity sewer main located at the intersection of Manor and 34th Street.

Observed Pressure System Problems

Many lift stations are very old, ranging from 25 to over 40 years old. There are a few that are in need of upgrades. Specifically, the Sunnyslope (Figure 5-1) and Florine (Photo 5-2) lift stations, two of the oldest in the District, are experiencing maintenance difficulties. Improvement projects to both lift stations are currently being evaluated.

Figure 5-1. Sunnyslope Lift Station Wet Well

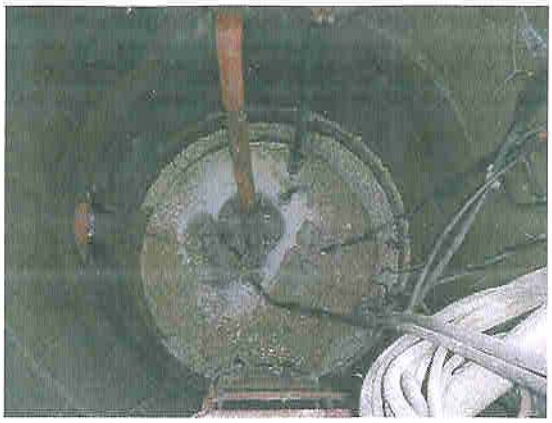

Figure 5-2. Florine Lift Station Wet Well

The Regional Wastewater Pump Station (Plant 1) currently operates at an adequate level of service. While the wet well serves its function as a component of the pump station, minor repairs may be required as shown in Figure 5-3. Further, according to District staff, the magmeter, which tabulates wastewater flow quantity readings, sometimes malfunctions during peak flows. There are no reported problems with all other components of this facility, including the pumps and the dry well.

Figure 5-3. Regional Wastewater Pump Station Wet Well

WASTEWATER TREATMENT PLANTS

As previously indicated, the District owns one wastewater treatment plant, the Indian Hills Wastewater Reclamation Plant (Figure 5-4), which treats only the sewage generated within the Indian Hills area.

The primary components of the Indian Hills Wastewater Reclamation Plant consist of an influent lift station, an oxidation ditch, two parallel clarifiers, a tertiary sand filter, a chlorine contact chamber, a sludge storage tank, and an effluent pump station. The reclamation plant was designed to remove 90 percent of the BOD and suspended solids, and 50 percent of the total nitrogen, with a total maximum head loss through the system of approximately 10 feet.

Figure 5-4. Indian Hills Wastewater Reclamation Plant

There are no plans of expanding this plant in the future. This facility is currently operated by the District, and is very well-maintained.

SECTION 6 - EXISTING SYSTEM ANALYSIS

HYDRAULIC MODEL

Based on tributary drainage areas discussed in previous sections and pipeline layouts, a hydraulic model was developed to determine the adequacy of the existing trunk sewer lines to convey wastewater generation for the Ultimate Buildout Conditions. The sewer system was modeled by utilizing computer software named SewerCAD. This software has the capabilities to analyze the system as a whole and to provide an efficient means of calculating the complex hydraulics that is attributed to sewer systems of this magnitude.

The program also calculates the depth of flow and the hydraulic grade line by using the standard step energy balance, an iterative procedure based on the Bernoulli equation. The ratio of the depth of flow to the diameter of the pipe can also indicate if the pipe is flowing above its capacity. Pipelines that convey flows exceeding their capacity are identified by the software.

Using the SewerCAD software, a hydraulic model of the existing trunk system was prepared. Input for the model consisted of pipeline data, manhole (nodal) elevations and locations, pipeline slopes, wet weather infiltration rates, peaking factors and wastewater input locations and quantities. In addition to the trunk system, pipelines with minimum slopes were modeled in order to evaluate possible constrictions within the system.

To initiate analysis of the system, it was necessary to identify the size and material of the pipes, as well as the lengths, elevations, and slopes. This information was obtained from the District's Atlas Map records. The data was manually inputted into the hydraulic model. Based on the layout of the existing sewer pipelines and the topography, specific nodes were established at various points within each tributary drainage area to denote major wastewater collection points. The tributary drainage areas were developed in Section 4 while the locations of these nodes corresponded to existing manhole locations within the District's trunk systems. It is noted that only nodes specified as wastewater collection points required flow inputs, while other nodes or manholes were utilized to designate grade breaks or other trunk system characteristics.

The flow inputs at these nodes were based on wastewater generation values tabulated in Appendix I, which provided average daily flow generation for Ultimate Buildout Conditions. Utilizing the SewerCAD software, the peaking factors as well as wet weather infiltration rates were applied to the flow inputs to determine the adequacy of each pipeline to convey the Ultimate Wastewater flows.

METHODOLOGY

The analysis of a sewer system such as the District's is rather complex. To model each and every pipe and manhole would be very time consuming and would yield results that may only be marginally different from a more efficient modeling scheme. However modeling too few pipes would yield inaccurate results. In an effort to find the middle ground, a generalized model was developed while maintaining significant aspects of the system. For this report, two major pipe classifications were identified. The smaller pipes (8-inches diameter and smaller) are considered a

part of the collection system. Pipes with diameters 10-inches and larger are considered a part of the trunk system. For the purpose of this report, pipes identified as part of the trunk systems were modeled (Plate 11). Pipes identified as part of the collection system were not modeled unless they served as a main flow path within the system.

INPUT DATA

The SewerCAD software requires input data from various sources. Much of the inputted data were derived from the criteria and standards discussed in Section 3. In order to provide an analysis consistent with District Standards, it was important to utilize these standards whenever possible.

Software Modules

The SewerCAD sewer modeling software functions in two distinct modules.

The "Analysis" module allows the user to convey flow through a system with given parameters, which will later be discussed, while maintaining the system's current attributes. This allows the user to review data such as flow, velocity, excess flow, hydraulic deficiencies, etc. as a result of passing a specified flow through the system. This module is best utilized for analysis of an "existing" sewer system and how it interacts when passing certain amounts of flow through the system. This module only provides the results of the interactions between flow and the existing system and does not "change" any system settings such as pipe diameters.

The "Design" module provides for changes in the system settings. This module searches for hydraulic deficiencies, as defined by the user, within the system and changes certain parameters within that system such as pipe diameters to meet the deficiencies. In essence, this module calculates the pipe diameter required to pass the specified flow without any deficiencies. This module is best utilized for the development of the "design" sewer system to pass flows of a certain magnitude without deficiencies such as manhole surcharging.

Pipe Design Criteria

Evaluation of system performance is subjective and is based on several factors such as flow generation characteristics, peaking factors, infiltration rates, as well as pipe characteristics. Pipe characteristics can greatly affect system performance but also can affect the analysis. Physical characteristics can be attributed to slope, length and roughness of the pipe. Slope and length input factors are discussed later in this section. The roughness of a pipe can be measured in terms of the Manning's "n" value. The District currently utilizes an "n" value of 0.013. The "n" value can be inputted into the software through the pipe dialog box and is an example of how the physical characteristic of the pipes can affect system performance.

Another pipe characteristic affecting the analysis of a sewer system is the design pipe capacity requirements. The pipe's design capacity, depending on District Standards, may not be the same as the pipe's "full" flow capacity. As discussed in previous technical memorandums, the design capacity for an 8-inch diameter gravity sewer main shall be based on a depth of flow versus diameter (D/d)

ratio of 0.50 full while the design capacity for mains 10-inches diameter and larger shall be based on a D/d ratio of 0.75 full. These values can be inputted into the software through the pipe dialog box. At these settings, the District Standards has defined the hydraulic deficiency of pipes though; these pipes may still have capacity because deficiency is based on the pipe flowing partially full. Therefore, in essence, the definition of pipe deficiencies are relative the District Standards thus affecting the analysis.

Pipe and Manhole (Node) Input and Identifiers

Manual input of the model was required. Information utilized for modeling input was derived from the District's Sewer Atlas Maps. These maps provided vital information such as pipe diameters, slopes, pipe material, manhole depths, etc. Though the maps provided a gamut of useful and vital information, they did not provide flowline elevations at the manholes (nodes).

Flowline elevations at the nodes are a required input parameter for the SewerCAD Modeling Software. The software utilizes input parameter such as the length of pipe in conjunction with the upstream and downstream nodal flowline elevations to calculate the slope of the respective pipe. Direct input of the slope values of the respective pipes is not permitted by the software.

The software calculations are based on slope of pipe, Manning's "n" value and D/d ratio; therefore, the flowline elevations are irrelevant. An arbitrary flowline elevation at the downstream node of a pipe may be utilized in conjunction with a known length and slope to manually calculate the upstream nodal flowline elevation. Once downstream and upstream nodal elevations have been established, these values along with the length may be inputted into the software, thus allowing the software to calculate the slope.

The flowline data of the Jurupa Trunk System was entered first because it is essentially the backbone trunk system of the District. The starting node or manhole of the Jurupa Trunk System is located at the Regional Wastewater Pump Station (Plant 1). The flowline elevation at this node will be utilized to establish a base elevation for the entire model. Using the slope and length values as shown in the District's Atlas Maps, the flowline elevations of the upstream manholes were calculated for each run of pipe to be modeled. This calculation was conducted to the furthest upstream node of the system.

To input other trunk systems connecting to the Jurupa Trunk System, the starting downstream point or node of those systems were the corresponding nodes located at various points along the Jurupa Trunk Line.

Not all the manholes and pipes of the trunk sewer systems were inputted into the model. If there was a long stretch of trunk sewer and manholes with consistent slopes and pipe diameters, it was modeled as one long pipe.

The pipe and nodal identifying numbers utilized in the model (Plate 12) corresponds to the identifying numbers utilized in the current District Sewer Atlas Maps. For modeled pipes consisting of multiple pipes and nodes, the most downstream pipe number and upstream node number was utilized in the model. These numbers were utilized in the model with the addition of a prefix to identify the trunk system in which it is a part of:

Prefix	Trunk System
J	Jurupa Trunk System
G	Glen Avon Trunk System
B	Bain Trunk System
P	Pedley Trunk System
I	Indian Hills Overflow Line (Indian Hills WRF Area)
H	Hamner Avenue Trunk (CFD Area)
W	Wineville Road Trunk (CFD Area)
E	Etiwanda Avenue Trunk (CFD Area)
PC	Pyrite Creek Interceptor

A model of the existing JCSD Trunk Systems was inputted based on the above methodology. The model consisted of 186 pipes (115,810 feet of pipe), 186 nodes (manholes) and 4 outlets (wastewater discharge points). Physical characteristics of the model consisted of pipe diameters, lengths, slopes, flowline elevations and nodal locations. Hydraulic characteristics of the model consisted of Manning's "n" value and D/d ratio.

Indian Hills Area

As previously discussed in Section 4, wastewater flow generated in Tributary Area No. J18 will not be included in the wastewater flow within the Indian Hills WRF (Plant 2) overflow line.

Flow Data

Once the trunk systems were established and entered into the model, the next step was entering the flow data. As previously discussed, the flow data was entered into the manhole dialog box of the software. This requires a review of the tributary drainage area to determine the location of the manholes to use as the wastewater collection point of a specific drainage area.

Flow input designations are shown on Plate 12 as the wastewater collection point. As previously discussed, flow input is based on wastewater generation factors developed in Section 3 while quantities are based on the values tabulated in Appendix I.

In addition to the tabulated values, point sources, as described in Section 3 were inputted into the model as tabulated in Table 6-1. Wastewater generated by the Metal Container Corporation and the Ion Exchange Plant will be tributary to the Etiwanda Avenue Trunk Sewer. Wastewater generated by the Chino 2 Desalter will be tributary to both the Wineville Road Trunk Sewer and the Etiwanda Avenue Trunk Sewer. The Chino 2 Desalter comprises of a Reverse Osmosis (RO) and an Ion Exchange portion. Wastewater generated from the RO portion will be tributary to the Etiwanda Trunk Sewer while wastewater generated from the Ion Exchange portion will be tributary to the Wineville Trunk Sewer.

Table 6-1. Point Source Data

Point Sources	Location / Tributary Trunk Sewer System	Flows
Metal Container Corporation	Etiwanda Ave and Philadelphia Ave / Etiwanda Trunk Sewer	0.15 mgd
Ion Exchange Plant [1]	East of Etiwanda Ave, South of State Highway 60 / Etiwanda Trunk Sewer	0.59 mgd
Chino 2 Desalter [2] (RO Portion)	West of Day Creek Channel, South of State Highway 60 / Etiwanda Trunk Sewer	3.0 mgd
Chino 2 Desalter [3] (Ion Exchange Portion)	West of Day Creek Channel, South of State Highway 60 / Wineville Trunk Sewer	0.46 mgd

(1) Flow projection from April 2001 Feasibility Study for Nitrate Removal for JCSD by Boyle Eng. in association w/ Albert A. Webb Associates. Projection based on 12.7 MGD production with well water nitrate inflow of 140 mg/L.
(2) Flow projection from Mary Hambel, RBF Engineering, March 23, 2003 (based on 18 mgd plant buildout and average brine waste of 2.2 mgd w/ worst case of 3.0 mgd). It is the responsibility of the CDA to acquire SARI Capacity for this flow.
(3) Flow projection from Mary Hambel, RBF Engineering, March 23, 2003 (based on 18 mgd plant buildout and average brine waste of 0.36 mgd w/0.1 mgd from wash down and sampling water). It is the responsibility of the CDA to acquire SARI Capacity for this flow.

The flow rate in each sewer in the network was determined based upon the flow data input at the nodes beginning at the most upstream points and working in a downstream direction. The total flow in a line is the sum of the accumulated flows and the individual line contribution.

The software allows several methods of input to account for wet weather flows. The method utilized for this study was the "Count Base" method found in the pipe dialog box of the software. This method allows the user to enter a typical unit flow in terms of gallons per day (gpd) per unit. In this case, the unit values are in acres. The unit values utilized for this model is consistent with values developed in Section 3:

Area Type	Infiltration Rate
Existing Areas	160 gpd / AC
Newly Developed Areas	100 gpd / AC

The amount of infiltration due to wet weather conditions are defined by the tributary drainage areas. Therefore, the unit values utilized for input into the software correspond to the area value of tributary drainage areas in terms of acres. This value is multiplied by the infiltration rates above, thus yielding the total flow in terms of gpd. Not all pipes required this input, in general pipes adjacent to manholes designated as wastewater collection points were utilized.

The following summarizes the tributary areas along with the designated Trunk Systems (Plate 12):

Trunk System	Tributary Flow Areas
Jurupa Trunk System	1, 4, 2, 5, 6, 3, 7, 8, 11, 12, 15A, 14B
Glen Avon Trunk System	21A, 21B, 22A, 22B, 20, 9, 10B
Bain Trunk System	23, 10A, 14A
Pedley Trunk System	17A, 13, 19, 15B
Indian Hills Overflow Line	17B, 16, 18 *
Hammer Avenue Trunk (CFD Area)	29, 30
Wineville Road Trunk (CFD Area)	28
Etiwanda Avenue Trunk (CFD Area)	24, 26, 27

* Tributary Area No. J18 contributes wastewater flow under normal Plant 2 operations, though does not contribute during Plant 2 shutdown.

Peaking Factors

Up to now, discussions have been focused on the "average" daily flows for Ultimate Buildout Conditions and wet weather infiltration. As discussed in Section 3, it is important to consider diurnal flow rate variations. These variations can be accounted for by introducing peaking factors into the model. Based on District Standards, peaking factors are calculated by the utilizing the peaking factor equation discussed in Section 3. The peaking factor is the ratio between the peak flow value and the average daily flow value:

Peaking Factor = Q_{PK} / Q_{ADF}, where

Q_{ADF} = Average Daily Flow (mgd),

Q_{PK} = Peak Flow (mgd) and

$Q_{PK} = 2.5 \times Q_{ADF}^{0.91}$

Fluctuations in the wastewater generated from Metal Container Corporation are marginal due to the utilization of on-site equalization facilities. In addition, flows generated by the Chino 2 Desalter and Ion Exchange Plant are considered the maximum buildout flow rate. Peaking factors shall not be applied to point sources.

Once all relative input parameters, such as pipe, nodal and flow characteristics are entered into the model, a computer model "run" was performed thus providing various hydraulic calculations in tabular format. Various data fields may be selected and added to the software's data table for review and analysis. The table can be imported into a spreadsheet for further enhancement of data analysis. Table 6-2 summarizes peak dry and wet weather flow as well as wet weather infiltration as a result of passing the specified flows through the various trunk systems. See Appendix N for a detailed breakdown of this table.

Table 6-2. Projected "Buildout" Peak and Wet Weather Flows

Tributary Drainage Areas	Peak Dry Weather Flow (gpd)	Wet Weather Infiltration (gpd)	Peak Wet Weather Flow (gpd)
JCSD Areas (J1 – J15B, J17A & J19 – J23)	16,283,239	1,434,544	17,717,783
Indian Hills Area (J16 & J17B) (1)	1,337,531	154,240	1,491,771
CFD Area No. 1 (J24, J26 – J30)	16,228,753	393,630	16,622,383
Totals (3)	17,620,770	1,588,784	19,209,554
JCSD Areas + Indian Hills Area (2)	**33,849,523**	**1,982,414**	**35,831,937**

(1) It is noted that wastewater generated in Tributary Area No. J18 was not inputted into the model and does not contribute to the wastewater flow in the 15-inch diameter Indian Hills WRF (Plant 2) Overflow Line during Plant 2 shutdown.

(2) Consideration of this analysis is based on all wastewater generated in the Indian Hills Area (with exception to Tributary Area No. J18) diverted from the Indian Hills WRF (Plant 2) to the Jurupa Trunk Line via the 15-inch diameter Indian Hills WRF (Plant 2) Overflow Line.

(3) Tributary Areas J25 and E1 was not inputted into the model and does not contribute to wastewater flow to the Jurupa Trunk Sewer System nor any of the other trunk sewer systems modeled.

As discussed in Section 5, the CFD Area No. 1 discharges wastewater flows into the existing SARI Line, therefore not affecting flows within the Jurupa Trunk System. In addition, flows from the Sky Country Development discharges directly into the Regional Wastewater Pump Station (Plant 1) via lift stations and forcemains and will be diverted to the Eastvale Area in the future (see May 1999 Eastvale Master Sewer Plan and June 17, 2002 Draft Eastvale Master Sewer Update Letter) thus not affecting flows within the Jurupa Trunk System. As indicated in Table 6-2, the summation of flows from the JCSD and Indian Hills Areas was performed to consider the possibility of diverting peak wet weather flow generated in the Indian Hills Areas into the Jurupa Trunk System (due to the Indian Hills WRF for maintenance shutdown or failure). Therefore, total "Ultimate" peak wet weather flow within the Jurupa Trunk Line as it discharges into Plant 1 is 19.3 mgd.

ANALYSIS RESULTS

A review of the data derived from the computer model runs provided vital insight as to the characteristics of the system. Conclusions can be drawn from the analysis, though may differ depending on the reviewer's perception of the data. The ultimate goal of this study is to determine and locate areas of deficiencies and provide cost effective and timely solutions. This ambiguity in the analysis can be reduced by setting concrete limitations and definitions. In order to facilitate a more objective review and analysis, terms and restrictions must be defined.

Hydraulic Deficiencies

As previously stated, the District Standard was used to define hydraulic deficiencies as the depth of wastewater flow exceeding the diameter of the pipe (D/d) ratio by more than 0.75. An example of this type of deficiency can be observed in Pipe No. J_E1425 (Appendix O). This pipe is 10 inch in diameter and is part of the Jurupa Trunk System. The District Standard D/d ratio for a pipe of this size is 0.75, therefore the allowable depth of flow through this pipe is 7 ½ inches. With a specified slope, roughness factor and a D/d, the allowable flow is 1,341,458 gpd. Based on ultimate buildout conditions (flow inputs into the model, peaking factors and wet weather infiltration rates), the amount of flow that is required to pass through this particular pipe is 1,365,471 gpd. This value is "above" the allowable flow capacity of this pipe by 24,014 gpd. Noting that the allowable flow capacity is based on the pipe flowing partially full, there is an additional 2 ½ inch of space left to the crown of the pipe. Therefore, raising the D/d ratio to 1.0, the "full flow" capacity of the pipe will be 1,471,094 gpd. The total flow required is "less" then the full flow capacity by 105,623 gpd. In this scenario, the District Standards defined the deficiency when the pipe still has physical capacity to pass a particular flow. This type of deficiency can be defined as a Hydraulic Deficiency.

Full Flow Failure

In contrast to the definition of a Hydraulic Deficiency, a Full Flow Failure is based on a D/d ratio of greater than 1.0. Thus analyzing the flow at the pipe's physical capacity. An example of this type of failure can be observed in Pipe No. G_E1490 (Appendix O). This pipe is 15 inch in diameter and is part of the Glen Avon Trunk System. With a specified slope and roughness factor, the full flow capacity of this pipe is 2,924,080 gpd. Based on ultimate buildout conditions (flow inputs into

the model, peaking factors and wet weather infiltration rates), the amount of flow that is required to pass through this particular pipe is 5,746,690 gpd. This value is "above" the full flow capacity of this pipe by 2,822,610 gpd. In this scenario, the physical dimensions of the pipe defined the failure criteria, therefore the pipe has no available capacity remaining. This type of failure can be defined as a Full Flow Failure.

Analysis

The District's Trunk System consists of mostly vitrified clay pipe (V.C.P.) with some exceptions. Sizes of the trunk lines range from 10-inch to 24-inch in diameter with the majority ranging from 12-inch to 21-inch. Table 6-3 summarizes the various pipe diameters utilized in the District's Trunk System. As previously stated, 8-inch sewers were modeled if acting as a main flow path. See Appendix P for a detailed breakdown of system statistics.

Table 6-3. Statistical Breakdown Various Pipe Diameters

Pipe Size	8-inch	10-inch	12-inch	15-inch	18-inch	21-inch	24-inch
Total Length (ft)	17,258 ft	6,336 ft	19,310 ft	31,650 ft	18,091 ft	20,136 ft	3,030 ft
Percentage (%)	15 %	5 %	17 %	27 %	16 %	17 %	3 %

Once all inputs and parameters have been established into the model, it was allowed to run yielding significant results. The analysis of the results was based on the previously defined parameters.

Table 6-4 summarizes pipe deficiencies based on Hydraulic Deficiencies. It is noted that these pipes have remaining capacity to convey ultimate wastewater flows. Based on the overall system, the number of pipes falling under this definition is relatively low. See Appendix Q for the pipe inventory and Plate 13 for the locations of modeled pipes falling under this definition.

Table 6-4. Hydraulic Deficiencies (0.75 < D/d Ratio < 1.0)

Pipe Size	8-inch	10-inch	12-inch	15-inch	18-inch	21-inch	24-inch
Lengths (ft)	1,885 ft	416 ft	85 ft	702 ft	0 ft	0 ft	0 ft
Percentage (%)	1.63 %	0.36 %	0.07 %	0.61 %	0 %	0 %	0 %

Table 6-5 summarizes pipe failures based on Full Flow Failure. It is noted that these pipes have no remaining capacity. Based on the overall system, the number of pipes falling under this definition is considerably high. See Appendix R for the pipe inventory and Plate 14 for the locations of modeled pipes falling under this definition.

Table 6-5. Full Flow Failures (D/d Ratio > 1.0)

Pipe Size	8-inch	10-inch	12-inch	15-inch	18-inch	21-inch	24-inch
Lengths (ft)	9,734 ft	5,276 ft	7,874 ft	10,538 ft	0 ft	12,632 ft	0 ft
Percentage (%)	8.4 %	4.6 %	6.8 %	9.1 %	0 %	10.9 %	0 %

Point Source Analysis

Initial model input of point source information was consistent with values set fourth in Table 6-1. A model run with this input revealed that the Etiwanda Trunk Sewer was overburdened and did not have capacity to convey additional wastewater generated by the RO Portion of the Chino 2 Desalter. It was noted that there was significant surplus capacity within the Wineville Trunk Sewer. A portion of the wastewater generated by the RO Portion of the Chino 2 Desalter was diverted into the Wineville Trunk Sewer in order to relieve capacity within the Etiwanda Trunk Sewer. Table 6-6 tabulates the revised flow data inputted into the model.

Table 6-6. Revised Point Source Data Model Input

Point Sources	Location / Tributary Trunk Sewer System	Flows
Metal Container Corporation	Etiwanda Ave and Philadelphia Ave / Etiwanda Trunk Sewer	0.15 mgd
Ion Exchange Plant (1)	East of Etiwanda Ave, South of State Highway 60 / Etiwanda Trunk Sewer	0.59 mgd
Chino 2 Desalter (2) (RO Portion)	West of Day Creek Channel, South of State Highway 60 / Etiwanda Trunk Sewer	1.8 mgd
Chino 2 Desalter (2) (RO Portion)	West of Day Creek Channel, South of State Highway 60 / Wineville Trunk Sewer	1.2 mgd
Chino 2 Desalter (3) (Ion Exchange Portion)	West of Day Creek Channel, South of State Highway 60 / Wineville Trunk Sewer	0.46 mgd

(1) Flow projection from April 2001 Feasibility Study for Nitrate Removal for JCSD by Boyle Eng. in association w/ Albert A. Webb Associates. Projection based on 12.7 MGD production with well water nitrate inflow of 140 mg/L.

(2) Flow projection from Mary Hambel, RBF Engineering, March 23, 2003 (based on 18 mgd plant buildout and average brine waste of 2.2 mgd w/ worst case of 3.0 mgd). It is the responsibility of the CDA to acquire SARI Capacity for this flow.

(3) Flow projection from Mary Hambel, RBF Engineering, March 23, 2003 (based on 18 mgd plant buildout and average brine waste of 0.36 mgd w/ 0.1 mgd from wash down and sampling water). It is the responsibility of the CDA to acquire SARI Capacity for this flow.

Once this revised data was inputted into the model, a review of the model's output for the Etiwanda and Wineville Trunk Sewers revealed that the trunk sewers did not fail under any conditions and there were no hydraulic deficiencies. Significant point source information was added into the model in addition to inputs such as typical wastewater generation factors and wet weather flow. A total of 60 acres was deducted from areas tributary to the Etiwanda and Wineville Trunk Sewers to account for the lands utilized by Metal Container Corporation, the Ion Exchange Plant and the Chino 2 Desalter. Based on the wastewater flows generated by these facilities, the generation factor can range from 5,000 gpd/ac for Metal Container and 95,000 to 346,000 gpd/ac for the Ion Exchange Plant and the Chino 2 Desalter respectively. These values are well above the typical generation factor of 2,000 gpd/ac as set forth in Section 3 for commercial and industrial land use areas.

The Etiwanda and Wineville Trunk Sewers will not require upgrade in pipe size to provide capacity for buildout flow conditions and point source contributions. It must be noted that these findings are

based on point source wastewater generation for "current" conditions of Metal Container and projected "buildout" wastewater generation for the Chino 2 Desalter and Ion Exchange Plant.

As indicated by RBF Engineering, March 27, 2003, buildout conditions for the Chino 2 Desalter are based on an 18 mgd production rate. Brine waste generated by the RO Portion will average approximately 2.2 mgd with a worst case of 3.0 mgd. This is a 0.80 mgd differential. As indicated in the April 2001 Feasibility Study for Nitrate Removal, buildout conditions for the Ion Exchange Plant is based on a 12.7 mgd production rate (Phase 3). If well water nitrate levels are found to be 60 mg/L, wastewater generated may be as low as 0.18 mgd. In contrast, if levels are found to be 140 mg/L, wastewater generated will be as high as 0.59 mgd. This is a 0.41 mgd differential. Therefore, total point source wastewater contributions may range from 3.0 mgd to 4.2 mgd. It is noted that the capacities of the Etiwanda and Wineville Trunk Sewers were evaluated assuming point sources at the higher range. Trunk sewer capacity must further be evaluated in the event of future expansion to any one of these facilities is considered.

Summary

The total length of pipes modeled was 115,810 feet. Out of this, approximately 3,088 feet or 3% of the total length fell under the definition of Hydraulic Deficiencies. As previously stated, pipes that fall under this definition have remaining capacity to convey ultimate wastewater flows. Approximately 46,054 feet or 40% of the total length fell under the definition of Full Flow Failure. Pipes that fall under this definition have no available capacity; therefore will require upgrade, replacement or parallel. Nearly half of the pipes in the District's Trunk System fail and do not have adequate capacity to convey wastewater generated for future buildout conditions.

A review of the locations of pipes falling under both definitions of failure was conducted (Plates 13 and 14). It appears that the majority of pipes that fall under the Hydraulic Deficiencies definition are located either adjacent or between pipes that fall under the Full Flow Failures definition. These pipes may be combined depending on their close proximity; therefore, replacement of the Hydraulic Deficient pipes will be on a case by case basis.

SECTION 7 - PROPOSED SYSTEM ANALYSIS

Wastewater generation factors in Section 3 were utilized to develop the "ultimate" average daily sewer flows generated by the District for buildout conditions. The flow values were applied to the hydraulic model to analyze how the existing trunk system convey ultimate flows. The model conveyed peak, wet weather flows through the existing system. Impacts to the existing system were substantial. Approximately 40% of the District's existing trunk sewer system did not have available capacity to convey the ultimate flows.

This section will provide viable and timely solutions by addressing the capacity short falls within the District's system. In addition to the modeled gravity systems, evaluation and discussions of pressure systems (sewer lift stations and forcemains) and wastewater treatment systems will be presented.

GRAVITY SYSTEM EVALUATION

As a result of loading ultimate wastewater flows on the existing trunk sewer system, various sewers required replacement, relief or rerouting to provide for adequate flow conveyance and minimize hydraulic deficiencies. Refer to Appendix S to review the analysis results for the "design" JCSD Trunk Sewer System.

Replacement of Sewers

This method requires the replacement of the existing sewer pipe with a "new" sewer pipe of larger diameter to provide for adequate flow conveyance. For planning purposes, it was assumed that the "new" sewer pipe will have the same slope and flowline elevations of the existing sewer pipe to be replaced.

Relief Sewers

This method requires an additional sewer pipe such as a parallel system to "relieve" an existing sewer main of its hydraulic deficiencies. The relief sewer may discharge back into the same trunk line downstream at a point where there are no hydraulic deficiencies or discharge into another trunk line with remaining capacity for additional flows.

Rerouting of Sewers

This method requires the abandonment of portions of the existing sewer with hydraulic deficiencies and rerouting the trunk line along a new alignment. This may also include the upgrade of sewer pipe size to larger diameter pipe.

Hydraulic Model of Design Trunk Sewer System

The hydraulic model of the "design" trunk sewer system is based on the same model developed in Section 6. Much of the attributes of the "existing" trunk sewer system such as wastewater flow generation, peaking factors, wet weather infiltration, etc. are utilized in this model. Pipe and manhole identifiers were also transferred to this model for ease of analysis. A model of the design JCSD Trunk Systems was inputted based on the methodologies discussed in Section 6. The model consisted of 187 pipes (124,479 feet of pipe), 187 nodes (manholes) and 4 outlets (wastewater discharge points).

Pipe Identifiers

As discussed in Section 6, pipes failing under the definition of "Hydraulic Deficiency" and "Full Flow Failure" were combined due to the relatively low number of "Hydraulic Deficiency" and the close proximate of both types of pipes. These pipes were either replaced with a larger diameter pipe, relieved or rerouted in order to convey ultimate wastewater flow with minimal hydraulic deficiencies.

Pipes that were replaced retained their existing identifier with an additional extension label of "DSN" for design. The following is an example of this case:

Existing Pipe Identifier:	J_E1245
Revised Pipe Identifier:	J_E1245_DSN

Pipes that were relieved or rerouted were given an arbitrary identifying number with prefixes of their respective trunk sewer system and the label "DSN" for design. The following is an example of this case:

Relief Pipe Identifier:	G_DSN-600 (Glen Avon Trunk Sewer)
Rerouted Pipe Identifier:	J_DSN-400 (Jurupa Trunk Sewer)

Plate 15 shows the locations of various "existing" and "design" modeled pipes within their respective trunk systems. Additional information such as tributary drainage areas, and wastewater flow input designation are provided as well.

Analysis

The District's Existing Trunk System consists of mostly vitrified clay pipe (V.C.P.) with some exceptions. It is assumed that the replaced, relieved and rerouted sewers will be V.C.P. as well. Sizes of the "design" system trunk lines range from 10-inch to 42-inch in diameter with the majority ranging from 15-inch to 18-inch. Table 7-1 summarizes the various pipe diameters utilized in the District's Trunk System. As previously stated, 8-inch sewers were modeled if they were a main flow path. See Appendix T for a detailed breakdown of system statistics.

Table 7-1. Statistical Breakdown Various Pipe Diameters (Existing and Proposed Improvements)

Pipe Size	8-inch	10-inch	12-inch	15-inch	18-inch	21-inch	24-inch	30-inch	36-inch	39-inch	42-inch
Total Length (ft)	9,639	9,088	16,438	33,096	22,660	12,614	4,385	4,260	3,947	2,533	5,815
Percentage (%)	8 %	7 %	13 %	27 %	18 %	10 %	4 %	3 %	3 %	2 %	5 %

Table 7-2 summarizes pipe failures based on Hydraulic Deficiency. It is noted that these pipes have remaining capacity to convey ultimate wastewater flows. See Appendix U for the pipe inventory and Plate 15 for the locations of modeled pipes falling under this definition.

Table 7-2. Hydraulic Deficiency (0.75 < D/d Ratio < 1.0)

Pipe Size	8-inch	10-inch	12-inch	15-inch	18-inch	21-inch	24-inch	30-inch	36-inch	39-inch	42-inch
Total Length (ft)	4,000	603	85	1,395	6,533	0	0	0	0	0	0
Percentage (%)	3.2 %	0.5 %	0.1 %	1.2 %	5.3 %	0 %	0 %	0 %	0 %	0 %	0 %

Based on the overall system, the number of pipes falling under the "Hydraulic Deficiency" definition is relatively low. The total length of pipe falling under this definition is 12,616 feet or about 10% of the total pipes modeled. Some of the pipes falling under this definition are existing pipes that gained capacity as a result of the addition of various relief sewers, such as the Glen Avon Trunk System. Other pipes falling under this definition are replacement pipes that are located within restrictive areas. Though these pipes fall under this condition, there is remaining capacity to convey ultimate flows, therefore for planning purposes, this will be acceptable.

Pipes falling under the "Full Flow Failure" definition were eliminated as a result of replacing, relieving and rerouting various trunk sewers. Therefore, all proposed and existing pipes within the "design" sewer system model have capacity to convey ultimate wastewater flows.

GRAVITY SYSTEM IMPROVEMENT LOCATIONS

Improvements to the existing trunk systems are necessary to provide adequate flow conveyance. As previously discussed, these improvements will require sewer pipe replacement, rerouting or relief and will be designated as the Design JCSD Trunk Sewer System.

Jurupa Trunk System Improvements

Plate 16 shows the "design" Jurupa Trunk System. In order to adequately convey ultimate wastewater flows through this trunk system, various pipes lengths were replaced while others were

rerouted. For planning purposes the proposed sewer improvements to the Jurupa Trunk System were broken up into five distinct projects (Table 7-3).

Table 7-3. Jurupa Trunk System Improvements

Project No.	Project Location	Project Type	Proposed Sewer Main Sizes
P-J-1	Felspar St & Limonite Ave	Sewer Pipe Rerouting	36, 39 & 42-inch
P-J-2	Adjacent to Metrolink between Jurupa Rd & 54th St	Sewer Pipe Replacement	30 & 36-inch
P-J-3	Along Jurupa Rd between Felspar St & Tyrolite St	Sewer Pipe Replacement	18, 21 & 24-inch
P-J-4	Valley Way between Soto Rd & 34th St	Sewer Pipe Replacement	12 & 15-inch
P-J-5	Armstrong Rd	Sewer Pipe Replacement	10-inch

Project No. P-J-1 requires the rerouting of the Jurupa Trunk Sewer from Pyrite Creek to Felspar Street and Limonite Avenue. The portion of the Jurupa Trunk System located in the channel will be abandoned in place and the sewer will be diverted via a 36, 39 and 42-inch trunk sewer along Felspar Street and Limonite Avenue. The portion of the sewer located in the channel does not have the capacity to convey ultimate wastewater flows. In addition to the capacity short falls, there are considerable maintenance issues. As discussed in Section 5, a State Revolving Fund (SRF) project report is being prepared to address these issues. The revised model reflects recommendations set forth in the SRF Report. Projects P-J-2 through P-J-5 requires the replacement of existing sewer pipes with larger diameter pipes to increase capacity.

New Pyrite Creek Interceptor

Plate 16 shows the "new" Pyrite Creek Interceptor. This proposed interceptor sewer utilizes a portion of the exiting Jurupa Trunk Sewer located at the intersection of 59th Street at Tumbleweed. This will be accomplished by the "slip lining" of the existing pipe (lining the inner diameter of an existing pipe, in place, with a polymer and epoxy resin mixture). The slip lining will continue along a portion of the existing sewer located within the Pyrite Creek to the intersection of Rutile Street at 60th Street. At this point, a new pipe will be installed by open trench method and will traverse westward along 60th Street to discharge into the Bain Trunk Sewer. The interceptor will not be located within Pyrite Creek but in the area adjacent to it. It is noted that the discharge point will be within the relocated portion of the Bain Trunk Sewer as described in the SRF Report. The portion to be slip lined shall be 21-inch in diameter resulting in a revised diameter ranging from 19-inch to 20-inch depending on the thickness of the liner system. Hydraulic evaluations were conducted to determine the effect a revised diameter would have on the system. The results of this evaluation revealed that even if the liner reduced the inner diameter of the existing sewer to 18-inch, there

would still be ample capacity to convey ultimate flows. This proposed work shall be designated as Project No. P-PC-1.

Glen Avon System Improvements

Plate 16 shows the "design" Glen Avon Trunk System. In order to adequately convey ultimate wastewater flows through this trunk system, various pipes lengths were replaced while others were relieved. For planning purposes the proposed sewer improvements to the Glen Avon Trunk System were broken up into two distinct projects (Table 7-4).

Table 7-4. Glen Avon Trunk System Improvements

Project No.	Project Location	Project Type	Proposed Sewer Main Sizes
P-G-1	Campbell St & Bellegrave Av	Relief Sewer	10 & 15-inch
P-G-2	Mission Blvd to Galena St, Felspar St & Jurupa Rd	Sewer Pipe Replacement	10, 12, 15, 18 & 21-inch

Project No. P-G-1 requires the relief of the existing Glen Avon Trunk Sewer by diverting Tributary Areas No. J22A and J22B from this trunk system. The proposed relief sewer will be designated as the Glen Avon Relief Sewer and will start at the intersection of Campbell Street at Granite Hill Drive. The sewer pipe will cross underneath State Route 60 traverse south along Campbell Street to Bellegrave Avenue. The sewer will then traverse westward along Bellegrave Avenue to Bain Street where it discharges into the existing Bain Trunk Sewer System. It is noted that the Bain Trunk Sewer System has capacity to convey the additional flow from the Glen Avon Area though will be above its design capacity in some areas. Project No. P-G-2 requires replacement of existing sewer pipes to increase capacity.

It should be noted that a detailed alignment evaluation should be conducted to determine if a pipeline between the Bly Channel and Campbell Street, which would cause the proposed Bellegrave line to be deeper, but would reduce downstream improvements on the Glen Avon Trunk Sewer, is a more cost effective alternative. This evaluation is beyond the scope of this report.

Bain Trunk System Improvements

Plate 16 shows the "design" Bain Trunk System. For the most part, this trunk system did not have any hydraulic deficiencies when conveying ultimate wastewater flows through it. A review of the system hydraulics revealed that this sewer had capacity for additional wastewater flow generated in Tributary Areas No. J22A and J22B from the Glen Avon area thus relieving capacity from the Glen Avon Trunk Sewer System. As previously discussed, flows within the Bain Trunk Sewer will be above its design capacity in some areas with the additional flows from the Glen Avon Area. Modification to the existing manhole is required to provide for the discharge point of the Glen Avon Relief Sewer. The location of this modification is at the intersection of Bellegrave Avenue and

Galena Street just east of Bain Street. This modification will be a part of the Project No. P-G-1, the Glen Avon Relief Sewer.

In accordance with the SRF Report, the southern portion of the Bain Trunk Sewer will be realigned to intercept flows from the new Pyrite Creek Interceptor. The realignment project will be designated as Project No. P-B-1 and should coincide with Project No. P-PC-1, the Pyrite Creek Interceptor.

Pedley Trunk System Improvements

Plate 16 shows the "design" Pedley Trunk System. It is noted that the discharge point of the Pedley Trunk Sewer System into the Jurupa Trunk Sewer System will be relocated from Felspar Street between 54th and 56th Street to the intersection of Corey Street at Limonite Avenue. This will eliminate the need to replace the Felspar Street portion the Pedley Trunk Sewer System. Portions of this trunk system that will require sewer pipe replacement located on 63rd Street between Van Buren Boulevard to Corey Street, then north on Corey Street to discharge into the "rerouted" Jurupa Trunk Sewer on Limonite Avenue. This sewer pipe replacement project will be designated as Project No. P-P-1.

A detailed alignment evaluation should be conducted to determine if alternative street alignments are feasible to avoid 63rd Street, which is a narrow road with numerous existing underground facilities. This evaluation is beyond the scope of this report.

Indian Hills Overflow Line Improvements

As shown in Section 6, the Indian Hills WRF Overflow Line has capacity to convey ultimate wastewater flows. There are some pipes that fail under the "Hydraulic Deficiency" definition. Though based on the discussions in Section 4, pipes under this definition still have remaining capacity therefore can adequately convey ultimate flows. It must be noted that ultimate wastewater flows conveyed within the Indian Hills WRF Overflow Line do not have flows from Tributary Area No. J18 as discussed in Section 4.

The discharge point will no longer be the located at the Pedley Trunk System along Felspar Street because of the elimination of this portion of the Pedley Trunk Sewer. The discharge point of the overflow line will be within the same general area but into the rerouted Jurupa Trunk Sewer instead of the Pedley Trunk Sewer. This will be a part of the Project No. P-J-1, the Realigned Jurupa Sewer.

Community Facilities District No. 1 Trunk Systems

As discussed in Section 6, the trunk sewers servicing the Community Facilities District (C.F.D.) No. 1 have the capacity to convey ultimate wastewater flows. Therefore, these trunk sewers will not require improvements.

PRESSURE SYSTEM EVALUATION AND PLANNING

The existing pressure systems (sewer lift stations and forcemains) located through out the District were not modeled in the SewerCAD Modeling Software. These systems were evaluated on a case by case basis.

Collection Pressure Systems

The "collection" pressure systems are located with in the District's sewer collection system and pump sewage flow from a "low" portions of a tributary area to "high" portions the same tributary area or to other tributary areas. Many of the District's sewer lift stations and forcemains are defined under this category. A review of the areas tributary to these lift stations was conducted and it appears that these areas are substantially developed. Table 7-5 tabulates the lift stations and forcemains that fall under this category.

Table 7-5. Collection System Lift Stations & Forcemains

Sewer Lift Station Name	District L.S. No.	Tributary Area No.	HP	Forcemain Dia. (inches)
Clay	L-7	J18 (Upper Portion)	25	10
Clay and Van Buren	L-11	J18 (Lower Portion)	25	8
Florine	L-3	J1	5	4
44th St	--	J9	1½	--
Lakeside	L-8	17B	5	6
Sunnyslope (33rd St)	L-1	J1	10	6
Sky Country 1	L-2	E1	20	6
Sky Country 2	L-5	E1	5	6
Sky Country 3	L-10	E1	7½	6

Based on the review of the developed tributary areas, these lift stations and forcemains have capacity to convey ultimate wastewater flow. Aside from maintenance issues, the District has not reported substantial capacity shortfalls. Therefore, these lift stations and forcemains do not require upgrade based upon hydraulic conditions. However, some lift stations are rather old and may require replacement or upgrade to continue to provide uninterrupted service.

It should be noted that the Eastvale Master Sewer Plan requires the Sky Country Development tributary area to discharge into the Proposed Eastvale Interceptor once it has been constructed. Therefore Sky Country 1 (L-2) and Sky Country 3 (L-10) will eventually be abandoned. Additional information can be found in the "1999 Eastvale Master Sewer Plan", the "June 17, 2002 Draft Eastvale Master Sewer Plan Update Letter" and the pending preliminary design report for the C.F.D. No. 1 Land Conversion Project.

Interim Pressure Systems

The "interim" pressure systems are generally located within the Eastvale Area of the District's Service Area. These systems were sized to pump wastewater flows from various developments within the Eastvale Area to discharge into the S.A.R.I. Line. These systems will be utilized on an interim basis until the Eastvale Interceptor is fully constructed. These lift stations and forcemains were designed to meet current and future demands. The wet wells for the various lift stations in these areas were designed for future expansion thus providing room for an additional pumping unit. Careful planning and flow monitoring must be conducted during this interim period to determine when and if these additional pumping units will be required. Table 7-6 tabulates the existing lift stations and forcemains that fall under this category.

Table 7-6. Interim System Lift Stations & Forcemains

Sewer Lift Station Name	District L.S. No.	Tributary Area	HP	Forcemain Dia. (inches)
Archibald/Chandler	--	Eastvale Area	75	12
Forecast	--	Eastvale Area	10	6
Hammer Ave	--	Eastvale Area	25	10

Regional Pressure Systems

The "regional " pressure systems are generally defined as pump stations and forcemain systems that pump wastewater flow from multiple tributary areas to regional wastewater treatment facilities. The District currently has one in operation and one in design. These lift stations are located or proposed to be located at the terminus of large trunk systems and have the ability to pump significant quantities of flow. These systems are required because the location of the terminus of a tributary trunk sewer is such that wastewater cannot flow by gravity to the corresponding treatment facility. Table 7-7 tabulates the lift stations and forcemains that fall under this category.

Table 7-7. Main System Lift Stations & Forcemains

Sewer Lift Station Name	District L.S. No. / Location	Tributary Area	Power Requirements (hp)	Forcemain Dia. (inches)
Existing Regional Wastewater Lift Station	Plant 1	Old J.C.S.D. Area	150	18
Proposed River Road Lift Station (Initial Phase)	Western Riverside County Regional WWRP	Eastvale Area	325	24
Proposed River Road Lift Station (Ultimate)	Western Riverside County Regional WWRP	Eastvale Area	675	24

Regional Wastewater Lift Station (Plant 1)

The Regional Wastewater Lift Station (Plant 1) pumps wastewater generated from Tributary Areas No. J1 through J23 including J25 and the Sky Country Development (E1). Flows generated from the Sky Country Development (including tributary area J25) will be diverted from Plant 1 to the Eastvale Interceptor within the near future. Other areas not tributary to Plant 1 are the Eastvale Area (Tributary Areas No. E2 to E50) and C.F.D. No. 1 (Tributary Areas No. J24, J26 to J30). For planning purposes, wastewater generated in these areas including Sky Country and J25 will not be considered in determining the ultimate flows to Plant 1.

Wastewater generated within the Indian Hills Area (Tributary Areas No. J16, J17B and J18) are conveyed to the Indian Hills Wastewater Reclamation Plant for treatment via a system of lift stations and gravity mains. During a plant shut down, the wastewater may be diverted through several means. Wastewater flows generated within Tributary Areas No. J16 and J17B are diverted by an existing 15-inch diameter gravity overflow main. Wastewater flows generated within Tributary Area No. J18 are diverted to the Regional Forcemain through a series of lift stations as described in Section 4. Therefore, wastewater generated within the Tributary Areas No. J16 and J17B will also be considered in determine the ultimate flows to Plant 1.

A range of values were derived in Section 4, for determining the "ultimate" wastewater flows generated within the District. Table 4-2 tabulates the wastewater flow values to be utilized in determining the ultimate trunk sewer system while the values tabulated in Table 4-4 were utilized in determining the ultimate wastewater treatment capacity. For planning purposes, the values utilized to determine the ultimate wastewater treatment capacity will be correlated with ultimate wastewater pumping capacities. Values tabulated in Table 4-4 were derived from Appendix L. This appendix will be utilized in determining the ultimate wastewater flow to Plant 1. Table 7-8 tabulates the "ultimate" wastewater flow to Plant 1 (refer to Appendix V for details).

Table 7-8. Projected "Buildout" Average Daily Flows for Ultimate Wastewater Pumping Capacity At The Regional Sewer Lift Station (Plant 1)

Tributary Drainage Areas	Residential Average Daily Flow (GPD)	Commercial/Industrial (1) Average Daily Flow (GPD)	Schools Average Daily Flow (GPD)	Total Average Daily Flow (GPD)
JCSD Areas (J1 – J17A & J19 – J23)	4,415,880	675,732 (2)	169,875	5,261,487
Indian Hills Area (J16 & J17B) (3)	346,800 (4)	4,355	0	351,155
Total	**4,762,680**	**680,087**	**169,875**	**5,612,642**

(1) Commercial and industrial wastewater generation factor based on 500 gpd/AC for determining wastewater treatment capacity per Section 4. It is noted that a wastewater generation factor of 2000 gpd/ac was utilized for determining pipeline design capacity.
(2) Area deduction of approximately 500 acres for commercial and industrial areas located above and some portion of areas below State Highway 60 of areas tributary to Plant 1 per Section 4.
(3) Wastewater generated with in Tributary Area J18 can be diverted to the Regional Forcemain, therefore does not contribute to influent at Plant 1 per Section 4.
(4) A wastewater generation factor for residential dwelling units of 200 gpd/EDU was utilized for projecting flows for ultimate treatment plant capacity for the Indian Hills Area only (refer to Section 3). A factor of 280 gpd/EDU was utilized for all other residential areas.

To account for wet weather infiltration, summation of the total areas contributing to the Plant 1 influent was multiplied by an infiltration rate (160 gpd/ac). The estimated total areas is approximately 9,920 acres, therefore flow contributions from wet weather will be approximately 1,587,118 gpd. To determine the peak wet weather flow to Plant 1, District Standard Peaking Factor was applied to the average daily flow as summarized in Table 7-8 and then added the wet weather contribution:

Q_{ADF} = Average Daily Flow (mgd) = 5.6 mgd

Q_{PK} = Peak Flow (mgd) = 2.5 x $Q_{ADF}^{0.91}$ (District Standard Peaking Factor per Section 3 & Section 6)

Q_{PK} = 2.5 x $(5.6)^{0.91}$ = 12.0 mgd and

Wet Weather Flow = 1.6 mgd

The summation of peak and wet weather contribution values yields a total flow to Plant 1 of 13.6 mgd. Table 7-9 tabulates the projected average and peak flows for ultimate conditions. This will be utilized to evaluate the current capacity of the existing Regional Sewer Lift Station (Plant 1).

Table 7-9. "Ultimate" Flows to Plant 1

Average Daily Flow	Peak Dry Weather Flow	Peak Wet Weather Flow
5.6 mgd	12.0 mgd	13.6 mgd

Currently, Plant 1 has a 3-pump configuration with an 18-inch diameter forcemain. The following summarizes the current Plant 1 capacities:

Existing Regional Wastewater Lift Station (Plant 1)

One Pump On	2,600 gpm (3.74 mgd) at 150 hp
Two Pumps On	3,500 gpm (5.04 mgd) at 300 hp
Third Pump	Standby

Existing 18-inch Diameter Regional Forcemain

Maximum Flow = 3,960 gpd (5.7 mgd) *

* Based on a maximum forcemain velocity of 5 fps.

As previously discussed, the ultimate wastewater flow, at peak wet weather conditions, is projected to be 13.6 mgd. This projection is significantly greater than current capacities; therefore Plant 1 and the Regional Forcemain do not have capacity to convey the projected flows. An additional lift station and forcemain should be proposed to alleviate the burden on existing Plant 1. For planning purposes, this proposed lift station shall be located at the same Plant 1 facility while the proposed forcemain will be assumed to parallel the existing Regional Forcemain. This proposed lift station shall be designated as the Proposed Plant 1 Sewer Lift Station Expansion (Plant 1 Expansion). The proposed forcemain shall be designated Proposed Regional Parallel Sewer Forcemain (Parallel Regional Forcemain). It is noted that the pumps inside the existing lift station at Plant 1 should not be upgraded with larger pumps due to the velocity restrictions in the existing Regional Forcemain. Therefore, it will be assumed that the existing lift station at Plant 1 will remain in operation at its

current capacity indefinitely. To determine the pumping requirements for the proposed facilities expansion, the ultimate peak wet weather flow (13.6 mgd) was subtracted from the current Plant 1 capacity (5.0 mgd) yielding a value of 8.6 mgd.

It was assumed that the Plant 1 Expansion will have a 3-pump configuration where one pump will be utilized for lower range flows, two pumps for peak flows and the third pump for stand-by. A value of 70 feet was assumed to be the static head for the forcemain system based on a preliminary review of available mapping. A total length of 16,000 feet was assumed for the proposed Parallel Regional Forcemain based on the length of the existing Regional Forcemain. Approximately 50 feet of equivalent pipe length was added to account for minor losses totaling 16,050 feet of forcemain.

This information will be utilized to determine:

- Pumping Power Requirements
- Forcemain Diameter
- System Design Parameters

It is important to review the velocity of wastewater flow within the forcemains. In accordance with current District standards, typical velocity values range from a minimum of 2.5 feet per second (fps) to 3 fps with a maximum of 5 fps. The minimum velocities requirement help prevent sedimentation of solids within the pipe. When velocities are greater than the maximum, pumping requirements will increase substantially, thus increasing operating cost. Tables 7-10 and 7-11 summarize minimum and maximum velocities within a range of alternative pipe diameters based on the District standards.

Table 7-10. Minimum Forcemain Velocities

Nominal Pipe Diameters *	Minimum Flow (mgd)	Minimum Flow (gpm)	Minimum Velocity (fps)
20-inch	3.60	2,500	2.55
24-inch	5.18	3,600	2.55
30-inch	7.92	5,500	2.50

* Nominal pipe diameters were utilized, pipe class not determined at this time

Table 7-11. Maximum Forcemain Velocities

Nominal Pipe Diameters *	Maximum Flow (mgd)	Maximum Flow (gpm)	Maximum Velocity (fps)
20-inch	7.20	5,000	5.11
24-inch	10.37	7,200	5.11
30-inch	15.98	11,100	5.04

* Nominal pipe diameters were utilized, pipe class not determined at this time

A review of Tables 7-10 and 7-11 above in conjunction with the Plant 1 Expansion peak flow requirements (8.6 mgd) was conducted to determine the Parallel Regional Forcemain configuration. Selecting a pipe diameter too large may not provide for proper minimum velocity requirement. In contrast, selecting a pipe diameter too small may not provide for proper maximum velocity requirements.

Utilization of a 20-inch diameter forcemain will not be suitable for this application. The maximum flow requirement is 8.6 mgd where as the maximum allowable flow through a 20-inch diameter pipe is 7.2 mgd. The minimum allowable flow through a 30-inch diameter pipe is 7.9 mgd and is very close to the peak flow requirement of 8.6 mgd. It is anticipated that flows may fall well below 8.6 mgd for an extended period of time and therefore, a 30-inch diameter pipe is not suitable. Allowable flow through a 24-inch diameter pipe ranges from a minimum of 5.2 mgd to a maximum of 10.4 mgd; therefore, a 24-inch diameter pipe is best suited for this application. Based on these assumptions and findings, calculations were conducted to determine the power requirements of the proposed lift station. The following summarizes preliminary design parameters for the Proposed Plant 1 Sewer Lift Station Expansion and Parallel Regional Forcemain (refer to Appendix W for system curve and calculations):

Proposed Plant 1 Expansion Wastewater Lift Station

Peak Wet Weather Flow	8.6 mgd
One Pump On	4,000 gpm (5.8 mgd) at 180 hp
Two Pumps On	6,000 gpm (8.6 mgd) at 350 hp
Third Pump	Standby
Pump Controls	Variable Frequency Drives

Proposed 24-inch Diameter Parallel Regional Sewer Forcemain

Minimum Flow	3,600 gpm (5.2 mgd)
Maximum Flow	7,200 gpm (10.4 mgd)
Approximate Length	16,000 feet

Plate 16 shows the location of the proposed lift station expansion and the proposed forcemain alignment. The work associated with the Plant 1 Expansion shall be designated as Project No. P-LS-1, Proposed Plant 1 Sewer Lift Station Expansion. The work associated with the Parallel Regional Forcemain shall be designated as Project No. P-FM-1, Proposed 24-inch Parallel Regional Sewer Forcemain. This work should include the following items:

- Site, Mechanical, Structural and Electrical work associated with the Lift Station Facility
    - Pump Selections
    - Controls by Variable Frequency Drives (VFD's)
    - Site Grading
- Connection of Flow from Terminus of the Jurupa Trunk System
- Expansion of Emergency Lagoon System at Lift Station Facility

- Additional Emergency Bypass Pumps for Lagoon System Expansion
- All work associated with Forcemain Alignment Study and Construction
    - Possibility to Directional Drill under Santa Ana River or
    - Install Forcemain to Van Buren Bridge
- Modifications to City of Riverside WWRP Influent for Forcemain Connection

This list is not a proposed scope of services, but recommendations of items that may be required for this project. Additional items may be required as the project is further defined. Also, this project may be postponed if wastewater from the Sky Country development and Tributary Area No. J25 is diverted to the Eastvale Interceptor, thus freeing some of the Plant 1 capacity. Based on a 4% growth rate as discussed in Section 2 and the current capacity of Plant 1, it is recommended that the District implement the planning phase of this project in order to meet future flow requirements in a timely fashion.

These findings are preliminary in nature and are based on many assumptions. There are alternate pumping configurations, lift station locations and forcemain alignments as well as alternate conveyance schemes that may be further investigated, though are beyond the scope of this study. Therefore, it is recommended that a "detailed" engineering design review be conducted to determine this project's feasibility and to further define system design requirements and parameters.

Western Riverside County Wastewater Reclamation Plant River Road Lift Station and Forcemains

The River Road Lift Station is currently in design. This lift station will be located adjacent to the Western Riverside County Regional WWRP at the terminus of the Eastvale Interceptor. Wastewater will be conveyed via two 24-inch forcemains discharging flows into this plant for treatment. Sizing of the lift station and forcemains were based on the ultimate buildout conditions for the Eastvale area while the construction phasing is based on the projected growth rate. Refer to the "1999 Eastvale Master Sewer Plan", the "June 17, 2002 Draft Eastvale Master Sewer Plan Update Letter," the "January 2003 Draft JCSD Wastewater Reclamation Plant Influent Lift Station Preliminary Design Report" and the "June 23, 2003 memo regarding the projected wastewater flow to the proposed River Road Lift Station" for additional information. These systems shall be designed and operated upon the recommendations of the aforementioned.

TREATMENT SYSTEM EVALUATION AND PLANNING

Wastewater generated by the District ultimately discharges into to four facilities for treatment. As discussed in Section 4, evaluations for the ultimate treatment capacity is based on a review of data collected within the Community Facilities District No. 1 for commercial and industrial wastewater generation (CFD Study). Based on the findings of this study, a wastewater generation factor of 500 gpd/ac was utilized in determining ultimate wastewater treatment capacities for industrial and commercial areas. In contrast, the District standard factor of 2,000 gpd/ac was used for commercial and industrial areas in determining the Design JCSD Trunk Sewer System. It is noted that wastewater treatment capacities will be based on average daily flows and will include wet weather infiltration.

Indian Hills Wastewater Reclamation Plant (Plant 2)

The Indian Hills Wastewater Reclamation Plant (Plant 2) serves the Indian Hills Area (Tributary J16 to J18). Wastewater generated in this area consists of mostly residential development with some commercial development. As discussed in Section 4, domestic wastewater generation factors for this area were based on 200 gpd/EDU in lieu of the District standard 280 gpd/EDU. Table 7-12 tabulates projected ultimate wastewater generation within this area.

Table 7-12. Projected "Buildout" Average Daily Flows for Ultimate Wastewater Treatment Plant Capacity at Indian Hills WWRP

Tributary Drainage Areas	Residential Average Daily Flow (GPD)	Commercial/Industrial (1) Average Daily Flow (GPD)	Schools Average Daily Flow (GPD)	Total Average Daily Flow (GPD)
Indian Hills Area (J16, J17B & J18 upper)	495,600 (2)	82,305	8,510	586,415

(1) Commercial and industrial wastewater generation factor based on 500 gpd/AC for determining wastewater treatment capacity per Section 4. It is noted that a wastewater generation factor of 2000 gpd/ac was utilized for determining pipeline design capacity.

(2) A wastewater generation factor for residential dwelling units of 200 gpd/EDU was utilized for projecting flows for ultimate treatment plant capacity for the Indian Hills Area only (refer to Section 3). A factor of 280 gpd/EDU was utilized for all other residential areas.

Wet weather infiltration is based on summation of the acreage of these tributary areas (1,361 ac) multiplied by an infiltration rate (160 gpd/ac) yielding a total of 218,270 gpd. Therefore, the projected ultimate wastewater flow to the Indian Hills WWRP may range from approximately 0.59 mgd for dry weather average daily to 0.80 mgd for wet weather average daily flow. Current capacity of this plant ranges from 0.75 mgd to 1.0 mgd, therefore Plant 2 currently has treatment capacity to serve the Indian Hills area for ultimate wastewater flows. Aside from routine maintenance, Plant 2 should not require modifications to increase its treatment capacity.

Western Riverside County Wastewater Reclamation Plant (WRCWWRP)

All of the wastewater generated within the Eastvale Area, including the Sky Country development and Tributary Area No. J25 (Jurupa Valley High School) will ultimately discharge into the WRCWWRP for treatment via the Eastvale Interceptor. Based on District standards, a domestic wastewater generation factor of 280 gpd/EDU was utilized. Commercial wastewater generation was based on factors established in the CFD Study in Section 4. Table 7-13 tabulates projected ultimate wastewater generation within this area.

Table 7-13. Projected "Buildout" Average Daily Flows for Ultimate Wastewater Treatment Plant Capacity at WRCWWRP

Tributary Drainage Areas	Residential Average Daily Flow (GPD)	Commercial/Industrial [1] Average Daily Flow (GPD)	Schools Average Daily Flow (GPD)	Total Average Daily Flow (GPD)
Eastvale Areas (E1 – E50 & J25)	6,254,680	478,600	203,550 [2]	6,936,830

[1] Commercial and industrial wastewater generation factor based on 500 gpd/AC for determining wastewater treatment capacity per Section 4. It is noted that a wastewater generation factor of 2000 gpd/ac was utilized for determining pipeline design capacity.

[2] Includes Tributary Area No. J25, which consist totally of flows from Jurupa Valley High School (68,750 gpd).

Wet weather infiltration is based on summation of the acreage of these tributary areas (7,515 ac) multiplied by an infiltration rate of 100 gpd/ac per the "May 1999 Eastvale Master Sewer Plan" and the "June 17, 2002 Draft Eastvale Master Sewer Plan Update". Applying this factor to the acreage yields a total of 751,500 gpd of infiltration flow. Therefore, the projected ultimate wastewater flow to the WRCWWRP may range from approximately 6.9 mgd for dry weather average daily to 7.7 mgd for wet weather average daily flow. Due to the rapid growth in this area, careful flow monitoring is recommended to project the rate of increase in wastewater generation. Determining this rate should be correlated to the WRCWWRP current (8 mgd) and future capacities.

The ultimate average daily flows projected in the "June 17, 2002 Draft Eastvale Master Sewer Plan Update" was based on utilizing a wastewater generation factor 2,000 gpd/ac for commercial and industrial areas and did not take into consideration additional flow conditions. The draft update shall be revised to reflect the following items:

- Revise wastewater generation factors for commercial and industrial areas as established in Section 4 to determine ultimate wastewater treatment capacity
- Account for Tributary Area No. J25 as a contributor to wastewater influent at the WRCWWRP
- Account for an increase of area due to the proposed dike construction adjacent to the terminus of the Eastvale Trunk Sewer
- Account for contributions from existing and future school facilities
- Account for contributions from the proposed C.F.D. No. 1 Land Conversion

Efforts in obtaining additional treatment capacity at the Western Riverside County WWRP shall be designated as Project No. P-WWRP-1.

It is noted that the values reflected in Table 7-13 above are preliminary, pending the results of the Eastvale Master Sewer Plan Update Letter.

City of Riverside Wastewater Reclamation Plant

As discussed in Section 4 and Section 6 wastewater generated within Tributary Areas No. J1 through J15B, J17A and J19 through J23 discharges directly into the Plant 1. This facility pumps wastewater

via the existing 18-inch diameter Regional Forcemain to the City of Riverside Wastewater Reclamation Plant for treatment. As previously discussed, wastewater generated in the Indian Hills area may flow through the Regional Forcemain during a shutdown of the Indian Hills WWRP (Plant 2) as well. It is noted that the Sky Country development including Tributary Area No. J25 (Jurupa Valley High School) will ultimately discharge into the Eastvale Interceptor and then to the WRCWWRP for treatment and therefore will not be treated at the City of Riverside. Based on District standards, a domestic wastewater generation factor of 280 gpd/EDU was utilized (200 gpd/EDU for domestic wastewater generation within the Indian Hills Area). Industrial wastewater generation was based on factors established in the CFD Study in Section 4. Table 7-14 tabulates projected ultimate wastewater generation within these areas.

Table 7-14. Projected "Buildout" Average Daily Flows for Ultimate Wastewater Treatment Plant Capacity at City of Riverside WWRP

Tributary Drainage Areas	Residential Average Daily Flow (GPD)	Commercial/Industrial (1) Average Daily Flow (GPD)	Schools Average Daily Flow (GPD)	Total Average Daily Flow (GPD)
JCSD Areas (J1 – J15B, J17A & J19 – J23)	4,415,880	675,732 (2)	169,875 (3)	5,261,487
Indian Hills Area (J16, J17B & J18)	495,600 (4)	82,305	8,510	586,415
Lower Portion of Tributary Area No. J18	0	38,450	0	38,450
Total	**4,911,480**	**796,937**	**178,385**	**5,886,352**

(1) Commercial and industrial wastewater generation factor based on 500 gpd/AC for determining wastewater treatment capacity per Section 4. It is noted that a wastewater generation factor of 2000 gpd/ac was utilized for determining pipeline design capacity.

(2) Area deduction of approximately 500 acres for commercial and industrial areas located above and some portion of areas below State Highway 60 of areas tributary to Plant 1.

(3) Excludes Tributary Area No. J25, which consist totally of flows from Jurupa Valley High School (68,750 gpd).

(4) A wastewater generation factor for residential dwelling units of 200 gpd/EDU was utilized for projecting flows for ultimate treatment plant capacity for the Indian Hills Area only (refer to Section 3). A factor of 280 gpd/EDU was utilized for all other residential areas.

Wet weather infiltration is based on summation of the acreage of these tributary areas (10,318 ac which includes the Indian Hills Area) multiplied by the District standard infiltration rate (160 gpd/ac) yielding a total of 1,650,880 gpd. Therefore, the projected ultimate wastewater flow to the City of Riverside WWRP may range from approximately 5.9 mgd for dry weather average daily to 7.6 mgd for wet weather average daily flow. Increase in wastewater generation due to the growth in this area should be correlated to the City of Riverside WWRP current and future capacities. Efforts in obtaining additional treatment capacity at the City of Riverside WWRP shall be designated as Project No. P-WWRP-2.

Santa Ana Regional Interceptor (SARI Line)

The Santa Ana Regional Interceptor (SARI Line) is utilized to convey wastewater generated by residential, commercial and industrial areas. Currently, the District is discharging wastewater generated in the Community Facilities District (CFD) No. 1 into the SARI Line through a series of trunk sewers. Also, through a series of interim pumping facilities, the District is discharging much of the wastewater generated within the Eastvale area directly into the SARI Line. As previously discussed, these interim pumping facilities will be replaced with the Eastvale Interceptor, thus diverting wastewater generated within the Eastvale Area out of the SARI Line. Therefore, wastewater discharge into the SARI Line will primarily serve the CFD No. 1 which is comprised of tributary areas J24, J26 through J30. As discussed in Section 4, ultimate wastewater generation within the CFD No. 1 varies considerably. This variation is dependent on the generation factor utilized and the addition of the proposed desalination and ion exchange facilities. Wet weather infiltration rates for this area are based on a factor of 100 gpd/ac due to the fairly new pipe construction. Total infiltration is based on the summation of the acreage of these tributary areas (4,104 ac for CFD Area No. 1) multiplied by the infiltration rate for this area yielding a total of 410,400 gpd. Table 7-15 tabulates projected ultimate wastewater generation within these areas (ranging from dry weather to wet weather flows) to be discharged into the SARI Line.

Table 7-15. Projected "Buildout" Average Daily Flows for Ultimate Discharge to SARI Line (for Treatment Capacity) from CFD Area No. 1

Residential Average Daily Flow (GPD)	Commercial/Industrial Average Daily Flow (GPD)	Subtotal Average Daily Flow (GPD)	Total W/ Point Source Discharge (GPD)	Total W/ Wet Weather Infiltration (GPD)
32,200	660,573 (1)	692,773	4,892,773 (3)	5,303,173 (4)
32,200	1,887,350 (2)	1,919,550	6,119,550 (3)	6,529,950 (4)

(1) Commercial and Industrial wastewater generation factor based on 175 gpd/AC per Section 4.
(2) Commercial and industrial wastewater generation factor based on 500 gpd/AC for determining wastewater treatment capacity per Section 4. It is noted that a wastewater generation factor of 2000 gpd/ac was utilized for determining pipeline design capacity.
(3) Point source discharge based on projected wastewater generated from the Chino 2 Desalter, Ion Exchange Plant and the Metal Container Corporation (Section 4 and Section 6) for a total of 4,200,000 gpd. Area deduction was based on approximately 60 acres to account for parcels utilized per these developments.
(4) Wet weather infiltration rate based on 100 gpd/ac multiplied by the total CFD No. 1 of 4,104 acres yielding a total flow of 410,400 gpd.

Increase in wastewater generation due to growth in the CFD No. 1 should be correlated to the District's current and future SARI capacity requirements. As discussed in Section 4 and Section 6, it is the responsibility of the Chino Desalter Authority (CDA) to acquire SARI capacity for flows generated by the Chino II Desalter (3.46 mgd). Therefore, flows generated by this desalter facility shall be evaluated separately when considering SARI capacity requirements. As discussed in Section 6, wastewater generated by the Chino II Desalter (18 mgd buildout production) and the Ion Exchange Plant (12.7 mgd buildout production) were based on worst case scenarios. Table 7-16 tabulates projected ultimate wastewater generation excluding the flows generated by the Chino II Desalter. This table represents the amount of SARI capacity that will be the District's responsibility.

Table 7-16. Projected "Buildout" Average Daily Flows for Ultimate Discharge to SARI Line (for Treatment Capacity) from CFD Area No. 1 Responsibility of the Jurupa Community Facilities District

Residential Average Daily Flow (GPD)	Commercial/Industrial Average Daily Flow (GPD)	Wastewater from Metal Container Corporation (GPD)	Wastewater from Ion Exchange Plant (GPD)	Total W/ Wet Weather Infiltration (GPD)
32,200	660,573 (1)	150,000	180,000 (3)	1,433,173 (5)
32,200	1,887,350 (2)	150,000	590,000 (4)	3,069,950 (5)

(1) Commercial and Industrial wastewater generation factor based on 175 gpd/AC per Section 4.

(2) Commercial and industrial wastewater generation factor based on 500 gpd/AC for determining wastewater treatment capacity per Section 4. It is noted that a wastewater generation factor of 2000 gpd/ac was utilized for determining pipeline design capacity.

(3) Wastewater generated may be as low as 0.18 mgd from the Ion Exchange Plant (Section 4 and Section 6) if well water nitrate levels are found to be 60 mg/L.

(4) Wastewater generated may be as low as 0.59 mgd from the Ion Exchange Plant (Section 4 and Section 6) if well water nitrate levels are found to be 140 mg/L.

(5) Wet weather infiltration rate based on 100 gpd/ac multiplied by the total CFD No. 1 of 4,104 acres yielding a total flow of 410,400 gpd.

Table 7-17 tabulates the projected Chino II Desalter flows. This table represents the amount of SARI capacity that will be the CDA's responsibility.

Table 7-17. Projected "Buildout" Average Daily Flows for Ultimate Discharge to SARI Line (for Treatment Capacity) from Chino II Desalter Responsibility of the Chino Desalter Authority

Ion Exchange Portion (GPD)	Reverse Osmosis Portion (GPD)	Total Wastewater Flow (GPD)
460,000 (1)	2,200,000 (2)	2,660,000
460,000 (1)	3,000,000 (2)	3,460,000

(1) Flow projection from Mary Hambel, RBF Engineering, March 23, 2003 (based on 18 mgd plant buildout and average brine waste of 0.36 mgd w/ 0.1 mgd from wash down and sampling water). It is the responsibility of the CDA to acquire SARI Capacity for this flow.

(2) Flow projection from Mary Hambel, RBF Engineering, March 23, 2003 (based on 18 mgd plant buildout and average brine waste of 2.2 mgd w/ worst case of 3.0 mgd). It is the responsibility of the CDA to acquire SARI Capacity for this flow.

It is noted that the District will recoup existing SARI capacity by diverting wastewater generated within the Eastvale Area from the SARI Line to the Western Riverside County WWRP via the Eastvale Interceptor (refer to the "May 1999 Eastvale Master Sewer Plan" and the "June 17, 2002 Draft Eastvale Master Sewer Plan Update" for additional information. This capacity may be utilized for other developing areas within the District, such as C.F.D. No. 1.

Managing SARI capacity shall be an on going process and should be implemented as such. Due to the dynamic nature of development with in the CFD No. 1 and Eastvale's current wastewater treatment scheme (SARI discharge via interim sewer lift stations as shown on Plate 11), it is important to evaluate SARI capacity as development occurs. All work associated with the management of SARI capacity shall be designated as Project No. P-SARI-1.

As previously stated, the CDA will be responsible for obtaining SARI capacity for the Chino II Desalter. Though the District is not responsible for the treatment of flows generated by this facility, these flows will be conveyed through the District's collection and trunk systems. The CDA will be responsible for all cost associated with this Project, including but not limited to planning, feasibility studies, engineering, construction cost, permit fees, etc. All work associated with infrastructure improvements such as collection and trunk system construction shall be designated as Project No. P-SARI-2.

SUMMARY OF PROPOSED CAPITAL IMPROVEMENT PROJECTS

Table 7-18 summarizes the capital improvement projects as previously described.

Table 7-18. Proposed Capital Improvement Projects
Jurupa Community Services District

Project Designation No.	Project Description
P-J-1	Jurupa Trunk Sewer – Felspar St & Limonite Ave, Sewer Pipe Rerouting (36, 39 & 42-inch)
P-J-2	Jurupa Trunk Sewer – Adjacent to Metrolink between Jurupa Rd & 54th St, Sewer Pipe Replacement (30 & 36-inch)
P-J-3	Jurupa Trunk Sewer – Along Jurupa Rd between Felspar St & Tyrolite St, Sewer Pipe Replacement (18, 21 & 24-inch)
P-J-4	Jurupa Trunk Sewer – Valley Way between Soto Rd & 34th St, Sewer Pipe Replacement (12 & 15-inch)
P-J-5	Jurupa Trunk Sewer – Armstrong Rd., Sewer Pipe Replacement (10-inch)
P-PC-1	New Pyrite Creek Interceptor – Slip line of a existing portion of Jurupa Trunk Sewer and new pipe starting on 59th St at Tumbleweed to Rutile St at 60th St (15-inch, 21-inch)
P-G-1	Glen Avon Relief Sewer – Campbell St & Bellegrave Av, Relief Sewer (12 & 15-inch)
P-G-2	Glen Avon Trunk Sewer – Mission Blvd to Galena St, Felspar St & Jurupa Rd, Sewer Pipe Replacement (15, 18 & 21-inch)
P-B-1	Bain Street Trunk Sewer – Realignment of Bain Street Trunk Sewer at lower end of sewer (18 & 27-inch)
P-P-1	Pedley Trunk Sewer – Replacement of sewers along the Pedley Trunk Sewer (12 & 15-inch)
P-LS-1	Proposed Plant 1 Sewer Lift Station Expansion at the Regional Lift Station Facility (8.6 mgd peak flow, 3 Pump Configuration)
P-FM-1	Proposed 24-inch Parallel Regional Sewer Forcemain parallel to the existing Regional Forcemain (16,000 feet)

Refer to Appendix X for approximate lengths and sizes of the proposed capital improvement projects for the gravity sewer. These lengths will be utilized to estimate the cost of this portion of the capital improvements. For parameters to be utilized for estimating capital improvement cost for the pressure system improvements, refer to the proposed sewer lift station expansion and parallel forcemain discussion in this report.

Table 7-19 summarizes future wastewater treatment capacities the District will be required to obtain and manage.

Table 7-19. Proposed Wastewater Treatment Capacity
Jurupa Community Services District

Project Designation No.	Project Description
P-WWRP-1	Obtain Wastewater Treatment Capacity at the Western Riverside Country Wastewater Reclamation Plant
P-WWRP-2	Obtain Wastewater Treatment Capacity at the City of Riverside Wastewater Reclamation Plant

Table 7-20 summarizes future SARI capacities the District will be required to obtain and manage.

Table 7-20. Proposed SARI Capacity
Jurupa Community Services District

Project Designation No.	Project Description
P-SARI-1	Managing SARI Capacity for the District's Wastewater Discharge from the Eastvale Area and CFD Area No. 1
P-SARI-2	Infrastructure Improvements Due to the Chino II Desalter Ultimate Wastewater Generation

SECTION 8 - COST ANALYSIS

PROPOSED TRUNK SEWER PIPELINE PROJECTS

The components used to develop unit construction costs for the trunk sewerlines include pipeline material and installation costs, manhole costs, and asphalt concrete removal, disposal, and replacement costs. Construction costs were determined by reviewing historical bids of similar projects and through a cost study where a "generic bid" was sent to three prominent contractors in the area. The generic bid was based on the assumptions that an average project for the District would consist of 2,500 linear feet of pipe, and that asphalt concrete roads would be removed, disposed of, and replaced. Road reconstruction was assumed to be 25 feet wide with 4 inches of AC pavement over 8 inches of Class II base. The average depth of the pipe was assumed to be 20 ft and would require B-2 bedding. It was assumed nine, 5 ft diameter manholes would be installed for each project. These costs were then updated to correlate with recent bid results that are about 25 percent higher than the "generic bid" results. Not included in the unit cost estimates are extraordinary construction items such as bore casings, dewatering, rock removal, etc… A summary of these estimated unit costs are as shown on Table 8-1.

Table 8-1. Estimated Unit Cost of Trunk Sewer Pipelines

Sewer Line Dia. (in.)	Construction Cost	Project Cost[1]
10	$181.00	$255.00
12	$206.00	$290.00
15	$219.00	$310.00
18	$244.00	$345.00
21	$263.00	$370.00
24	$300.00	$420.00
27	$325.00	$455.00
30	$363.00	$510.00
36	$419.00	$590.00
39	$500.00	$700.00
42	$550.00	$770.00
48	$606.00	$850.00

[1]*Project cost is 1.4 times construction cost rounded up to nearest $5. Project cost includes: construction cost, construction contingencies, design engineering including plans and specifications; design and construction surveying and mapping; geotechnical evaluation and report; engineering contract administration; field inspection and basic environmental documentation. Costs are based on Engineering New Record (E.N.R.). The Engineering news Record Construction Cost Index for the Los Angeles Areas for August, 2004 was utilized. This value is 7,857. Escalation, financing, interest during construction, legal, land, R.O.W. agent, and environmental impact report costs are not included in construction costs. Additionally, not included in the unit cost estimates are extraordinary construction items such as bore casings, dewatering, rock removal etc…*

The unit costs shown on Table 8-1 were applied to the proposed capital improvement projects shown on Table 7-18 to develop project cost estimates. These project cost estimates are provided in Appendix Y. As shown in Appendix Y, the total estimated project cost for gravity flow pipelines is $22,770,000. Plate 16 shows the project locations.

SEWER SYSTEM REHABILITATION/REPLACEMENT PROJECTS

As previously mentioned in Section 5 the District has collection pipes that were built to substandard grades that create operation and maintenance problems. Additionally, there are collection lines that have been damaged by roots. The District is currently reviewing these sewerlines which are operational problems. Upon completion of the District review and evaluation of these pipelines, a project list will be completed which will serve as the basis for a pipeline rehabilitation program.

In addition to the pipeline rehabilitation/replacement projects that will be identified in the future, a sewerage lift station replacement project needs to occur. As shown on Plate 11, in the northeast corner of the District, there are two lift stations; Sunnyslope and Florine. Both of these stations are older and the District has determined that a more efficient pumping scenario exists. The proposed pumping scenario is as follows. The existing Sunnyslope and Florine lift stations will be abandoned. Wastewater flows currently tributary to the Sunnyslope Lift Station will be intercepted with a new trunk sewer that will traverse approximately 2,000 LF to the southerly end of Florine Avenue where a new lift station will be constructed. The existing Florine Lift Station will be abandoned with it's tributary flows diverted back to the new station. Because the new lift station will pump the combined flows of the existing Sunnyslope and Florine Lift Stations, construction of about 2,500 LF of a new force main will be required from the new lift station to just easterly of Armstrong Road. The estimated project cost of the lift station replacement project is shown on Table 8-2.

Table 8-2. Sunnyslope/Florine Lift Station Replacement Project

Item	Quantity	Unit	Unit Price	Extension
12" Dia. VCP Sewer	2,000	LF	$206	$412,000
8" Dia. PVC Force Main	2,500	LF	$60	$150,000
Submersible Type Lift Station	LS	LS	$500,000	$500,000
			Total Estimated Construction Cost	$1,062,000
			Total Estimated Project Cost	$1,490,000[1]

[1] *Project is 1.4 times the construction cost rounded to the nearest $10,000. Project cost includes: construction cost, construction contingencies, design engineering including plans and specifications; design and construction surveying and mapping; geotechnical evaluation and report; engineering contract administration; field inspection and basic environmental documentation. Costs are based on Engineering New Record (E.N.R.). The Engineering news Record Construction Cost Index for the Los Angeles Areas for August, 2004 was utilized. This value is 7,857. Escalation, financing, interest during construction, legal, land, R.O.W. agent, and environmental impact report costs are not included in construction costs.*

TBD – To Be Determined.

REGIONAL WASTEWATER PUMP STATION EXPANSION (PLANT 1)

As discussed in Section 7, the Regional Wastewater Pump Station at Plant 1 currently has a capacity of 5.0 mgd. Ultimate peak design flows that could occur at Plant 1 are projected to be 13.6 mgd. Therefore, an additional 8.6 mgd of pumping capacity is required. The 8.6 mgd (6,000 gpm ±) expansion is estimated to have a project cost of approximately $6,400,000[1].

It should be noted that the feasibility of intercepting flows upstream of Plant 1 and constructing a subregional lift station and force main should be evaluated. However, this evaluation is beyond the scope of this report.

NEW REGIONAL FORCE MAIN TO THE CITY OF RIVERSIDE WWTP

A total length of 16,000 LF was used for the 24 inch diameter Regional Forcemain assumed to run parallel to the existing Regional Forcemain. It was assumed that 600 feet of the 16,000 feet total length would be HDPE pipe directionally bored under the Santa Anna River yielding 15,400 of conventionally installed 24 inch pipe. Construction cost for the 15,400 feet of pipe was determined to be $145 per foot by reviewing the three lowest bids of similar recent projects. For the construction cost of the 600 feet of directionally bored HDPE, local contractors were contacted for a cost estimate. The HDPE was estimated to have a construction cost about $400 per foot. The total estimated project cost for the new regional force main is $3,460,000.

CITY OF RIVERSIDE WASTEWATER TREATMENT PLANT CAPACITY PURCHASE

The purchase of treatment plant capacity at the City of Riverside wastewater treatment plant was assumed to reflect the current costs to construct a wastewater treatment plant. Presently, due to the increasing costs of solids treatment and disposal, and dependent upon the amount of treatment capacity being constructed, typical unit project costs range from $9/gallon/day to almost $14/gallon/day[2]. The District currently owns 4 mgd of treatment capacity at the City of Riverside's facility. Using this project cost range and the projected additional ultimate average daily flow of 1.9 mgd (5.9 mgd ultimately required – 4.0 mgd currently owned), the total estimated project cost for treatment could vary from $17,100,000 to $26,600,000.

A summary of the estimated project costs for the Jurupa sewer system are shown on Table 8-3. As shown on Table 8-3, the total project cost estimate of the updated sewer system improvements range from $51,220,000 to $60,720,000 depending upon ultimate treatment plant capacity purchase costs.

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[1] *Pumping Station Design, Second Edition,* Robert L. Sanks, George Tchobanoglous, Baynard E. Bosserman II, and Garr M. Jones, Butterworth – Heinemann, MA: Woburn, 1998. Construction cost updated to ENR CCI = 7187.62 (August, 2004) multiplied by a 1.4 factor to obtain project costs.

[2] *JCSD New Wastewater Treatment Cost Estimate" letter prepared by Carollo Engineers, dated April 1, 2004.*

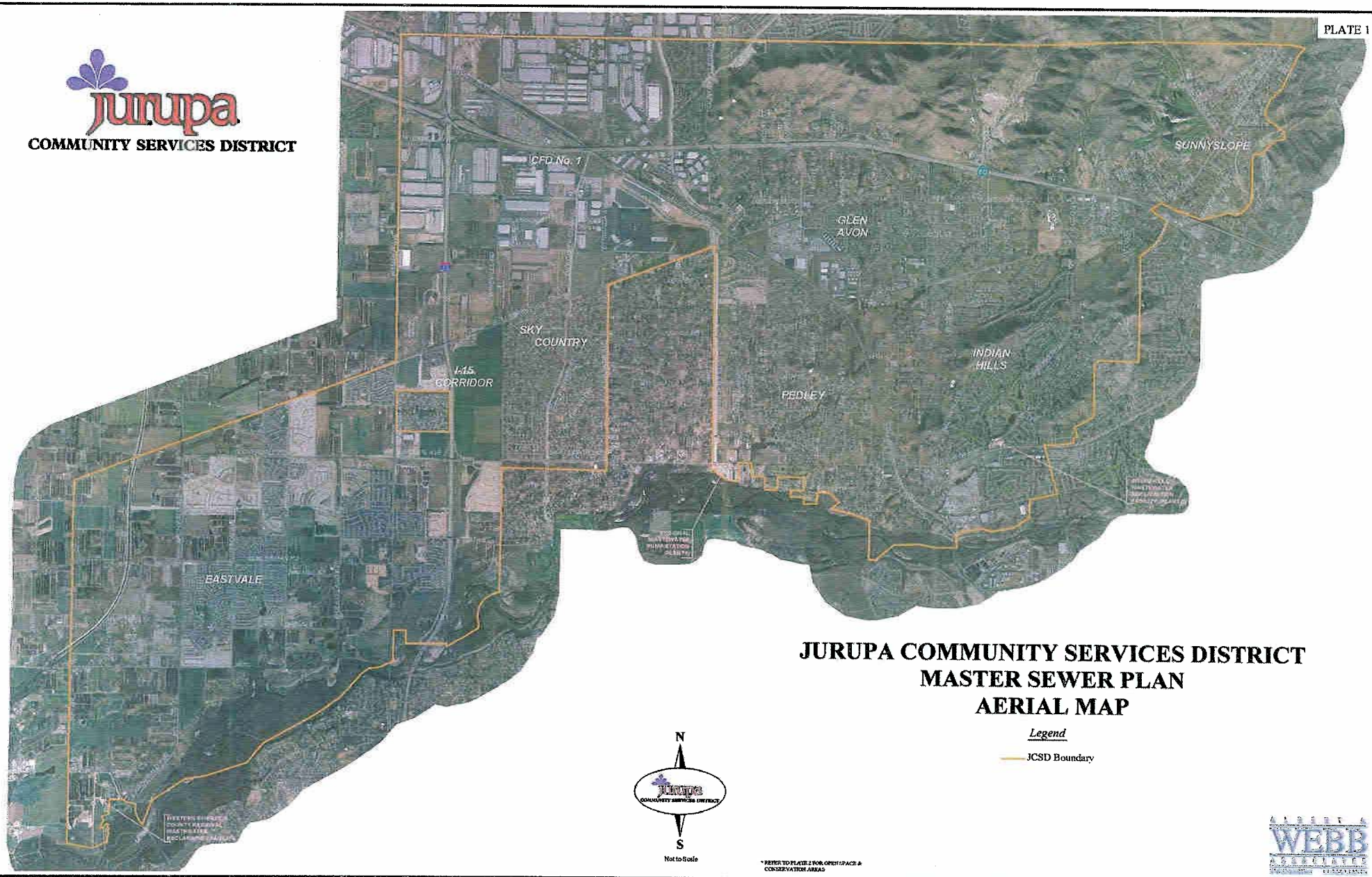
Table 8-3 – Estimated Project Cost Summary

Master Plan Improvement	Estimated Project Cost
Proposed Gravity Flow Pipelines and Projects	$22,770,000[1,2,3]
Pipeline Rehabilitation/Replacement Projects	TBD
Lift Station Rehabilitation/Replacement Projects	$ 1,490,000
Regional Wastewater Pump Station Expansion (Plant 1)	$ 6,400,000[2,3]
New Regional Force Main to the City of Riverside WWTP	$ 3,460,000[2,3]
City of Riverside Treatment Plant Capacity Purchase	$17,100,000-$26,600,000[3]
Total Estimated Project Cost	**$51,220,000-$60,720,000**

[1]*Refer to Appendix Y for a breakdown of cost per project*
[2]*Total estimated construction cost rounded up to the nearest $10,000.*
[3]*Project is 1.4 times the construction cost. Project cost includes: construction cost, construction contingencies, design engineering including plans and specifications; design and construction surveying and mapping; geotechnical evaluation and report; engineering contract administration; field inspection and basic environmental documentation. Costs are based on Engineering New Record (E.N.R.). The Engineering news Record Construction Cost Index for the Los Angeles Areas for August, 2004 was utilized. This value is 7,857. Escalation, financing, interest during construction, legal, land, R.O.W. agent, and environmental impact report costs are not included in construction costs.*
TBD – To Be Determined.

PLATE 1

Jurupa
COMMUNITY SERVICES DISTRICT



JURUPA COMMUNITY SERVICES DISTRICT
MASTER SEWER PLAN
AERIAL MAP

Legend

JCSD Boundary

N
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Not to Scale

* REFER TO PLATE 1 FOR OPEN SPACE & CONSERVATION AREAS

WEBB

PLATE 2

jurupa
COMMUNITY SERVICES DISTRICT

JURUPA COMMUNITY SERVICES DISTRICT
MASTER SEWER PLAN
LAND USE MAP

WESTERN RIVERSIDE COUNTY REGIONAL WASTEWATER RECLAMATION FACILITY

N
S
Not to Scale

LEGEND

- JURUPA COMMUNITY SERVICES DISTRICT
- PRADO FLOOD BOUNDARY
- 100 YEAR FLOOD BOUNDARY
- PARCELS

RESIDENTIAL
- RURAL RESIDENTIAL (<0.2 D.U./AC.)
- VERY LOW DENSITY (0.4-2 D.U./AC.)
- LOW DENSITY (2-5 D.U./AC.)
- MEDIUM DENSITY (5-8 D.U./AC.)
- MEDIUM HIGH DENSITY (8-14 D.U./AC.)
- HIGH DENSITY (14-20 D.U./AC.)

COMMERCIAL
- RETAIL
- OFFICE
- COMMUNITY CENTERS

INDUSTRIAL
- LIGHT
- HEAVY
- BUSINESS PARK
- PUBLIC FACILITIES

OPEN SPACE
- CONSERVATION
- CONSERVATION HABITAT
- OPEN SPACE - MINERAL
- OPEN SPACE - RECREATION
- OPEN SPACE - RURAL
- OPEN SPACE - WATER

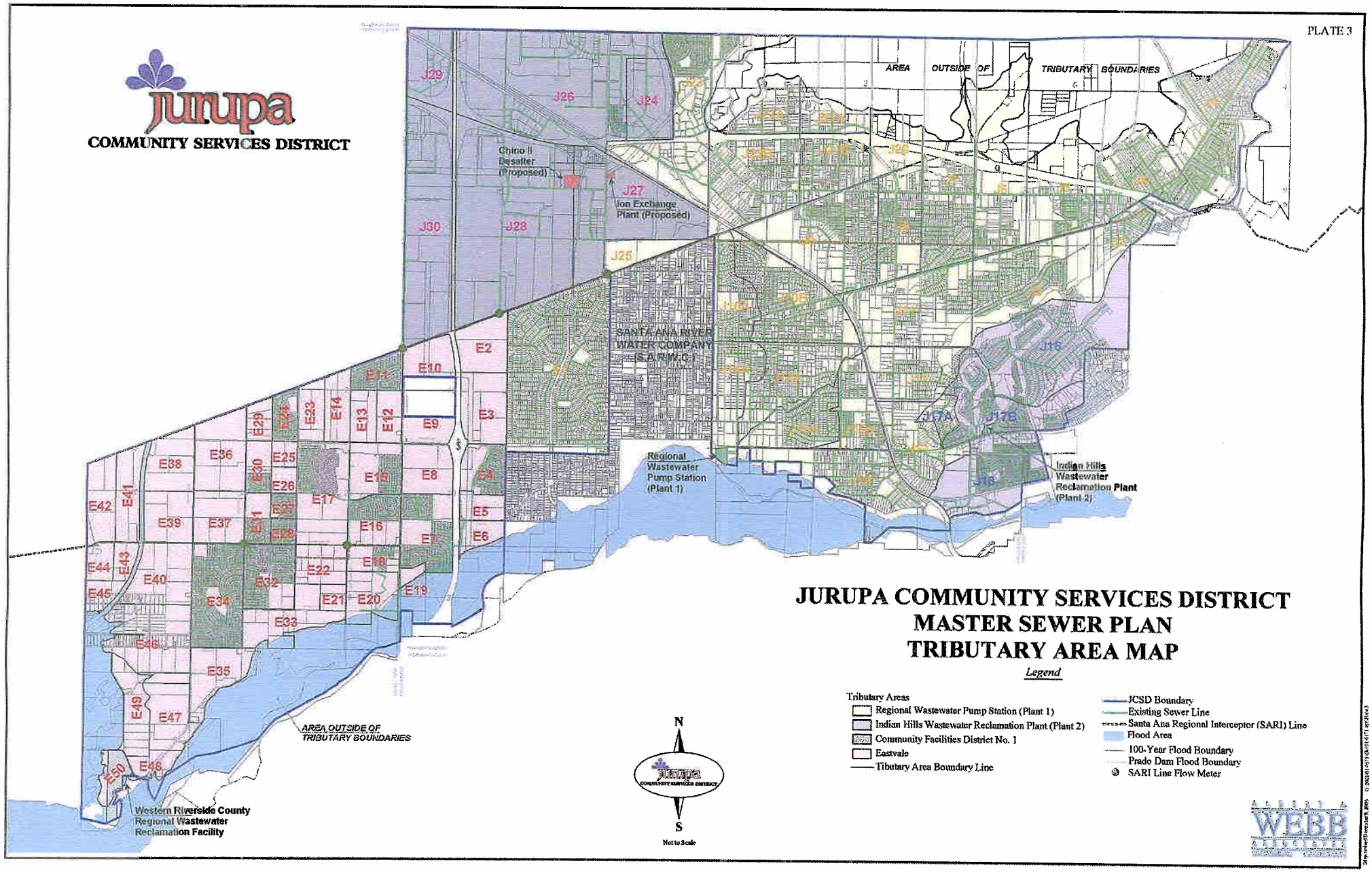
MISCELLANEOUS
- AGRICULTURE
- I-15 CORRIDOR
- SKY COUNTRY
- TRACT
- WRCRWRF
- FLOOD
- FREEWAY

SOURCE: RIVERSIDE COUNTY INTEGRATED PROJECT (APRIL 2000)
JURUPA AREA LAND USE PLAN (APRIL 2001) &
EASTVALE AREA LAND USE PLAN (APRIL 2001)
*ADDITIONAL SOURCES FOR THE EASTVALE AREA
INCLUDED TENTATIVE TRACT MAPS AND THE
I-15 CORRIDOR SPECIFIC PLAN (NOVEMBER 1993)

ALBERT A. WEBB ASSOCIATES

Map revised October 22, 2002 O:\JOB\1497\FIGURES\Figure 2

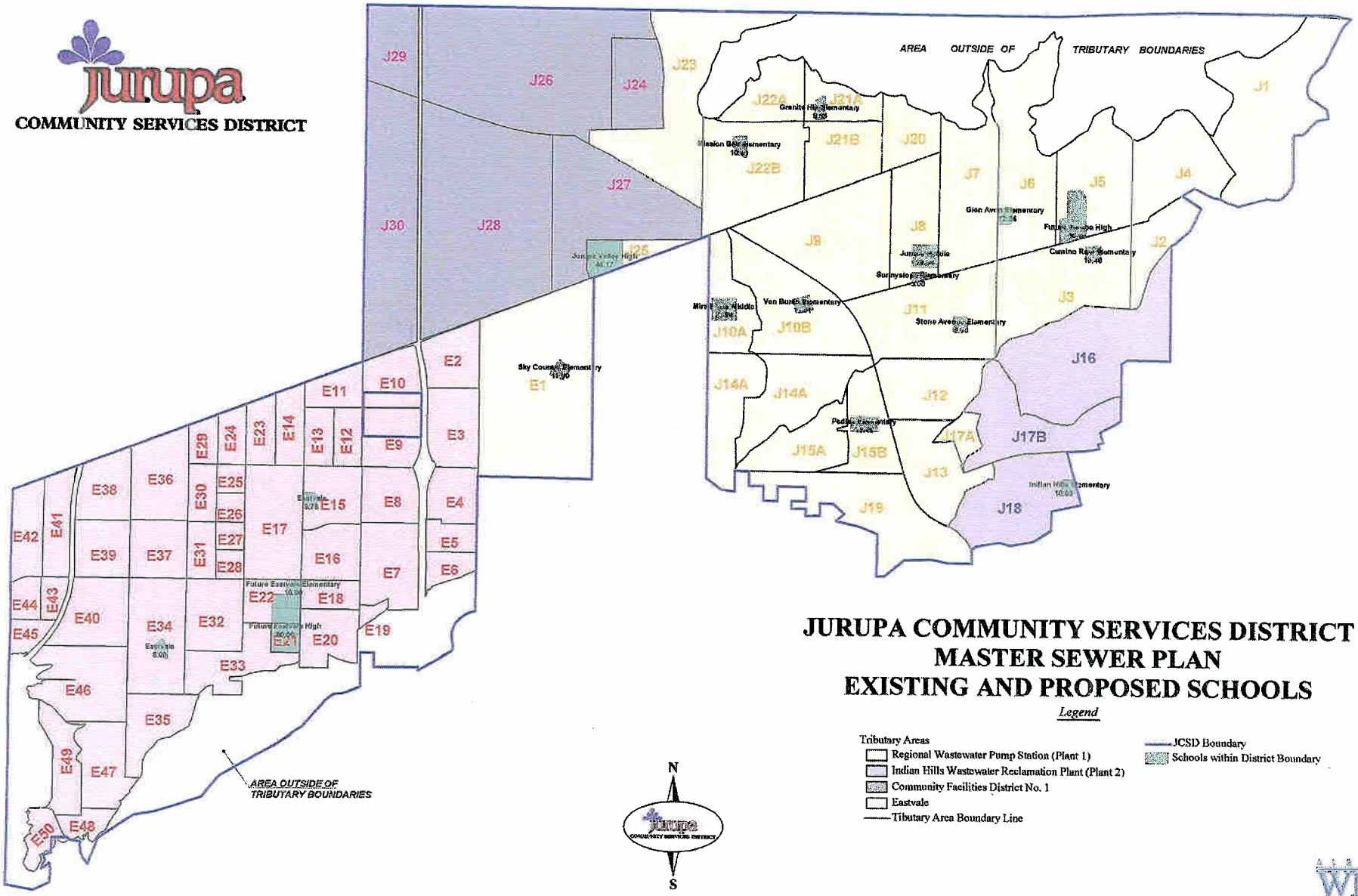
PLATE 3



JURUPA COMMUNITY SERVICES DISTRICT
MASTER SEWER PLAN
TRIBUTARY AREA MAP

Legend

PLATE 4


jurupa
COMMUNITY SERVICES DISTRICT
AREA OUTSIDE OF TRIBUTARY BOUNDARIES
J1
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J3
J4
J5
J6
J7
J8
J9
J10A
J10B
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J14A
J15A
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E50
Sky Country Elementary
Mission Bay Elementary
Granite Hills Elementary
Glen Avon Elementary
Future Jurupa High
Cantina Real Elementary
Jurupa Valley High
Jurupa Middle
Sunnyslope Elementary
Van Buren Elementary
Stone Avenue Elementary
Pedley Elementary
Indian Hills Elementary
Eastvale
Future Eastvale Elementary
Future Eastvale High
AREA OUTSIDE OF TRIBUTARY BOUNDARIES
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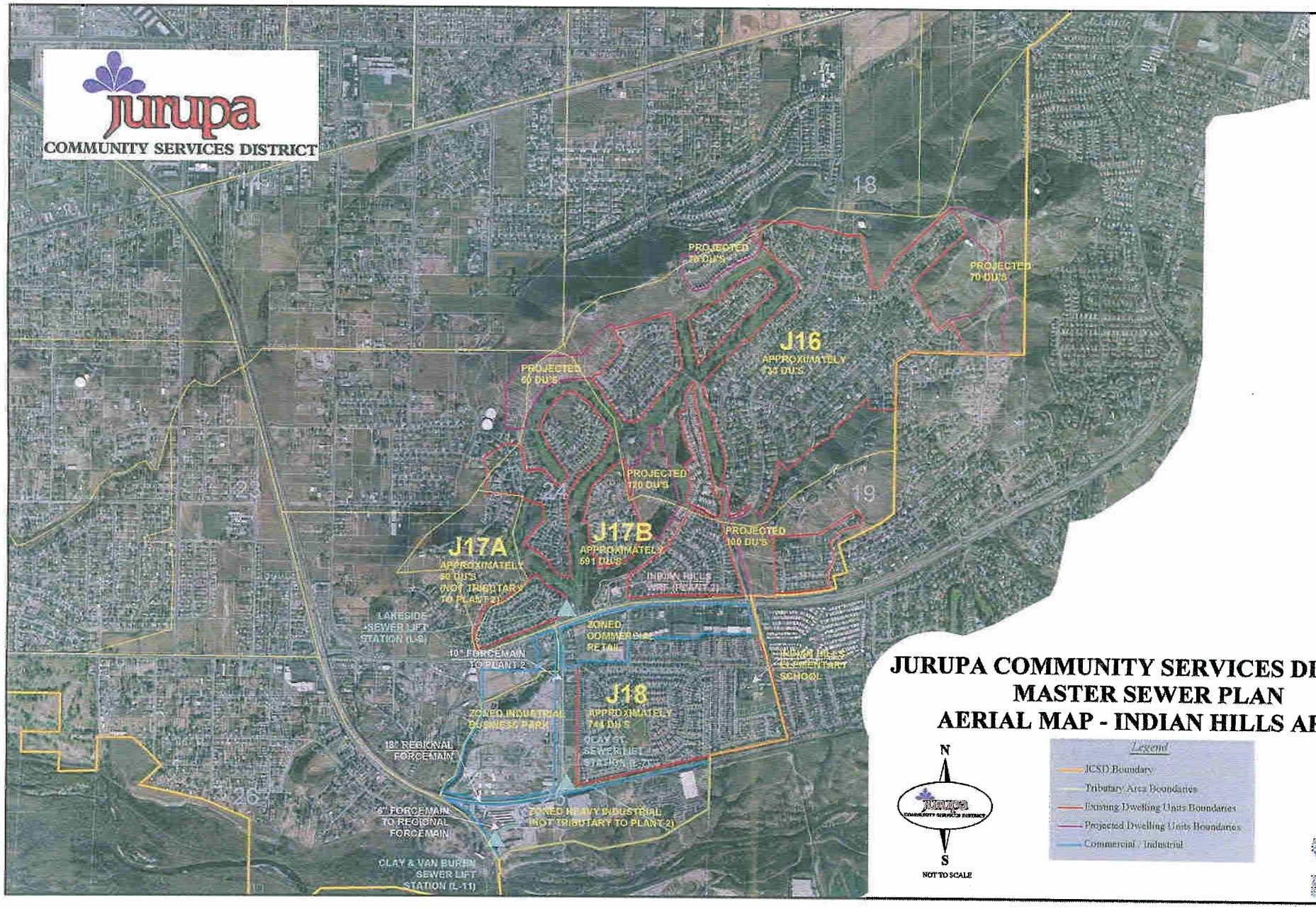
Not to Scale
JURUPA COMMUNITY SERVICES DISTRICT
MASTER SEWER PLAN
EXISTING AND PROPOSED SCHOOLS
Legend
Tributary Areas
Regional Wastewater Pump Station (Plant 1)
Indian Hills Wastewater Reclamation Plant (Plant 2)
Community Facilities District No. 1
Eastvale
Tibutary Area Boundary Line
JCSD Boundary
Schools within District Boundary
WEBB



JURUPA COMMUNITY SERVICES DISTRICT
MASTER SEWER PLAN
AERIAL MAP - INDIAN HILLS AREA

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NOT TO SCALE

Legend

- JCSD Boundary
- Tributary Area Boundaries
- Existing Dwelling Units Boundaries
- Projected Dwelling Units Boundaries
- Commercial / Industrial

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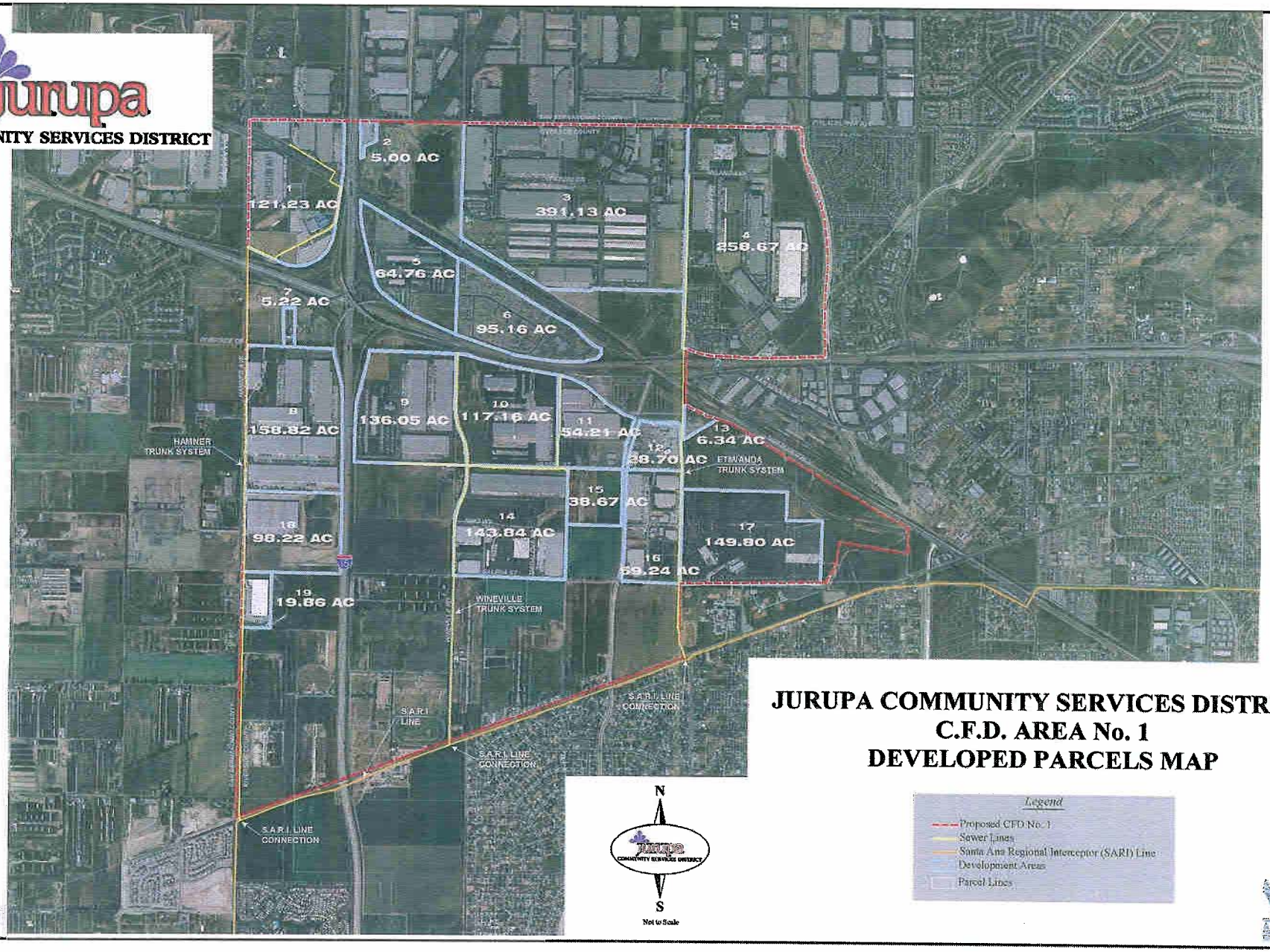
jurupa
COMMUNITY SERVICES DISTRICT



JURUPA COMMUNITY SERVICES DISTRICT
C.F.D. AREA No. 1
DEVELOPED PARCELS MAP

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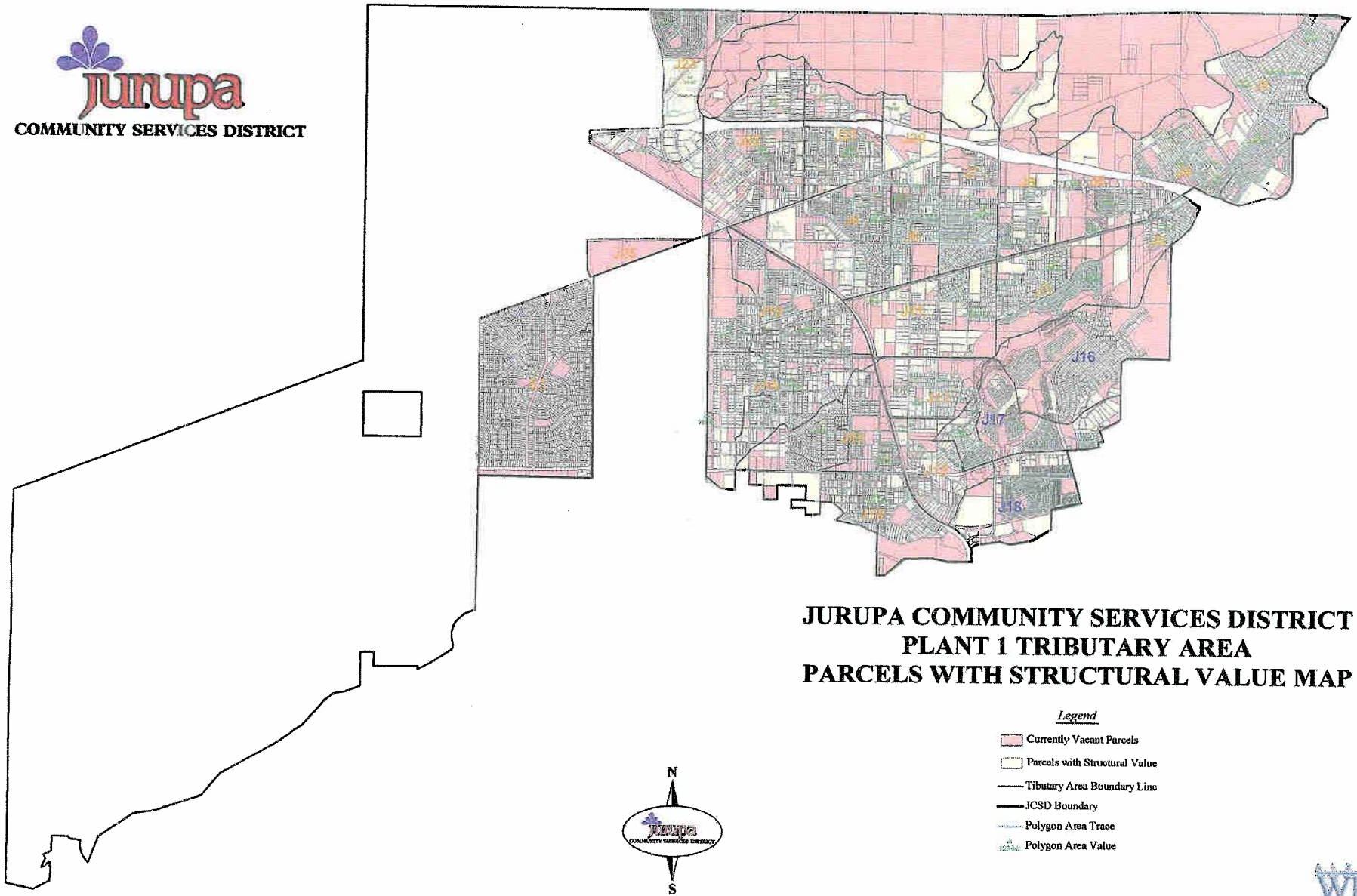
Jurupa
COMMUNITY SERVICES DISTRICT



JURUPA COMMUNITY SERVICES DISTRICT
PLANT 1 TRIBUTARY AREA
PARCELS WITH STRUCTURAL VALUE MAP

Legend

- Currently Vacant Parcels
- Parcels with Structural Value
- Tibutary Area Boundary Line
- JCSD Boundary
- Polygon Area Trace
- Polygon Area Value

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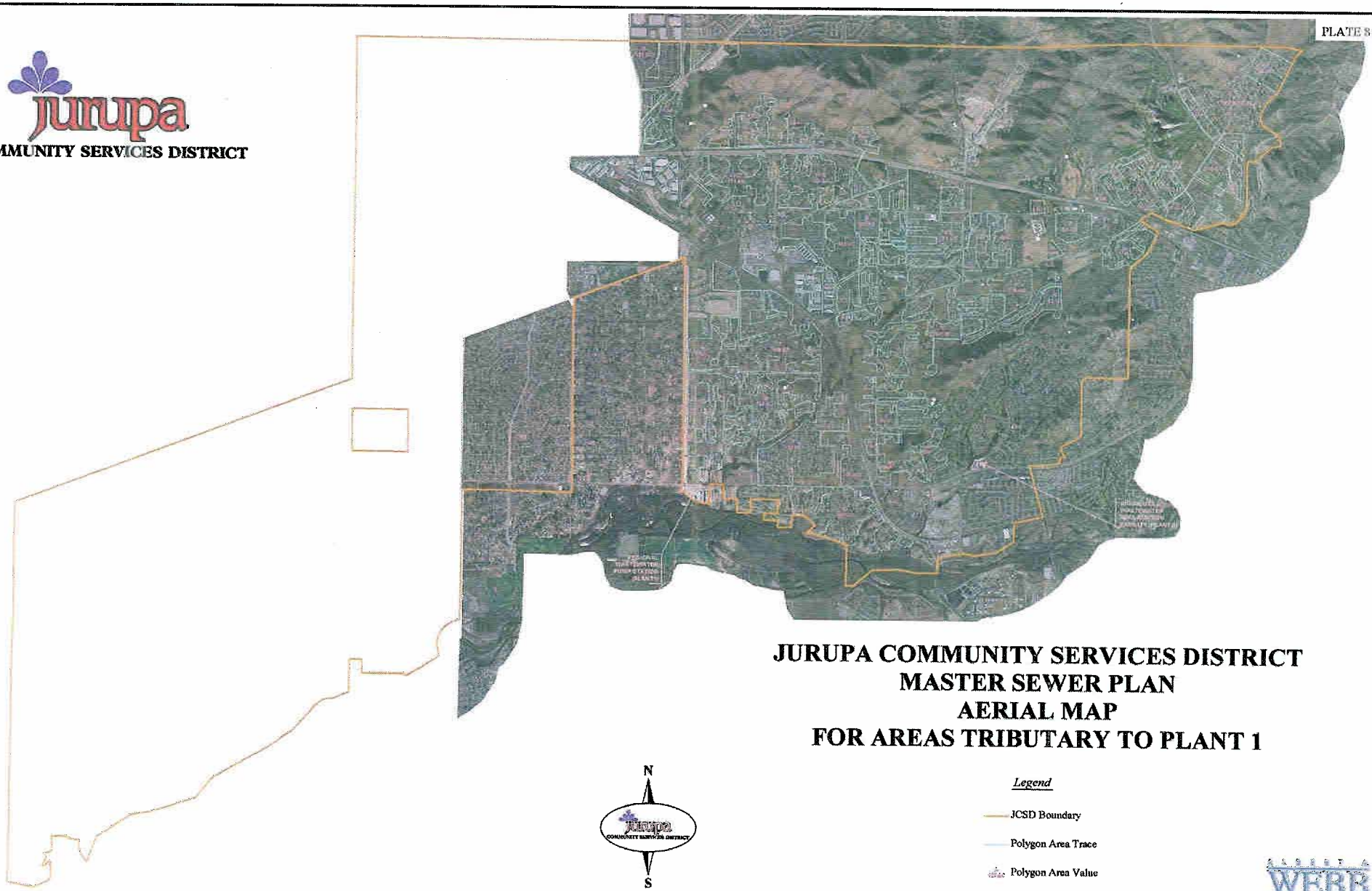
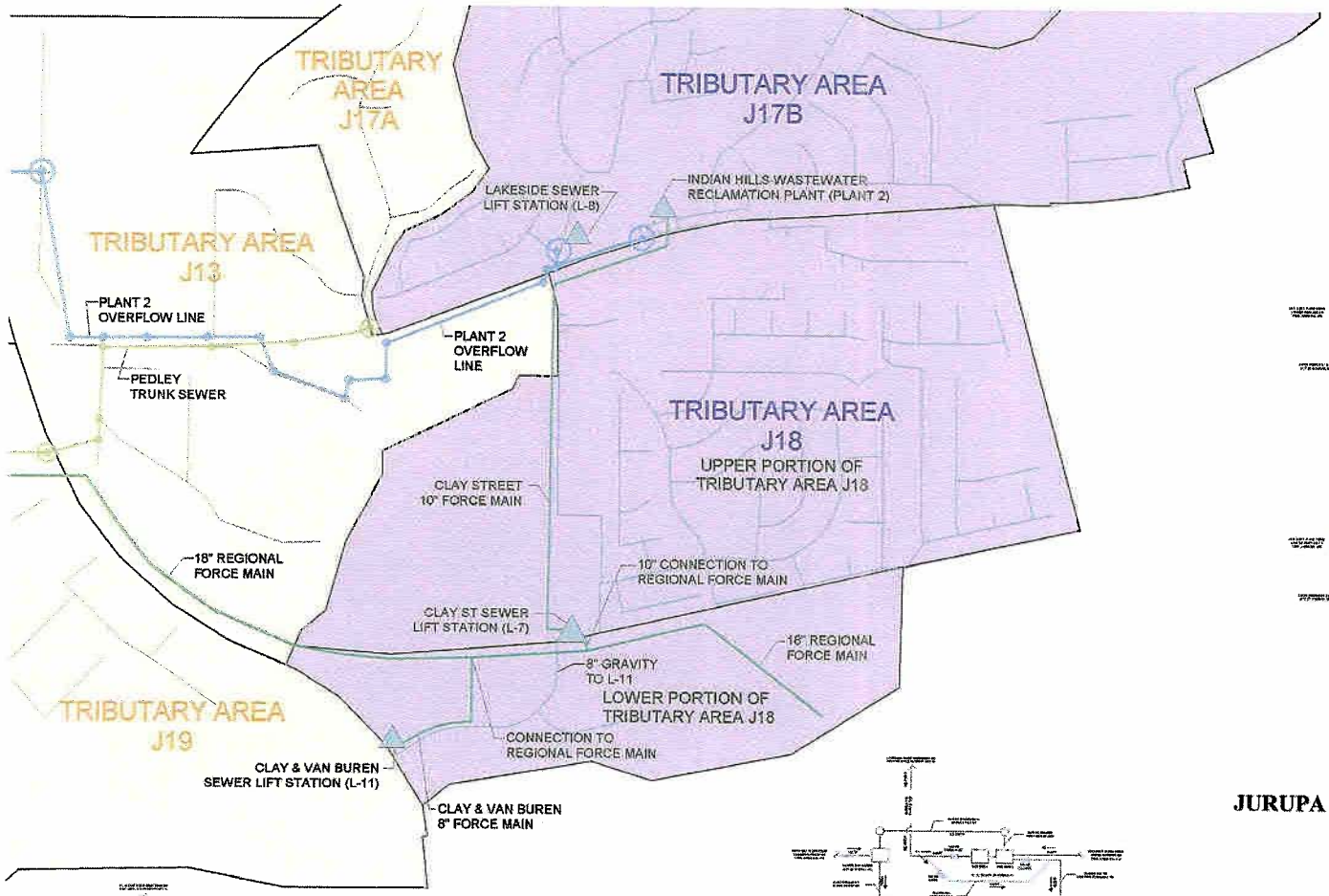
PLATE 8

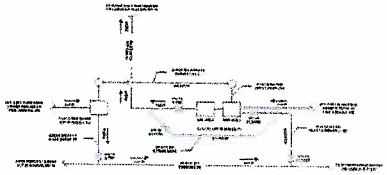
jurupa
COMMUNITY SERVICES DISTRICT



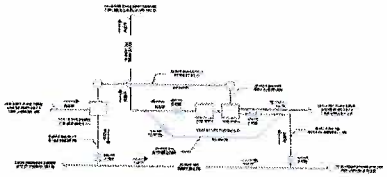
JURUPA COMMUNITY SERVICES DISTRICT
MASTER SEWER PLAN
AERIAL MAP
FOR AREAS TRIBUTARY TO PLANT 1

jurupa
COMMUNITY SERVICES DISTRICT

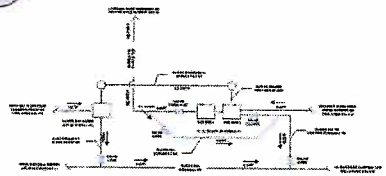




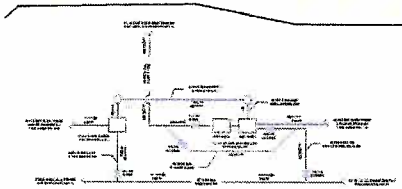
CLAY STLIFT STATION UNDER NORMAL OPERATIONS PUMPING FLOW TO THE INDIAN HILLS WRP(PLANT 2)



CLAY STLIFT STATION PUMPING SCHEME TO DIVERT A PORTION OF FLOW FROM THE REGIONAL FORCEMAIN FOR TREATMENT AT THE INDIAN HILLS WRP(PLANT 2)



CLAY STLIFT STATION AT "ON" SETTING TO DIVERT FLOW DIRECTLY TO THE REGIONAL FORCEMAIN



CLAY STLIFT STATION AT "OFF" SETTING TO DIVERT FLOW TO THE CLAY & VAN BUREN LIFT STATION

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JURUPA COMMUNITY SERVICES DISTRICT
MASTER SEWER PLAN
TRIBUTARY AREA No. J18
PUMPING SCHEME

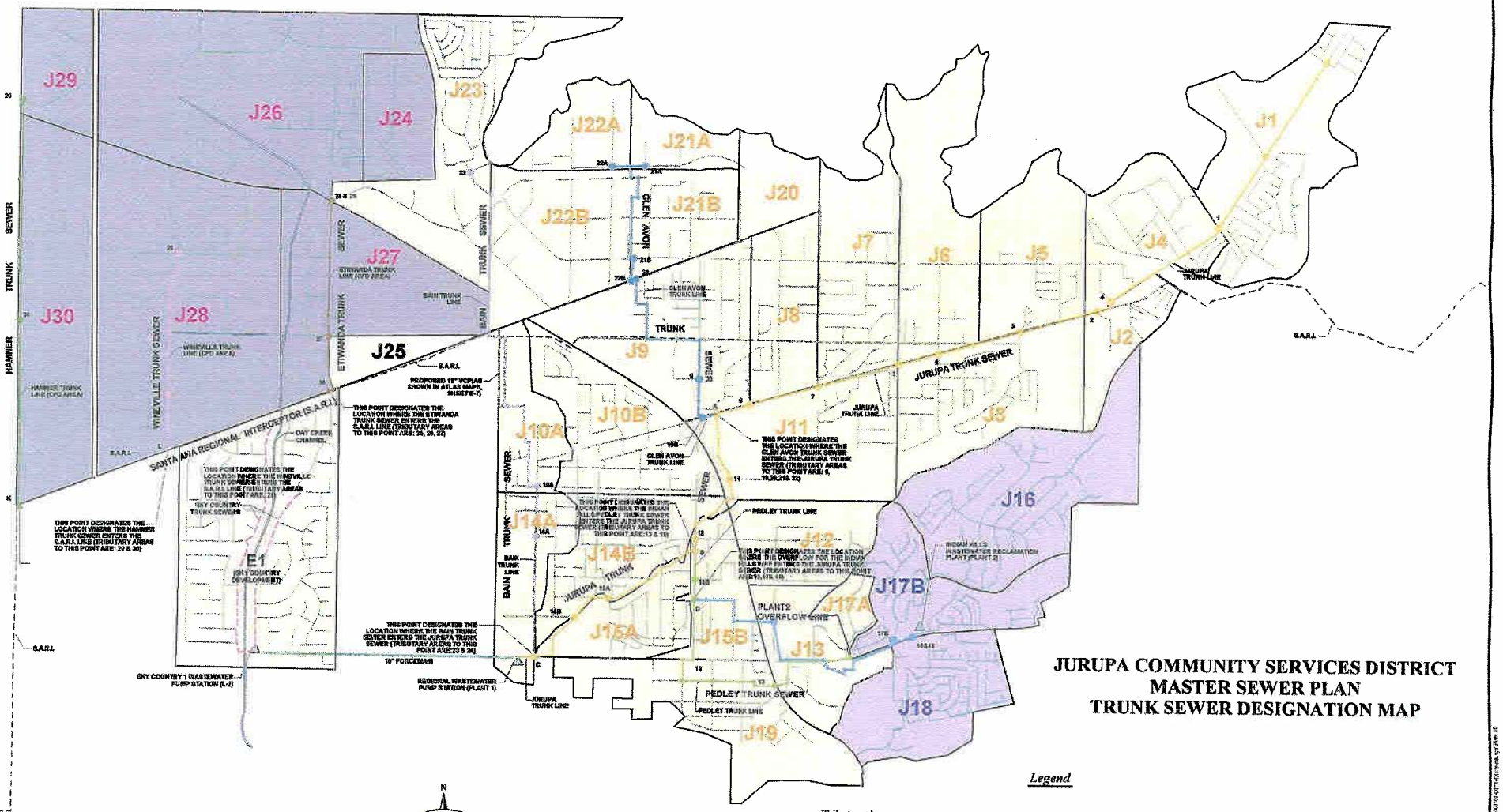
Legend

Tributary Areas
- Regional Wastewater Pump Station (Plant 1)
- Indian Hills Wastewater Reclamation Plant (Plant 2)

- Lift Station and Facilities
- Tibutary Area Boundary Line
- Existing Sewer Line

WEBB

jurupa
COMMUNITY SERVICES DISTRICT



JURUPA COMMUNITY SERVICES DISTRICT
MASTER SEWER PLAN
TRUNK SEWER DESIGNATION MAP

Legend

Tributary Areas
- Regional Wastewater Pump Station (Plant 1)
- Indian Hills Wastewater Reclamation Plant (Plant 2)
- Community Facilities District No. 1 (S.A.R.I.)

- Tibutary Area Boundary Line
- Existing Sewer Line
- Santa Ana Regional Interceptor (SARI) Line
- Tributary Area Flow Input Points

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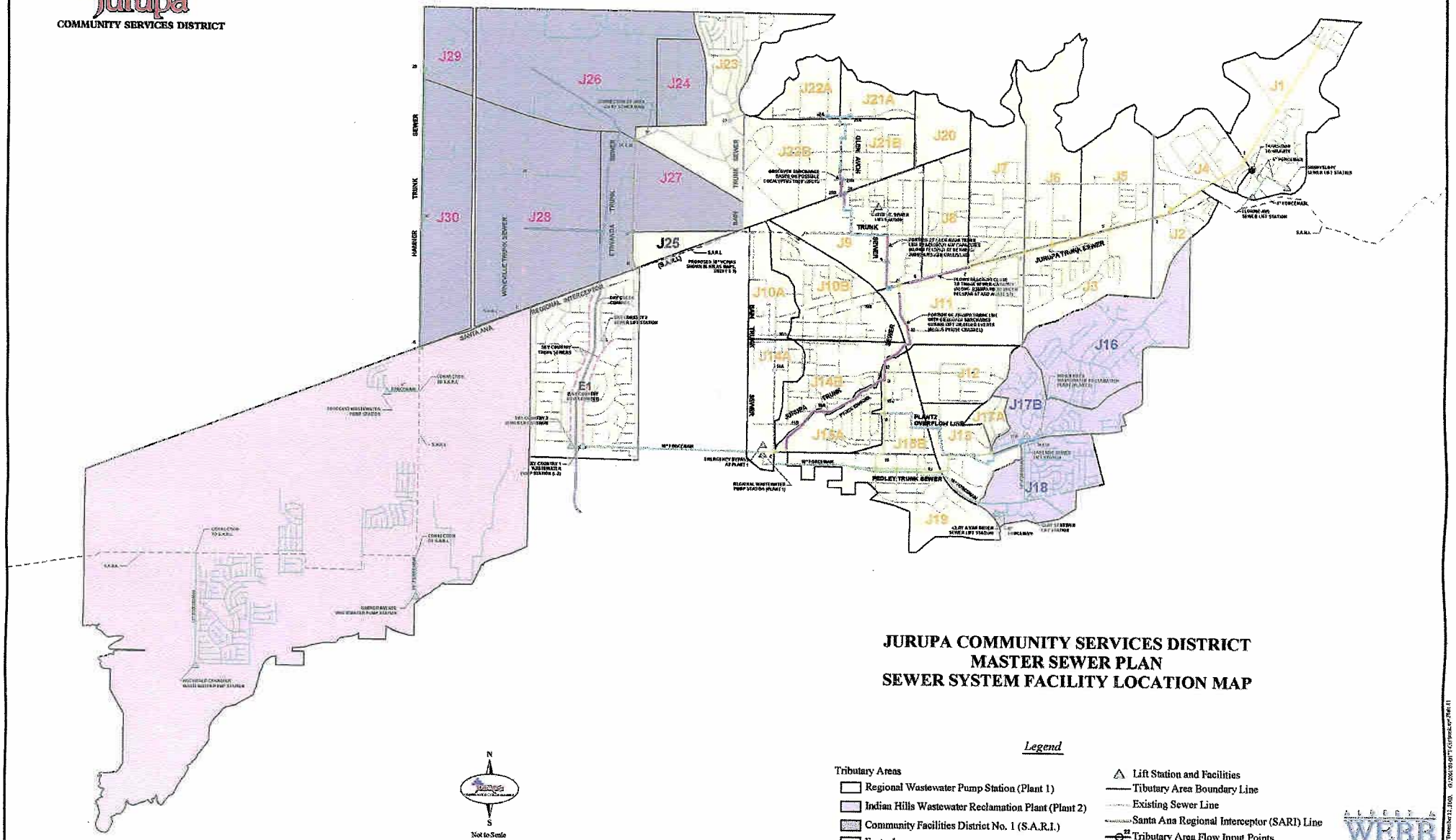
COMMUNITY SERVICES DISTRICT



JURUPA COMMUNITY SERVICES DISTRICT
MASTER SEWER PLAN
SEWER SYSTEM FACILITY LOCATION MAP

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Not to Scale

Legend

Tributary Areas
- Regional Wastewater Pump Station (Plant 1)
- Indian Hills Wastewater Reclamation Plant (Plant 2)
- Community Facilities District No. 1 (S.A.R.I.)
- Eastvale

- Lift Station and Facilities
- Tibutary Area Boundary Line
- Existing Sewer Line
- Santa Ana Regional Interceptor (SARI) Line
- Tributary Area Flow Input Points
- Observed Trunk Sewer Problem Areas

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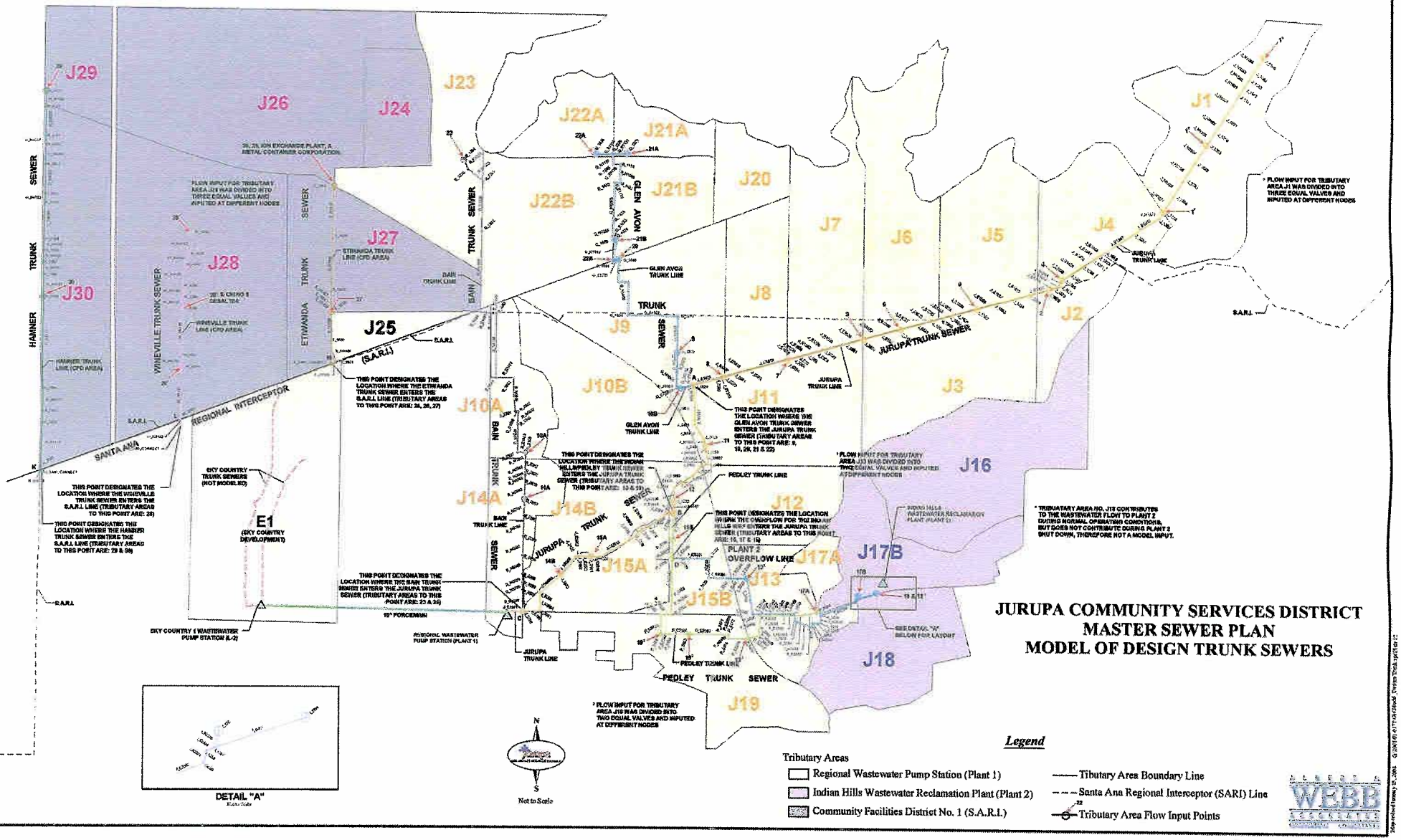
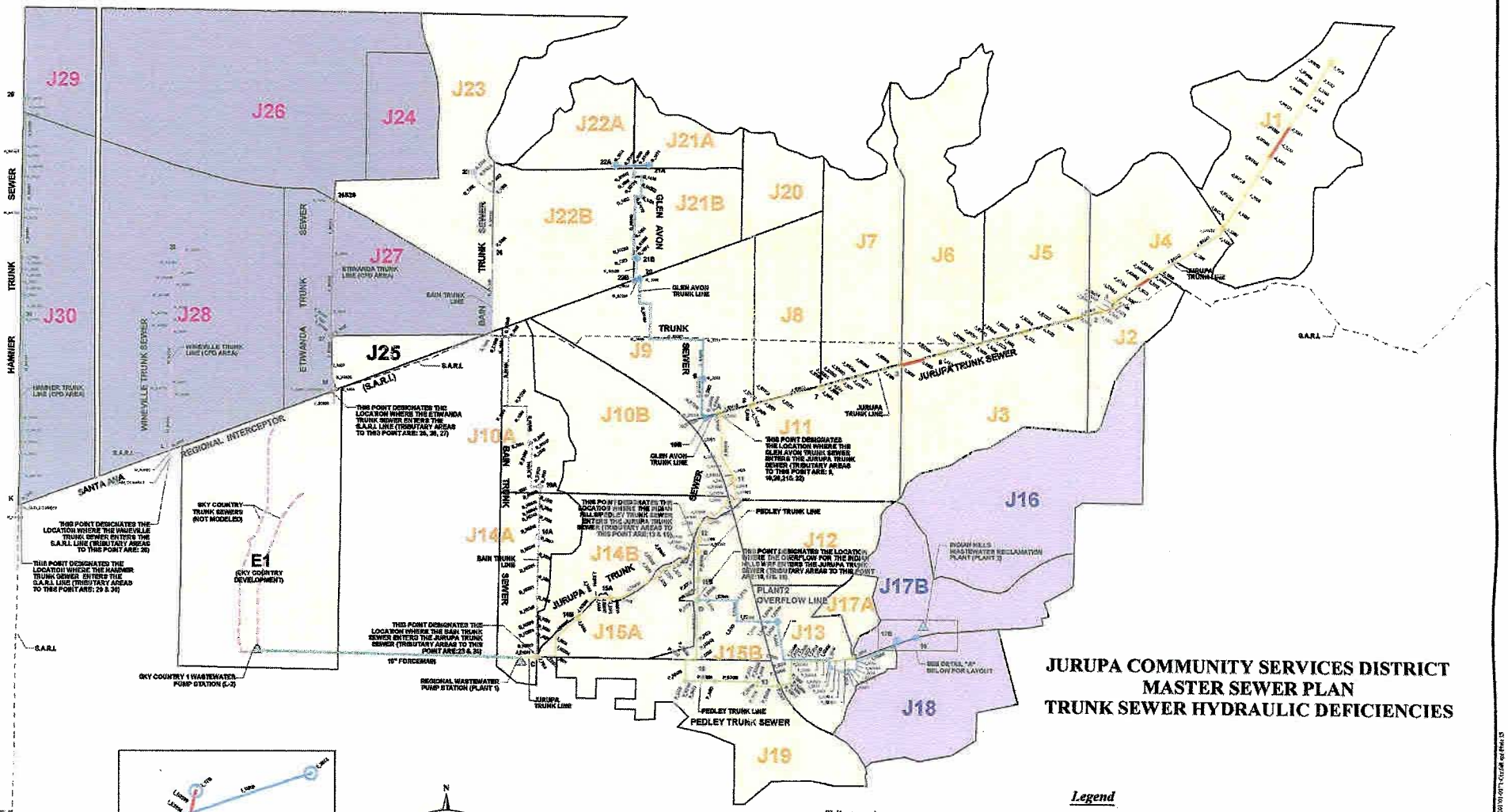
COMMUNITY SERVICES DISTRICT



JURUPA COMMUNITY SERVICES DISTRICT
MASTER SEWER PLAN
MODEL OF DESIGN TRUNK SEWERS

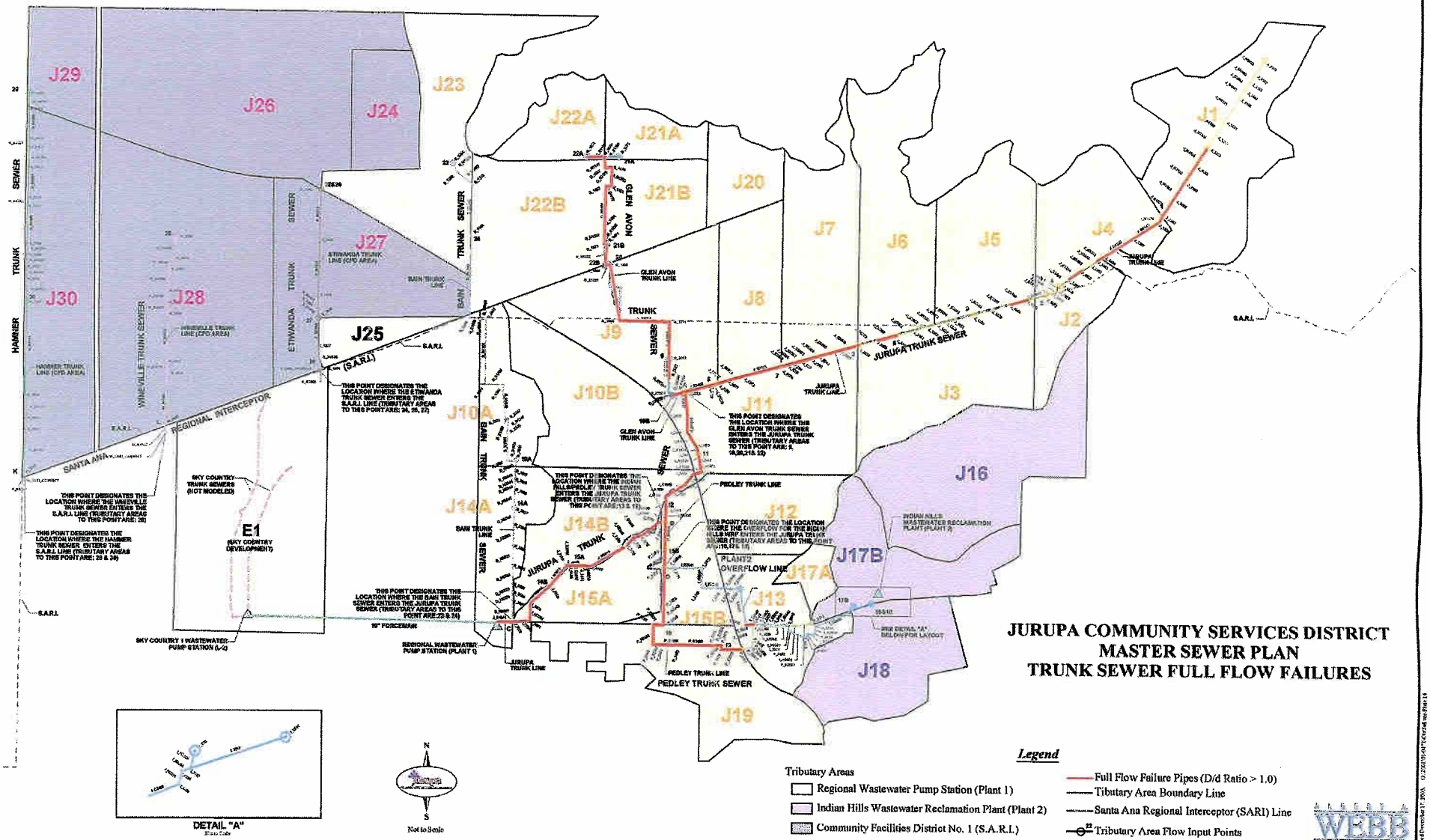
jurupa
COMMUNITY SERVICES DISTRICT



JURUPA COMMUNITY SERVICES DISTRICT
MASTER SEWER PLAN
TRUNK SEWER HYDRAULIC DEFICIENCIES

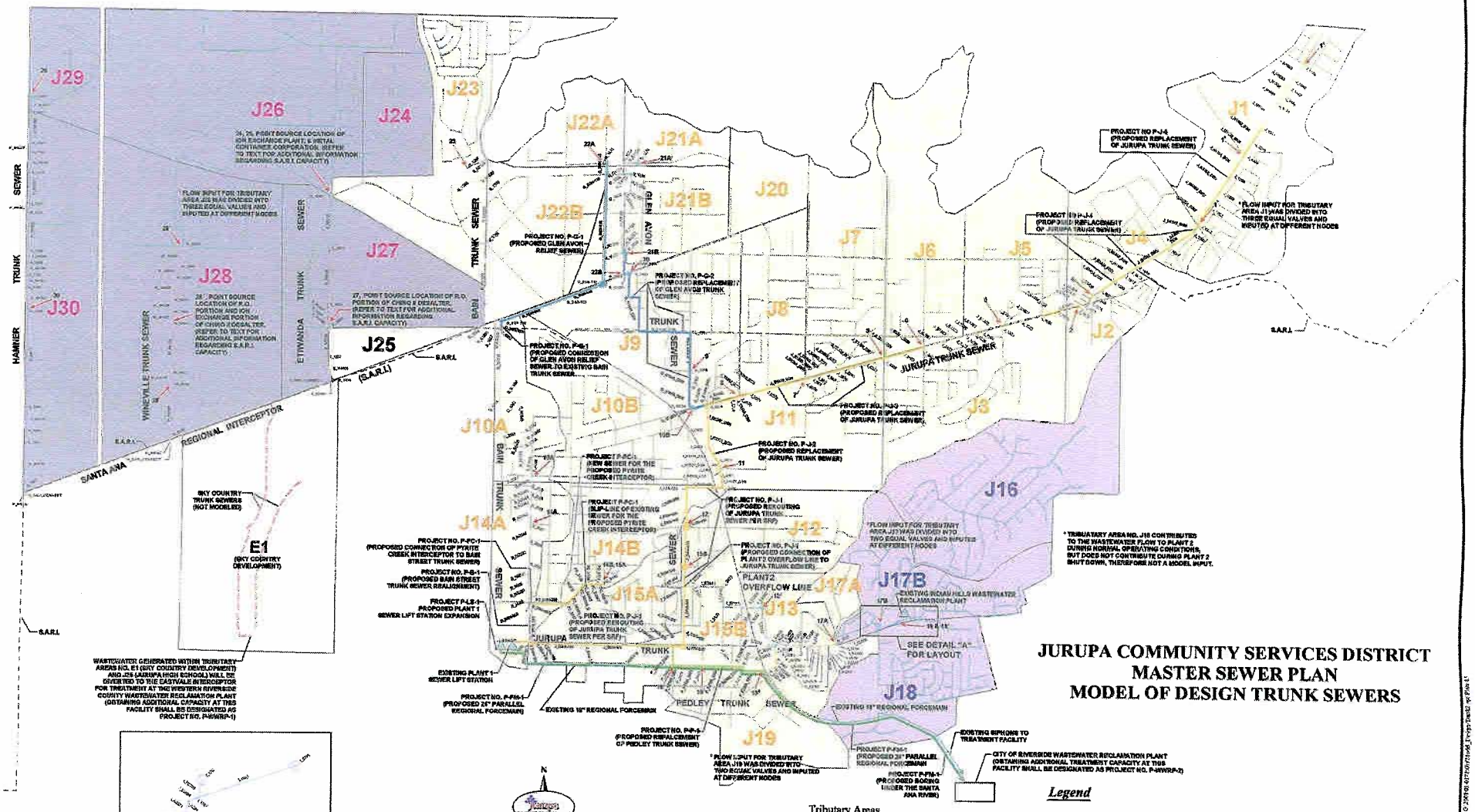
WEBB

jurupa
COMMUNITY SERVICES DISTRICT



JURUPA COMMUNITY SERVICES DISTRICT
MASTER SEWER PLAN
TRUNK SEWER FULL FLOW FAILURES

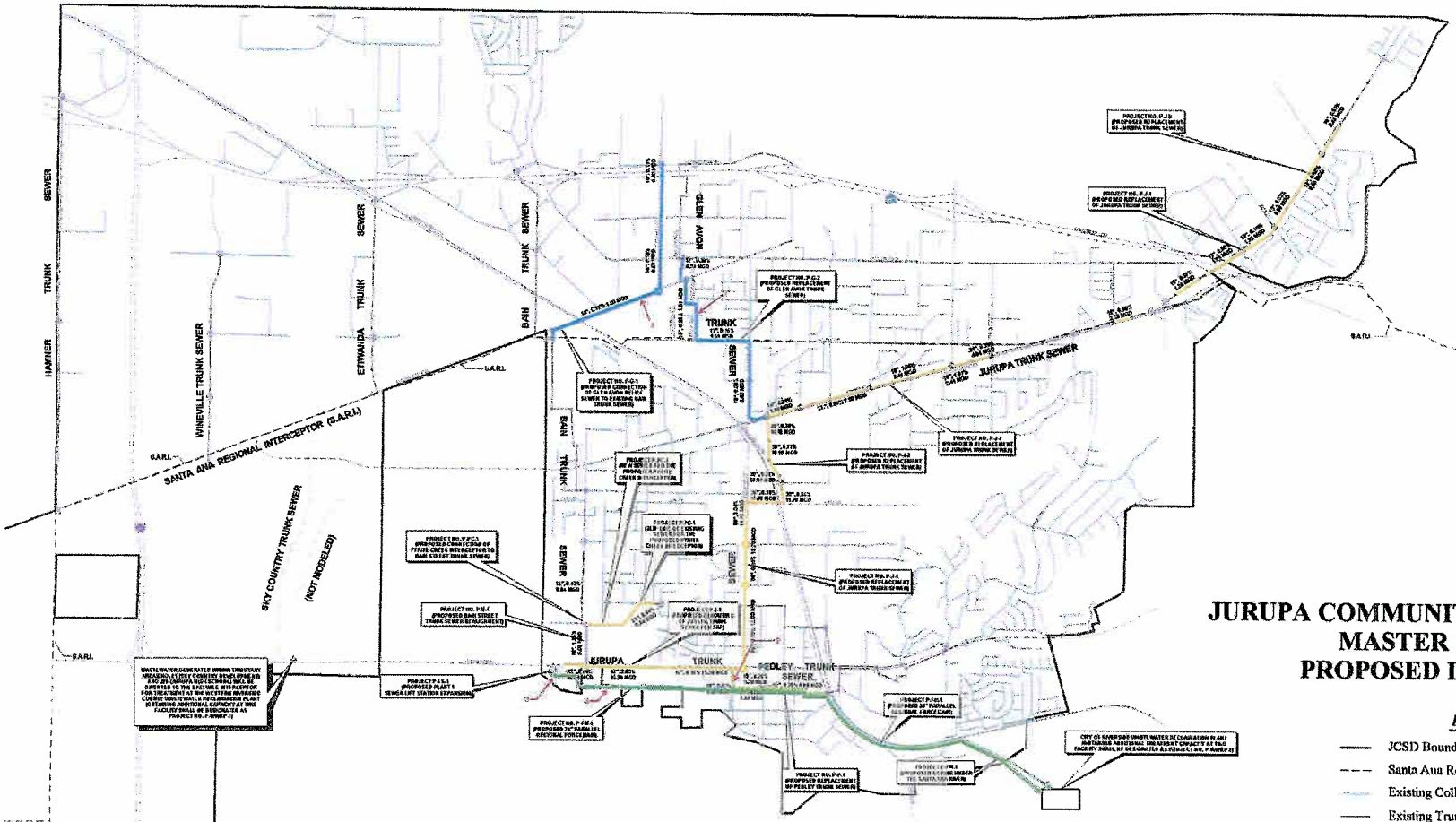
jurupa
COMMUNITY SERVICES DISTRICT



JURUPA COMMUNITY SERVICES DISTRICT
MASTER SEWER PLAN
MODEL OF DESIGN TRUNK SEWERS

WEBB

jurupa
COMMUNITY SERVICES DISTRICT



JURUPA COMMUNITY SERVICES DISTRICT
MASTER SEWER PLAN
PROPOSED IMPROVEMENTS

Legend

- JCSD Boundary
- Santa Ana Regional Interceptor (SARI) Line
- Existing Collection Lines
- Existing Trunk Sewer
- Bain Trunk Sewer Improvement
- Glen Avon Trunk Sewer Improvement
- Jurupa Trunk Sewer Improvement
- Pedley Trunk Sewer Improvement
- Proposed Forcemain Sewer

WEBB ASSOCIATES

Notes:

1. A detailed alignment evaluation should be conducted to determine if a pipeline between the Bly Channel and Campbell Street is a more cost effective alternative. This would cause the proposed Bellegrave Line to be deeper, but would reduce downstream improvements on the Glen Avon Trunk Sewer.

2. A detailed alignment evaluation should be conducted to determine if alternative street alignments are feasible to avoid 63rd Street which is a narrow road with numerous existing underground facilities.

3. While it is beyond the scope of this report, it should be noted that the feasibility of intercepting flows upstream of Plant 1 and constructing a subregional lift station and force main should be evaluated.

Maps created August 30, 2004 D:\2001\01-6.7\Bin\Projects\Improvements\Plate 16

APPENDIX A

JURUPA COMMUNITY SERVICES DISTRICT DRAFT MASTER SEWER PLAN

MASTER SEWER PLAN

APPENDICES

Prepared for:

Jurupa
COMMUNITY SERVICES DISTRICT

September, 2004

ALBERT A WEBB ASSOCIATES
ENGINEERING CONSULTANTS

APPENDIX A

PROJECTED ULTIMATE LAND USE BY TRIBUTARY DRAINAGE AREA

Appendix A Projected Ultimate Land Use by Tributary Drainage Area

Tributary Drainage Area No. [1]	Area (ac)	Residential [2] Rural Residential (<0.2 du/ac)	Very Low Density (0.4-2 du/ac)	SP125-W (2du/ac)	Low Density (2-5 du/ac)	Medium Density (5-8 du/ac)	Med-High Density (8-14 du/ac)	High Density (14-20 du/ac)	Proposed Developments # of edu's	Tract Number	Area (ac)	du's	Total # of edu's	Commercial Retail (ac)	Office (ac)	Community Centers (ac)	Industrial [3] Light (ac)	Heavy (ac)	Business Park (ac)	Public Facilities (ac)	City Overlay (ac)	Conservation (ac)	Conservation Habitat (ac)	Open Space Recreation (ac)	Rural (ac)	Water (ac)	Mineral Resources (ac)	Agricultural (ac)	Highway (ac)
J1	668.6		316.0		203.8	9.3			1,512				1,512	7.0			23.6										108.9		
J2	129.3		109.3		12.8				270				270	7.2															
J3	483.1		311.1		132.1				1,150				1,150									38.2	1.7						
J4	340.3		187.1		70.7				657				657	46.3													16.0		20.2
J5	381.7	7.4	60.3		187.2	27.9			1,066				1,066	25.4										41.9					31.6
J6	516.9		175.3		57.5				581				581	18.5				208.0									24.4		33.2
J7	427.4		196.5		79.6	1.7			723				723	52.7			18.5	51.1						0.3					27.0
J8	283.4		163.1		34.3	47.8	2.1		823				823	26.5										9.6					
J9	569.7		141.1		62.7	10.0	4.2		653				653	43.5					308.2										
J10A	213.9		180.8						362				362	29.2			0.8		1.2					1.8					
J10B	454.1		384.0						768				768	62.1			1.8		2.4					3.9					
J11	520.5		418.1						836				836	4.2					80.4			17.2		0.6					
J12	275.3		272.8						546				546	2.4					0.1										
J13	275.2		81.2						162				162	139.2		45.2				9.6									
J14A	260.5		250.0						500				500	1.3									4.9					4.3	
J14B	338.2		324.5						649				649	1.8									6.3					5.6	
J15A	230.0		206.8						414				414	22.8															
J15B	216.0		194.3						389				389	21.5															
J16	614.7		391.5		61.1	2.0	15.4	17.7	1,545				1,545	0.2								19.5		73.6		2.1			
J17A	61.0		17.4		22.2	2.3	1.4		157				157	1.5										10.2					
J17B	348.2		99.2		126.8	12.9	7.9		891				891	8.5										58.2					
J18	398.1				45.1	110.4			953				953	59.1				76.9	96.8					3.9					
J19	475.8		242.2			6.0			526				526	37.4				0.7	17.0				16.4	75.8		80.3			
J20	163.4		1.7			56.3			397				397	31.8			38.1							5.1	0.9				29.5
J21A	138.2		82.9		13.2	2.5			237				237	21.7					2.5					2.4					13.1
J21B	241.7		145.0		23.0	4.5			413				413	37.9					4.3					4.2					22.8
J22A	189.8		119.3		12.3				288				288	24.8			3.7		11.1						7.1				11.6
J22B	487.3		306.2		31.7				739				739	63.5			9.4		28.4						18.3				29.7
J23	615.4				192.4	110.4			1,543				1,543	26.5			243.6							8.5	7.7				26.3
J24	223.6								0				0				216.1												7.5
J25	104.7								0				0							54.4				50.3					
J26	1,140.0				28.7				115				115	3.2			1,030.3												77.8
J27	609.7								0				0				532.7		75.5	1.5									
J28	1,248.8								0				0				706.7		498.7										43.4
J29	209.2								0				0	41.2			122.4												45.6
J30	672.4								0				0				21.9		584.5										66.0
J1-J30	**14,526.0**	**7.4**	**5,377.7**	**0.0**	**1,397.2**	**404.0**	**31.0**	**17.7**	**19,865**				**19,865**	**868.9**	**0.0**	**45.2**	**2,969.6**	**336.7**	**1,711.1**	**65.5**	**0.0**	**74.9**	**29.3**	**350.3**	**34.0**	**82.4**	**149.3**	**9.9**	**485.3**

[1] Refer to Plate 1.

[2] Land use designations for tributary areas J1-J30 were determined from Jurupa Area Land Use Plan for the Riverside County Integrated Project, April 2001.

The following densities were used to calculate residential land uses: Rural Residential (0.2 du/ac); Very Low Density (2 du/ac); SP125-W (2du/ac); Low Density (4 du/ac); Medium Density (7 du/ac); Medium-High Density (12 du/ac); High Density (18 du/ac)

[3] Distinction between "light" and "heavy" industrial land use is based on air and noise pollution factors; wastewater generation is assumed equal for both land uses.

Appendix A Projected Ultimate Land Use by Tributary Drainage Area

Tributary Drainage Area No.[1]	Area (ac)	Residential[2] Rural Residential (<0.2 du/ac)	Very Low Density (0.4-2 du/ac)	SP125-W (2du/ac)	Low Density (2-5 du/ac)	Medium Density (5-8 du/ac)	Med-High Density (8-14 du/ac)	High Density (14-20 du/ac)	Proposed Developments # of edu's	Tract Number	Area (ac)	du's	Total # of edu's	Commercial Retail (ac)	Office (ac)	Community Centers (ac)	Industrial[3] Light (ac)	Heavy (ac)	Business Park (ac)	Public Facilities (ac)	City Overlay (ac)	Conservation (ac)	Conservation Habitat (ac)	Open Space Recreation (ac)	Rural (ac)	Water (ac)	Mineral Resources (ac)	Agricultural (ac)	Highway (ac)
E1	1,026.5		60.6	939.4	18.9				2,076				2,076	2.8										4.8					
E2	155.2								0		98.7	297	297											19.4					
									0		37.1	118	118																
E3	194.3								0		22.8	67	67											10.0					
									0		29.8	140	140																
									0		26.5	112	112																
									0		24.6	89	89	80.6															
E4	131.1								0	TT 29124	60.5	265	265	70.6															
E5	73.3				46.1				185				185	17.2										10.0					
E6	68.8		68.8						138				138																
E7	237.1				53.5				214	TT 28783	38.8	143	357																
									0	TT 28784	67.3	260	260																
									0	TT 29093	47.5	187	187																
									0	TT 29115	30.0	132	132																
E8	152.8					77.8			545		25.6	322[6]	729	49.4															
E9	168.2								0		81.7	438[6]	250	86.5															
E10	153.3								0		49.6	244	244																
									0		59.9	738[6]	422																
									0		43.8	282[6]	161																
E11	97.1								0	TT 28910	59.3	180	180																
									0	TT 28933	37.8	172	172																
E12	80.2								0				0						80.2										
E13	83.1				83.1				332				332																
E14	107.2				107.2				429				429																
E15	170.0								0	TT 28520	60.1	205	205	26.6															
									0	TT 28943	83.3	364	364																
E16	155.8				44.0				176	TT 28945	43.2	151	327																
									0	TT 28946	68.6	271	271																
E17	321.3				115.3				461	TT 28880	115.7	499	960											34.3					
									0	TT 29334	56.0	200	200																
E18	83.1				83.1				332				332																
E19	21.0				21.0				84				84																
E20	152.6								0				0			152.6													
E21	40.5				40.5				162				162																
E22	120.3				120.3				481				481																
E23	94.2								0	TT 30633	77.6	318	318	16.6															
E24	74.3								0	TT 29207	66.3	251	251											8.0					
E25	39.7								0	TT 29208	39.7	151	151																
E26	40.1								0	TT 28821	40.1	158	158																
E27	38.9								0	TT 28821	34.2	158	158											4.7					
E28	39.3								0	TT 28621	16.5	89	89																
									0	TT 28622	22.8	84	84																
E29	62.0				62.0				248				248																
E30	79.9				50.5				202	TT 29533	29.4	119	321																
E1-E30	**4,261.2**	**0.0**	**129.4**	**939.4**	**845.5**	**77.8**	**0.0**	**0.0**	**6,065**		**1,594.8**	**6,568**	**12,506**	**350.3**	**0.0**	**152.6**	**0.0**	**0.0**	**80.2**	**0.0**	**0.0**	**0.0**	**0.0**	**91.2**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**

[1] Refer to Plate 1.

[2] Land use designations for tributary areas E1-E30 were determined from Eastvale Area Land Use Plan for the Riverside County Integrated Project, April 2001.

The following densities were used to calculate residential land uses: Rural Residential (0.2 du/ac); Very Low Density (2 du/ac); SP125-W (2du/ac); Low Density (4 du/ac); Medium Density (7 du/ac); Medium-High Density (12 du/ac); High Density (18 du/ac)

[3] Distinction between "light" and "heavy" industrial land use is based on air and noise pollution factors; wastewater generation is assumed equal for both land uses.

Appendix A Projected Ultimate Land Use by Tributary Drainage Area

Tributary Drainage Area No.[1]	Area (ac)	Residential[2]												Commercial			Industrial[3]							Open Space					
		Rural Residential (<0.2 du/ac)	Very Low Density (0.4-2 du/ac)	SP125-W (2du/ac)	Low Density (2-5 du/ac)	Medium Density (5-8 du/ac)	Med-High Density (8-14 du/ac)	High Density (14-20 du/ac)	Proposed Developments # of edu's	Tract Number	Area (ac)	du's	Total # of edu's	Retail (ac)	Office (ac)	Community Centers (ac)	Light (ac)	Heavy (ac)	Business Park (ac)	Public Facilities (ac)	City Overlay (ac)	Conservation (ac)	Conservation Habitat (ac)	Recreation (ac)	Rural (ac)	Water (ac)	Mineral Resources (ac)	Agricultural (ac)	Highway (ac)
E31	80.2				41.7				167	TT 29104	38.5	157	324																
E32	199.2								0	TT 28623	19.1	83	83											15.6					
									0	TT 28624	20.4	97	97																
									0	TT 28641	31.2	117	117																
									0	TT 28642	29.2	106	106																
									0	TT 28643	20.7	95	95																
									0	TT 28644	29.4	119	119																
									0	TT 29248	33.6	139	139																
E33A	39.9				39.9				160				160																	
E33B	162.3				89.5				358	TT 27591	29.5	15	373																	
									0	TT 28742	43.3	200	200																
E34	318.4								0	TT 28369	27.6	126	126	10.4										25.3					
									0	TT 28387	26.6	121	121																
									0	TT 28388	23.6	109	109																
									0	TT 28680	25.9	119	119																
									0	TT 28681	37.2	98	98																
									0	TT 28682	22.4	112	112																
									0	TT 28683	20.5	80	80																
									0	TT 28684	20.3	81	81																
									0	TT 28685	16.6	118	118																
									0	TT 28686	26.0	109	109																
									0	TT 28687	36.0	153	153																
E35	174.6		26.7		147.9				645				645																	
E36	234.1				31.0				124	TT 29148	129.8	487	611				65.3							8.0					
E37	161.8				161.8				647				647																	
E38	165.1								0				0				165.1													
E39	153.4				153.4				614				614																	
E40	217.0		20.7		177.0				749	TT 30480	19.3	50	799																	
E41	140.7				73.8				295				295				66.9													
E42	143.2				76.8				307				307				66.4													
E43	49.1				49.1				196				196																	
E44	59.7				59.7				239				239																	
E45	54.9		25.6		29.3				168				168																	
E46	310.5				169.2				677	TT 30480	99.3	256	933																	
									0	TT 29677	42.0	173	173																
E47	198.0				133.9				536	TT 29677	64.1	263	799																	
E48	63.1				63.1				252				252																	
E49	147.9				147.9				592				592																	
E50	75.7								0				0												75.7					
E31-E50	**3,148.8**	**0.0**	**73.0**	**0.0**	**1,645.0**	**0.0**	**0.0**	**0.0**	**6,726**		**932.1**	**3,583**	**10,309**	**10.4**	**0.0**	**0.0**	**363.7**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**48.9**	**75.7**	**0.0**	**0.0**	**0.0**	**0.0**
Eastvale Subtotal[4]	**7,410.0**	**0.0**	**202.4**	**939.4**	**2,490.5**	**77.8**	**0.0**	**0.0**	**12,791.0**		**2,526.9**	**10,151**	**22,815**[6]	**360.7**	**0.0**	**152.6**	**363.7**	**0.0**	**80.2**	**0.0**	**0.0**	**0.0**	**0.0**	**140.1**	**75.7**	**0.0**	**0.0**	**0.0**	**0.0**
DISTRICT TOTAL[5]	**21,936.0**	**7.4**	**5,580.1**	**939.4**	**3,887.7**	**481.8**	**31.0**	**17.7**	**32,656.0**		**2,526.9**	**10,151**	**42,680**	**1,229.6**	**0.0**	**197.8**	**3,333.3**	**336.7**	**1,791.3**	**65.5**	**0.0**	**74.9**	**29.3**	**490.4**	**109.7**	**82.4**	**149.3**	**9.9**	**485.3**

[1] Refer to Plate 1.

[2] Land use designations for tributary areas E31-E50 were determined from Eastvale Area Land Use Plan for the Riverside County Integrated Project, April 2001.
The following densities were used to calculate residential land uses: Rural Residential (0.2 du/ac); Very Low Density (2 du/ac); SP125-W (2du/ac); Low Density (4 du/ac); Medium Density (7 du/ac); Medium-High Density (12 du/ac); High Density (18 du/ac)

[3] Distinction between "light" and "heavy" industrial land use is based on air and noise pollution factors; wastewater generation is assumed equal for both land uses.

[4] Eastvale Subtotal consists of tributary areas E1-E50.

[5] The District Total for this spreadsheet totalizes areas within the tributary boundaries only. Areas outside the tributary areas but withing the District Boundaries account for approximately 3,800 acres, therefore, the total area within the District is approximately 25,800 acres.

[6] Total District Residential EDU's (Households)

APPENDIX B

PRELIMINARY APRIL 2001 RIVERSIDE COUNTY INTEGRATED PROJECT (RCIP) GENERAL PLAN

Land Use Designation	DU/AC		
	Minimum	Midpoint	Maximum
Agriculture (AG)	0	0.05	0.1
Rural Residential (RR)	0.1	0.15	0.2
Rural Mountainous (RM)	0	0.05	0.1
Rural Desert (RD)	0	0.05	0.1
Open Space – Rural (OS-RUR)	0	0.025	0.05
Very Low Density (VLDR)	0.4	1.2	2
Low Density (LDR)	2	3.5	5
Medium Density (MDR)	5	6.5	8
Medium High Density (MHDR)	8	11	14
High Density (HDR)	14	17	20
Very High Density (VHDR)	20	30	40

Dwelling Units (DU): Dwelling unit projections are estimated by multiplying the number of gross acres by the DU/AC factor ranges for each land use designation. For example, 400 acres of Low Density Residential with a density range of 2, 3.5, and 5 DU/AC would result in a range of 800; 1,400; and 2,000 DUs respectively.

Average Household Size: To reflect the variations of household size between different regions of Riverside County, separate average household size figures were used to determine population. Western Riverside County, with the exception of REMAP, uses a factor of 3.01 persons. A factor of 2.97[1] persons was used for REMAP, Western Coachella Valley, Eastern Coachella Valley, Desert Center and Palo Verde Valley.

Population: Population is determined by multiplying the projected number of dwelling units by the average persons per household factor. For example, 1,000 dwelling units with an average persons per household size of 3.01 would yield 3,010 residents.

Participation Rate: Participation rate, as defined in *Riverside County Population and Employment Forecasts*[2], is the percent of the total population that is either employed or not employed but actively seeking employment. The report identifies a rate of 44.86% for Riverside County.

Potential Workers: Potential workers are determined by multiplying the total population projected for each residential land use designation by the participation rate. For instance, a Medium Density Residential land use that yields a population of 15,000 would, in turn, yield 6,729 potential workers (15,000 x .4486 = 6,729).

Non-Residential: Building Square Footage & Employment

Employment generation for Commercial, Industrial and Business Park land uses were calculated using the following method:

Net Acres: To determine the actual amount of land available for development, gross acres must be converted to net acres. For Commercial, Heavy Industrial and Business Park land uses, 25% of the gross area is assumed to be reserved for roads, right-of-ways, easements, etc. Since the Light Industrial designation allows uses that typically require less land for roads, right-of-ways, easements, etc. (i.e., warehouses), a separate gross to net acre factor of

[1] Source: SCAG, 1998 RTP Adopted Forecast, April 1998

[2] Source: Riverside County Population and Employment Forecasts, Stanley R. Hoffman Associates, January 2000

APPENDIX C

2000 U.S. CENSUS BUREAU HOUSEHOLDS AND FAMILIES DATA PER COUNTY

U.S. Census Bureau

American FactFinder

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Geographic Comparison Table

GCT-P7. Households and Families: 2000
Data Set: Census 2000 Summary File 1 (SF 1) 100-Percent Data
Geographic Area: **California -- County**

NOTE: For information on confidentiality protection, nonsampling error, and definitions, see http://factfinder.census.gov/home/en/datanotes/expsf1u.htm.

Geographic area	Total households	Percent of total households: Family households: Total	With own children under 18 years	Type of family: Married-couple family	Female householder, no husband present	Nonfamily households: Total	Householder living alone: Total	65 years and over	Average population per-: Household	Family
California	11,502,870	68.9	35.8	51.1	12.6	31.1	23.5	7.8	2.87	3.43
COUNTY										
Alameda County	523,366	64.8	32.6	47.0	13.0	35.2	26.0	7.3	2.71	3.31
Alpine County	483	61.1	25.5	43.9	11.0	38.9	27.7	5.4	2.50	2.96
Amador County	12,759	71.1	26.2	58.9	8.7	28.9	23.9	11.3	2.39	2.81
Butte County	79,566	62.1	28.4	46.7	11.2	37.9	27.2	11.1	2.48	3.02
Calaveras County	16,469	71.3	26.7	58.9	8.6	28.7	23.3	10.1	2.44	2.85
Colusa County	6,097	75.1	41.4	59.6	9.6	24.9	21.5	10.1	3.01	3.51
Contra Costa County	344,129	70.4	35.4	54.5	11.5	29.6	22.9	8.0	2.72	3.23
Del Norte County	9,170	68.6	33.5	50.0	13.6	31.4	25.3	10.1	2.58	3.08
El Dorado County	58,939	73.0	34.2	60.1	8.9	27.0	20.1	7.3	2.63	3.04
Fresno County	252,940	73.8	41.2	52.5	15.2	26.2	20.6	7.8	3.09	3.59
Glenn County	9,172	73.4	38.1	56.7	10.9	26.6	22.0	10.7	2.84	3.33
Humboldt County	51,238	59.8	28.5	43.1	11.8	40.2	28.9	9.2	2.39	2.95
Imperial County	39,384	79.9	46.7	57.7	17.1	20.1	17.1	8.1	3.33	3.77
Inyo County	7,703	64.1	27.9	49.8	9.9	35.9	31.4	13.6	2.31	2.88
Kern County	208,652	75.0	42.2	54.6	14.5	25.0	20.3	7.8	3.03	3.50
Kings County	34,418	78.4	46.4	58.0	14.3	21.6	17.0	6.8	3.18	3.59
Lake County	23,974	64.1	26.6	47.7	11.3	35.9	29.0	13.4	2.39	2.92
Lassen County	9,625	70.4	35.9	55.8	10.3	29.6	24.5	9.2	2.59	3.08
Los Angeles County	3,133,774	68.2	36.8	47.6	14.7	31.8	24.6	7.1	2.98	3.61
Madera County	36,155	79.1	40.2	60.9	12.2	20.9	16.5	7.7	3.18	3.52
Marin County	100,650	60.3	27.5	48.4	8.5	39.7	29.8	9.6	2.34	2.90
Mariposa County	6,613	67.9	25.6	55.6	8.0	32.1	26.5	11.2	2.37	2.86
Mendocino County	33,266	65.7	31.4	48.9	11.7	34.3	27.0	10.4	2.53	3.04
Merced County	63,815	78.0	45.4	57.8	14.1	22.0	17.7	7.4	3.25	3.69
Modoc County	3,784	67.4	29.1	54.6	8.8	32.6	28.1	12.7	2.39	2.91
Mono County	5,137	61.2	28.7	50.6	6.5	38.8	26.6	4.3	2.43	2.98
Monterey County	121,236	72.5	39.1	56.0	11.6	27.5	21.2	8.2	3.14	3.65
Napa County	45,402	67.6	31.4	53.2	9.9	32.4	25.8	11.6	2.62	3.16
Nevada County	36,894	70.3	28.7	57.6	8.8	29.7	22.8	9.8	2.47	2.88
Orange County	935,287	71.4	37.0	55.9	10.7	28.6	21.1	7.2	3.00	3.48
Placer County	93,382	72.5	35.3	59.4	9.2	27.5	21.3	[illegible]	2.63	3.06
Plumas County	9,000	67.2	26.4	55.4	8.0	32.8	27.5	10.[illegible]	2.29	2.77
Riverside County	506,218	73.6	38.9	56.5	12.0	26.4	20.7	9.3	2.98	3.47
Sacramento County	453,602	65.6	33.7	46.4	14.1	34.4	26.7	8.0	2.64	3.24
San Benito County	15,885	81.2	46.3	65.7	10.5	18.8	14.1	5.4	3.32	3.64
San Bernardino County	528,594	76.5	43.7	55.8	14.8	23.5	18.4	6.6	3.15	3.58
San Diego County	994,677	66.7	33.9	50.7	11.8	33.3	24.2	7.9	2.73	3.29
San Francisco County	329,700	44.0	16.6	31.6	8.9	56.0	38.6	9.8	2.30	3.22

APPENDIX D

2000 U.S. CENSUS BUREAU HOUSEHOLDS AND FAMILIES DATA PER CENSUS TRACT

Back to Basic Facts

Geographic Comparison Table

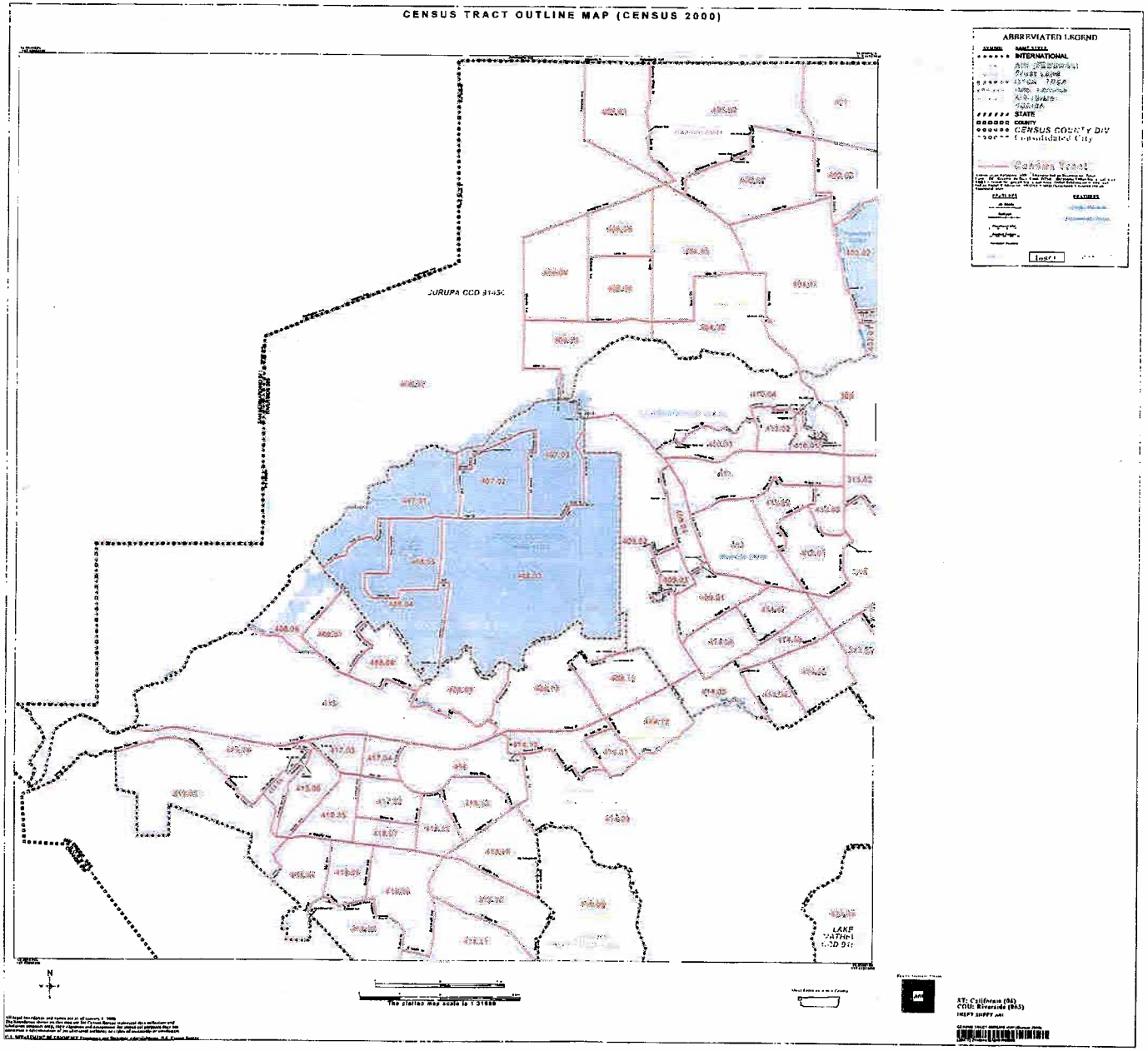
GCT-P7. Households and Families: 2000
Data Set: Census 2000 Summary File 1 (SF 1) 100-Percent Data
Geographic Area: **Riverside County, California -- Census Tract**

NOTE: For information on confidentiality protection, nonsampling error, and definitions, see http://factfinder.census.gov/home/en/datanotes/expsf1u.htm.

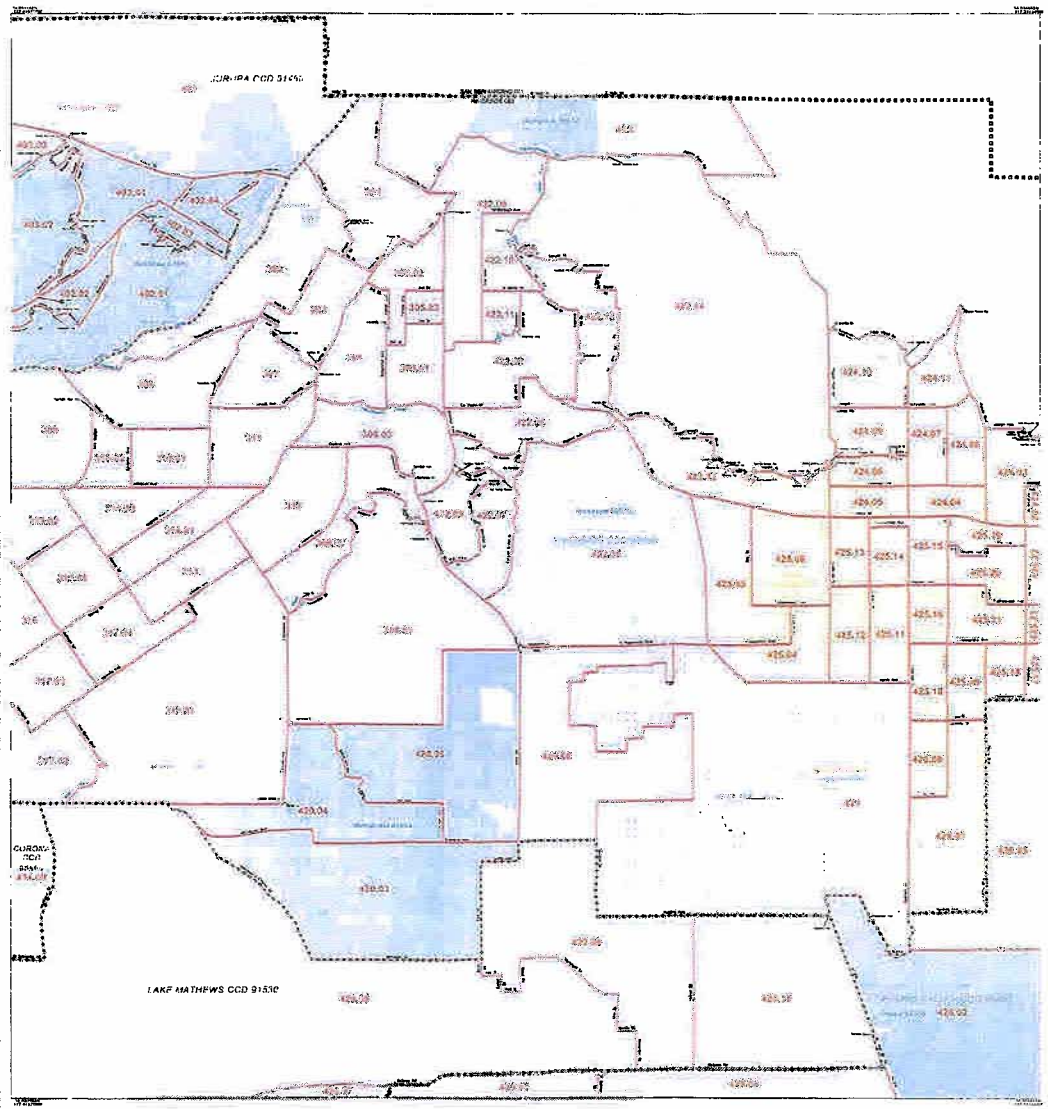
Geographic area	Total households	Percent of total households: Family households: Total	With own children under 18 years	Type of family: Married-couple family	Female householder, no husband present	Nonfamily households: Total	Householder living alone: Total	65 years and over	Average population per-: Household	Family
Riverside County	506,218	73.6	38.9	56.5	12.0	26.4	20.7	9.3	2.98	3.47
CENSUS TRACT										
Tract 100	979	50.4	14.3	41.0	6.5	49.6	36.4	19.5	2.00	2.65
Tract 101	1,485	35.8	15.7	22.3	10.7	64.2	53.3	22.7	1.79	2.77
Tract 102	1,802	45.6	16.3	31.5	10.7	54.4	37.9	13.9	2.03	2.76
Tract 103	1,390	46.5	9.6	37.7	5.6	53.5	40.9	22.1	1.83	2.43
Tract 104	1,492	39.5	4.3	33.6	4.3	60.5	47.7	31.4	1.63	2.22
Tract 105	1,038	40.5	7.3	33.2	5.0	59.5	51.0	30.5	1.66	2.35
Tract 106	1,359	45.5	1.2	40.5	3.8	54.5	46.4	34.3	1.58	2.08
Tract 107	713	41.0	6.9	37.2	2.2	59.0	47.0	19.5	1.72	2.40
Tract 108	817	53.1	6.6	44.9	6.9	46.9	37.7	24.8	1.82	2.32
Tract 109	759	52.6	5.0	47.8	3.7	47.4	40.2	23.6	1.72	2.20
Tract 301	2,251	77.0	48.1	52.2	17.2	23.0	18.1	7.6	3.47	3.93
Tract 302	1,896	58.1	31.5	36.0	16.8	41.9	31.6	8.3	2.43	3.09
Tract 303	1,533	43.5	28.2	19.0	17.5	56.5	46.1	17.6	2.29	3.41
Tract 304	1,583	75.2	45.0	45.5	21.2	24.8	20.7	9.2	3.70	4.28
Tract 305.01	1,215	76.8	46.2	44.9	23.9	23.2	17.7	6.8	3.62	4.04
Tract 305.02	483	81.2	58.2	54.7	18.0	18.8	13.3	5.4	4.17	4.53
Tract 305.03	1,102	80.1	60.1	49.3	19.7	19.9	12.9	2.3	3.92	4.27
Tract 306.01	1,400	88.4	43.2	79.4	5.9	11.6	8.9	3.4	3.09	3.27
Tract 306.02	1,270	76.5	29.3	66.9	7.5	23.5	20.1	9.5	2.62	3.01
Tract 306.03	1,064	79.4	27.2	69.4	7.4	20.6	15.4	8.9	2.58	2.85
Tract 307	2,128	62.6	33.7	40.8	16.8	37.4	28.3	7.7	2.49	3.06
Tract 308	2,353	70.8	33.6	51.0	14.1	29.2	22.5	9.3	2.71	3.19
Tract 309	829	84.3	46.4	61.4	15.8	15.7	11.9	4.9	3.69	3.93
Tract 310.01	1,810	65.4	34.0	42.9	16.2	34.6	27.8	10.2	2.56	3.14
Tract 310.02	1,114	83.1	47.8	54.8	20.5	16.9	11.9	4.4	3.69	3.95
Tract 311	1,681	66.9	37.1	40.9	21.2	33.1	25.2	9.2	2.61	3.13
Tract 312	2,138	74.7	37.4	55.5	14.6	25.3	20.9	10.1	2.95	3.42
Tract 313	606	82.8	44.9	50.3	22.8	17.2	12.0	5.8	4.30	4.54
Tract 314.01	2,129	70.4	39.7	45.8	18.3	29.6	21.9	6.7	2.82	3.31
Tract 314.02	2,267	60.2	31.4	39.0	16.0	39.8	32.5	14.5	2.55	3.28
Tract 315.01	2,083	62.5	35.8	39.6	16.9	37.5	30.2	16.1	2.70	3.39
Tract 315.02	2,525	67.9	36.6	45.6	16.3	32.1	26.9	13.6	2.77	3.37
Tract 316	2,859	70.7	41.0	44.8	19.1	29.3	23.6	10.6	3.05	3.58
Tract 317.01	773	82.9	43.6	57.2	20.4	17.1	13.5	6.3	3.55	3.79
Tract 317.02	712	85.7	44.5	70.8	8.4	14.3	10.8	4.8	3.33	3.57
Tract 317.03	832	85.6	46.9	66.5	12.5	14.4	10.2	2.9	3.42	3.63
Tract 317.04	1,587	66.4	36.5	47.4	13.7	33.6	29.6	16.7	2.97	3.70
Tract 401	1,935	87.1	50.7	65.9	14.2	12.9	9.1	2.9	4.06	4.25

Geographic area	Total households	Percent of total households							Average population per-	
		Family households				Nonfamily households				
				Type of family			Householder living alone			
		Total	With own children under 18 years	Married-couple family	Female householder, no husband present	Total	Total	65 years and over	Household	Family
Tract 402.01	1,239	81.6	49.2	59.9	15.3	18.4	13.1	3.7	3.48	3.75
Tract 402.02	818	74.7	38.3	50.7	16.6	25.3	19.3	7.8	3.01	3.46
Tract 402.03	1,043	79.6	55.2	45.2	23.7	20.4	15.5	5.3	3.63	3.97
Tract 402.04	840	82.9	60.0	47.0	27.0	17.1	13.3	3.2	4.14	4.45
Tract 403.01	1,775	76.9	46.6	54.0	15.6	23.1	17.8	8.4	3.62	4.13
Tract 403.02	1,868	85.5	45.6	71.4	8.9	14.5	10.5	2.5	3.44	3.66
Tract 403.03	686	78.9	43.1	61.7	9.0	21.1	17.1	5.9	3.66	4.10
Tract 404.01	2,250	82.0	48.2	65.9	10.2	18.0	12.8	5.6	3.38	3.69
Tract 404.02	997	85.3	46.6	59.9	15.6	14.7	11.2	3.2	3.73	3.90
Tract 404.03	1,084	86.1	49.8	66.7	12.0	13.9	9.2	2.5	4.06	4.24
Tract 405.01	1,589	82.8	46.4	61.5	13.6	17.2	13.0	4.8	3.62	3.87
Tract 405.02	1,125	79.2	47.0	55.1	15.9	20.8	15.2	5.2	3.78	4.09
Tract 405.03	1,757	47.7	20.4	39.2	5.5	52.3	48.3	30.1	2.21	3.35
Tract 406.02	1,234	82.3	48.2	57.9	16.1	17.7	13.0	5.6	3.58	3.85
Tract 406.03	576	80.0	42.5	63.2	10.4	20.0	14.4	3.8	3.71	4.05
Tract 406.04	1,405	88.3	47.4	75.9	7.7	11.7	6.9	1.6	3.67	3.80
Tract 406.05	700	80.7	49.0	58.9	13.4	19.3	13.9	3.9	3.99	4.30
Tract 406.06	724	83.7	47.4	60.8	14.2	16.3	11.0	4.0	3.86	4.07
Tract 407.01	692	89.3	47.0	75.7	9.4	10.7	8.1	3.0	3.39	3.54
Tract 407.02	907	77.3	35.3	60.4	11.7	22.7	15.2	4.2	2.97	3.29
Tract 407.03	862	76.3	37.8	60.2	10.6	23.7	16.4	2.9	3.00	3.36
Tract 408.03	2,034	77.0	34.6	59.4	11.4	23.0	16.7	7.3	3.10	3.44
Tract 408.04	1,060	86.6	37.9	72.4	8.5	13.4	8.7	2.1	3.36	3.52
Tract 408.05	174	94.8	59.8	85.6	6.3	5.2	3.4	0.0	3.64	3.68
Tract 408.06	806	88.2	48.8	77.2	5.7	11.8	7.3	1.1	3.27	3.43
Tract 408.07	1,016	90.6	51.6	78.1	8.3	9.4	6.4	1.2	3.42	3.54
Tract 408.08	1,751	81.9	55.9	60.7	13.8	18.1	12.3	0.6	3.55	3.81
Tract 408.09	868	82.1	46.8	65.7	11.5	17.9	12.7	3.3	3.19	3.47
Tract 408.10	3,766	76.1	46.7	60.1	11.4	23.9	17.2	1.0	3.03	3.47
Tract 408.11	2,680	72.2	45.4	55.9	11.4	27.8	18.8	0.9	3.00	3.49
Tract 409.01	936	81.4	53.1	54.4	20.5	18.6	15.4	4.1	3.48	3.81
Tract 409.02	1,524	74.9	31.9	60.6	9.8	25.1	20.2	9.7	2.82	3.24
Tract 409.03	781	78.0	41.0	58.1	14.7	22.0	15.5	5.6	3.17	3.47
Tract 409.04	883	86.6	52.2	66.6	13.4	13.4	9.4	3.2	3.79	3.97
Tract 410.01	792	76.3	51.6	49.6	18.2	23.7	16.7	1.6	3.56	3.97
Tract 410.02	777	84.4	52.4	63.4	13.9	15.6	11.5	3.3	3.83	4.09
Tract 410.03	642	80.5	45.3	64.0	10.1	19.5	15.1	5.8	3.37	3.72
Tract 410.04	1,331	74.0	47.9	51.2	15.7	26.0	19.1	1.4	3.20	3.68
Tract 411	1,938	85.3	58.0	56.4	19.0	14.7	9.2	2.3	4.10	4.31
Tract 412.01	900	84.1	55.1	59.2	18.3	15.9	11.2	2.8	3.81	4.05
Tract 412.02	948	86.5	52.7	64.9	13.7	13.5	9.7	3.9	4.20	4.40
Tract 412.03	943	75.6	49.6	47.7	18.1	24.4	17.5	1.7	3.49	3.92
Tract 413	1,775	84.5	54.8	62.3	14.6	15.5	10.8	3.3	3.95	4.19
Tract 414.03	969	67.9	36.3	55.7	8.4	32.1	28.3	17.6	2.82	3.49
Tract 414.04	853	87.6	53.5	71.2	9.5	12.4	9.3	1.8	3.79	3.99
Tract 414.05	1,180	79.7	47.5	60.6	13.5	20.3	16.4	6.4	3.28	3.67
Tract 414.06	1,533	65.6	39.5	46.0	13.4	34.4	24.8	1.4	2.74	3.35
Tract 414.07	1,653	69.8	41.4	47.1	16.9	30.2	25.0	9.9	3.00	3.61
Tract 414.08	1,383	65.4	39.3	34.9	20.3	34.6	24.2	3.1	2.76	3.27
Tract 414.09	2,167	87.1	49.9	75.7	7.1	12.9	9.0	1.3	3.28	3.46
Tract 414.10	566	88.2	58.1	64.1	15.4	11.8	6.2	2.7	5.16	5.06
Tract 414.11	761	84.9	41.1	66.8	11.8	15.1	12.2	7.9	4.04	4.28
Tract 414.12	1,376	72.3	37.6	58.8	8.9	27.7	23.7	12.9	3.00	3.56
Tract 415	486	84.6	48.6	52.1	20.0	15.4	9.9	3.7	4.18	4.35
Tract 416	1,707	79.3	54.1	48.8	21.3	20.7	15.8	6.2	3.93	4.25
Tract 417.02	1,238	83.0	41.7	65.9	11.7	17.0	13.0	5.8	3.46	3.78

CENSUS TRACT OUTLINE MAP (CENSUS 2000)



CENSUS TRACT OUTLINE MAP (CENSUS 2000)



ABBREVIATED LEGEND

SYMBOL	NAME STYLE
++++++	INTERNATIONAL
++++++	AIR (FOREIGN)
++++++	TRIBAL LAND
++++++	AIR (TRIBAL)
++++++	AIR (STATE)
++++++	STATE
++++++	COUNTY
++++++	CENSUS COUNTY DIV
++++++	(unincorporated City)

CENSUS TRACT

FEATURES | FEATURES

Index

N

The plotted map scale is 1:31680

ST: California (06)
CO: Riverside (065)
INSET QUFT: 02

APPENDIX E

REGIONAL WASTEWATER PUMP STATION
INDIAN HILLS WASTEWATER RECLAMATION PLANT
2001 FLOW SUMMARIES

Jurupa Community Services District
Regional Wastewater Pump Station
2001 Monitoring Report

Flow Summary

Month	Avg. Flow (mgd)
Jan 01	3.23
Feb 01	3.37
Mar 01	3.23
Apr 01	3.17
May 01	3.27
Jun 01	3.18
Jul 01	3.15
Aug 01	3.06
Sep 01	3.24
Oct 01	3.16
Nov 01	3.28
Dec 01	3.36
Total 01	38.70
Avg. 01	3.23

Jurupa Community Services District
Indian Hills Wastewater Reclamation Plant
2001 Monitoring Report

Flow Summary

Month	Avg. Flow (mgd)
Jan 01	0.34
Feb 01	0.21
Mar 01	0.24
Apr 01	0.42
May 01	0.60
Jun 01	0.60
Jul 01	0.66
Aug 01	0.69
Sep 01	0.55
Oct 01	0.60
Nov 01	0.53
Dec 01	0.39
Total 01	5.83
Avg 01	0.49

Jurupa Community Services District
Regional Wastewater Pump Station
Daily Flow Records

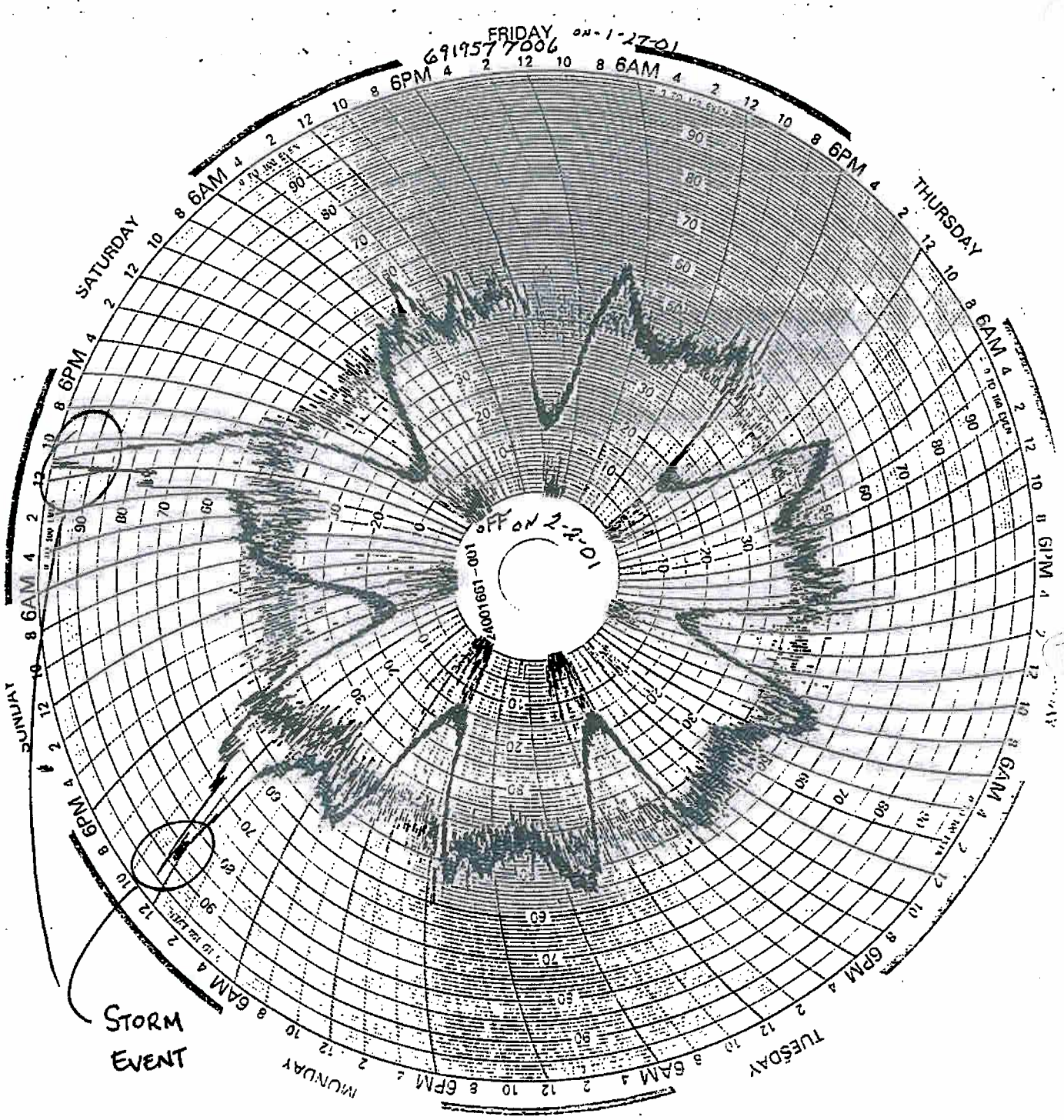
February, 2001

Date	Reads	Flow
2/1/01	83762016	2.98
2/2/01	83764998	3.06
2/3/01	83768065	3.16
2/4/01	83771231	3.20
2/5/01	83774436	3.08
2/6/01	83777518	3.01
2/7/01	83780532	3.00
2/8/01	83783532	2.99
2/9/01	83786520	3.01
2/10/01	83789528	3.15
2/11/01	83792679	3.16
2/12/01	83795840	4.28
2/13/01	83800118	3.40
2/14/01	83803515	3.11
2/15/01	83806622	3.12
2/16/01	83809748	3.32
2/17/01	83813071	3.01
2/18/01	83816080	3.31
2/19/01	83819389	3.08
2/20/01	83822471	3.19
2/21/01	83825663	2.99
2/22/01	83828653	2.99
2/23/01	83831649	3.17
2/24/01	83834828	3.33
2/25/01	83838163	4.43
2/26/01	83842597	4.60
2/27/01	83847193	4.71
2/28/01	83851907	4.62
3/1/01	83856528	
Avg.		3.37
Max		4.71
Min		2.98

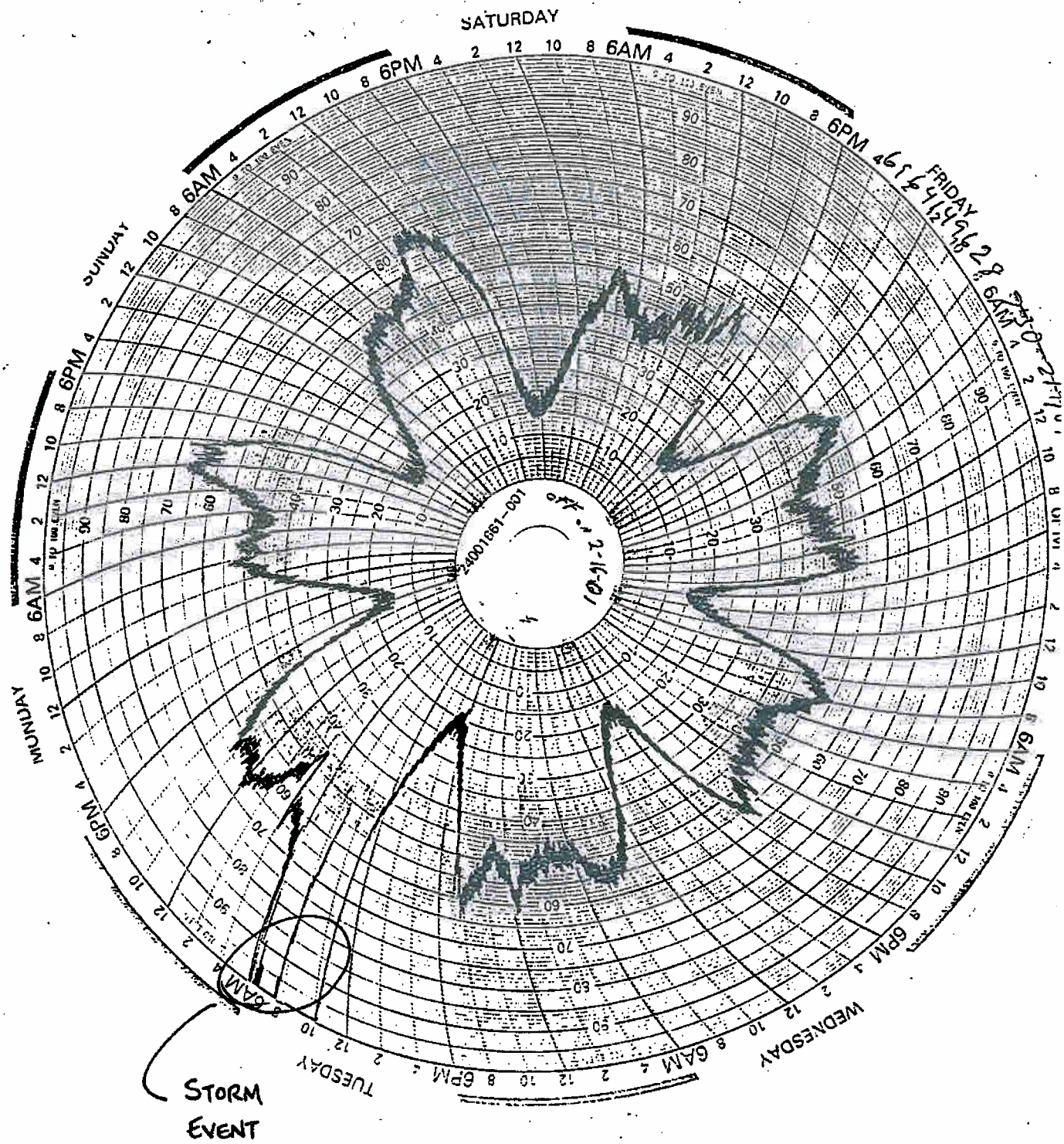
APPENDIX F

REGIONAL WASTEWATER PUMP STATION
INDIAN HILLS WASTEWATER RECLAMATION PLANT
WET WEATHER FLOW CHART EXAMPLES

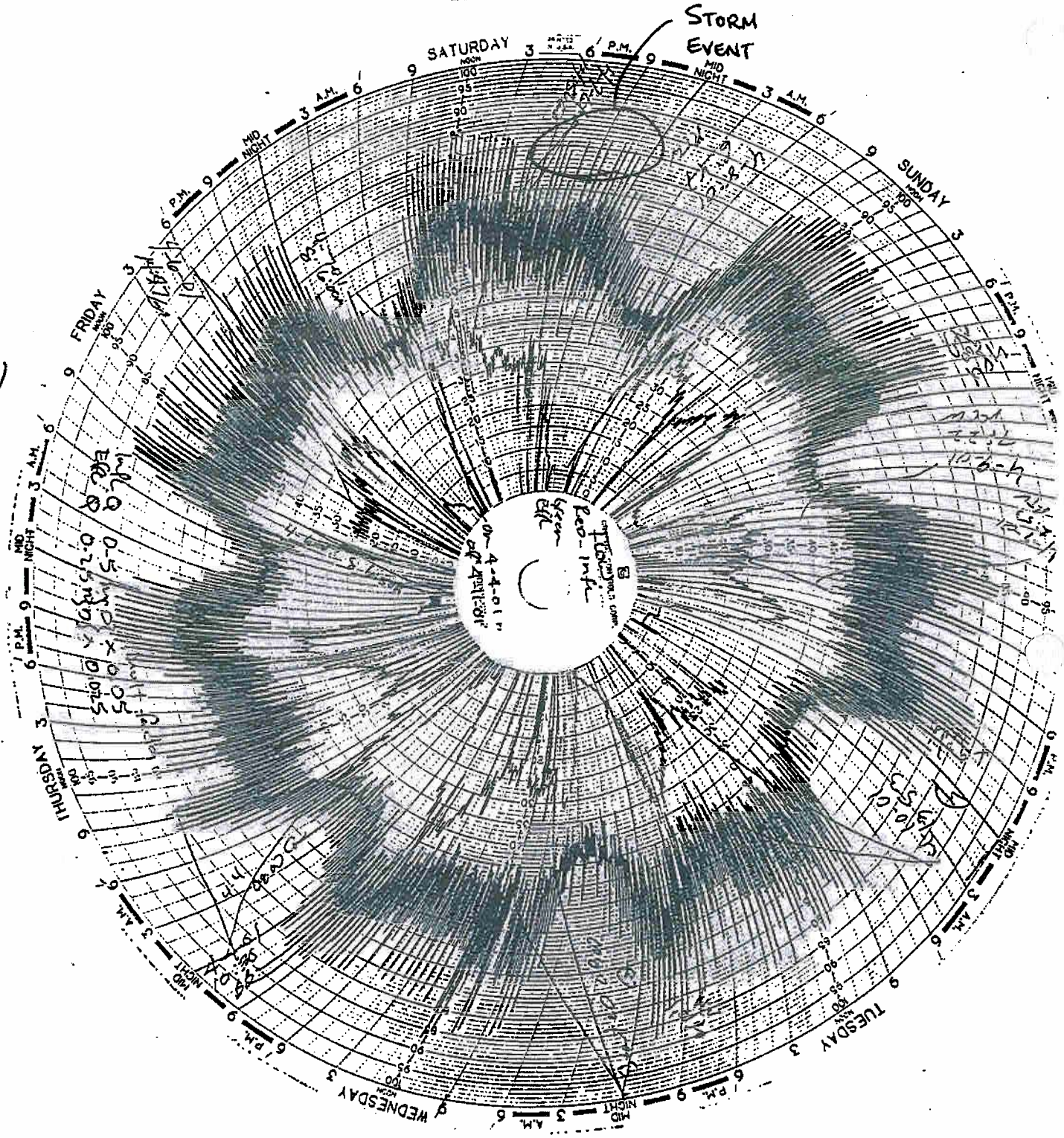
PLANT 1


FRIDAY
6919577006
ON-1-27-01
SATURDAY
THURSDAY
SUNDAY
TUESDAY
MONDAY
6AM
6PM
OFF ON 2-2-01
100-1551004001
STORM EVENT

PLANT 1


SATURDAY
FRIDAY
WEDNESDAY
TUESDAY
MONDAY
SUNDAY
6AM
6PM
STORM EVENT

PLANT 2

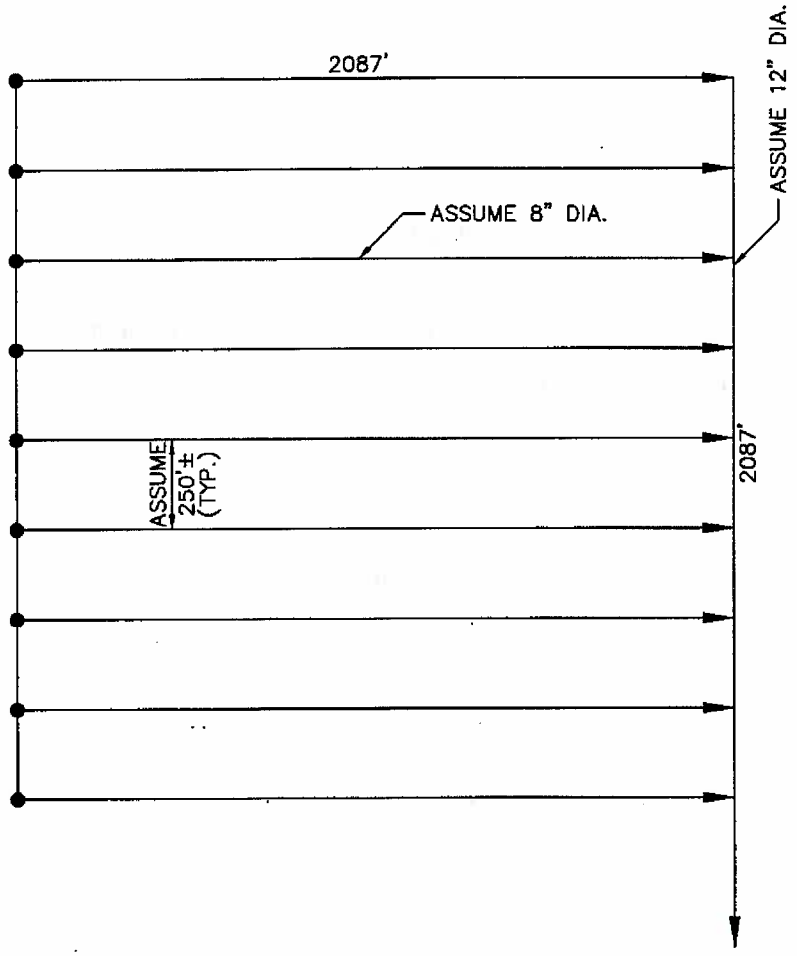

STORM EVENT
SATURDAY
SUNDAY
FRIDAY
THURSDAY
WEDNESDAY
TUESDAY
MID NIGHT
A.M.
P.M.
NOON

APPENDIX G

INFILTRATION / INFLOW ESTIMATE
NEW DEVELOPMENT AREAS

APPENDIX G. INFILTRATION ESTIMATION

ASSUME A = 100 ACRES
INFILTRATION ALLOWANCE = 100 gpd/in dia/MI *
ASSUME 3 du/ac
ASSUME TYPICAL HOUSE LATERAL LENGTH = 50'



12" DIA. : 1 x 2087' = 2087' = 0.395 MI x (100 gpd/in dia/MI) x (12") = 474 gpd
8" DIA. : 9 x 2087' = 18783' = 3.557 MI x (100 gpd/in dia/MI) x (8") = 2846 gpd
4" DIA. : 300 x 50' = 15000' = 2.841 MI x (100 gpd/in dia/MI) x (4") = 1136 gpd

TOTAL INFILTRATION = 4456 gpd

$$\text{TOTAL INFILTRATION PER ACRE} = \frac{4456 \text{ gpd}}{100 \text{ ac}} \cong 46 \text{ gpd/ac}$$

∴ USE 50 gpd/ac

* "GRAVITY SANITARY SEWER DESIGN AND CONSTRUCTION", AMERICAN SOCIETY OF CIVIL ENGINEERS.

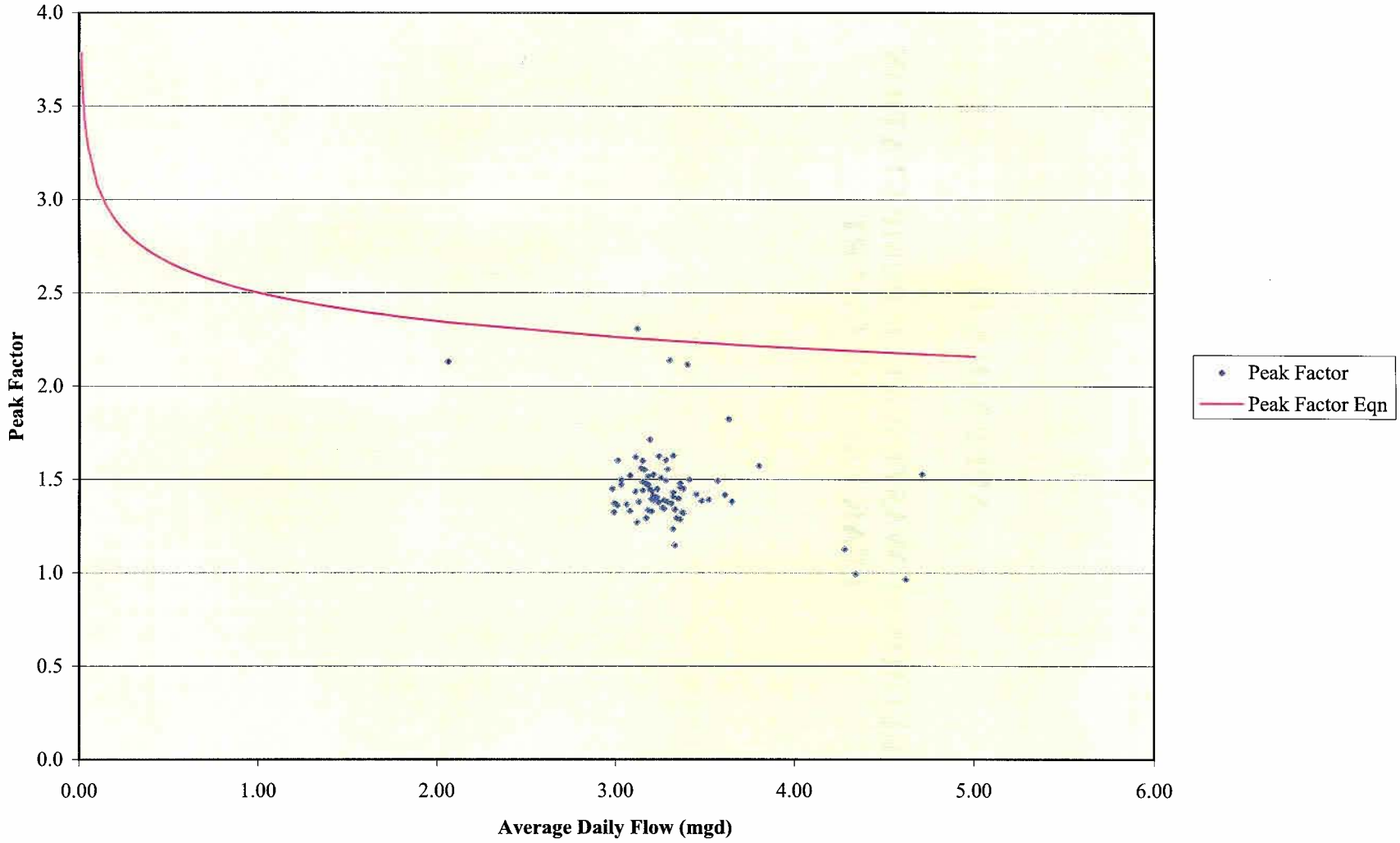
ALBERT A. WEBB ASSOCIATES
ENGINEERING CONSULTANTS

01-0171\acad\infl.dwg 4-APR-02

APPENDIX H

REGIONAL WASTEWATER PUMP STATION PEAK FACTOR CHART

PEAK FACTOR GRAPH (PLANT 1)



G:\2001\01-0171\Master Sewer Plan\Appendix H.xls

APPENDIX I

PROJECTED ULTIMATE LAND USE
AND AVERAGE DAILY FLOW
BY TRIBUTARY DRAINAGE AREA
(DESIGN FLOW FOR ULTIMATE TRUNK SEWER SYSTEM)

Appendix I. Projected Ultimate Land Use and Average Daily Flow
By Tributary Drainage Area (Design Flow for Ultimate Trunk Sewer System)

Tributary Drainage Area No.[1]	Area (ac)	Residential[2]												Commercial			Industrial[4]				Comm/Ind	Schools		City Overlay	Conservation	Conservation Habitat	Open Space				Agricultural	Highway	Total
		Rural Residential (<0.2 du/ac)	Very Low Density (0.4-2 du/ac)	SP125-W (2du/ac)	Low Density (2-5 du/ac)	Medium Density (5-8 du/ac)	Med-High Density (8-14 du/ac)	High Density (14-20 du/ac)	# of edu's	Proposed Developments Tract Number	Proposed Developments Area (ac)	Proposed Developments du's	Total # of edu's	Q_{ADF}[3] (gpd)	Retail (ac)	Office (ac)	Community Centers (ac)	Light (ac)	Heavy (ac)	Business Park (ac)	Public Facilities (ac)	Q_{ADF}[3] (gpd)	No. of Students (each)	Q_{ADF}[7] (gpd)	(ac)	(ac)	(ac)	Recreation (ac)	Rural (ac)	Water (ac)	Mineral Resources (ac)	(ac)	(ac)	Q_{ADF} (gpd)
J1	668.6		316.0		203.8	9.3			1,512				1,512	423,360	7.0			23.6				40,432									108.9			463,792
J2	129.3		109.3		12.8				270				270	75,600	7.2							14,400												90,000
J3	483.1		300.6		132.1				1,129				1,129	316,120								0	715	7,150		38.2	1.7							323,270
J4	340.3		187.1		70.7				657				657	183,960	46.3							92,600									16.0		20.2	276,560
J5	381.7	7.4	60.3		136.2	27.9			862				862	241,360	25.4							50,800	3,000	75,000				41.9					31.6	367,160
J6	516.9		163.1		57.5				556				556	155,680	18.5				208.0			453,000	741	7,410							24.4		33.2	616,090
J7	427.4		196.5		79.6	1.7			723				723	202,440	52.7			18.5	51.1			228,320						0.3					27.0	430,760
J8	283.4		133.7		34.3	47.8	2.1		764				764	213,920	16.5							33,000	1,909	24,590				9.6						271,510
J9	569.7		141.1		62.7	10.0	4.2		653				653	182,840	43.5					308.2		703,400												886,240
J10A	213.9		155.9						312				312	87,360	29.2			0.8		1.2		61,706	1,321	19,815				1.8						168,881
J10B	454.1		372.0						744				744	208,320	62.1			1.8		2.4		131,006	707	7,070				3.9						346,396
J11	520.5		408.4						817				817	228,760	4.2					80.4		169,200	657	6,570		17.2		0.6						404,530
J12	275.3		272.8						546				546	152,880	2.4					0.1		5,000												157,880
J13	275.2		81.2						162				162	45,360	139.2		45.2				9.6	378,400												423,760
J14A	260.5		250.0						500				500	140,000	1.3							2,698					4.9					4.3		142,098
J14B	338.2		324.5						649				649	181,720	1.8							3,502					6.3					5.6		185,222
J15A	230.0		187.4						375				375	105,000	22.8							45,691	815	8,150										158,841
J15B	216.0		194.3						389				389	108,920	21.5							42,909												151,829
J16	614.7								923				923	258,440	0.2							400				19.5		73.6		2.1				258,840
J17A	61.0								50				50	14,000	1.5							2,982						10.2						16,982
J17B	348.2								811				811	227,080	8.5							17,018						58.2						244,098
J18	398.1								744				744	208,320	59.1					96.8		311,800	851	8,510				3.9						528,630
J18(Lower)									0				0	0					76.9			153,800						3.9						153,800
J19	475.8		242.2			6.0			526				526	147,280	37.4				0.7	17.0		110,200					16.4	75.8		80.3				257,480
J20	163.4		1.7			56.3			397				397	111,160	31.8			38.1				106,272						5.1	0.9				29.5	217,432
J21A	138.2		73.0		13.2	2.5			217				217	60,760	21.7					2.5		48,299	741	7,410				2.4					13.1	116,369
J21B	241.7		145.0		23.0	4.5			413				413	115,640	37.9					4.3		84,501						4.2					22.8	200,141
J22A	189.8		108.5		12.3				266				266	74,480	24.8			3.7		11.1		75,757	671	6,710					7.1				11.6	158,947
J22B	487.3		306.2		31.7				739				739	206,920	63.5			9.4		28.4		194,515							18.3				29.7	401,435
J23	615.4				192.4	110.4			1,543				1,543	432,040	26.5			243.6				325,832						8.5	7.7				26.3	757,872
J24	223.6								0				0	0				216.1				242,032											7.5	242,032
J25	104.7								0				0	0							0.0	0	2,750	68,750				50.3						68,750
J26	1,140.0				28.7				115				115	32,200	3.2			1,030.3				1,160,336											77.8	1,192,536
J27	609.7								0				0	0				532.7		75.5	1.5	749,124												749,124
J28	1,248.8								0				0	0				706.7		498.7		1,788,904											43.4	1,788,904
J29	209.2								0				0	0	41.2			122.4				219,488											45.6	219,488
J30	672.4								0				0	0				21.9		584.5		1,193,528											66.0	1,193,528
J1-J30	**14,526.0**	**7.4**	**4,730.8**	**0.0**	**1,891.0**	**276.4**	**6.3**	**0.8**	**18,364**				**18,364**	***5,141,920***	**858.9**	**0.0**	**45.2**	**2,969.6**	**336.7**	**1,711.1**	**11.1**	***9,240,852***	**14,878.0**	***247,135***	**0.0**	**74.9**	**29.3**	**354.2**	**34.8**	**82.4**	**149.3**	**9.9**	**485.3**	***14,629,907***

[1] Refer to Plate 1.

[2] Land use designations for tributary areas J1-J30 were determined from Jurupa Area Land Use Plan for the Riverside County Integrated Project, April 2001.
The following densities were used to calculate residential land uses: Rural Residential (0.2 du/ac); Very Low Density (2 du/ac); SP125-W (2du/ac); Low Density (4 du/ac); Medium Density (7 du/ac); Medium-High Density (12 du/ac); High Density (18 du/ac).

[3] Based on 280 gpd/edu and 160 gpd for mobile homes and multi-family units.

[4] Distinction between "light" and "heavy" industrial land use is based on air and noise pollution factors; wastewater generation is assumed equal for both land uses.

[5] Commercial and industrial wastewater flow quantities are based on 2,000 gpd/ac.

[6] Total number of multi-family units. Converted to edu's by multiplying by 160/280.

[7] Based on type of school and number of studunts: 10gpd/stu for elementary; 15gpd/stu for middle; 25gpd/stu highschool

Infiltration/inflow (not shown on this table) was factored into SewerCAD calculations for final pipe designs.

Summary	Residential (gpd)	Commercial/Industrial (gpd)	Schools (gpd)	Ave. Day Flows (gpd)
J1 to J15B, J17A and J19 to J23 & J25 are a part of the "original" JCSD Area	4,415,880	3,558,222	238,625	8,212,727
J16, J17B and J18 are a part of the Indian Hills Area	693,840	329,218	8,510	1,031,568
J24, 26 to J30 are a part of the Com. Facilities Distric Area No. 1	32,200	5,353,412	0	5,385,612

Appendix I. Projected Ultimate Land Use and Average Daily Flow
By Tributary Drainage Area (Design Flow for Ultimate Trunk Sewer System)

Tributary Drainage Area No.[1]	Area (ac)	Residential[2] Rural Residential (<0.2 du/ac)	Very Low Density (0.4-2 du/ac)	SP125-W (2du/ac)	Low Density (2-5 du/ac)	Medium Density (5-8 du/ac)	Med-High Density (8-14 du/ac)	High Density (14-20 du/ac)	# of edu's	Proposed Developments Tract Number	Area (ac)	du's	Total # of edu's	Q_{ADF}[3] (gpd)
E1[4]	1,026.5		41.1	939.4	18.9				2,037				2,037	570,360
E2	155.2								0		83.7	297	297	83,160
									0		37.1	118	118	33,040
E3	194.3								0		22.8	67	67	18,760
									0		29.8	140	140	39,200
									0		26.5	112	112	31,360
									0		24.6	89	89	24,920
E4	131.1								0	TT 29124	60.5	265	265	74,200
E5	73.3				46.1				185				185	51,800
E6	68.8		68.8						138				138	38,640
E7	237.1				53.5				214	TT 28783	38.8	143	357	99,960
									0	TT 28784	67.3	260	260	72,800
									0	TT 29093	47.5	187	187	52,360
									0	TT 29115	30.0	132	132	36,960
E8	152.8					77.8			545		25.6	322[6]	729	204,120
E9	168.2								0		81.7	438[6]	250	70,080
E10	153.3								0		49.6	244	244	68,320
									0		59.9	738[6]	422	118,080
									0		43.8	282[6]	161	45,120
E11	97.1								0	TT 28910	59.3	180	180	50,400
									0	TT 28933	37.8	172	172	48,160
E12	80.2								0				0	0
E13	83.1				83.1				332				332	92,960
E14	107.2				107.2				429				429	120,120
E15	170.0								0	TT 28520	60.1	205	205	57,400
									0	TT 28943	83.3	364	364	101,920
E16	155.8				44.0				176	TT 28945	43.2	151	327	91,560
									0	TT 28946	68.6	271	271	75,880
E17	321.3				106.3				425	TT 28880	115.7	499	924	258,720
									0	TT 29334	56.0	200	200	56,000
E18	83.1				83.1				332				332	92,960
E19	21.0				21.0				84				84	23,520
E20	152.6								0				0	0
E21	40.5				0.0				0				0	0
E22	120.3				60.2				241				241	67,480
E23	94.2								0	TT 30633	77.6	318	318	89,040
E24	74.3								0	TT 29207	66.3	251	251	70,280
E25	39.7								0	TT 29208	39.7	151	151	42,280
E26	40.1								0	TT 28821	40.1	158	158	44,240
E27	38.9								0	TT 28821	34.2	158	158	44,240
E28	39.3								0	TT 28621	16.5	89	89	24,920
									0	TT 28622	22.8	84	84	23,520
E29	62.0				62.0				248				248	69,440
E30	79.9				50.5				202	TT 29533	29.4	119	321	89,880
E1-E30	**4,261.2**	**0.0**	**109.9**	**939.4**	**735.9**	**77.8**	**0.0**	**0.0**	***5,588***		**1,579.8**	**6,568**	**12,029**	***3,368,160***

Tributary Drainage Area No.[1]	Commercial Retail (ac)	Office (ac)	Community Centers (ac)	Industrial[4] Light (ac)	Heavy (ac)	Business Park (ac)	Public Facilities (ac)	Comm/Ind Q_{ADF}[5] (gpd)	Schools No. of Students (each)	Q_{ADF}[7] (gpd)	City Overlay (ac)	Conservation (ac)	Conservation Habitat (ac)	Open Space Recreation (ac)	Rural (ac)	Water (ac)	Mineral Resources (ac)	Agricultural[8] (ac)	Highway (ac)	Total Q_{ADF} (gpd)
E1[4]	2.8							5,600	730	7,300				4.8						583,260
E2								0	800	8,000				19.4						91,160
								0												33,040
E3								0						10.0						18,760
								0												39,200
								0												31,360
E4	80.6							161,200												186,120
E5	70.6							141,200												215,400
E6	17.2							34,400						10.0						86,200
E7								0												38,640
								0												99,960
								0												72,800
								0												52,360
								0												36,960
E8	49.4							98,800												302,920
E9	86.5							173,000												243,080
E10								0												68,320
								0												118,080
								0												45,120
E11								0												50,400
								0												48,160
E12						80.2		160,400												160,400
E13								0												92,960
E14								0												120,120
E15	26.6							53,200	800	12,000										122,600
E16								0												101,920
								0												91,560
E17								0												75,880
								0	800	8,000				34.3						266,720
E18								0												56,000
E19								0												92,960
E20			152.6					305,200												23,520
E21								0	1,750	43,750										305,200
E22								0	1,750	43,750										43,750
E23	16.6							33,200												111,230
E24								0						8.0						122,240
E25								0												70,280
E26								0												42,280
E27								0						4.7						44,240
E28								0												44,240
								0												24,920
E29								0												23,520
E30								0												69,440
																				89,880
E1-E30	**350.3**	**0.0**	**352.6**	**0.0**	**0.0**	**80.2**	**0.0**	***1,166,200***	**6,630.0**	***122,800***	**0.0**	**0.0**	**0.0**	**91.2**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	***4,657,160***

[1] Refer to Plate 1.
[2] Land use designations for tributary areas E1-E30 were determined from Eastvale Area Land Use Plan for the Riverside County Integrated Project, April 2001.
The following densities were used to calculate residential land uses: Rural Residential (0.2 du/ac); Very Low Density (2 du/ac); SP125-W (2du/ac); Low Density (4 du/ac); Medium Density (7 du/ac); Medium-High Density (12 du/ac); High Density (18 du/ac).
[3] Based on 280 gpd/edu and 160 gpd for mobile homes and multi-family units.
[4] Distinction between "light" and "heavy" industrial land use is based on air and noise pollution factors; wastewater generation is assumed equal for both land uses.
[5] Commercial and industrial wastewater flow quantities are based on 2,000 gpd/ac.
[6] Total number of multi-family units. Converted to edu's by multiplying by 160/280.
[7] Based on type of school and number of studunts: 10gpd/stu for elementary; 15gpd/stu for middle; 25gpd/stu highschool
[8] Area No. 25 will be included in the Sky Country tributary area (Area No. E1) because there is a sewer that connects No. 25 to the north east portion of the Sky Country Development.
Infiltration/inflow (not shown on this table) was factored into SewerCAD calculations for final pipe designs.

Appendix I. Projected Ultimate Land Use and Average Daily Flow
By Tributary Drainage Area (Design Flow for Ultimate Trunk Sewer System)

Tributary Drainage Area No.[1]	Area (ac)	Residential[2] Rural Residential (<0.2 du/ac)	Very Low Density (0.4-2 du/ac)	SP125-W (2du/ac)	Low Density (2-5 du/ac)	Medium Density (5-8 du/ac)	Med-High Density (8-14 du/ac)	High Density (14-20 du/ac)	# of edu's	Proposed Developments Tract Number	Area (ac)	du's	Total # of edu's	Q_{ADF}[3] (gpd)
E31	80.2				41.7				167	TT 29104	38.5	157	324	90,720
E32	199.2								0	TT 28623	19.1	83	83	23,240
									0	TT 28624	20.4	97	97	27,160
									0	TT 28641	31.2	117	117	32,760
									0	TT 28642	29.2	106	106	29,680
									0	TT 28643	20.7	95	95	26,600
									0	TT 28644	29.4	119	119	33,320
									0	TT 29248	33.6	139	139	38,920
E33A	39.9				39.9				160				160	44,800
E33B	162.3				89.5				358	TT 27591	29.5	15	373	104,440
									0	TT 28742	43.3	200	200	56,000
E34	318.4								0	TT 28369	27.6	126	126	35,280
									0	TT 28387	26.6	121	121	33,880
									0	TT 28388	23.6	109	109	30,520
									0	TT 28680	25.9	119	119	33,320
									0	TT 28681	37.2	98	98	27,440
									0	TT 28682	22.4	112	112	31,360
									0	TT 28683	20.5	80	80	22,400
									0	TT 28684	20.3	81	81	22,680
									0	TT 28685	16.6	118	118	33,040
									0	TT 28686	26.0	109	109	30,520
									0	TT 28687	36.0	153	153	42,840
E35	174.6		26.7		147.9				645				645	180,600
E36	234.1				31.0				124	TT 29148	129.8	487	611	171,080
E37	161.8				161.8				647				647	181,160
E38	165.1								0				0	0
E39	153.4				153.4				614				614	171,920
E40	217.0		20.7		177.0				749	TT 30480	19.3	50	799	223,720
E41	140.7				73.8				295				295	82,600
E42	143.2				76.8				307				307	85,960
E43	49.1				49.1				196				196	54,880
E44	59.7				59.7				239				239	66,920
E45	54.9		25.6		29.3				168				168	47,040
E46	310.5				169.2				677	TT 30480	99.3	256	933	261,240
									0	TT 29677	42.0	173	173	48,440
E47	198.0				133.9				536	TT 29677	64.1	263	799	223,720
E48	63.1				63.1				252				252	70,560
E49	147.9				147.9				592				592	165,760
E50	75.7								0				0	0
E31-E50	**3,148.8**	**0.0**	**73.0**	**0.0**	**1,645.0**	**0.0**	**0.0**	**0.0**	**6,726**		**932.1**	**3,583**	**10,309**	***2,886,520***
Eastvale Subtotal[9]	**7,410.0**	**0.0**	**182.9**	**939.4**	**2,380.9**	**77.8**	**0.0**	**0.0**	**12,314.8**		**2,511.9**	**10,151**	**22,338**	***6,254,680***
DISTRICT TOTAL[10]	**21,936.0**	**7.4**	**4,913.7**	**939.4**	**3,471.9**	**354.2**	**6.3**	**0.0**	**30,678.0**[11]		**2,511.9**	**10,151**	**40,702**	***11,396,600***

Tributary Drainage Area No.[1]	Commercial Retail (ac)	Office (ac)	Community Centers (ac)	Industrial[4] Light (ac)	Heavy (ac)	Business Park (ac)	Public Facilities (ac)	Comm/Ind Q_{ADF}[5] (gpd)	Schools No. of Students (each)	Q_{ADF}[7] (gpd)	City Overlay (ac)	Conservation (ac)	Conservation Habitat (ac)	Open Space Recreation (ac)	Rural (ac)	Water (ac)	Mineral Resources (ac)	Agricultural (ac)	Highway (ac)	Total Q_{ADF} (gpd)
E31								0												90,720
E32								0						15.6						23,240
								0												27,160
								0												32,760
								0												29,680
								0												26,600
								0												33,320
								0												38,920
E33A								0												44,800
E33B								0												104,440
								0												56,000
E34	10.4							20,800	800	12,000				25.3						68,080
								0												33,880
								0												30,520
								0												33,320
								0												27,440
								0												31,360
								0												22,400
								0												22,680
								0												33,040
								0												30,520
								0												42,840
E35								0												180,600
E36				65.3				73,136						8.0						254,216
E37								0												181,160
E38				165.1				184,912												184,912
E39								0												171,920
E40								0												223,720
E41				66.9				74,928												157,528
E42				66.4				74,368												160,328
E43								0												54,880
E44								0												66,920
E45								0												47,040
E46								0												261,240
								0												48,440
E47								0												223,720
E48								0												70,560
E49								0												165,760
E50								0							75.7					0
E31-E50	**10.4**	**0.0**	**0.0**	**363.7**	**0.0**	**0.0**	**0.0**	***428,144***	**800.0**	***12,000***	**0.0**	**0.0**	**0.0**	**48.9**	**75.7**	**0.0**	**0.0**	**0.0**	**0.0**	***3,326,664***
Eastvale Subtotal[9]	**360.7**	**0.0**	**152.6**	**363.7**	**0.0**	**80.2**	**0.0**	***1,594,344***	**7,430.0**	***134,800***	**0.0**	**0.0**	**0.0**	**140.1**	**75.7**	**0.0**	**0.0**	**0.0**	**0.0**	***7,983,824***
DISTRICT TOTAL[10]	**1,219.6**	**0.0**	**197.8**	**3,333.3**	**336.7**	**1,791.3**	**11.1**	***10,835,196***	**22,308.0**	***381,935***	**0.0**	**74.9**	**29.3**	**494.3**	**109.7**	**82.4**	**149.3**	**9.9**	**485.3**	***22,613,731***

[1] Refer to Plate 1.
[2] Land use designations for tributary areas E31-E50 were determined from Eastvale Area Land Use Plan for the Riverside County Integrated Project, April 2001.
The following densities were used to calculate residential land uses: Rural Residential (0.2 du/ac); Very Low Density (2 du/ac); SP125-W (2du/ac); Low Density (4 du/ac); Medium Density (7 du/ac); Medium-High Density (12 du/ac); High Density (18 du/ac).
[3] Based on 280 gpd/edu and 160 gpd for mobile homes and multi-family units.
[4] Distinction between "light" and "heavy" industrial land use is based on air and noise pollution factors; wastewater generation is assumed equal for both land uses.
[5] Commercial and industrial wastewater flow quantities are based on 2,000 gpd/ac.
[6] Total number of multi-family units. Converted to edu's by multiplying by 160/280.
[7] Based on type of school and number of students: 10gpd/stu for elementary; 15gpd/stu for middle; 25gpd/stu highschool
[8] Area No. 25 will be included in the Sky Country tributary area (Area No. E1) because there is a sewer that connects No. 25 to the north east portion of the Sky Country Development.
[9] Eastvale Subtotal consists of tributary areas E1-E50.
[10] The District Total for this spreadsheet totalizes areas within the tributary boundaries only. Areas outside the tributary areas but withing the District Boundaries account for approximately 3,800 acres, therefore, the total area within the District is approximately 25,800 acres.
[11] Total District Residential EDU's (Households)
Infiltration/inflow (not shown on this table) was factored into SewerCAD calculations for final pipe designs.

APPENDIX J

2002 WASTEWATER FLOW ANALYSIS FOR THE C.F.D. AREA NO. 1

Appendix J. 2002 Wastewater Flow Analysis for the C.F.D. Area No. 1

Etiwanda

Flow Development						Area Development			
Month	Million Gallons	Gallons	No. Of Days Per Month	Gallons Per Day	Aveage Daily Flow Values (gpd)	Area No.	Developed Parcels (Acres)	Total Developed Parcels (Acres)	Wastewater Flow (gpd / AC)
January	6.73	6,730,000	31	217,097	Ave. gpd by Month:	2	5.0	1,058.8	254
February	5.91	5,911,000	28	211,107	**268,099**	3	391.1		
March	6.61	6,613,000	31	213,323		4	258.7		
April	8.01	8,008,000	30	266,933	Ave. gpd by Year:	5	64.8		
May	7.63	7,627,000	31	246,032	**268,504**	6	95.2		
June	9.50	9,498,000	30	316,600		12	28.7		
July	9.23	9,226,000	31	297,613	Use the following:	13	6.3		
August	9.88	9,878,000	31	318,645	**268,504**	16	59.2		
September	9.55	9,546,300	31	307,945		17	149.8		
October	8.86	8,856,400	31	285,690					
November	N/A	N/A	N/A	N/A					
December	N/A	N/A	N/A	N/A					
Total	**81.89**	**81,893,700**	**305**						

Wineville

Flow Development						Area Development			
Month	Million Gallons	Gallons	No. Of Days Per Month	Gallons Per Day	Aveage Daily Flow Values (gpd)	Area No.	Developed Parcels (Acres)	Total Developed Parcels (Acres)	Wastewater Flow (gpd / AC)
January	0.84	838,000	31	27,032	Ave. gpd by Month:	9	136.1	489.9	53
February	0.76	761,000	28	27,179	**26,200**	10	117.2		
March	0.78	784,000	31	25,290		11	54.2		
April	0.65	653,000	30	21,767	Ave. gpd by Year:	14	143.8		
May	0.85	848,000	30	28,267	**26,174**	15	38.7		
June	1.01	1,006,000	30	33,533					
July	0.81	810,000	31	26,129	Use the following:				
August	0.70	696,000	31	22,452	**26,174**				
September	0.70	698,800	31	22,542					
October	0.86	862,000	31	27,806					
November	N/A	N/A	N/A	N/A					
December	N/A	N/A	N/A	N/A					
Total	**7.96**	**7,956,800**	**304**						

Hamner

Flow Development						Area Development			
Month	Million Gallons	Gallons	No. Of Days Per Month	Gallons Per Day	Aveage Daily Flow Values (gpd)	Area No.	Developed Parcels (Acres)	Total Developed Parcels (Acres)	Wastewater Flow (gpd / AC)
January	0.54	543,000	31	17,516	Ave. gpd by Month:	1	121.2	403.4	113
February	0.38	379,000	28	13,536	**44,827**	7	5.2		
March	0.40	400,000	31	12,903		8	158.8		
April	0.28	278,000	30	9,267	Ave. gpd by Year:	18	98.2		
May	0.38	383,000	30	12,767	**45,461**	19	19.9		
June	0.41	406,000	30	13,533					
July	0.35	349,000	31	11,258	Use the following:				
August	0.71	712,000	31	22,968	**45,461**				
September	3.14	3,139,300	31	101,268					
October	7.23	7,230,900	31	233,255					
November	N/A	N/A	N/A	N/A					
December	N/A	N/A	N/A	N/A					
Total	**13.82**	**13,820,200**	**304**						

Summary

Trunk System	Total Gallons	Total Acres	gpd / AC
Etiwanda	81,893,700	1058.8	254
Wineville	7,956,800	489.93	53
Hamner	13,820,200	403.35	113

The above summary tabulates the average wastewater flow in terms of gallons per day per acre per the tributary trunk systems. In order to determine the wastewater generation for the entire C.F.D. Area No. 1, the sum of the "Total Gallons" over the total number of days of flow data collected over the total developed parcels must be done.

N/A = Data was not available for these months

Wastewater Flow Per Acre

Wastewater Generation Factor based on the C.F.D. Area No. 1 for Industrial / Commercial Areas

Total Gallons of flow for this area =	**103,670,700**	**gallons**
Total No. of days of data collection =	**304**	**days**
Total gallons of flow collected per day =	**341,022**	**gpd for all of CDF**
Total Developed Parcels =	**1,952**	**Acres for all of CFD**
Generation Factor =	**175**	**gpd / Acre**

APPENDIX K

EXISTING 2001 LAND USE AND AVERAGE DAILY FLOW BY TRIBUTARY DRAINAGE AREA FOR POLYGON TRACE (USED TO DETERMINE CURRENT FLOWS ONLY TO PLANT 1)

Appendix K. Existing 2001 Land Use and Average Daily Flow
By Tributary Drainage Area for Polygon Trace (Used to Determine Current Flows Only to Plant 1)

Tributary Drainage Area No.[1]	Area (ac)	Residential[2]												Commercial			Industrial[4]				Comm/Ind	Schools		City Overlay (ac)	Conservation (ac)	Conservation Habitat (ac)	Open Space						Total Q_{ADF} (gpd)
		Rural Residential (<0.2 du/ac)	Very Low Density (0.4-2 du/ac)	SP125-W (2du/ac)	Low Density (2-5 du/ac)	Medium Density (5-8 du/ac)	Med-High Density (8-14 du/ac)	High Density (14-20 du/ac)	# of edu's	Proposed Developments: Tract Number	Proposed Developments: Area (ac)	Proposed Developments: du's	Total # of edu's	Q_{ADF}[3] (gpd)	Retail (ac)	Office (ac)	Community Centers (ac)	Light (ac)	Heavy (ac)	Business Park (ac)	Public Facilities (ac)	Q_{ADF}[5] (gpd)	No. of Students (each)	Q_{ADF}[8] (gpd)				Recreation (ac)	Rural (ac)	Water (ac)	Mineral Resources (ac)	Agricultural (ac)	Highway (ac)	
J1	668.6		94.0		146.0				772				772	216,160	7.0			23.6				15,300									108.9			231,460
J2	129.3		44.0		10.0				128				128	35,840	7.2							3,600												39,440
J3	483.1		100.0		20.0				280				280	78,400								0	715	7,150		38.2	1.7							85,550
J4	340.3		110.0		16.0				284				284	79,520	40.0							20,000									16.0		20.2	99,520
J5	381.7	7.4	1.0		70.0				283				283	79,240								0						41.9					31.6	79,240
J6	516.9		34.0		22.0				156				156	43,680					7.6			3,815	741	7,410							24.4		33.2	54,905
J7	427.4		142.0		29.0	2.0			414				414	115,920	30.0			18.5	51.1			49,800						0.3					27.0	165,720
J8	283.4		104.0		10.0	10.0	2.0		342				342	95,760								0	1,909	24,590				9.6						120,350
J9	569.7		100.0		65.0	12.0	5.0		604				604	169,120	11.0					62.0		36,500												205,620
J10A	213.9		76.0						152				152	42,560	3.0			0.8		1.2		2,493	1,321	19,815				1.8						64,868
J10B	454.1		276.0						552				552	154,560	6.0			1.8		2.4		5,107	707	7,070				3.9						166,737
J11	520.5		140.0						280				280	78,400	2.0					17.0		9,500	657	6,570		17.2		0.6						94,470
J12	275.3		96.0						192				192	53,760	2.4					0.1		1,250												55,010
J13	275.2		34.0						68				68	19,040	8.0		5.0				4.8	6,505												25,545
J14A	260.5		100.0						200				200	56,000	1.3							674					4.9							56,674
J14B	338.2		172.0						344				344	96,320	1.8							876					6.3					4.3		97,196
J15A	230.0		130.0						260				260	72,800	4.0							2,000	815	8,150								5.6		82,950
J15B	216.0		120.0						240				240	67,200	2.0							1,000												68,200
J17A	61.0		10.0		23.0				112				112	31,360								0						10.2						31,360
J19	475.8		182.0			6.0			406				406	113,680	37.4				0.7	17.0		27,550					16.4	75.8		80.3				141,230
J20	163.4		0.6			20.8			147				147	41,160								0						5.1	0.9				29.5	41,160
J21A	138.2		10.0		2.4	0.5			34				34	9,520	3.9					0.1		2,015	741	7,410				2.4					13.1	18,945
J21B	241.7		107.0		23.0	4.5			337				337	94,360	37.9					4.3		21,125						4.2					22.8	115,485
J22A	189.8		32.0		3.7				79				79	22,120	7.4			1.1		3.3		5,900	671	6,710					7.1				11.6	34,730
J22B	487.3		100.0		14.0				256				256	71,680	44.6			6.5		20.2		35,625							18.3				29.7	107,305
J23	615.4				122.0	75.0			1,013				1,013	283,640	15.0			47.0				31,000						8.5	7.7				26.3	314,640
J25	104.7								0				0	0							0.0	0	2,750	68,750				50.3						68,750
E1[7]	1,026.5		60.6	928.4	18.9				2,054				2,054	575,120	2.8							1,400	730	7,300				4.8						583,820
J1 to J30 and E1	**10,087.7**	**7.4**	**2,375.2**	**928.4**	**595.0**	**130.8**	**7.0**	**0.0**	**9,989**				**9,989**	**2,796,920**	**274.8**	**0.0**	**5.0**	**99.3**	**59.4**	**127.6**	**4.8**	**283,035**	**11,757.0**	**170,925**	**0.0**	**55.4**	**29.3**	**219.4**	**34.0**	**80.3**	**149.3**	**9.9**	**245.0**	**3,250,880**

[1] Refer to Plate 1.
[2] Land use designations for tributary areas J1-J30 were determined from Jurupa Area Land Use Plan for the Riverside County Integrated Project, April 2001.
The following densities were used to calculate residential land uses: Rural Residential (0.2 du/ac); Very Low Density (2 du/ac); SP125-W (2du/ac); Low Density (4 du/ac); Medium Density (7 du/ac); Medium-High Density (12 du/ac); High Density (18 du/ac)
[3] Based on 280 gpd/edu and 160 gpd for mobile homes and multi-family units.
[4] Distinction between "light" and "heavy" industrial land use is based on air and noise pollution factors; wastewater generation is assumed equal for both land uses.
[5] Commercial and industrial wastewater flow quantities are based on 500 gpd/ac.
[6] Total number of multi-family units. Converted to edu's by multiplying by 160/280.
[7] Tributary Drainage Area E1 is derived from the Sky Country Development and is tributary to Plant 1
[8] Based on type of school and number of students: 10gpd/stu for elementary; 15gpd/stu for middle; 25gpd/stu highschool
Infiltration/inflow (not shown on this table) was factored into SewerCAD calculations for final pipe designs.

APPENDIX L

PROJECTED ULTIMATE LAND USE AND AVERAGE DAILY FLOW BY TRIBUTARY DRAINAGE AREA (FOR ULTIMATE WASTEWATER TREATMENT CAPACITY)

Appendix L. Projected Ultimate Land Use and Average Daily Flow
By Tributary Drainage Area (For Ultimate Wastewater Treatment Capacity)

Tributary Drainage Area No.[1]	Area (ac)	Residential[2] Rural Residential (<0.2 du/ac)	Very Low Density (0.4-2 du/ac)	SP125-W (2du/ac)	Low Density (2-5 du/ac)	Medium Density (5-8 du/ac)	Med-High Density (8-14 du/ac)	High Density (14-20 du/ac)	# of edu's	Proposed Developments Tract Number	Area (ac)	du's	Total # of edu's	Q_{ADF}[3] (gpd)
J1	668.6		316.0		203.8	9.3			1,512				1,512	423,360
J2	129.3		109.3		12.8				270				270	75,600
J3	483.1		300.6		132.1				1,129				1,129	316,120
J4	340.3		187.1		70.7				657				657	183,960
J5	381.7	7.4	60.3		136.2	27.9			862				862	241,360
J6	516.9		163.1		57.5				556				556	155,680
J7	427.4		196.5		79.6	1.7			723				723	202,440
J8	283.4		133.7		34.3	47.8	2.1		764				764	213,920
J9	569.7		141.1		62.7	10.0	4.2		653				653	182,840
J10A	213.9		155.9						312				312	87,360
J10B	454.1		372.0						744				744	208,320
J11	520.5		408.4						817				817	228,760
J12	275.3		272.8						546				546	152,880
J13	275.2		81.2						162				162	45,360
J14A	260.5		250.0						500				500	140,000
J14B	338.2		324.5						649				649	181,720
J15A	230.0		187.4						375				375	105,000
J15B	216.0		194.3						389				389	108,920
J16	614.7								923				923	184,600
J17A	61.0								50				50	14,000
J17B	348.2								811				811	162,200
J18	398.1								744				744	148,800
J18(Lower)									0				0	0
J19	475.8		242.2			6.0			526				526	147,280
J20	163.4		1.7			56.3			397				397	111,160
J21A	138.2		73.0		13.2	2.5			217				217	60,760
J21B	241.7		145.0		23.0	4.5			413				413	115,640
J22A	189.8		108.5		12.3				266				266	74,480
J22B	487.3		306.2		31.7				739				739	206,920
J23	615.4				192.4	110.4			1,543				1,543	432,040
J24	223.6								0				0	0
J25	104.7								0				0	0
J26	1,140.0				28.7				115				115	32,200
J27	609.7								0				0	0
J28	1,248.8								0				0	0
J29	209.2								0				0	0
J30	672.4								0				0	0
J1-J30	**14,526.0**	**7.4**	**4,738.8**	**0.0**	**1,091.0**	**276.4**	**6.3**	**0.0**	**18,364**				**18,364**	***4,943,680***

Tributary Drainage Area No.[1]	Commercial Retail (ac)	Office (ac)	Community Centers (ac)	Industrial[4] Light (ac)	Heavy (ac)	Business Park (ac)	Public Facilities (ac)	Comm/Ind Q_{ADF}[5] (gpd)	Schools No. of Students (each)	Q_{ADF}[7] (gpd)	City Overlay (ac)	Conservation (ac)	Conservation Habitat (ac)	Open Space Recreation (ac)	Rural (ac)	Water (ac)	Mineral Resources (ac)	Agricultural (ac)	Highway (ac)	Total Q_{ADF} (gpd)
J1								0									108.9			423,360
J2	7.2							3,600												79,200
J3								0	715	7,150		38.2	1.7							323,270
J4	41.3							20,650									16.0		20.2	204,610
J5	25.4							12,700	3,000	75,000				41.9					31.6	329,060
J6	15.3							7,650	741	7,410							24.4		33.2	170,740
J7	40.7							20,350						0.3					27.0	222,790
J8	16.5							8,250	1,909	24,590				9.6						248,760
J9	43.6					278.2		160,875												343,715
J10A	29.2			0.8		1.2		15,610	1,321	19,815				1.8						172,785
J10B	57.1			1.8		2.4		30,640	707	7,070				3.9						246,030
J11	4.2					80.4		42,300	657	6,570		17.2		0.6						277,630
J12	2.4					0.1		1,250												154,130
J13	119.2		45.2				9.6	87,000												132,360
J14A	1.3							674					4.9					4.3		140,674
J14B	1.8							876					6.3					5.6		187,596
J15A	20.8							10,423	815	8,150										123,573
J15B	19.5							9,727												118,647
J16	0.2							100				19.5		73.6		2.1				184,700
J17A	1.5							746						10.2						14,746
J17B	8.5							4,255						58.2						166,455
J18	59.1					96.8		77,950	851	8,510				3.9						235,260
J18(Lower)					76.9			38,450												38,450
J19	32.4				0.7	17.0		25,050					16.4	75.8		80.3				172,330
J20	24.0							12,000						5.1	0.9				29.5	123,360
J21A						2.5		1,237	741	7,410				2.4					13.1	69,407
J21B	32.9					4.3		18,625						4.2					22.8	134,265
J22A	22.8			3.7		11.1		18,747	671	6,710					7.1				11.6	99,957
J22B	57.5			9.4		28.4		47,703							18.3				29.7	254,623
J23	24.5			213.6				119,050						8.5	7.7				26.3	551,090
J24				216.1				108,050											7.5	108,050
J25							0.0	0	2,750	68,750				50.3						68,750
J26	3.2			1,030.3				516,750											77.8	548,950
J27				532.7		75.5	1.5	304,850												304,850
J28				706.7		498.7		602,700											43.4	602,700
J29	41.2			122.4				81,800											45.6	81,800
J30				21.9		584.5		303,200											66.0	303,200
J1-J30	**753.3**	**0.0**	**45.2**	**2,859.4**	**77.6**	**1,681.1**	**11.1**	***2,713,837***	**14,878.0**	***247,135***	**0.0**	**74.9**	**29.3**	**350.3**	**34.0**	**82.4**	**149.3**	**9.9**	**485.3**	***7,904,652***

[1] Refer to Plate 1.

[2] Land use designations for tributary areas J1-J30 were determined from Jurupa Area Land Use Plan for the Riverside County Integrated Project, April 2001.

The following densities were used to calculate residential land uses: Rural Residential (0.2 du/ac); Very Low Density (2 du/ac); SP125-W (2du/ac); Low Density (4 du/ac); Medium Density (7 du/ac); Medium-High Density (12 du/ac); High Density (18 du/ac)

[3] Based on 280 gpd/edu and 160 gpd for mobile homes and multi-family units.

[4] Distinction between "light" and "heavy" industrial land use is based on air and noise pollution factors; wastewater generation is assumed equal for both land uses.

[5] Commercial and industrial wastewater flow quantities are based on 500 gpd/ac. For areas tributary to Plant 1 - deductions were applied the commercial and industrial areas based on existing site conditions totaling 507 acres.

[6] Total number of multi-family units. Converted to edu's by multiplying by 160/280.

[7] Based on type of school and number of studunts: 10gpd/stu for elementary; 15gpd/stu for middle; 25gpd/stu highschool

Infiltration/inflow (not shown on this table) was factored into SewerCAD calculations for final pipe designs.

Summary	Residential (gpd)	Commercial/Industrial (gpd)	Schools (gpd)	Ave. Day Flows (gpd)
J1 to J15B, J17A and J19 to J23 & J25 are a part of the "original" JCSD Area	4,415,880	714,182	238,625	5,368,687
J16, J17B and J18 are a part of the Indian Hills Area	495,600	82,305	8,510	586,415
J24, 26 to J30 are a part of the Com. Facilities Distric Area No. 1	32,200	1,917,350	0	1,949,550

Appendix L. Projected Ultimate Land Use and Average Daily Flow
By Tributary Drainage Area (For Ultimate Wastewater Treatment Capacity)

Tributary Drainage Area No.[1]	Area (ac)	Residential[2]													Commercial			Industrial[4]				Comm/Ind	Schools		City Overlay	Conservation	Conservation Habitat	Open Space				Agricultural	Highway	Total
		Rural Residential (<0.2 du/ac)	Very Low Density (0.4-2 du/ac)	SP125-W (2du/ac)	Low Density (2-5 du/ac)	Medium Density (5-8 du/ac)	Med-High Density (8-14 du/ac)	High Density (14-20 du/ac)	# of edu's	Proposed Developments Tract Number	Proposed Developments Area (ac)	Proposed Developments du's	Total # of edu's	Q_{ADF}[3] (gpd)	Retail (ac)	Office (ac)	Community Centers (ac)	Light (ac)	Heavy (ac)	Business Park (ac)	Public Facilities (ac)	Q_{ADF}[5] (gpd)	No. of Students (each)	Q_{ADF}[7] (gpd)		(ac)	(ac)	Recreation (ac)	Rural (ac)	Water (ac)	Mineral Resources (ac)	(ac)	(ac)	Q_{ADF} (gpd)
E1[8]	1,026.5		41.1	939.4	18.9				2,037				2,037	570,360	2.8							1,400	730	7,300				4.8						579,060
E2	155.2								0		83.7	297	297	83,160								0	800	8,000				19.4						91,160
									0		37.1	118	118	33,040								0												33,040
E3	194.3								0		22.8	67	67	18,760								0						10.0						18,760
									0		29.8	140	140	39,200								0												39,200
									0		26.5	112	112	31,360								0												31,360
									0		24.6	89	89	24,920	80.6							40,300												65,220
E4	131.1								0	TT 29124	60.5	265	265	74,200	70.6							35,300												109,500
E5	73.3				46.1				185				185	51,800	17.2							8,600						10.0						60,400
E6	68.8		68.8						138				138	38,640								0												38,640
E7	237.1				53.5				214	TT 28783	38.8	143	357	99,960								0												99,960
									0	TT 28784	67.3	260	260	72,800								0												72,800
									0	TT 29093	47.5	187	187	52,360								0												52,360
									0	TT 29115	30.0	132	132	36,960								0												36,960
E8	152.8					77.8			545		25.6	322[6]	729	204,120	49.4							24,700												228,820
E9	168.2								0		81.7	438[6]	250	70,080	86.5							43,250												113,330
E10	153.3								0		49.6	244	244	68,320								0												68,320
									0		59.9	738[6]	422	118,080								0												118,080
									0		43.8	282[6]	161	45,120								0												45,120
E11	97.1								0	TT 28910	59.3	180	180	50,400								0												50,400
									0	TT 28933	37.8	172	172	48,160								0												48,160
E12	80.2								0				0	0						80.2		40,100												40,100
E13	83.1				83.1				332				332	92,960								0												92,960
E14	107.2				107.2				429				429	120,120								0												120,120
E15	170.0								0	TT 28520	60.1	205	205	57,400	26.6							13,300	800	12,000										82,700
									0	TT 28943	83.3	364	364	101,920								0												101,920
E16	155.8				44.0				176	TT 28945	43.2	151	327	91,560								0												91,560
									0	TT 28946	68.6	271	271	75,880								0												75,880
E17	321.3				106.3				425	TT 28880	115.7	499	924	258,720								0	800	8,000				34.3						266,720
									0	TT 29334	56.0	200	200	56,000								0												56,000
E18	83.1				83.1				332				332	92,960								0												92,960
E19	21.0				21.0				84				84	23,520								0												23,520
E20	152.6								0				0	0			152.6					76,300												76,300
E21	40.5				0.0				0				0	0								0	1,750	43,750										43,750
E22	120.3				60.2				241				241	67,480								0	1,750	43,750										111,230
E23	94.2								0	TT 30633	77.6	318	318	89,040	16.6							8,300												97,340
E24	74.3								0	TT 29207	66.3	251	251	70,280								0						8.0						70,280
E25	39.7								0	TT 29208	39.7	151	151	42,280								0												42,280
E26	40.1								0	TT 28821	40.1	158	158	44,240								0												44,240
E27	38.9								0	TT 28821	34.2	158	158	44,240								0						4.7						44,240
E28	39.3								0	TT 28621	16.5	89	89	24,920								0												24,920
									0	TT 28622	22.8	84	84	23,520								0												23,520
E29	62.0				62.0				248				248	69,440								0												69,440
E30	79.9				50.5				202	TT 29533	29.4	119	321	89,880								0												89,880
E1-E30	***4,261.2***	**0.0**	**109.9**	**939.4**	**735.9**	**77.8**	**0.0**	**0.0**	***5,588***		**1,579.8**	**6,568**	**12,029**	***3,368,160***	**350.3**	**0.0**	**152.6**	**0.0**	**0.0**	**80.2**	**0.0**	***291,550***	**6,630.0**	***122,800***	**0.0**	**0.0**	**0.0**	**91.2**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	***3,782,510***

[1] Refer to Plate 1.

[2] Land use designations for tributary areas E1-E30 were determined from Eastvale Area Land Use Plan for the Riverside County Integrated Project, April 2001.
The following densities were used to calculate residential land uses: Rural Residential (0.2 du/ac); Very Low Density (2 du/ac); SP125-W (2du/ac); Low Density (4 du/ac); Medium Density (7 du/ac); Medium-High Density (12 du/ac); High Density (18 du/ac)

[3] Based on 280 gpd/edu and 160 gpd for mobile homes and multi-family units.

[4] Distinction between "light" and "heavy" industrial land use is based on air and noise pollution factors; wastewater generation is assumed equal for both land uses.

[5] Commercial and industrial wastewater flow quantities are based on 500 gpd/ac. For areas tributary to Plant 1 - deductions were applied the commercial and industrial areas based on existing site conditions totaling 507 acres.

[6] Total number of multi-family units. Converted to edu's by multiplying by 160/280.

[7] Based on type of school and number of studunts: 10gpd/stu for elementary; 15gpd/stu for middle; 25gpd/stu highschool

[8] Area No. 25 will be included in the Sky Country tributary area (Area No. E1) because there is a sewer that connects No. 25 to the north east portion of the Sky Country Development.
Infiltration/inflow (not shown on this table) was factored into SewerCAD calculations for final pipe designs.

Appendix L. Projected Ultimate Land Use and Average Daily Flow
By Tributary Drainage Area (For Ultimate Wastewater Treatment Capacity)

Tributary Drainage Area No. [1]	Area (ac)*	Residential[2] Rural Residential (<0.2 du/ac)	Very Low Density (0.4-2 du/ac)	SP125-W (2du/ac)	Low Density (2-5 du/ac)	Medium Density (5-8 du/ac)	Med-High Density (8-14 du/ac)	High Density (14-20 du/ac)	# of edu's	Proposed Developments Tract Number	Area (ac)	du's	Total # of edu's	Q_{ADF}[5] (gpd)
E31	80.2				41.7				167	TT 29104	38.5	157	324	90,720
E32	199.2								0	TT 28623	19.1	83	83	23,240
									0	TT 28624	20.4	97	97	27,160
									0	TT 28641	31.2	117	117	32,760
									0	TT 28642	29.2	106	106	29,680
									0	TT 28643	20.7	95	95	26,600
									0	TT 28644	29.4	119	119	33,320
									0	TT 29248	33.6	139	139	38,920
E33A	39.9				39.9				160				160	44,800
E33B	162.3				89.5				358	TT 27591	29.5	15	373	104,440
									0	TT 28742	43.3	200	200	56,000
E34	318.4								0	TT 28369	27.6	126	126	35,280
									0	TT 28387	26.6	121	121	33,880
									0	TT 28388	23.6	109	109	30,520
									0	TT 28680	25.9	119	119	33,320
									0	TT 28681	37.2	98	98	27,440
									0	TT 28682	22.4	112	112	31,360
									0	TT 28683	20.5	80	80	22,400
									0	TT 28684	20.3	81	81	22,680
									0	TT 28685	16.6	118	118	33,040
									0	TT 28686	26.0	109	109	30,520
									0	TT 28687	36.0	153	153	42,840
E35	174.6		26.7		147.9				645				645	180,600
E36	234.1				31.0				124	TT 29148	129.8	487	611	171,080
E37	161.8				161.8				647				647	181,160
E38	165.1								0				0	0
E39	153.4				153.4				614				614	171,920
E40	217.0		20.7		177.0				749	TT 30480	19.3	50	799	223,720
E41	140.7				73.8				295				295	82,600
E42	143.2				76.8				307				307	85,960
E43	49.1				49.1				196				196	54,880
E44	59.7				59.7				239				239	66,920
E45	54.9		25.6		29.3				168				168	47,040
E46	310.5				169.2				677	TT 30480	99.3	256	933	261,240
									0	TT 29677	42.0	173	173	48,440
E47	198.0				133.9				536	TT 29677	64.1	263	799	223,720
E48	63.1				63.1				252				252	70,560
E49	147.9				147.9				592				592	165,760
E50	75.7								0				0	0
E31-E50	**3,148.8**	**0.0**	**73.0**	**0.0**	**1,645.0**	**0.0**	**0.0**	**0.0**	**6,726**		**932.1**	**3,583**	**10,309**	***2,886,520***
Eastvale Subtotal[9]	**7,410.0**	**0.0**	**182.9**	**939.4**	**2,380.9**	**77.8**	**0.0**	**0.0**	**12,314.0**		**2,511.9**	**10,151**	**22,338**	***6,254,680***
DISTRICT TOTAL[10]	**21,936.0**	**7.4**	**4,913.7**	**939.4**	**3,471.9**	**354.2**	**6.3**	**0.0**	**30,678.0[11]**		**2,511.9**	**10,151**	**40,702**	***11,198,360***

Tributary Drainage Area No. [1]	Commercial Retail (ac)	Office (ac)	Community Centers (ac)	Industrial[4] Light (ac)	Heavy (ac)	Business Park (ac)	Public Facilities (ac)	Comm/Ind Q_{ADF}[5] (gpd)	Schools No. of Students (each)	Q_{ADF}[7] (gpd)	City Overlay (ac)	Conservation (ac)	Conservation Habitat (ac)	Open Space Recreation (ac)	Rural (ac)	Water (ac)	Mineral Resources (ac)	Agricultural (ac)	Highway (ac)	Total Q_{ADF} (gpd)
E31								0												90,720
E32								0						15.6						23,240
								0												27,160
								0												32,760
								0												29,680
								0												26,600
								0												33,320
								0												38,920
E33A								0												44,800
E33B								0												104,440
								0												56,000
E34	10.4							5,200	800	12,000				25.3						52,480
								0												33,880
								0												30,520
								0												33,320
								0												27,440
								0												31,360
								0												22,400
								0												22,680
								0												33,040
								0												30,520
								0												42,840
E35								0												180,600
E36				65.3				32,650						8.0						203,730
E37								0												181,160
E38				165.1				82,550												82,550
E39								0												171,920
E40								0												223,720
E41				66.9				33,450												116,050
E42				66.4				33,200												119,160
E43								0												54,880
E44								0												66,920
E45								0												47,040
E46								0												261,240
								0												48,440
E47								0												223,720
E48								0												70,560
E49								0												165,760
E50								0							75.7					0
E31-E50	**10.4**	**0.0**	**0.0**	**363.7**	**0.0**	**0.0**	**0.0**	***187,050***	**800.0**	***12,000***	**0.0**	**0.0**	**0.0**	**48.9**	**75.7**	**0.0**	**0.0**	**0.0**	**0.0**	***3,085,570***
Eastvale Subtotal[9]	**360.7**	**0.0**	**152.6**	**363.7**	**0.0**	**80.2**	**0.0**	***478,600***	**7,430.0**	***134,800***	**0.0**	**0.0**	**0.0**	**140.1**	**75.7**	**0.0**	**0.0**	**0.0**	**0.0**	***6,868,080***
DISTRICT TOTAL[10]	**1,114.0**	**0.0**	**197.8**	**3,223.1**	**77.6**	**1,761.3**	**11.1**	***3,192,437***	**22,308.0**	***381,935***	**0.0**	**74.9**	**29.3**	**490.4**	**109.7**	**82.4**	**149.3**	**9.9**	**485.3**	***14,772,732***

[1] Refer to Plate 1.

[2] Land use designations for tributary areas E31-E50 were determined from Eastvale Area Land Use Plan for the Riverside County Integrated Project, April 2001.

The following densities were used to calculate residential land uses: Rural Residential (0.2 du/ac); Very Low Density (2 du/ac); SP125-W (2du/ac); Low Density (4 du/ac); Medium Density (7 du/ac); Medium-High Density (12 du/ac); High Density (18 du/ac)

[3] Based on 280 gpd/edu and 160 gpd for mobile homes and multi-family units.

[4] Distinction between "light" and "heavy" industrial land use is based on air and noise pollution factors; wastewater generation is assumed equal for both land uses.

[5] Commercial and industrial wastewater flow quantities are based on 500 gpd/ac. For areas tributary to Plant 1 - deductions were applied the commercial and industrial areas based on existing site conditions totaling 507 acres.

[6] Total number of multi-family units. Converted to edu's by multiplying by 160/280.

[7] Based on type of school and number of students: 10gpd/stu for elementary; 15gpd/stu for middle; 25gpd/stu highschool

[8] Area No. 25 will be included in the Sky Country tributary area (Area No. E1) because there is a sewer that connects No. 25 to the north east portion of the Sky Country Development.

[9] Eastvale Subtotal consists of tributary areas E1-E50.

[10] The District Total for this spreadsheet totalizes areas within the tributary boundaries only. Areas outside the tributary areas but withing the District Boundaries account for approximately 3,800 acres, therefore, the total area within the District is

[11] Total District Residential EDU's (Households)

Infiltration/inflow (not shown on this table) was factored into SewerCAD calculations for final pipe designs.

APPENDIX M

POINT SOURCE ANALYSIS
(FOR ULTIMATE SARI LINE DISCHARGE)

Appendix M. Point Source Analysis (For Ultimate SARI Line Discharge)

Commercial and Industrial Wastewater Factor Based on 175 gpd/AC

Tributary Drainage Area No.[1]	Area (ac)	Residential[2] Rural Residential (<0.2 du/ac)	Very Low Density (0.4-2 du/ac)	SP125-W (2du/ac)	Low Density (2-5 du/ac)	Medium Density (5-8 du/ac)	Med-High Density (8-14 du/ac)	High Density (14-20 du/ac)	# of edu's	Proposed Developments Tract Number	Area (ac)	du's	Total # of edu's	Q_{ADF}[3] (gpd)	Commercial Retail (ac)	Office (ac)	Community Centers (ac)	Industrial[4] Light (ac)	Heavy (ac)	Business Park (ac)	Public Facilities (ac)	Comm/Ind Q_{ADF}[5] (gpd)	Schools No. of Students (each)	Q_{ADF}[7] (gpd)	City Overlay (ac)	Conservation (ac)	Conservation Habitat (ac)	Open Space Recreation (ac)	Rural (ac)	Water (ac)	Mineral Resources (ac)	Agricultural (ac)	Highway (ac)	Total Q_{ADF} (gpd)
J24	223.6								0				0	0				216.1				37,818											7.5	37,818
J26	1,140.0				28.7				115				115	32,200	3.2			1,030.3				180,863											77.8	213,063
J27	609.7								0				0	0				517.7		75.5	1.5	104,073												104,073
J28	1,248.8								0				0	0				661.7		498.7		203,070											43.4	203,070
J29	209.2								0				0	0	41.2			122.4				28,630											45.6	28,630
J30	672.4								0				0	0				21.9		584.5		106,120											66.0	106,120
J24-J30	**4,103.6**	**0.0**	**0.0**	**0.0**	**28.7**	**0.0**	**0.0**	**0.0**	**115**				**115**	***32,200***	**44.4**	**0.0**	**0.0**	**2,570.1**	**0.0**	**1,158.7**	**1.5**	***660,573***	**0.0**	***0***	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**240.3**	***692,773***

Commercial and Industrial Wastewater Factor Based on 500 gpd/AC

Tributary Drainage Area No.[1]	Area (ac)	Residential[2] Rural Residential (<0.2 du/ac)	Very Low Density (0.4-2 du/ac)	SP125-W (2du/ac)	Low Density (2-5 du/ac)	Medium Density (5-8 du/ac)	Med-High Density (8-14 du/ac)	High Density (14-20 du/ac)	# of edu's	Proposed Developments Tract Number	Area (ac)	du's	Total # of edu's	Q_{ADF}[3] (gpd)	Commercial Retail (ac)	Office (ac)	Community Centers (ac)	Industrial[4] Light (ac)	Heavy (ac)	Business Park (ac)	Public Facilities (ac)	Comm/Ind Q_{ADF}[5] (gpd)	Schools No. of Students (each)	Q_{ADF}[7] (gpd)	City Overlay (ac)	Conservation (ac)	Conservation Habitat (ac)	Open Space Recreation (ac)	Rural (ac)	Water (ac)	Mineral Resources (ac)	Agricultural (ac)	Highway (ac)	Total Q_{ADF} (gpd)
J24	223.6								0				0	0				216.1				108,050											7.5	108,050
J26	1,140.0				28.7				115				115	32,200	3.2			1,030.3				516,750											77.8	548,950
J27	609.7								0				0	0				517.7		75.5	1.5	297,350												297,350
J28	1,248.8								0				0	0				661.7		498.7		580,200											43.4	580,200
J29	209.2								0				0	0	41.2			122.4				81,800											45.6	81,800
J30	672.4								0				0	0				21.9		584.5		303,200											66.0	303,200
J24-J30	**4,103.6**	**0.0**	**0.0**	**0.0**	**28.7**	**0.0**	**0.0**	**0.0**	**115**				**115**	***32,200***	**44.4**	**0.0**	**0.0**	**2,570.1**	**0.0**	**1,158.7**	**1.5**	***1,887,350***	**0.0**	***0***	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**240.3**	***1,919,550***

[1] Refer to Plate 1.

[2] Land use designations for tributary areas J1-J30 were determined from Jurupa Area Land Use Plan for the Riverside County Integrated Project, April 2001.

The following densities were used to calculate residential land uses: Rural Residential (0.2 du/ac); Very Low Density (2 du/ac); SP125-W (2du/ac); Low Density (4 du/ac); Medium Density (7 du/ac); Medium-High Density (12 du/ac); High Density (18 du/ac)

[3] Based on 280 gpd/edu and 160 gpd for mobile homes and multi-family units.

[4] Distinction between "light" and "heavy" industrial land use is based on air and noise pollution factors; wastewater generation is assumed equal for both land uses.

[5] Commercial and industrial wastewater flow quantities are based on 500 gpd/ac or 175 gpd/ac - see heading

[6] Total number of multi-family units. Converted to edu's by multiplying by 160/280.

[7] Based on type of school and number of students: 10gpd/stu for elementary; 15gpd/stu for middle; 25gpd/stu highschool

Infiltration/inflow (not shown on this table) was factored into SewerCAD calculations for final pipe designs.

Point Source Analysis

(A) It is noted that approximately 60 acres were deducted from the CFD Area No. 1 to account for the Chino 2 Desaulter, Ion Exchange Plant and Metal Container Corporation.

(B) The following are the projected wastwater generated for these point sources:

1. Chino 2 Desalter - RO (mgd)	3.00
2. Chino 2 Desalter - Ion Exchange (mgd)	0.46
3. Ion Exchange Plant (mgd)	0.59
4. Metal Contain Corporation (mgd)	0.15
5. Total Point Source Contribution (mgd)	**4.20**

(C) As indicated in the spreadsheets above the wastewater generated within the CFD Area No. 1 can varies depending on which generation factor utilized.

1. Utilizing 175 gpd/AC (gpd)	692,773	or	0.69	mgd
2. Utilizing 500 gpd/AC (gpd)	1,919,550	or	1.92	mgd

(D) Therefore projected wastewater discharge into the SARI Line can range from:

1. Utilizing 175 gpd/AC (mgd)	4.89
2. Utilizing 500 gpd/AC (mgd)	6.12

APPENDIX N

SANITARY AND WET WEATHER FLOW ANALYSIS

Appendix N
Sanitary and Wet Weather Flow Analysis

Trunk Sewer System	Pipe Label	gpd / AC	AC	Total gpd	Total Infiltration Only (gpd)	Total Flow w/ Infiltration	Total Flow w/out Infiltration	Total Sanitary Flow (gpd)	Total Wet Weather Flow (gpd)
Bain Street Trunk	B_65-39B	160	223.6	35776		2,208,840		2,074,600	134,240
Bain Street Trunk	B_E1459	0	0	0		2,208,840		2,074,600	134,240
Bain Street Trunk	B_E1628	0	0	0		2,208,840		2,074,600	134,240
Bain Street Trunk	B_E1638	0	0	0		2,208,840		2,074,600	134,240
Bain Street Trunk	B_E1680	0	0	0		2,208,840		2,074,600	134,240
Bain Street Trunk	B_E3269	0	0	0		2,208,840		2,074,600	134,240
Bain Street Trunk	B_N1223	160	615.4	98464		2,173,064		2,074,600	98,464
Bain Street Trunk	B_N1225	0	0	0		2,173,064		2,074,600	98,464
Bain Street Trunk	B_N1235	0	0	0		2,173,064		2,074,600	98,464
Bain Street Trunk	B_N1844	0	0	0		2,208,840		2,074,600	134,240
Bain Street Trunk	B_N1847	0	0	0		2,208,840		2,074,600	134,240
Bain Street Trunk	B_N1849	0	0	0		2,208,840		2,074,600	134,240
Bain Street Trunk	B_N1855	160	213.9	34224		2,630,996		2,462,532	168,464
Bain Street Trunk	B_N2041	0	0	0		2,953,880		2,785,416	168,464
Bain Street Trunk	B_N2042	0	0	0		2,630,996		2,462,532	168,464
Bain Street Trunk	B_N2043	0	0	0		2,630,996		2,462,532	168,464
Bain Street Trunk	B_N2044	0	0	0		2,630,996		2,462,532	168,464
Bain Street Trunk	B_N2045	0	0	0		2,630,996		2,462,532	168,464
Bain Street Trunk	B_N2277	0	0	0		***2,953,880***	***2,785,416***	***2,785,416***	***168,464***
Bain Street Trunk	B_N2278	0	0	0		2,953,880		2,785,416	168,464
Bain Street Trunk	B_N2279	0	0	0		2,953,880		2,785,416	168,464
Bain Street Trunk	B_N2280	0	0	0		2,953,880		2,785,416	168,464
Bain Street Trunk	B_N2281	0	0	0		2,953,880		2,785,416	168,464
Bain Street Trunk	B_N2282	0	0	0		2,953,880		2,785,416	168,464
Bain Street Trunk	**B_N4334**	**0**	**0**	**0**	**168,464.00**	2,208,840		2,074,600	134,240
Etiwanda Avenue Trunk (CFD)	E_E3360	0	0	0		***7,341,168***	***7,155,698***	***7,155,698***	***185,470***
Etiwanda Avenue Trunk (CFD)	E_N1212	100	1140	114000		4,062,929		3,948,929	114,000
Etiwanda Avenue Trunk (CFD)	E_N1426	100	610	61000		4,123,929		3,948,929	175,000
Etiwanda Avenue Trunk (CFD)	E_N1427	0	0	0		4,123,929		3,948,929	175,000
Etiwanda Avenue Trunk (CFD)	E_N1428	0	0	0		4,123,929		3,948,929	175,000
Etiwanda Avenue Trunk (CFD)	E_N1598	100	104.7	10470		7,341,168		7,155,698	185,470
Etiwanda Avenue Trunk (CFD)	**E_N4436**	**0**	**0**	**0**	**185,470.00**	7,341,168		7,155,698	185,470
Glen Avon Area Trunk	G_97-0261	0	0	0		4,938,404		4,651,988	286,416
Glen Avon Area Trunk	G_E1119	160	189.8	30368		494,398		464,030	30,368
Glen Avon Area Trunk	G_E1120	160	138.2	22112		375,730		353,618	22,112
Glen Avon Area Trunk	G_E1175	0	0	0		821,373		768,893	52,480
Glen Avon Area Trunk	G_E1178	0	0	0		821,373		768,893	52,480
Glen Avon Area Trunk	G_E1283	0	0	0		860,045		768,893	91,152
Glen Avon Area Trunk	G_E1291	0	0	0		2,383,049		2,213,929	169,120
Glen Avon Area Trunk	G_E1307	0	0	0		2,904,682		2,709,418	195,264
Glen Avon Area Trunk	G_E1490	160	454.1	72656		***5,746,690***	***5,387,618***	***5,387,618***	***359,072***
Glen Avon Area Trunk	G_N1177	0	0	0		821,373		768,893	52,480
Glen Avon Area Trunk	G_N1266	0	0	0		821,373		768,893	52,480
Glen Avon Area Trunk	G_N1268	0	0	0		821,373		768,893	52,480
Glen Avon Area Trunk	G_N1269	160	241.7	38672		860,045		768,893	91,152
Glen Avon Area Trunk	G_N1458	160	487.3	77968		1,435,852		1,266,732	169,120
Glen Avon Area Trunk	G_N1460	160	163.4	26144		2,904,682		2,709,418	195,264
Glen Avon Area Trunk	G_N1641	160	569.7	91152		2,995,834		2,709,418	286,416
Glen Avon Area Trunk	G_N1643	0	0	0		4,938,404		4,651,988	286,416
Glen Avon Area Trunk	**G_N1644**	**0**	**0**	**0**	**359,072.00**	4,938,404		4,651,988	286,416
Hamner Avenue Trunk (CFD)	H_N4082	100	100	10000		638,961		628,961	10,000
Hamner Avenue Trunk (CFD)	H_N4086	100	109.2	10920		649,881		628,961	20,920
Hamner Avenue Trunk (CFD)	H_N4087	0	0	0		649,881		628,961	20,920
Hamner Avenue Trunk (CFD)	H_N4089	0	0	0		649,881		628,961	20,920
Hamner Avenue Trunk (CFD)	H_N4091	0	0	0		649,881		628,961	20,920
Hamner Avenue Trunk (CFD)	H_N4092	0	0	0		649,881		628,961	20,920
Hamner Avenue Trunk (CFD)	H_N4098	0	0	0		649,881		628,961	20,920
Hamner Avenue Trunk (CFD)	H_N4099	0	0	0		649,881		628,961	20,920
Hamner Avenue Trunk (CFD)	H_N4100	0	0	0		649,881		628,961	20,920
Hamner Avenue Trunk (CFD)	H_N4101	0	0	0		649,881		628,961	20,920
Hamner Avenue Trunk (CFD)	H_N4103	0	0	0		649,881		628,961	20,920
Hamner Avenue Trunk (CFD)	H_N4111	100	672.4	67240		3,512,476		3,424,316	88,160
Hamner Avenue Trunk (CFD)	H_N4113	0	0	0		3,512,476		3,424,316	88,160
Hamner Avenue Trunk (CFD)	H_N4114	0	0	0		3,512,476		3,424,316	88,160
Hamner Avenue Trunk (CFD)	H_N4119	0	0	0		3,512,476		3,424,316	88,160
Hamner Avenue Trunk (CFD)	**H_N4120**	**0**	**0**	**0**	**88,160.00**	***3,512,476***	***3,424,316***	***3,424,316***	***88,160***
Indian Hills WRF Overflow Line	I_2362	0	0	0		1,491,771		1,337,531	154,240
Indian Hills WRF Overflow Line	I_E2040	0	0	0		***1,491,771***	***1,337,531***	***1,337,531***	***154,240***
Indian Hills WRF Overflow Line	I_E2041	0	0	0		1,491,771		1,337,531	154,240
Indian Hills WRF Overflow Line	I_E2049	0	0	0		1,491,771		1,337,531	154,240
Indian Hills WRF Overflow Line	I_E2050	0	0	0		1,491,771		1,337,531	154,240
Indian Hills WRF Overflow Line	I_E2051	0	0	0		1,491,771		1,337,531	154,240
Indian Hills WRF Overflow Line	I_E2052	0	0	0		1,491,771		1,337,531	154,240
Indian Hills WRF Overflow Line	I_E2056	0	0	0		1,491,771		1,337,531	154,240
Indian Hills WRF Overflow Line	I_E2058	0	0	0		1,491,771		1,337,531	154,240
Indian Hills WRF Overflow Line	I_E2059	0	0	0		1,491,771		1,337,531	154,240
Indian Hills WRF Overflow Line	I_E2069	0	0	0		1,491,771		1,337,531	154,240
Indian Hills WRF Overflow Line	I_E2094	0	0	0		1,491,771		1,337,531	154,240
Indian Hills WRF Overflow Line	I_E2219	0	0	0		1,491,771		1,337,531	154,240
Indian Hills WRF Overflow Line	I_N2046	0	0	0		1,491,771		1,337,531	154,240
Indian Hills WRF Overflow Line	I_N2371	0	0	0		1,491,771		1,337,531	154,240

Appendix N
Sanitary and Wet Weather Flow Analysis

Trunk Sewer System	Pipe Label	gpd / AC	AC	Total gpd	Total Infiltration Only (gpd)	Total Flow w/ Infiltration	Total Flow w/out Infiltration	Total Sanitary Flow (gpd)	Total Wet Weather Flow (gpd)
Indian Hills WRF Overflow Line	I_N2399	160	200	32000		431,244		399,244	32,000
Indian Hills WRF Overflow Line	I_N2523	0	0	0		1,491,771		1,337,531	154,240
Indian Hills WRF Overflow Line	I_N2524	0	0	0		1,491,771		1,337,531	154,240
Indian Hills WRF Overflow Line	I_N2527	0	0	0		1,491,771		1,337,531	154,240
Indian Hills WRF Overflow Line	I_N2528	0	0	0		1,491,771		1,337,531	154,240
Indian Hills WRF Overflow Line	**I_WRF**	**160**	**764**	**122240**	**154,240.00**	1,133,131		1,010,891	122,240
Jurupa Trunk	J_E1242	0	0	0		1,349,471		1,242,494	106,978
Jurupa Trunk	J_E1245	0	0	0		1,349,471		1,242,494	106,978
Jurupa Trunk	J_E1392	0	0	0		3,193,912		2,945,606	248,306
Jurupa Trunk	J_E1393	0	0	0		3,193,912		2,945,606	248,306
Jurupa Trunk	J_E1394	0	0	0		3,193,912		2,945,606	248,306
Jurupa Trunk	J_E1395	160	381.7	61072		3,193,912		2,945,606	248,306
Jurupa Trunk	J_E1396	0	0	0		2,298,138		2,110,905	187,234
Jurupa Trunk	J_E1397	0	0	0		2,298,138		2,110,905	187,234
Jurupa Trunk	J_E1410	0	0	0		2,298,138		2,110,905	187,234
Jurupa Trunk	J_E1411	160	161.3	25808		2,298,138		2,110,905	187,234
Jurupa Trunk	J_E1413	0	0	0		2,063,068		1,901,642	161,426
Jurupa Trunk	J_E1414	0	0	0		2,063,068		1,901,642	161,426
Jurupa Trunk	J_E1423	160	100	16000		1,397,471		1,242,494	154,978
Jurupa Trunk	J_E1424	160	100	16000		1,381,471		1,242,494	138,978
Jurupa Trunk	J_E1425	160	100	16000		1,365,471		1,242,494	122,978
Jurupa Trunk	J_E1444	0	0	0		1,349,471		1,242,494	106,978
Jurupa Trunk	J_E1445	0	0	0		1,349,471		1,242,494	106,978
Jurupa Trunk	J_E1492	0	0	0		6,985,877		6,461,603	524,274
Jurupa Trunk	J_E1516	160	283.4	45344		6,985,877		6,461,603	524,274
Jurupa Trunk	J_E1517	0	0	0		6,375,708		5,896,779	478,930
Jurupa Trunk	J_E1518	0	0	0		6,375,708		5,896,779	478,930
Jurupa Trunk	J_E1519	160	427.4	68384		6,375,708		5,896,779	478,930
Jurupa Trunk	J_E1530	0	0	0		5,399,832		4,989,287	410,546
Jurupa Trunk	J_E1531	0	0	0		5,399,832		4,989,287	410,546
Jurupa Trunk	J_E1532	0	0	0		5,399,832		4,989,287	410,546
Jurupa Trunk	J_E1533	0	0	0		5,399,832		4,989,287	410,546
Jurupa Trunk	J_E1534	0	0	0		5,399,832		4,989,287	410,546
Jurupa Trunk	J_E1535	0	0	0		5,399,832		4,989,287	410,546
Jurupa Trunk	J_E1536	160	497.1	79536		5,399,832		4,989,287	410,546
Jurupa Trunk	J_E1579	0	0	0		4,628,483		4,297,474	331,010
Jurupa Trunk	J_E1580	160	516.9	82704		4,628,483		4,297,474	331,010
Jurupa Trunk	J_E1581	0	0	0		3,193,912		2,945,606	248,306
Jurupa Trunk	J_E1582	0	0	0		3,193,912		2,945,606	248,306
Jurupa Trunk	J_E1705	0	0	0		12,894,937		11,928,311	966,626
Jurupa Trunk	J_E1846	0	0	0		16,170,068		14,840,674	1,329,394
Jurupa Trunk	J_E1847	0	0	0		16,170,068		14,840,674	1,329,394
Jurupa Trunk	J_E1857	0	0	0		12,894,937		11,928,311	966,626
Jurupa Trunk	J_E1858	0	0	0		12,894,937		11,928,311	966,626
Jurupa Trunk	J_E1971	0	0	0		***19,209,554***	***18,467,026***	***17,620,785***	***1,588,770***
Jurupa Trunk	J_E1973	0	0	0		16,915,906		15,495,601	1,420,306
Jurupa Trunk	J_E2006	0	0	0		16,509,391		15,143,198	1,366,194
Jurupa Trunk	J_E2007	160	230	36800		16,509,391		15,143,198	1,366,194
Jurupa Trunk	J_N1081	0	0	0		492,867		457,208	35,659
Jurupa Trunk	J_N1082	0	0	0		492,867		457,208	35,659
Jurupa Trunk	J_N1083	0	0	0		492,867		457,208	35,659
Jurupa Trunk	J_N1085	160	222.9	35664		492,867		457,208	35,659
Jurupa Trunk	J_N1191	0	0	0		492,867		457,208	35,659
Jurupa Trunk	J_N1192	0	0	0		492,867		457,208	35,659
Jurupa Trunk	J_N1193	0	0	0		492,867		457,208	35,659
Jurupa Trunk	J_N1194	160	222.9	35664		930,433		859,115	71,318
Jurupa Trunk	J_N1196	0	0	0		930,433		859,115	71,318
Jurupa Trunk	J_N1371	0	0	0		930,433		859,115	71,318
Jurupa Trunk	J_N1372	160	222.9	35664		1,349,471		1,242,494	106,978
Jurupa Trunk	J_N1406	0	0	0		930,433		859,115	71,318
Jurupa Trunk	J_N1564	160	40.3	6448		2,063,068		1,901,642	161,426
Jurupa Trunk	J_N1657	0	0	0		12,020,486		11,137,141	883,346
Jurupa Trunk	J_N1901	0	0	0		12,020,486		11,137,141	883,346
Jurupa Trunk	J_N1907	0	0	0		12,894,937		11,928,311	966,626
Jurupa Trunk	J_N1908	160	520.5	83280		12,894,937		11,928,311	966,626
Jurupa Trunk	J_N1910	0	0	0		12,020,486		11,137,141	883,346
Jurupa Trunk	J_N1911	0	0	0		12,020,486		11,137,141	883,346
Jurupa Trunk	J_N2010	0	0	0		16,170,068		14,840,674	1,329,394
Jurupa Trunk	J_N2090	0	0	0		16,170,068		14,840,674	1,329,394
Jurupa Trunk	J_N2091	0	0	0		16,170,068		14,840,674	1,329,394
Jurupa Trunk	J_N2107	160	275.3	44048		13,246,341		12,235,667	1,010,674
Jurupa Trunk	J_N2108	0	0	0		12,894,937		11,928,311	966,626
Jurupa Trunk	J_N2119	0	0	0		12,894,937		11,928,311	966,626
Jurupa Trunk	J_N2284	0	0	0		16,915,906		15,495,601	1,420,306
Jurupa Trunk	J_N2285	160	338.2	54112		16,915,906		15,495,601	1,420,306
Jurupa Trunk	J_N2286	0	0	0		16,509,391		15,143,198	1,366,194
Jurupa Trunk	J_N2315	0	0	0		16,170,068		14,840,674	1,329,394
Jurupa Trunk	**J_N2317**	**0**	**0**	**0**	**742,528.00**	16,170,068		14,840,674	1,329,394
Pedley Area Trunk	P_E2024	0	0	0		1,240,009		1,186,217	53,792
Pedley Area Trunk	P_E2065	0	0	0		71,087		61,327	9,760
Pedley Area Trunk	P_E2067	160	61	9760		71,087		61,327	9,760

Appendix N
Sanitary and Wet Weather Flow Analysis

Trunk Sewer System	Pipe Label	gpd / AC	AC	Total gpd	Total Infiltration Only (gpd)	Total Flow w/ Infiltration	Total Flow w/out Infiltration	Total Sanitary Flow (gpd)	Total Wet Weather Flow (gpd)
Pedley Area Trunk	P_E2182	0	0	0		1,240,009		1,186,217	53,792
Pedley Area Trunk	P_E2184	0	0	0		1,240,009		1,186,217	53,792
Pedley Area Trunk	P_E2186	0	0	0		1,240,009		1,186,217	53,792
Pedley Area Trunk	P_E2202	0	0	0		71,087		61,327	9,760
Pedley Area Trunk	P_E2206	0	0	0		1,240,009		1,186,217	53,792
Pedley Area Trunk	P_E2208	160	275.2	44032		1,240,009		1,186,217	53,792
Pedley Area Trunk	P_E2211	0	0	0		71,087		61,327	9,760
Pedley Area Trunk	P_N2106	160	216	34560		***3,610,603***	***3,446,123***	***3,291,883***	***318,720***
Pedley Area Trunk	P_N2340	160	475.8	76128		1,932,873		1,802,953	129,920
Pedley Area Trunk	P_N2342	0	0	0		1,932,873		1,802,953	129,920
Pedley Area Trunk	P_N2343	0	0	0		3,237,931		2,953,771	284,160
Pedley Area Trunk	P_N2473	0	0	0		1,240,009		1,186,217	53,792
Pedley Area Trunk	P_N2489	0	0	0		1,240,009		1,186,217	53,792
Pedley Area Trunk	P_N2498	0	0	0		71,087		61,327	9,760
Pedley Area Trunk	**P_N2499**	**0**	**0**	**0**	**164,480.00**	71,087		61,327	9,760
Wineville Road Trunk (CFD)	W_N4162	100	200	20000		1,581,751		1,561,751	20,000
Wineville Road Trunk (CFD)	W_N4163	100	100	10000		1,591,751		1,561,751	30,000
Wineville Road Trunk (CFD)	W_N4165	100	200	20000		1,611,751		1,561,751	50,000
Wineville Road Trunk (CFD)	W_N4166	100	100	10000		1,621,751		1,561,751	60,000
Wineville Road Trunk (CFD)	W_N4167	100	100	10000		1,631,751		1,561,751	70,000
Wineville Road Trunk (CFD)	W_N4175	100	300	30000		4,460,814		4,360,814	100,000
Wineville Road Trunk (CFD)	W_N4176	100	100	10000		4,470,814		4,360,814	110,000
Wineville Road Trunk (CFD)	W_N4181	100	100	10000		5,768,739		5,648,739	120,000
Wineville Road Trunk (CFD)	**W_N4182**	**0**	**0**	**0**	**120,000.00**	***5,768,739***	***5,648,739***	***5,648,739***	***120,000***
				Sum =	**1,982,414.00**	**gpd**			
					1.98	**mgd**			

Total Peak Flow			+	***Total Wet Weather Flow***		=	***Total Peak Wet Weather Flow***	
JCSD:	**16,283,239.00**	**gpd**		**1,434,544.00**	**gpd**		**17,717,783.00**	**gpd**
	16.28	**mgd**		**1.43**	**mgd**		**17.72**	**mgd**
Indian Hills:	**1,337,531.00**	**gpd**		**154,240.00**	**gpd**		**1,491,771.00**	**gpd**
	1.34	**mgd**		**0.15**	**mgd**		**1.49**	**mgd**
CFD:	**16,228,753.00**	**gpd**		**393,630.00**	**gpd**		**16,622,383.00**	**gpd**
	16.23	**mgd**		**0.39**	**mgd**		**16.62**	**mgd**
JCSD + Indian Hills:	**17,620,770.00**	**gpd**		**1,588,784.00**	**gpd**		**19,209,554.00**	**gpd**
	17.62	**mgd**		**1.59**	**mgd**		**19.21**	**mgd**
JCSD + Indian Hills + CFD:	**33,849,523.00**	**gpd**		**1,982,414.00**	**gpd**		**35,831,937.00**	**gpd**
	33.85	**mgd**		**1.98**	**mgd**		**35.83**	**mgd**

APPENDIX O

EXISTING JCSD SEWER SYSTEM WITH FLOWS FROM PROJECTED ULTIMATE LAND USE BY TRIBUTARY DRAINAGE AREA

Appendix O
Existing JCSD Sewer System with Flows From Projected Ultimate Land Use
By Tributary Drainage Area

Label	Upstream Node	Upstream Invert Elevation (ft)	Downstream Node	Downstream Invert Elevation (ft)	Constructed Slope (ft/ft)	Length (ft)	Section Size	Mannings n	Material	Section Shape	Full Capacity (gpd)	Design Capacity (gpd)	Total Flow (gpd)	Excess Full Capacity (gpd)	Excess Design Capacity (gpd)	Average Velocity (ft/s)	Depth In (ft)	Depth Out (ft)	Infiltration Unit Load Flow per Unit (gpd)	Infiltration Unit Load Count
B_65-39B	B_1364	738.77	B_1654	709.20	0.0100	2957	18 inch	0.013	Vitrified Clay Pipe	Circular	6,788,761.00	6,190,520	2,208,840	4,579,921	3,981,680	4.99	0.59	0.65	160	223.6
B_E1459	B_4394	699.24	B_1962	697.22	0.0030	672	18 inch	0.013	Vitrified Clay Pipe	Circular	3,722,045.00	3,394,049	2,208,840	1,513,205	1,185,210	3.40	0.83	0.83		
B_E1628	B_2337	688.06	B_2338	687.16	0.0030	300	18 inch	0.013	Vitrified Clay Pipe	Circular	3,718,358.00	3,390,687	2,208,840	1,509,518	1,181,847	3.39	0.83	0.83		
B_E1638	B_2351	693.59	B_2347	692.43	0.0040	291	18 inch	0.013	Vitrified Clay Pipe	Circular	4,286,206.00	3,908,495	2,208,840	2,077,366	1,699,656	3.59	0.76	0.83		
B_E1680	B_1654	709.20	B_1657	706.62	0.0070	369	18 inch	0.013	Vitrified Clay Pipe	Circular	5,676,586.00	5,176,352	2,208,840	3,467,746	2,967,512	4.03	0.65	0.83		
B_E3269	B_1657	706.62	B_4387	705.93	0.0030	230	18 inch	0.013	Vitrified Clay Pipe	Circular	3,718,358.00	3,390,687	2,208,840	1,509,518	1,181,847	3.39	0.83	0.83		
B_N1223	B_1254	765.06	B_1372	761.07	0.0114	350	15 inch	0.013	Vitrified Clay Pipe	Circular	4,457,516.00	4,064,710	2,173,064	2,284,453	1,891,646	5.03	0.62	0.73	160	615.4
B_N1225	B_1372	761.07	B_1375	756.51	0.0064	713	15 inch	0.013	Vitrified Clay Pipe	Circular	3,338,706.00	3,044,492	2,173,064	1,165,642	871,428	4.48	0.73	0.73		
B_N1235	B_1375	756.51	B_1364	738.77	0.0100	1774	15 inch	0.013	Vitrified Clay Pipe	Circular	4,174,847.00	3,806,950	2,173,064	2,001,783	1,633,886	5.32	0.64	0.64		
B_N1844	B_2345	691.05	B_2337	688.06	0.0030	998	18 inch	0.013	Vitrified Clay Pipe	Circular	3,716,804.00	3,389,271	2,208,840	1,507,964	1,180,431	3.39	0.83	0.83		
B_N1847	B_2347	692.43	B_2345	691.05	0.0030	457	18 inch	0.013	Vitrified Clay Pipe	Circular	3,730,542.00	3,401,798	2,208,840	1,521,702	1,192,958	3.40	0.83	0.83		
B_N1849	B_1962	697.22	B_2351	693.59	0.0030	1211	18 inch	0.013	Vitrified Clay Pipe	Circular	3,716,822.00	3,389,287	2,208,840	1,507,982	1,180,447	3.39	0.83	0.83		
B_N1855	B_2338	687.16	B_2372	685.19	0.0059	335	18 inch	0.013	Vitrified Clay Pipe	Circular	5,205,965.00	4,747,203	2,630,996	2,574,968	2,116,207	4.57	0.75	0.75	160	213.9
B_N2041	B_2687	674.73	B_2686	671.23	0.0053	660	18 inch	0.013	Vitrified Clay Pipe	Circular	4,943,705.00	4,508,055	2,953,880	1,989,825	1,554,174	4.52	0.84	0.84		
B_N2042	B_2688	678.68	B_2687	674.73	0.0060	659	18 inch	0.013	Vitrified Clay Pipe	Circular	5,255,891.00	4,792,730	2,630,996	2,624,895	2,161,733	4.31	0.75	0.84		
B_N2043	B_2689	680.00	B_2688	678.68	0.0075	177	18 inch	0.013	Vitrified Clay Pipe	Circular	5,862,608.00	5,345,981	2,630,996	3,231,612	2,714,985	4.80	0.70	0.75		
B_N2044	B_2690	681.19	B_2689	680.00	0.0080	148	18 inch	0.013	Vitrified Clay Pipe	Circular	6,087,418.00	5,550,981	2,630,996	3,456,422	2,919,984	5.06	0.69	0.70		
B_N2045	B_2372	685.19	B_2690	681.19	0.0123	325	18 inch	0.013	Vitrified Clay Pipe	Circular	7,531,454.00	6,867,765	2,630,996	4,900,458	4,236,769	5.57	0.61	0.69		
B_N2277	B_3084	646.02	J_3078	637.86	0.0126	648	18 inch	0.013	Vitrified Clay Pipe	Circular	7,618,125.00	6,946,798	2,953,880	4,664,245	3,992,918	2.59	6.77	13.70		
B_N2278	B_3085	650.41	B_3084	646.02	0.0154	285	18 inch	0.013	Vitrified Clay Pipe	Circular	8,425,591.00	7,683,108	2,953,880	5,471,710	4,729,228	2.59	2.92	6.77		
B_N2279	B_3089	660.81	B_3085	650.41	0.0321	324	18 inch	0.013	Vitrified Clay Pipe	Circular	12,162,831.00	11,091,015	2,953,880	9,208,951	8,137,134	5.68	0.50	2.92		
B_N2280	B_3095	664.21	B_3089	660.81	0.0052	654	18 inch	0.013	Vitrified Clay Pipe	Circular	4,894,869.00	4,463,522	2,953,880	1,940,989	1,509,642	4.49	0.84	0.84		
B_N2281	B_2685	667.20	B_3095	664.21	0.0045	665	18 inch	0.013	Vitrified Clay Pipe	Circular	4,552,137.00	4,150,992	2,953,880	1,598,256	1,197,111	4.24	0.88	0.88		
B_N2282	B_2686	671.23	B_2685	667.20	0.0061	660	18 inch	0.013	Vitrified Clay Pipe	Circular	5,304,825.00	4,837,352	2,953,880	2,350,945	1,883,471	4.51	0.80	0.88		
B_N4334	B_4387	705.93	B_4394	699.24	0.0030	2230	18 inch	0.013	Vitrified Clay Pipe	Circular	3,718,358.00	3,390,687	2,208,840	1,509,518	1,181,847	3.39	0.83	0.83		
E_E3360	E_1934	727.00	E_SARI_CONNE	726.14	0.0064	134	21 inch	0.013	Vitrified Clay Pipe	Circular	8,203,744.00	7,480,811	7,341,168	862,576	139,643	5.97	1.29	1.29		
E_N1212	E_1342	764.11	E_1626	757.61	0.0036	1806	21 inch	0.013	Vitrified Clay Pipe	Circular	6,143,461.00	5,602,085	4,062,929	2,080,532	1,539,156	4.22	1.04	1.04	100	1,140.00
E_N1426	E_1626	757.61	E_1623	748.18	0.0048	1964	21 inch	0.013	Vitrified Clay Pipe	Circular	7,095,784.00	6,470,487	4,123,929	2,971,856	2,346,559	4.74	0.96	0.96	100	610
E_N1427	E_1623	748.18	E_1624	745.17	0.0080	376	21 inch	0.013	Vitrified Clay Pipe	Circular	9,162,302.00	8,354,899	4,123,929	5,038,374	4,230,970	5.74	0.82	0.82		
E_N1428	E_1624	745.17	E_1625	736.53	0.0258	335	21 inch	0.013	Vitrified Clay Pipe	Circular	16,445,601.00	14,996,377	4,123,929	12,321,673	10,872,448	6.08	0.60	1.29		
E_N1598	E_1625	736.53	E_1937	730.04	0.0064	1013	21 inch	0.013	Vitrified Clay Pipe	Circular	8,196,584.00	7,474,282	7,341,168	855,416	133,114	5.84	1.29	1.35	100	104.7
E_N4436	E_1937	730.04	E_1934	727.00	0.0040	760	24 inch	0.013	Vitrified Clay Pipe	Circular	9,249,822.00	8,434,707	7,341,168	1,908,654	1,093,538	5.05	1.35	1.35		
G_97-0261	G_2023A	705.62	G_2023B	703.68	0.0318	61	15 inch	0.013	Vitrified Clay Pipe	Circular	7,445,202.00	6,789,113	4,938,404	2,506,798	1,850,710	6.23	10.91	12.00		
G_E1119	G_1276	748.38	G_1270	746.12	0.0037	604	8 inch	0.013	Vitrified Clay Pipe	Circular	477,719.00	238,860	494,398	-16,678	-255,538	2.19	5.24	5.08	160	189.8
G_E1120	G_1278	756.42	G_1270	746.12	0.0213	484	8 inch	0.013	Vitrified Clay Pipe	Circular	1,139,287.00	569,643	375,730	763,557	193,914	3.10	0.26	5.08	160	138.2
G_E1175	G_1295	745.44	G_1419	744.82	0.0025	250	8 inch	0.013	Vitrified Clay Pipe	Circular	388,922.00	194,461	821,373	-432,450	-626,912	3.64	12.23	10.08		
G_E1178	G_1421	742.59	G_1422	741.82	0.0035	221	8 inch	0.013	Vitrified Clay Pipe	Circular	460,985.00	230,492	821,373	-360,388	-590,881	3.64	7.75	6.08		
G_E1283	G_1673	730.06	G_1674	729.66	0.0039	102	8 inch	0.013	Vitrified Clay Pipe	Circular	489,066.00	244,533	860,045	-370,979	-615,512	3.81	8.92	8.08		
G_E1291	G_1684	727.27	G_1685	726.28	0.0060	165	10 inch	0.013	Vitrified Clay Pipe	Circular	1,096,830.00	1,000,175	2,383,049	-1,286,219	-1,382,874	6.76	11.76	8.08		
G_E1307	G_1690	721.73	G_1711	719.04	0.0016	1684	12 inch	0.013	Vitrified Clay Pipe	Circular	920,278.00	839,181	2,904,682	-1,984,404	-2,065,501	5.72	33.64	9.53		
G_E1490	G_2023B	703.68	J_2024	700.82	0.0049	583	15 inch	0.013	Vitrified Clay Pipe	Circular	2,924,080.00	2,666,403	5,746,690	-2,822,610	-3,080,287	7.25	21.19	13.00	160	454.1
G_N1177	G_1270	746.12	G_1295	745.44	0.0018	379	10 inch	0.013	Vitrified Clay Pipe	Circular	599,789.00	546,934	821,373	-221,584	-274,438	2.33	10.16	9.56		
G_N1266	G_1419	744.82	G_1421	742.59	0.0034	655	8 inch	0.013	Vitrified Clay Pipe	Circular	455,689.00	227,845	821,373	-365,684	-593,528	3.64	11.10	6.08		
G_N1268	G_1422	741.82	G_1424	735.32	0.0049	1318	8 inch	0.013	Vitrified Clay Pipe	Circular	548,449.00	274,224	821,373	-272,924	-547,148	3.64	12.75	4.68		
G_N1269	G_1424	735.32	G_1673	730.06	0.0077	686	8 inch	0.013	Vitrified Clay Pipe	Circular	683,861.00	341,931	860,045	-176,184	-518,114	3.81	11.00	7.94	160	241.7
G_N1458	G_1674	729.66	G_1684	727.27	0.0030	795	10 inch	0.013	Vitrified Clay Pipe	Circular	776,389.00	707,972	1,435,852	-659,463	-727,881	4.07	12.86	7.08	160	487.3
G_N1460	G_1685	726.28	G_1690	721.73	0.0020	2275	12 inch	0.013	Vitrified Clay Pipe	Circular	1,029,743.00	939,000	2,904,682	-1,874,939	-1,965,682	5.72	36.73	5.08	160	163.4

Appendix O
Existing JCSD Sewer System with Flows From Projected Ultimate Land Use
By Tributary Drainage Area

Label	Upstream Node	Upstream Invert Elevation (ft)	Downstream Node	Downstream Invert Elevation (ft)	Constructed Slope (ft/ft)	Length (ft)	Section Size	Mannings n	Material	Section Shape	Full Capacity (gpd)	Design Capacity (gpd)	Total Flow (gpd)	Excess Full Capacity (gpd)	Excess Design Capacity (gpd)	Average Velocity (ft/s)	Depth In (ft)	Depth Out (ft)	Infiltration Unit Load Flow per Unit (gpd)	Infiltration Unit Load Count
G_N1641	G_1711	719.04	G_2019	716.81	0.0016	1395	15 inch	0.013	Vitrified Clay Pipe	Circular	1,669,190.00	1,522,097	2,995,834	-1,326,644	-1,473,737	3.78	9.53	4.58	160	569.7
G_N1643	G_2019	716.81	G_2022	713.79	0.0036	837	15 inch	0.013	Vitrified Clay Pipe	Circular	2,507,733.00	2,286,746	4,938,404	-2,430,671	-2,651,658	6.23	12.77	4.08		
G_N1644	G_2022	713.79	G_2023A	705.62	0.0171	478	15 inch	0.013	Vitrified Clay Pipe	Circular	5,458,051.00	4,977,075	4,938,404	519,647	38,671	6.23	9.43	10.91		
H_N4082	H_4175	804.50	H_4177	802.90	0.0024	665	12 inch	0.013	Vitrified Clay Pipe	Circular	1,129,440.00	1,029,911	638,961	490,478	390,950	2.29	0.54	0.54	100	100
H_N4086	H_4177	802.90	H_4181	792.10	0.0080	1350	12 inch	0.013	Vitrified Clay Pipe	Circular	2,059,486.00	1,877,999	649,881	1,409,605	1,228,118	3.60	0.39	0.39	100	109.2
H_N4087	H_4181	792.10	H_4182	788.12	0.0135	295	12 inch	0.013	Vitrified Clay Pipe	Circular	2,674,511.00	2,438,827	649,881	2,024,630	1,788,946	3.79	0.34	0.42		
H_N4089	H_4182	788.12	H_7012	783.89	0.0060	706	12 inch	0.013	Vitrified Clay Pipe	Circular	1,782,304.00	1,625,243	649,881	1,132,422	975,362	3.24	0.42	0.42		
H_N4091	H_7012	783.89	H_7011	775.49	0.0080	1050	12 inch	0.013	Vitrified Clay Pipe	Circular	2,059,486.00	1,877,999	649,881	1,409,605	1,228,118	3.60	0.39	0.39		
H_N4092	H_7011	775.49	H_7010	768.26	0.0250	289	12 inch	0.013	Vitrified Clay Pipe	Circular	3,641,951.00	3,321,014	649,881	2,992,070	2,671,132	4.66	0.29	0.36		
H_N4098	H_7010	768.26	H_7009	755.46	0.0100	1280	12 inch	0.013	Vitrified Clay Pipe	Circular	2,302,575.00	2,099,667	649,881	1,652,694	1,449,786	3.90	0.36	0.36		
H_N4099	H_7009	755.46	H_7008	749.06	0.0160	400	12 inch	0.013	Vitrified Clay Pipe	Circular	2,912,553.00	2,655,892	649,881	2,262,672	2,006,011	3.93	0.32	0.42		
H_N4100	H_7008	749.06	H_7007	746.66	0.0060	400	12 inch	0.013	Vitrified Clay Pipe	Circular	1,783,567.00	1,626,395	649,881	1,133,686	976,514	3.24	0.42	0.42		
H_N4101	H_7007	746.66	H_7006	744.26	0.0060	400	15 inch	0.013	Vitrified Clay Pipe	Circular	3,233,822.00	2,948,850	649,881	2,583,941	2,298,969	3.19	0.38	0.38		
H_N4103	H_7006	744.26	H_7005	737.86	0.0080	800	15 inch	0.013	Vitrified Clay Pipe	Circular	3,734,096.00	3,405,039	649,881	3,084,215	2,755,158	2.31	0.35	0.88		
H_N4111	H_7005	737.86	H_7004	705.56	0.0100	3230	15 inch	0.013	Vitrified Clay Pipe	Circular	4,174,847.00	3,806,950	3,512,476	662,371	294,473	5.90	0.88	0.88	100	672.4
H_N4113	H_7004	705.56	H_7003	699.16	0.0080	800	18 inch	0.013	Vitrified Clay Pipe	Circular	6,072,052.00	5,536,969	3,512,476	2,559,576	2,024,493	5.12	0.82	0.93		
H_N4114	H_7003	699.16	H_7002	697.00	0.0054	400	18 inch	0.013	Vitrified Clay Pipe	Circular	4,988,700.00	4,549,084	3,512,476	1,476,224	1,036,608	4.36	0.93	1.08		
H_N4119	H_7002	697.00	H_7001	693.24	0.0024	1564	21 inch	0.013	Vitrified Clay Pipe	Circular	5,021,007.00	4,578,544	3,512,476	1,508,531	1,066,068	3.49	1.08	1.08		
H_N4120	H_7001	693.24	H_SARI_CONNE	693.00	0.0024	100	21 inch	0.013	Vitrified Clay Pipe	Circular	5,016,732.00	4,574,646	3,512,476	1,504,256	1,062,170	3.49	1.08	1.08		
I_2362	I_3225	716.02	I_3232	707.81	0.0060	1368	15 inch	0.013	Vitrified Clay Pipe	Circular	3,234,216.00	2,949,210	1,491,771	1,742,445	1,457,438	4.00	0.60	0.60		
I_E2040	I_3191	686.21	P_3176	679.05	0.0162	442	15 inch	0.013	Vitrified Clay Pipe	Circular	5,313,564.00	4,845,320	1,491,771	3,821,792	3,353,549	1.88	2.40	9.00		
I_E2041	I_3172	689.97	I_3191	686.21	0.0040	940	15 inch	0.013	Vitrified Clay Pipe	Circular	2,640,405.00	2,407,726	1,491,771	1,148,633	915,955	2.66	0.67	2.40		
I_E2049	I_3226	717.63	I_3225	716.02	0.0072	223	12 inch	0.013	Vitrified Clay Pipe	Circular	1,956,475.00	1,784,066	1,491,771	464,704	292,295	4.24	0.65	0.65		
I_E2050	I_3227	729.51	I_3226	717.63	0.0264	450	12 inch	0.013	Vitrified Clay Pipe	Circular	3,741,242.00	3,411,555	1,491,771	2,249,470	1,919,784	5.60	0.44	0.65		
I_E2051	I_3248	735.81	I_3227	729.51	0.0140	450	12 inch	0.013	Vitrified Clay Pipe	Circular	2,724,444.00	2,484,359	1,491,771	1,232,672	992,588	5.49	0.53	0.53		
I_E2052	I_3249	742.11	I_3248	735.81	0.0140	450	12 inch	0.013	Vitrified Clay Pipe	Circular	2,724,444.00	2,484,359	1,491,771	1,232,672	992,588	5.49	0.53	0.53		
I_E2056	I_3242	695.01	I_3169	692.56	0.0040	612	15 inch	0.013	Vitrified Clay Pipe	Circular	2,641,483.00	2,408,710	1,491,771	1,149,712	916,938	3.43	0.67	0.67		
I_E2058	I_3243	702.36	I_3242	695.01	0.0209	352	15 inch	0.013	Vitrified Clay Pipe	Circular	6,032,716.00	5,501,099	1,491,771	4,540,944	4,009,327	4.87	0.42	0.67		
I_E2059	I_3232	707.81	I_3243	702.36	0.0158	345	15 inch	0.013	Vitrified Clay Pipe	Circular	5,247,220.00	4,784,822	1,491,771	3,755,448	3,293,051	5.70	0.46	0.46		
I_E2069	I_3258	765.71	I_3254	757.52	0.0060	1365	12 inch	0.013	Vitrified Clay Pipe	Circular	1,783,567.00	1,626,395	1,491,771	291,796	134,624	3.93	0.70	0.70		
I_E2094	I_1787	766.45	I_3259	766.10	0.0060	58	12 inch	0.013	Vitrified Clay Pipe	Circular	1,788,685.00	1,631,062	1,491,771	296,913	139,290	3.72	0.70	0.78		
I_E2219	I_3516	752.63	I_3515	748.24	0.0172	255	12 inch	0.013	Vitrified Clay Pipe	Circular	3,021,176.00	2,754,943	1,491,771	1,529,404	1,263,171	4.93	0.50	0.70		
I_N2046	I_3169	692.56	I_3172	689.97	0.0040	647	15 inch	0.013	Vitrified Clay Pipe	Circular	2,641,425.00	2,408,656	1,491,771	1,149,653	916,885	3.43	0.67	0.67		
I_N2371	I_3259	766.10	I_3258	765.71	0.0046	85	12 inch	0.013	Vitrified Clay Pipe	Circular	1,559,684.00	1,422,241	1,491,771	67,913	-69,530	3.50	0.78	0.78		
I_N2399	I_17B	766.89	I_1787	766.45	0.0032	136	8 inch	0.013	Vitrified Clay Pipe	Circular	444,216.00	222,108	431,244	12,971	-209,137	1.91	0.67	0.70	160	200
I_N2523	I_3512	744.02	I_3249	742.11	0.0072	265	12 inch	0.013	Vitrified Clay Pipe	Circular	1,954,824.00	1,782,560	1,491,771	463,052	290,789	4.24	0.65	0.65		
I_N2524	I_3513	747.39	I_3512	744.02	0.0072	468	12 inch	0.013	Vitrified Clay Pipe	Circular	1,953,916.00	1,781,732	1,491,771	462,144	289,961	4.24	0.65	0.65		
I_N2527	I_3515	748.24	I_3513	747.39	0.0059	143	12 inch	0.013	Vitrified Clay Pipe	Circular	1,775,233.00	1,618,795	1,491,771	283,461	127,024	3.92	0.70	0.70		
I_N2528	I_3254	757.52	I_3516	752.63	0.0234	209	12 inch	0.013	Vitrified Clay Pipe	Circular	3,522,047.00	3,211,676	1,491,771	2,030,275	1,719,904	6.29	0.45	0.50		
I_WRF	I_3314	769.79	I_1787	766.45	0.0058	580	12 inch	0.013	Vitrified Clay Pipe	Circular	1,747,322.00	1,593,344	1,133,131	614,191	460,213	3.33	0.59	0.70	160	764
J_E1242	J_1537	884.97	J_1919	879.22	0.0050	1150	10 inch	0.013	Vitrified Clay Pipe	Circular	1,001,265.00	913,031	1,349,471	-348,207	-436,440	3.83	7.49	2.79		
J_E1245	J_1552	886.64	J_1537	884.97	0.0016	1050	10 inch	0.013	Vitrified Clay Pipe	Circular	564,713.00	514,949	1,349,471	-784,759	-834,522	3.83	14.87	7.00		
J_E1392	J_1849	794.15	J_1848	788.60	0.0194	286	15 inch	0.013	Vitrified Clay Pipe	Circular	5,815,727.00	5,303,232	3,193,912	2,621,815	2,109,320	6.35	0.66	0.90		
J_E1393	J_1850	802.82	J_1849	794.15	0.0278	312	15 inch	0.013	Vitrified Clay Pipe	Circular	6,959,416.00	6,346,136	3,193,912	3,765,504	3,152,224	8.05	0.59	0.66		
J_E1394	J_1851	812.19	J_1850	802.82	0.0278	337	15 inch	0.013	Vitrified Clay Pipe	Circular	6,961,381.00	6,347,928	3,193,912	3,767,469	3,154,016	8.59	0.59	0.59		
J_E1395	J_1852	822.13	J_1851	812.19	0.0174	571	15 inch	0.013	Vitrified Clay Pipe	Circular	5,508,276.00	5,022,874	3,193,912	2,314,364	1,828,962	7.20	0.68	0.68	160	381.7
J_E1396	J_1853	832.11	J_1852	822.13	0.0137	729	15 inch	0.013	Vitrified Clay Pipe	Circular	4,884,747.00	4,454,291	2,298,138	2,586,608	2,156,153	5.62	0.60	0.68		

Appendix O
Existing JCSD Sewer System with Flows From Projected Ultimate Land Use
By Tributary Drainage Area

Label	Upstream Node	Upstream Invert Elevation (ft)	Downstream Node	Downstream Invert Elevation (ft)	Constructed Slope (ft/ft)	Length (ft)	Section Size	Mannings n	Material	Section Shape	Full Capacity (gpd)	Design Capacity (gpd)	Total Flow (gpd)	Excess Full Capacity (gpd)	Excess Design Capacity (gpd)	Average Velocity (ft/s)	Depth In (ft)	Depth Out (ft)	Infiltration Unit Load Flow per Unit (gpd)	Infiltration Unit Load Count
J_E1397	J_1854	836.80	J_1853	832.11	0.0077	608	15 inch	0.013	Vitrified Clay Pipe	Circular	3,666,698.00	3,343,580	2,298,138	1,368,560	1,045,442	4.88	0.72	0.72		
J_E1410	J_1870	838.50	J_1854	836.80	0.0030	566	15 inch	0.013	Vitrified Clay Pipe	Circular	2,288,004.00	2,086,380	2,298,138	-10,134	-211,759	3.34	1.02	1.01		
J_E1411	J_1872	847.24	J_1870	838.50	0.0122	716	15 inch	0.013	Vitrified Clay Pipe	Circular	4,612,536.00	4,206,068	2,298,138	2,314,397	1,907,930	4.56	0.62	1.02	160	161.3
J_E1413	J_1873	850.07	J_1872	847.24	0.0152	186	15 inch	0.013	Vitrified Clay Pipe	Circular	5,149,645.00	4,695,846	2,063,068	3,086,577	2,632,778	5.67	0.55	0.62		
J_E1414	J_1874	852.26	J_1873	850.07	0.0094	233	15 inch	0.013	Vitrified Clay Pipe	Circular	4,047,479.00	3,690,806	2,063,068	1,984,411	1,627,738	5.13	0.63	0.63		
J_E1423	J_1887	863.17	J_1886	853.21	0.0236	422	10 inch	0.013	Vitrified Clay Pipe	Circular	2,175,391.00	1,983,690	1,397,471	777,920	586,219	6.04	0.49	0.56	160	100
J_E1424	J_1888	867.66	J_1887	863.17	0.0093	483	10 inch	0.013	Vitrified Clay Pipe	Circular	1,365,254.00	1,244,945	1,381,471	-16,217	-136,527	4.04	0.85	0.74	160	100
J_E1425	J_1917	872.15	J_1888	867.66	0.0108	416	10 inch	0.013	Vitrified Clay Pipe	Circular	1,471,094.00	1,341,458	1,365,471	105,623	-24,014	4.31	0.63	0.85	160	100
J_E1444	J_1918	878.30	J_1917	872.15	0.0277	222	10 inch	0.013	Vitrified Clay Pipe	Circular	2,357,023.00	2,149,316	1,349,471	1,007,551	799,845	5.80	0.45	0.63		
J_E1445	J_1919	879.22	J_1918	878.30	0.0028	327	10 inch	0.013	Vitrified Clay Pipe	Circular	750,627.00	684,480	1,349,471	-598,844	-664,991	3.95	2.79	0.74		
J_E1492	J_2069	704.53	J_2024	700.82	0.0038	975	15 inch	0.013	Vitrified Clay Pipe	Circular	2,575,284.00	2,348,344	6,985,877	-4,410,592	-4,637,532	8.81	36.59	13.00		
J_E1516	J_2070	705.95	J_2069	704.53	0.0092	155	15 inch	0.013	Vitrified Clay Pipe	Circular	3,995,939.00	3,643,808	6,985,877	-2,989,938	-3,342,069	8.81	9.92	7.00	160	283.4
J_E1517	J_2071	710.05	J_2070	705.95	0.0092	445	15 inch	0.013	Vitrified Clay Pipe	Circular	4,007,306.00	3,654,172	6,375,708	-2,368,403	-2,721,536	8.04	13.28	7.00		
J_E1518	J_2072	717.97	J_2071	710.05	0.0136	583	15 inch	0.013	Vitrified Clay Pipe	Circular	4,865,963.00	4,437,164	6,375,708	-1,509,745	-1,938,545	8.04	11.68	6.00		
J_E1519	J_2074	730.18	J_2072	717.97	0.0089	1372	15 inch	0.013	Vitrified Clay Pipe	Circular	3,938,413.00	3,591,351	6,375,708	-2,437,295	-2,784,357	8.04	25.79	6.00	160	427.4
J_E1530	J_001	730.87	J_2074	730.18	0.0020	344	15 inch	0.013	Vitrified Clay Pipe	Circular	1,869,760.00	1,704,992	5,399,832	-3,530,072	-3,694,840	6.81	13.06	8.00		
J_E1531	J_002	731.07	J_001	730.87	0.0056	36	15 inch	0.013	Vitrified Clay Pipe	Circular	3,111,747.00	2,837,533	5,399,832	-2,288,085	-2,562,300	6.81	7.53	7.13		
J_E1532	J_003	733.80	J_002	731.07	0.0087	314	15 inch	0.013	Vitrified Clay Pipe	Circular	3,892,755.00	3,549,716	5,399,832	-1,507,078	-1,850,116	6.81	10.06	7.53		
J_E1533	J_2098	738.58	J_003	733.80	0.0124	385	15 inch	0.013	Vitrified Clay Pipe	Circular	4,651,833.00	4,241,903	5,399,832	-747,999	-1,157,929	6.81	9.66	8.00		
J_E1534	J_2090	742.17	J_2098	738.58	0.0124	290	15 inch	0.013	Vitrified Clay Pipe	Circular	4,645,033.00	4,235,701	5,399,832	-754,800	-1,164,131	6.81	7.26	6.00		
J_E1535	J_2091	748.19	J_2090	742.17	0.0086	700	15 inch	0.013	Vitrified Clay Pipe	Circular	3,871,594.00	3,530,420	5,399,832	-1,528,239	-1,869,412	6.81	12.19	6.50		
J_E1536	J_2092	757.67	J_2091	748.19	0.0141	672	15 inch	0.013	Vitrified Clay Pipe	Circular	4,958,611.00	4,521,647	5,399,832	-441,221	-878,185	6.81	8.76	7.00	160	497.1
J_E1579	J_2150	767.14	J_2092	757.67	0.0135	702	15 inch	0.013	Vitrified Clay Pipe	Circular	4,848,942.00	4,421,642	4,628,483	220,459	-206,841	5.84	5.16	6.00		
J_E1580	J_2149	770.16	J_2150	767.14	0.0045	670	15 inch	0.013	Vitrified Clay Pipe	Circular	2,802,894.00	2,555,896	4,628,483	-1,825,590	-2,072,587	5.84	10.37	5.16	160	516.9
J_E1581	J_2151	783.69	J_2149	770.16	0.0224	604	15 inch	0.013	Vitrified Clay Pipe	Circular	6,248,431.00	5,697,805	3,193,912	3,054,519	2,503,893	5.97	0.63	8.00		
J_E1582	J_1848	788.60	J_2151	783.69	0.0077	638	15 inch	0.013	Vitrified Clay Pipe	Circular	3,662,444.00	3,339,701	3,193,912	468,532	145,789	5.20	0.90	0.90		
J_E1705	J_2460	688.66	J_2459	686.34	0.0080	290	21 inch	0.013	Vitrified Clay Pipe	Circular	9,159,258.00	8,352,123	12,894,937	-3,735,679	-4,542,814	8.29	10.28	8.00		
J_E1846	J_2774	666.16	J_2767	663.13	0.0100	302	21 inch	0.013	Vitrified Clay Pipe	Circular	10,255,948.00	9,352,170	16,170,068	-5,914,120	-6,817,898	10.40	15.50	11.00		
J_E1847	J_2792	676.51	J_2777	670.56	0.0318	187	21 inch	0.013	Vitrified Clay Pipe	Circular	18,266,400.00	16,656,723	16,170,068	2,096,332	486,655	10.40	5.71	7.00		
J_E1857	J_2799	679.45	J_2794	678.93	0.0016	322	21 inch	0.013	Vitrified Clay Pipe	Circular	4,099,324.00	3,738,082	12,894,937	-8,795,613	-9,156,855	8.29	13.59	9.00		
J_E1858	J_2813	683.36	J_2799	679.45	0.0085	460	21 inch	0.013	Vitrified Clay Pipe	Circular	9,441,147.00	8,609,171	12,894,937	-3,453,790	-4,285,766	8.29	8.38	5.00		
J_E1971	J_3078	637.86	REGIONAL P.S.	636.67	0.0022	539	21 inch	0.013	Vitrified Clay Pipe	Circular	4,811,654.00	4,387,640	19,209,554	-14,397,900	-14,821,914	12.37	19.51	1.73		
J_E1973	J_3081	639.22	J_3078	637.86	0.0022	617	21 inch	0.013	Vitrified Clay Pipe	Circular	4,807,753.00	4,384,083	16,915,906	-12,108,153	-12,531,823	10.88	29.18	13.70		
J_E2006	J_3139	646.43	J_3138	645.88	0.0038	145	21 inch	0.013	Vitrified Clay Pipe	Circular	6,312,583.00	5,756,303	16,509,391	-10,196,809	-10,753,088	10.62	14.22	11.00		
J_E2007	J_3141	650.52	J_3139	646.43	0.0109	375	21 inch	0.013	Vitrified Clay Pipe	Circular	10,691,251.00	9,749,114	16,509,391	-5,818,140	-6,760,278	10.62	14.66	9.00	160	230
J_N1081	J_1142	959.10	J_1141	951.33	0.0250	311	8 inch	0.013	Vitrified Clay Pipe	Circular	1,234,663.00	617,332	492,867	741,796	124,464	5.16	0.29	0.29		
J_N1082	J_1143	969.12	J_1142	959.10	0.0318	315	8 inch	0.013	Vitrified Clay Pipe	Circular	1,392,824.00	696,412	492,867	899,957	203,545	5.40	0.27	0.29		
J_N1083	J_1144	976.46	J_1143	969.12	0.0233	315	8 inch	0.013	Vitrified Clay Pipe	Circular	1,192,107.00	596,053	492,867	699,239	103,186	5.03	0.30	0.30		
J_N1085	J_1146	978.94	J_1144	976.46	0.0040	621	8 inch	0.013	Vitrified Clay Pipe	Circular	493,932.00	246,966	492,867	1,065	-245,901	2.50	0.55	0.55	160	222.9
J_N1191	J_1141	951.33	J_1311	923.21	0.0296	950	8 inch	0.013	Vitrified Clay Pipe	Circular	1,343,640.00	671,820	492,867	850,773	178,953	3.84	0.28	5.41		
J_N1192	J_1311	923.21	J_1310	920.16	0.0058	525	8 inch	0.013	Vitrified Clay Pipe	Circular	594,773.00	297,386	492,867	101,906	-195,481	2.18	5.41	6.36		
J_N1193	J_1310	920.16	J_1308	917.45	0.0045	603	8 inch	0.013	Vitrified Clay Pipe	Circular	523,894.00	261,947	492,867	31,027	-230,920	2.18	6.36	6.67		
J_N1194	J_1308	917.45	J_1309	912.51	0.0071	696	8 inch	0.013	Vitrified Clay Pipe	Circular	658,061.00	329,031	930,433	-272,372	-601,402	4.12	11.60	6.66	160	222.9
J_N1196	J_1309	912.51	J_1335	905.26	0.0106	684	8 inch	0.013	Vitrified Clay Pipe	Circular	804,063.00	402,031	930,433	-126,370	-528,402	4.12	9.69	7.23		
J_N1371	J_1564	896.55	J_1553	887.03	0.0140	680	8 inch	0.013	Vitrified Clay Pipe	Circular	924,062.00	462,031	930,433	-6,371	-468,402	4.12	6.13	6.00		
J_N1372	J_1553	887.03	J_1552	886.64	0.0016	240	10 inch	0.013	Vitrified Clay Pipe	Circular	570,809.00	520,508	1,349,471	-778,663	-828,964	3.83	13.79	12.00	160	222.9
J_N1406	J_1335	905.26	J_1564	896.55	0.0126	691	8 inch	0.013	Vitrified Clay Pipe	Circular	876,642.00	438,321	930,433	-53,791	-492,112	4.12	7.23	6.13		

Appendix O
Existing JCSD Sewer System with Flows From Projected Ultimate Land Use
By Tributary Drainage Area

Label	Upstream Node	Upstream Invert Elevation (ft)	Downstream Node	Downstream Invert Elevation (ft)	Constructed Slope (ft/ft)	Length (ft)	Section Size	Mannings n	Material	Section Shape	Full Capacity (gpd)	Design Capacity (gpd)	Total Flow (gpd)	Excess Full Capacity (gpd)	Excess Design Capacity (gpd)	Average Velocity (ft/s)	Depth In (ft)	Depth Out (ft)	Infiltration Unit Load Flow per Unit (gpd)	Infiltration Unit Load Count
J_N1564	J_1886	0.00	J_1874	852.26	-3.9456	216	15 inch	0.013	Vitrified Clay Pipe	Circular	-82,927,717.00	-75,619,935	2,063,068	-84,990,785	-77,683,003	2.84	853.77	0.98	160	40.3
J_N1657	J_2024	700.82	J_2465	698.42	0.0030	798	21 inch	0.013	Vitrified Clay Pipe	Circular	5,615,901.00	5,121,015	12,020,486	-6,404,585	-6,899,471	7.73	16.60	8.00		
J_N1901	J_2463	691.95	J_2462	691.48	0.0022	212	21 inch	0.013	Vitrified Clay Pipe	Circular	4,821,657.00	4,396,761	12,020,486	-7,198,830	-7,623,725	7.73	17.64	15.19		
J_N1907	J_2461	691.02	J_2460	688.66	0.0056	421	21 inch	0.013	Vitrified Clay Pipe	Circular	7,667,084.00	6,991,443	12,894,937	-5,227,853	-5,903,494	8.29	12.32	8.00		
J_N1908	J_2462	691.48	J_2461	691.02	0.0022	210	21 inch	0.013	Vitrified Clay Pipe	Circular	4,792,748.00	4,370,400	12,894,937	-8,102,189	-8,524,537	8.29	15.19	12.32	160	520.5
J_N1910	J_2464	693.32	J_2463	691.95	0.0022	623	21 inch	0.013	Vitrified Clay Pipe	Circular	4,802,104.00	4,378,931	12,020,486	-7,218,382	-7,641,555	7.73	23.21	16.00		
J_N1911	J_2465	698.42	J_2464	693.32	0.0077	663	21 inch	0.013	Vitrified Clay Pipe	Circular	8,981,391.00	8,189,930	12,020,486	-3,039,095	-3,830,556	7.73	13.04	9.00		
J_N2010	J_3143	654.16	J_3141	650.52	0.0109	334	21 inch	0.013	Vitrified Clay Pipe	Circular	10,693,747.00	9,751,390	16,170,068	-5,476,321	-6,418,679	10.40	16.69	12.00		
J_N2090	J_2767	663.13	J_3159	659.12	0.0078	514	21 inch	0.013	Vitrified Clay Pipe	Circular	9,044,945.00	8,247,883	16,170,068	-7,125,123	-7,922,185	10.40	19.98	11.17		
J_N2091	J_2777	670.56	J_2774	666.16	0.0055	800	21 inch	0.013	Vitrified Clay Pipe	Circular	7,591,003.00	6,922,066	16,170,068	-8,579,065	-9,248,002	10.40	23.55	8.00		
J_N2107	J_2793	678.13	J_2792	676.51	0.0041	395	21 inch	0.013	Vitrified Clay Pipe	Circular	6,549,942.00	5,972,746	13,246,341	-6,696,399	-7,273,595	8.52	10.71	5.71	160	275.3
J_N2108	J_2794	678.93	J_2793	678.13	0.0016	505	21 inch	0.013	Vitrified Clay Pipe	Circular	4,096,145.00	3,735,183	12,894,937	-8,798,792	-9,159,754	8.29	17.91	10.71		
J_N2119	J_2459	686.34	J_2813	683.36	0.0066	452	21 inch	0.013	Vitrified Clay Pipe	Circular	8,314,846.00	7,582,123	12,894,937	-4,580,091	-5,312,814	8.29	12.19	8.00		
J_N2284	J_3082	640.43	J_3081	639.22	0.0022	548	21 inch	0.013	Vitrified Clay Pipe	Circular	4,803,155.00	4,379,890	16,915,906	-12,112,751	-12,536,016	10.88	22.75	9.00		
J_N2285	J_3083	642.60	J_3082	640.43	0.0022	990	21 inch	0.013	Vitrified Clay Pipe	Circular	4,803,155.00	4,379,890	16,915,906	-12,112,751	-12,536,016	10.88	31.84	7.00	160	338.2
J_N2286	J_3138	645.88	J_3083	642.60	0.0038	862	21 inch	0.013	Vitrified Clay Pipe	Circular	6,312,583.00	5,756,303	16,509,391	-10,196,809	-10,753,088	10.62	28.13	9.00		
J_N2315	J_3145	657.67	J_3143	654.16	0.0028	1255	21 inch	0.013	Vitrified Clay Pipe	Circular	5,417,379.00	4,939,987	16,170,068	-10,752,689	-11,230,081	10.40	37.78	10.00		
J_N2317	J_3159	659.12	J_3145	657.67	0.0581	25	21 inch	0.013	Vitrified Clay Pipe	Circular	24,683,308.00	22,508,158	16,170,068	8,513,240	6,338,090	10.40	11.17	12.00		
P_E2024	P_3162	682.77	P_3163	682.21	0.0016	350	12 inch	0.013	Vitrified Clay Pipe	Circular	921,030.00	839,867	1,240,009	-318,978	-400,142	2.44	8.46	8.00		
P_E2065	P_3251	755.45	P_3228	728.45	0.0450	600	8 inch	0.013	Vitrified Clay Pipe	Circular	1,656,698.00	828,349	71,087	1,585,612	757,263	2.90	0.09	0.14		
P_E2067	P_3253	772.31	P_3251	755.45	0.0273	618	8 inch	0.013	Vitrified Clay Pipe	Circular	1,289,946.00	644,973	71,087	1,218,860	573,887	3.07	0.11	0.11	160	61
P_E2182	P_3451	689.65	P_3449	686.69	0.0090	329	8 inch	0.013	Vitrified Clay Pipe	Circular	740,773.00	370,386	1,240,009	-499,236	-869,622	5.50	12.68	7.35		
P_E2184	P_3453	690.97	P_3451	689.65	0.0020	660	8 inch	0.013	Vitrified Clay Pipe	Circular	349,263.00	174,631	1,240,009	-890,746	-1,065,377	5.50	26.32	11.00		
P_E2186	P_3471	693.74	P_3453	690.97	0.0028	989	8 inch	0.013	Vitrified Clay Pipe	Circular	413,313.00	206,656	1,240,009	-826,696	-1,033,352	5.50	29.16	7.00		
P_E2202	P_3228	728.45	P_3224	719.08	0.0100	940	8 inch	0.013	Vitrified Clay Pipe	Circular	779,728.00	389,864	71,087	708,641	318,777	2.03	0.14	0.15		
P_E2206	P_3473	701.17	P_3471	693.74	0.0203	366	8 inch	0.013	Vitrified Clay Pipe	Circular	1,112,733.00	556,367	1,240,009	-127,275	-683,642	5.50	12.79	10.99		
P_E2208	P_3477	704.10	P_3474	701.51	0.0038	681	8 inch	0.013	Vitrified Clay Pipe	Circular	481,630.00	240,815	1,240,009	-758,379	-999,194	5.50	20.58	6.00	160	275.2
P_E2211	P_3483	705.74	P_3477	704.10	0.0040	411	8 inch	0.013	Vitrified Clay Pipe	Circular	493,331.00	246,665	71,087	422,244	175,579	0.32	7.39	9.00		
P_N2106	P_2790	677.99	J_2792	676.51	0.0016	925	12 inch	0.013	Vitrified Clay Pipe	Circular	921,030.00	839,867	3,610,603	-2,689,573	-2,770,736	7.11	26.98	5.71	160	216
P_N2340	P_3163	682.21	P_3173	681.16	0.0016	660	12 inch	0.013	Vitrified Clay Pipe	Circular	918,410.00	837,477	1,932,873	-1,014,463	-1,095,395	3.81	15.60	12.00	160	475.8
P_N2342	P_3173	681.16	P_3176	679.05	0.0016	1320	12 inch	0.013	Vitrified Clay Pipe	Circular	920,594.00	839,469	1,932,873	-1,012,279	-1,093,404	3.81	16.19	9.00		
P_N2343	P_3176	679.05	P_2790	677.99	0.0016	660	12 inch	0.013	Vitrified Clay Pipe	Circular	922,773.00	841,456	3,237,931	-2,315,158	-2,396,475	6.38	29.99	18.00		
P_N2473	P_3449	686.69	P_3162	682.77	0.0057	687	10 inch	0.013	Vitrified Clay Pipe	Circular	1,069,618.00	975,360	1,240,009	-170,391	-264,648	3.52	7.35	6.00		
P_N2489	P_3474	701.51	P_3473	701.17	0.0028	122	8 inch	0.013	Vitrified Clay Pipe	Circular	412,284.00	206,142	1,240,009	-827,724	-1,033,866	5.50	8.74	6.00		
P_N2498	P_3224	719.08	P_3482	715.22	0.0072	537	8 inch	0.013	Vitrified Clay Pipe	Circular	662,131.00	331,065	71,087	591,044	259,979	1.92	0.15	0.15		
P_N2499	P_3482	715.22	P_3483	705.74	0.0600	158	8 inch	0.013	Vitrified Clay Pipe	Circular	1,912,990.00	956,495	71,087	1,841,904	885,409	2.18	0.09	7.39		
W_N4162	W_4283	743.02	W_4292	740.02	0.0040	749	15 inch	0.012	Vitrified Clay Pipe	Circular	2,862,347.00	2,610,111	1,581,751	1,280,596	1,028,359	3.58	0.66	0.70	100	200
W_N4163	W_4292	740.02	W_4294	738.67	0.0040	337	15 inch	0.013	Vitrified Clay Pipe	Circular	2,642,363.00	2,409,512	1,591,751	1,050,611	817,760	3.49	0.70	0.70	100	100
W_N4165	W_4294	738.67	W_4295	733.92	0.0060	792	15 inch	0.013	Vitrified Clay Pipe	Circular	3,233,142.00	2,948,230	1,611,751	1,621,390	1,336,478	4.07	0.62	0.62	100	200
W_N4166	W_4295	733.92	W_7296	730.56	0.0084	400	15 inch	0.013	Vitrified Clay Pipe	Circular	3,826,310.00	3,489,127	1,621,751	2,204,559	1,867,375	4.62	0.57	0.57	100	100
W_N4167	W_7296	730.56	W_4305	722.40	0.0204	400	15 inch	0.013	Vitrified Clay Pipe	Circular	5,962,874.00	5,437,412	1,631,751	4,331,122	3,805,660	4.5	0.45	0.93	100	100
W_N4175	W_4305	722.40	W_4317	708.01	0.0088	1636	18 inch	0.013	Vitrified Clay Pipe	Circular	6,366,918.00	5,805,851	4,460,814	1,906,104	1,345,036	6.03	0.93	0.93	100	300
W_N4176	W_4317	708.01	W_4318	704.50	0.0088	400	24 inch	0.013	Vitrified Clay Pipe	Circular	13,695,694.00	12,488,798	4,470,814	9,224,880	8,017,984	4.54	0.79	1.36	100	100
W_N4181	W_4318	704.50	W_4323	700.08	0.0024	1837	24 inch	0.013	Vitrified Clay Pipe	Circular	7,171,616.00	6,539,637	5,768,739	1,402,878	770,898	3.93	1.36	1.36	100	100
W_N4182	W_4323	700.08	W_SARI_CONNE	700.00	0.0024	33	24 inch	0.013	Vitrified Clay Pipe	Circular	7,198,608.00	6,564,250	5,768,739	1,429,869	795,511	3.94	1.35	1.35		

Appendix O
Existing JCSD Sewer System with Flows From Projected Ultimate Land Use
By Tributary Drainage Area

Label	Design Capacity Failure	Length (ft) Design Capacity Failure	Full Flow Failure	Length (ft) Full Flow Failure	8-inch Full Flow Failure	10-inch Full Flow Failure	12-inch Full Flow Failure	15-inch Full Flow Failure	18-inch Full Flow Failure	21-inch Full Flow Failure	24-inch Full Flow Failure	8-inch Design Cap. Failure	10-inch Design Cap. Failure	12-inch Design Cap. Failure	15-inch Design Cap. Failure	18-inch Design Cap. Failure	21-inch Design Cap. Failure	24-inch Design Cap. Failure	8-inch Totals	10-inch Totals	12-inch Totals	15-inch Totals	18-inch Totals	21-inch Totals	24-inch Totals
B_65-39B																							2957		
B_E1459																							672		
B_E1628																							300		
B_E1638																							291		
B_E1680																							369		
B_E3269																							230		
B_N1223																						350			
B_N1225																						713			
B_N1235																						1774			
B_N1844																							997.5		
B_N1847																							457		
B_N1849																							1211		
B_N1855																							335		
B_N2041																							660		
B_N2042																							659		
B_N2043																							177		
B_N2044																							148		
B_N2045																							325		
B_N2277																							648		
B_N2278																							285		
B_N2279																							324		
B_N2280																							654		
B_N2281																							665		
B_N2282																							660		
B_N4334																							2230		
E_E3360																								134	
E_N1212																								1806	
E_N1426																								1964	
E_N1427																								376	
E_N1428																								335	
E_N1598																								1013	
E_N4436																									759.5
G_97-0261																						61			
G_E1119			8 inch	604	604														604						
G_E1120																			484						
G_E1175			8 inch	250	250														250						
G_E1178			8 inch	221	221														221						
G_E1283			8 inch	102	102														102						
G_E1291			10 inch	165		165														165					
G_E1307			12 inch	1684			1684														1684				
G_E1490			15 inch	583				583														583			
G_N1177			10 inch	379		379														379					
G_N1266			8 inch	655	655														655						
G_N1268			8 inch	1318	1318														1318						
G_N1269			8 inch	686	686														686						
G_N1458			10 inch	795		795														795					
G_N1460			12 inch	2275			2275														2275				

Appendix O
Existing JCSD Sewer System with Flows From Projected Ultimate Land Use
By Tributary Drainage Area

Label	Design Capacity Failure	Length (ft) Design Capacity Failure	Full Flow Failure	Length (ft) Full Flow Failure	8-inch Full Flow Failure	10-inch Full Flow Failure	12-inch Full Flow Failure	15-inch Full Flow Failure	18-inch Full Flow Failure	21-inch Full Flow Failure	24-inch Full Flow Failure	8-inch Design Cap. Failure	10-inch Design Cap. Failure	12-inch Design Cap. Failure	15-inch Design Cap. Failure	18-inch Design Cap. Failure	21-inch Design Cap. Failure	24-inch Design Cap. Failure	8-inch Totals	10-inch Totals	12-inch Totals	15-inch Totals	18-inch Totals	21-inch Totals	24-inch Totals
G_N1641			15 inch	1395				1395														1395			
G_N1643			15 inch	837				837														837			
G_N1644																						478			
H_N4082																					665				
H_N4086																					1350				
H_N4087																					295				
H_N4089																					706				
H_N4091																					1050				
H_N4092																					289				
H_N4098																					1280				
H_N4099																					400				
H_N4100																					400				
H_N4101																						400			
H_N4103																						800			
H_N4111																						3230			
H_N4113																							800		
H_N4114																							400		
H_N4119																								1564	
H_N4120																								100	
I_2362																						1368			
I_E2040																						442			
I_E2041																						940			
I_E2049																					223				
I_E2050																					450				
I_E2051																					450				
I_E2052																					450				
I_E2056																						612			
I_E2058																						352			
I_E2059																						345			
I_E2069																					1365				
I_E2094																					58				
I_E2219																					255				
I_N2046																						647			
I_N2371	12 inch	85												85							85				
I_N2399	8 inch	136										136							136						
I_N2523																					265				
I_N2524																					468				
I_N2527																					143				
I_N2528																					209				
I_WRF																					580				
J_E1242			10 inch	1150		1150														1150					
J_E1245			10 inch	1050		1050														1050					
J_E1392																						286			
J_E1393																						312			
J_E1394																						337			
J_E1395																						571			
J_E1396																						729			

Appendix O
Existing JCSD Sewer System with Flows From Projected Ultimate Land Use
By Tributary Drainage Area

Label	Design Capacity Failure	Length (ft) Design Capacity Failure	Full Flow Failure	Length (ft) Full Flow Failure	8-inch Full Flow Failure	10-inch Full Flow Failure	12-inch Full Flow Failure	15-inch Full Flow Failure	18-inch Full Flow Failure	21-inch Full Flow Failure	24-inch Full Flow Failure	8-inch Design Cap. Failure	10-inch Design Cap. Failure	12-inch Design Cap. Failure	15-inch Design Cap. Failure	18-inch Design Cap. Failure	21-inch Design Cap. Failure	24-inch Design Cap. Failure	8-inch Totals	10-inch Totals	12-inch Totals	15-inch Totals	18-inch Totals	21-inch Totals	24-inch Totals
J_E1397																						608			
J_E1410			15 inch	566				566														566			
J_E1411																						716			
J_E1413																						186			
J_E1414																						233			
J_E1423																				422					
J_E1424			10 inch	483		483														483					
J_E1425	10 inch	416											416							416					
J_E1444																				222					
J_E1445			10 inch	327		327														327					
J_E1492			15 inch	975				975														975			
J_E1516			15 inch	155				155														155			
J_E1517			15 inch	445				445		290												445			
J_E1518			15 inch	583				583		302												583			
J_E1519			15 inch	1372				1372														1372			
J_E1530			15 inch	344				344		322												344			
J_E1531			15 inch	36				36		460												36			
J_E1532			15 inch	314				314		539												314			
J_E1533			15 inch	385				385		617												385			
J_E1534			15 inch	290				290		145												290			
J_E1535			15 inch	700				700		375												700			
J_E1536			15 inch	672				672														672			
J_E1579	15 inch	702													702							702			
J_E1580			15 inch	670				670														670			
J_E1581																						604			
J_E1582																						638			
J_E1705			21 inch	290																				290	
J_E1846			21 inch	302																				302	
J_E1847																								187	
J_E1857			21 inch	322																				322	
J_E1858			21 inch	460																				460	
J_E1971			21 inch	539																				539	
J_E1973			21 inch	617																				617	
J_E2006			21 inch	145																				145	
J_E2007			21 inch	375						798														375	
J_N1081										212									311						
J_N1082										421									315						
J_N1083										210									315						
J_N1085	8 inch	621								623		621							621						
J_N1191										663									950						
J_N1192	8 inch	525								334		525							525						
J_N1193	8 inch	603								514		603							603						
J_N1194			8 inch	696	696					800									696						
J_N1196			8 inch	684	684					395									684						
J_N1371			8 inch	680	680					505									680						
J_N1372			10 inch	240		240				452										240					
J_N1406			8 inch	691	691					548									691						

Appendix O
Existing JCSD Sewer System with Flows From Projected Ultimate Land Use
By Tributary Drainage Area

Label	Design Capacity Failure	Length (ft) Design Capacity Failure	Full Flow Failure	Length (ft) Full Flow Failure	8-inch Full Flow Failure	10-inch Full Flow Failure	12-inch Full Flow Failure	15-inch Full Flow Failure	18-inch Full Flow Failure	21-inch Full Flow Failure	24-inch Full Flow Failure	8-inch Design Cap. Failure	10-inch Design Cap. Failure	12-inch Design Cap. Failure	15-inch Design Cap. Failure	18-inch Design Cap. Failure	21-inch Design Cap. Failure	24-inch Design Cap. Failure	8-inch Totals	10-inch Totals	12-inch Totals	15-inch Totals	18-inch Totals	21-inch Totals	24-inch Totals
J_N1564			15 inch	216				216		990												216			
J_N1657			21 inch	798						862														798	
J_N1901			21 inch	212						1255														212	
J_N1907			21 inch	421																				421	
J_N1908			21 inch	210																				210	
J_N1910			21 inch	623																				623	
J_N1911			21 inch	663																				663	
J_N2010			21 inch	334																				334	
J_N2090			21 inch	514																				514	
J_N2091			21 inch	800																				800	
J_N2107			21 inch	395																				395	
J_N2108			21 inch	505																				505	
J_N2119			21 inch	452																				452	
J_N2284			21 inch	548																				548	
J_N2285			21 inch	990																				990	
J_N2286			21 inch	862																				862	
J_N2315			21 inch	1255																				1255	
J_N2317																								25	
P_E2024			12 inch	350			350														350				
P_E2065																			600						
P_E2067																			618						
P_E2182			8 inch	329	329														329						
P_E2184			8 inch	660	660														660						
P_E2186			8 inch	989	989														989						
P_E2202																			940						
P_E2206			8 inch	366	366														366						
P_E2208			8 inch	681	681														681						
P_E2211																			411						
P_N2106			12 inch	925			925														925				
P_N2340			12 inch	660			660														660				
P_N2342			12 inch	1320			1320														1320				
P_N2343			12 inch	660			660														660				
P_N2473			10 inch	687		687														687					
P_N2489			8 inch	122	122														122						
P_N2498																			537						
P_N2499																			158						
W_N4162																						749			
W_N4163																						337			
W_N4165																						792			
W_N4166																						400			
W_N4167																						400			
W_N4175																							1636		
W_N4176																									400
W_N4181																									1837
W_N4182																									33

APPENDIX P

EXISTING JCSD SEWER SYSTEM STATISTICAL ANALYSIS

Appendix P
Existing JCSD Sewer System
Statistical Analysis

Statiscal Analysis by Failure

	Hyd. Dfct.	Full
Failure Length (ft):	3,088	46,054
Length Modeled (ft):	115,810	115,810
	2.7%	39.8%

Statiscal Analysis by Total JCSD Sewer System (Excluding Eastvale & Sky Country)

Pipe Size	8 inch	10 inch	12 inch	15 inch	18 inch	21 inch	24 inch
Total Length Per Pipe Size	17,258	6,336	19,310	31,650	18,091	20,136	3,030
Percentage Per Pipe Size	15%	5%	17%	27%	16%	17%	3%
Hydraulic Deficient Lengths	1,885	416	85	702	0	0	0
Percentage Design Capacity Failures [1]	1.63%	0.36%	0.07%	0.61%	0%	0.00%	0.00%
Full Flow Failure Lengths	9,734	5,276	7,874	10,538	0	12,632	0
Percentage Full Flow Failures [2]	8.41%	4.56%	6.80%	9.10%	0.00%	10.91%	0.00%
Total Modeled Length	115,810	115,810	115,810	115,810	115,810	115,810	115,810

Statistical Analysis by of Pipe Sizes per Trunk System

Trunk System Totals:	Total Length	8 inch (ft / %)[3]		10 inch (ft / %)[3]		12 inch (ft / %)[3]		15 inch (ft / %)[3]		18 inch (ft / %)[3]		21 inch (ft / %)[3]		24 inch (ft / %)[3]		Check Sum	
Bain Trunk System	18,092	0	0%	0	0%	0	0%	2,837	16%	15,255	84%	0	0%	0	0%	18,092	100%
Etiwanda Avenue Trunk (CFD)	6,388	0	0%	0	0%	0	0%	0	0%	0	0%	5,628	88%	760	12%	6,388	100%
Glen Avon Area Trunk	12,972	4,320	33%	1,339	10%	3,959	31%	3,354	26%	0	0%	0	0%	0	0%	12,972	100%
Hamner Avenue Trunk (CFD)	13,729	0	0%	0	0%	6,435	47%	4,430	32%	1,200	9%	1,664	12%	0	0%	13,729	100%
Indian Hills WRF Overflow Line	9,843	136	1%	0	0%	5,001	51%	4,706	48%	0	0%	0	0%	0	0%	9,843	100%
Jurupa Trunk System	37,190	6,391	17%	4,310	12%	0	0%	13,645	37%	0	0%	12,844	35%	0	0%	37,190	100%
Pedley Area Trunk	11,013	6,411	58%	687	6%	3,915	36%	0	0%	0	0%	0	0%	0	0%	11,013	100%
Wineville Road Trunk (CFD)	6,584	0	0%	0	0%	0	0%	2,678	41%	1,636	25%	0	0%	2,270	34%	6,584	100%
Check Total:	115,810	17,258		6,336		19,310		31,650		18,091		20,136		3,030		115,810	

Statistical Analysis by Hydraulic Deficiencies per pipe size at Respective Trunk System (0.75 < D/d < 1.0)

Trunk System Totals:	Total Length	8 inch (ft / %)[4]		10 inch (ft / %)[4]		12 inch (ft / %)[4]		15 inch (ft / %)[4]		18 inch (ft / %)[4]		21 inch (ft / %)[4]		24 inch (ft / %)[4]		Check Sum	
Bain Trunk System	18,092	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%
Etiwanda Avenue Trunk (CFD)	6,388	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%
Glen Avon Area Trunk	12,972	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%
Hamner Avenue Trunk (CFD)	13,729	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%
Indian Hills WRF Overflow Line	9,843	136	1%	0	0%	85	1%	0	0%	0	0%	0	0%	0	0%	221	2%
Jurupa Trunk System	37,190	1,749	5%	416	1%	0	0%	702	2%	0	0%	0	0%	0	0%	2,867	8%
Pedley Area Trunk	11,013	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%
Wineville Road Trunk (CFD)	6,584	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%
Check Total:	115,810	1,885		416		85		702		0		0		0		3,088	

Statistical Analysis by Full Flow Failures per pipe size at Respective Trunk System (D/d > 1.0)

Trunk System Totals:	Total Length	8 inch (ft / %)[5]		10 inch (ft / %)[5]		12 inch (ft / %)[5]		15 inch (ft / %)[5]		18 inch (ft / %)[5]		21 inch (ft / %)[5]		24 inch (ft / %)[5]		Check Sum	
Bain Trunk System	18,092	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%
Etiwanda Avenue Trunk (CFD)	6,388	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%
Glen Avon Area Trunk	12,972	3,836	30%	1,339	10%	3,959	31%	2,815	22%	0	0%	0	0%	0	0%	11,949	92%
Hamner Avenue Trunk (CFD)	13,729	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%
Indian Hills WRF Overflow Line	9,843	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%
Jurupa Trunk System	37,190	2,751	7%	3,250	9%	0	0%	7,723	21%	0	0%	12,632	34%	0	0%	26,356	71%
Pedley Area Trunk	11,013	3,147	29%	687	6%	3,915	36%	0	0%	0	0%	0	0%	0	0%	7,749	70%
Wineville Road Trunk (CFD)	6,584	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%
Check Total:	115,810	9,734		5,276		7,874		10,538		0		12,632		0		46,054	

Notes:
1. This percentage is based on the length of pipe failures within a particular size category vs. the total modeled length.
2. This percentage is based on the total length within a particular size category vs. the total modeled length.
3. This percentage is based on the length of pipe withing a size category in the respective trunk sewer.
4. This percentage is based on the length of pipe with a design capacity failure in that size category within the respective trunk sewer.
5. This percentage is based on the length of pipe with a full flow failure in that size category within the respective trunk sewer.

APPENDIX Q

INVENTORY OF HYDRAULIC DEFICIENCIES

Appendix Q
Inventory of Hydraulic Deficiencies (0.75 < D/d < 1.0)

Jurupa Trunk Sewer System

Label	Length (ft)	Section Size	Full Capacity (gpd)	Design Capacity (gpd)	Total Flow (gpd)	Excess Full Capacity (gpd)	Hydraulic Deficiencies (gpd)
J_E1425	416	10 inch	1,471,093.74	1,341,457.55	1,367,578.16	103,515.58	-26,120.61
J_E1579	702	15 inch	4,848,941.74	4,421,641.77	4,639,226.41	209,715.33	-217,584.64
J_N1192	525	8 inch	594773.00	297,386.00	492,867.00	101,906.00	-195,481.00
J_N1193	603	8 inch	523894.00	261,947.00	492,867.00	31,027.00	-230,920.00

Indian Hills WRF Overflow Line

Label	Length (ft)	Section Size	Full Capacity (gpd)	Design Capacity (gpd)	Total Flow (gpd)	Excess Full Capacity (gpd)	Hydraulic Deficiencies (gpd)
I_N2371	85	12 inch	1,559,684.20	1,422,241.22	1,491,468.74	68,215.45	-69,227.53
I_N2399	136	8 inch	444,215.82	222,107.91	433,853.74	10,362.08	-211,745.83

APPENDIX R

INVENTORY OF FULL FLOW CAPACITY FAILURES

Appendix R
Inventory of Full Flow Capacity Failures (D/d > 1.0)

Jurupa Trunk Sewer System

Label	Length (ft)	Section Size	Full Capacity (gpd)	Design Capacity (gpd)	Total Flow (gpd)	Excess Full Capacity (gpd)	Hydraulic Deficiencies (gpd)
J_E1242	1,150	10 inch	1,001,265	913,031	1,349,471	-348,207	-436,440
J_E1245	1,050	10 inch	564,713	514,949	1,349,471	-784,759	-834,522
J_E1410	566	15 inch	2,288,004	2,086,380	2,298,138	-10,134	-211,759
J_E1424	483	10 inch	1,365,254	1,244,945	1,381,471	-16,217	-136,527
J_E1445	327	10 inch	750,627	684,480	1,349,471	-598,844	-664,991
J_E1492	975	15 inch	2,575,284	2,348,344	6,985,877	-4,410,592	-4,637,532
J_E1516	155	15 inch	3,995,939	3,643,808	6,985,877	-2,989,938	-3,342,069
J_E1517	445	15 inch	4,007,306	3,654,172	6,375,708	-2,368,403	-2,721,536
J_E1518	583	15 inch	4,865,963	4,437,164	6,375,708	-1,509,745	-1,938,545
J_E1519	1,372	15 inch	3,938,413	3,591,351	6,375,708	-2,437,295	-2,784,357
J_E1530	344	15 inch	1,869,760	1,704,992	5,399,832	-3,530,072	-3,694,840
J_E1531	36	15 inch	3,111,747	2,837,533	5,399,832	-2,288,085	-2,562,300
J_E1532	314	15 inch	3,892,755	3,549,716	5,399,832	-1,507,078	-1,850,116
J_E1533	385	15 inch	4,651,833	4,241,903	5,399,832	-747,999	-1,157,929
J_E1534	290	15 inch	4,645,033	4,235,701	5,399,832	-754,800	-1,164,131
J_E1535	700	15 inch	3,871,594	3,530,420	5,399,832	-1,528,239	-1,869,412
J_E1536	672	15 inch	4,958,611	4,521,647	5,399,832	-441,221	-878,185
J_E1580	670	15 inch	2,802,894	2,555,896	4,628,483	-1,825,590	-2,072,587
J_E1705	290	21 inch	9,159,258	8,352,123	12,894,937	-3,735,679	-4,542,814
J_E1846	302	21 inch	10,255,948	9,352,170	16,170,068	-5,914,120	-6,817,898
J_E1857	322	21 inch	4,099,324	3,738,082	12,894,937	-8,795,613	-9,156,855
J_E1858	460	21 inch	9,441,147	8,609,171	12,894,937	-3,453,790	-4,285,766
J_E1971	539	21 inch	4,811,654	4,387,640	19,209,554	-14,397,900	-14,821,914
J_E1973	617	21 inch	4,807,753	4,384,083	16,915,906	-12,108,153	-12,531,823
J_E2006	145	21 inch	6,312,583	5,756,303	16,509,391	-10,196,809	-10,753,088
J_E2007	375	21 inch	10,691,251	9,749,114	16,509,391	-5,818,140	-6,760,278
J_N1194	696	8 inch	658,061	329,031	930,433	-272,372	-601,402
J_N1196	684	8 inch	804,063	402,031	930,433	-126,370	-528,402
J_N1371	680	8 inch	924,062	462,031	930,433	-6,371	-468,402
J_N1372	240	10 inch	570,809	520,508	1,349,471	-778,663	-828,964
J_N1406	691	8 inch	876,642	438,321	930,433	-53,791	-492,112
J_N1657	798	21 inch	5,615,901	5,121,015	12,020,486	-6,404,585	-6,899,471
J_N1901	212	21 inch	4,821,657	4,396,761	12,020,486	-7,198,830	-7,623,725
J_N1907	421	21 inch	7,667,084	6,991,443	12,894,937	-5,227,853	-5,903,494
J_N1908	210	21 inch	4,792,748	4,370,400	12,894,937	-8,102,189	-8,524,537
J_N1910	623	21 inch	4,802,104	4,378,931	12,020,486	-7,218,382	-7,641,555
J_N1911	663	21 inch	8,981,391	8,189,930	12,020,486	-3,039,095	-3,830,556
J_N2010	334	21 inch	10,693,747	9,751,390	16,170,068	-5,476,321	-6,418,679
J_N2090	514	21 inch	9,044,945	8,247,883	16,170,068	-7,125,123	-7,922,185
J_N2091	800	21 inch	7,591,003	6,922,066	16,170,068	-8,579,065	-9,248,002
J_N2107	395	21 inch	6,549,942	5,972,746	13,246,341	-6,696,399	-7,273,595
J_N2108	505	21 inch	4,096,145	3,735,183	12,894,937	-8,798,792	-9,159,754
J_N2119	452	21 inch	8,314,846	7,582,123	12,894,937	-4,580,091	-5,312,814
J_N2284	548	21 inch	4,803,155	4,379,890	16,915,906	-12,112,751	-12,536,016
J_N2285	990	21 inch	4,803,155	4,379,890	16,915,906	-12,112,751	-12,536,016
J_N2286	862	21 inch	6,312,583	5,756,303	16,509,391	-10,196,809	-10,753,088
J_N2315	1,255	21 inch	5,417,379	4,939,987	16,170,068	-10,752,689	-11,230,081

Appendix R
Inventory of Full Flow Capacity Failures (D/d > 1.0)

Glen Avon Trunk Sewer System

Label	Length (ft)	Section Size	Full Capacity (gpd)	Design Capacity (gpd)	Total Flow (gpd)	Excess Full Capacity (gpd)	Hydraulic Deficiencies (gpd)
G_E1119	604	8 inch	477,719	238,860	494,398	-16,678	-255,538
G_E1175	250	8 inch	388,922	194,461	821,373	-432,450	-626,912
G_E1178	221	8 inch	460,985	230,492	821,373	-360,388	-590,881
G_E1283	102	8 inch	489,066	244,533	860,045	-370,979	-615,512
G_E1291	165	10 inch	1,096,830	1,000,175	2,383,049	-1,286,219	-1,382,874
G_E1307	1684	12 inch	920,278	839,181	2,904,682	-1,984,404	-2,065,501
G_E1490	583	15 inch	2,924,080	2,666,403	5,746,690	-2,822,610	-3,080,287
G_N1177	379	10 inch	599,789	546,934	821,373	-221,584	-274,438
G_N1266	655	8 inch	455,689	227,845	821,373	-365,684	-593,528
G_N1268	1318	8 inch	548,449	274,224	821,373	-272,924	-547,148
G_N1269	686	8 inch	683,861	341,931	860,045	-176,184	-518,114
G_N1458	795	10 inch	776,389	707,972	1,435,852	-659,463	-727,881
G_N1460	2275	12 inch	1,029,743	939,000	2,904,682	-1,874,939	-1,965,682
G_N1641	1395	15 inch	1,669,190	1,522,097	2,995,834	-1,326,644	-1,473,737
G_N1643	837	15 inch	2,507,733	2,286,746	4,938,404	-2,430,671	-2,651,658

Appendix R
Inventory of Full Flow Capacity Failures (D/d > 1.0)

Pedley Trunk Sewer System

Label	Length (ft)	Section Size	Full Capacity (gpd)	Design Capacity (gpd)	Total Flow (gpd)	Excess Full Capacity (gpd)	Hydraulic Deficiencies (gpd)
P_E2024	350	12 inch	921,030	839,867	1,240,009	-318,978	-400,142
P_E2182	329	8 inch	740,773	370,386	1,240,009	-499,236	-869,622
P_E2184	660	8 inch	349,263	174,631	1,240,009	-890,746	-1,065,377
P_E2186	989	8 inch	413,313	206,656	1,240,009	-826,696	-1,033,352
P_E2206	366	8 inch	1,112,733	556,367	1,240,009	-127,275	-683,642
P_E2208	681	8 inch	481,630	240,815	1,240,009	-758,379	-999,194
P_N2106	925	12 inch	921,030	839,867	3,610,603	-2,689,573	-2,770,736
P_N2340	660	12 inch	918,410	837,477	1,932,873	-1,014,463	-1,095,395
P_N2342	1,320	12 inch	920,594	839,469	1,932,873	-1,012,279	-1,093,404
P_N2343	660	12 inch	922,773	841,456	3,237,931	-2,315,158	-2,396,475
P_N2473	687	10 inch	1,069,618	975,360	1,240,009	-170,391	-264,648
P_N2489	122	8 inch	412,284	206,142	1,240,009	-827,724	-1,033,866

APPENDIX S

DESIGN JCSD SEWER SYSTEM WITH FLOWS FROM PROJECTED ULTIMATE LAND USE BY TRIBUTARY DRAINAGE AREA

Appendix S
Design JCSD Sewer System with Flows From Projected Ultimate Land Use
By Tributary Drainage Area

Label	Upstream Node	Upstream Invert Elevation (ft)	Downstream Node	Downstream Invert Elevation (ft)	Constructed Slope (ft/ft)	Length (ft)	Section Size	Mannings n	Material	Section Shape	Full Capacity (gpd)	Design Capacity (gpd)	Total Flow (gpd)	Excess Full Capacity (gpd)	Excess Design Capacity (gpd)	Average Velocity (ft/s)	Depth In (ft)	Depth Out (ft)	Infiltration Unit Load Flow per Unit (gpd)	Infiltration Unit Load Count (AC)	Design Capacity Failure	Length (ft) Design Capacity Failure	Full Flow Failure	Length (ft) Full Flow Failure
B_65-39B	B_1364	738.77	B_1654	709.20	0.0100	2957	18 inch	0.013	Vitrified Clay Pipe	Circular	6,788,761.00	6,190,520	2,208,840	4,579,921	3,981,680	4.75	0.71	0.59	160	223.6				
B_DSN-600	B_3089	660.81	B_DSN-900	640.50	0.2334	87	18 inch	0.013	Vitrified Clay Pipe	Circular	32,798,118.00	29,907,872	4,295,027	28,503,091	25,612,845	5.11	1.00	1.08						
B_DSN_820	B_DSN-900	640.25	J_DSN-500	638.73	0.0011	1333	30 inch	0.013	Vitrified Clay Pipe	Circular	8,961,625.00	8,961,625	4,957,548	4,004,076	4,004,076	3.79	1.33	0.92						
B_E1459	B_4394	699.24	B_1962	697.22	0.0030	672	18 inch	0.013	Vitrified Clay Pipe	Circular	3,722,045.00	3,394,049	3,578,651	143,394	-184,601	3.71	1.18	1.18			18 inch	672		
B_E1628	B_2337	688.06	B_2338	687.16	0.0030	300	18 inch	0.013	Vitrified Clay Pipe	Circular	3,718,358.00	3,390,687	3,578,651	139,707	-187,963	4.11	1.18	0.98			18 inch	300		
B_E1638	B_2351	693.59	B_2347	692.43	0.0040	291	18 inch	0.013	Vitrified Clay Pipe	Circular	4,286,206.00	3,908,495	3,578,651	707,555	329,845	3.96	1.05	1.18						
B_E1680	B_1654	709.20	B_1657	706.62	0.0070	369	18 inch	0.013	Vitrified Clay Pipe	Circular	5,676,586.00	5,176,352	2,208,840	3,467,746	2,967,512	3.75	0.71	0.85						
B_E3269	B_1657	706.62	B_4387	705.93	0.0030	230	18 inch	0.013	Vitrified Clay Pipe	Circular	3,718,358.00	3,390,687	2,208,840	1,509,518	1,181,847	2.80	0.85	1.18						
B_N1223	B_1254	765.06	B_1372	761.07	0.0114	350	15 inch	0.013	Vitrified Clay Pipe	Circular	4,457,516.00	4,064,710	2,173,064	2,284,453	1,891,646	5.02	0.74	0.62	160	615.4				
B_N1225	B_1372	761.07	B_1375	756.51	0.0064	713	15 inch	0.013	Vitrified Clay Pipe	Circular	3,338,706.00	3,044,492	2,173,064	1,165,642	871,428	4.47	0.74	0.73						
B_N1235	B_1375	756.51	B_1364	738.77	0.0100	1774	15 inch	0.013	Vitrified Clay Pipe	Circular	4,174,847.00	3,806,950	2,173,064	2,001,783	1,633,886	4.88	0.74	0.64						
B_N1844	B_2345	691.05	B_2337	688.06	0.0030	998	18 inch	0.013	Vitrified Clay Pipe	Circular	3,716,804.00	3,389,271	3,578,651	138,154	-189,380	3.71	1.18	1.18			18 inch	997.5		
B_N1847	B_2347	692.43	B_2345	691.05	0.0030	457	18 inch	0.013	Vitrified Clay Pipe	Circular	3,730,542.00	3,401,798	3,578,651	151,892	-176,852	3.71	1.18	1.18			18 inch	457		
B_N1849	B_1962	697.22	B_2351	693.59	0.0030	1211	18 inch	0.013	Vitrified Clay Pipe	Circular	3,716,822.00	3,389,287	3,578,651	138,171	-189,363	3.95	1.18	1.05			18 inch	1211		
B_N1855	B_2338	687.16	B_2372	685.19	0.0059	335	18 inch	0.013	Vitrified Clay Pipe	Circular	5,205,965.00	4,747,203	3,984,269	1,221,696	762,934	5.09	0.98	0.96	160	213.9				
B_N2041	B_2687	674.73	B_2686	671.23	0.0053	660	18 inch	0.013	Vitrified Clay Pipe	Circular	4,943,705.00	4,508,055	4,295,027	648,678	213,027	5.02	1.08	1.02						
B_N2042	B_2688	678.68	B_2687	674.73	0.0060	659	18 inch	0.013	Vitrified Clay Pipe	Circular	5,255,891.00	4,792,730	3,984,269	1,271,622	808,461	4.79	0.98	1.08						
B_N2043	B_2689	680.00	B_2688	678.68	0.0075	177	18 inch	0.013	Vitrified Clay Pipe	Circular	5,862,608.00	5,345,981	3,984,269	1,878,339	1,361,712	5.11	0.96	0.98						
B_N2044	B_2690	681.19	B_2689	680.00	0.0080	148	18 inch	0.013	Vitrified Clay Pipe	Circular	6,087,418.00	5,550,981	3,984,269	2,103,149	1,566,712	5.42	0.96	0.88						
B_N2045	B_2372	685.19	B_2690	681.19	0.0123	325	18 inch	0.013	Vitrified Clay Pipe	Circular	7,531,454.00	6,867,765	3,984,269	3,547,185	2,883,496	5.93	0.96	0.78						
B_N2280-DSN	B_3095	664.21	B_3089	660.81	0.0052	654	18 inch	0.013	Vitrified Clay Pipe	Circular	4,894,869.00	4,463,522	4,295,027	599,842	168,495	5.08	1.09	1.00						
B_N2281	B_2685	667.20	B_3095	664.21	0.0045	665	18 inch	0.013	Vitrified Clay Pipe	Circular	4,552,137.00	4,150,992	4,295,027	257,109	-144,035	4.68	1.16	1.09			18 inch	665		
B_N2282	B_2686	671.23	B_2685	667.20	0.0061	660	18 inch	0.013	Vitrified Clay Pipe	Circular	5,304,825.00	4,837,352	4,295,027	1,009,798	542,324	4.85	1.02	1.16						
B_N4334	B_4387	705.93	B_4394	699.24	0.0030	2230	18 inch	0.013	Vitrified Clay Pipe	Circular	3,718,358.00	3,390,687	3,578,651	139,707	-187,963	3.71	1.18	1.18			18 inch	2230		
E_E3360	E_1934	727.00	E_SARI_CONNE	726.14	0.0064	134	21 inch	0.013	Vitrified Clay Pipe	Circular	8,203,744.00	7,480,811	7,341,168	862,576	139,643	6.06	1.29	1.26						
E_N1212	E_1342	764.11	E_1626	757.61	0.0036	1806	21 inch	0.013	Vitrified Clay Pipe	Circular	6,143,461.00	5,602,085	4,062,929	2,080,532	1,539,156	4.44	1.04	0.96	100	1,140.00				
E_N1426	E_1626	757.61	E_1623	748.18	0.0048	1964	21 inch	0.013	Vitrified Clay Pipe	Circular	7,095,784.00	6,470,487	4,123,929	2,971,856	2,346,559	4.82	0.96	0.93	100	610.00				
E_N1427	E_1623	748.18	E_1624	745.17	0.0080	376	21 inch	0.013	Vitrified Clay Pipe	Circular	9,162,302.00	8,354,899	4,123,929	5,038,374	4,230,970	5.32	0.93	0.82						
E_N1428	E_1624	745.17	E_1625	736.53	0.0258	335	21 inch	0.013	Vitrified Clay Pipe	Circular	16,445,601.00	14,996,377	4,123,929	12,321,673	10,872,448	4.12	0.93	1.29						
E_N1598	E_1625	736.53	E_1937	730.04	0.0064	1013	21 inch	0.013	Vitrified Clay Pipe	Circular	8,196,584.00	7,474,282	7,341,168	855,416	133,114	5.84	1.29	1.35	100	104.7				
E_N4436	E_1937	730.04	E_1934	727.00	0.0040	760	24 inch	0.013	Vitrified Clay Pipe	Circular	9,249,822.00	8,434,707	7,341,168	1,908,654	1,093,538	5.17	1.35	1.29						
G_97-0261_DSN	G_2023A	705.62	G_2023B	703.68	0.0318	61	15 inch	0.013	Vitrified Clay Pipe	Circular	7,445,202.00	6,789,113	3,630,229	3,814,973	3,158,884	5.45	0.96	1.00						
G_DSN-600	G_DSN-700	706.49	B_4387	705.93	0.0018	319	15 inch	0.013	Vitrified Clay Pipe	Circular	1,749,199.00	1,595,055	1,579,454	169,745	15,601	2.15	1.02	1.18						
G_DSN-620	G_1276	748.38	G_DSN-715	746.93	0.0038	381	10 inch	0.013	Vitrified Clay Pipe	Circular	872,308.00	795,438	494,398	377,910	301,040	2.82	0.45	0.39	160	189.8				
G_DSN-650	G_DSN-650	725.23	G_DSN-700	717.67	0.0091	834	15 inch	0.013	Vitrified Clay Pipe	Circular	3,973,777.00	3,623,598	1,579,454	2,394,323	2,044,144	4.35	0.63	0.55						
G_DSN-705	G_DSN-705	727.72	G_DSN-650	725.23	0.0017	1429	15 inch	0.013	Vitrified Clay Pipe	Circular	1,742,706.00	1,589,135	1,579,454	163,252	9,680	3.23	0.93	0.63						
G_DSN-710	G_DSN-710	730.16	G_DSN-705	727.72	0.0017	1400	15 inch	0.013	Vitrified Clay Pipe	Circular	1,742,896.00	1,589,308	1,579,454	163,442	9,854	2.49	0.93	0.93	160	487.3				
G_DSN-712	G_DSN-712	731.79	G_DSN-710	730.16	0.0016	1016	10 inch	0.013	Vitrified Clay Pipe	Circular	567,167.00	517,187	494,398	72,769	22,789	1.61	0.60	0.93						
G_DSN-714	G_DSN-714	733.94	G_DSN-712	731.79	0.0016	1347	10 inch	0.013	Vitrified Clay Pipe	Circular	565,717.00	515,865	494,398	71,319	21,467	1.81	0.60	0.60						
G_DSN-715	G_DSN-715	735.98	G_DSN-714	733.94	0.0016	1277	10 inch	0.013	Vitrified Clay Pipe	Circular	565,957.00	516,084	494,398	71,559	21,686	1.81	0.60	0.60						
G_E1120	G_1278	756.42	G_1270	746.12	0.0213	484	8 inch	0.013	Vitrified Clay Pipe	Circular	1,139,287.00	569,643	375,730	763,557	193,914	2.61	0.36	0.48	160	136.2				
G_E1175	G_1295	745.44	G_1419	744.82	0.0023	265	8 inch	0.013	Vitrified Clay Pipe	Circular	377,755.00	188,877	375,730	2,025	-186,852	2.09	0.54	0.46			8 inch	265		
G_E1178	G_1421	742.59	G_1422	741.82	0.0035	221	8 inch	0.013	Vitrified Clay Pipe	Circular	460,985.00	230,492	375,730	85,255	-145,237	2.45	0.46	0.41			8 inch	221		
G_E1283	G_1673	730.06	G_1674	729.66	0.0039	102	8 inch	0.013	Vitrified Clay Pipe	Circular	489,066.00	244,533	414,402	74,664	-169,869	2.07	0.50	0.64			8 inch	102		
G_E1291	G_1684	727.27	G_1685	726.28	0.0060	165	10 inch	0.013	Vitrified Clay Pipe	Circular	1,096,830.00	1,000,175	952,142	144,689	48,033	3.10	0.60	0.85						
G_E1307_DSN	G_1690	721.73	G_1711	719.04	0.0016	1684	15 inch	0.013	Vitrified Clay Pipe	Circular	1,668,575.00	1,521,536	1,512,471	156,103	9,065	2.32	0.93	0.98						
G_E1490_DSN	G_2023B	703.68	J_2024	700.82	0.0049	583	21 inch	0.013	Vitrified Clay Pipe	Circular	7,172,392.00	6,540,344	4,458,513	2,713,879	2,081,832	3.92	1.00	1.61	160	454.1				
G_N1177	G_1270	746.12	G_1295	745.44	0.0018	379	10 inch	0.013	Vitrified Clay Pipe	Circular	599,789.00	548,934	375,730	224,060	171,205	1.67	0.48	0.54						
G_N1266	G_1419	744.82	G_1421	742.59	0.0034	651	8 inch	0.013	Vitrified Clay Pipe	Circular	457,087.00	228,544	375,730	81,358	-147,186	2.27	0.46	0.46			8 inch	651		
G_N1268	G_1422	741.82	G_1424	735.32	0.0049	1318	8 inch	0.013	Vitrified Clay Pipe	Circular	548,449.00	274,224	375,730	172,719	-101,505	2.74	0.41	0.38			8 inch	1318		
G_N1269	G_1424	735.32	G_1673	730.06	0.0077	686	8 inch	0.013	Vitrified Clay Pipe	Circular	683,861.00	341,931	414,402	269,459	-72,471	2.72	0.38	0.50	160	241.7	8 inch	686		
G_N1458_DSN	G_1674	729.66	G_1684	727.27	0.0030	795	12 inch	0.013	Vitrified Clay Pipe	Circular	1,262,494.00	1,151,240	938,628	323,866	212,612	2.84	0.64	0.60						
G_N1460_DSN	G_1685	726.28	G_1690	721.73	0.0020	2275	15 inch	0.013	Vitrified Clay Pipe	Circular	1,867,048.00	1,702,520	1,512,471	354,577	190,048	2.50	0.85	0.93	160	163.4				
G_N1641_DSN	G_1711	719.04	G_2019	716.81	0.0016	1395	15 inch	0.013	Vitrified Clay Pipe	Circular	1,669,190.00	1,522,097	1,603,623	65,567	-81,526	2.28	0.98	1.10	160	569.7	15 inch	1395		
G_N1643_DSN	G_2019	716.81	G_2022	713.79	0.0036	837	18 inch	0.013	Vitrified Clay Pipe	Circular	4,077,850.00	3,718,501	3,630,229	447,621	88,271	4.37	1.10	0.96						
G_N1644_DSN	G_2022	713.79	G_2023A	705.62	0.0171	478	15 inch	0.013	Vitrified Clay Pipe	Circular	5,458,051.00	4,977,075	3,630,229	1,827,822	1,346,846	6.46	0.96	0.75						
H_N4082	H_4175	804.50	H_4177	802.90	0.0024	665	12 inch	0.013	Vitrified Clay Pipe	Circular	1,129,440.00	1,029,911	638,961	490,478	390,950	2.72	0.54	0.42	100	100				
H_N4086	H_4177	802.90	H_4181	792.10	0.0080	1350	12 inch	0.013	Vitrified Clay Pipe	Circular	2,059,486.00	1,877,999	649,881	1,409,605	1,228,118	3.40	0.42	0.39	100	109.2				
H_N4087	H_4181	792.10	H_4182	788.12	0.0135	295	12 inch	0.013	Vitrified Clay Pipe	Circular	2,674,511.00	2,438,827	649,881	2,024,630	1,788,946	3.77	0.42	0.34						
H_N4089	H_4182	788.12	H_7012	783.89	0.0060	706	12 inch	0.013	Vitrified Clay Pipe	Circular	1,782,304.00	1,625,243	649,881	1,132,422	975,362	3.22	0.42	0.42						

Appendix S
Design JCSD Sewer System with Flows From Projected Ultimate Land Use
By Tributary Drainage Area

Label	Upstream Node	Upstream Invert Elevation (ft)	Downstream Node	Downstream Invert Elevation (ft)	Constructed Slope (ft/ft)	Length (ft)	Section Size	Mannings n	Material	Section Shape	Full Capacity (gpd)	Design Capacity (gpd)	Total Flow (gpd)	Excess Full Capacity (gpd)	Excess Design Capacity (gpd)	Average Velocity (ft/s)	Depth In (ft)	Depth Out (ft)	Infiltration Unit Load Flow per Unit (gpd)	Infiltration Unit Load Count (AC)	Design Capacity Failure	Length (ft) Design Capacity Failure	Full Flow Failure	Length (ft) Full Flow Failure
H_N4091	H_7012	783.89	H_7011	775.49	0.0080	1050	12 inch	0.013	Vitrified Clay Pipe	Circular	2,059,486.00	1,877,999	649,881	1,409,605	1,228,118	3.40	0.42	0.39						
H_N4092	H_7011	775.49	H_7010	768.26	0.0250	289	12 inch	0.013	Vitrified Clay Pipe	Circular	3,641,951.00	3,321,014	649,881	2,992,070	2,671,132	4.31	0.42	0.29						
H_N4098	H_7010	768.26	H_7009	755.46	0.0100	1280	12 inch	0.013	Vitrified Clay Pipe	Circular	2,302,575.00	2,099,667	649,881	1,652,694	1,449,786	3.55	0.42	0.36						
H_N4099	H_7009	755.46	H_7008	749.06	0.0160	400	12 inch	0.013	Vitrified Clay Pipe	Circular	2,912,553.00	2,655,892	649,881	2,262,672	2,006,011	3.91	0.42	0.32						
H_N4100	H_7008	749.06	H_7007	746.66	0.0060	400	12 inch	0.013	Vitrified Clay Pipe	Circular	1,783,567.00	1,626,395	649,881	1,133,686	976,514	3.22	0.42	0.42						
H_N4101	H_7007	746.66	H_7006	744.26	0.0060	400	15 inch	0.013	Vitrified Clay Pipe	Circular	3,233,822.00	2,948,850	649,881	2,583,941	2,298,969	3.11	0.39	0.38						
H_N4103	H_7006	744.26	H_7005	737.86	0.0080	800	15 inch	0.013	Vitrified Clay Pipe	Circular	3,734,096.00	3,405,039	649,881	3,084,215	2,755,158	2.02	0.39	0.94						
H_N4111	H_7005	737.86	H_7004	705.56	0.0100	3230	15 inch	0.013	Vitrified Clay Pipe	Circular	4,174,847.00	3,806,950	3,512,476	662,371	294,473	5.68	0.94	0.88	100	672.4				
H_N4113	H_7004	705.56	H_7003	699.16	0.0080	800	18 inch	0.013	Vitrified Clay Pipe	Circular	6,072,052.00	5,536,969	3,512,476	2,559,576	2,024,493	4.83	0.90	0.93						
H_N4114	H_7003	699.16	H_7002	697.00	0.0054	400	18 inch	0.013	Vitrified Clay Pipe	Circular	4,988,700.00	4,549,084	3,512,476	1,476,224	1,036,608	4.36	0.93	1.08						
H_N4119	H_7002	697.00	H_7001	693.24	0.0024	1564	21 inch	0.013	Vitrified Clay Pipe	Circular	5,021,007.00	4,578,544	3,512,476	1,508,531	1,066,068	3.55	1.08	1.05						
H_N4120	H_7001	693.24	H_SARI_CONNE	693.00	0.0024	100	21 inch	0.013	Vitrified Clay Pipe	Circular	5,016,732.00	4,574,646	3,512,476	1,504,256	1,062,170	4.12	1.05	0.86						
I_2362	I_3225	716.02	I_3232	707.81	0.0060	1368	15 inch	0.013	Vitrified Clay Pipe	Circular	3,234,216.00	2,949,210	1,491,771	1,742,445	1,457,438	3.56	0.61	0.71						
I_E2040	I_3191	686.21	J_DSN-535	681.09	0.0162	316	15 inch	0.013	Vitrified Clay Pipe	Circular	5,314,128.00	4,845,834	2,010,014	3,304,113	2,835,820	5.28	0.71	0.53						
I_E2041	I_3172	689.97	I_3191	686.21	0.0040	940	15 inch	0.013	Vitrified Clay Pipe	Circular	2,840,405.00	2,407,726	2,010,014	830,391	397,712	3.99	0.82	0.71						
I_E2049	I_3226	717.63	I_3225	716.02	0.0072	223	12 inch	0.013	Vitrified Clay Pipe	Circular	1,956,475.00	1,784,066	1,491,771	464,704	292,295	4.26	0.65	0.65						
I_E2050	I_3227	729.51	I_3226	717.63	0.0264	450	12 inch	0.013	Vitrified Clay Pipe	Circular	3,741,242.00	3,411,555	1,491,771	2,249,470	1,919,784	4.26	0.65	0.65						
I_E2051	I_3248	735.81	I_3227	729.51	0.0140	450	12 inch	0.013	Vitrified Clay Pipe	Circular	2,724,444.00	2,484,359	1,491,771	1,232,672	992,588	4.88	0.65	0.53						
I_E2052	I_3249	742.11	I_3248	735.81	0.0140	450	12 inch	0.013	Vitrified Clay Pipe	Circular	2,724,444.00	2,484,359	1,491,771	1,232,672	992,588	4.88	0.65	0.53						
I_E2056	I_3242	695.01	I_3169	692.56	0.0040	612	15 inch	0.013	Vitrified Clay Pipe	Circular	2,641,483.00	2,408,710	2,010,014	631,469	398,695	3.67	0.82	0.82						
I_E2058	I_3243	702.36	I_3242	695.01	0.0209	352	15 inch	0.013	Vitrified Clay Pipe	Circular	6,032,716.00	5,501,099	2,010,014	4,022,702	3,491,085	3.99	0.71	0.82						
I_E2059	I_3232	707.81	I_3243	702.36	0.0158	345	15 inch	0.013	Vitrified Clay Pipe	Circular	5,247,220.00	4,784,822	2,010,014	3,237,205	2,774,808	5.25	0.71	0.54						
I_E2069	I_3258	765.71	I_3254	757.52	0.0060	1365	12 inch	0.013	Vitrified Clay Pipe	Circular	1,783,567.00	1,626,395	1,491,771	291,796	134,624	4.10	0.70	0.65						
I_E2094	I_1787	766.45	I_3259	766.10	0.0060	58	12 inch	0.013	Vitrified Clay Pipe	Circular	1,788,685.00	1,631,062	1,491,771	296,913	139,290	3.73	0.70	0.78						
I_E2219	I_3516	752.63	I_3515	748.24	0.0172	255	12 inch	0.013	Vitrified Clay Pipe	Circular	3,021,176.00	2,754,943	1,491,771	1,529,404	1,263,171	4.09	0.65	0.70						
I_N2046	I_3169	692.56	I_3172	689.97	0.0040	647	15 inch	0.013	Vitrified Clay Pipe	Circular	2,641,425.00	2,408,656	2,010,014	631,411	398,642	3.67	0.82	0.82						
I_N2371	I_3259	766.10	I_3258	765.71	0.0046	85	12 inch	0.013	Vitrified Clay Pipe	Circular	1,559,684.00	1,422,241	1,491,771	67,913	-69,530	3.73	0.78	0.70			12 inch	85		
I_N2399	I_17B	766.89	I_1787	766.45	0.0032	136	8 inch	0.013	Vitrified Clay Pipe	Circular	444,216.00	222,108	431,244	12,971	-209,137	1.91	0.67	0.70	160	200	8 inch	136		
I_N2523	I_3512	744.02	I_3249	742.11	0.0072	265	12 inch	0.013	Vitrified Clay Pipe	Circular	1,954,824.00	1,782,560	1,491,771	463,052	290,789	4.26	0.65	0.65						
I_N2524	I_3513	747.39	I_3512	744.02	0.0072	468	12 inch	0.013	Vitrified Clay Pipe	Circular	1,953,916.00	1,781,732	1,491,771	462,144	289,961	4.24	0.65	0.65						
I_N2527	I_3515	748.24	I_3513	747.39	0.0059	143	12 inch	0.013	Vitrified Clay Pipe	Circular	1,775,233.00	1,618,795	1,491,771	283,461	127,024	4.08	0.70	0.65						
I_N2528	I_3254	757.52	I_3516	752.63	0.0234	209	12 inch	0.013	Vitrified Clay Pipe	Circular	3,522,047.00	3,211,676	1,491,771	2,030,275	1,719,904	5.46	0.65	0.45						
I_WRF	I_3314	769.79	I_1787	766.45	0.0058	580	12 inch	0.013	Vitrified Clay Pipe	Circular	1,747,322.00	1,593,344	1,133,131	614,191	460,213	3.33	0.59	0.70	160	764				
J_DSN-400	J_3078	636.38	REGIONAL P.S.	632.06	0.0080	539	42 inch	0.013	Vitrified Clay Pipe	Circular	58,211,587.00	58,211,587	19,328,512	38,883,075	38,883,075	7.46	1.69	1.39						
J_DSN-410	J_DSN-505	641.66	J_DSN-500	637.48	0.0080	523	42 inch	0.013	Vitrified Clay Pipe	Circular	58,129,856.00	58,129,856	15,266,387	42,863,469	42,863,469	5.58	1.49	1.69						
J_DSN-415	J_DSN-510	669.66	J_DSN-505	641.66	0.0200	1400	42 inch	0.013	Vitrified Clay Pipe	Circular	91,955,338.00	91,955,338	15,266,387	76,688,951	76,688,951	8.49	1.49	0.96						
J_DSN-420	J_DSN-515	671.49	J_DSN-510	669.66	0.0010	1827	42 inch	0.013	Vitrified Clay Pipe	Circular	20,578,713.00	20,578,713	15,266,387	5,312,326	5,312,326	4.83	2.24	1.49						
J_DSN-425	J_DSN-520	672.46	J_DSN-515	671.49	0.0010	971	42 inch	0.013	Vitrified Clay Pipe	Circular	20,551,248.00	20,551,248	15,266,387	5,284,861	5,284,861	3.62	2.25	2.24						
J_DSN-430	J_DSN-525	672.86	J_DSN-520	672.46	0.0010	417	42 inch	0.013	Vitrified Clay Pipe	Circular	20,138,352.00	20,138,352	14,130,536	6,007,815	6,007,815	3.39	2.21	2.25						
J_DSN-435	J_DSN-530	673.62	J_DSN-525	672.86	0.0010	745	39 inch	0.013	Vitrified Clay Pipe	Circular	17,043,736.00	17,043,736	14,130,536	2,913,199	2,913,199	3.61	2.24	2.21						
J_DSN-440	J_DSN-535	674.78	J_DSN-530	673.62	0.0010	1159	39 inch	0.013	Vitrified Clay Pipe	Circular	16,881,981.00	16,881,981	14,130,536	2,751,444	2,751,444	3.56	2.27	2.24	160	190				
J_DSN-445	J_DSN-540	675.41	J_DSN-535	674.78	0.0010	629	39 inch	0.013	Vitrified Clay Pipe	Circular	16,888,111.00	16,888,111	12,545,163	4,342,948	4,342,948	3.23	2.16	2.27	160	276				
J_DSN-450	J_DSN-445	676.73	J_DSN-540	675.41	0.0010	1310	36 inch	0.013	Vitrified Clay Pipe	Circular	13,683,226.00	13,683,226	12,146,869	1,536,357	1,536,357	3.42	2.19	2.16	160	275.3				
J_DSN-455	J_DSN-550	677.38	J_DSN-445	676.73	0.0010	657	36 inch	0.013	Vitrified Clay Pipe	Circular	13,558,485.00	13,558,485	11,703,631	1,854,854	1,854,854	3.29	2.17	2.19						
J_DSN-460	J_DSN-555	687.43	J_DSN-550	677.38	0.0134	750	36 inch	0.013	Vitrified Clay Pipe	Circular	49,898,740.00	49,898,740	11,703,631	38,195,108	38,195,108	4.55	1.36	2.17						
J_DSN-465	J_2460	688.66	J_DSN-555	687.43	0.0010	1230	36 inch	0.013	Vitrified Clay Pipe	Circular	13,631,297.00	13,631,297	11,703,631	1,927,666	1,927,666	4.60	2.11	1.36						
J_DSN_405	J_DSN-500	637.48	J_3078	636.38	0.0080	138	42 inch	0.013	Vitrified Clay Pipe	Circular	58,052,209.00	58,052,209	19,328,512	38,723,697	38,723,697	7.45	1.69	1.39						
J_E1242_DSN	J_1537	884.97	J_1919	879.22	0.0050	1150	12 inch	0.013	Vitrified Clay Pipe	Circular	1,628,167.00	1,484,669	1,349,470	278,697	135,219	3.56	0.69	0.70						
J_E1245_DSN	J_1552	886.64	J_1537	884.97	0.0016	1050	15 inch	0.013	Vitrified Clay Pipe	Circular	1,664,961.00	1,518,241	1,349,470	315,492	168,771	2.66	0.85	0.69						
J_E1392	J_1849	794.15	J_1848	788.60	0.0194	286	15 inch	0.013	Vitrified Clay Pipe	Circular	5,815,727.00	5,303,232	3,193,910	2,621,817	2,109,321	5.21	0.90	0.90						
J_E1393	J_1850	802.82	J_1849	794.15	0.0278	312	15 inch	0.013	Vitrified Clay Pipe	Circular	6,959,416.00	6,346,136	3,193,910	3,765,506	3,152,226	6.90	0.90	0.59						
J_E1394	J_1851	812.19	J_1850	802.82	0.0278	337	15 inch	0.013	Vitrified Clay Pipe	Circular	6,961,381.00	6,347,928	3,193,910	3,767,470	3,154,017	6.90	0.90	0.59						
J_E1395	J_1852	822.13	J_1851	812.19	0.0174	571	15 inch	0.013	Vitrified Clay Pipe	Circular	5,508,276.00	5,022,874	3,193,910	2,314,365	1,828,963	6.21	0.90	0.68	160	381.7				
J_E1396	J_1853	832.11	J_1852	822.13	0.0137	729	15 inch	0.013	Vitrified Clay Pipe	Circular	4,884,747.00	4,454,291	2,298,137	2,586,610	2,156,155	4.15	0.76	0.90						
J_E1397	J_1854	836.80	J_1853	832.11	0.0077	608	15 inch	0.013	Vitrified Clay Pipe	Circular	3,666,698.00	3,343,580	2,298,137	1,368,561	1,045,443	4.71	0.76	0.72						
J_E1410_DSN	J_1870	838.50	J_1854	836.80	0.0030	566	18 inch	0.013	Vitrified Clay Pipe	Circular	3,720,547.00	3,720,547	2,298,137	1,422,410	1,422,410	3.69	0.85	0.76						
J_E1411	J_1872	847.24	J_1870	838.50	0.0122	716	15 inch	0.013	Vitrified Clay Pipe	Circular	4,612,536.00	4,206,068	2,298,137	2,314,399	1,907,932	4.27	0.76	0.85	160	161.3				
J_E1413	J_1873	850.07	J_1872	847.24	0.0152	186	15 inch	0.013	Vitrified Clay Pipe	Circular	5,149,645.00	4,695,846	2,063,066	3,086,579	2,632,780	4.22	0.72	0.76						
J_E1414	J_1874	852.26	J_1873	850.07	0.0094	233	15 inch	0.013	Vitrified Clay Pipe	Circular	4,047,479.00	3,690,806	2,063,066	1,984,413	1,627,740	4.75	0.72	0.63						
J_E1423	J_1887	863.17	J_1886	853.21	0.0236	422	10 inch	0.013	Vitrified Clay Pipe	Circular	2,175,391.00	1,983,690	1,397,470	777,921	586,221	4.34	0.66	0.80	160	100				
J_E1424_DSN	J_1888	867.66	J_1887	863.17	0.0093	483	12 inch	0.013	Vitrified Clay Pipe	Circular	2,220,053.00	2,024,417	1,381,470	838,584	642,948	4.02	0.62	0.66	160	100				

Appendix S
Design JCSD Sewer System with Flows From Projected Ultimate Land Use
By Tributary Drainage Area

Label	Upstream Node	Upstream Invert Elevation (ft)	Downstream Node	Downstream Invert Elevation (ft)	Constructed Slope (ft/ft)	Length (ft)	Section Size	Mannings n	Material	Section Shape	Full Capacity (gpd)	Design Capacity (gpd)	Total Flow (gpd)	Excess Full Capacity (gpd)	Excess Design Capacity (gpd)	Average Velocity (ft/s)	Depth In (ft)	Depth Out (ft)	Infiltration Unit Load Flow per Unit (gpd)	Infiltration Unit Load Count (AC)	Design Capacity Failure	Length (ft) Design Capacity Failure	Full Flow Failure	Length (ft) Full Flow Failure
J_E1425_DSN	J_1917	872.15	J_1888	867.66	0.0108	416	12 inch	0.013	Vitrified Clay Pipe	Circular	2,392,161.00	2,181,358	1,365,470	1,026,691	815,888	4.11	0.62	0.62	160	100				
J_E1444	J_1918	878.30	J_1917	872.15	0.0277	222	10 inch	0.013	Vitrified Clay Pipe	Circular	2,357,023.00	2,149,316	1,349,470	1,007,553	799,847	5.75	0.65	0.45						
J_E1445_DSN	J_1919	879.22	J_1918	878.30	0.0028	327	15 inch	0.013	Vitrified Clay Pipe	Circular	2,213,099.00	2,213,099	1,349,470	863,629	863,629	3.09	0.70	0.65						
J_E1492_DSN	J_2069	704.53	J_2024	700.82	0.0038	975	24 inch	0.013	Vitrified Clay Pipe	Circular	9,018,725.00	9,018,725	6,985,875	2,032,850	2,032,850	4.45	1.32	1.61						
J_E1516_DSN	J_2070	705.95	J_2069	704.53	0.0092	155	21 inch	0.013	Vitrified Clay Pipe	Circular	9,801,524.00	8,937,791	6,985,875	2,815,649	1,951,916	5.78	1.23	1.32	160	283.4				
J_E1517_DSN	J_2071	710.05	J_2070	705.95	0.0092	445	21 inch	0.013	Vitrified Clay Pipe	Circular	9,829,405.00	8,963,215	6,375,707	3,453,698	2,587,508	5.63	1.17	1.23						
J_E1518_DSN	J_2072	717.97	J_2071	710.05	0.0136	583	21 inch	0.013	Vitrified Clay Pipe	Circular	11,935,582.00	10,883,791	6,375,707	5,559,875	4,508,084	6.79	1.17	0.91						
J_E1519_DSN	J_2074	730.18	J_2072	717.97	0.0089	1372	21 inch	0.013	Vitrified Clay Pipe	Circular	9,660,421.00	8,809,123	6,375,707	3,284,715	2,433,416	6.21	1.17	1.04	160	427.4				
J_E1530_DSN	J_001	730.87	J_2074	730.18	0.0020	344	24 inch	0.013	Vitrified Clay Pipe	Circular	6,547,957.00	6,547,957	5,399,831	1,148,126	1,148,126	4.01	1.37	1.17						
J_E1531_DSN	J_002	731.07	J_001	730.87	0.0056	36	24 inch	0.013	Vitrified Clay Pipe	Circular	10,897,434.00	9,937,127	5,399,831	5,497,603	4,537,296	4.00	1.17	1.37						
J_E1532_DSN	J_003	733.80	J_002	731.07	0.0087	314	18 inch	0.013	Vitrified Clay Pipe	Circular	6,330,048.00	5,772,230	5,399,831	930,218	372,399	5.77	1.12	1.17						
J_E1533_DSN	J_2098	738.58	J_003	733.80	0.0124	385	18 inch	0.013	Vitrified Clay Pipe	Circular	7,564,393.00	6,897,802	5,399,831	2,164,563	1,497,971	6.55	1.12	0.94						
J_E1534_DSN	J_2090	742.17	J_2098	738.58	0.0124	290	18 inch	0.013	Vitrified Clay Pipe	Circular	7,553,335.00	6,887,718	5,399,831	2,153,504	1,487,887	6.55	1.12	0.94						
J_E1535_DSN	J_2091	748.19	J_2090	742.17	0.0086	700	18 inch	0.013	Vitrified Clay Pipe	Circular	6,295,638.00	5,740,852	5,399,831	895,807	341,021	6.05	1.12	1.07						
J_E1536_DSN	J_2092	757.67	J_2091	748.19	0.0141	672	18 inch	0.013	Vitrified Clay Pipe	Circular	8,063,249.00	7,352,697	5,399,831	2,663,418	1,952,866	6.74	1.12	0.90	160	497.1				
J_E1579_DSN	J_2150	767.14	J_2092	757.67	0.0135	702	18 inch	0.013	Vitrified Clay Pipe	Circular	7,884,914.00	7,190,077	4,628,482	3,256,432	2,561,595	5.28	1.04	1.12						
J_E1580_DSN	J_2149	770.16	J_2150	767.14	0.0045	670	21 inch	0.013	Vitrified Clay Pipe	Circular	6,875,137.00	6,875,137	4,628,482	2,246,656	2,246,656	4.79	1.05	1.04	160	516.9				
J_E1581	J_2151	783.69	J_2149	770.16	0.0224	604	15 inch	0.013	Vitrified Clay Pipe	Circular	6,248,431.00	5,697,605	3,193,910	3,054,520	2,503,694	4.85	0.90	1.05						
J_E1582	J_1848	788.60	J_2151	783.69	0.0077	638	15 inch	0.013	Vitrified Clay Pipe	Circular	3,662,444.00	3,339,701	3,193,910	468,533	145,790	5.21	0.90	0.90						
J_N1081	J_1142	959.10	J_1141	951.33	0.0250	311	8 inch	0.013	Vitrified Clay Pipe	Circular	1,234,433.00	617,216	492,867	741,566	124,350	4.26	0.41	0.29						
J_N1082	J_1143	969.12	J_1142	959.10	0.0318	315	8 inch	0.013	Vitrified Clay Pipe	Circular	1,392,886.00	696,443	492,867	900,020	203,577	4.50	0.41	0.27						
J_N1083	J_1144	976.46	J_1143	969.12	0.0233	315	8 inch	0.013	Vitrified Clay Pipe	Circular	1,192,147.00	596,074	492,867	699,281	103,207	4.20	0.41	0.30						
J_N1085	J_1146	978.94	J_1144	976.46	0.0040	621	8 inch	0.013	Vitrified Clay Pipe	Circular	493,534.00	246,767	492,867	667	-246,100	2.93	0.55	0.41	160	222.867	8 inch	621		
J_N1191	J_1141	951.33	J_1311	923.21	0.0296	950	8 inch	0.013	Vitrified Clay Pipe	Circular	1,343,640.00	671,820	492,867	850,774	178,953	4.43	0.41	0.28						
J_N1192_DSN	J_1311	923.21	J_1310	920.16	0.0058	525	10 inch	0.013	Vitrified Clay Pipe	Circular	1,079,280.00	539,640	492,867	586,413	46,773	2.86	0.40	0.43						
J_N1193_DSN	J_1310	920.16	J_1308	917.45	0.0045	603	10 inch	0.013	Vitrified Clay Pipe	Circular	949,270.00	474,635	492,867	456,403	-18,232	2.35	0.43	0.55			10 inch	603		
J_N1194_DSN	J_1308	917.45	J_1309	912.51	0.0071	696	10 inch	0.013	Vitrified Clay Pipe	Circular	1,192,951.00	1,087,826	930,432	262,519	157,394	3.81	0.55	0.54	160	222.867				
J_N1196_DSN	J_1309	912.51	J_1335	905.26	0.0106	684	10 inch	0.013	Vitrified Clay Pipe	Circular	1,457,823.00	1,329,356	930,432	527,391	398,924	4.13	0.54	0.48						
J_N1371_DSN	J_1564	896.55	J_1553	887.03	0.0140	680	10 inch	0.013	Vitrified Clay Pipe	Circular	1,675,436.00	1,527,793	930,432	745,004	597,361	3.26	0.54	0.85						
J_N1372_DSN	J_1553	887.03	J_1552	886.64	0.0016	240	15 inch	0.013	Vitrified Clay Pipe	Circular	1,682,935.00	1,682,935	1,349,470	333,465	333,465	2.35	0.85	0.85	160	222.867				
J_N1406_DSN	J_1335	905.26	J_1564	896.55	0.0126	691	10 inch	0.013	Vitrified Clay Pipe	Circular	1,589,769.00	1,449,674	930,432	659,337	519,242	4.28	0.54	0.46						
J_N1564	J_1886	853.21	J_1874	852.26	0.0044	216	15 inch	0.013	Vitrified Clay Pipe	Circular	2,768,697.00	2,768,697	2,063,066	705,631	705,631	4.10	0.80	0.72	160	40.3				
J_N1657_DSN	J_2024	700.82	J_2465	698.42	0.0030	798	30 inch	0.013	Vitrified Clay Pipe	Circular	14,537,555.00	14,537,555	10,821,394	3,716,161	3,716,161	5.51	1.61	1.38						
J_N1901_DSN	J_2463	691.95	J_2462	691.48	0.0022	212	30 inch	0.013	Vitrified Clay Pipe	Circular	12,481,540.00	12,481,540	10,821,394	1,660,147	1,660,147	4.35	1.81	1.84						
J_N1907_DSN	J_2461	691.02	J_2460	688.66	0.0056	421	30 inch	0.013	Vitrified Clay Pipe	Circular	19,847,332.00	18,098,339	11,703,631	8,143,701	6,394,708	5.14	1.44	2.11						
J_N1908_DSN	J_2462	691.48	J_2461	691.02	0.0022	210	30 inch	0.013	Vitrified Clay Pipe	Circular	12,406,705.00	12,406,705	11,703,631	703,074	703,074	5.43	1.84	1.44	160	520.5				
J_N1910_DSN	J_2464	693.32	J_2463	691.95	0.0022	623	30 inch	0.013	Vitrified Clay Pipe	Circular	12,430,925.00	12,430,925	10,821,394	1,609,531	1,609,531	4.40	1.80	1.81						
J_N1911_DSN	J_2465	698.42	J_2464	693.32	0.0077	663	30 inch	0.013	Vitrified Clay Pipe	Circular	23,249,601.00	21,200,793	10,821,394	12,428,208	10,379,399	5.21	1.38	1.80						
P_E2065	P_3251	755.45	P_3228	728.45	0.0450	600	8 inch	0.013	Vitrified Clay Pipe	Circular	1,656,698.00	828,349	182,534	1,474,164	645,815	3.62	0.25	0.15						
P_E2067	P_3253	772.31	P_3251	755.45	0.0273	618	8 inch	0.013	Vitrified Clay Pipe	Circular	1,289,946.00	644,973	182,534	1,107,413	462,439	3.23	0.25	0.17	160	61				
P_E2182_DSN	P_3451	689.65	P_3449	686.69	0.0090	329	15 inch	0.013	Vitrified Clay Pipe	Circular	3,959,938.00	3,610,980	1,200,257	2,759,682	2,410,723	3.37	0.54	0.61						
P_E2184_DSN	P_3453	690.97	P_3451	689.65	0.0020	660	15 inch	0.013	Vitrified Clay Pipe	Circular	1,867,048.00	1,702,520	1,200,257	666,791	502,263	3.07	0.73	0.54	160	475.8				
P_E2186_DSN	P_3471	693.74	P_3453	690.97	0.0028	989	12 inch	0.013	Vitrified Clay Pipe	Circular	1,218,584.00	1,111,200	800,248	418,336	310,952	2.29	0.59	0.73						
P_E2202	P_3228	728.45	P_3224	719.08	0.0100	940	8 inch	0.013	Vitrified Clay Pipe	Circular	779,728.00	389,864	182,534	597,194	207,330	2.62	0.25	0.22						
P_E2206_DSN	P_3473	701.17	P_3471	693.74	0.0203	366	12 inch	0.013	Vitrified Clay Pipe	Circular	3,280,709.00	2,991,605	800,248	2,480,461	2,191,357	2.99	0.47	0.59						
P_E2208_DSN	P_3477	704.10	P_3474	701.51	0.0038	681	12 inch	0.013	Vitrified Clay Pipe	Circular	1,420,006.00	1,294,872	800,248	619,758	494,624	2.72	0.54	0.59	160	275.2				
P_E2211	P_3483	705.74	P_3477	704.10	0.0040	411	8 inch	0.013	Vitrified Clay Pipe	Circular	493,331.00	246,665	182,534	310,797	64,131	1.48	0.28	0.54						
P_N2473_DSN	P_3449	686.69	J_DSN-520	682.96	0.0057	654	15 inch	0.013	Vitrified Clay Pipe	Circular	3,153,859.00	2,875,933	1,514,564	1,639,295	1,361,370	3.93	0.61	0.61						
P_N2489_DSN	P_3474	701.51	P_3473	701.17	0.0028	122	12 inch	0.013	Vitrified Clay Pipe	Circular	1,215,552.00	1,108,434	800,248	415,303	308,186	2.99	0.59	0.47						
P_N2498	P_3224	719.08	P_3482	715.22	0.0072	537	8 inch	0.013	Vitrified Clay Pipe	Circular	662,131.00	331,065	182,534	479,597	148,531	2.46	0.25	0.24						
P_N2499	P_3482	715.22	P_3483	705.74	0.0600	158	8 inch	0.013	Vitrified Clay Pipe	Circular	1,912,990.00	956,495	182,534	1,730,456	773,961	2.22	0.25	0.28						
PC_DSN-300	J_3083	642.60	B_DSN-900	641.00	0.0013	1273	18 inch	0.013	Vitrified Clay Pipe	Circular	2,406,780.00	2,194,689	839,681	1,567,099	1,355,008	1.99	0.61	0.58						
PC_E2006	J_3139	646.43	J_3138	645.88	0.0038	145	21 inch	0.013	Vitrified Clay Pipe	Circular	6,312,583.00	5,756,303	785,569	5,527,014	4,970,735	2.73	0.42	0.42						
PC_E2007	J_3141	650.52	J_3139	646.43	0.0109	375	21 inch	0.013	Vitrified Clay Pipe	Circular	10,691,251.00	9,749,114	785,569	9,905,683	8,963,545	2.88	0.39	0.42	160	170				
PC_N2010	J_3142	653.05	J_3141	650.52	0.0192	132	21 inch	0.013	Vitrified Clay Pipe	Circular	14,183,581.00	12,933,691	758,369	13,425,213	12,175,323	2.92	0.39	0.39						
PC_N2286_A	NODE	644.24	J_3083	642.60	0.0038	431	21 inch	0.013	Vitrified Clay Pipe	Circular	6,321,057.00	5,764,031	839,681	5,481,376	4,924,350	2.28	0.43	0.61	160	169.1				
PC_N2286_B	J_3138	645.88	NODE	644.24	0.0038	431	21 inch	0.013	Vitrified Clay Pipe	Circular	6,311,041.00	5,754,897	812,625	5,498,416	4,942,273	2.76	0.42	0.43	160	169.1				
W_N4162	W_4283	743.02	W_4292	740.02	0.0040	749	15 inch	0.013	Vitrified Clay Pipe	Circular	2,642,167.00	2,409,333	1,581,751	1,060,415	827,582	3.47	0.70	0.70	100	200				
W_N4163	W_4292	740.02	W_4294	738.67	0.0040	337	15 inch	0.013	Vitrified Clay Pipe	Circular	2,642,363.00	2,409,512	1,591,751	1,050,611	817,760	3.72	0.70	0.63	100	100				
W_N4165	W_4294	738.67	W_4295	733.92	0.0060	792	15 inch	0.013	Vitrified Clay Pipe	Circular	3,233,142.00	2,948,230	1,611,751	1,621,390	1,336,478	4.00	0.63	0.63	100	200				
W_N4166	W_4295	733.92	W_7296	730.56	0.0084	400	15 inch	0.013	Vitrified Clay Pipe	Circular	3,826,310.00	3,489,127	1,621,751	2,204,559	1,867,375	4.00	0.63	0.64	100	100				
W_N4167	W_7296	730.56	W_4305	722.40	0.0204	400	15 inch	0.013	Vitrified Clay Pipe	Circular	5,962,874.00	5,437,412	1,631,751	4,331,122	3,805,660	3.19	0.64	1.02	100	100				
W_N4175	W_4305	722.40	W_4317	708.01	0.0088	1636	18 inch	0.013	Vitrified Clay Pipe	Circular	6,366,918.00	5,805,851	4,460,814	1,906,104	1,345,036	5.72	1.02	0.93	100	300				
W_N4176	W_4317	708.01	W_4318	704.50	0.0088	400	24 inch	0.013	Vitrified Clay Pipe	Circular	13,695,694.00	12,488,798	4,470,814	9,224,880	8,017,984	3.93	0.93	1.36	100	100				
W_N4181	W_4318	704.50	W_4323	700.08	0.0024	1837	24 inch	0.013	Vitrified Clay Pipe	Circular	7,171,616.00	6,539,637	5,768,739	1,402,878	770,898	4.16	1.36	1.23	100	100				
W_N4182	W_4323	700.08	W_SARI_CONNI	700.00	0.0024	33	24 inch	0.013	Vitrified Clay Pipe	Circular	7,198,608.00	6,564,250	5,768,739	1,429,869	795,511	4.81	1.23	1.07						

Appendix S
Design JCSD Sewer System with Flows From Projected Ultimate Land Use
By Tributary Drainage Area

Label	8-inch Full Flow Failure	10-inch Full Flow Failure	12-inch Full Flow Failure	15-inch Full Flow Failure	18-inch Full Flow Failure	21-inch Full Flow Failure	24-inch Full Flow Failure	30-inch Full Flow Failure	36-inch Full Flow Failure	39-inch Full Flow Failure	42-inch Full Flow Failure	8-inch Design Cap. Failure	10-inch Design Cap. Failure	12-inch Design Cap. Failure	15-inch Design Cap. Failure	18-inch Design Cap. Failure	21-inch Design Cap. Failure	24-inch Design Cap. Failure	30-inch Design Cap. Failure	36-inch Design Cap. Failure	39-inch Design Cap. Failure	42-inch Design Cap. Failure	8-inch Totals	10-inch Totals	12-inch Totals	15-inch Totals	18-inch Totals	21-inch Totals	24-inch Totals	30-inch Totals	36-inch Totals	39-inch Totals	42-inch Totals
B_65-39B																											2957						
B_DSN-800																											87						
B_DSN_820																														1333			
B_E1459																672											672						
B_E1628																300											300						
B_E1638																											291						
B_E1680																											369						
B_E3269																											230						
B_N1223																									350								
B_N1225																									713								
B_N1235																									1774								
B_N1844																997.5											997.5						
B_N1847																457											457						
B_N1849																1211											1211						
B_N1855																											335						
B_N2041																											660						
B_N2042																											659						
B_N2043																											177						
B_N2044																											148						
B_N2045																											325						
B_N2280-DSN																											654						
B_N2281																665											665						
B_N2282																											660						
B_N4334																2230											2230						
E_E3360																												134					
E_N1212																												1806					
E_N1426																												1964					
E_N1427																												376					
E_N1428																												335					
E_N1598																												1013					
E_N4436																													759.5				
G_97-0261_DSN																									61								
G_DSN-600																									319								
G_DSN-620																								381									
G_DSN-650																									834								
G_DSN-705																									1429								
G_DSN-710																									1400								
G_DSN-712																								1016									
G_DSN-714																								1347									
G_DSN-715																								1277									
G_E1120																							484										
G_E1175												265											265										
G_E1178												221											221										
G_E1283												102											102										
G_E1291																								165									
G_E1307_DSN																									1684								
G_E1490_DSN																												583					
G_N1177																								379									
G_N1266												651											651										
G_N1268												1318											1318										
G_N1269												686											686										
G_N1458_DSN																									795								
G_N1460_DSN																										2275							
G_N1641_DSN															1395											1395							
G_N1643_DSN																											837						
G_N1644_DSN																										478							
H_N4082																									665								
H_N4086																									1350								
H_N4087																									295								
H_N4089																									706								

Appendix S
Design JCSD Sewer System with Flows From Projected Ultimate Land Use
By Tributary Drainage Area

Label	8-inch Full Flow Failure	10-inch Full Flow Failure	12-inch Full Flow Failure	15-inch Full Flow Failure	18-inch Full Flow Failure	21-inch Full Flow Failure	24-inch Full Flow Failure	30-inch Full Flow Failure	36-inch Full Flow Failure	39-inch Full Flow Failure	42-inch Full Flow Failure	8-inch Design Cap. Failure	10-inch Design Cap. Failure	12-inch Design Cap. Failure	15-inch Design Cap. Failure	18-inch Design Cap. Failure	21-inch Design Cap. Failure	24-inch Design Cap. Failure	30-inch Design Cap. Failure	36-inch Design Cap. Failure	39-inch Design Cap. Failure	42-inch Design Cap. Failure	8-inch Totals	10-inch Totals	12-inch Totals	15-inch Totals	18-inch Totals	21-inch Totals	24-inch Totals	30-inch Totals	36-inch Totals	39-inch Totals	42-inch Totals
H_N4091																									1050								
H_N4092																									289								
H_N4098																									1280								
H_N4099																									400								
H_N4100																									400								
H_N4101																										400							
H_N4103																										800							
H_N4111																										3230							
H_N4113																											800						
H_N4114																											400						
H_N4119																												1564					
H_N4120																												100					
I_2362																										1368							
I_E2040																										316							
I_E2041																										940							
I_E2049																									223								
I_E2050																									450								
I_E2051																									450								
I_E2052																									450								
I_E2056																										612							
I_E2058																										352							
I_E2059																										345							
I_E2069																									1365								
I_E2094																									58								
I_E2219																									255								
I_N2046																										647							
I_N2371														85											85								
I_N2399												136											136										
I_N2523																									265								
I_N2524																									468								
I_N2527																									143								
I_N2528																									209								
I_WRF																									580								
J_DSN-400																																	539
J_DSN-410																																	523
J_DSN-415																																	1400
J_DSN-420																																	1827
J_DSN-425																																	971
J_DSN-430																																	417
J_DSN-435																																745	
J_DSN-440																																1159	
J_DSN-445																																629	
J_DSN-450																															1310		
J_DSN-455																															657		
J_DSN-460																															750		
J_DSN-465																															1230		
J_DSN_405																																	138
J_E1242_DSN																									1150								
J_E1245_DSN																										1050							
J_E1392																										286							
J_E1393																										312							
J_E1394																										337							
J_E1395																										571							
J_E1396																										729							
J_E1397																										608							
J_E1410_DSN																											566						
J_E1411																										716							
J_E1413																										186							
J_E1414																										233							
J_E1423																								422									
J_E1424_DSN																									483								

Appendix S
Design JCSD Sewer System with Flows From Projected Ultimate Land Use
By Tributary Drainage Area

Label	8-inch Full Flow Failure	10-inch Full Flow Failure	12-inch Full Flow Failure	15-inch Full Flow Failure	18-inch Full Flow Failure	21-inch Full Flow Failure	24-inch Full Flow Failure	30-inch Full Flow Failure	36-inch Full Flow Failure	39-inch Full Flow Failure	42-inch Full Flow Failure	8-inch Design Cap. Failure	10-inch Design Cap. Failure	12-inch Design Cap. Failure	15-inch Design Cap. Failure	18-inch Design Cap. Failure	21-inch Design Cap. Failure	24-inch Design Cap. Failure	30-inch Design Cap. Failure	36-inch Design Cap. Failure	39-inch Design Cap. Failure	42-inch Design Cap. Failure	8-inch Totals	10-inch Totals	12-inch Totals	15-inch Totals	18-inch Totals	21-inch Totals	24-inch Totals	30-inch Totals	36-inch Totals	39-inch Totals	42-inch Totals
J_E1425_DSN																									416								
J_E1444																								222									
J_E1445_DSN																										327							
J_E1492_DSN																													975				
J_E1516_DSN																												155					
J_E1517_DSN																												445					
J_E1518_DSN																												583					
J_E1519_DSN																												1372					
J_E1530_DSN																													344				
J_E1531_DSN																													36				
J_E1532_DSN																											314						
J_E1533_DSN																											385						
J_E1534_DSN																											290						
J_E1535_DSN																											700						
J_E1536_DSN																											672						
J_E1579_DSN																											702						
J_E1580_DSN																												670					
J_E1581																										604							
J_E1582																										638							
J_N1081																							311										
J_N1082																							315										
J_N1083																							315										
J_N1085												621											621										
J_N1191																							950										
J_N1192_DSN																								525									
J_N1193_DSN													603											603									
J_N1194_DSN																								696									
J_N1196_DSN																								684									
J_N1371_DSN																								680									
J_N1372_DSN																										240							
J_N1406_DSN																								691									
J_N1564																										216							
J_N1657_DSN																														798			
J_N1901_DSN																														212			
J_N1907_DSN																														421			
J_N1908_DSN																														210			
J_N1910_DSN																														623			
J_N1911_DSN																														663			
P_E2065																							600										
P_E2067																							618										
P_E2182_DSN																										329							
P_E2184_DSN																										660							
P_E2186_DSN																									989								
P_E2202																							940										
P_E2206_DSN																									366								
P_E2208_DSN																									681								
P_E2211																							411										
P_N2473_DSN																										653.59							
P_N2489_DSN																									122								
P_N2498																							537										
P_N2499																							158										
PC_DSN-300																											1273						
PC_E2006																												145					
PC_E2007																												375					
PC_N2010																												132					
PC_N2286_A																												431					
PC_N2286_B																												431					
W_N4162																										749							
W_N4163																										337							
W_N4165																										792							
W_N4166																										400							
W_N4167																										400							
W_N4175																											1636						
W_N4176																													400				
W_N4181																													1837				
W_N4182																													33				

APPENDIX T

DESIGN JCSD SEWER SYSTEM STATISTICAL ANALYSIS

Appendix T
Design JCSD Sewer System
Statistical Analysis

Statiscal Analysis by Failure

	Design	Full
Failure Length (ft):	12,616	0
Length Modeled (ft):	124,474	124,474
	10%	0%

Statiscal Analysis by Total JCSD Sewer System (Excluding Eastvale & Sky Country

Pipe Size	8 inch	10 inch	12 inch	15 inch	18 inch	21 inch	24 inch	30 inch	36 inch	39 inch	42 inch
Total Length Per Pipe Size	9,639	9,088	16,438	33,096	22,660	12,614	4,385	4,260	3,947	2,533	5,815
Percentage Per Pipe Size	8%	7%	13%	27%	18%	10%	4%	3%	3%	2%	5%
Design Capacity Failure Lengths	4,000	603	85	1,395	6,533	0	0	0	0	0	0
Percentage Design Capacity Failures[1]	3.21%	0.48%	0.07%	1.12%	5.25%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Full Flow Failure Lengths	0	0	0	0	0	0	0	0	0	0	0
Percentage Full Flow Failures[2]	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Total Modeled Length	124,474	124,474	124,474	124,474	124,474	124,474	124,474	124,474	124,474	124,474	124,474

Statistical Analysis by of Pipe Sizes per Trunk System

Trunk System Totals:	Total Length	8 inch (ft / %)[3]		10 inch (ft / %)[3]		12 inch (ft / %)[3]		15 inch (ft / %)[3]		18 inch (ft / %)[3]		21 inch (ft / %)[3]		24 inch (ft / %)[3]		30 inch (ft / %)[3]		36 inch (ft / %)[3]		39 inch (ft / %)[3]		42 inch (ft / %)[3]		Check Sum	
Bain Trunk System	18,255	0	0%	0	0%	0	0%	2,837	16%	14,085	77%	0	0%	0	0%	1,333	7%	0	0%	0	0%	0	0%	18,255	100%
Etiwanda Avenue Trunk (CFD)	6,388	0	0%	0	0%	0	0%	0	0%	0	0%	5,628	88%	760	12%	0	0%	0	0%	0	0%	0	0%	6,388	100%
Glen Avon Area Trunk	20,382	3,727	18%	4,565	22%	795	4%	9,875	48%	837	4%	583	3%	0	0%	0	0%	0	0%	0	0%	0	0%	20,382	100%
Hamner Avenue Trunk (CFD)	13,729	0	0%	0	0%	6,435	47%	4,430	32%	1,200	9%	1,664	12%	0	0%	0	0%	0	0%	0	0%	0	0%	13,729	100%
Indian Hills WRF Overflow Line	9,717	136	1%	0	0%	5,001	51%	4,580	47%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	9,717	100%
Jurupa Trunk System	39,568	2,512	6%	4,523	11%	2,049	5%	7,053	18%	3,629	9%	3,225	8%	1,355	3%	2,927	7%	3,947	10%	2,533	6%	5,815	15%	39,568	100%
Pedley Area Trunk	7,065	3,264	46%	0	0%	2,158	31%	1,643	23%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	7,065	100%
Pyrite Creek Area Trunk	2,787	0	0%	0	0%	0	0%	0	0%	1,273	46%	1,514	54%	0	0%	0	0%	0	0%	0	0%	0	0%	2,787	100%
Wineville Road Trunk (CFD)	6,584	0	0%	0	0%	0	0%	2,678	41%	1,636	25%	0	0%	2,270	34%	0	0%	0	0%	0	0%	0	0%	6,584	100%
Check Total:	124,474	9,639		9,088		16,438		33,096		22,660		12,614		4,385		4,260		3,947		2,533		5,815		124,474	

Statistical Analysis by Design Capacity Failures per pipe size at Respective Trunk System (0.75 < D/d < 1.0)

Trunk System Totals:	Total Length	8 inch (ft / %)[4]		10 inch (ft / %)[4]		12 inch (ft / %)[4]		15 inch (ft / %)[4]		18 inch (ft / %)[4]		21 inch (ft / %)[4]		24 inch (ft / %)[4]		30 inch (ft / %)[3]		36 inch (ft / %)[3]		39 inch (ft / %)[3]		42 inch (ft / %)[3]		Check Sum	
Bain Trunk System	18,255	0	0%	0	0%	0	0%	0	0%	6,533	36%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	6,533	36%
Etiwanda Avenue Trunk (CFD)	6,388	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%
Glen Avon Area Trunk	20,382	3,243	16%	0	0%	0	0%	1,395	7%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	4,638	23%
Hamner Avenue Trunk (CFD)	13,729	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%
Indian Hills WRF Overflow Line	9,717	136	1%	0	0%	85	1%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	221	2%
Jurupa Trunk System	39,568	621	2%	603	2%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	1,224	3%
Pedley Area Trunk	7,065	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%
Pyrite Creek Area Trunk	2,787	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%
Wineville Road Trunk (CFD)	6,584	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%
Check Total:	124,474	4,000		603		85		1,395		6,533		0		0		0		0		0		0		12,616	

Statistical Analysis by Full Flow Failures per pipe size at Respective Trunk System (D/d > 1.0)

Trunk System Totals:	Total Length	8 inch (ft / %)[5]		10 inch (ft / %)[5]		12 inch (ft / %)[5]		15 inch (ft / %)[5]		18 inch (ft / %)[5]		21 inch (ft / %)[5]		24 inch (ft / %)[5]		30 inch (ft / %)[3]		36 inch (ft / %)[3]		39 inch (ft / %)[3]		42 inch (ft / %)[3]		Check Sum	
Bain Trunk System	18,255	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%
Etiwanda Avenue Trunk (CFD)	6,388	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%
Glen Avon Area Trunk	20,382	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%
Hamner Avenue Trunk (CFD)	13,729	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%
Indian Hills WRF Overflow Line	9,717	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%
Jurupa Trunk System	39,568	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%
Pedley Area Trunk	7,065	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%
Pyrite Creek Area Trunk	2,787	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%
Wineville Road Trunk (CFD)	6,584	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%
Check Total:	124,474	0		0		0		0		0		0		0		0		0		0		0		0	

Notes:
1. This percentage is based on the length of pipe failures within a particular size category vs. the total modeled length.
2. This percentage is based on the total length within a particular size category vs. the total modeled length.
3. This percentage is based on the length of pipe withing a size category in the respective trunk sewer.
4. This percentage is based on the length of pipe with a design capacity failure in that size category within the respective trunk sewer.
5. This percentage is based on the length of pipe with a full flow failure in that size category within the respective trunk sewer.

APPENDIX U

INVENTORY OF DESIGN CAPACITY FAILURES

Appendix U
Inventory of Design Capacity Failures (0.75 < D/d < 1.0)

Bain Street Trunk Sewer System

Label	Length (ft)	Section Size	Full Capacity (gpd)	Design Capacity (gpd)	Total Flow (gpd)	Excess Full Capacity (gpd)	Excess Design Capacity (gpd)
B_E1459	672	18 inch	3,722,045	3,394,049	3,578,651	143,394	-184,601
B_E1628	300	18 inch	3,718,358	3,390,687	3,578,651	139,707	-187,963
B_N1844	998	18 inch	3,716,804	3,389,271	3,578,651	138,154	-189,380
B_N1847	457	18 inch	3,730,542	3,401,798	3,578,651	151,892	-176,852
B_N1849	1211	18 inch	3,716,822	3,389,287	3,578,651	138,171	-189,363
B_N2281	665	18 inch	4,552,137	4,150,992	4,295,027	257,109	-144,035
B_N4334	2230	18 inch	3,718,358	3,390,687	3,578,651	139,707	-187,963

Glen Avon Trunk Sewer System

Label	Length (ft)	Section Size	Full Capacity (gpd)	Design Capacity (gpd)	Total Flow (gpd)	Excess Full Capacity (gpd)	Excess Design Capacity (gpd)
G_E1175	265	8 inch	377,755	188,877	375,730	2,025	-186,852
G_E1178	221	8 inch	460,985	230,492	375,730	85,255	-145,237
G_E1283	102	8 inch	489,066	244,533	414,402	74,664	-169,869
G_N1266	651	8 inch	457,087	228,544	375,730	81,358	-147,186
G_N1268	1318	8 inch	548,449	274,224	375,730	172,719	-101,505
G_N1269	686	8 inch	683,861	341,931	414,402	269,459	-72,471
G_N1641_DSN	1395	15 inch	1,669,190	1,522,097	1,603,623	65,567	-81,526

Indian Hills WRF Overflow Line

Label	Length (ft)	Section Size	Full Capacity (gpd)	Design Capacity (gpd)	Total Flow (gpd)	Excess Full Capacity (gpd)	Excess Design Capacity (gpd)
I_N2371	85	12 inch	1,559,684	1,422,241	1,491,771	67,913	-69,530
I_N2399	136	8 inch	444,216	222,108	431,244	12,971	-209,137

Jurupa Trunk Sewer System

Label	Length (ft)	Section Size	Full Capacity (gpd)	Design Capacity (gpd)	Total Flow (gpd)	Excess Full Capacity (gpd)	Excess Design Capacity (gpd)
J_N1085	621	8 inch	493,534	246,767	492,867	667	-246,100
J_N1193_DSN	603	10 inch	949,270	474,635	492,867	456,403	-18,232

APPENDIX V

PROJECTED ULTIMATE LAND USE AND AVERAGE DAILY FLOW BY TRIBUTARY DRAINAGE AREA (FOR ULTIMATE WASTEWATER PROPOSED PLANT 1 EXPANSION PUMPING CAPACITY)

Appendix V. Projected Ultimate Land Use and Average Daily Flow
By Tributary Drainage Area (For Ultimate Wastewater Plant 2 Pumping Capacity)

Tributary Drainage Area No.[1]	Area (ac)	Residential[2]												Commercial			Industrial[4]				Comm/Ind	Schools		City Overlay	Conservation	Conservation	Open Space				Agricultural	Highway	Total
		Rural Residential (<0.2 du/ac)	Very Low Density (0.4-2 du/ac)	SP125-W (2du/ac)	Low Density (2-5 du/ac)	Medium Density (5-8 du/ac)	Med-High Density (8-14 du/ac)	High Density (14-20 du/ac)	# of edu's	Proposed Developments Tract Number	Proposed Developments Area (ac)	Proposed Developments du's	Total # of edu's	Q_{ADF}[3] (gpd)	Retail (ac)	Office (ac)	Community Centers (ac)	Light (ac)	Heavy (ac)	Business Park (ac)	Public Facilities (ac)	Q_{ADF}[5] (gpd)	No. of Students (each)	Q_{ADF}[7] (gpd)	(ac)	(ac)	Habitat (ac)	Recreation (ac)	Rural (ac)	Water (ac)	Mineral Resources (ac)	(ac)	(ac)	Q_{ADF} (gpd)
Existing JCSD Areas																																	
J1	668.6		316.0		203.8	9.3			1,512				1,512	423,360								0								108.9			423,360
J2	129.3		109.3		12.8				270				270	75,600	7.2							3,600											79,200
J3	483.1		300.6		132.1				1,129				1,129	316,120								0	715	7,150		38.2	1.7						323,270
J4	340.3		187.1		70.7				657				657	183,960	41.3							20,650								16.0		20.2	204,610
J5	381.7	7.4	60.3		136.2	27.9			862				862	241,360	25.4							12,700	3,000	75,000				41.9				31.6	329,060
J6	516.9		163.1		57.5				556				556	155,680	15.3							7,650	741	7,410						24.4		33.2	170,740
J7	427.4		196.5		79.6	1.7			723				723	202,440	40.7							20,350						0.3				27.0	222,790
J8	283.4		133.7		34.3	47.8	2.1		764				764	213,920	16.5							8,250	1,909	24,590				9.6					246,760
J9	569.7		141.1		62.7	10.0	4.2		653				653	182,840	43.6					278.2		160,875											343,715
J10A	213.9		155.9						312				312	87,360	29.2			0.8		1.2		15,610	1,321	19,815				1.8					122,785
J10B	454.1		372.0						744				744	208,320	57.1			1.8		2.4		30,640	707	7,070				3.9					246,030
J11	520.5		408.4						817				817	228,760	4.2					80.4		42,300	657	6,570		17.2		0.6					277,630
J12	275.3		272.8						546				546	152,880	2.4					0.1		1,250											154,130
J13	275.2		81.2						162				162	45,360	119.2		45.2				9.6	87,000											132,360
J14A	260.5		250.0						500				500	140,000	1.3							674					4.9				4.3		140,674
J14B	338.2		324.5						649				649	181,720	1.8							876					6.3				5.6		182,596
J15A	230.0		187.4						375				375	105,000	20.8							10,423	815	8,150									123,573
J15B	216.0		194.3						389				389	108,920	19.5							9,727											118,647
J17A	61.0								50				50	14,000	1.5							746						10.2					14,746
J19	475.8		242.2			6.0			526				526	147,280	32.4				0.7	17.0		25,050					16.4	75.8		80.3				172,330
J20	163.4		1.7			56.3			397				397	111,160	24.0							12,000						5.1	0.9			29.5	123,160
J21A	138.2		73.0		13.2	2.5			217				217	60,760						2.5		1,237	741	7,410				2.4				13.1	69,407
J21B	241.7		145.0		23.0	4.5			413				413	115,640	32.9					4.3		18,625						4.2				22.8	134,265
J22A	189.8		108.5		12.3				266				266	74,480	22.8			3.7		11.1		18,747	671	6,710					7.1			11.6	99,937
J22B	487.3		306.2		31.7				739				739	206,920	57.5			9.4		28.4		47,703							18.3			29.7	254,623
J23	615.4				192.4	110.4			1,543				1,543	432,040	24.5			213.6				119,050						8.5	7.7			26.3	551,090
													subtotal:	4,415,880							subtotal:	675,732	subtotal:	169,875								Old JCSD Areas Subtotal:		5,261,487
Indian Hills Areas:																																	
J16	614.7								923				923	184,600	0.2							100				19.5		73.6		2.1			184,700
J17B	348.2								811				811	162,200	8.5							4,255						58.2					166,455
													subtotal:	346,800							subtotal:	4,355	subtotal:	0								Indian Hills Areas Subtotal:		351,155
J1-J30	**9,919.5**	**7.4**	**4,730.8**	**0.0**	**1,062.3**	**276.4**	**6.3**	**0.0**	**17,505**				**17,505**	***4,762,680***	**649.8**	**0.0**	**45.2**	**229.3**	**8.7**	**425.6**	**9.6**	***680,087***	**11,277.0**	***169,875***	**0.0**	**74.9**	**29.3**	**296.1**	**34.0**	**82.4**	**149.3**	**9.9**	**245.0**	***5,612,642***

[1] Refer to Plate 1.

[2] Land use designations for tributary areas J1-J30 were determined from Jurupa Area Land Use Plan for the Riverside County Integrated Project, April 2001.
The following densities were used to calculate residential land uses: Rural Residential (0.2 du/ac); Very Low Density (2 du/ac); SP125-W (2du/ac); Low Density (4 du/ac); Medium Density (7 du/ac); Medium-High Density (12 du/ac); High Density (18 du/ac)

[3] Based on 280 gpd/edu and 160 gpd for mobile homes and multi-family units.

[4] Distinction between "light" and "heavy" industrial land use is based on air and noise pollution factors; wastewater generation is assumed equal for both land uses.

[5] Commercial and industrial wastewater flow quantities are based on **500 gpd/ac**. For areas tributary to Plant 1 - deductions were applied the commercial and industrial areas based on existing site conditions totaling 507 acres.

[6] Total number of multi-family units. Converted to edu's by multiplying by 160/280.

[7] Based on type of school and number of students: 10gpd/stu for elementary; 15gpd/stu for middle; 25gpd/stu highschool

	I/I Rate (gpd/ac)		total areas (ac)		I/I Contribution (gpd)
Wet weather is accounted by multiplying the total summation of the total areas by the District Standard Infiltration Rate of 160 gpd / ac:	160	X	9,919	=	**1,587,118**

APPENDIX W

SYSTEM CURVE AND CALCULATIONS FOR PROPOSED FORCEMAIN AND PUMPING REQUIREMENTS

Appendix W. System Curve for Proposed 24-inch Parallel Regional Forcemain

Jurupa Community Services District
JCSD Master Sewer Plan
Plant 3 (Plant 1 Upgrade)
Albert A. Webb Associates

W.O. No.: 01-0171
03/25/03
Designed by: Sinnaro Yos
Checked by: _____

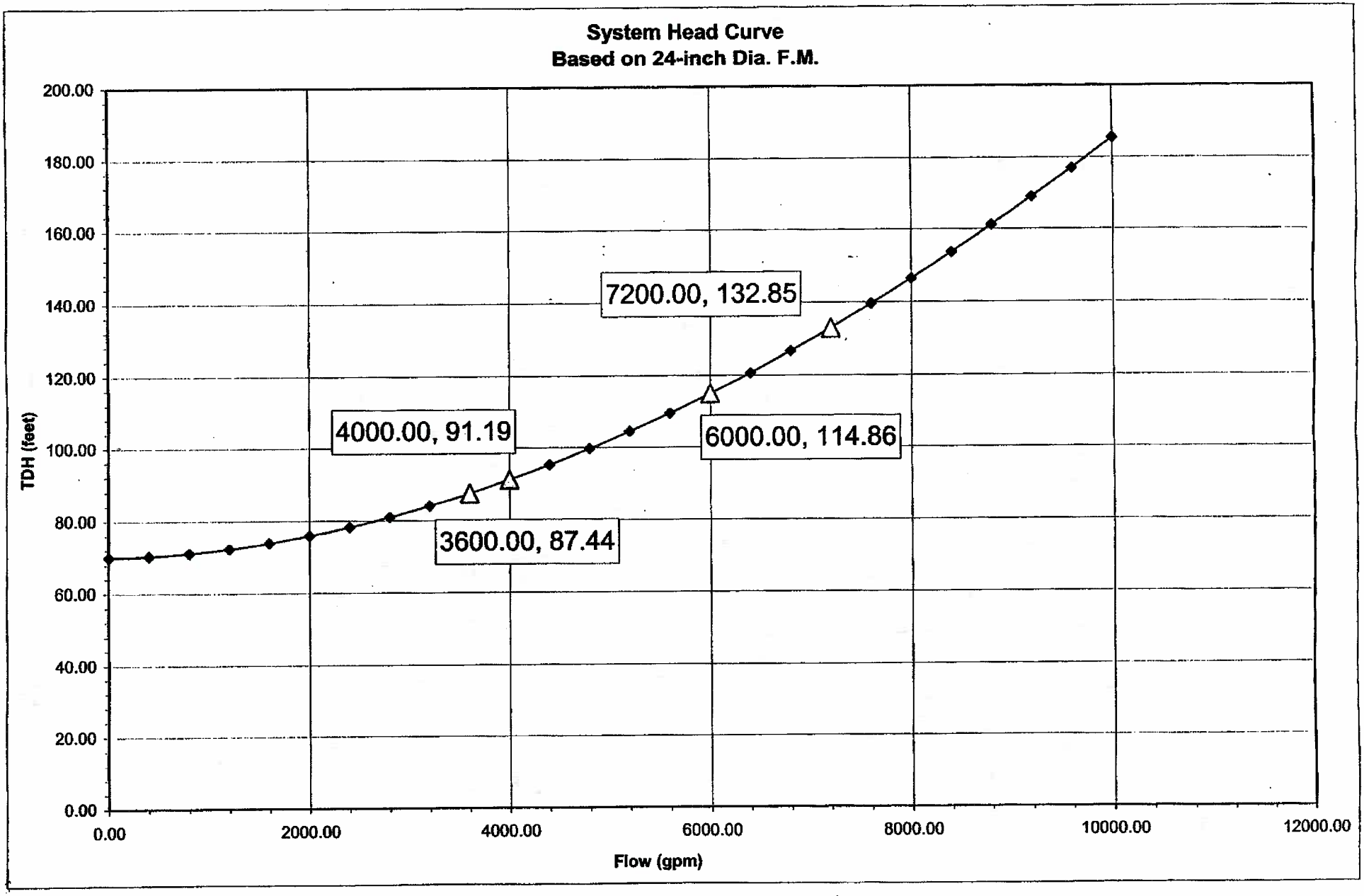
Low Water Elev:	650	
Dischage Elev:	720	
Minor Losses:	50	*(Equivalent Lengths)
C DIP	120	
L DIP (feet)	16000	
d DIP (inch)	24	**

Q (gpm)	H-static (ft)	Head Loss (ft)	TDH-130 (ft)
0.00	70.00	0.00	70.00
400.00	70.00	0.30	70.30
800.00	70.00	1.08	71.08
1200.00	70.00	2.28	72.28
1600.00	70.00	3.89	73.89
2000.00	70.00	5.88	75.88
2400.00	70.00	8.23	78.23
2800.00	70.00	10.95	80.95
3200.00	70.00	14.02	84.02
3600.00	**70.00**	**17.44**	**87.44**
4000.00	**70.00**	**21.19**	**91.19**
4400.00	70.00	25.27	95.27
4800.00	70.00	29.69	99.69
5200.00	70.00	34.43	104.43
5600.00	70.00	39.48	109.48
6000.00	**70.00**	**44.86**	**114.86**
6400.00	70.00	50.55	120.55
6800.00	70.00	56.55	126.55
7200.00	**70.00**	**62.85**	**132.85**
7600.00	70.00	69.47	139.47
8000.00	70.00	76.38	146.38
8400.00	70.00	83.60	153.60
8800.00	70.00	91.11	161.11
9200.00	70.00	98.92	168.92
9600.00	70.00	107.02	177.02
10000.00	70.00	115.42	185.42

* Minor Losses were not calculated at this time. This value was assumed and should account for minor in the station piping as well as forcemain. As the project continues and becomes more defined, a detailed breakdown of the minor losses will be done.

** The nominal pipe diamter was utilized for this review. Pipe class not determined.

Appendix W. System Curve for Proposed 24-inch Parellel Regional Forcemain



APPENDIX • CALCULATIONS FOR
PROPOSED PLANT 1 PUMPING RQMNT'S (EXPANSION)

PER APPENDIX AVE. DAY FLOW = 5.6 MGD

WET WEATER FLOW BASED ON 160 gpd/AC = 1.6 MGD

$Q_{PK} = 2.5\, Q_{AVE}^{0.91} = 2.5 \times 5.6^{0.91} = 12$ MGD

$Q_{PW} = 12 + 1.6$ MGD $= 13.6$ MGD

CURRENT PLANT 1 PUMPING CAPACITY = 3,500 gpm OR 5 MGD

FLOW REQUIRED TO PUMP AT PROPOSED PLANT 3 = 13.6 − 5 = 8.6 MGD

BASED ON MIN. & MAX. VELOCITY REQUIREMENTS A 24-INCH DIA. PIPE TO BE USED FOR PROPOSED PLANT 3 REGIONAL FORCEMAIN.

SEE SYSTEM CURVE ASSUMPTIONS BELOW:
LENGTH = 16,000 LF
EQUV. LNTH = 50 LF
STATIC HEAD = 70 feet
C = 120 (HAZEN-WILLIAMS FRICT. FACT.)
BASED ON THIS INFO, A SYSTEM CURVE WAS DEVELOPED
@ PEAK FLOW REQUIREMENST FOR PROP. L.S. ⇒ 8.6 MGD OR 6000 gpm
THE TDH WAS 115 feet

POWER REQUIREMENTS:

$$hp = \frac{Q \times TDH}{3960 \times \eta}, \quad \eta = 50\% \qquad hp = \frac{4000 \times 31}{3960 \times 0.5} \cong 180 \text{ hp}$$

$$= \frac{6000 \times 115}{3960 \times 0.50} \cong 350 \text{ hp}$$

WITH A PUMP CONFIGURATION OF 3-PUMPS, TWO PUMPS WILL BE REQUIRED TO PRODUCE THE 350 hp, THEREFORE EACH PUMP WILL BE APPROXIMATELY 180 TO 220 hp DEPENDING ON TYPE OF PUMPS SELECTED.

SUMMARY

MAX. F.M. FLOW = 7200 gpm OR 10.4 MGD
MIN. F.M. FLOW = 3600 gpm OR 5.2 MGD
PEAK PLANT 3 FLOWS = 6000 gpm OR 8.6 MGD
POWER REQUIREMENTS = ~~Each~~ PUMP = 180 HP TO 220 HP
= TOTAL FOR PEAKED = 350 hp

No. OF PUMPS = 3 PUMPS
FORCEMAIN LENGTH = 16,000 LF
C = 120 (HAZEN-WILLIAMS)

APPENDIX X

ESTIMATED LENGTHS AND SIZES OF PROPOSED CAPITAL IMPROVEMENT PROJECTS FOR THE GRAVITY SEWER SYSTEM

Appendix X
JCSD Proposed Capital Improvement Projects
(Gravity Sewers)

Bain Street Trunk - Project No. P-B-1

Label	Section Size	Length (ft)	Material	Upstream Node	Upstream Invert Elevation (ft)	Downstream Node	Downstream Invert Elevation (ft)	Constructed Slope (ft/ft)
B_DSN-800	18 inch	87	Vitrified Clay Pipe	B_3089	660.81	B_DSN-900	640.25	0.2334
B_DSN_820	27 inch	1333	Vitrified Clay Pipe	B_DSN-900	640.25	J_DSN-500	637.48	0.0011

Total Length (18 inch) = 87 ft
Total Length (27 inch) = 1,333 ft

Glen Avon Area Trunk - Project No. P-G-1

Label	Section Size	Length (ft)	Material	Upstream Node	Upstream Invert Elevation (ft)	Downstream Node	Downstream Invert Elevation (ft)	Constructed Slope (ft/ft)
G_DSN-620	10 inch	381	Vitrified Clay Pipe	G_1276	748.38	G_DSN-715	735.98	0.0038
G_DSN-715	10 inch	1277	Vitrified Clay Pipe	G_DSN-715	735.98	G_DSN-714	733.94	0.0016
G_DSN-712	10 inch	1016	Vitrified Clay Pipe	G_DSN-712	731.79	G_DSN-710	730.16	0.0016
G_DSN-714	10 inch	1347	Vitrified Clay Pipe	G_DSN-714	733.94	G_DSN-712	731.79	0.0016
G_DSN-600	15 inch	319	Vitrified Clay Pipe	G_DSN-700	706.49	B_4387	705.93	0.0018
G_DSN-710	15 inch	1400	Vitrified Clay Pipe	G_DSN-710	730.16	G_DSN-705	727.72	0.0017
G_DSN-705	15 inch	1429	Vitrified Clay Pipe	G_DSN-705	727.72	G_DSN-650	725.23	0.0017
G_DSN-650	15 inch	834	Vitrified Clay Pipe	G_DSN-650	725.23	G_DSN-700	706.49	0.0091

Total Length (10 inch) = 4,021 ft
Total Length (15 inch) = 3,982 ft

Glen Avon Area Trunk - Project No. P-G-2

Label	Section Size	Length (ft)	Material	Upstream Node	Upstream Invert Elevation (ft)	Downstream Node	Downstream Invert Elevation (ft)	Constructed Slope (ft/ft)
G_E1291	10 inch	165	Vitrified Clay Pipe	G_1684	727.27	G_1685	726.28	0.0060
G_N1458_DSN	12 inch	795	Vitrified Clay Pipe	G_1674	729.66	G_1684	727.27	0.0030
G_N1644_DSN	15 inch	478	Vitrified Clay Pipe	G_2022	713.79	G_2023A	705.62	0.0171
G_N1641_DSN	15 inch	1395	Vitrified Clay Pipe	G_1711	719.04	G_2019	716.81	0.0016
G_97-0261_DSN	15 inch	61	Vitrified Clay Pipe	G_2023A	705.62	G_2023B	703.68	0.0318
G_E1307_DSN	15 inch	1684	Vitrified Clay Pipe	G_1690	721.73	G_1711	719.04	0.0016
G_N1460_DSN	15 inch	2275	Vitrified Clay Pipe	G_1685	726.28	G_1690	721.73	0.0020
G_N1643_DSN	18 inch	837	Vitrified Clay Pipe	G_2019	716.81	G_2022	713.79	0.0036
G_E1490_DSN	21 inch	583	Vitrified Clay Pipe	G_2023B	703.68	J_2024	700.82	0.0049

Total Length (10 inch) = 165 ft
Total Length (12 inch) = 795 ft
Total Length (15 inch) = 5,893 ft
Total Length (18 inch) = 837 ft
Total Length (21 inch) = 583 ft

Appendix X
JCSD Proposed Capital Improvement Projects
(Gravity Sewers)

Jurupa Trunk - Project No. P-J-1

Label	Section Size	Length (ft)	Material	Upstream Node	Upstream Invert Elevation (ft)	Downstream Node	Downstream Invert Elevation (ft)	Constructed Slope (ft/ft)
J_DSN-465	36 inch	1230	Vitrified Clay Pipe	J_2460	688.66	J_DSN-555	687.43	0.0010
J_DSN-455	36 inch	657	Vitrified Clay Pipe	J_DSN-550	677.38	J_DSN-445	676.73	0.0010
J_DSN-450	36 inch	1310	Vitrified Clay Pipe	J_DSN-445	676.73	J_DSN-540	675.41	0.0010
J_DSN-460	36 inch	750	Vitrified Clay Pipe	J_DSN-555	687.43	J_DSN-550	677.38	0.0134
J_DSN-435	39 inch	745	Vitrified Clay Pipe	J_DSN-530	673.62	J_DSN-525	672.86	0.0010
J_DSN-445	39 inch	629	Vitrified Clay Pipe	J_DSN-540	675.41	J_DSN-535	674.78	0.0010
J_DSN-440	39 inch	1159	Vitrified Clay Pipe	J_DSN-535	674.78	J_DSN-530	673.62	0.0010
J_DSN-415	42 inch	1400	Vitrified Clay Pipe	J_DSN-510	669.66	J_DSN-505	641.66	0.0200
J_DSN_405	42 inch	138	Vitrified Clay Pipe	J_DSN-500	637.48	J_3078	636.38	0.0080
J_DSN-430	42 inch	417	Vitrified Clay Pipe	J_DSN-525	672.86	J_DSN-520	672.46	0.0010
J_DSN-425	42 inch	971	Vitrified Clay Pipe	J_DSN-520	672.46	J_DSN-515	671.49	0.0010
J_DSN-400	42 inch	539	Vitrified Clay Pipe	J_3078	636.38	REGIONAL P.S.	632.06	0.0080
J_DSN-410	42 inch	523	Vitrified Clay Pipe	J_DSN-505	641.66	J_DSN-500	637.48	0.0080
J_DSN-420	42 inch	1827	Vitrified Clay Pipe	J_DSN-515	671.49	J_DSN-510	669.66	0.0010

Total Length (36 inch) = 3,947 ft
Total Length (39 inch) = 2,533 ft
Total Length (42 inch) = 5,815 ft

Jurupa Trunk - Project No. P-J-2

Label	Section Size	Length (ft)	Material	Upstream Node	Upstream Invert Elevation (ft)	Downstream Node	Downstream Invert Elevation (ft)	Constructed Slope (ft/ft)
J_N1907_DSN	30 inch	421	Vitrified Clay Pipe	J_2461	691.02	J_2460	688.66	0.0056
J_N1910_DSN	30 inch	623	Vitrified Clay Pipe	J_2464	693.32	J_2463	691.95	0.0022
J_N1911_DSN	30 inch	663	Vitrified Clay Pipe	J_2465	698.42	J_2464	693.32	0.0077
J_N1901_DSN	30 inch	212	Vitrified Clay Pipe	J_2463	691.95	J_2462	691.48	0.0022
J_N1908_DSN	30 inch	210	Vitrified Clay Pipe	J_2462	691.48	J_2461	691.02	0.0022
J_N1657_DSN	30 inch	798	Vitrified Clay Pipe	J_2024	700.82	J_2465	698.42	0.0030

Total Length (30 inch) = 2,927 ft

Appendix X
JCSD Proposed Capital Improvement Projects
(Gravity Sewers)

Jurupa Trunk - Project No. P-J-3

Label	Section Size	Length (ft)	Material	Upstream Node	Upstream Invert Elevation (ft)	Downstream Node	Downstream Invert Elevation (ft)	Constructed Slope (ft/ft)
J_E1533_DSN	18 inch	385	Vitrified Clay Pipe	J_2098	738.58	J_003	733.80	0.0124
J_E1579_DSN	18 inch	702	Vitrified Clay Pipe	J_2150	767.14	J_2092	757.67	0.0135
J_E1536_DSN	18 inch	672	Vitrified Clay Pipe	J_2092	757.67	J_2091	748.19	0.0141
J_E1534_DSN	18 inch	290	Vitrified Clay Pipe	J_2090	742.17	J_2098	738.58	0.0124
J_E1535_DSN	18 inch	700	Vitrified Clay Pipe	J_2091	748.19	J_2090	742.17	0.0086
J_E1410_DSN	18 inch	566	Vitrified Clay Pipe	J_1870	838.50	J_1854	836.80	0.0030
J_E1532_DSN	18 inch	314	Vitrified Clay Pipe	J_003	733.80	J_002	731.07	0.0087
J_E1519_DSN	21 inch	1372	Vitrified Clay Pipe	J_2074	730.18	J_2072	717.97	0.0089
J_E1580_DSN	21 inch	670	Vitrified Clay Pipe	J_2149	770.16	J_2150	767.14	0.0045
J_E1518_DSN	21 inch	583	Vitrified Clay Pipe	J_2072	717.97	J_2071	710.05	0.0136
J_E1517_DSN	21 inch	445	Vitrified Clay Pipe	J_2071	710.05	J_2070	705.95	0.0092
J_E1516_DSN	21 inch	155	Vitrified Clay Pipe	J_2070	705.95	J_2069	704.53	0.0092
J_E1492_DSN	24 inch	975	Vitrified Clay Pipe	J_2069	704.53	J_2024	700.82	0.0038
J_E1530_DSN	24 inch	344	Vitrified Clay Pipe	J_001	730.87	J_2074	730.18	0.0020
J_E1531_DSN	24 inch	36	Vitrified Clay Pipe	J_002	731.07	J_001	730.87	0.0056

Total Length (18 inch) = 3,629 ft
Total Length (21 inch) = 3,225 ft
Total Length (24 inch) = 1,355 ft

Jurupa Trunk - Project No. P-J-4

Label	Section Size	Length (ft)	Material	Upstream Node	Upstream Invert Elevation (ft)	Downstream Node	Downstream Invert Elevation (ft)	Constructed Slope (ft/ft)
J_E1242_DSN	12 inch	1150	Vitrified Clay Pipe	J_1537	884.97	J_1919	879.22	0.0050
J_E1424_DSN	12 inch	483	Vitrified Clay Pipe	J_1888	867.66	J_1887	863.17	0.0093
J_E1425_DSN	12 inch	416	Vitrified Clay Pipe	J_1917	872.15	J_1888	867.66	0.0108
J_E1445_DSN	15 inch	327	Vitrified Clay Pipe	J_1919	879.22	J_1918	878.30	0.0028
J_E1245_DSN	15 inch	1050	Vitrified Clay Pipe	J_1552	886.64	J_1537	884.97	0.0016
J_N1372_DSN	15 inch	240	Vitrified Clay Pipe	J_1553	887.03	J_1552	886.64	0.0016

Total Length (12 inch) = 2,049 ft
Total Length (15 inch) = 1,617 ft

Appendix X
JCSD Proposed Capital Improvement Projects
(Gravity Sewers)

Jurupa Trunk - Project No. P-J-5

Label	Section Size	Length (ft)	Material	Upstream Node	Upstream Invert Elevation (ft)	Downstream Node	Downstream Invert Elevation (ft)	Constructed Slope (ft/ft)
J_N1192_DSN	10 inch	525	Vitrified Clay Pipe	J_1311	923.21	J_1310	920.16	0.0058
J_N1193_DSN	10 inch	603	Vitrified Clay Pipe	J_1310	920.16	J_1308	917.45	0.0045
J_N1194_DSN	10 inch	696	Vitrified Clay Pipe	J_1308	917.45	J_1309	912.51	0.0071
J_N1196_DSN	10 inch	684	Vitrified Clay Pipe	J_1309	912.51	J_1335	905.26	0.0106
J_N1371_DSN	10 inch	680	Vitrified Clay Pipe	J_1564	896.55	J_1553	887.03	0.0140
J_N1406_DSN	10 inch	691	Vitrified Clay Pipe	J_1335	905.26	J_1564	896.55	0.0126

Total Length (10 inch) = 3,879 ft

Pedley Area Trunk - Project No. P-P-1

Label	Section Size	Length (ft)	Material	Upstream Node	Upstream Invert Elevation (ft)	Downstream Node	Downstream Invert Elevation (ft)	Constructed Slope (ft/ft)
P_E2206_DSN	12 inch	366	Vitrified Clay Pipe	P_3473	701.17	P_3471	693.74	0.0203
P_E2208_DSN	12 inch	681	Vitrified Clay Pipe	P_3477	704.10	P_3474	701.51	0.0038
P_N2489_DSN	12 inch	122	Vitrified Clay Pipe	P_3474	701.51	P_3473	701.17	0.0028
P_E2186_DSN	12 inch	989	Vitrified Clay Pipe	P_3471	693.74	P_3453	690.97	0.0028
P_E2182_DSN	15 inch	329	Vitrified Clay Pipe	P_3451	689.65	P_3449	686.69	0.0090
P_N2473_DSN	15 inch	654	Vitrified Clay Pipe	P_3449	686.69	J_DSN-520	672.46	0.0057
P_E2184_DSN	15 inch	660	Vitrified Clay Pipe	P_3453	690.97	P_3451	689.65	0.0020

Total Length (12 inch) = 2,158 ft
Total Length (15 inch) = 1,643 ft

Appendix X
JCSD Proposed Capital Improvement Projects
(Gravity Sewers)

Pyrite Creek Interceptor - Project No. P-PC-1

Label	Section Size	Length (ft)	Material	Upstream Node	Upstream Invert Elevation (ft)	Downstream Node	Downstream Invert Elevation (ft)	Constructed Slope (ft/ft)
PC_N2286_B	21 inch	431	Vitrified Clay Pipe	J_3138	645.88	NODE	644.24	0.00380
PC_E2006	21 inch	145	Vitrified Clay Pipe	J_3139	646.43	J_3138	645.88	0.00380
PC_N2286_A	21 inch	431	Vitrified Clay Pipe	NODE	644.24	J_3083	642.6	0.00381
PC_E2007	21 inch	375	Vitrified Clay Pipe	J_3141	650.52	J_3139	646.43	0.01090
PC_N2010	21 inch	132	Vitrified Clay Pipe	J_3142	653.05	J_3141	650.52	0.01918
PC_DSN-300	18 inch	1,273	Vitrified Clay Pipe	J_3083	642.6	B_DSN-900	640.25	0.001257

Total Length (21 inch) = 1,514 ft (Epoxy Slip Line of Existing Pipe)
Total Length (18 inch) = 1,273 ft (New Pipe)

APPENDIX Y

PROPOSED CAPITAL IMPROVEMENT
GRAVITY PIPELINES
ESTIMATED PROJECT COSTS

Appendix Y
JCSD Proposed Capital Improvement Projects
(Gravity Sewers)

Bain Street Trunk - Project No. P-B-1

Label	Diameter (in.)	Quantity	Unit	Unit Price	Total Estimated Construction Cost	Total Estimated Project Cost[1]
B_DSN-800	18	87	LF	$244	$21,228	$30,000
B_DSN_820	30	1333	LF	$363	$483,879	$677,000
Subtotal					**$505,107**	**$707,000**

Total Length (18 inch) = 87 ft
Total Length (27 inch) = 1,333 ft

Glen Avon Area Trunk - Project No. P-G-1

Label	Diameter (in.)	Quantity	Unit	Unit Price	Total Estimated Construction Cost	Total Estimated Project Cost[1]
G_DSN-620	10	381	LF	$181	$68,961	$97,000
G_DSN-714	10	1347	LF	$181	$243,807	$341,000
G_DSN-712	10	1016	LF	$181	$183,896	$257,000
G_DSN-715	10	1277	LF	$181	$231,137	$324,000
G_DSN-710	15	1400	LF	$219	$306,600	$429,000
G_DSN-650	15	834	LF	$219	$182,646	$256,000
G_DSN-705	15	1429	LF	$219	$312,951	$438,000
G_DSN-600	15	319	LF	$219	$69,861	$98,000
Subtotal					**$1,599,859**	**$2,240,000**

Total Length (10 inch) = 4,021 ft
Total Length (15 inch) = 3,982 ft

Appendix Y
JCSD Proposed Capital Improvement Projects
(Gravity Sewers)

Glen Avon Area Trunk - Project No. P-G-2

Label	Diameter (in.)	Quantity	Unit	Unit Price	Total Estimated Construction Cost	Total Estimated Project Cost[1]
G_E1291	10	165	LF	$181	$29,865	$42,000
G_N1458_DSN	12	795	LF	$206	$163,770	$229,000
G_97-0261_DSN	15	61	LF	$219	$13,359	$19,000
G_E1307_DSN	15	1684	LF	$219	$368,796	$516,000
G_N1460_DSN	15	2275	LF	$219	$498,225	$698,000
G_N1644_DSN	15	478	LF	$219	$104,682	$147,000
G_N1641_DSN	15	1395	LF	$219	$305,505	$428,000
G_N1643_DSN	18	837	LF	$244	$204,228	$286,000
G_E1490_DSN	21	583	LF	$263	$153,329	$215,000
Subtotal					**$1,841,759**	**$2,580,000**

Total Length (10 inch) =	**165**	**ft**
Total Length (12 inch) =	**795**	**ft**
Total Length (15 inch) =	**5,893**	**ft**
Total Length (18 inch) =	**837**	**ft**
Total Length (21 inch) =	**583**	**ft**

Appendix Y
JCSD Proposed Capital Improvement Projects
(Gravity Sewers)

Jurupa Trunk - Project No. P-J-1

Label	Diameter (in.)	Quantity	Unit	Unit Price	Total Estimated Construction Cost	Total Estimated Project Cost[1]
J_DSN-465	36	1230	LF	$419	$515,370	$722,000
J_DSN-460	36	750	LF	$419	$314,250	$440,000
J_DSN-450	36	1310	LF	$419	$548,890	$768,000
J_DSN-455	36	657	LF	$419	$275,283	$385,000
J_DSN-435	39	745	LF	$500	$372,500	$522,000
J_DSN-445	39	629	LF	$500	$314,500	$440,000
J_DSN-440	39	1159	LF	$500	$579,500	$811,000
J_DSN-415	42	1400	LF	$550	$770,000	$1,078,000
J_DSN_405	42	138	LF	$550	$75,900	$106,000
J_DSN-400	42	539	LF	$550	$296,450	$415,000
J_DSN-420	42	1827	LF	$550	$1,004,850	$1,407,000
J_DSN-430	42	417	LF	$550	$229,350	$321,000
J_DSN-410	42	523	LF	$550	$287,650	$403,000
J_DSN-425	42	971	LF	$550	$534,050	$748,000
Subtotal					**$6,118,543**	**$8,566,000**

Total Length (36 inch) = 3,947 ft
Total Length (39 inch) = 2,533 ft
Total Length (42 inch) = 5,815 ft

Jurupa Trunk - Project No. P-J-2

Label	Diameter (in.)	Quantity	Unit	Unit Price	Total Estimated Construction Cost	Total Estimated Project Cost[1]
J_N1657_DSN	30	798	LF	$363	$289,674	$406,000
J_N1901_DSN	30	212	LF	$363	$76,956	$108,000
J_N1907_DSN	30	421	LF	$363	$152,823	$214,000
J_N1908_DSN	30	210	LF	$363	$76,230	$107,000
J_N1910_DSN	30	623	LF	$363	$226,149	$317,000
J_N1911_DSN	30	663	LF	$363	$240,669	$337,000
Subtotal					**$1,062,501**	**$1,489,000**

Total Length (30 inch) = 2,927 ft

Appendix Y
JCSD Proposed Capital Improvement Projects
(Gravity Sewers)

Jurupa Trunk - Project No. P-J-3

Label	Diameter (in.)	Quantity	Unit	Unit Price	Total Estimated Construction Cost	Total Estimated Project Cost[1]
J_E1532_DSN	18	314	LF	$244	$76,616	$107,000
J_E1536_DSN	18	672	LF	$244	$163,968	$230,000
J_E1579_DSN	18	702	LF	$244	$171,288	$240,000
J_E1533_DSN	18	385	LF	$244	$93,940	$132,000
J_E1410_DSN	18	566	LF	$244	$138,104	$193,000
J_E1535_DSN	18	700	LF	$244	$170,800	$239,000
J_E1534_DSN	18	290	LF	$244	$70,760	$99,000
J_E1516_DSN	21	155	LF	$263	$40,765	$57,000
J_E1580_DSN	21	670	LF	$263	$176,210	$247,000
J_E1517_DSN	21	445	LF	$263	$117,035	$164,000
J_E1519_DSN	21	1372	LF	$263	$360,836	$505,000
J_E1518_DSN	21	583	LF	$263	$153,329	$215,000
J_E1492_DSN	24	975	LF	$300	$292,500	$410,000
J_E1530_DSN	24	344	LF	$300	$103,200	$144,000
J_E1531_DSN	24	36	LF	$300	$10,800	$15,000
Subtotal					**$2,140,151**	**$2,997,000**

Total Length (18 inch) =	**3,629**	**ft**
Total Length (21 inch) =	**3,225**	**ft**
Total Length (24 inch) =	**1,355**	**ft**

Appendix Y
JCSD Proposed Capital Improvement Projects
(Gravity Sewers)

Jurupa Trunk - Project No. P-J-4

Label	Diameter (in.)	Quantity	Unit	Unit Price	Total Estimated Construction Cost	Total Estimated Project Cost[1]
J_E1242_DSN	12	1150	LF	$206	$236,900	$332,000
J_E1424_DSN	12	483	LF	$206	$99,498	$139,000
J_E1425_DSN	12	416	LF	$206	$85,696	$120,000
J_N1372_DSN	15	240	LF	$219	$52,560	$74,000
J_E1245_DSN	15	1050	LF	$219	$229,950	$322,000
J_E1445_DSN	15	327	LF	$219	$71,613	$100,000
Subtotal					**$776,217**	**$1,087,000**

Total Length (12 inch) = 2,049 ft
Total Length (15 inch) = 1,617 ft

Jurupa Trunk - Project No. P-J-5

Label	Diameter (in.)	Quantity	Unit	Unit Price	Total Estimated Construction Cost	Total Estimated Project Cost[1]
J_N1194_DSN	10	696	LF	$181	$125,976	$176,000
J_N1193_DSN	10	603	LF	$181	$109,143	$153,000
J_N1371_DSN	10	680	LF	$181	$123,080	$172,000
J_N1406_DSN	10	691	LF	$181	$125,071	$175,000
J_N1196_DSN	10	684	LF	$181	$123,804	$173,000
J_N1192_DSN	10	525	LF	$181	$95,025	$133,000
Subtotal					**$702,099**	**$982,000**

Total Length (10 inch) = 3,879 ft

Appendix Y
JCSD Proposed Capital Improvement Projects
(Gravity Sewers)

Pedley Area Trunk - Project No. P-P-1

Label	Diameter (in.)	Quantity	Unit	Unit Price	Total Estimated Construction Cost	Total Estimated Project Cost[1]
P_E2186_DSN	12	989	LF	$206	$203,734	$285,000
P_E2208_DSN	12	681	LF	$206	$140,286	$196,000
P_N2489_DSN	12	122	LF	$206	$25,132	$35,000
P_E2206_DSN	12	366	LF	$206	$75,396	$106,000
P_E2182_DSN	15	329	LF	$219	$72,051	$101,000
P_N2473_DSN	15	653.59	LF	$219	$143,136	$200,000
P_E2184_DSN	15	660	LF	$219	$144,540	$202,000
Subtotal					**$804,275**	**$1,125,000**

Total Length (12 inch) = 2,158 ft
Total Length (15 inch) = 1,643 ft

Appendix Y
JCSD Proposed Capital Improvement Projects
(Gravity Sewers)

Pyrite Creek Interceptor - Project No. P-PC-1

Label	Diameter (in.)	Quantity	Unit	Unit Price	Total Estimated Construction Cost	Total Estimated Project Cost[1]
PC_E2006	21	145	LF	$263	$38,135	$53,000
PC_N2286_B	21	431	LF	$263	$113,353	$159,000
PC_E2007	21	375	LF	$263	$98,625	$138,000
PC_N2010	21	132	LF	$263	$34,716	$49,000
PC_N2286_A	21	431	LF	$263	$113,353	$159,000
PC_DSN-300	18	1,273	LF	$244	$310,612	$435,000
Subtotal					**$708,794**	**$993,000**
Grand Total					**$16,259,305**	**$22,770,000**[2]

Total Length (21 inch) = **1,514 ft (Epoxy Slip Line of Existing Pipe)**

Total Length (18 inch) = **1,273 ft (New Pipe)**

[1]Project cost is 1.4 times construction cost rounded to nearest $1,000. Project cost includes: construction costs, construction contingencies, design engineering including plans and specifications; design and construction surveying and mapping; geotechnical evaluation and report; engineering contract administration; field inspection and basic environmental documentation. Costs are based on Engineering News Record (ENR) The Engineering News Record Construction Cost Index (Los Angeles) for August, 2004 is 7,857 Escalation, financing, interest during construction, legal, land, R-O-W agent, and environmental impact report costs are not included.

[2]Rounded to nearest $10,000.

Appendix 3B.2

2004 EASTVALE MASTER SEWER PLAN UPDATE FOR JURUPA COMMUNITY SERVICES DISTRICT

Attachment 1A

jurupa
COMMUNITY SERVICES DISTRICT

EASTVALE MASTER SEWER PLAN UPDATE

February, 2004

Prepared By
Albert A. Webb Associates

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INTRODUCTION

As requested by the District, Webb Associates has updated the Master Sewer Plan for the Eastvale area to include developments that have been submitted since our original report was completed in May, 1999. The results of our review are contained in this letter report, which is divided into the following sections:

- Introduction
- Projected Land Use
- Tributary Wastewater Drainage Areas
- Wastewater Design Flow Determination
- Hydraulic Analysis
- Cost Analysis
- Findings, Conclusions, and Recommendations

BACKGROUND

In May, 1999, Webb Associates completed a Master Sewer Plan for the Eastvale area. Since the completion of this report, several trunk sewer facilities have been designed and constructed (Plate 1). Additionally, more detailed development plans have been submitted to the District over the last five years in the form of the tentative tract maps and sewer improvement plans. Consequently, we have updated the May, 1999 report. The updated letter report includes revisions to the tributary wastewater drainage areas and land use projections. We have also conducted another hydraulic analysis of the proposed sewer system.

PROJECTED LAND USE

The land use projections incorporated in this revised sewer system are updated from the information presented in the May, 1999 report. The projected land uses in areas where developments are not currently proposed were based on the preliminary Riverside County Integrated Project (RCIP) Eastvale Area Land Use Plan. However, in cases where a proposed tentative tract has been submitted to the District, the projected land use was based upon the proposed development plans.

TRIBUTARY WASTEWATER DRAINAGE AREAS

The tributary wastewater drainage areas were adjusted based upon the street layouts in areas of proposed developments that have occurred in the last five years. Each tributary area ultimately drains to a point of collection in the proposed trunk sewer system. As with the original Master Plan, where no development plans were proposed, the general topography of the undeveloped areas was used to determine sewerage flow directions. The exact boundaries of these tributary areas may vary

when future engineering plans are developed. Several tributary areas were reconfigured from the previous study. The revised tributary wastewater drainage areas are shown on Plate 2.

In addition to land use changes that have occurred during the last five years, two additional tributary areas have been included in this update. The May, 1999 report did not include the Santa Ana River Water Company (SARWC) as a tributary area. Because of the topography within the Water Company boundaries and the shared boarders with the District, it is probable that if sewerlines are ever constructed within the SARWC area, they would be tributary to the Eastvale trunk sewer system. Therefore, estimated potential wastewater flows from the SARWC were included in this study.

The second tributary area incorporated into this update includes an area that was previously proposed to flow to the SARI line that will now be tributary to the Eastvale trunk sewer system. The subject area is identified on Plate 2 as the "Proposed CFD Land Conservation Area".

WASTEWATER DESIGN FLOW DETERMINATION

The average daily wastewater flow was determined based upon the land uses for each tributary area. A wastewater generation factor was applied to each land use, summarized by the following:

• Residential (single family)	280 gpd/edu
• Residential (multi family)	160 gpd/edu
• Commercial	2,000 gpd/ac
• Industrial	
- Heavy	2,000 gpd/ac
- Light	1,120 gpd/ac
• Schools	
- Elementary	10 gpd/student
- Middle	15 gpd/student
- High	25 gpd/student
• Infiltration	100 gpd/ac

A summary of the projected average daily wastewater flows is enclosed in Appendix A.

A peaking factor was applied to the wastewater flow quantities (average daily flows) to obtain the "design flow" to account for the diurnal flow rate variations. The peak factor utilized in this study was as follows:

$$Q_{peak} = 2.5Q_{ADF}^{(0.91)}$$

Where Q_{peak} and Q_{ADF} are in millions of gallons per day (mgd)

It should be noted that the District standard peak factor equation is somewhat conservative in comparison to recent District flow measurements (flow meter data) as indicted on Figure 1 and in comparison to other jurisdictions as shown on Figure 2.

HYDRAULIC ANALYSIS

The computer software utilized for hydraulic analysis and modeling was SewerCAD. Input for this model consisted of pipeline diameters, nodal elevations, pipe flow line elevations, and wastewater design flow quantities and locations. Based on this input information, the software calculated the pipeline capacities for the sewer system and determined if the pipeline diameters were sufficient for the design flows.

All pipelines in the proposed sewer system are trunk sewers which are 10" in diameter or larger. The maximum pipeline design capacity was based upon a maximum flow depth ("D") to diameter ("d") ratio (D/d) of 0.75. An assumed Manning's roughness coefficient "n" of 0.013 was taken into account as well except for a reach of pipeline along the Hall Avenue extension between Chandler Street and the River Road Lift Station. In this reach, a roughness coefficient of 0.009 was used to reflect the currently proposed pipeline design material of PVC lined RCP pipe. Nodal elevations of proposed sewerlines were based upon the natural terrain of the undeveloped regions, design slopes (if available), and minimum slope requirements for each pipe diameter.

All but one of the projected average daily flows shown in Appendix A were multiplied by the appropriate District standard peak factor and were applied to the computer model at the locations indicated on Plate 2. The one flow that did not follow this methodology was Tributary Area 1 ("Sky Country"), which is completely developed. The flow input into the model for Tributary Area 1 was based upon the highest actual peak flow that was measured by the District.

The results of the hydraulic computer analysis indicated five reaches of pipeline were over design capacity ($D/d \leq 0.75$) and three reaches of pipe were over the pipeline's full flow capacity. The pipelines that were over "design" capacity were still below full flow capacity thereby indicating pipe flow surcharging will not occur. The data for the three reaches of pipe theoretically over full flow capacity are shown on Table 1.

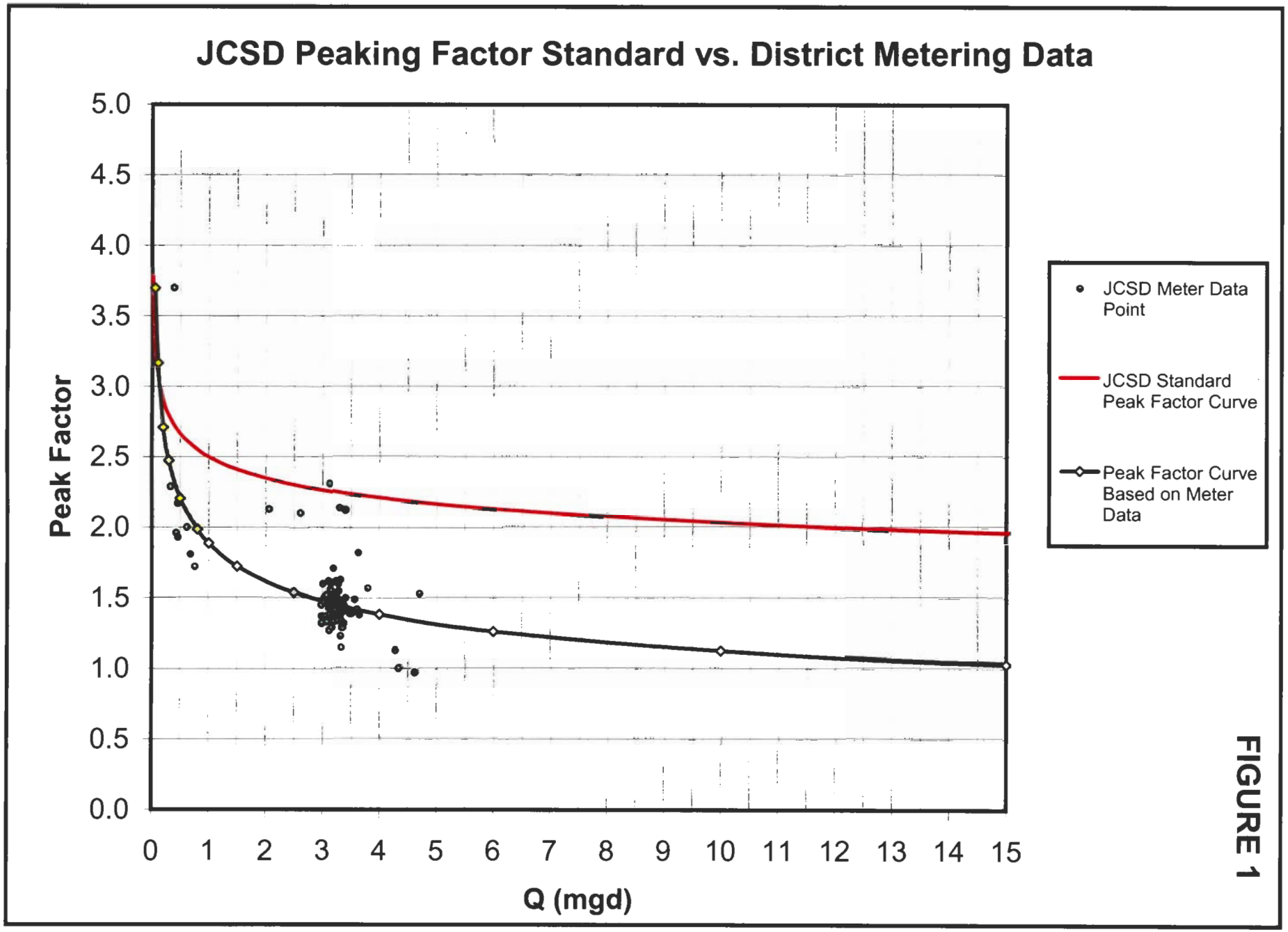


FIGURE 1

G:\2001\01-0288\Peaking Factor Study.xls

Peaking Factor Comparison

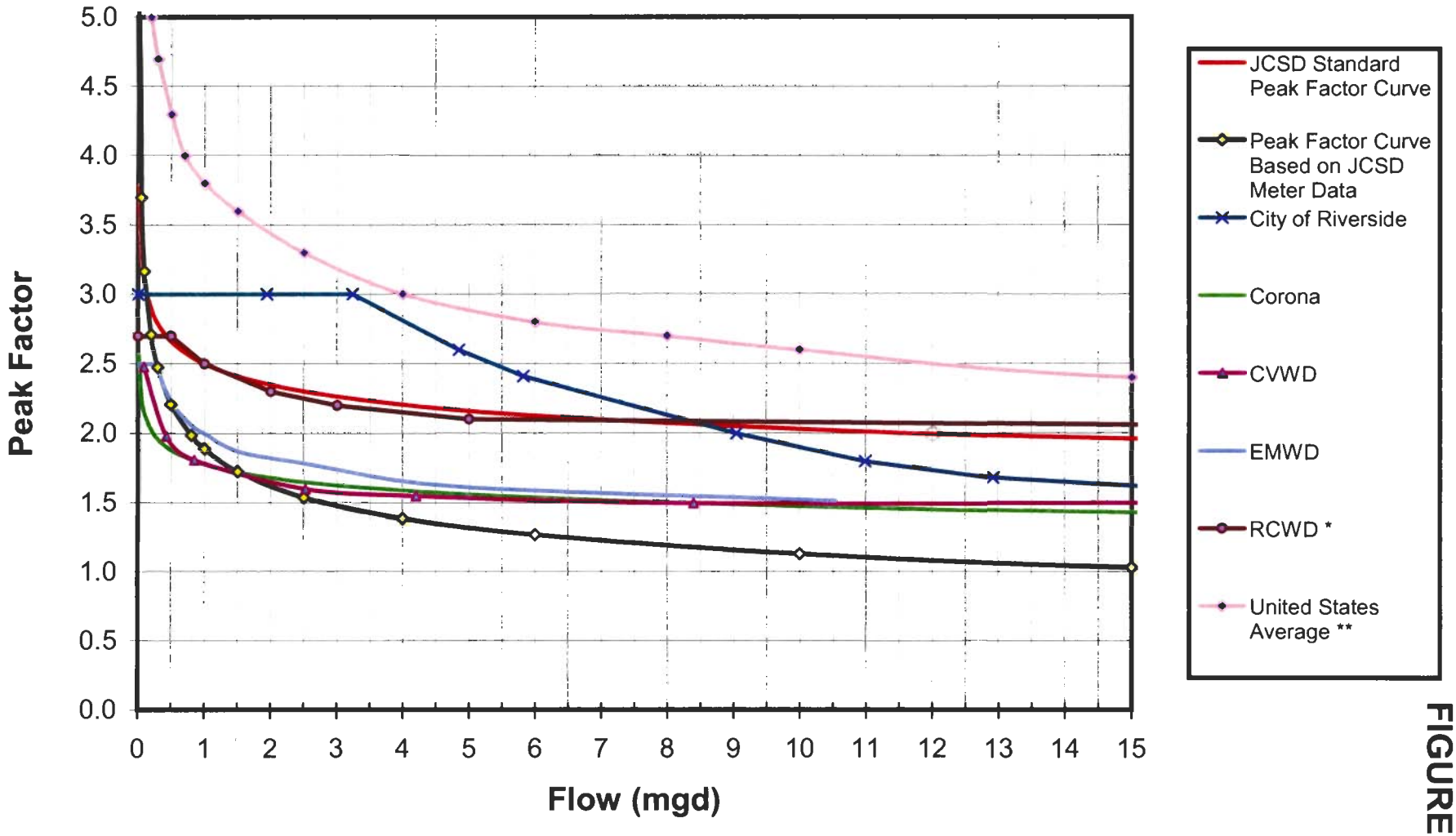


FIGURE 2

* Maximum flow rate of range used for curve.

** From Gravity Sanitary Sewer Design and Construction, 1982, ASCE Water Pollution Control Federation, p. 40. Peak on Maximum day.

G:\2001\01-0288\Peaking Factor Study.xls

Table 1 – Pipeline Reaches Requiring Additional Capacity Review

Reach	Pipeline Reach Description	Modeled Pipeline Peak Flow (mgd)	Full Pipe Capacity (mgd)	Percentage Above Full Pipe Capacity
A	Cleveland Avenue north of Schleisman Road	3.70	3.54	4.5%
B	Citrus Street between Sumner Avenue & Cleveland Avenue	10.29	8.37 ✓	22.9%
C	Easement pipeline between Hamner Avenue & Tract 28784	5.74	5.41	6.1%

Reaches A and C are not of a concern since, as previously stated, the District's peak factor equation is conservative and the theoretical percentage above full flow pipe capacity is small. Further investigation of Reach B indicated the peak factor (District standard) applied to this reach was 2.2. As shown on Figure 2, this peak factor, for a projected average daily flow of 4.4 mgd, is much higher than other local jurisdictions. Further, the Eastvale computer model was also analyzed using the District's actual metered peak factor curve shown on Figure 1. The results of the analysis utilizing the actual experienced peak flows indicated all pipelines as shown on Plate 1 would flow at a capacity below the District standard design flow criteria ($D/d \leq 0.75$). Therefore, the Eastvale plan sewer system shown on Plate 1 is adequate to convey the projected wastewater peak flows.

COST ANALYSIS

Pipelines

The unit costs used for sewerlines include pipeline material and installation, manholes, asphalt concrete removal, disposal, and replacement. Construction costs were determined by reviewing the three lowest bids of similar recent projects and through a cost study where a "generic bid" was sent to three prominent contractors in the area. The generic bid was based on the assumptions that an average project for the District would consist of 2,500 linear feet of pipe, and that asphalt concrete roads would be removed, disposed of, and replaced. Road reconstruction was assumed to be 25 feet wide with 4 inches of AC pavement over 8 inches of Class II base. The average depth of the pipe was assumed to be 20 ft and would require B-2 bedding. It was assumed nine, 5 ft diameter manholes would be installed for each project. Not included in the unit cost estimates are extraordinary construction items such as bore casings, dewatering, rock removal, etc… A summary of these estimated unit costs are as shown on Table 2.

Table 2 – Estimated Unit Cost of Pipelines

Sewer Line Dia. (in.)	Construction Cost	Project Cost*
10	$145.00	$205.00
12	$165.00	$230.00
15	$175.00	$245.00
18	$195.00	$275.00
21	$210.00	$295.00
24	$240.00	$335.00
27	$260.00	$365.00
30	$290.00	$405.00
36	$335.00	$470.00
39	$400.00	$560.00
42	$440.00	$615.00
48	$485.00	$680.00

**Project cost is 1.4 times construction cost rounded to nearest $5. Project cost includes: construction cost, construction contingencies, design engineering including plans and specifications; design and construction surveying and mapping; geotechnical evaluation and report; engineering contract administration; field inspection and basic environmental documentation. Costs are based on Engineering New Record (E.N.R.). The Engineering news Record Construction Cost Index for the Los Angeles Areas for October 2003 was utilized. This value is 7,543.67. Escalation, financing, interest during construction, legal, land, R.O.W. agent, and environmental impact report costs are not included in construction costs. Additionally, not included in the unit cost estimates are extraordinary construction items such as bore casings, dewatering, rock removal etc…*

Lift Station, Forcemain, and Treatment Plant Capacity

Additional lift station, forcemain, and treatment plant capacity project costs associated with the Eastvale Master Sewer Plan update include the River Road lift station and force main and wastewater treatment capacity purchase at the Western Riverside County Regional Wastewater Reclamation Plant (WRCRWRP). The River Road lift station and force main estimated project cost is $6,650,000[1]. The purchase of treatment plant capacity at WRCRWRP was assumed to reflect the current costs to construct a wastewater treatment plant. Presently, due to the increasing costs of solids treatment and disposal, a typical unit construction cost is $8/gallon. Using an estimated unit construction cost of $8/gallon multiplied by the projected ultimate average daily flow of 9.6 mgd and the aforementioned 1.4 project cost factor, the total estimated project cost for treatment is $107,520,000. The project cost could be even more considering that the increasing cost for solids treatment and disposal is amongst other unknowns.

[1] *"River Road Lift Station Preliminary Design Report", November 2003, prepared by Albert A. Webb Associates.*

A summary of the estimated project costs for the Eastvale sewer system are shown on Table 3. As shown on Table 3, the total project cost estimate of the updated sewer system is about $140 million.

Table 3 – Estimated Project Cost Summary

Master Plan Improvement	Estimated Project Cost
Trunk & Interceptor Sewerlines	$ 25,330,000[1,2,3]
River Road Lift Station & Associated Force Mains	$ 6,650,000[2,3]
Treatment Plant Capacity Purchase at WRCRWRP	$107,520,000
Total Estimated Project Cost	$139,500,000

[1] *Refer to Appendix B for Details*
[2] *Total estimated construction cost rounded up to the nearest $10,000.*
[3] *Project is 1.4 times the construction cost. Project cost includes: construction cost, construction contingencies, design engineering including plans and specifications; design and construction surveying and mapping; geotechnical evaluation and report; engineering contract administration; field inspection and basic environmental documentation. Costs are based on Engineering New Record (E.N.R.). The Engineering news Record Construction Cost Index for the Los Angeles Areas for October 2003 was utilized. This value is 7,543.67. Escalation, financing, interest during construction, legal, land, R.O.W. agent, and environmental impact report costs are not included in construction costs.*

FINDINGS, CONCLUSIONS, AND RECOMMENDATIONS

As summarized in Appendix A, the total projected average daily wastewater flow for the Eastvale area is about 9.6 MGD. This amount is approximately 1.4 MGD greater than the 8.2 MGD projected in the original report primarily due to additional flows from the Santa Ana River Water Company area and the CFD land conversion area. The updated projected development estimates 27,838 dwelling units as opposed to the original report that projected 24,657 dwelling units. Finally, the estimated project cost of the updated Eastvale Master Sewer Plan improvements is $139,500,000.

We have concluded that the proposed trunk sewer system as shown on Plate 1 is adequately sized to accommodate the projected design flows. As such, it is our recommendation that the Master Sewer Plan for the Eastvale area be amended as described in this letter report.

REGISTERED PROFESSIONAL ENGINEER
WALLACE H. FRANZ
No. 26979
Exp. 3-31-05
CIVIL
STATE OF CALIFORNIA

APPENDIX A

TRIBUTARY WASTEWATER DRAINAGE AREA AVERAGE DAILY FLOWS

JURUPA COMMUNITY SERVICES DISTRICT
EASTVALE MASTER SEWER PLAN UPDATE

Appendix A. Projected Ultimate Land Use and Average Daily Flow
By Tributary Drainage Area

Tributary Drainage Area No.[1]	Area (ac)	Residential[2]: Rural Residential (<0.2 du/ac)	Very Low Density (0.4-2 du/ac)	SP125-W (2du/ac)	Low Density (2-5 du/ac)	Medium Density (5-8 du/ac)	Med-High Density (8-14 du/ac)	High Density (14-20 du/ac)	# of edu's	Proposed Developments: Tract Number	Area (ac)	du's	Total # of edu's	Q_{ADF}[3] (gpd)
E1[6]	**1,026.5**		**41.1**	**939.4**	**18.9**				**2,037**				**2,037**	**570,360**[7]
E2	**155.2**								**0**		**83.7**	**297**	**297**	**83,160**
									0		**37.1**	**118**	**118**	**33,040**
E3	194.3								0		22.8	67	67	18,760
									0		29.8	140	140	39,200
									0		26.5	112	112	31,360
									0		**24.6**	**89**	**89**	**24,920**
E4	**131.1**								**0**	**TT 29124**	**60.5**	**265**	**265**	**74,200**
E5	**73.3**				**46.1**				**185**				**185**	**51,800**
E6	68.8		68.8						138				138	38,640
E7	237.1				53.5				214	TT 28783	38.8	143	357	99,960
									0	TT 28784	67.3	260	260	72,800
									0	**TT 29093**	**47.5**	**187**	**187**	**52,360**
									0	**TT 29125**	**30.0**	**132**	**132**	**36,960**
E8	**152.8**					**77.8**			**545**		**25.6**	**322**[6]	**729**	**204,120**
E9	168.2								0		81.7	438[6]	250	70,080
E10	153.3								0		49.6	244	244	68,320
									0		59.9	738[6]	422	118,080
									0		**43.8**	**282**[6]	**161**	**45,120**
E11	**97.1**								**0**	**TT 28910**	**59.3**	**180**	**180**	**50,400**
									0	**TT 28933**	**37.8**	**172**	**172**	**48,160**
E12	80.2								0				0	0
E13	83.1				83.1				332				332	92,960
E14	107.2				107.2				429				429	120,120
E15	**170.0**								**0**	**TT 28520**	**60.1**	**205**	**205**	**57,400**
									0	**TT 28943**	**83.3**	**364**	**364**	**101,920**
E16	**155.8**				**44.0**				**176**	**TT 28945**	**43.2**	**151**	**327**	**91,560**
									0	TT 28946	68.6	271	271	75,880
E17	321.3				106.3				425	TT 28880	115.7	499	924	258,720
									0	TT 29334	56.0	200	200	56,000
E18	**83.1**				**83.1**				**332**				**332**	**92,960**
E19	**21.0**				**21.0**				**84**				**84**	**23,520**
E20	**152.6**								**0**				**0**	**0**
E21	40.5				0.0				0				0	0
E22	120.3				60.2				241				241	67,480
E23	94.2								0	TT 30633	77.6	318	318	89,040
E24	**74.3**								**0**	**TT 29287**	**66.3**	**251**	**251**	**70,280**
E25	**39.7**								**0**	**TT 28208**	**39.7**	**151**	**151**	**42,280**
E26	**40.1**								**0**	**TT 28821**	**40.1**	**158**	**158**	**44,240**
E27	38.9								0	TT 28821	34.2	158	158	44,240
E28	39.3								0	TT 28621	16.5	89	89	24,920
									0	TT 28622	22.8	84	84	23,520
E29	**62.0**				**62.0**				**248**				**248**	**69,440**
E30	**79.9**				**50.5**				**202**	**TT 29533**	**29.4**	**119**	**321**	**89,880**
E1-E30	**4,261.2**	**0.0**	**109.9**	**939.4**	**735.9**	**77.8**	**0.0**	**0.0**	***5,588***		**1,579.8**	**6,568**	**12,029**	***3,368,160***

Tributary Drainage Area No.[1]	Commercial: Retail (ac)	Office (ac)	Community Centers (ac)	Industrial[4]: Light (ac)	Heavy (ac)	Business Park (ac)	Public Facilities (ac)	Comm/Ind Q_{ADF}[5] (gpd)	Schools: No. of Students (each)	Q_{ADF}[7] (gpd)	City Overlay (ac)	Conservation (ac)	Conservation Habitat (ac)	Open Space: Recreation (ac)	Rural (ac)	Water (ac)	Mineral Resources (ac)	Agricultural (ac)	Highway (ac)	Total Q_{ADF} (gpd)
E1[6]	**2.8**	X 2000						**5,600**	**730**	**7,300**				**4.8**						**583,260**
E2								**0**	**800**	**8,000**				**19.4**						**91,160**
								0												**33,040**
E3								0						10.0						18,760
								0												39,200
								0												31,360
	80.6	X 2000						**161,200**												**186,120**
E4	**70.6**	"						**141,200**												**215,400**
E5	**17.2**	"						**34,400**						**10.0**						**86,200**
E6								0												38,640
E7								0												99,960 ✓
								0												72,800 ✓
								0												**52,360** ✓
								0												**36,960** ✓
E8	**49.4**	"						**98,800**												**302,920**
E9	86.5	"						173,000												243,080
E10								0												68,320
								0												118,080
								0												**45,120**
E11								**0**												**50,400**
								0												**48,160**
E12						80.2	X 2000	160,400												160,400
E13								0												92,960
E14								0												120,120
E15	**26.6**	"						**53,200**	**800**	**12,000**										**122,600**
								0												**101,920**
E16								**0**												**91,560**
								0												75,880
E17								0	800	8,000				34.3						266,720
								0												56,000
E18								**0**												**92,960**
E19								**0**												**23,520**
E20			**152.6**					**305,200**												**305,200**
E21								0	1,750	43,750										43,750
E22								0	1,750	43,750										111,230
E23	16.6	"						33,200												122,240
E24								**0**						**8.0**						**70,280**
E25								**0**												**42,280**
E26								**0**												**44,240**
E27								0						4.7						44,240
E28								0												24,920
								0												23,520
E29								**0**												**69,440**
E30								**0**												**89,880**
E1-E30	**350.3**	**0.0**	**152.6**	**0.0**	**0.0**	**80.2**	**0.0**	***1,166,200***	**6,630.0**	***122,800***	**0.0**	**0.0**	**0.0**	**91.2**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	***4,657,160***

[1] Refer to Plate 2.

[2] Land use designations for tributary areas E1-E30 were determined from Eastvale Area Land Use Plan for the Riverside County Integrated Project, April 2001.
The following densities were used to calculate residential land uses: Rural Residential (0.2 du/ac); Very Low Density (2 du/ac); SP125-W (2du/ac); Low Density (4 du/ac); Medium Density (7 du/ac); Medium-High Density (12 du/ac); High Density (18 du/ac)

[3] Based on 280 gpd/edu and 160 gpd for mobile homes and multi-family units.

[4] Distinction between "light" and "heavy" industrial land use is based on air and noise pollution factors; wastewater generation is assumed equal for both land uses.

[5] Commercial and industrial wastewater flow quantities are based on 2,000 gpd/ac.

[6] Total number of multi-family units. Converted to edu's by multiplying by 160/280.

[7] Based on type of school and number of studunts: 10gpd/stu for elementary; 15gpd/stu for middle; 25gpd/stu highschool

[8] Area No. 25 will be included in the Sky Country tributary area (Area No. E1) because there is a sewer that connects No. 25 to the north east portion of the Sky Country Development.

Infiltration/inflow (not shown on this table) was factored into SewerCAD calculations for final pipe designs.

JURUPA COMMUNITY SERVICES DISTRICT
EASTVALE MASTER SEWER PLAN UPDATE

Appendix A. Projected Ultimate Land Use and Average Daily Flow
By Tributary Drainage Area

Tributary Drainage Area No.[1]	Area (ac)	Residential[2]: Rural Residential (< 0.2 du/ac)	Very Low Density (0.4-2 du/ac)	SP125-W (2du/ac)	Low Density (2-5 du/ac)	Medium Density (5-8 du/ac)	Med-High Density (8-14 du/ac)	High Density (14-20 du/ac)	# of edu's	Proposed Developments: Tract Number	Area (ac)	du's	Total # of edu's	Q_{ADF}[5] (gpd)
E31	80.2				41.7				167	TT 29104	38.5	157	324	90,720
E32	199.2								0	TT 28623	19.1	83	83	23,240
									0	TT 28624	20.4	97	97	27,160
									0	TT 28641	31.2	117	117	32,760
									0	TT 28642	29.2	106	106	29,680
									0	TT 28643	20.7	95	95	26,600
									0	TT 28644	29.4	119	119	33,320
									0	TT 29248	33.6	139	139	38,920
E33A	39.9				39.9				160				160	44,800
E33B	162.3				89.5				358	TT 27591	29.5	15	373	104,440
									0	TT 28742	43.3	200	200	56,000
E34	318.4								0	TT 28369	27.6	126	126	35,280
									0	TT 28387	26.6	121	121	33,880
									0	TT 28388	23.6	109	109	30,520
									0	TT 28680	25.9	119	119	33,320
									0	TT 28681	37.2	98	98	27,440
									0	TT 28682	22.4	112	112	31,360
									0	TT 28683	20.5	80	80	22,400
									0	TT 28684	20.3	81	81	22,680
									0	TT 28685	16.6	118	118	33,040
									0	TT 28686	26.0	109	109	30,520
									0	TT 28687	36.0	153	153	42,840
E35	174.6		26.7		147.9				645				645	180,600
E36	234.1				31.0				124	TT 29148	129.8	487	611	171,080
E37	161.8				161.8				647				647	181,160
E38	165.1								0				0	0
E39	153.4				153.4				614				614	171,920
E40	217.0		20.7		177.0				749	TT 30480	19.3	50	799	223,720
E41	140.7				73.8				295				295	82,600
E42	143.2				76.8				307				307	85,960
E43	49.1				49.1				196				196	54,880
E44	59.7				59.7				239				239	66,920
E45	54.9		25.6		29.3				168				168	47,040
E46	310.5				169.2				677	TT 30480	99.3	256	933	261,240
									0	TT 29677	42.0	173	173	48,440
E47	198.0				133.9				536	TT 29677	64.1	263	799	223,720
E48	63.1				63.1				252				252	70,560
E49	147.9				147.9				592				592	165,760
E50	75.7								0				0	0
Swan Lake														
J25														
CFD Conv.	652												3,400	952,000
SARWC	1,664												2,100	588,000
E31-E50	3,148.8	0.0	73.0	0.0	1,645.0	0.0	0.0	0.0	6,726		932.1	3,583	10,309	2,886,520
Eastvale[9]	7,410.0	0.0	182.9	939.4	2,380.9	77.8	0.0	0.0	12,314.0		2,511.9	10,151	22,338	6,254,680
Tributary Total	9,726	0	182.9	939.4	2,380.9	77.8	0.0	0.0	12,314.0	0.0	2,511.9	10,151	27,838	7,794,680

Tributary Drainage Area No.[1]	Commercial: Retail (ac)	Office (ac)	Community Centers (ac)	Industrial[4]: Light (ac)	Heavy (ac)	Business Park (ac)	Public Facilities (ac)	Comm Ind Q_{ADF}[6] (gpd)	Schools: No. of Students (each)	Q_{ADF}[7] (gpd)	City Overlay (ac)	Conservation (ac)	Conservation Habitat (ac)	Open Space: Recreation (ac)	Rural (ac)	Water (ac)	Mineral Resources (ac)	Agricultural (ac)	Highway (ac)	Total Q_{ADF} (gpd)
E31								0												90,720
E32								0						15.6						23,240
								0												27,160
								0												32,760
								0												29,680
								0												26,600
								0												33,320
								0												38,920
E33A								0												44,800
E33B								0												104,440
								0												56,000
E34	10.4					X 2000 =		20,800	800	12,000				25.3						68,080
								0												33,880
								0												30,520
								0												33,320
								0												27,440
								0												31,360
								0												22,400
								0												22,680
								0												33,040
								0												30,520
								0												42,840
E35								0												180,600
E36				65.3		X 1120		73,136						8.0						244,216
E37								0												181,160
E38				165.1		X 1120 =		184,912												184,912
E39								0												171,920
E40								0												223,720
E41				66.9		X 1120		74,928												157,528
E42				66.4		X 1120		74,368												160,328
E43								0												54,880
E44								0												66,920
E45								0												47,040
E46								0												261,240
								0												48,440
E47								0												223,720
E48								0												70,560
E49								0												165,760
E50								0							75.7					0
Swan Lake																				
J25									2,750	68,750				50.3						68,750
CFD Conv.																				952,000
SARWC																				588,000
E31-E50	10.4	0.0	0.0	363.7	0.0	0.0	0.0	428,144	800.0	12,000	0.0	0.0	0.0	48.9	75.7	0.0	0.0	0.0	0.0	3,326,664
Eastvale[9]	360.7	0.0	152.6	363.7	0.0	80.2	0.0	1,594,344	7,430.0	134,800	0.0	0.0	0.0	140.1	75.7	0.0	0.0	0.0	0.0	7,983,824
Tributary Total	360.7	0	152.6	363.7	0.0	80.2	0.0	1,594,344	10,180.0	203,550	0	0	0	190.4	75.7	0.0	0.0	0.0	0.0	9,592,574

9.6

[1] Refer to Plate 2.
[2] Land use designations for tributary areas E31-E50 were determined from Eastvale Area Land Use Plan for the Riverside County Integrated Project, April 2001.
The following densities were used to calculate residential land uses: Rural Residential (0.2 du/ac); Very Low Density (2 du/ac); SP125-W (2du/ac); Low Density (4 du/ac); Medium Density (7 du/ac); Medium-High Density (12 du/ac); High Density (18 du/ac)
[3] Based on 280 gpd/edu and 160 gpd for mobile homes and multi-family units.
[4] Distinction between "light" and "heavy" industrial land use is based on air and noise pollution factors; wastewater generation is assumed equal for both land uses.
[5] Commercial and industrial wastewater flow quantities are based on 2,000 gpd/ac.
[6] None.
[7] Based on type of school and number of students: 10gpd/stu for elementary, 15gpd/stu for middle; 25gpd/stu highschool
[8] Area No. 25 will be included in the Sky Country tributary area (Area No. E1) because there is a sewer that connects No. 25 to the north east portion of the Sky Country Development.
[9] Eastvale Subtotal consists of tributary areas E1-E50.
[10] The District Total for this spreadsheet totalizes areas within the tributary boundaries only. Areas outside the tributary areas but withing the District Boundaries account for approximately 3,800 acres, therefore, the total area within the District is
[11] Total District Residential EDU's (Households)
Infiltration/inflow (not shown on this table) was factored into SewerCAD calculations for final pipe designs.

5,972 EDU'S
727 EDU'S
11,257 EDU'S
SARWC
2,100
32,157
2,329 (SKY COUNTRY E1 & 22)
29,830

APPENDIX B

PIPELINE COST ESTIMATES

APPENDIX B
PIPELINE COST ESTIMATES

Nodal Map Pipe Reach Label	Description	Quantity	Unit	Unit Price	Construction Cost	Project Cost[1]
1	10 inch	1,168	LF	$145	$169,360	$237,104
2	10 inch	1,232	LF	$145	$178,640	$250,096
3	10 inch	1,436	LF	$145	$208,220	$291,508
4	10 inch	2,070	LF	$145	$300,150	$420,210
5	15 inch	720	LF	$175	$126,000	$176,400
6	18 inch	2,145	LF	$195	$418,275	$585,585
7	42 inch	1,263	LF	$440	$555,720	$778,008
8	42 inch	46	LF	$440	$20,240	$28,336
9	42 inch	1,985	LF	$440	$873,400	$1,222,760
10	42 inch	300	LF	$440	$132,000	$184,800
11	42 inch	3,000	LF	$440	$1,320,000	$1,848,000
12	42 inch	202	LF	$440	$88,880	$124,432
13	12 inch	367	LF	$165	$60,555	$84,777
14	12 inch	2,306	LF	$165	$380,490	$532,686
15	12 inch	2,248	LF	$165	$370,920	$519,288
16	NOT USED					
17	NOT USED					

APPENDIX B
PIPELINE COST ESTIMATES

Nodal Map Pipe Reach Label	Description	Quantity	Unit	Unit Price	Construction Cost	Project Cost[1]
18	NOT USED					
19	27 inch	1,122	LF	$260	$291,686	$408,360
20	10 inch	3,650	LF	$145	$529,250	$740,950
21	12 inch	670	LF	$165	$110,550	$154,770
22	15 inch	1,950	LF	$175	$341,250	$477,750
23	12 inch	860	LF	$165	$141,900	$198,660
24	18 inch	1,806	LF	$195	$352,170	$493,038
25	18 inch	2,664	LF	$195	$519,480	$727,272
26	18 inch	1,976	LF	$195	$385,320	$539,448
27	12 inch	1,972	LF	$165	$325,380	$455,532
28	10 inch	4,000	LF	$145	$580,000	$812,000
29	30 inch	2,641	LF	$290	$765,867	$1,072,214
30	12 inch	2,170	LF	$165	$358,050	$501,270
31	10 inch	2,351	LF	$145	$340,939	$477,315
32	12 inch	1,588	LF	$165	$262,020	$366,828
33	15 inch	2,830	LF	$175	$495,250	$693,350
34	18 inch	1,297	LF	$195	$252,915	$354,081
35	18 inch	2,829	LF	$195	$551,655	$772,317

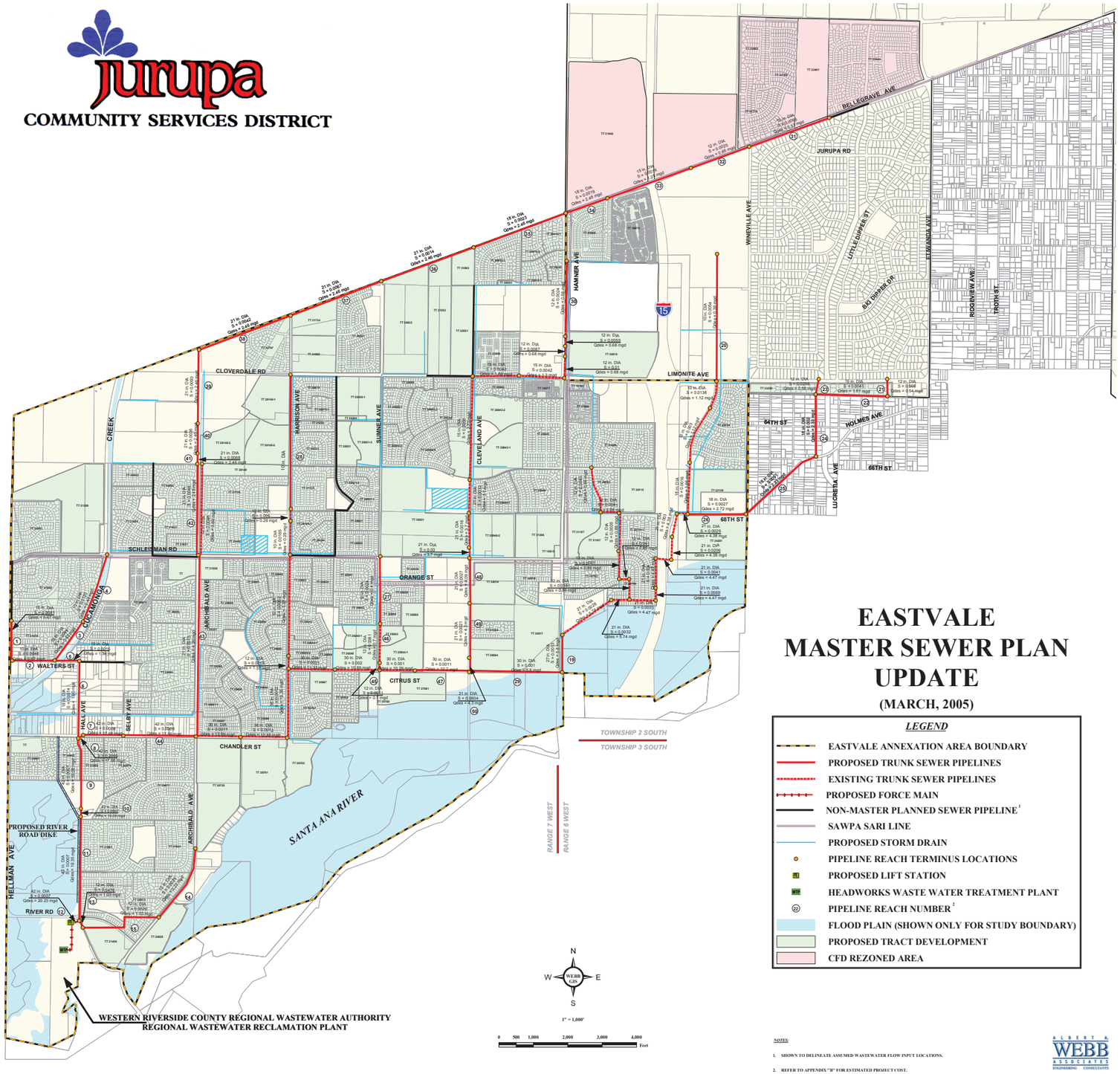
APPENDIX B
PIPELINE COST ESTIMATES

Nodal Map Pipe Reach Label	Description	Quantity	Unit	Unit Price	Construction Cost	Project Cost[1]
36	21 inch	2,833	LF	$210	$594,930	$832,902
37	21 inch	2,826	LF	$210	$593,460	$830,844
38	21 inch	2,841	LF	$210	$596,610	$835,254
39	21 inch	2,181	LF	$210	$458,010	$641,214
40	21 inch	856	LF	$210	$179,760	$251,664
41	21 inch	345	LF	$210	$72,450	$101,430
42	21 inch	2,570	LF	$210	$539,700	$755,580
43	21 inch	5,270	LF	$210	$1,106,700	$1,549,380
44	42 inch	2,115	LF	$440	$930,600	$1,302,840
45	12 inch	106	LF	$165	$17,490	$24,486
46	12 inch	1,203	LF	$165	$198,495	$277,893
47	30 inch	1,322	LF	$290	$383,380	$536,732
48	21 inch	1,325	LF	$210	$278,250	$389,550
49	21 inch	1,262	LF	$210	$264,957	$370,940
50	21 inch	350	LF	$210	$73,500	$102,900
Totals:		84,269	LF		**$18,094,824**	**$25,330,000**

[1]Project cost is 1.4 times construction cost rounded to nearest $10,000. Project cost includes: construction costs, construction contingencies, design engineering including plans and specifications; design and construction surveying and mapping; geotechnical evaluation and report; engineering contract administration; field inspection and basic environmental documentation. Costs are based on Engineering News Record(ENR) The Engineering News Record Construction Cost Index (Los Angeles) for October, 2003 is 7,543.67 Escalation, financing, interest during construction, legal, land, R-O-W agent, and environmental impact report costs are not included.

Plate 1

Jurupa
COMMUNITY SERVICES DISTRICT



EASTVALE MASTER SEWER PLAN UPDATE

(MARCH, 2005)

LEGEND

- EASTVALE ANNEXATION AREA BOUNDARY
- PROPOSED TRUNK SEWER PIPELINES
- EXISTING TRUNK SEWER PIPELINES
- PROPOSED FORCE MAIN
- NON-MASTER PLANNED SEWER PIPELINE[1]
- SAWPA SARI LINE
- PROPOSED STORM DRAIN
- PIPELINE REACH TERMINUS LOCATIONS
- PROPOSED LIFT STATION
- HEADWORKS WASTE WATER TREATMENT PLANT
- PIPELINE REACH NUMBER[2]
- FLOOD PLAIN (SHOWN ONLY FOR STUDY BOUNDARY)
- PROPOSED TRACT DEVELOPMENT
- CFD REZONED AREA

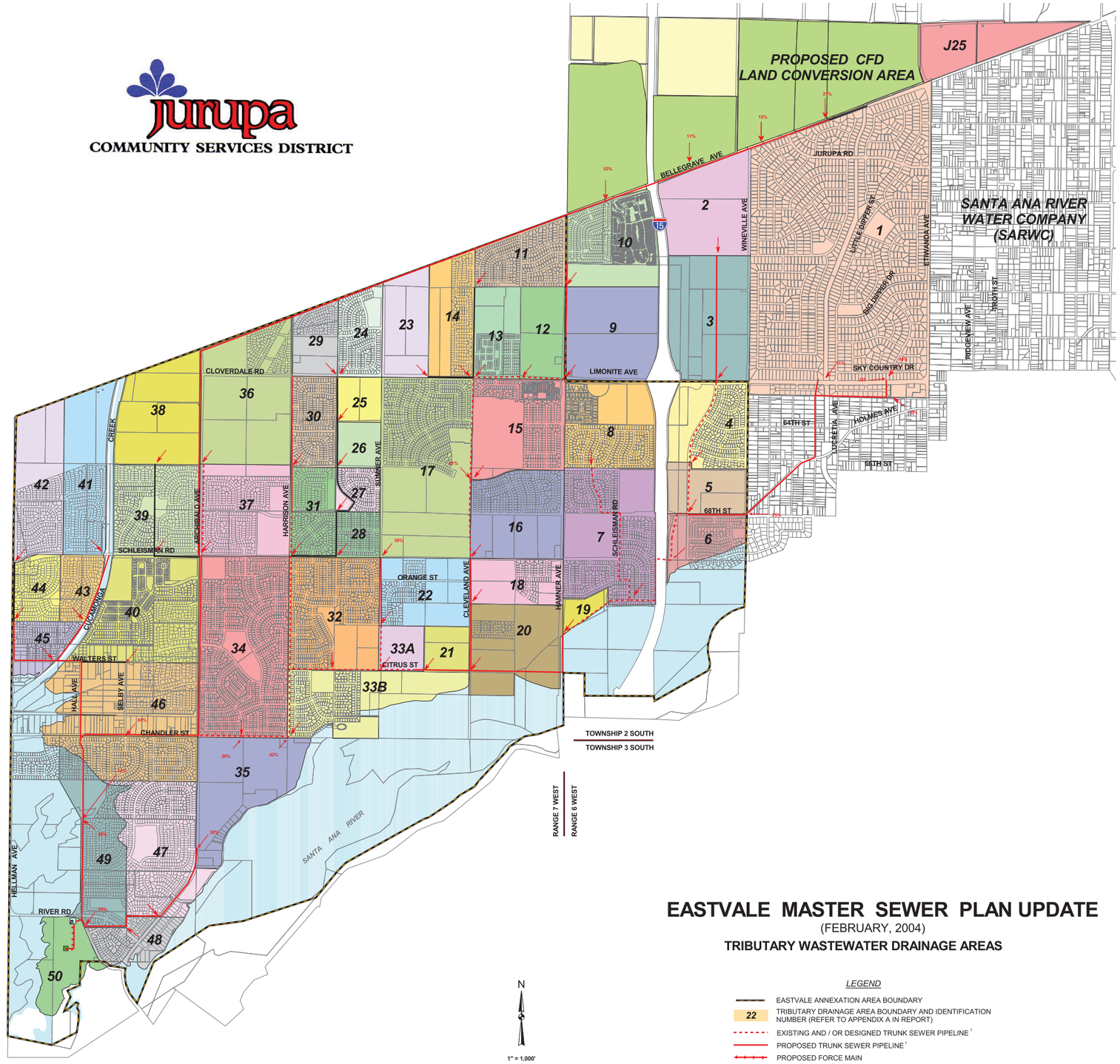
NOTES:

1. SHOWN TO DELINEATE ASSUMED WASTEWATER FLOW INPUT LOCATIONS.
2. REFER TO APPENDIX "B" FOR ESTIMATED PROJECT COST.

ALBERT A. WEBB ASSOCIATES
ENGINEERING CONSULTANTS

Map revised March 23, 2005 k:\gis\gis-data\webb_planning\map.mxd

PLATE 2



EASTVALE MASTER SEWER PLAN UPDATE

(FEBRUARY, 2004)

TRIBUTARY WASTEWATER DRAINAGE AREAS

LEGEND

- EASTVALE ANNEXATION AREA BOUNDARY
- 22 — TRIBUTARY DRAINAGE AREA BOUNDARY AND IDENTIFICATION NUMBER (REFER TO APPENDIX A IN REPORT)
- EXISTING AND / OR DESIGNED TRUNK SEWER PIPELINE [1]
- PROPOSED TRUNK SEWER PIPELINE [1]
- PROPOSED FORCE MAIN
- NON-MASTER PLANNED SEWER PIPELINE SHOWN TO DELINEATE ASSUMED WASTEWATER FLOW INPUT LOCATIONS
- APPROXIMATE WASTEWATER INPUT LOCATION FOR TRIBUTARY AREA (INPUT IS 100% UNLESS OTHERWISE ANNOTATED)
- U — PROPOSED SEWER LIFT STATION

[1] 8" DIAMETER PIPELINES ARE NEITHER SHOWN NOR CONSIDERED TO BE TRUNK SEWERS AND ARE ASSUMED TO BE CONSTRUCTED BY PRIVATE DEVELOPERS.

ALBERT A. WEBB ASSOCIATES
ENGINEERING CONSULTANTS

Map revised February 19, 2004 G:\2001\01-0289\gis\01-0289.aor

Appendix 3B.3

2004 EASTVALE MASTER SEWER PLAN UPDATE ADDENDUM NO. 1 FOR JURUPA COMMUNITY SERVICES DISTRICT

jurupa
COMMUNITY SERVICES DISTRICT

EASTVALE MASTER SEWER PLAN UPDATE

ADDENDUM NO. 1

September, 2004

Prepared by
Albert A. Webb Associates

INTRODUCTION

Due to the strength of the local economy, recent construction bids have been higher than expected. This is especially true for sewer projects. As a result, the District has increased the unit construction and project costs for the February, 2004 Eastvale Master Sewer Plan Update. The updated cost estimates are approximately 25 percent higher than the referenced reports' costs. The updated unit construction costs that are shown on Table 1, were based on recent publicly bid projects. Recent bids have been from 14 to 42 percent higher than anticipated. The 42 percent figure was for an extremely deep sewer (Citrus Street trunk sewer), which for the most part, will not be constructed in the District after the Citrus Street Trunk Sewer is completed. It was therefore determined that a 25 percent increase to the previous used Master Plan unit costs would be appropriate.

It should be noted that unlike water pipeline projects that normally have a relatively consistent and shallow depth, and therefore a fairly predictable construction cost, sewer pipeline construction costs can vary significantly due to the unknown depths of the sewerlines at the project planning stage. Construction costs for sewerlines can increase rapidly with increased depth due to additional shoring costs, larger volume of excavation, larger volumes of pavement removals and replacements and the increased possibility of encountering groundwater and rock material. As such, in order to ensure the District will collect adequate funds to construct future master planned trunk sewers, relatively conservative costs should be used in the concept stage of planning studies such as the subject report. As additional engineering facts are obtained, refinement in the cost estimates can occur.

COST ANALYSIS

Pipelines

The unit costs for sewerlines include pipeline material and installation, manholes, asphalt concrete removal, disposal, and replacement. Construction costs were determined by reviewing historical bids of similar projects and through a cost study where a "generic bid" was sent to three prominent contractors in the area. The generic bid was based on the assumptions that an average project for the District would consist of 2,500 linear feet of pipe, and that asphalt concrete roads would be removed, disposed of, and replaced. Road reconstruction was assumed to be 25 feet wide with 4 inches of AC pavement over 8 inches of Class II base. The average depth of the pipe was assumed to be 20 ft and would require B-2 bedding. It was assumed nine, 5 ft diameter manholes would be installed for each project. These costs were then updated to correlate with recent bid results and are about 25 percent higher than the previously used data. Not included in the unit cost estimates are extraordinary construction items such as bore casings, dewatering, rock removal, etc... A summary of these estimated unit costs are as shown on Table 1.

Table 1 – Estimated Unit Cost of Pipelines

Sewer Line Dia. (in.)	Construction Cost	Project Cost*
10	$181.00	$255.00
12	$206.00	$290.00
15	$219.00	$310.00
18	$244.00	$345.00
21	$263.00	$370.00
24	$300.00	$420.00
27	$325.00	$455.00
30	$363.00	$510.00
36	$419.00	$590.00
39	$500.00	$700.00
42	$550.00	$770.00
48	$606.00	$850.00

**Project cost is 1.4 times construction cost rounded up to nearest $5. Project cost includes: construction cost, construction contingencies, design engineering including plans and specifications; design and construction surveying and mapping; geotechnical evaluation and report; engineering contract administration; field inspection and basic environmental documentation. Costs are based on Engineering New Record (E.N.R.). The Engineering news Record Construction Cost Index for the Los Angeles Areas for August, 2004 was utilized. This value is 7,857. Escalation, financing, interest during construction, legal, land, R.O.W. agent, and environmental impact report costs are not included in construction costs. Additionally, not included in the unit cost estimates are extraordinary construction items such as bore casings, dewatering, rock removal etc...*

Lift Station, Forcemain, and Treatment Plant Capacity

Additional lift station, forcemain, and treatment plant capacity project costs associated with the Eastvale Master Sewer Plan Update include the River Road lift station and force main and wastewater treatment capacity purchase at the Western Riverside County Regional Wastewater Reclamation Plant (WRCRWRP). The River Road lift station and force main estimated project cost is $7,320,000[1].

The purchase of treatment plant capacity at WRCRWRP was assumed to reflect the current costs to construct a wastewater treatment plant. Presently, due to the increasing costs of solids treatment and disposal, and dependent upon the amount of treatment capacity being constructed, typical unit project costs range from $9/gallon/day to almost $14/gallon/day[2]. Using this project cost range and the projected ultimate average daily flow of 9.6 mgd, the total estimated project cost for treatment could vary from $86,400,000 to $134,400,000.

[1] *"River Road Lift Station Preliminary Design Report", November 2003, prepared by Albert A. Webb Associates. Increased 10 percent to reflect actual bid results for the Phase I facility.*

[2] *"JCSD New Wastewater Treatment Cost Estimate" letter prepared by Carollo Engineers, dated April 1, 2004.*

A summary of the estimated project costs for the Eastvale sewer system are shown on Table 2. As shown on Table 2, the total project cost estimate of the ultimate sewer system ranges from $125,400,000 to $173,400,000.

Table 2 – Estimated Project Cost Summary

Master Plan Improvement	Estimated Project Cost
Trunk & Interceptor Sewerlines	$ 31,680,000[1,2,3]
River Road Lift Station & Associated Force Mains	$ 7,320,000[2,3]
Treatment Plant Capacity Purchase and/or Construction at WRCRWRP	$ 86,400,000- $134,400,000
Total Estimated Project Cost	$125,400,000-$173,400,000

[1] *Refer to Appendix A for Details*
[2] *Total estimated construction cost rounded up to the nearest $10,000.*
[3] *Project cost is 1.4 times construction cost rounded up to nearest $5. Project cost includes: construction cost, construction contingencies, design engineering including plans and specifications; design and construction surveying and mapping; geotechnical evaluation and report; engineering contract administration; field inspection and basic environmental documentation. Costs are based on Engineering New Record (E.N.R.). The Engineering news Record Construction Cost Index for the Los Angeles Areas for August, 2004 was utilized. This value is 7,857. Escalation, financing, interest during construction, legal, land, R.O.W. agent, and environmental impact report costs are not included in construction costs. Additionally, not included in the unit cost estimates are extraordinary construction items such as bore casings, dewatering, rock removal etc…*

FINDINGS, CONCLUSIONS, AND RECOMMENDATIONS

As summarized in Appendix A, the total projected average daily wastewater flow for the Eastvale area is about 9.6 MGD. This amount is approximately 1.4 MGD greater than the 8.2 MGD projected in the original report primarily due to additional flows from the Santa Ana River Water Company area and the CFD land conversion area. The updated projected development estimates 27,838 dwelling units as opposed to the original report that projected 24,657 dwelling units. Finally, the estimated project cost of the ultimate Eastvale Master Sewer Plan improvements range from $125,400,000 to $173,400,000 depending upon treatment plant capacity purchase and/or construction costs.

We have concluded that the proposed trunk sewer system as shown on Plate 1 is adequately sized to accommodate the projected design flows. As such, it is our recommendation that the Master Sewer Plan for the Eastvale area be amended as described in this addendum to the February, 2004 letter report.

REGISTERED PROFESSIONAL ENGINEER
WALLACE H. FRANZ
No. 26979
Exp. 3-31-05
CIVIL
STATE OF CALIFORNIA

APPENDIX A

PIPELINE COST ESTIMATES

APPENDIX A
PIPELINE COST ESTIMATES

Nodal Map Pipe Reach Label	Description	Quantity	Unit	Unit Price	Construction Cost	Project Cost[1]
1	10 inch	1,168	LF	$181	$211,408	$295,971
2	10 inch	1,232	LF	$181	$222,992	$312,189
3	10 inch	1,436	LF	$181	$259,916	$363,882
4	10 inch	2,070	LF	$181	$374,670	$524,538
5	15 inch	720	LF	$219	$157,680	$220,752
6	18 inch	2,145	LF	$244	$523,380	$732,732
7	42 inch	1,263	LF	$550	$694,650	$972,510
8	42 inch	46	LF	$550	$25,300	$35,420
9	42 inch	1,985	LF	$550	$1,091,750	$1,528,450
10	42 inch	300	LF	$550	$165,000	$231,000
11	42 inch	3,000	LF	$550	$1,650,000	$2,310,000
12	42 inch	202	LF	$550	$111,100	$155,540
13	12 inch	367	LF	$206	$75,602	$105,843
14	12 inch	2,306	LF	$206	$475,036	$665,050
15	12 inch	2,248	LF	$206	$463,088	$648,323
16	NOT USED					
17	NOT USED					

APPENDIX A
PIPELINE COST ESTIMATES

Nodal Map Pipe Reach Label	Description	Quantity	Unit	Unit Price	Construction Cost	Project Cost[1]
18	NOT USED					
19	27 inch	1,122	LF	$325	$364,608	$510,451
20	10 inch	3,650	LF	$181	$660,650	$924,910
21	12 inch	670	LF	$206	$138,020	$193,228
22	15 inch	1,950	LF	$219	$427,050	$597,870
23	12 inch	860	LF	$206	$177,160	$248,024
24	18 inch	1,806	LF	$244	$440,664	$616,930
25	18 inch	2,664	LF	$244	$650,016	$910,022
26	18 inch	1,976	LF	$244	$482,144	$675,002
27	12 inch	1,972	LF	$206	$406,232	$568,725
28	10 inch	4,000	LF	$181	$724,000	$1,013,600
29	30 inch	2,641	LF	$363	$958,654	$1,342,116
30	12 inch	2,170	LF	$206	$447,020	$625,828
31	10 inch	2,351	LF	$181	$425,585	$595,819
32	12 inch	1,588	LF	$206	$327,128	$457,979
33	15 inch	2,830	LF	$219	$619,770	$867,678
34	18 inch	1,297	LF	$244	$316,468	$443,055
35	18 inch	2,829	LF	$244	$690,276	$966,386

APPENDIX A
PIPELINE COST ESTIMATES

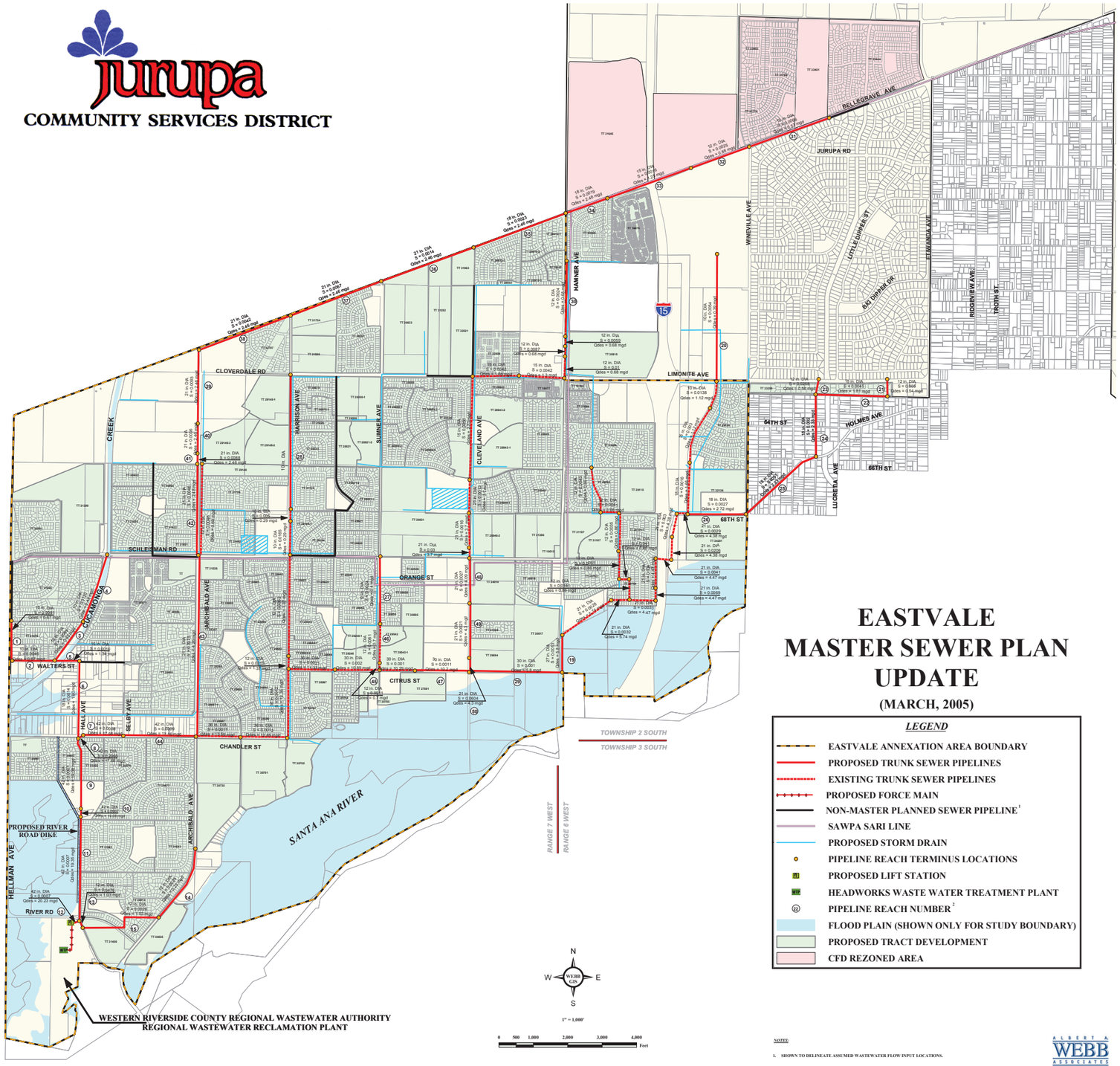
Nodal Map Pipe Reach Label	Description	Quantity	Unit	Unit Price	Construction Cost	Project Cost[1]
36	21 inch	2,833	LF	$263	$745,079	$1,043,111
37	21 inch	2,826	LF	$263	$743,238	$1,040,533
38	21 inch	2,841	LF	$263	$747,183	$1,046,056
39	21 inch	2,181	LF	$263	$573,603	$803,044
40	21 inch	856	LF	$263	$225,128	$315,179
41	21 inch	345	LF	$263	$90,735	$127,029
42	21 inch	2,570	LF	$263	$675,910	$946,274
43	21 inch	5,270	LF	$263	$1,386,010	$1,940,414
44	42 inch	2,115	LF	$550	$1,163,250	$1,628,550
45	12 inch	106	LF	$206	$21,836	$30,570
46	12 inch	1,203	LF	$206	$247,818	$346,945
47	30 inch	1,322	LF	$363	$479,886	$671,840
48	21 inch	1,325	LF	$263	$348,475	$487,865
49	21 inch	1,262	LF	$263	$331,827	$464,558
50	21 inch	350	LF	$263	$92,050	$128,870
Totals:		84,269	LF		**$22,529,045**	**$31,680,000** [2]

[1]Project cost is 1.4 times construction cost. Project cost includes: construction cost, construction contingencies, design engineering including plans and specifications; design and construction surveying and mapping; geotechnical evaluation and report; engineering contract administration; field inspection and basic environmental documentation. Costs are based on Engineering News Record (E.N.R.) The Engineering News Record Construction Cost Index for the Los Angeles area for August 2004 was utilized. This value is 7,857.10. Escalation, financing, interest during construction, legal, land, R-O-W agent, and environmental impact report costs are not included in construction costs.

[2]Rounded to the nearest $10,000.

Plate 1

Jurupa
COMMUNITY SERVICES DISTRICT



EASTVALE MASTER SEWER PLAN UPDATE

(MARCH, 2005)

LEGEND

- EASTVALE ANNEXATION AREA BOUNDARY
- PROPOSED TRUNK SEWER PIPELINES
- EXISTING TRUNK SEWER PIPELINES
- PROPOSED FORCE MAIN
- NON-MASTER PLANNED SEWER PIPELINE[1]
- SAWPA SARI LINE
- PROPOSED STORM DRAIN
- PIPELINE REACH TERMINUS LOCATIONS
- PROPOSED LIFT STATION
- HEADWORKS WASTE WATER TREATMENT PLANT
- PIPELINE REACH NUMBER[2]
- FLOOD PLAIN (SHOWN ONLY FOR STUDY BOUNDARY)
- PROPOSED TRACT DEVELOPMENT
- CFD REZONED AREA

NOTES:

1. SHOWN TO DELINEATE ASSUMED WASTEWATER FLOW INPUT LOCATIONS.
2. REFER TO APPENDIX "B" FOR ESTIMATED PROJECT COST.

ALBERT A. WEBB ASSOCIATES
ENGINEERING CONSULTANTS

Map revised March 23, 2005 k:\gis\gis-data\webb_planner.mxd

Appendix 3B.4

2007 MASTER SEWER PLAN ADDENDUM FOR JURUPA COMMUNITY SERVICES DISTRICT

MASTER SEWER PLAN ADDENDUM

Prepared for:

jurupa
COMMUNITY SERVICES DISTRICT

October, 2007

ALBERT A. WEBB ASSOCIATES
ENGINEERING CONSULTANTS

ALBERT A. WEBB ASSOCIATES

3788 McCRAY STREET • RIVERSIDE, CA 92506
PHONE: 951.686.1070 • FAX: 951.788.1256
WWW.WEBBASSOCIATES.COM

W.O.: 07-0176
File: 1432.1234

October 12, 2007

OFFICE OF THE DISTRICT ENGINEER

Mr. Eldon Horst
General Manager
Jurupa Community Services District
11201 Harrel Street
Mira Loma, CA 91752

RE: Master Sewer Plan Addendum

Dear Mr. Horst:

In accordance with the Jurupa Community Services District (District) authorization, we have completed the Master Sewer Plan Addendum for the 2004 Master Sewer Plan. The original Master Sewer Plan provided "build-out" average daily flows for the District, based on District standard waste water generation factors. The purpose of this addendum is to re-evaluate the waste water generation factors based on current District flow records and re-calculate the waste water generation factors using the recorded data. New "build-out" average daily flows are calculated using the new waste water generation factors. These updated flow projections will be used primarily for the purpose of predicting ultimate treatment plant capacity and the resulting amount of plant expansion and/or purchase that will be required. All project costs have been updated to October 2007 from the 2004 Master Sewer Plan and are presented in this addendum. Waste water quality is also presented based on recorded data.

A. WASTE WATER GENERATION FACTORS

Previous Waste Water Generation Factors

The 2004 Master Sewer Plan used various waste water generation factors to project flows for the various tributary areas within the District. Domestic waste water flow was based on equivalent dwelling units (EDU's), and was developed by using the District's standard generation factor and the number of residential EDU's tributary to each treatment plant. Commercial and industrial waste flows were based on land acreages and the District's standard generation factors. Waste flows for schools were based on student population and estimated generation factors from reference publications.

These previously calculated generation factors can be found in Table 3-1 of the 2004 Master Sewer Plan and are referenced in **Table 1**.

Table 1 – Summary of Wastewater Generation Factors from the 2004 Master Sewer Plan(1)

Land Use	Wastewater Generation Factor
Residential Wastewater	280 gpd/edu
Commercial/Industrial	2,000 gpd/acre
Public Uses (excluding schools)	1,000 gpd/acre
Elementary Schools	10 gpd/student
Middle Schools	15 gpd/student
High Schools	25 gpd/student
Infiltration/Inflow (existing development areas)	160 gpd/acre
Infiltration/Inflow (current and future development areas)	50 gpd/acre

(1) From Table 3-1 of JCSD's 2004 Master Sewer Plan.

Existing Waste Water Generation Factors

A review of existing District waste water flow records (within the last five years) were used in developing the new domestic waste water generation factors. The District was divided up into various tributary areas as shown on **Plate 1**. Waste water generation factors were calculated based on actual flows experienced within the tributary areas, and the number of active sewer connections[1]. It should be noted that the tributary areas used in this study are slightly different than those used in the 2004 Master Sewer Plan. While the 2004 Master Sewer Plan used tributary areas based on the Riverside County Integrated Project (RCIP) Jurupa Area Land Use Plan and the RCIP Eastvalc Area Land Use Plan (**Plate 3**), this study was based on areas tributary to the various metering stations, lift stations, and treatment plants throughout the District (**Plate 1**). However, the areas tributary to the City of Riverside WWTP and the Western Riverside County Regional Wastewater Reclamation Facility (WRCRWWRF) are the same in this study as in the 2004 Master Sewer Plan, and thus direct comparisons can be made.

Flow records were obtained for as many of the tributary areas as the District was able to provide. Several of the tributary areas were not metered sufficiently to obtain accurate flow records, however most of the larger areas had flow records for a period of several years. All flow data were provided by the District and spanned some time period between January 2003 and May 2007 (**Appendix A**). It should be noted that the subject

[1] Active account and EDU data were provided by Glenn Reiter of Reiter Lowry Consultants, based on data provided by JCSD.

flow records may in some instances have combined residential, commercial, and industrial flow sources. Metered flow data represented flows from each tributary area as a whole, and could not therefore be separated into residential, commercial, and industrial flows.

Average daily flows for each month were evaluated in conjunction with the number of active EDU's contributing to each flow. It was therefore necessary to obtain a record of active accounts for each month of the same time period between January 2003 and May 2007. This information was provided by Glenn Reiter of Reiter Lowry Consultants. Glenn Reiter provided a list of the active accounts that were served by the sewer system, and the corresponding billing records associated with each account. The billing records were used to determine when the accounts were active. Glenn Reiter also provided the number of EDU's associated with each of the active accounts, and these EDU data were cross checked with the EDU information obtained directly from the District in order to insure an accurate number of EDU's for each account. Finally, each account was grouped into its corresponding tributary area using GIS technology and address information provided by the District. This provided a total number of EDU's per month for each tributary area (**Appendix A**). Residential and non-residential EDU's were determined for the areas pertaining to Plant 1 (City of Riverside WWTP) and Eastvale (WRCRWWRF) (**Appendix D**). However, for each tributary area shown in **Plate 1**, all EDU's were summed together into totals in order that they could be directly compared to the flows.

Plate 2 shows the areas tributary to Plant 1, Plant 2, River Road lift station, and the smaller Clay St. and Van Buren lift stations as of May 2007. Parcels with active accounts are shown within each tributary area and the number of active accounts and EDU's for each tributary area is displayed in the legend. Plate 2 assists in visualizing how the accounts were divided into their respective tributary areas and how many EDU's contributed to the various waste water flows. It should be noted that that Sky Country (RCIP land use area E1) is currently tributary to Plant 1, however for "build-out," Sky Country waste water flow was projected to be tributary to Eastvale (**Table 4**).

Having obtained an average daily flow and total number of EDU's per month for each tributary area, the amount of flow per EDU (gpd/EDU) could then be calculated. These calculations are shown in **Appendix A**. New waste generation factors were developed by comparing the flow per EDU from each of the tributary areas. Unlike the waste generation factors from the 2004 Master Sewer Plan (shown in **Table 1**) which were separated into residential, commercial/industrial, and schools, new waste generation factors represent all categories summed together. **Table 2** provides a summary of the results of the wastewater flow generation factors for each metering station.

Table 2 – Summary of Existing Wastewater Flow Generation Factors

TRIBUTARY AREA[1]	Highest Annual Avg. Flow (gpd/EDU)	Lowest Annual Avg. Flow (gpd/EDU)	Annual Avg. Flow (gpd/EDU)	Comments
PLANT 1	261	242	252	Consistent Average Flows (+/- 4%)
PLANT 2	264	263	263	Consistent Average Flows, however flexibility in operational scenarios (ie Clay St. LS pumps to plant 2 or to regional force main) could affect results
EASTVALE				
RIVER RD. L.S.	205	61	167	Small database (5 mon.); Average flows trending to increase each month
ARCHIBALD M.S.	213	100	157	Low initial average flows; Trend Increasing flows each month
CELEBRATION M.S.	207	70	146	Low initial average flows; Trend Increasing flows each month
CHANDLER L.S.	182	158	167	Low Annual Average Flows
CLEVELAND M.S.	253	170	196	No consistency, flows vary annually up and down
CITRUS L.S.	154	154	154	Small data range; 11 mon.
HAMNER L.S.	371	165	248	Los initial average flows; Trend Increasing flows each month
HARRISON M.S.	177	68	135	No consistency, flows vary annually up and down
EASTVALE AVG. FLOWS	220	118	171	

[1] Refer to Plate 1

Projected Wastewater Generation Factors

As shown on **Table 2**, there is a significant difference in the existing wastewater generation results between the older areas (Plant 1 and Plant 2), and the new development area (Eastvale). While Plant 1 and 2 average daily wastewater generation factors are 10% to 6% respectively below the current District standard (280 gpd/EDU), the Eastvale average is approximately 40% below the current District standard. The Eastvale area has been subject to very dynamic growth, which has produced unreliable results since the monthly EDU totals vary significantly. This has resulted in a wide range of wastewater generation factors. As already illustrated by the Eastvale areas largest tributary area base, the River Road lift station, there is an increasing trend in the average daily waste water generation factor. Additionally, wet weather conditions, for the most part, are not included in the Eastvale Area's data base. As such, we would not recommend using a factor less than 200 gpd/EDU. In fact, pending additional monitoring results at River Road, we believe it would be prudent at this point in time to assume an Eastvale wastewater generation factor of at least 220 gpd/EDU.

Regarding the older area (Plants 1 and 2), due to the flexibility in operational scenarios in the Plant 2 area, as commented on in **Table 2**, we recommend using the more stable data base from the Plant 1 results. Using the 4 year average generation factor of 252 gpd/EDU would be an appropriate factor to use in the older development areas.

B. PROJECTED BUILD-OUT FLOWS

Previously Projected "Build-out" Flows

The "build-out" average daily flows for the District were calculated in the 2004 Master Sewer Plan. These "build-out" flows were based on the RCIP land use plans for Jurupa and Eastvale, and calculated using the previously presented waste generation factors shown in **Table 1**. Table 4-4 of the 2004 Master Sewer Plan provides the flows for ultimate wastewater treatment plant capacity. All flow projections in this study were compared to Table 4-4 of the 2004 Master Sewer Plan, modified in this report as **Table 3**.

Table 3 – Previously Projected "Build-out" Average Daily Flows for Ultimate Wastewater Treatment Plant Capacity [1]

Tributary Drainage Areas[2]	Residential Average Daily Flow (GPD)	Commercial / Industrial [3] Average Daily Flow (GPD)	School Average Daily Flow (GPD)	Total Average Daily Flow (GPD)
JCSD Areas (J1–J15B, J17A & J19 – J23)	4,415,880	675,732 [4]	169,875	5,261,487
Indian Hills Area (J16, J17B & J18)	495,600 [5]	82,305	8,510	586,415
Lower Portion of Tributary Area No. J18	0	38,450	0	38,450
City of Riverside WWTP Subtotal	**4,911,480**	**796,487**	**178,385**	**5,886,352**
CFD Area No. 1 (J24, J26 – J30)	32,200	1,917,350	0	1,949,550
Eastvale Areas (E1 – E50 & J25)				
Western Riverside Co. WWTP Subtotal	**6,254,680**	**478,600**	**203,550**	**6,936,830**
TOTAL	**11,198,360**	**3,192,437**	**381,935**	**14,772,732**

[1] Table 3 is modified from Table 4-4 in the Master Sewer Plan with added subtotals.

[2] Refer to Plate 3

[3] Commercial and industrial wastewater generation factor based on 500 gpd/AC.

[4] Area deduction of approximately 500 acres for commercial and industrial areas located above and some portion of areas below State Highway 60 of areas tributary to Plant 1.

[5] A wastewater generation factor for residential dwelling units of 200 gpd/EDU was utilized for projecting flows for ultimate treatment plant capacity for the Indian Hills Area only (refer to Section 3). A factor of 280 gpd/EDU was utilized for all other residential areas.

New Projected "Build-out" Flows

New "build-out" flows were calculated based on the new wastewater generation factors. Eastvale "build-out" flows (5.7 MGD) are tributary to the Western Riverside County Regional Wastewater Reclamation Facility, and Plant 1 "build-out" flows (4.9 MGD) are tributary to the City of Riverside Wastewater Treatment Plant (**Table 4**). All flows from the various drainage areas were summed together in order to calculate total "build-out" flows for each treatment plant, and the District as a whole. It should be noted that "build-out" flows in **Table 4** reflect average daily dry weather flows, and that wet weather and peak flows will be higher than those in the table. Using the District standard peaking factors and accounting for infiltration, potential peak flows are estimated to be approximately 12.0 mgd for the City of Riverside WWTP and 12.3 mgd for the Western Riverside County WWTP.

Table 4 – New Projected "Build-out" Average Daily Flows for Ultimate Wastewater Treatment Plant Capacity

TRIBUTARY WASTEWATER TREATMENT PLANT	Residential		Comm./Ind.	Schools	"Build-out"
	Res. EDU's[1]	Flows (gpd)	Flows (gpd)	Flows (gpd)	Flows (gpd)
City of Riverside WWTP[2]	18,249	4,598,748[3]	265,230[4]	59,402[4]	4,923,380
Western Riverside Co. WWTP[5]	22,338	4,979,544[6]	478,600[7]	203,550[7]	5,661,694
Total[8]	40,587	9,578,292	743,830	262,952	10,585,074

[1] From the 2004 Master Sewer Plan (refer to Appendix L of 2004 Master Sewer Plan)
[2] Includes Land Use areas J1-J18, J19-J23.
[3] Calculated by multiplying the EDU's times the projected wastewater generation factors of 252 gpd/EDU.
[4] 1/3 of the projected "buildout" flows from the 2004 Master Sewer Plan. 2/3 of non-residential EDU's have already been built (Appendix D) and accounted for in the wastewater generation factor of 252 gpd/EDU.
[5] Includes Land Use areas E1-E50, J25.
[6] Calculated by multiplying the EDU's times the projected wastewater generation factors, 220 gpd/EDU for Eastvale and 252 gpd/EDU for Sky Country (Land Use Area E1).
[7] From the 2004 Master Sewer Plan (refer to Appendix L of 2004 Master Sewer Plan). Flows added because the vast majority of the buildout non-residential EDU's have not yet been constructed (Appendix D)
[8] Total wastewater flows do not include wastewater generated in Land Use Areas pertaining to CFD No. 1 (J24, J26-30).

Wastewater Quality

In projecting ultimate wastewater treatment plant capacity it is also important to consider the influent wastewater quality at the plant. Recorded wastewater quality data was obtained from the District for Plant 1 and River Road lift station (**Appendix C**). Plant 1 data shows monthly TSS and BOD levels between January 2006 and June 2007[1], and River Road shows the same data from April to September of 2007[2]. According to the recorded data, average BOD levels are higher for the River Road lift station than Plant 1. This may be a result of lower wastewater flow which tends to concentrate the pollutants.

[1] Average BOD and TSS is 252 mg/L and 250 mg/L respectively.
[2] Average BOD and TSS is 311 mg/L and 274 mg/L respectively.

C. UPDATED PROJECT COSTS

This section of the report serves to update all the project costs from the 2004 Master Sewer Plan. Previous project costs are found in Section 8 of the Master Sewer Plan. As there are numerous tables in the Master Sewer Plan showing the various project costs, it is recommended that the reader refer to those tables in the Master Sewer Plan for comparison of previous versus updated costs. All previous costs were updated using the October 2007 Engineering News Record (ENR) Los Angeles, which has a value of 9,215.

Proposed Trunk Sewer Pipeline Projects

Unit costs from Table 8-1 of the 2004 Sewer Master Plan have been updated and are shown in **Table 5**. The new unit costs were then applied to the proposed capital improvement projects shown in Table 7-18 of the 2004 Master Sewer Plan in order to develop new project cost estimates. These project cost estimates are provided in **Appendix B**. As shown in **Appendix B**, the total estimated project cost for gravity flow pipelines is $26,660,000, which is higher than the $22,770,000 estimated in the 2004 Master Sewer Plan. **Plate 4** shows the locations of the projects.

Table 5 - Estimated Unit Cost of Trunk Sewer Pipelines

Sewer Line Dia. (in.)	Construction Cost	Project Cost[1]
10	$212.00	$297.00
12	$242.00	$338.00
15	$257.00	$360.00
18	$286.00	$401.00
21	$308.00	$432.00
24	$352.00	$493.00
27	$381.00	$534.00
30	$426.00	$596.00
36	$491.00	$688.00
39	$586.00	$821.00
42	$645.00	$903.00
48	$711.00	$995.00

[1]Project cost is 1.4 times construction cost rounded up to nearest $1. Project cost includes: construction cost, construction contingencies, design engineering including plans and specifications; design and construction surveying and mapping; geotechnical evaluation and report; engineering contract administration; field inspection and basic environmental documentation. Costs are based on Engineering New Record (E.N.R.). The Engineering news Record Construction Cost Index for the Los Angeles Areas for October, 2007 (9,215) was utilized. Escalation, financing, interest during construction, legal, land, R.O.W. agent, and environmental impact report costs are not included in project costs. Additionally, not included in the unit cost estimates are extraordinary construction items such as bore casings, dewatering, rock removal etc…

Sewer System Rehabilitation/Replacement Projects

The District is currently reviewing sewer lines which have operational problems. Upon completion of the District review and evaluation of these pipelines, a project list will be completed which will serve as the basis for a pipeline rehabilitation program. Therefore, costs for pipeline rehabilitation/replacement projects are yet to be determined.

In addition to pipeline rehabilitation/replacement projects, there are two lift stations that need replacement, as discussed in the 2004 Master Sewer Plan. The costs for replacing these lift stations have been updated and are shown in **Table 6**. Cost updates are based on estimates done during pre-design for the Florine Lift Station Replacement Project in July of 2006.

Table 6 - Sunnyslope/Florine Lift Station Replacement Project

Item	Quantity	Unit	Unit Price	Construction Cost
10" Dia. VCP Sewer	1,561	LF	$212	$330,932
15" Dia. VCP Sewer	340	LF	$257	$87,380
10" Dia. PVC Force Main	2,550	LF	$90	$229,500
Lift Station	1	LS	$870,000	$870,000
	Total Estimated Construction Cost			$1,517,812
	Total Estimated Project Cost			$2,120,000[(1)]

[(1)]Project cost is 1.4 times construction cost rounded up to nearest $10,000. Project cost includes: construction cost, construction contingencies, design engineering including plans and specifications; design and construction surveying and mapping; geotechnical evaluation and report; engineering contract administration; field inspection and basic environmental documentation. Costs are based on Engineering New Record (E.N.R.). The Engineering news Record Construction Cost Index for the Los Angeles Areas for October, 2007 (9,215) was utilized. Escalation, financing, interest during construction, legal, land, R.O.W. agent, and environmental impact report costs are not included in project costs. Additionally, not included in the unit cost estimates are extraordinary construction items such as bore casings, dewatering, rock removal etc…

Regional Wastewater Pump Station Expansion (Plant 1)

As discussed in the 2004 Master Sewer Plan, the Regional Wastewater Pump Station at Plant 1 currently has a capacity of 5.0 mgd. Ultimate peak design flows that could occur at Plant 1 are projected to be 12.0 mgd. Therefore, an additional 7.0 mgd of pumping capacity is required. The 7.0 mgd (4900 gpm $^{\pm}$) expansion is estimated to have a project cost of approximately $6,900,000[1].

[1] Based on bid results of similar projects, and then multiplied by ENR factor of 1.173.

New Regional Force Main to the City of Riverside

A total length of 16,000 LF was used for the 24 inch diameter Regional Force main assumed to run parallel to the existing Regional Force main. It was assumed that 600 feet of the 16,000 feet total length would be HDPE pipe directionally bored under the Santa Anna River yielding 15,400 of conventionally installed 24 inch pipe. Construction cost for the 15,400 of conventionally installed 24 inch pipe was determined to be approximately $200 per foot using current estimates[1]. The HDPE was estimated to have a construction cost of about $469 per foot[2]. The total estimated project cost for the new regional force main is $4,700,000.

City of Riverside Wastewater Treatment Plant Capacity Purchase

The purchase of treatment plant capacity at the City of Riverside wastewater treatment plant was assumed to reflect the current costs to construct a wastewater treatment plant. Costs from the 2004 Master Sewer Plan were updated using the October 2007 ENR, showing a new typical unit project costs range from $10/gallon/day to almost $16/gallon/day. The District currently owns 4 mgd of treatment capacity at the City of Riverside's facility. Using this project cost range and the projected additional ultimate average daily flow of 0.9 mgd (4.9 mgd ultimately required – 4.0 mgd currently owned), the total estimated project cost for treatment could vary from $9,000,000 to $14,400,000.

Western Riverside County Regional Wastewater Authority Treatment Plant Purchase

The purchase of treatment plant capacity at the Western Riverside County Regional Wastewater Authority treatment plant was assumed to reflect the current costs to construct a wastewater treatment plant. The District currently owns 3.25 mgd of treatment capacity at the Western Riverside County facility. Using the same project cost range as was used for the City of Riverside WWTP, and the projected additional ultimate average daily flow of 2.45 mgd (5.7 mgd ultimately required – 3.25 mgd currently owned), the total estimated project cost for treatment could vary from $24,500,000 to $39,200,000.

Summary of Updated Project Costs

A summary of the estimated project costs for the Jurupa sewer system are shown in **Table 7**. As shown on **Table 7**, the total project cost estimate of the updated sewer system improvements range from $73,880,000 to $93,980,000 depending upon ultimate treatment plant capacity purchase costs.

---

[1] Based on current bid results from similar projects.

[2] Based on cost from 2004 Master Sewer Plan, multiplied by ENR factor of 1.173.

Table 7 – Estimated Project Cost Summary

Master Plan Improvement	Estimated Project Cost
Proposed Gravity Flow Pipelines and Projects	$26,660,000[1,2,3]
Pipeline Rehabilitation/Replacement Projects	TBD
Lift Station Rehabilitation/Replacement Projects	$ 2,120,000
Regional Wastewater Pump Station Expansion (Plant 1)	$ 6,900,000[2,3]
New Regional Force Main to the City of Riverside WWTP	$ 4,700,000[2,3]
City of Riverside Treatment Plant Capacity Purchase	$9,000,000-$14,400,000[3]
Western Riverside County Treatment Plant Capacity Purchase	$24,500,000-$39,200,000[3]
Total Estimated Project Cost	**$73,880,000-$93,980,000**

[1]Refer to Appendix D for a breakdown of cost per project
[2]Total estimated construction cost rounded up to the nearest $10,000.
[(1)]Project cost is 1.4 times construction cost rounded up to nearest $10,000. Project cost includes: construction cost, construction contingencies, design engineering including plans and specifications; design and construction surveying and mapping; geotechnical evaluation and report; engineering contract administration; field inspection and basic environmental documentation. Costs are based on Engineering New Record (E.N.R.). The Engineering news Record Construction Cost Index for the Los Angeles Areas for October, 2007 (9,215) was utilized. Escalation, financing, interest during construction, legal, land, R.O.W. agent, and environmental impact report costs are not included in project costs. Additionally, not included in the unit cost estimates are extraordinary construction items such as bore casings, dewatering, rock removal etc…
TBD – To Be Determined.

All fees, costs, and credits are subject to updates as well as inflationary adjustments by the District depending upon the commencement and completion of the projects. If project scopes change, the subject study is no longer valid and a new study will be required. If you have any questions, please feel free to telephone me at (951) 686-1070.

Sincerely,

ALBERT A. WEBB ASSOCIATES

Wally Franz, P.E.
Vice President

REGISTERED PROFESSIONAL ENGINEER
WALLACE H. FRANZ
No. 26979
Exp. 3-31-09
CIVIL
STATE OF CALIFORNIA

WF:dc
Encl.

Appendix 3B.5

2009 MASTER SEWER PLAN ADDENDUM NO. 2 FOR JURUPA COMMUNITY SERVICES DISTRICT

DRAFT

3066LF

W.O.: 09-64

September 8, 2009

Mr. Eldon Horst
General Manager
Jurupa Community Services District
11201 Harrel Street
Mira Loma, CA 91752

RE: Master Sewer Plan Addendum No. 2

Dear Mr. Horst:

In accordance with the Jurupa Community Services District's (District) authorization, we have completed the second addendum for the 2004 Master Sewer Plan. The purpose of the second addendum is to address significant planned infrastructure changes that have occurred since the 2004 document was published.

Introduction

The September, 2004 Master Sewer Plan was an update to the December, 1983 Wastewater Management Plan for the District. In October of 2007, the first addendum to the 2004 Master Sewer Plan was completed. The purpose of the first addendum was to re-evaluate the wastewater generation factors based upon current District flow records and re-calculate the factors using recorded data. New "build out" average daily flows were calculated using the new wastewater generation factors. The updated flow projections were used primarily for the purpose of predicting ultimate treatment plant capacity and estimating the project cost of adding and/or purchasing treatment plant capacity. Also, the first addendum reviewed the District's wastewater influent quality and updated the project cost of the Master Plan Improvement to an Engineering News Record and Construction Cost Index for Los Angeles (October, 2007).

Since the publication of the 2004 Master Sewer Plan and subsequent October, 2007 Addendum, significant changes concerning the District's sewer system has occurred. These changes include the following:

1. The District's concept of delivering flows to the City of Riverside's Water Quality Control Plant (WQCP) has changed (i.e. crossing the Santa Ana River at a new Van Buren Bridge). The infrastructure required to deliver the flows to the bridge crossing and from the bridge crossing to the City's WQCP need to be determined.

2. With the change indicated in Item 1, re-evaluation of delivering wastewater flows from the area east of Van Buren, south of Limonite, and the Indian Hills area to the City of Riverside.

3. A factor affecting Item 2 is the possible reconstruction of the Indian Hills Wastewater Treatment Plant (WWTP) which would also affect JCSD's need to purchase additional capacity at the City of Riverside's WQCP.

4. The concept of accommodating increased flows in JCSD's Plant 1 Tributary Area (Plate 1) (shown in light yellow) includes an evaluation of a subregional lift station in the vicinity of Felspar and Limonite (separate study).

5. A possible alternative or subalternative to Item 4 is the construction of a new forcemain in Limonite from the Regional Wastewater Pump Station to the Van Buren bridge crossing the Santa Ana River.

6. In view of Items 4 and 5, an evaluation of the planned expansion of the storage ponds at Plant 1 requires additional analysis including review of overall need and/or sizing.

7. JCSD's Master Sewer Plan Addendum (October, 2007) was primarily commissioned for predicting ultimate treatment plant capacity and the resulting amount of plant expansion and/or purchase that will be required. The study concluded that two different generation factors should be used; 220 gpd/EDU in Eastvale and 252 gpd/EDU in the Plant 1 Tributary area. The September, 2004 Master Sewer Plan (MSP) utilized a wastewater generation factor of 280 gpd/EDU that is the current District Standard. The affects of these reduced generation factors on existing and proposed sewage infrastructure were not evaluated and should be used to verify proposed improvements identified in the 2004 MSP.

8. Since the September, 2004 MSP was published, land use changes have occurred within JCSD.

Pursuant to our February 25, 2009 meeting, it is our understanding the District does not wish at this time to pursue any affects to the sewer system as discussed in Items 7 and 8. Therefore, the Scope of Work for Addendum No. 2 includes Items 1-6 as described above.

Additionally, the District requested estimated implementation time frames (i.e. "trigger points") whereby the new identified infrastructure would be required.

Analysis

Plant 1 Wastewater Pump Station and Forcemains

As previously indicated, one of the major changes to the proposed District sewer system is the methodology of conveying wastewater flows across the Santa Ana River to the City of Riverside for treatment. Currently, flows are conveyed under the Santa Ana River to the City via inverted siphons. The new methodology is to convey the wastewater flows across the river via the new Van Buren Bridge. Currently, the Regional Wastewater Pump Station's capacity at Plant 1 is 5 mgd and potential peak "buildout" flows are estimated to be in excess of 12 mgd. As such, one of the primary decisions to be made is to determine how to accommodate ultimate buildout flows in the Plant 1 Tributary Drainage Area (Plate 1).

A separate study to evaluate the most cost effective method to provide sufficient pumping capacity in the Plant 1 area is nearing completion. The District commissioned Webb Associates to prepare a report entitled the "Feasibility and Planning Study for the Felspar Lift Station Site and Forcemain Alignment". This study reviewed alternatives of providing additional pumping capacity in the Plant 1 Tributary Area. One of the alternatives was the construction of a "subregional" lift station at the corner of Felspar Street and Limonite Avenue. Without addressing the details of this study, the report concluded that the Felspar Lift Station was not the most cost effective alternative and the construction of the additional capacity for the Plant 1 Tributary Area would be best suited at Plant 1 by either constructing an additional pump station for the flows exceeding the existing stations capacity or the construction of a new pump station to accommodate all of the buildout design flows. The analysis of which of the two Plant 1 alternatives should be selected, is beyond the scope of this report and should be determined by a separate, more detailed, evaluation. However, common to both of the additional Plant 1 pumping alternatives is the construction of a new 24" diameter force main from Plant 1 to the new Van Buren Bridge (Plate 2). The 24" diameter force main will carry flows in addition to the existing 18" diameter force main thus creating an equivalent pipe diameter of approximately 28 inches.

Plant 1 Wastewater Storage Ponds

With the construction of a new 24" diameter Regional Force Main, the District's current plans of expanding the wastewater storage ponds at Plant 1 needs to be re-evaluated. As a brief background, the existing storage ponds at Plant 1 (5 MG±) were required by the California Regional Water Quality Control Board for two primary reasons. First, wet weather peak flows to the Regional Wastewater Pump Station exceeded it's capacity. Therefore, there was a need to equalize the flows by storing the quantity of wastewater that exceeded the pump station's capacity and slowly release the wastewater back to the station as the peak flows dissipated. The second primary reason was with a single force main from Plant 1 to the City of Riverside's WQCP there was no method to take the forcemain out of service for inspection purposes or repair.

With the construction of a second forcemain, a certain amount of pipeline redundancy is obtained and additional pumping capacity is achieved. Pumping the flows from the station directly to the treatment plant is the preferred scenario. This would eliminate the additional step of temporarily storing the wastewater and then waiting to pump until the peak flows subside. As such, it is our recommendation, contingent upon concurrence of the Regional Board, that the District not pursue the storage pond expansion project and utilize the allocated funds for the additional Regional Force Main and Pump Station Expansion project at the Plant 1 site.

Indian Hills Area Wastewater Pump Stations and Forcemains

With the plan of pumping the wastewater across the new Van Buren Bridge, facilities must be proposed to transport Indian Hills Area flows (Plate 1 Tributary Areas J16, J17 and J18) to the crossing. Plate 3 illustrates the existing Indian Hills Area Backbone Sewer System. Currently, the majority of the Indian Hills Area flows enter the existing 18" Regional Forcemain by (1) a 10" dia. Clay Street pressurized gravity main (2) Clay Street Lift Station and (3) Clay & Van Buren Lift Station. The proposed Indian Hills Area Backbone System is shown on Plate 4.

The proposed system would still utilize the Clay Street and Clay & Van Buren Lift Stations, modified for new pumping conditions, however they will now pump into a proposed 12" dia. forcemain that would traverse from the existing Clay Street Lift Station site and parallel the existing Regional Forcemain to General Drive. The proposed forcemain would then traverse along General Drive, to Clay Street and connect into the proposed 24" dia. forcemain that transitions into two 24" HDPE pipelines in a bridge crossing the Santa Ana River (Plate 2). It should be noted that due to an upcoming Clay Street/Railroad crossing grade separation project, currently in the early design phase and

scheduled for construction in 2012, the future disposition (i.e. whether the station requires a new site or is not affected) of the Clay Street Lift Station is unknown.

It is recommended, if feasible, that the existing 18" Regional forcemain, southeasterly of General Drive, and inverted siphons crossing under the Santa Ana River remain in place as an emergency bypass to the City of Riverside's WQCP.

Wastewater Treatment Capacity

As determined in the October, 2007 Addendum to the District's Master Sewer Plan, the Plant 1 and Indian Hills Tributary Drainage Areas at ultimate buildout will require approximately 1 mgd additional treatment plant capacity. The additional treatment capacity can be obtained by two alternatives. The first alternative is to purchase additional capacity at the City of Riverside's Regional Treatment Plant. The second alternative is to reconstruct the Indian Hills Wastewater Treatment Plant. As will be discussed in the cost section of this addendum, preliminary project costs indicate both alternatives are approximately the same with regards to capital costs. Even though the cost of acquiring 1 mgd of additional treatment plant capacity at either Indian Hills or at the City of Riverside facility is comparable, there is a benefit of having a source of tertiary reclaimed water within JCSD's service area which can be used for irrigation purposes.

As will be discussed in a subsequent section, the decision concerning which alternative of obtaining additional capacity is not an immediate need and further evaluation of the overall costs and benefits can be made.

It should be noted that if the Indian Hills alternative become the most viable method of obtaining additional treatment capacity, the pumping capacities of the Clay Street Lift Station could be configured to pump either to the Indian Hills Plant or the 24" dia. forcemain in Van Buren Blvd.

Wastewater Pump Station and Forcemain Sizing

In order to size the proposed facilities, updated estimated design flows were developed based upon the new flow projections from the October, 2007 Master Sewer Plan Addendum. Table 1 shows the flow projections from the referenced 2007 Addendum. Using the flows tributary to the City of Riverside's WQCP shown on Table 1, flows were allocated to each facility as shown on Table 2.

Table 1 – New Projected "Build-out" Average Daily

Flows for Ultimate Wastewater Treatment Plant Capacity

TRIBUTARY WASTEWATER TREATMENT PLANT	Residential		Comm./Ind.	Schools	"Build-out"
	Res. EDU's[1]	Flows (gpd)	Flows (gpd)	Flows (gpd)	Flows (gpd)
City of Riverside WCQP[2]	18,249	4,598,748[3]	265,230[4]	59,402[4]	4,923,380
Western Riverside Co. WWTP[5]	22,338	4,979,544[6]	478,600[7]	203,550[7]	5,661,694
Total[8]	40,587	9,578,292	743,830	262,952	10,585,074

[1] From the 2004 Master Sewer Plan (refer to Appendix L of 2004 Master Sewer Plan)
[2] Includes Land Use areas J1-J18, J19-J23.
[3] Calculated by multiplying the EDU's times the projected wastewater generation factors of 252 gpd/EDU.
[4] 1/3 of the projected "buildout" flows from the 2004 Master Sewer Plan. 2/3 of non-residential EDU's have already been built (Appendix D of 2007 Addendum) and accounted for in the wastewater generation factor of 252 gpd/EDU.
[5] Includes Land Use areas E1-E50, J25.
[6] Calculated by multiplying the EDU's times the projected wastewater generation factors, 220 gpd/EDU for Eastvale and 252 gpd/EDU for Sky Country (Land Use Area E1).
[7] From the 2004 Master Sewer Plan (refer to Appendix L of 2004 Master Sewer Plan). Flows added because the vast majority of the buildout non-residential EDU's have not yet been constructed (Appendix D of 2007 Addendum)
[8] Total wastewater flows do not include wastewater generated in Land Use Areas pertaining to CFD No. 1 (J24, J26-30).

TABLE 2
WASTEWATER PUMPING FACILITY
ESTIMATED DESIGN FLOWS[1]

Facility Name	Approximate Service Area (AC)	No. of Residential EDU's	Residential Q_{ADF} (mgd)[5]	Non-Residential Q_{ADF} (mgd)[6]	Total Q_{ADF} (mgd)	Q_{PK} (dry) (mgd)[8]	Infiltration/Inflow Allowance (mgd)[9]	Q_{PK} (wet) (mgd)	Q_{PK} (wet) (gpm)	Assumed Q_{DESIGN} (gpm)	Required Forcemain Diameter (in.)[10]
Regional Wastewater Pump Station (Plant 1)	8,956.7 [2]	15,771	3.974	0.281	4.255	9.338	1.433	10.771	7,480	7,500	24
Clay Lift Station	1,284.1 [3]	2,478	0.624	0.013	0.637	1.658	0.205	1.863	1,294	1,300	12
Clay & Van Buren Lift Station	76.9 [4]	0	0	0.038 [7]	0.038	0.128	0.012	0.140	97	100	4
TOTALS	**10,317.7**	**18,249**	**4.598**	**0.332**	**4.930**	**11.124**	**1.650**	**12.774**	**8,871**	**8,900**	**N/A**

[1]Tributary to the City of Riverside WQCP (assumes Sky Country Area (Tributary Areas E1 & J25 flows are treated at the Western Riverside County Regional Wastewater Authority's plant) in accordance with the District's September, 2004 Master Sewer Plan (MSP).
[2]MSP Areas J1-J15B, J17A, J19-J23.
[3]MSP Areas J16, J17B, J18.
[4]MSP Area J18 (Lower).
[5](No. EDU's x 252 gpd/EDU) ÷ 1,000,000.
[6]Total non-residental City of Riverside tributary wastewater flows (Table 1) allocated based upon percentage of non-residential flow ratios from MSP within each service area.
[7]Based upon 500 gpd/AC x 76.9 AC.
[8]$Q_{PK} = 2.5\ [Q_{ADF}\ (mgd)]^{0.91}$ District Standard Peaking Equation.
[9]Based upon 160 gpd/AC per 2004 MSP.
[10]Based upon peak velocities between 2.5 - 5.0 fps.

Preliminary Design Reports (PDR's) should be prepared to refine and detail each wastewater pump station's design. Especially important is the analysis of the three wastewater pump stations having the capability of pumping into a common forcemain a the same time. Due to the "flat nature" of sewage pump curves, pump control and pump control valves will be an important element of this analysis.

Concerning the PDR for the Clay Street Lift Station, an analysis should be made to determine if a low head pressurized gravity pipeline traversing from a point in the vicinity of the existing station, southerly on Clay Street across the proposed grade separation to the 24" dia. forcemain in Van Buren is feasible. Without additional hydraulic study and the specific details of the grade separation, it is difficult to determine if this alternative is feasible. However, based upon a conceptual analysis, it does not appear this alternative is feasible due to the elevation of the hydraulic grade line on the 24" dia. forcemain at Van Buren and Clay Street.

City of Riverside Connection

As indicated on Plate 2, the terminus of the 30" dia. force main is currently planned to occur at the City of Riverside's DeAnza Trunk Sewer. However the exact location of the point of connection to the City's system requires discussions with City staff. For the purposes of this addendum, the City's DeAnza Trunk Sewer is the assumed connection point.

It is our understanding that the City is planning to construct a new DeAnza trunk sewer and therefore additional upsizing maybe required in this pipeline to accommodate the District's flows. Further, it is currently anticipated that a new headworks including a mag meter to measure the flows entering the City's pipeline and facility to analyze wastewater quality will also be required.

It should be emphasized that coordination with the City of Riverside needs to occur immediately so that all design parameters and agreement terms can be established now for future service. Pursuant to a meeting that occurred at the District on August 10, 2009, it is our understanding that District staff will coordinate with City staff to obtain an agreement to connect to the City's system. Webb Associates is ready to assist the District in any manner concerning obtaining an agreement with the City of Riverside.

Cost Estimates

The estimated project costs for each of the proposed facilities are shown on Table 3.

Estimated Implementation Schedule

Implementation of the facilities described in Table 3 are governed by three primary factors (1) construction completion of the new Van Buren Bridge, (2) construction completion of the new City of Riverside's WQCP and associated DeAnza Trunk Sewer, and (3) expected growth within the Plant 1 Tributary Area. Currently, construction of the new Van Buren Bridge is expected to be complete in late 2011. Construction of the City's WQCP and associated DeAnza Trunk Sewer is expected to be complete in 20

Regarding growth within the District, for the purposes of this Addendum, the current water supply growth assumption is used which is 1100 EDU's/Year for 10 years. The 1100 EDU/Year assumption is District wide, therefore adjustment must be made for the Plant 1 area only. Since the Eastvale and CFD No. 1 areas of the District have been the major growth areas within the last several years, these areas are expected to continue to grow faster because there are larger parcels of land to develop and the newer development areas tend to attract new projects. The Plant 1 area tends to have much smaller parcels for development and as such, is expected to be more of an "infill" type of development (i.e. smaller number of units constructed in pocket vacant areas). Therefore for the purposes of this addendum, it is assumed two thirds of the District's growth will occur in the Eastvale and CFD No. 1 areas and one third in the Plant 1 area. One third of 1100 EDU's/Yr. is approximately 367 EDU's/Yr. In terms of average daily wastewater flow increase, the 367 EDU's translate to approximately 92,500 gpd.

Therefore, with the Plant 1 area having a current average daily flow of approximately 3.4 mgd, it would take about 6.5 years for the area to reach it's current City of Riverside Treatment Plant capacity alignment of 4 mgd. However, as the Plant 1 area's average daily flow increases, peak flows will increase accordingly meaning the chances of using the existing storage ponds on a regular basis will increase.

Table 3 - Estimated Project Costs

Facility	Estimated Project Cost[1][2]
Regional Wastewater Pump Station Capacity Increase (Plant 1)	$12,600,000 [3]
Regional Forcemain	
13,500 LF 24" dia. Forcemain	$2,700,000
1220 LF 24" dia. HDPE Forcemains (dual) Across New Van Buren Bridge	$910,000 [4]
1800 LF 30" dia. Forcemain	$430,000
Headworks Connection to City of Riverside's Sewer System	$2,000,000 [5]
Clay Street Lift Station	$2,300,000 [6]
Clay Street Lift Station's Forcemain – 3500 LF 12" dia.	$350,000
Van Buren Lift Station & Forcemain & 100 LF 4" dia.	$200,000 [7]
1 MGD Wastewater Treatment Plant Capacity	$10,600,000 [8]
18" Plug Valve Installations on Existing Regional Forcemain	$50,000
TOTAL	$32,140,000

[1]Refer to Plate 2 for locations.

[2]Project cost is 1.4 times construction cost rounded to nearest $10,000. Project cost includes: construction costs, construction contingencies, design engineering including plans and specifications; design and construction surveying and mapping; geotechnical evaluation and report; engineering contract administration; field inspection and basic environmental documentation. Costs are based on Engineering News Record (ENR) Construction Cost Index Los Angeles, August 2009 (ENR = 9,766.19). **Escalation, financing, interest during construction, legal, land ROW agent, and environmental impact report costs are not included.**

[3]Although requiring additional study for the purposes of this Addendum, it is assumed a new Regional Pump Station capable of pumping the total ultimate build out flows will be constructed.

[4]Cost based upon Van Buren Bridge bid item prices increased to project costs.

[5]Allowance for automated screen, grinder, headworks structure, flow measurement, and water quality sampling facility.

[6]Although requiring additional study for the purposes of this Addendum, it is assumed a new pump station capable of pumping ultimate build out flows will be constructed.

[7]Assumes renovation of existing facility including pump replacements and addition of a standby generator.

[8]Based upon a "Non-Potable Water Study" May, 2009 by Albert A. Webb Associates.

Implementation times for the Plant 1 Area improvements could be extended a number of years by changing the treatment location for the Sky Country Area (Areas E1 and J25 of Plate 1) from the City of Riverside to the WRCRWA Plant in accordance with the 2004 Master Sewer Plan. However, construction of additional trunk sewers in Eastvale and additional treatment plant capacity purchase/construction would be required. Therefore, the assumption of this addendum is implementation of the improvements described in Table 3 will be required in about 5 years.

It is expected that the planning, design, and construction period to obtain operating facilities will take 2-3 years. Therefore, it is our recommendation the District consider immediate action on authorizing the previously discussed preliminary design reports for the required improvements.

If you have any questions, please feel free to telephone me at (951) 686-1070.

Sincerely,

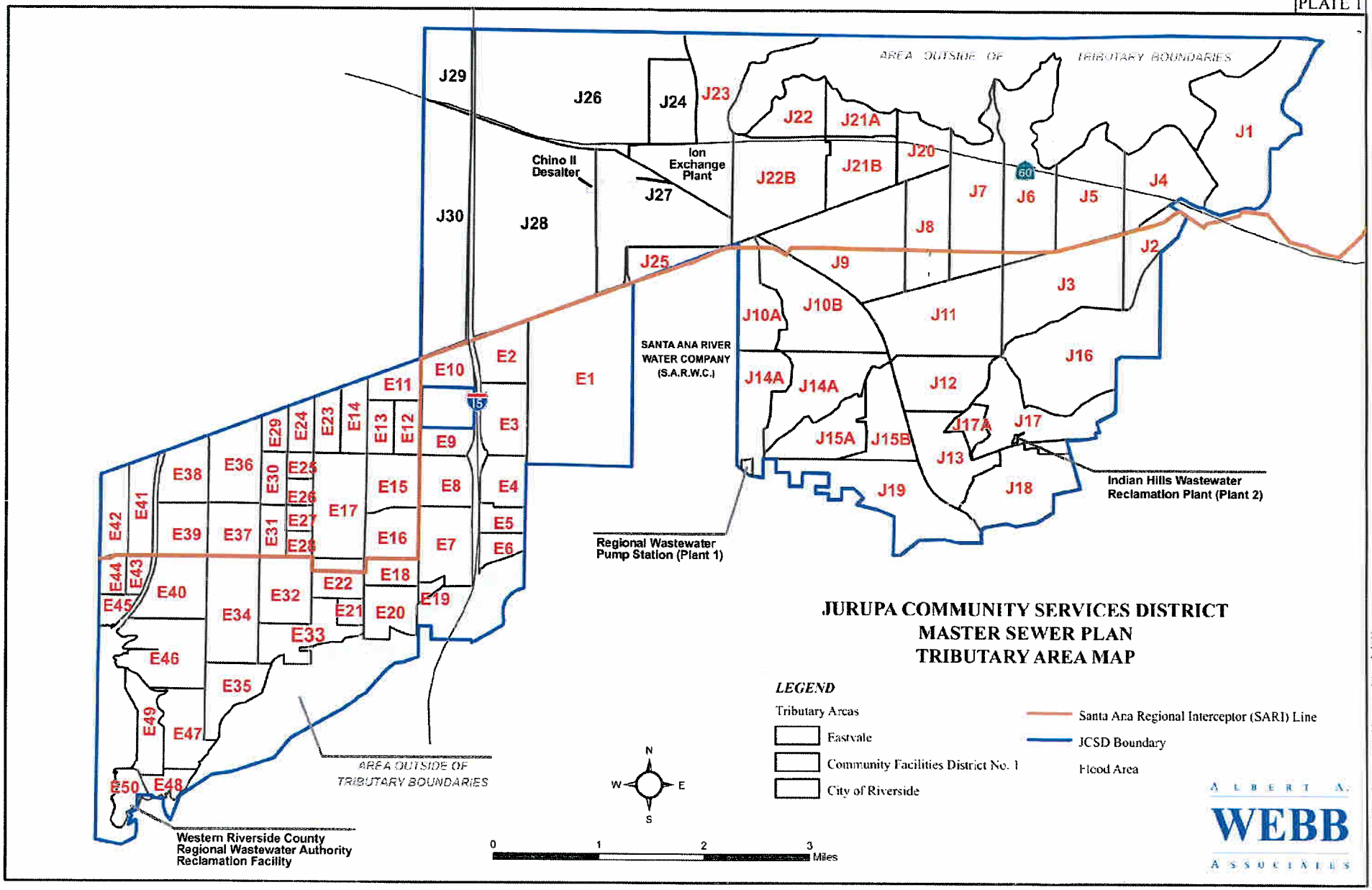
ALBERT A. WEBB ASSOCIATES

Wally Franz, P.E.
Vice President

WF:at

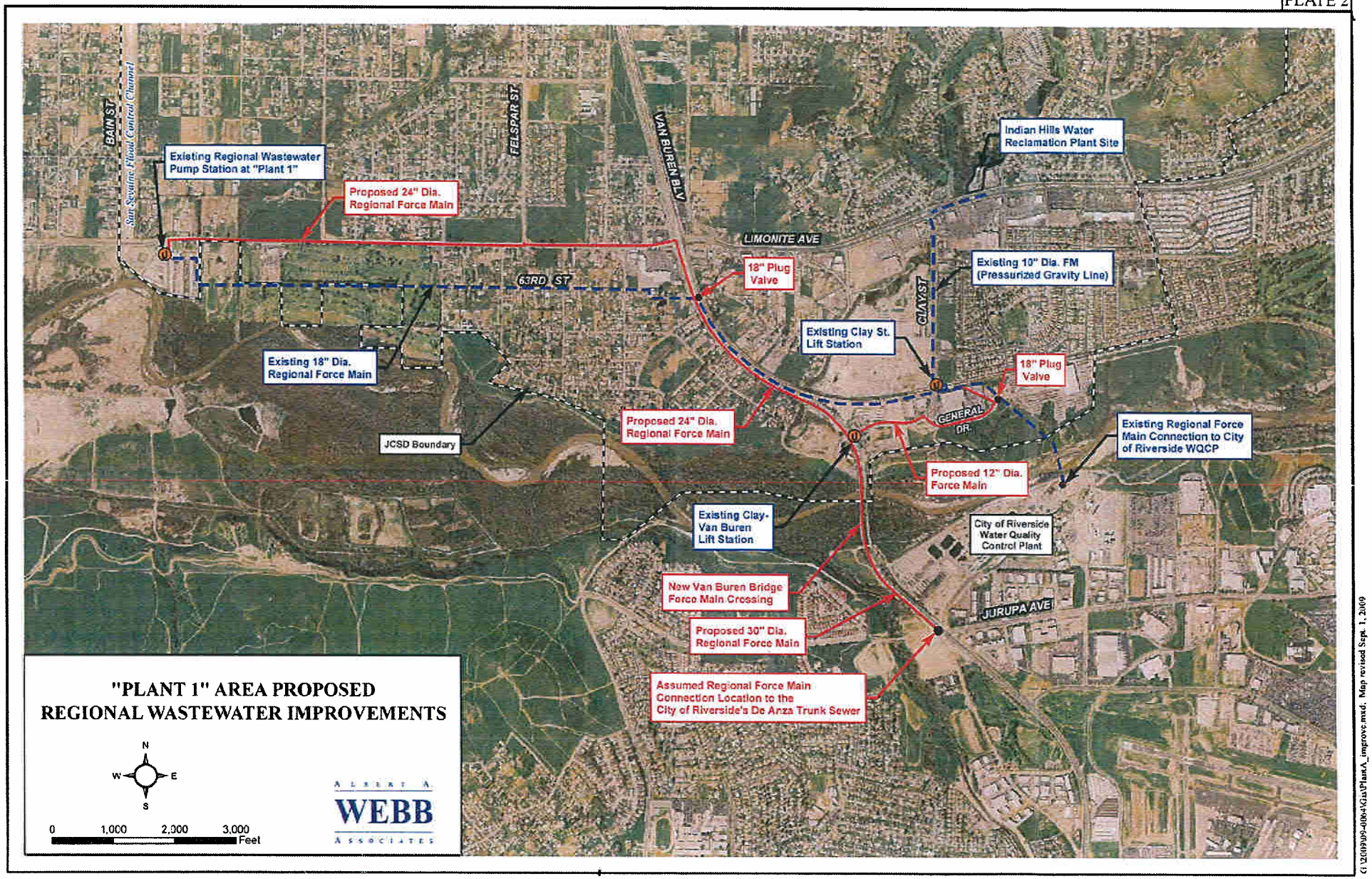
cc: Robert Tock, JCSD
Don Cutler, JCSD
Todd Minten, JCSD
Dan DuCasse, JCSD
Umesh Shah, JCSD
Sam Gershon, Webb Associates
Bill Malone, Webb Associates

PLATE 1



© 2009 [illegible] Map revised Sept. 2, 2009

PLATE 2



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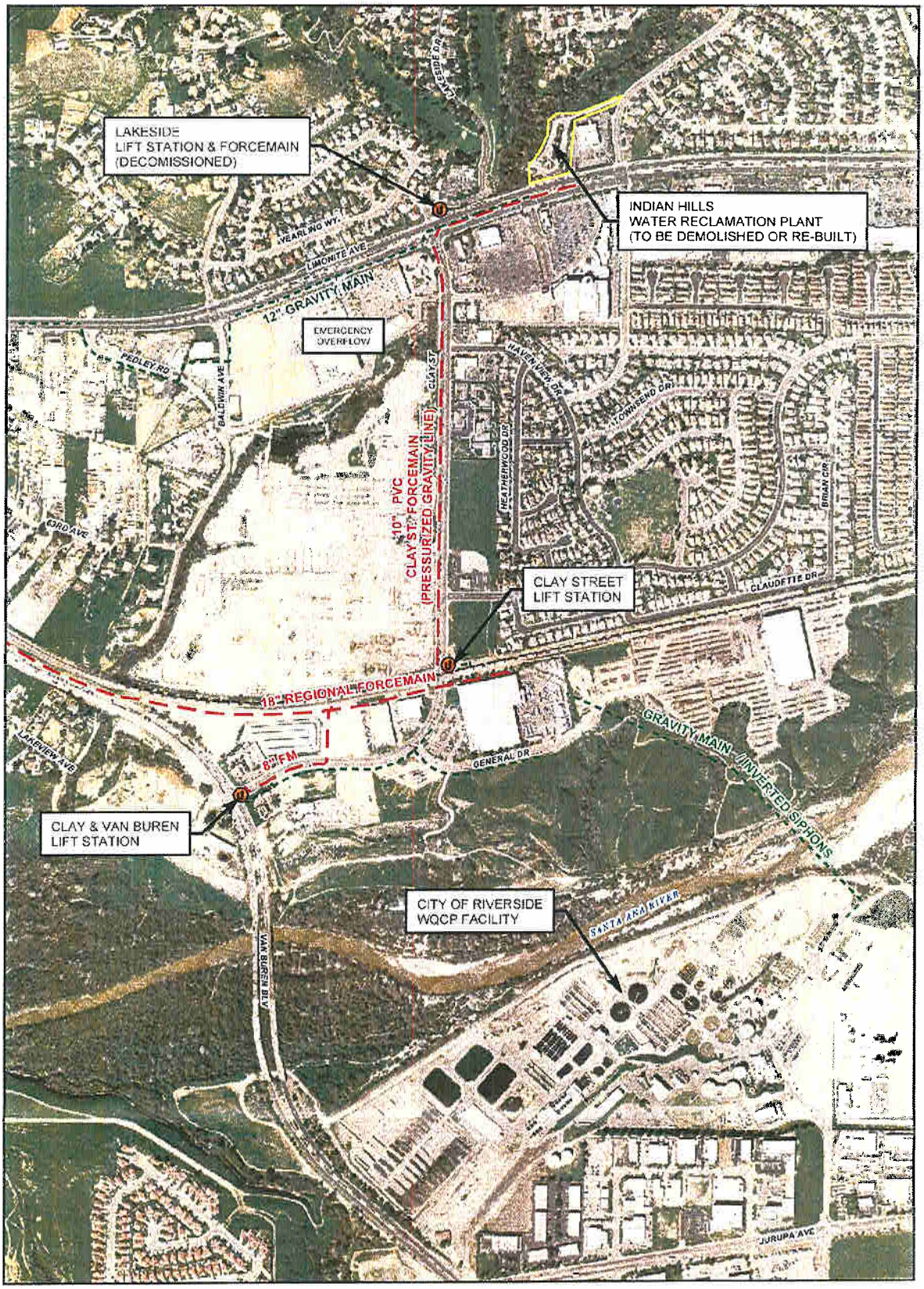

Image: Digital Globe, March 2008
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WEBB ASSOCIATES

Legend

- Lift Station
- Force Main
- Gravity Main

Existing Indian Hills Area Backbone Sewer System

PLATE 3

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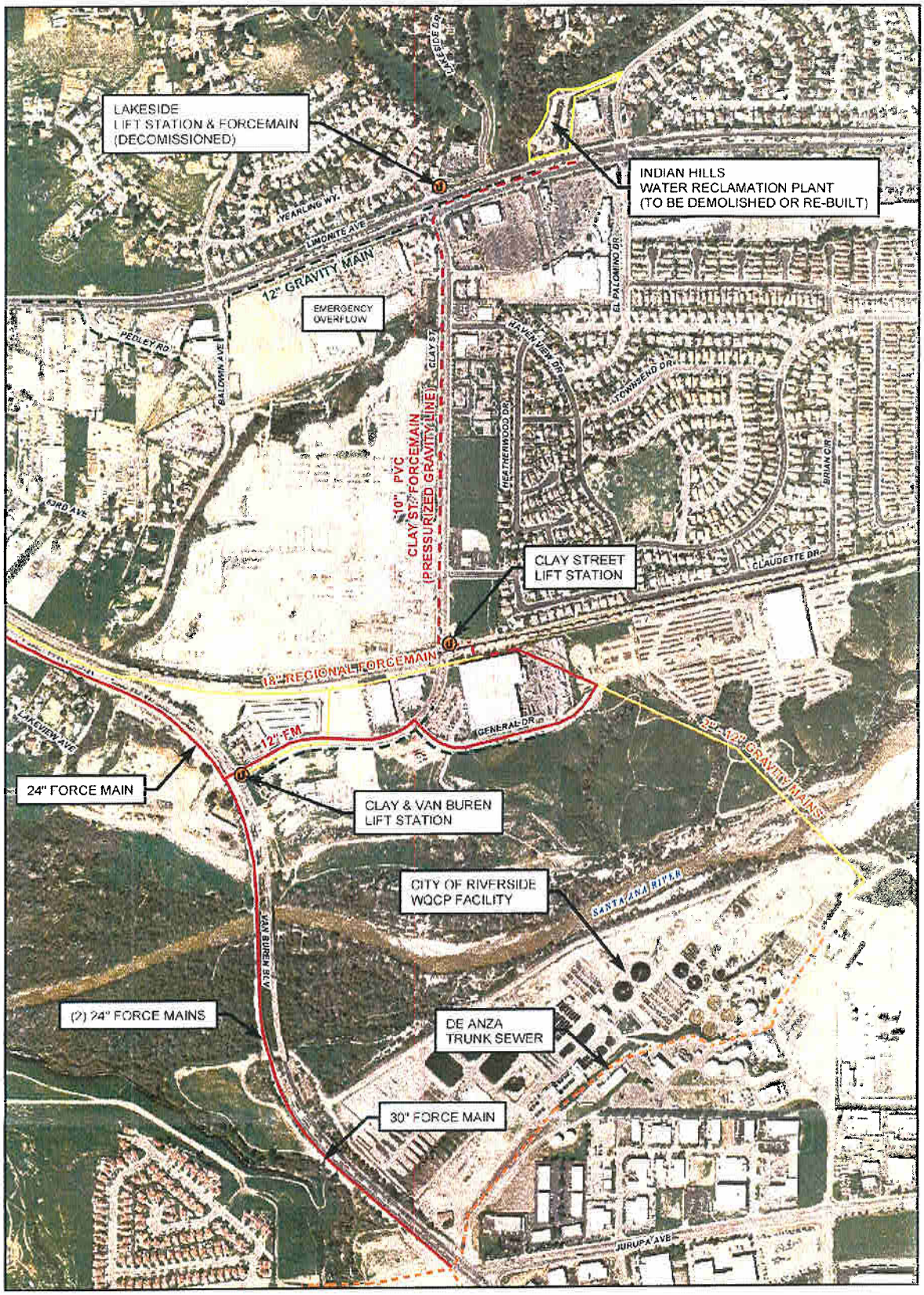


Image: Digital Globe, March 2008
Scale: 1" = 600'

ALBERT A. WEBB ASSOCIATES

N W E S

Legend

- Lift Station
- Future Force Main
- Future Gravity Line
- Existing Force Main
- Existing Gravity Line
- Not in Use

Proposed Indian Hills Area Backbone Sewer System

PLATE 4

G:\2009\09-006.4\Gis\prop_system_PI4.mxd: Map revised Sept. 1, 2009.

Appendix 3B.6

2009 MASTER SEWER PLAN ADDENDUM NO. 2 SUPPLEMENTAL INFORMATION FOR JURUPA COMMUNITY SERVICES DISTRICT

ALBERT A.
WEBB
ASSOCIATES

3788 McCray Street
Riverside, Ca 92506-2973

Telephone (951) 686-1070
FAX (951) 788-1256

W.O. 09-64
File:

MEMO

TO: Robert Tock, Director of Engineering & Operations
Jurupa Community Services District

FROM: Wally Franz

RE: Master Sewer Plan Addendum No. 2
Supplemental Information

DATE: December 15, 2009

Pursuant to your request, we have prepared the subject memorandum to provide additional information concerning the referenced project. The additional information primarily consists of the following:

1. Locations of the Plant 1 Tributary Trunk Sewers which segments need to be replaced, why they are required, and a discussion concerning alignments.

2. An updated preliminary sewer project implementation schedule (over the next 20 years) and estimated project costs.

Plant 1 Trunk Sewers

Plate 1 shows the proposed Trunk Sewer Capital Improvement projects within the Plant 1 Tributary Sewer System Area. As a point of clarification, the District's "Pyrite Creek Project" that may be funded by SRF includes the Bain Trunk Sewer, Jurupa Trunk Sewer (downstream) and the Pyrite Creek Intercepter (Plate 1).

The alignments shown on Plate 1 are planning level locations. A Preliminary Design Report (PDR) will be required to determine examples of the final design location of the proposed improvements. Pipeline refinements, during the PDR phase, could include the following: potential realignment of the Pedley Trunk due to existing utility congestion in 63rd Street; potential realignment of the Glen Avon Sewer at Bellegrave Avenue and the railroad tracks due to a future grade separation project, etc…

The proposed trunk sewer projects are required due to hydraulic deficiencies that will occur as a result of growth within each Tributary Area as determined in the District's Master Sewer Plan dated September, 2004. In order to provide the District with a sense of how much of the area is currently serviced by the Plant 1 Tributary Area's sewer system, Plate 2 highlights parcels with existing sewer customers.

Preliminary Implementation Plan

Table 1 provides a Preliminary Project Implementation Plan based upon the assumptions shown on Table 2. It should be emphasized that future growth within each of the trunk sewers' tributary areas is what will "trigger" the actual implementation of the pipeline replacement. For most of the facilities shown on Table 1, a 2-3 year process must be assumed for the planning, design, and construction of the facility. Thus if projected growth indicates the requirement for the facility in year "X" the time to start the process to assure the project will be operational when needed is "X-3".

It should be noted that we are not familiar with the implementation timing of sewer improvements shown in the District's Strategic Plan and 2009-10 Capital Improvement Program because we were not involved in the development process of these documents. As indicated, the timing shown on Table 1 are based upon the *assumptions* provided in Table 2. It should be emphasized that the timing shown on Table 1 is for developing a financial strategy to fund required sewage infrastructure and the actual construction of the facilities will be determined by a sewer system monitoring program consisting of periodic flow measurements at key locations throughout the system, new EDU tracking within subregional systems, etc… As such we recommend JCSD immediately conduct flow monitoring and, subsequent to the data collection, workshops be conducted to identify "critical projects". Projects would be deemed "critical" in that if the assumed growth rates were exceeded in a much shorter time frame than that assumed, funds may not be in place for a more immediate project implementation time frame thus subjecting JCSD to potential system problems and/or sewage spills.

We look forward to discussing this information in more detail with JCSD's staff.

TABLE 1
JURUPA COMMUNITY SERVICES DISTRICT
SEWAGE SYSTEM
PROJECT COST ALLOCATION SUMMARY[1, 10]
DRAFT 12/15/09

				Projected Project Implementation Year[2,3]																			
Facility	Total Estimated Project Cost	Existing Customers	Future Customers	FY 09-10	FY 10-11	FY 11-12	FY 12-13	FY 13-14	FY 14-15	FY 15-16	FY 16-17	FY 17-18	FY 18-19	FY 19-20	FY 20-21	FY 21-22	FY 22-23	FY 23-24	FY 24-25	FY 25-26	FY 26-27	FY 27-28	FY 28-29
Trunk Sewers																							
Pyrite Creek Project[4]	$ 13,960,000								$ 4,600,000	$ 4,600,000	$ 4,760,000												
Glen Avon Trunk Sewer	$ 5,720,000										$ 5,720,000												
Jurupa Trunk Sewer (upstream)	$ 6,820,000 [8]								$ 1,170,000		$ 1,380,000		$ 1,120,000						$ 2,220,000				$ 930,000
Pedley Trunk Sewer	$ 1,340,000								$ 1,340,000														
Subtotal Trunk Sewers	$ 27,840,000	$ 14,337,620	$ 13,502,380																				
Regional Wastewater Pump Station Expansion	$ 21,540,000	$ 13,139,400	$ 8,400,600		$ 5,400,000	$ 5,400,000	$ 5,400,000	$ 5,340,000															
and New Forcemain to the City of Riverside's																							
WWTP[9]																							
City of Riverside WWTP Capacity Purchase	$ 14,600,000	N/A	$ 14,600,000								$ 7,300,000				$ 7,300,000								
Subtotals	$ 63,980,000	$ 27,477,020	$ 36,502,980																				
Florine Lift Station Replacement	$ 2,900,000 [5]	$ 1,815,400	$ 1,084,600	$ 1,500,000	$ 1,400,000																		
Subtotals	$ 66,880,000	$ 29,292,420	$ 37,587,580																				
Sky Country Trunk Sewer	$ 4,030,000	$ 4,030,000	N/A		$ 1,000,000	$ 1,000,000	$ 1,000,000	$ 1,030,000															
Annual Sewer Replacement/Rehabilitation	$ 26,470,000 [6]	$ 26,470,000 [6]	N/A	$ 1,000,000					$ 1,100,000	$ 1,200,000	$ 1,300,000	$ 1,400,000	$ 1,500,000	$ 1,600,000	$ 1,700,000	$ 1,800,000	$ 1,900,000	$ 2,000,000	$ 2,000,000	$ 2,000,000	$ 2,000,000	$ 2,000,000	$ 2,000,000
Program																							
WRCRWA Treatment Plant Capacity Upgrade	$ 5,000,000 [7]	$ 5,000,000 [7]	N/A		$ 2,500,000 [7]	$ 2,500,000 [7]																	
WRCRWA Treatment Plant Capacity Purchase	$ 39,740,000	N/A	$ 39,740,000						$ 6,670,000	$ 6,600,000	$ 6,600,000										$ 6,670,000	$ 6,600,000	$ 6,600,000
River Road Lift Station Expansion and	$ 1,320,000	N/A	$ 1,320,000													$ 1,320,000							
Additional Force Main																							
TOTALS	**$ 143,440,000**	**$ 64,792,420**	**$ 78,647,580**	**$ 2,500,000**	**$ 10,300,000**	**$ 8,900,000**	**$ 6,400,000**	**$ 6,370,000**	**$ 14,880,000**	**$ 12,400,000**	**$ 27,060,000**	**$ 1,400,000**	**$ 2,620,000**	**$ 1,600,000**	**$ 9,000,000**	**$ 3,120,000**	**$ 1,900,000**	**$ 2,000,000**	**$ 4,220,000**	**$ 2,000,000**	**$ 8,670,000**	**$ 8,600,000**	**$ 9,530,000**

[1] Excludes CFD No. 1 and Eastvale Area "B" (Plate A) Improvements since these areas have separate financing arrangements for their specific locations.

[2] Project cost, or portions thereof, allocated to fiscal year when construction or WWTP capacity purchase is estimated to occur. Project cost is 1.4 times construction cost. Project cost includes: construction cost, construction contingencies, design engineering including plans and specifications; design and construction surveying and mapping; geotechnical evaluation and report; engineering contract administration; field inspection and basic environmental documentation. Costs are based on Engineering News Record (ENR). The ENR Construction Cost Index for the Los Angeles Area for December, 2009 (9764) was utilized. Escalation, financing, interest during construction, legal, land, R.O.W. agent, and environmental impact report costs are not included in project costs. Additionally, not included in the unit cost estimates are extraordinary construction items such as bore casings, dewatering, rock removal, etc.

[3] Refer to Table 2 for project implementation assumptions. Additional expenditures will occur more than 20 years from FY 09-10.

[4] Includes Bain Street Trunk Sewer, Jurupa Trunk Sewer (downstream), and Pyrite Creek Interceptor (i.e. "SRF Creek Project") (Plate 1).

[5] Previous costs escalated from the PDR in the amount of $2,180,000 were factored up to match the District's current Capital Budget.

[6] Sum of annual costs for 20 years. Future analysis is necessary to evaluate the actual condition of the existing facilities so that the actual replacement or rehabilitation costs and prioritization of the work can be determined.

[7] Assume the amount indicated may be required to restore the original design capacity to WRCRWA Treatment Plant. Actual amount is pending future WWTP studies.

[8] Excludes $2,000,000 in FY 08-09 budget for current construction of Phases 1 & 2.

[9] Includes new Van Buren Bridge crossing the Santa Ana River, new headworks connection to the City of Riverside's WWTP, new Clay Street Lift Station and Forcemain, and renovation of Van Buren Lift Station and new forcemain.

[10] Projects not included in this summary but are shown in the District's 2009-2010 Capital Projects Budget are listed below along with the District's funding amounts:

- River Road Lift Station litigation - $325,000 funding FY 08-09 to 11-12
- River Road Lift Station repair - $1,575,000 funding FY 09-10 & 10-11
- Archibald/Chandler LS purchase & upgrade - $800,000 funding beyond 2014
- Hamner LS purchase & upgrade - $800,000 funding beyond 2014
- Recycled Waterline through the Van Buren Bridge - Portion of $480,000 funding FY 09-10 & 10-11
- Area "B" Trunk Sewer - funded by future Development

Table 2
PROJECT IMPLEMENTATION ASSUMPTIONS
Draft (12/15/09)

Facility	Project Implementation Assumptions					
	Critical Downstream Pipe Dia. & Slope	Q Max. Dia. D/d ≤ 0.75 (mgd)	Estimated No. of Existing EDU's[1]	Estimated Existing Qpk (mgd)[4]	Est. No. of Allowable New EDU's	Est. No. of Years Until Replacement Required[5]
Trunk Sewers						
Pyrite Creek Project	Assumes funding will be required in 8 years from Fiscal Year 2008-2009.					
Glen Avon Trunk Sewer	15" @ 0.32%	2.2	2471	1.6	850	8
Jurupa Trunk Sewer (upstream)	N/A	N/A	N/A	N/A	N/A	Various[7]
Pedley Trunk Sewer	8" @ 0.20%	0.32	642[3]	0.48[6]	N/A	6[6]
Regional Wastewater Pump Station Expansion	Assumes 100 EDU's/year in Plant 1 Tributary Area; then 4% growth rate thereafter.					
and New Forcemain to the City of Riverside's						
WWTP						
City of Riverside WWTP Capacity Purchase[8]	Assumes a 5-year District-wide growth rate of 200 EDU's/Year; 100 EDU's/Year in Eastvale Area;					
	100 EDU's/Year in Plant 1 tributary area; then a 4% /year growth rate thereafter.					
	Assumes 2 equal capacity purchases.					
Florine Lift Station Replacement	Project currently in design; assumes construction in fiscal year 2010-2011.					
Annual Sewer Replacement/Rehabilitation	Assumptions as shown on Table 1.					
Program						
WRCRWA Treatment Plant Capacity Purchase[8]	For Phase 1 Capacity Purchase (50% of ultimate additional flow capacity) assumes					
	funding will be required in 6 years from Fiscal Year 2008-2009. Phase 2 capacity purchase					
	(50% of ultimate additional flow capacity) assumes a 5-year District-wide growth rate of					
	200 EDU's/Year; 100 EDU's/Year in Eastvale Area;					
	100 EDU's/Year in Plant 1 tributary area; then a 4% /year growth rate thereafter.					
River Road Lift Station Expansion and	Assumes an area wide growth rate of 4%/year.					
Additional Force Main						
Sky Country Trunk Sewer[9]	Assumes funding will be required in 5 years.					

[1] EDU's determined through GIS query of District database.

[2] An additional 2331 EDU's from the Bain Trunk Sewer are tributary to the last two reaches of the Jurupa Trunk Sewer to the Regional Wastewater Pump Station. With the additional growth allowed to occur in the upstream part of the trunk system, these last two reaches are expected to surcharge and therefore should be monitored closely and perhaps may require replacement in advance of the remainder of the trunk sewer.

[3] Existing tributary area has 3210 EDU's, however 2568 EDU's are being pumped directly into the 18" dia. Regional force main.

[4] $Qpk=2.5\ Q_{ADF}(mgd)^{0.91}$ & EDU = 252 gpd per October, 2007 Master Sewer Plan Addendum.

[5] Assumes a 5 year growth rate of 100 EDU's/year for the Jurupa Trunk and 50 EDU's/year for the Glen Avon Trunk; then an area wide growth rate = 4% /year. Number of years decreased by 2 for planning, design, and construction activities.

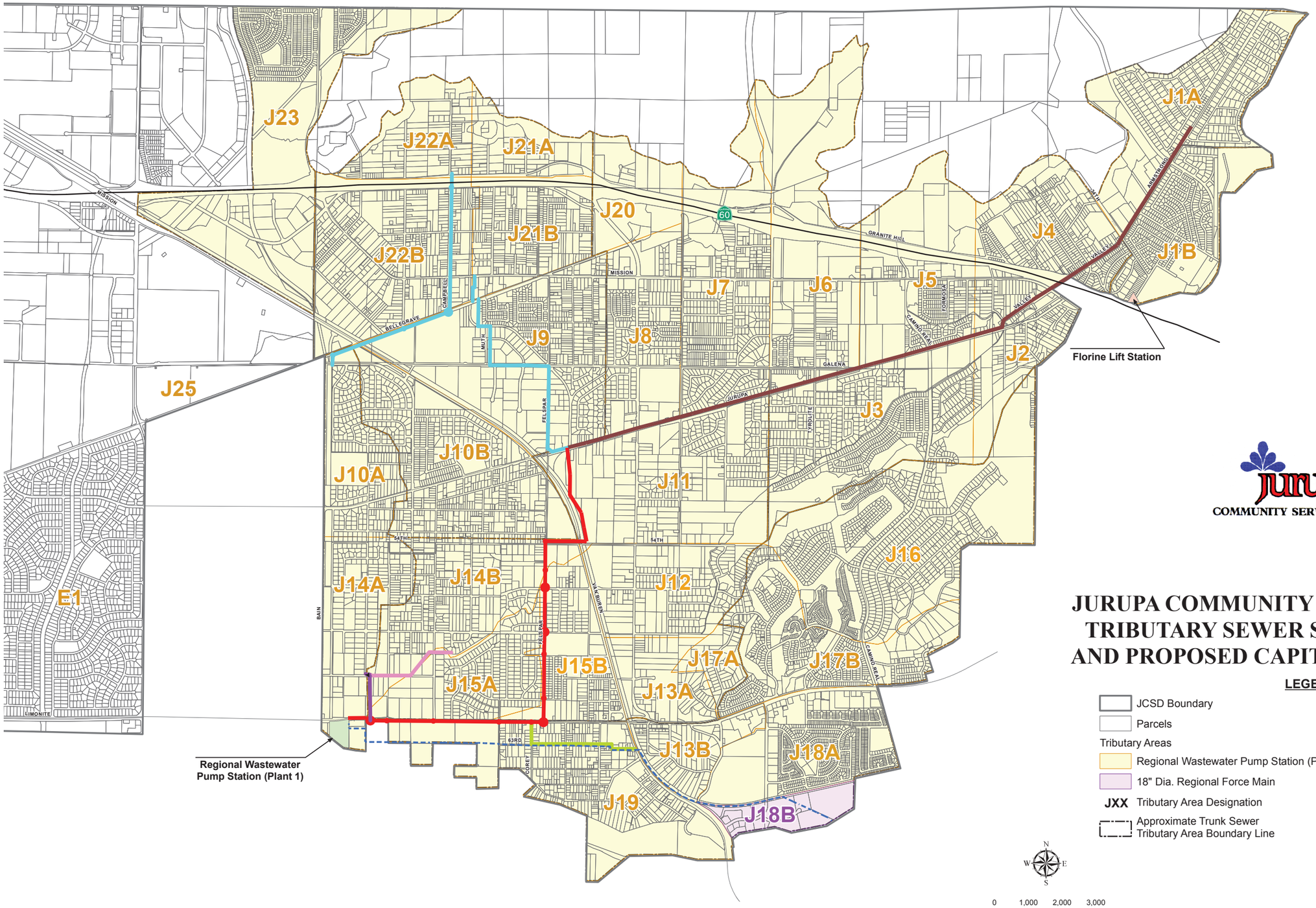
[6] 8" dia. pipe should be limited to D/d ≤ 0.5 per District Standards. This trunk system requires further investigation; 6 years has been assumed for CIP replacement purposes.

[7] Implementation timing per Jurupa Road Sewer Improvement Study dated March 17, 2008. Costs provided do not include Phases 1 & 2 which are completed.

[8] Timing of capacity purchases is based upon growth rate assumptions shown. Earlier purchase times may be required based upon pending purchase agreements.

[9] Trunk sewer required to connect the Sky Country Area (Tributary Areas J25 & E1; Plate 1) to the Eastvale (Tributary to the WRCRWA Plant) sewer system in accordance with the Eastvale Master Sewer Plan Update (Addendum No. 1) September, 2004. Implementation was previously assumed to occur when funding through connection charges were available but now is a priority due to District concerns with the existing Sky Country Force Main material.

PLATE 1



Jurupa
COMMUNITY SERVICES DISTRICT

JURUPA COMMUNITY SERVICES DISTRICT TRIBUTARY SEWER SERVICE AREA MAP AND PROPOSED CAPITAL IMPROVEMENTS

LEGEND

- JCSD Boundary
- Parcels
- Tributary Areas
- Regional Wastewater Pump Station (Plant 1)
- 18" Dia. Regional Force Main
- JXX Tributary Area Designation
- Approximate Trunk Sewer Tributary Area Boundary Line
- Jurupa Trunk (Upstream)
- Jurupa Trunk (Downstream)
- Glen Avon Trunk
- Pedley Trunk
- Pyrite Creek Interceptor
- Bain Trunk
- Regional Force Main to the City of Riverside WWTP

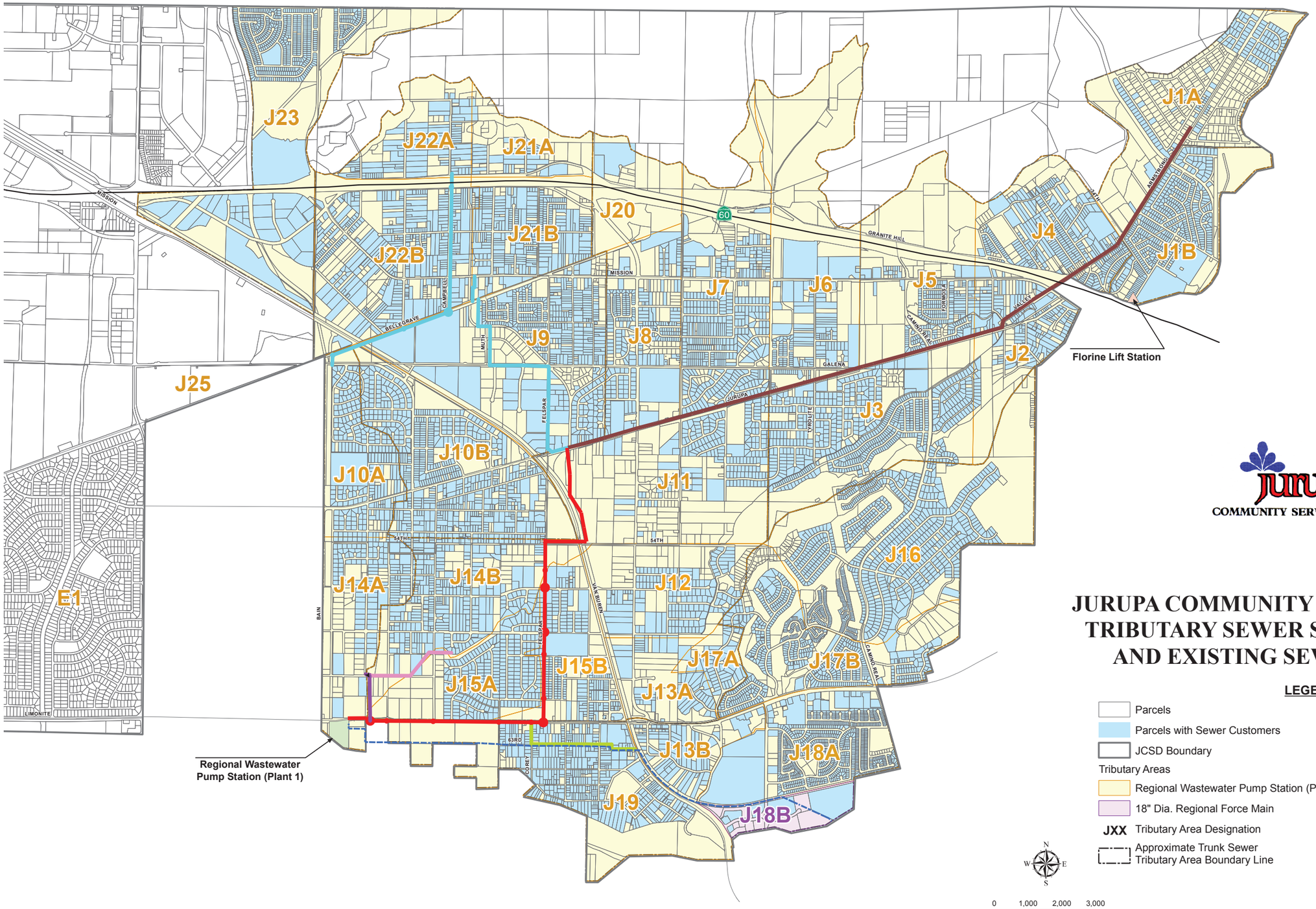
N W E S

0 1,000 2,000 3,000
Feet

ALBERT A. WEBB ASSOCIATES

Map created Sept. 15, 2008; G:\2008\08-0271\GisSewer_EDUs.mxd

PLATE 2



Jurupa
COMMUNITY SERVICES DISTRICT

JURUPA COMMUNITY SERVICES DISTRICT TRIBUTARY SEWER SERVICE AREA MAP AND EXISTING SEWERED PARCELS

LEGEND

- Parcels
- Parcels with Sewer Customers
- JCSD Boundary

Tributary Areas

- Regional Wastewater Pump Station (Plant 1)
- 18" Dia. Regional Force Main
- JXX Tributary Area Designation
- Approximate Trunk Sewer Tributary Area Boundary Line
- Jurupa Trunk (Upstream)
- Jurupa Trunk (Downstream)
- Glen Avon Trunk
- Pedley Trunk
- Pyrite Creek Interceptor
- Bain Trunk
- Regional Force Main to the City of Riverside WWTP

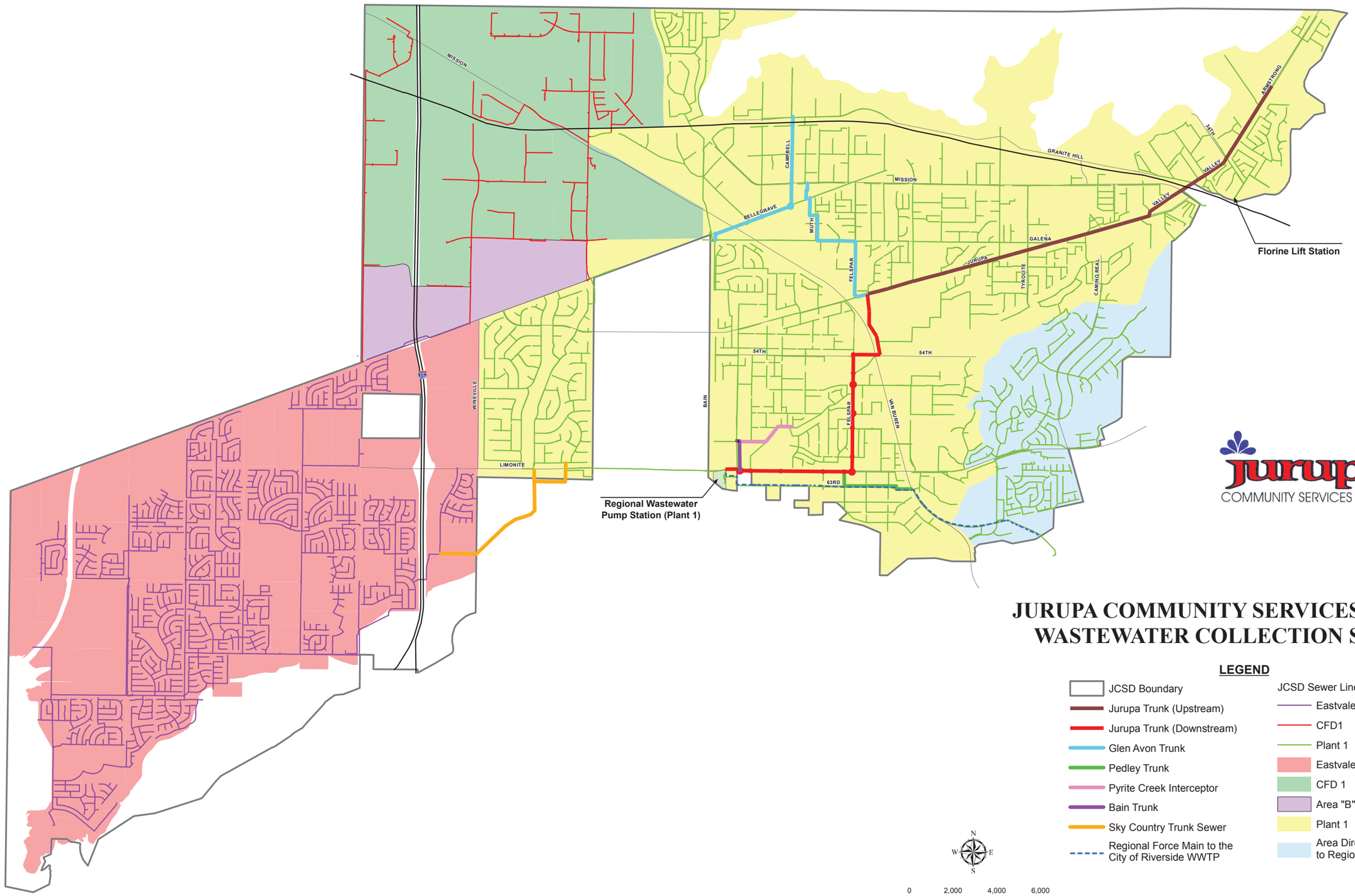
N W E S

0 1,000 2,000 3,000
Feet

ALBERT A. WEBB ASSOCIATES

Map created Sept. 15, 2008; G:\2008\08-0271\GisSewer_EDUs_PI2.mxd

PLATE A



jurupa
COMMUNITY SERVICES DISTRICT

JURUPA COMMUNITY SERVICES DISTRICT WASTEWATER COLLECTION SYSTEMS

LEGEND

- JCSD Boundary
- Jurupa Trunk (Upstream)
- Jurupa Trunk (Downstream)
- Glen Avon Trunk
- Pedley Trunk
- Pyrite Creek Interceptor
- Bain Trunk
- Sky Country Trunk Sewer
- Regional Force Main to the City of Riverside WWTP

JCSD Sewer Lines

- Eastvale
- CFD1
- Plant 1
- Eastvale
- CFD 1
- Area "B"
- Plant 1
- Area Directly Tributary to Regional FM

N W E S

0 2,000 4,000 6,000
Feet

ALBERT A. WEBB ASSOCIATES

Map created Dec. 15, 2009; G:\2009\09-0064\Gis\Sewer_line_areas.mxd

Appendix 3B.7

2010 MASTER SEWER PLAN ADDENDUM NO. 2 FOR JURUPA COMMUNITY SERVICES DISTRICT

ALBERT A. WEBB ASSOCIATES

3788 McCray Street • Riverside, CA 92506
Phone: 951.686.1070 • Fax: 951.788.1256
www.webbassociates.com

W.O.: 09-64

May 25, 2010

Mr. Eldon Horst
General Manager
Jurupa Community Services District
11201 Harrel Street
Mira Loma, CA 91752

RE: Master Sewer Plan Addendum No. 2

Dear Mr. Horst:

In accordance with the Jurupa Community Services District's (District) authorization, we have completed the second addendum for the 2004 Master Sewer Plan. The purpose of the second addendum is to address significant planned infrastructure changes that have occurred since the 2004 document was published.

Introduction

The September, 2004 Master Sewer Plan was an update to the December, 1983 Wastewater Management Plan for the District. In October of 2007, the first addendum to the 2004 Master Sewer Plan was completed. The purpose of the first addendum was to re-evaluate the wastewater generation factors based upon current District flow records and re-calculate the factors using recorded data. New "build out" average daily flows were calculated using the new wastewater generation factors. The updated flow projections were used primarily for the purposed of predicting ultimate treatment plant capacity and estimating the project cost of adding and/or purchasing treatment plant capacity. Also, the first addendum reviewed the District's wastewater influent quality and updated the project costs of the Master Plan Improvements to an Engineering News Record and Construction Cost Index for Los Angeles (October, 2007).

Since the publication of the 2004 Master Sewer Plan and subsequent October, 2007 Addendum, significant changes concerning the District's sewer system has occurred. These changes include the following:

1. The District's concept of delivering flows to the City of Riverside's Water Quality Control Plant (WQCP) has changed (i.e. crossing the Santa Ana River at a new Van Buren Bridge). The infrastructure required to deliver the flows to the bridge crossing and from the bridge crossing to the City's WQCP need to be determined.

2. With the change indicated in Item 1, re-evaluation of delivering wastewater flows from the area east of Van Buren, south of Limonite, and the Indian Hills area to the City of Riverside needs to occur.

3. A factor affecting Item 2 is the possible reconstruction of the Indian Hills Wastewater Treatment Plant (WWTP) which would also affect JCSD's need to purchase additional capacity at the City of Riverside's WQCP.

4. The concept of accommodating increased flows in JCSD's Plant 1 Tributary Area (Plate 1) (shown in light yellow) includes an evaluation of a subregional lift station in the vicinity of Felspar and Limonite (separate study).

5. A possible alternative or subalternative to Item 4 is the construction of a new forcemain in Limonite from the Regional Wastewater Pump Station to the Van Buren bridge crossing the Santa Ana River.

6. In view of Items 4 and 5, an evaluation of the planned expansion of the storage ponds at Plant 1 requires additional analysis including review of overall need and/or sizing.

7. JCSD's Master Sewer Plan Addendum (October, 2007) was primarily commissioned for predicting ultimate treatment plan capacity and the resulting amount of plant expansion and/or purchase that will be required. The study concluded that two different generation factors should be used; 220 gpd/EDU in Eastvale and 252 gpd/EDU in the Plant 1 Tributary area. The September, 2004 Master Sewer Plan (MSP) utilized a wastewater generation factor of 280 gpd/EDU that is the current District Standard. The affects of these reduced generation factors on existing and proposed sewage infrastructure were not evaluated and should be used to verify proposed improvements identified in the 2004 MSP.

8. Since the September, 2004 MSP was published, land use changes have occurred within JCSD.

Pursuant to our February 25, 2009 meeting, it is our understanding the District does not wish at this time to pursue any affects to the sewer system as discussed in Items 7 and 8. Therefore, the Scope of Work for Addendum No. 2 includes Items 1-6 as described above.

Additionally, the District requested estimated implementation time frames (i.e. "trigger points") whereby the new identified infrastructure would be required.

Analysis

Plant 1 Wastewater Pump Station and Forcemains

As previously indicated, one of the major changes to the proposed District sewer system is the methodology of conveying wastewater flows across the Santa Ana River to the City of Riverside for treatment. Currently, flows are conveyed under the Santa Ana River to the City via inverted siphons. The new methodology is to convey the wastewater flows across the river via the new Van Buren Bridge. Currently, the Regional Wastewater pump Station's capacity at Plant 1 is 5 mgd and potential peak "buildout" flows are estimated to be in excess of 12 mgd. As such, one of the primary decisions to be made is to determine how to accommodate ultimate buildout flows in the Plant 1 Tributary Drainage Area (Plate 1).

A separate study to evaluate the most cost effective method to provide sufficient pumping capacity in the Plant 1 area is nearing completion. The District commissioned Webb Associates to prepare a report entitled the "Feasibility and Planning Study for the Felspar Lift Station Site and Forcemain Alignment". This study reviewed alternatives of providing additional pumping capacity in the Plant 1 Tributary Area. One of the alternatives was the construction of a "subregional" lift station at the corner of Felspar Street and Limonite Avenue. Without addressing the details of this study, the report concluded that the Felspar Lift Station was not the most cost effective alternative and the construction of the additional capacity for the Plant 1 Tributary Area would be best suited at Plant 1 by either constructing an additional pump station for the flows exceeding the existing stations capacity or the construction of a new pump station to accommodate all of the buildout design flows. The analysis of which of the two Plant 1 pumping alternatives should be selected, is beyond the scope of this report and should be determined by a separate, more detailed, evaluation. However, common to both of the additional Plant 1 pumping alternatives is the construction of a new 24" diameter force main from Plant 1 to the new Van Buren Bridge (Plate 2). The 24" diameter force main will carry flows in addition to the existing 18" diameter force main thus creating an equivalent pipe diameter of approximately 28 inches.

Plant 1 Wastewater Storage Ponds

With the construction of a new 24" diameter Regional Force Main, the District's current plans of expanding the wastewater storage ponds at Plant 1 needs to be re-evaluated. As a brief background, the existing storage ponds at Plant 1 (5 MG$^{\pm}$) were

required by the California Regional Water Quality Control Board for two primary reasons. First, wet weather peak flows to the Regional Wastewater Pump Station exceeded it's capacity. Therefore, there was a need to equalize the flows by storing the quantity of wastewater that exceeded the pump station's capacity and slowly release the wastewater back to the station as the peak flows dissipated. The second primary reason was with a single force main from Plant 1 to the City of Riverside's WQCP there was no method to take the forcemain out of service for inspection purposes or repair.

With the construction of a second forcemain, a certain amount of pipeline redundancy is obtained and additional pumping capacity is achieved. Pumping the flows from the station directly to the treatment plant is the preferred scenario. This would eliminate the additional step of temporarily storing the wastewater and then waiting to pump until the peak flows subside. As such, it is our recommendation, contingent upon concurrence of the Regional Board, that the District not pursue the storage pond expansion project and utilize the allocated funds for the additional Regional Force Main and Pump Station Expansion project at the Plant 1 site.

Indian Hills Area Wastewater Pump Stations and Forcemains

With the plan of pumping the wastewater across the new Van Buren Bridge, facilities must be proposed to transport Indian Hills Area flows (Plate 1 Tributary Areas J16, J17, and J18) to the crossing. Plate 3 illustrates the existing Indian Hills Area Backbone Sewer System. Currently, the majority of the Indian Hills Area flows enter the existing 18" Regional Forcemain by (1) a 10" dia. Clay Street pressurized gravity main (2) Clay Street Lift Station and (3) Clay & Van Buren Lift Station. The proposed Indian Hills Area Backbone System is shown on Plate 4.

The proposed system would still utilize the Clay Street and Clay & Van Buren Lift Stations, modified for new pumping conditions, however they will now pump into a proposed 12" dia. forcemain that would traverse from the existing Clay Street Lift Station site and parallel the existing Regional Forcemain to General Dirve. The proposed forcemain would then traverse along General Drive, to Clay Street and connect into the proposed 24" dia. forcemain that transitions into two 24" HDPE pipelines in a bridge crossing the Santa Ana River (Plate 2). It should be noted that due to an upcoming Clay Street/Railroad crossing grade separation project, currently in the early design phase and scheduled for construction in 2012, the future disposition (i.e. whether the station requires a new site or is not affected) of the Clay Street Lift Station is unknown.

It is recommended, if feasible, that the existing 18" Regional forcemain, southeasterly of General Drive, and inverted siphons crossing under the Santa Ana River remain in place as an emergency bypass to the City of Riverside's WQCP.

Wastewater Treatment Capacity

As determined in the October, 2007 Addendum to the District's Master Sewer Plan, the Plant 1 and Indian Hills Tributary Drainage Areas as ultimate buildout will require approximately 1 mgd additional treatment plant capacity. The additional treatment capacity can be obtained by two alternatives. The first alternative is to purchase additional capacity at the City of Riverside's Regional Treatment Plant. The second alternative is to reconstruct the Indian Hills Wastewater Treatment Plant. As will be discussed in the cost section of this addendum, preliminary project costs indicate both alternatives are approximately the same with regards to capital costs. Even though the cost of acquiring 1 mgd of additional treatment plant capacity at either Indian Hills or at the City of Riverside facility is comparable, there is a benefit of having a source of tertiary reclaimed water within JCSD's service area which can be used for irrigation purposes.

As will be discussed in a subsequent section, the decision concerning which alternative of obtaining additional capacity is not an immediate need and further evaluation of the overall costs and benefits can be made.

It should be noted that if the Indian Hills alternative becomes the most viable method of obtaining additional treatment capacity, the pumping capacities of the Clay Street Lift Station could be configured to pump either to the Indian Hills Plant or the 24" dia. forcemain in Van Buren Blvd.

Wastewater Pump Station and Forcemain Sizing

In order to size the proposed facilities, updated estimated design flows were developed based upon the new flow projections from the October, 2007 Master Sewer Plan Addendum. Table 1 shows the flow projections from the referenced 2007 Addendum. Using the flows tributary to the City of Riverside's WQCP shown on Table 1, flows were allocated to each facility as shown on Table 2.

Preliminary Design Reports (PDR's) should be prepared to refine and detail each wastewater pump station's design. Especially important is the analysis of the three wastewater pump stations having the capability of pumping into a common forcemain at the same time. Due to the "flat nature" of sewage pump curves, pump control and pump control valves will be an important element of this analysis.

Concerning the PDR for the Clay Street Lift Station, an analysis should be made to determine if a low head pressurized gravity pipeline traversing from a point in the

Table 1 – New Projected "Build-out" Average Daily Flows for Ultimate Wastewater Treatment Plant Capacity

TRIBUTARY WASTEWATER TREATMENT PLANT	Residential Res. EDU's[1]	Flows (gpd)	Comm./Ind. Flows (gpd)	Schools Flows (gpd)	"Build-out" Flows (gpd)
City of Riverside WCQP[2]	18,249	4,598,748[3]	265,230[4]	59,402[4]	4,923,380
Western Riverside Co. WWTP[5]	22,338	4,979,544[6]	478,600[7]	203,550[7]	5,661,694
Total[8]	40,587	9,578,292	743,830	262,952	10,585,074

[1] From the 2004 Master Sewer Plan (refer to Appendix L of 2004 Master Sewer Plan)
[2] Includes Land Use areas J1-J18, J19-J23.
[3] Calculated by multiplying the EDU's times the projected wastewater generation factors of 252 gpd/EDU.
[4] 1/3 of the projected "buildout" flows from the 2004 Master Sewer Plan. 2/3 of non-residential EDU's have already been built (Appendix D of 2007 Addendum) and accounted for in the wastewater generation factor of 252 gpd/EDU.
[5] Includes Land Use areas E1-E50, J25.
[6] Calculated by multiplying the EDU's times the projected wastewater generation factors, 220 gpd/EDU for Eastvale and 252 gpd/EDU for Sky Country (Land Use Area E1).
[7] From the 2004 Master Sewer Plan (refer to Appendix L of 2004 Master Sewer Plan). Flows added because the vast majority of the buildout non-residential EDU's have not yet been constructed (Appendix D of 2007 Addendum)
[8] Total wastewater flows do not include wastewater generated in Land Use Areas pertaining to CFD No. 1 (J24, J26-30).

TABLE 2
WASTEWATER PUMPING FACILITY
ESTIMATED DESIGN FLOWS[1]

Facility Name	Approximate Service Area (AC)	No. of Residential EDU's	Residential Q_{ADF} (mgd)[5]	Non-Residential Q_{ADF} (mgd)[6]	Total Q_{ADF} (mgd)	Q_{PK} (dry) (mgd)[8]	Infiltration/Inflow Allowance (mgd)[9]	Q_{PK} (wet) (mgd)	Q_{PK} (wet) (gpm)	Assumed Q_{DESIGN} (gpm)	Required Forcemain Diameter (in.)[10]
Regional Wastewater Pump Station (Plant 1)	8,956.7 [2]	15,771	3.974	0.281	4.255	9.338	1.433	10.771	7,480	7,500	24
Clay Lift Station	1,284.1 [3]	2,478	0.624	0.013	0.637	1.658	0.205	1.863	1,294	1,300	12
Clay & Van Buren Lift Station	76.9 [4]	0	0	0.038 [7]	0.038	0.128	0.012	0.140	97	100	4
TOTALS	**10,317.7**	**18,249**	**4.598**	**0.332**	**4.930**	**11.124**	**1.650**	**12.774**	**8,871**	**8,900**	N/A

[1]Tributary to the City of Riverside WQCP (assumes Sky Country Area (Tributary Areas E1 & J25 flows are treated at the Western Riverside County Regional Wastewater Authority's plant) in accordance with the District's September, 2004 Master Sewer Plan (MSP).
[2]MSP Areas J1-J15B, J17A, J19-J23.
[3]MSP Areas J16, J17B, J18.
[4]MSP Area J18 (Lower).
[5](No. EDU's x 252 gpd/EDU) ÷ 1,000,000.
[6]Total non-residental City of Riverside tributary wastewater flows (Table 1) allocated based upon percentage of non-residential flow ratios from MSP within each service area.
[7]Based upon 500 gpd/AC x 76.9 AC.
[8]$Q_{PK} = 2.5\ [Q_{ADF}\ (mgd)]^{0.91}$ District Standard Peaking Equation.
[9]Based upon 160 gpd/AC per 2004 MSP.
[10]Based upon peak velocities between 2.5 - 5.0 fps.

vicinity of the existing station, southerly on Clay Street across the proposed grade separation to the 24" dia. forcemain in Van Buren is feasible. Without additional hydraulic study and the specific details of the grade separation, it is difficult to determine if this alternative is feasible. However, based upon a conceptual analysis, it does not appear this alternative is feasible due to the elevation of the hydraulic grade line on the 24" dia. forcemain at Van Buren and Clay Street.

City of Riverside Connection

As indicated on Plate 2, the terminus of JCSD's "Plant 1" Area Proposed Regional Wastewater Improvements is currently assumed to occur at the Existing Regional Force Main Connection to the City of Riverside WQCP. However the exact location of the point of connection to the City's system requires discussions with City staff. It is currently anticipated that a new headworks including a mag meter to measure the flows entering the City's plant and facilities to analyze wastewater quality will also be required.

A potential alternate connection location to the City's system is the Arlanza Trunk Sewer as shown on Plate 2. However, it is our understanding that the City has not anticipated flows from JCSD to be included in the Arlanza Trunk Sewer. While portions of the Arlanza Trunk Sewer will be upsized as part of the City's WQCP renovation, the majority of it's length is not identified for replacement.

As such, it should be emphasized that coordination with the City of Riverside needs to occur immediately so that all design parameters and agreement terms can be established now for future service. Pursuant to a meeting that occurred at the District on August 10, 2009, it is our understanding that District staff will coordinate with City staff to obtain an agreement to connect to the City's system. Webb Associates is ready to assist the District in any manner concerning obtaining an agreement with the City of Riverside.

For the purposes of this addendum, we have assumed an independent pipeline (sized only for ultimate District flows), crossing the Van Buren Bridge to Jurupa Avenue then traversing easterly in Jurupa Avenue to Acorn Street, and then traversing northerly on Acorn Street to the current District connection point to the City's plant will be required as shown on Plate 2.

Cost Estimates

The estimated project costs for regional conveyance and treatment at the City of Riverside for each of the proposed facilities are shown on Table 3.

Estimated Regional Conveyance and Treatment Implementation Schedule

Implementation of the facilities described in Table 3 are governed by three primary factors (1) construction completion of the new Van Buren Bridge, (2) construction completion of the new City of Riverside's WQCP and (3) expected growth within the Plant 1 Tributary Area. Currently, construction of the new Van Buren Bridge is expected to be complete in late 2011. Construction of the City's WQCP is expected to be complete in 2014.

Regarding growth within JCSD, for the purposes of this Addendum, the current water supply growth assumption is used which is 1100 EDU's/Year for 10 years. The 1100 EDU/Year assumption is JCSD wide, therefore adjustment must be made for the Plant 1 area only. Since the Eastvale and CFD No. 1 areas of JCSD have been the major growth areas within the last several years, these areas are expected to continue to grow faster because there are larger parcels of land to develop and the newer development areas tend to attract new projects. The Plant 1 area tends to have much smaller parcels for development and as such, is expected to be more of an "infill" type of development (i.e. smaller number of units constructed in pocket vacant areas). Therefore for the purposes of this addendum, it is assumed two thirds of JCSD's future growth will occur in the Eastvale and CFD No. 1 areas on one third in the Plant 1 service area. One third of 1100 EDU's/Yr. is approximately 367 EDU's/Yr. In terms of average daily wastewater flow increase, the 367 EDU's translate to approximately 92,500 gpd.

Therefore, with the Plant 1 area having a current average daily flow of approximately 3.4 mgd, it would take about 6.5 years for the area to reach it's current City of Riverside Treatment Plant capacity allotment of 4 mgd. However, as the Plant 1 area's average daily flow increases, peak flows will increase accordingly meaning the chances of using the existing storage ponds on a regular basis will increase.

Implementation times for the Plant 1 Area improvements could be extended a number of years by changing the treatment location for the Sky Country Area (Areas E1 and J25 of Plate 1) from the City of Riverside to the WRCRWA Plant in accordance with the 2004 Master Sewer Plan. However, construction of additional trunk sewers in Eastvale and additional treatment plant capacity purchase/construction would be required. Therefore, the assumption of this addendum is implementation of the improvements described in Table 3 will be required within 5 years.

Table 3 – City of Riverside Regional Conveyance and Treatment Estimated Project Costs

Facility	Estimated Project Cost[1] [2]
Regional Wastewater Pump Station Capacity Increase (Plant 1)	$12,600,000 [3]
Regional Forcemain	
13,500 LF 24" dia. Forcemain	$2,700,000
1220 LF 24" dia. HDPE Forcemains (dual) Across New Van Buren Bridge	$910,000 [4]
4100 LF 30" dia. Forcemain	$980,000
2200 LF 27" dia. Gravity Trunk Sewer	$1,240,000[9]
Headworks Connection to City of Riverside's Sewer System	$2,000,000 [5]
Clay Street Lift Station	$2,300,000 [6]
Clay Street Lift Station's Forcemain – 3500 LF 12" dia.	$350,000
Van Buren Lift Station & Forcemain & 100 LF 4" dia.	$200,000 [7]
1 MGD Wastewater Treatment Plant Capacity	$14,600,000 [8]
18" Plug Valve Installations on Existing Regional Forcemain	$50,000
TOTAL	$37,930,000

[1]Refer to Plate 2 for locations.
[2]Project cost is 1.4 times construction cost rounded to nearest $10,000. Project cost includes: construction costs, construction contingencies, design engineering including plans and specifications; design and construction surveying and mapping: geotechnical evaluation and report; engineering contract administration; field inspection and basic environmental documentation. Costs are based on Engineering News Record (ENR) Construction Cost Index Los Angeles, August 2009 (ENR = 9;766.19). Escalation, financing, interest during construction, legal, land ROW agent, and environmental impact report costs are not included.
[3]Although requiring additional study for the purposes of this Addendum, it is assumed a new Regional Pump Station capable of pumping the total ultimate build out flows will be constructed.
[4]Cost based upon Van Buren Bridge bid item prices increased to project costs.
[5]Allowance for automated screen, grinder, headworks structure, flow measurement, and water quality sampling facility.
[6]Although requiring additional study for the purposes of this Addendum, it is assumed a new pump station capable of pumping ultimate build out flows will be constructed.
[7]Assumes renovation of existing facility including pump replacements and addition of a standby generator.
[8]Jurupa Community Services District Sewer System Capital Improvement Program.
[9]Assumes trunk sewer slope of 0.80%.

It is expected that the planning, design, and construction period to obtain operating facilities will take 2-3 years. Therefore, it is our recommendation the District consider immediate action on authorizing the previously discussed preliminary design reports for the required improvements.

If you have any questions, please feel free to telephone me at (951) 686-1070.

Sincerely,

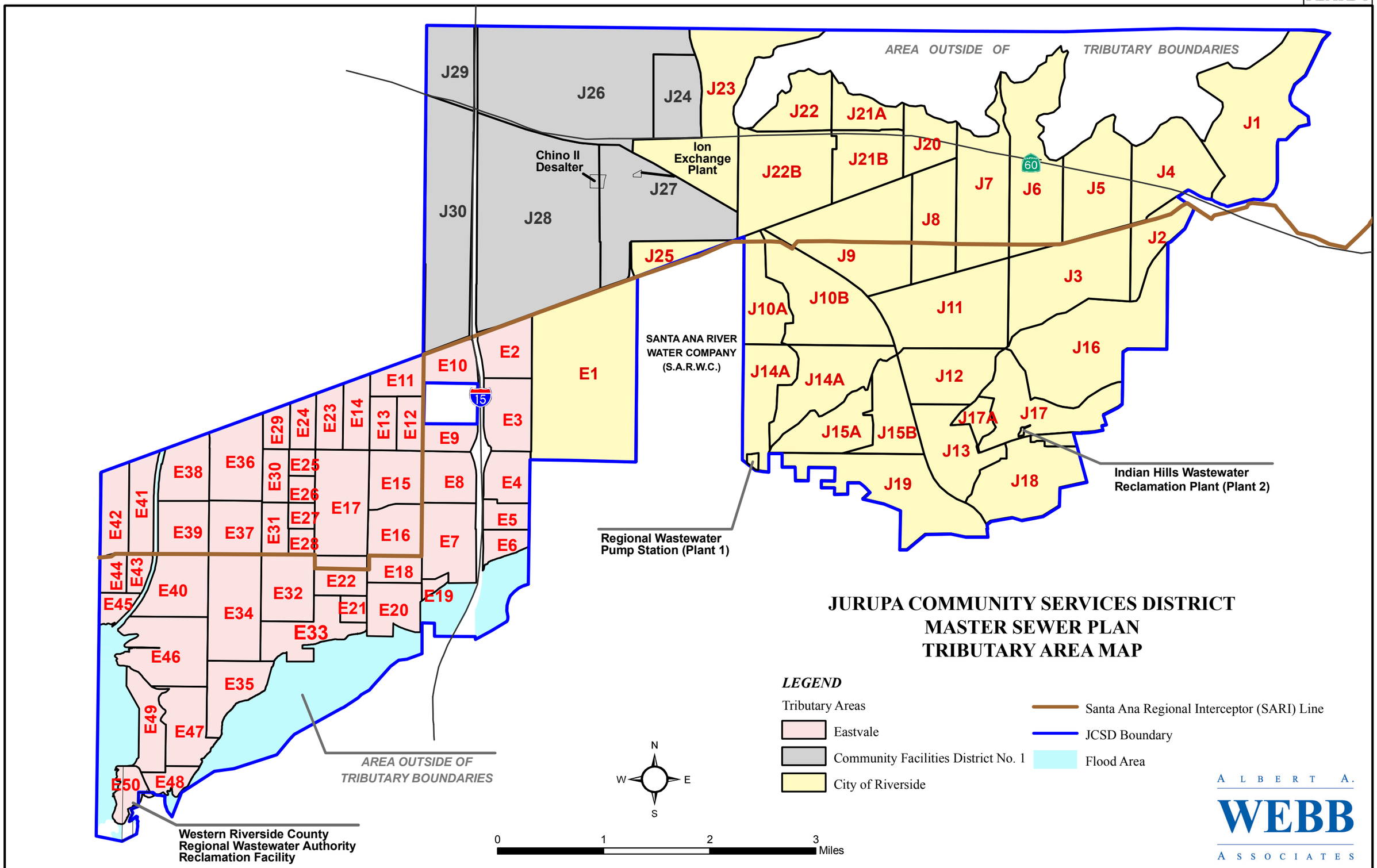
ALBERT A. WEBB ASSOCIATES

Wallace H. Franz, P.E.
Vice President

REGISTERED PROFESSIONAL ENGINEER
WALLACE H. FRANZ
NO. 26979
EXP. 3-31-11
CIVIL
STATE OF CALIFORNIA

WF:at

cc: Robert Tock, JCSD
David Yang, JCSD
Todd Minten, JCSD
Dan DuCasse, JCSD
Umesh Shah, JCSD
Sam Gershon, Webb Associates
Bill Malone, Webb Associates



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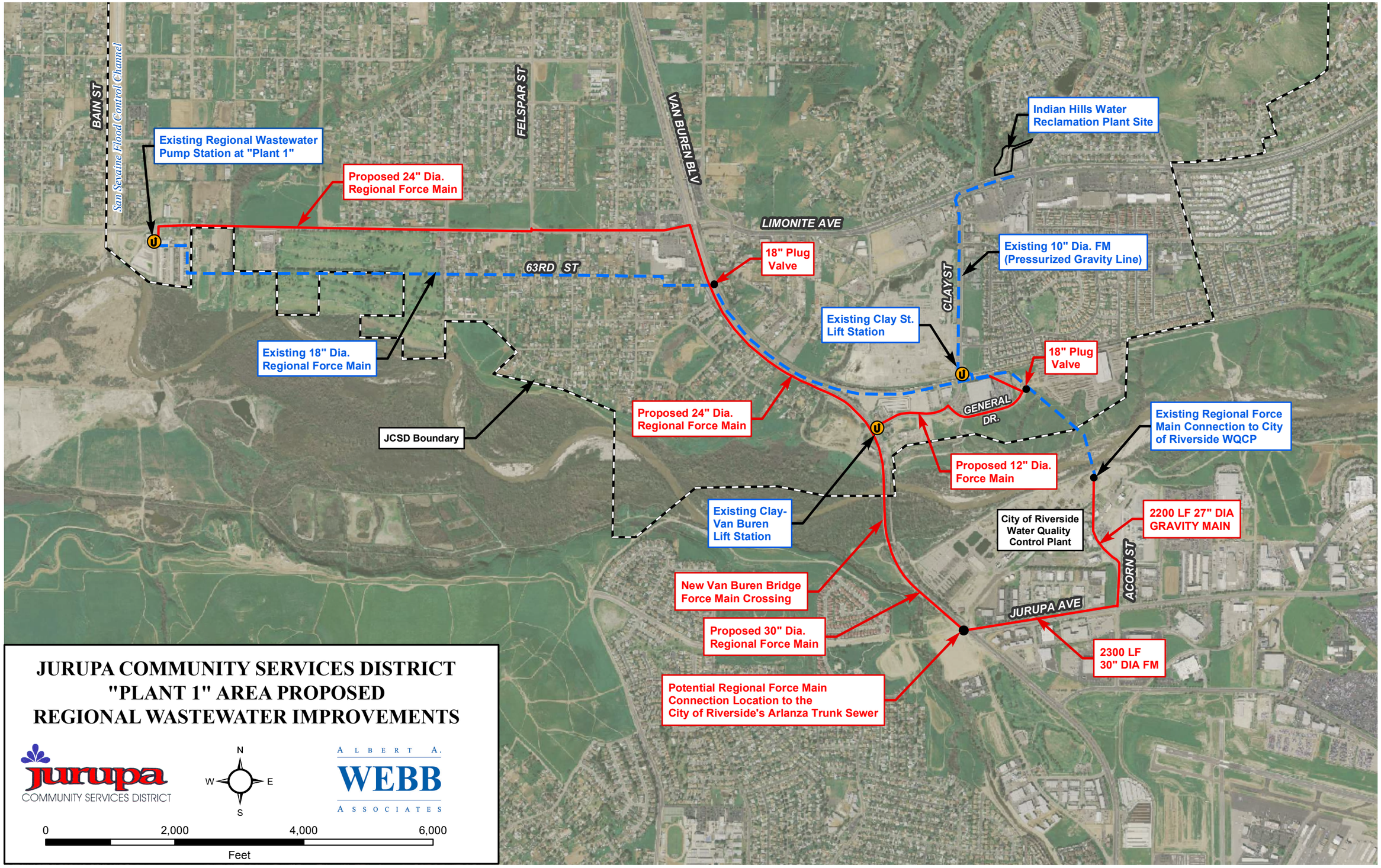

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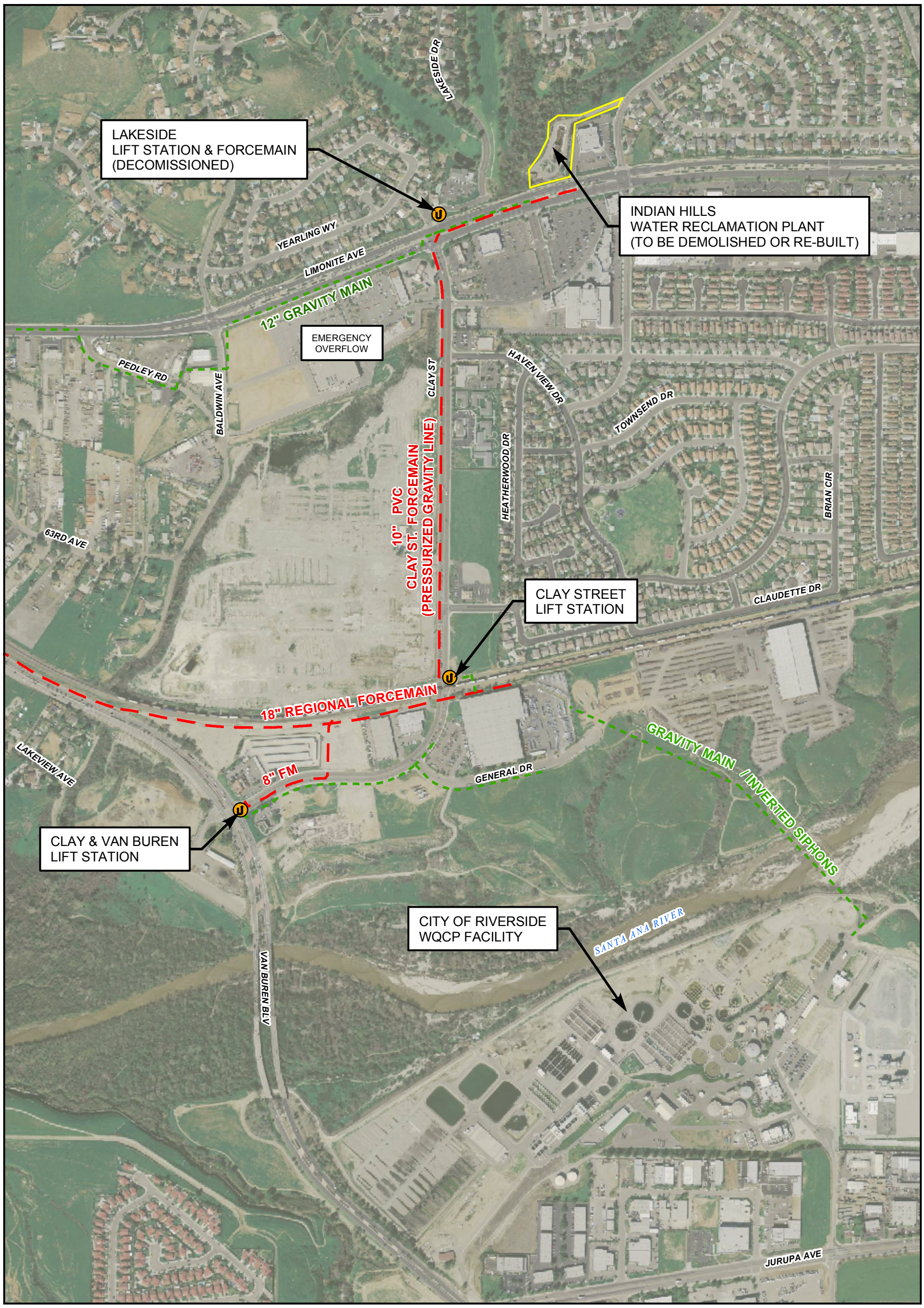

Image: Digital Globe,
March 2008
Scale: 1" = 600'

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N
W E
S

Legend

- Lift Station
- Force Main
- Gravity Main

Existing Indian Hills Area Backbone Sewer System

PLATE 3

G:\2009\09-0064\Gis\exisit_system_Pl3.mxd; Map revised Sept. 1, 2009.

LAKESIDE
LIFT STATION & FORCEMAIN
(DECOMISSIONED)

INDIAN HILLS
WATER RECLAMATION PLANT
(TO BE DEMOLISHED OR RE-BUILT)

LAKESIDE DR
YEARLING WY
LIMONITE AVE
12" GRAVITY MAIN
EMERGENCY
OVERFLOW
PEDLEY RD
BALDWIN AVE
63RD AVE
CLAY ST
10" PVC
CLAY ST. FORCEMAIN
(PRESSURIZED GRAVITY LINE)
EL PALOMINO DR
HAVEN VIEW DR
TOWNSEND DR
HEATHERWOOD DR
BRIAN CIR
CLAUDETTE DR
CLAY STREET
LIFT STATION
18" REGIONAL FORCEMAIN
LAKEVIEW AVE
12" FM
GENERAL DR
2" - 12" GRAVITY MAINS
24" FORCE MAIN
CLAY & VAN BUREN
LIFT STATION
CITY OF RIVERSIDE
WQCP FACILITY
SANTA ANA RIVER
VAN BUREN BLV
(2) 24" FORCE MAINS
ARLANZA
TRUNK SEWER
27" GRAVITY MAIN
30" FORCE MAIN
JURUPA AVE

Image: Digital Globe,
March 2008
Scale: 1" = 600'

ALBERT A. WEBB ASSOCIATES

N
W E
S

Legend

- Lift Station
- Future Force Main
- Future Gravity Line
- Existing Force Main
- Existing Gravity Line
- Not in Use

Proposed Indian Hills Area Backbone Sewer System

PLATE 4

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Appendix 3B.8

2015 RUBIDOUX COMMUNITY SERVICES DISTRICT WASTEWATER FACILITIES MASTER PLAN

RUBIDOUX COMMUNITY SERVICES DISTRICT
3590 RUBIDOUX BOULEVARD
JURUPA VALLEY, CA 92509-4525
(915) 684-7580

RUBIDOUX COMMUNITY SERVICES DISTRICT
WASTEWATER FACILITIES MASTER PLAN

November 2015

Prepared by

KRIEGER & STEWART
Engineering Consultants
3602 UNIVERSITY AVENUE
RIVERSIDE, CALIFORNIA 92501
(951) 684-6900

SIGNATURE Mark E Messersmith

DATE 11/30/15

REGISTERED PROFESSIONAL ENGINEER
MARK E. MESSERSMITH
No. 22020
Exp. 09/30/17
CIVIL
STATE OF CALIFORNIA

587-44
(REPORTS/587-44-RPT)
MEM/lge

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Plates

1 Existing Wastewater System Facilities
2 Proposed Wastewater System Facilities

Executive Summary

EXECUTIVE SUMMARY

The following represents a summary of the Wastewater Facilities Master Plan. The summary's format follows that of the general text, and emphasizes the most important elements of each chapter of the Plan.

CHAPTER I – INTRODUCTION

Krieger & Stewart prepared the District's Wastewater Facilities Master Plan in 1997 (1997 Master Plan). This Master Plan supersedes the 1997 Master Plan. It reflects current conditions within the service area based on time-dependent trends which have developed over the past 18 years. It also presents projected wastewater flows and recommended system improvements based on these conditions and trends.

The purpose of this Master Plan is to serve as a guide for wastewater system improvements during the next 10 to 20, just as the earlier Master Plan served as a guide for system improvements during the past 18 years. Permanent population, wastewater flows, required system improvements, and related capital expenditures have been projected to year 2035, since estimates and projections beyond ten to twenty years are uncertain. Needs for system improvements presented herein are considered reasonably accurate, particularly for the next ten years; however, this Master Plan should be reviewed from time to time, and revised as necessary, as conditions and trends change.

The District's wastewater system is comprised of the collection system and trunk sewers; lift stations and force mains; and treatment facilities.

The existing wastewater collection system and trunk sewers consist of the following:

- 291,000± LF of gravity sewers 8" or smaller
- 21,200± LF of 10" gravity sewers
- 20,000± LF of 12" gravity sewers
- 9,500± LF of 15" gravity sewers
- 6,400± LF of 18" gravity sewers
- 7,300± LF of 21" gravity sewers
- 3,100± LF of 24" gravity sewers
- 2,300± LF of 27" gravity sewers

The District operates and maintains six (6) wastewater lift stations as follows:

- Fleetwood Lift Station
- Belltown Lift Station
- Exmoor Lift Station
- Jurupa Hills Lift Station
- Juan Diaz Lift Station
- Regional Lift Station

All of the District's wastewater is conveyed through the Regional and Juan Diaz Lift Stations and Force Mains to the Riverside Regional Water Quality Control Plant for treatment and disposal. The Riverside Regional Water Quality Control Plant is owned and operated by the City of Riverside. Currently, through several agreements with the City of Riverside, the District has acquired 3.055 MGD (average daily flow) of capacity rights in the Riverside Regional Water Quality Control Plant for wastewater treatment and disposal.

The existing wastewater facilities are shown on **Plate 1**.

CHAPTER II – PROJECTED POPULATION AND WASTEWATER FLOWS

Historic and projected wastewater flows are set forth in **Table II-2**.

TABLE II-2
HISTORIC AND PROJECTED WASTEWATER FLOWS

Year	Historic and Projected Wastewater Flows (MGD)	Projected Wastewater Flows from 1997 Master Plan (MGD)
1970		
1980	2.1	
1990		
1995	2.7	
2000	2.0	2.3
2005	2.1	2.7
2010	2.0	3.1
2015	2.4	3.4
2020	2.8	3.8
2025	3.2	4.3 (1)
2030	3.6	
2035	4.0	

(1) Wastewater Flow Projection for 2026 (ultimate conditions).

Of the 2.0 MGD projected increase in wastewater flow between 2010 and 2035, approximately 0.85 MGD (43%) is attributable to two major developments, Emerald Meadows (0.35 MGD) and Rio Vista (0.50 MGD), as shown on **Figure II-2**.

CHAPTER III – RECOMMENDED WASTEWATER SYSTEM IMPROVEMENTS

The wastewater system improvements presented in this chapter are intended to enable the District to meet anticipated wastewater system requirements over the next 10 to 20 years.

A. WASTEWATER CONVEYANCE FACILITIES

1. To accommodate existing peak wastewater flows, the recommended wastewater conveyance facilities are summarized as follows:

   - Project 1 - Rustic Lane, Pacific Avenue, and 42nd Street

     Replace 6,900± LF of existing 8" and 10" sewers with a 12" sewer.

   - Project 2 - Limonite Avenue and Plaza Lane

     Replace 330± LF of an existing 8" sewer with a 12" sewer.

2. To accommodate ultimate peak wastewater flows, the recommended wastewater conveyance facilities are summarized as follows:

   - Project 3 - Agua Mansa Road

     Replace 2,900± LF of existing 8" and 10" sewers with a 12" sewer.

   - Project 4 - 20th Street

     Replace 240± LF of the existing 10" sewer with a 12" sewer.

   - Project 5 - Rubidoux Boulevard/24th Street

     Replace 2,730± LF of existing 10", 12", and 15" sewers with a 15" sewer.

   - Project 6 - Hall Avenue

     Replace 3,300± LF of the existing 15" sewer with an 18" sewer.

- Project 7 - Wallace Street

  Replace 800± LF of the existing 18" sewer with a 21" sewer.

- Project 8 - Pontiac Avenue (Northerly of the 60 Freeway and Mission Boulevard to 34th Street)

  Replace 2,000± LF of the existing 8" sewer with 10" and 12" sewers.

- Project 9 - 42nd Street (Fort Drive to Rubidoux Boulevard)

  Replace 500± LF of the existing 21" sewer with a 24" sewer.

- Project 10 - Rubidoux Boulevard/Riverside County Flood Control and Water Conservation District (RCFC&WCD) Right-of-Way (42nd Street to 46th Street)

  Replace 700 LF± of the existing 21" sewer with a 24" sewer and replace 2,300± LF of the existing 24" sewer with a 27" sewer.

B. LIFT STATIONS

As set forth in Chapter I, the District has six (6) wastewater lift stations with the Juan Diaz Lift Station and the Regional Lift Station being the District's two major lift stations. Both the Juan Diaz and Regional Lift Stations have adequate capacity to accommodate the ultimate peak wastewater flows.

C. WASTEWATER TREATMENT FACILITIES

All of the District's wastewater is conveyed through the Regional and Juan Diaz Lift Stations and Force Mains for treatment at the Riverside Regional Water Quality Control Plant, owned and operated by the City of Riverside. Currently, the District has 3.055 MGD (average daily flow) of capacity rights in the Riverside Regional Water Quality Control Plant for wastewater treatment and disposal.

Based on the projected wastewater flows (**Table II-2**), it is anticipated the District will require 0.50 MGD of additional wastewater treatment and disposal capacity between 2020 and 2025 and then an additional 0.445 MGD of wastewater treatment and disposal capacity between 2025 and 2030.

D. ESTIMATED PROJECT COST AND PROPOSED CONSTRUCTION SCHEDULE

Estimated project costs and related construction schedules for the proposed wastewater system improvements are set forth in **Table III-1** and summarized as follows:

Projects	2015-2020	2020-2025	2025-2030	2030-2035	Total
Wastewater Conveyance Facilities (1)	$2,770,000	$6,940,000			**$9,710,000**
Additional Wastewater Treatment and Disposal Capacity (2)		$5,500,000	$4,895,000		**$10,395,000**
Total:	**$2,770,000**	**$12,440,000**	**$4,895,000**	**$0**	**$20,105,000**

(1) It is unclear when the various projects will be required since the schedules are dependent on when and where future development projects are implemented. Therefore, for purposes of this Master Plan, all improvements to accommodate ultimate peak wastewater flows are shown for the 2020-2025 time period.

(2) For purposes of this Master Plan, it is assumed additional wastewater treatment and disposal capacity will be provided by construction of a new wastewater treatment plant.

The estimated project costs for facilities are based on 2015 costs (ENR CCI for Los Angeles for June 2015 is 10,981) and consists of construction costs, a 20% allowance for construction contingencies, and a 15% allowance for administrative, legal, and engineering fees. Proposed facilities are shown on **Plate 2**.

CHAPTER I

INTRODUCTION

CHAPTER I
INTRODUCTION

A. BACKGROUND, PURPOSE, AND SCOPE

Krieger & Stewart prepared the District's Wastewater Facilities Master Plan in 1997 (1997 Master Plan). This Master Plan supersedes the 1997 Master Plan. It reflects current conditions within the service area based on time-dependent trends which have developed over the past 18 years. It also presents projected wastewater flows and recommended system improvements based on these conditions and trends.

The purpose of this Master Plan is to serve as a guide for wastewater system improvements during the next 10 to 20, just as the earlier Master Plan served as a guide for system improvements during the past 18 years. Permanent population, wastewater flows, required system improvements, and related capital expenditures have been projected to year 2035, since estimates and projections beyond ten to twenty years are uncertain. Needs for system improvements presented herein are considered reasonably accurate, particularly for the next ten years; however, this Master Plan should be reviewed from time to time, and revised as necessary, as conditions and trends change.

Since this Master Plan serves as a guide, the specific projects and their locations and schedules indicated herein may be altered or relocated during project design. For example, sewers may be specifically located and scheduled differently than generally planned sewer facilities to accommodate rights-of-way, development, redevelopment, roadwork, traffic, natural features, utility interferences, and other factors.

B. SERVICE AREA

The District was organized on November 24, 1952 in accordance with State of California Community Services Law (Government Code §60000, et seq.) for the purposes of providing certain public services, including wastewater collection and treatment. The District routinely constructs new facilities, maintains them, and replaces them as necessary to maintain adequate and reliable wastewater service to its customers.

The District is situated in the City of Jurupa Valley (incorporated 2011), approximately 50 miles east of Los Angeles. The District's current boundaries, which are shown on **Figure I-1**, encompass an area of approximately 7.7 square miles. The ultimate service area boundary encloses an area of approximately 8.9 square miles and is also shown on **Figure I-1**.

Although certain small portions of the service area are approaching ultimate development, large portions remain available for future development. Based on current wastewater flows and ultimate wastewater flows, the ultimate service area is now about 50% developed. The Emerald Meadows and Rio Vista Developments are anticipated to be the first to be developed during the next housing up-cycle.

The District's wastewater system must be capable of meeting wastewater collection and treatment requirements for existing and continuing land development and corresponding increases in population. System improvements will be needed for continuing service to existing customers, as well as for expanded service to future customers. The system improvements set forth herein are intended to serve as a guide for construction of wastewater facilities to meet immediate as well as long range needs, all in accordance with the current City of Jurupa Valley Zoning Maps.

C. EXISTING WASTEWATER SYSTEM FACILITIES

Construction drawings are not available for older portions of the existing system; therefore, it is difficult to estimate the age of the sewers therein. However, based on dates shown on available record drawings, portions of the system date back to approximately the 1950s.

The District's wastewater system comprises the collection system and trunk sewers; lift stations and force mains; and treatment facilities.

The existing wastewater collection system and trunk sewers consist of the following:

- 291,000± LF of gravity sewers 8" or smaller
- 21,200± LF of 10" gravity sewers
- 20,000± LF of 12" gravity sewers
- 9,500± LF of 15" gravity sewers
- 6,400± LF of 18" gravity sewers

- 7,300± LF of 21" gravity sewers
- 3,100± LF of 24" gravity sewers
- 2,300± LF of 27" gravity sewers

The District operates and maintains six (6) wastewater lift stations as follows:

- Fleetwood Lift Station
  - Two (2) 7 hp pumping units (430 gpm each)
  - 400± LF of 8" force main

- Belltown Lift Station
  - Two (2) 4 hp pumping units (150 gpm each)
  - 800± LF of 4" force main

- Exmoor Lift Station
  - Two (2) 15 hp pumping units (625 gpm each)
  - 900± LF of 8" force main

- Jurupa Hills Lift Station
  - Two (2) 10 hp pumping units (500 gpm each)
  - 1,300± LF of 6" force main

- Juan Diaz Lift Station
  - Two (2) 7.5 hp pumping units (420 gpm each)
  - 50± LF of parallel 6" force mains

- Regional Lift Station
  - Four (4) 50 hp pumping units (1,850 gpm each)
  - 12,200± LF of parallel 14" and 18" force mains

All of the District's wastewater is conveyed through the Regional and Juan Diaz Lift Stations and Force Mains to the Riverside Regional Water Quality Control Plant for treatment and disposal. The Riverside Regional Water Quality Control Plant is owned and operated by the City of Riverside. Currently, through several agreements with the City of Riverside, the District has acquired 3.055 MGD (average daily flow) of capacity rights in the Riverside Regional Water Quality Control Plant for wastewater treatment and disposal.

The existing wastewater facilities are shown on **Plate 1**.

D. PLAN PREPARATION

Preparation of the Master Plan involved the following tasks:

- Conferences with District staff
- Review of District data and records
- Review of District's GIS database for preparation of wastewater system model
- Gathering and review of available population data including projections
- Gathering and review of existing and proposed land use data
- Determination of future wastewater requirements
- Evaluation of existing wastewater system facilities
- Determination of required wastewater system improvements (including wastewater system modeling)
- Development of estimated improvement capital costs
- Establishment of improvement construction schedule
- Summarization of findings

E. ABBREVIATIONS AND DEFINITIONS

The following abbreviations and definitions are used in this report:

ABBREVIATIONS

DDW	State Water Resources Control Board Division of Drinking Water
gpcd	Gallons per Capita per Day
gpm	Gallons per Minute
hp	Horsepower
JCSD	Jurupa Community Services District
LF	Linear Feet
MGD	Million Gallons per Day
RWQCB	Regional Water Quality Control Board(s) (California)
SCAG	Southern California Association of Governments
SWRCB	State Water Resources Control Board (California)
TDS	Total Dissolved Solids
USEPA	United States Environmental Protection Agency
USGS	United States Geological Survey
VCP	Vitrified Clay Pipe

DEFINITIONS

District	Rubidoux Community Services District (RCSD)
Infiltration	Groundwater entering the collection system through faulty joints, damaged pipe, or manholes
Inflow	Discharges of storm drainage from roofs, foundations, and paved areas to the wastewater collection system
Project Cost	The value in 2015 dollars for facilities including construction cost, 20% allowance for construction contingencies, and 15% allowance for administration, legal, and engineering costs
Service Area	The domestic wastewater system service area, shown by **Figure I-1**
Unit Wastewater Flow	Wastewater flow per active service connection

LEGEND

- EXISTING RCSD BOUNDARY
- ULTIMATE SERVICE AREA BOUNDARY

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

KRIEGER & STEWART INCORPORATED
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RUBIDOUX COMMUNITY SERVICES DISTRICT

WASTEWATER FACILITIES MASTER PLAN

EXISTING AND ULTIMATE SERVICE AREA BOUNDARIES

FIGURE I-1

SCALE: 1"=1000' DATE: 04/24/15 DRAWN BY: JGS CHECKED BY: MEM W.O.: 587-44

DWG. NO.: 587-4411 FILE NO.: 587-44 UPDATE BY: SPK PROJ. ENG.: MEM PLOT DATE: 04/24/15 PLOT TIME: 10:33AM PLOT SCALE: 1=1

CHAPTER II

PROJECTED POPULATION AND WASTEWATER FLOWS

CHAPTER II
PROJECTED POPULATION AND WASTEWATER FLOWS

A. POPULATION PROJECTIONS

Historic population and population projections within the District's service area are set forth in **Table II-1**.

TABLE II-1
HISTORIC AND PROJECTED SERVICE AREA POPULATION

Year	Historic and Projected Population	Population Projections from 1997 Master Plan
1970	10,900	
1980	14,900	
1990	21,000	
2000	23,200	26,700
2005	25,900	28,500
2010	26,200	30,300
2015	***32,900***	32,200
2020	***36,400***	34,100
2025	***39,500***	36,700 (1)
2030	***42,200***	
2035	***45,200***	

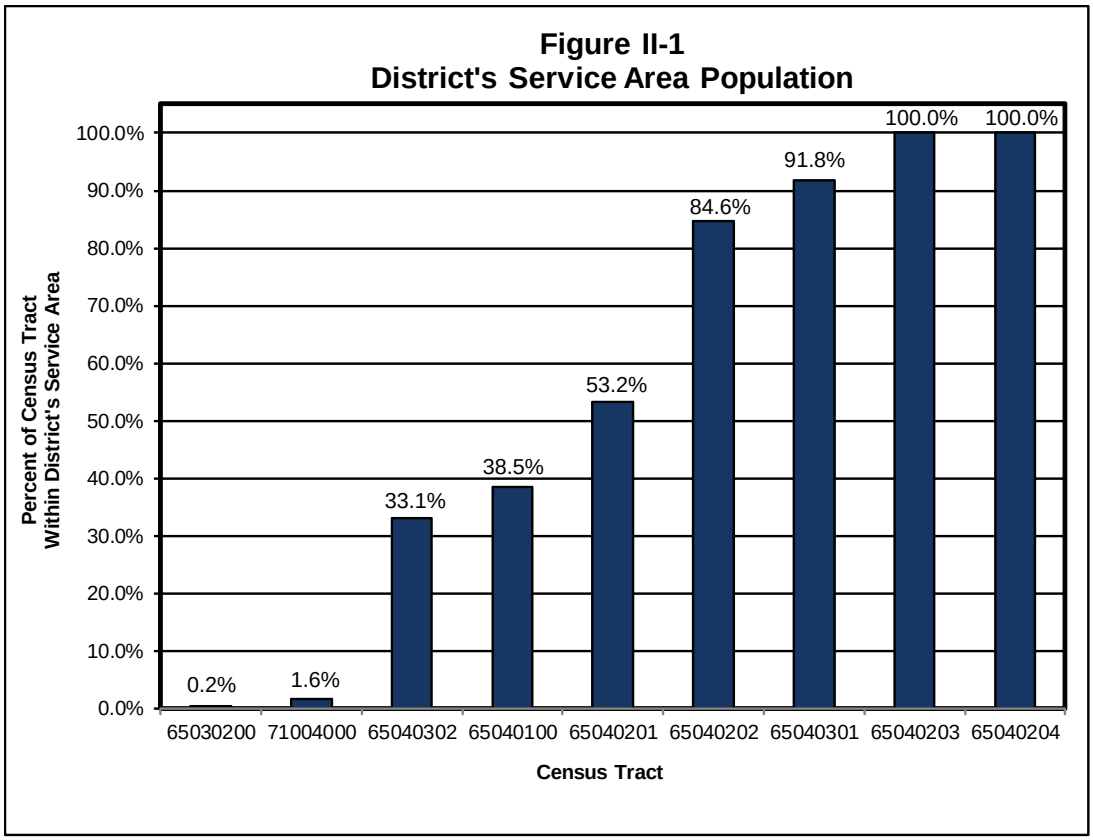
(1) Population Projection for 2026.

The service area population is projected to increase from approximately 26,200 in 2010 to approximately 45,200 by 2035. Population figures as set forth in **Table II-1** are based on the following:

1. The 1970 and 1980 population figures are based on data from the 1997 Master Plan.

2. The 1990 population figure is based on data from the Southern California Association of Governments (SCAG) assuming the District's service area population equals 100% of Census Tract 402, 60% of Census Tract 403, and 20% of Census Tract 401 (the same assumptions were used in the 1997 Master Plan).

3. The 2000 through 2035 population figures are based on SCAG's population data (obtained September 2011), assuming the District's service area population is composed of the following census tract portions, as shown on **Figure II-1**:



As shown in **Table II-1**, there is a large population increase between 2010 and 2015 (26,200 to 32,900). The SCAG population projections for 2015 through 2035 were based on a 2010 population of approximately 30,000. Recently, SCAG reduced the 2010 population to 26,200 based on 2010 census data. As of the date of this plan, SCAG has not yet made the corresponding adjustments to the population projections for 2015 to 2035 based on the 2010 census data. The information set forth in **Table II-1** is based on SCAG's latest population projections.

B. WASTEWATER FLOWS

Historic and projected wastewater flows are set forth in **Table II-2**.

TABLE II-2
HISTORIC AND PROJECTED WASTEWATER FLOWS

Year	Historic and Projected Wastewater Flows (MGD)	Projected Wastewater Flows from 1997 Master Plan (MGD)
1970		
1980	2.1	
1990		
1995	2.7	
2000	2.0	2.3
2005	2.1	2.7
2010	2.0	3.1
2015	2.4	3.4
2020	2.8	3.8
2025	3.2	4.3 (1)
2030	3.6	
2035	4.0	

(1) Wastewater Flow Projection for 2026 (ultimate conditions).

The wastewater flow is projected to increase from 2.0 MGD in 2010 to approximately 4.0 MGD in 2035. Historic and projected wastewater flows are based on the following:

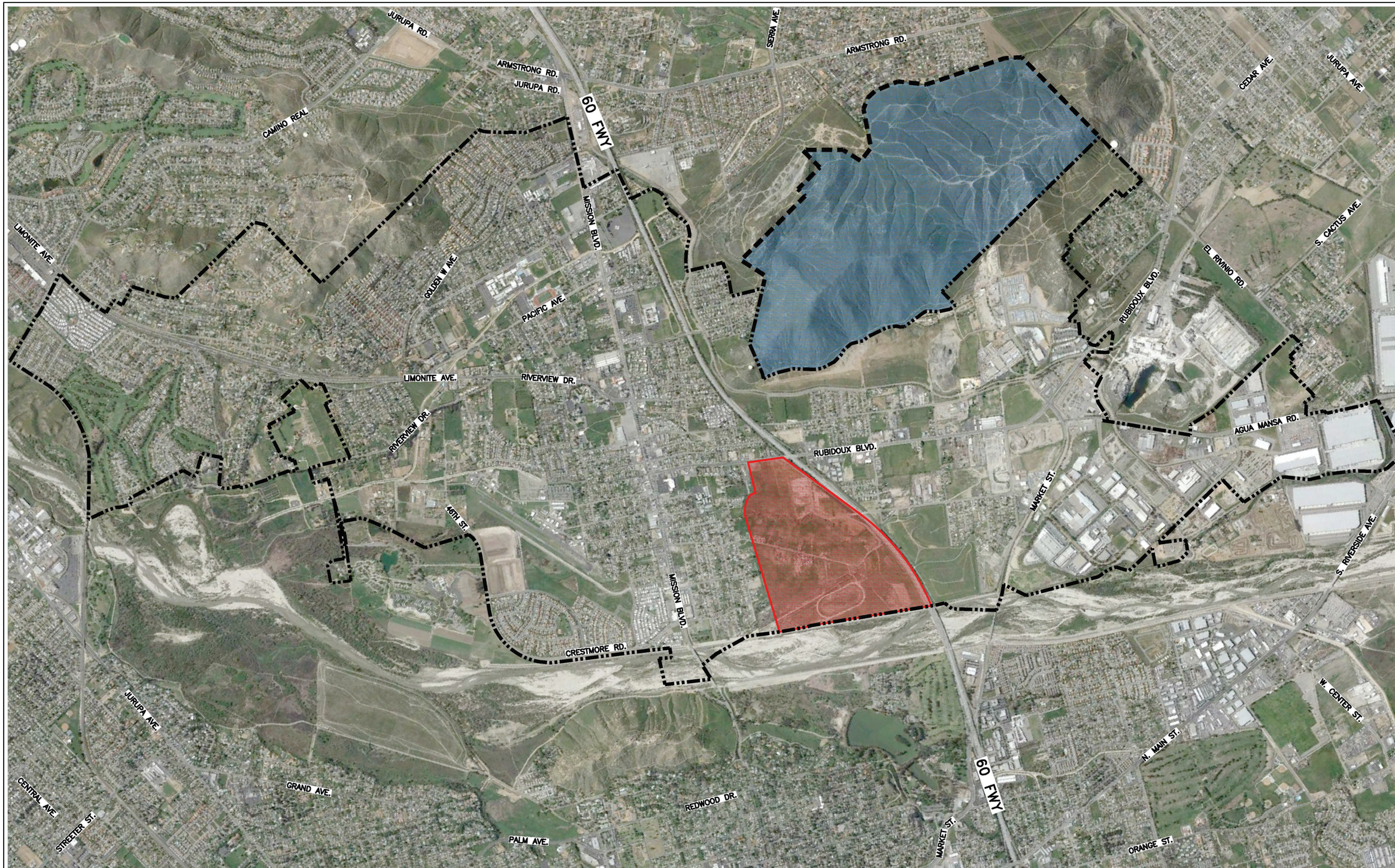
1. The 1980 and 1995 historic wastewater flows are based on data from the 1997 Master Plan.

2. The 2000, 2005, and 2010 historic wastewater flows are based on District records.

3. The 2035 projected wastewater flow (4.0 MGD) is based on the data presented in **Appendix A** (Service Area Wastewater Flows), assuming ultimate development within the service area occurs by 2035.

4. The wastewater flows for 2015, 2020, 2025, and 2030 are based on equal, incremental wastewater flow increases for each of the 5-year increments between 2010 and 2035.

Of the 2.0 MGD projected increase in wastewater flow between 2010 and 2035, approximately 0.85 MGD (43%) is attributable to two major developments, Emerald Meadows (0.35 MGD) and Rio Vista (0.50 MGD), as shown on **Figure II-2**.



LEGEND

EXISTING RCSD BOUNDARY	DEVELOPMENT	APPROXIMATE WASTEWATER FLOW
ULTIMATE SERVICE AREA BOUNDARY	EMERALD MEADOWS	0.35 MGD
	RIO VISTA	0.50 MGD

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RUBIDOUX COMMUNITY SERVICES DISTRICT

WASTEWATER FACILITIES MASTER PLAN

MAJOR FUTURE DEVELOPMENTS

FIGURE II-2

SCALE: 1"=1000' DATE: 04/24/15 DRAWN BY: JGS CHECKED BY: MEM W.O.: 587-44

DWG. NO.: 587-4413 FILE NO.: 587-44 UPDATE BY: MRN PROJ. ENG.: MEM PLOT DATE: 08/06/15 PLOT TIME: 11:35AM PLOT SCALE: 1=1

CHAPTER III

RECOMMENDED WASTEWATER SYSTEM IMPROVEMENTS

CHAPTER III
RECOMMENDED WASTEWATER SYSTEM IMPROVEMENTS

Portions of the District's wastewater collection system are currently operating at or near capacity. The system was analyzed to determine existing and ultimate flows within the collection system, to identify existing and ultimate collection system deficiencies, and to recommend needed collection system improvements, including additions, reinforcements, and replacements.

A. WASTEWATER CONVEYANCE SYSTEM CAPACITY

1. Design Criteria

The District's Sewer Design Criteria are set forth in the District's Water and Sanitary Sewer Design & Construction Manual. Said design criteria were utilized to determine capacity of existing wastewater conveyance facilities for both existing and ultimate wastewater flows and are summarized as follows:

- The minimum sewer diameter (D) will be 8".
- The coefficient of roughness (n) for gravity sewers will be 0.013.
- Peak flow (Q_{Peak}) will be computed from the average daily flow and the following equation (both Q_{Peak} and Q_{Avg} are expressed in MGD):

  $$Q_{Peak} = 2.3\,(Q_{Avg})^{0.89}$$

- Capacity of sewers will be determined by the "Manning" formula:

  $$Q = A\,\frac{1.486}{n}\,r^{2/3}\,s^{1/2}$$

  (where A = cross-sectional area of sewer in ft^2, r = hydraulic radius in ft, n = coefficient of roughness, and s = sewer slope)

- The ratio of the depth of flow to the sewer diameter (d/D) at peak flow will not exceed 0.50 for sewer diameters 10" and smaller, and 0.75 for sewer diameters 12" and larger.
- Gravity sewers will be designed for a minimum velocity of 2 fps and a maximum velocity of 10 fps at peak flow.

2. Capacity

Groundwater infiltration and wet weather inflow into the existing wastewater collection system were investigated and evaluated in the 1997 Master Plan and determined at the time, to be insignificant. For the purposes of this Master Plan, it is assumed that they remain insignificant.

As set forth in **Appendix A**, the distribution of wastewater flows was determined by dividing the District's service area into 106 planning areas based on current City of Jurupa Valley Zoning Maps. The number of existing residential dwelling units and the acreage of existing non-residential development were identified for each planning area by aerial photographs. Wastewater unit flows (based on District's records and the 1997 Master Plan) were applied to existing development densities to estimate the existing wastewater flow for each planning area.

Future wastewater flows within each of the 106 planning areas were projected based on ultimate development. The type and maximum permissible densities for future development were based on the current City of Jurupa Zoning Maps.

To determine the capacity of existing wastewater conveyance facilities, nodes were assigned to all major junctions and the planning areas tributary to each node were determined. Thereafter, using the existing and future wastewater flows for each planning area as set forth in **Appendix A**, the existing and ultimate average daily flow and peak flow at each node were determined.

Capacities of existing sewers for both existing and ultimate peak wastewater flows were determined by utilizing an H_2OMAP Sewer Model developed for this Master Plan. Data for the model was entered using GIS data provided by the District. The model calculated the sewer slope based on manhole invert elevations and length of sewer between manholes.

For all deficient sewers, the sewer slope as calculated by the model was checked against the sewer slope shown on the District's sewer atlas sheets. In the case of a significant discrepancy, the slope as shown on the sewer atlas sheets was used to determine if a sewer was deficient. A sewer was considered deficient if the ratio of the depth of flow to the sewer diameter (d/D ratio) at peak flow exceeded 0.50 for sewers 10" and smaller, and 0.75 for sewers 12" and larger.

A tabulation of existing and ultimate wastewater flows for each reach of the modeled sewers is set forth in **Appendix B**. **Figures B-1 and B-2 in Appendix B** show all modeled sewers, which sewers are deficient for ultimate peak wastewater flows, and recommended improvements for the deficient sewers. **Figures B-1 and B-2** also show existing average daily flow, existing peak flow, ultimate average daily flow, and ultimate peak flow for major junctions of the District's wastewater conveyance system.

B. CONVEYANCE SYSTEM DEFICIENCIES AND RECOMMENDED CAPITAL IMPROVEMENTS

The wastewater system deficiencies and recommended corrective facilities described below are based on the data presented in **Appendix B**. Proposed wastewater system facilities are shown on **Plate 2**.

1. Existing Wastewater Flows

For existing wastewater flows, the following reaches of the District's wastewater conveyance facilities are deficient:

- Agua Mansa Road

  A short segment of the existing 8" sewer between Wilson Street and Brown Avenue has a d/D ratio of between 0.52 and 0.62 for existing peak wastewater flows.

Since the d/D of 0.62 represents a depth of flow of approximately only 1" in excess of the District's design criteria, it would not be practical to replace the sewer in this reach to accommodate existing peak wastewater flows.

- Pontiac Avenue

One segment of the existing 8" sewer in Pontiac Avenue just northerly of Mission Boulevard has a d/D ratio of 0.58 for existing peak wastewater flows.

Since the d/D of 0.58 represents a depth of flow of approximately only 1" in excess of the District's design criteria, it would not be practical to replace this sewer to accommodate existing peak wastewater flows.

- Project 1 - Rustic Lane, Pacific Avenue, and 42nd Street

An extensive length of the existing 8" and 10" sewers (6,900± LF) in Rustic Lane, Pacific Avenue, and 42nd Street have d/D ratios that range from 0.52 to 1.00 for existing peak wastewater flows.

The existing 8" and 10" sewers should be replaced with a 12" sewer (6,900± LF) to accommodate existing peak wastewater flows and ultimate peak wastewater flows. Said work will include replacement of 21 sewer manholes and connections to approximately 135± sewer laterals.

- Project 2 - Limonite Avenue and Plaza Lane

A short section of the existing 8" sewer (330± LF) in Limonite Avenue and Plaza Lane has a d/D ratio that ranges from 0.73 to 1.0 for existing peak wastewater flows.

The existing 8" sewer should be replaced with a 12" sewer to accommodate existing peak wastewater flows and ultimate peak wastewater flows. Said work will include connections to approximately four sewer laterals.

2. Ultimate Wastewater Flows

For ultimate wastewater flows, the following reaches of the District's wastewater conveyance facilities are deficient:

- Limonite Avenue and Plaza Lane

  In addition to the short segment of 8" sewer to be replaced to accommodate existing peak wastewater flows, three additional segments of 8" sewer have d/D ratios that vary from 0.51 to 0.55 for ultimate peak wastewater flows.

  Since these d/D ratios represent a depth of flow of approximately only 0.40" in excess of the District's design criteria, it would not be practical to replace these segments of existing sewers to accommodate the ultimate peak wastewater flow.

- Project 3 - Agua Mansa Road

  The existing 8" and 10" sewers in Agua Mansa Road between Hall Avenue and Wilson Street have d/D ratios that vary from 0.52 to 1.0 for ultimate peak wastewater flows.

  Approximately 1,800 LF of the existing 8" sewer and approximately 1,100 LF of the existing 10" sewer should be replaced with a 12" sewer (2,900± LF) to accommodate ultimate peak wastewater flows (it would not be practical to replace those sections of the existing 8" sewer with a d/D ratio of only 0.52). Said work will include replacement of 11 sewer manholes and connections to approximately eight sewer laterals.

  A new 8" or 10" sewer constructed parallel to the existing 8" and 10" sewers would not have sufficient capacity to accommodate ultimate peak wastewater flows.

- Project 4 - 20th Street

  Two segments of the existing 10" sewer in 20th Street westerly of Rubidoux Boulevard have d/D ratios that vary from 0.53 to 0.64 for ultimate peak wastewater flows. Two segments of the existing 12" sewer in 20th Street westerly of Rubidoux Boulevard have d/D ratios of 0.77 for ultimate peak wastewater flows.

  Approximately 240 LF of the existing 10" sewer should be replaced with a 12" sewer to accommodate ultimate peak wastewater flows (it would not be practical to replace the existing 10" sewer with a d/D ratio of only 0.53 and the 12" sewers with a d/D ratio of only 0.77). Said work will include connection to one sewer lateral.

- Project 5 - Rubidoux Boulevard/24th Street

  The existing 12" and 15" sewers in Rubidoux Boulevard between 20th Street and 24th Street and the existing 10" and 12" sewers in 24th Street between Rubidoux Boulevard and Hall Avenue have d/D ratios of 1.0 for ultimate peak wastewater flows.

  In Rubidoux Boulevard between 20th Street and 24th Street, approximately 1,300 L.F. of the existing 12" and 15" sewers should be replaced with a 15" sewer to accommodate ultimate peak wastewater flows. The existing 15" sewer just southerly of 20th Street should be replaced with a new 15" sewer at a steeper slope. Said work will include replacement of three sewer manholes and connections to approximately two sewer laterals.

  In 24th Street between Rubidoux Boulevard and Hall Avenue, approximately 1,430 L.F. of the existing 10" and 12" sewers should be replaced with a 15" sewer to accommodate ultimate peak wastewater flows. Said work will include replacement of four sewer manholes and connections to approximately six sewer laterals.

As an alternative, if the existing 10", 12", and 15" sewers remain in service and sufficient space is available, a parallel 12" sewer in conjunction with the existing 10", 12", and 15" sewers could accommodate ultimate peak wastewater flows. However, for the purposes of this Master Plan, it is assumed the existing sewers will be removed and the new 15" sewer will be constructed in the same location.

- Project 6 - Hall Avenue

The existing 15" sewer in Hall Avenue between 24th Street and the 60 Freeway has a d/D ratio of 1.0 for ultimate peak wastewater flows.

Approximately 3,300 LF of the existing 15" sewer should be replaced with an 18" sewer to accommodate ultimate peak wastewater flows. Said work will include replacement of ten sewer manholes and connections to approximately 41 sewer laterals.

As an alternative, if the existing 15" sewer remains in service and sufficient space is available, a parallel 12" sewer in conjunction with the existing 15" sewer could accommodate ultimate peak wastewater flows. However, for the purposes of this Master Plan, it is assumed the existing 15" sewer will be removed and the new 18" sewer will be constructed in the same location.

- Project 7 - Wallace Street

The existing 18" sewer in Wallace Street between 34th Street and the 60 Freeway has d/D ratios that vary from 0.69 to 1.0 for ultimate peak wastewater flows; assuming one half of the wastewater flow from the Emerald Meadows development is discharged into Manhole G7118 and the other one half of the Emerald Meadows wastewater flow is discharged into Manhole H7104 as shown on **Figure B-1**.

Approximately 800 LF of the existing 18" sewer should be replaced with a 21" sewer to accommodate ultimate peak wastewater flows (it would not be practical to replace the existing 18" sewer with a d/D ratio of only 0.76 to 0.80). Said work will include replacement of one sewer manhole and connections to approximately nine sewer laterals. The precise length of existing sewer to be replaced will depend on the actual location of the discharge point(s) of the wastewater flow from the Emerald Meadows Development.

As an alternative, if the existing 18" sewer remains in service and sufficient space is available, a parallel 10" sewer in conjunction with the existing 18" sewer could accommodate ultimate peak wastewater flows. However, for the purposes of this Master Plan, it is assumed the existing 18" sewer will be removed and the new 21" sewer will be constructed in the same location.

- Project 8 - Pontiac Avenue (Northerly of the 60 Freeway and Mission Boulevard to 34th Street)

  The existing 8" sewer in Pontiac Avenue northerly of the 60 Freeway has a d/D of 1.0 for ultimate peak wastewater flows.

  The existing 8" sewer in Pontiac Avenue between Mission Boulevard and 34th Street has a d/D ratio that varies from 0.39 to 1.0 for ultimate peak wastewater flows.

  Approximately 600 LF of the existing 8" sewer in Pontiac Avenue northerly of the 60 Freeway should be replaced with a 12" sewer to accommodate ultimate peak wastewater flows. Approximately 1,400 LF of the existing 8" sewer in Pontiac Avenue between Mission Boulevard and 34th Street should be replaced with a 10" sewer to accommodate ultimate peak wastewater flows. Said work will include replacement of four sewer manholes and connections to approximately 34 sewer laterals.

- Project 9 - 42nd Street (Fort Drive to Rubidoux Boulevard)

  The existing 21" sewer in 42nd Street between Fort Drive and Rubidoux Boulevard has a d/D ratio of 1.0 for ultimate peak wastewater flows.

  Approximately 500 LF of the existing 21" sewer should be replaced with a 24" sewer to accommodate ultimate peak wastewater flows. Said work will include replacement of five sewer manholes and connections to approximately two sewer laterals.

  As an alternative, if the existing 21" sewer remains in service and sufficient space is available, a parallel 10" sewer in conjunction with the existing 21" sewer could accommodate ultimate peak wastewater flows. However, for purposes of this Master Plan, it is assumed the existing 21" sewer will be removed and the new 24" sewer will be constructed in the same location.

- Project 10 - Rubidoux Boulevard/Riverside County Flood Control and Water Conservation District (RCFC&WCD) Right-of-Way (42nd Street to 46th Street)

  The existing 21" and 24" sewers in Rubidoux Boulevard and the RCFC&WCD right-of-way have d/D ratios of 1.0 for ultimate peak wastewater flows. Approximately 700 LF of the existing 21" sewer should be replaced with a 24" sewer to accommodate ultimate peak wastewater flows. Said work will include replacement of four sewer manholes.

  As an alternative, if the existing 21" sewer remains in service and sufficient space is available, a parallel 12" sewer in conjunction with the existing 21" sewer could accommodate ultimate peak wastewater flows. However, for purposes of this Master Plan, it is assumed the existing 21" sewer will be removed and the new 24" sewer will be constructed in the same location.

Approximately 2,300 LF of the existing 24" sewer should be replaced with a 27" sewer to accommodate ultimate peak wastewater flows. Said work will include replacement of nine sewer manholes and connections to approximately three sewer laterals.

As an alternative, if the 24" sewer remains in service and sufficient space is available, a parallel 15" sewer in conjunction with the existing 24" sewer could accommodate ultimate peak wastewater flows. However, for purposes of this Mater Plan, it is assumed the existing 24" sewer will be removed and the new 27" sewer will be constructed in the same location.

C. LIFT STATIONS

As set forth in Chapter I, the District has six (6) wastewater lift stations, with the Juan Diaz Lift Station and the Regional Lift Station being the District's two major lift stations.

The Juan Diaz Lift Station and the Regional Lift Station capacities and estimated ultimate peak wastewater flows, are summarized as follows:

Lift Station	Pumping Units	Lift Station Capacity with One Pumping Unit as a Standby Unit	Ultimate Peak Wastewater Flow
Juan Diaz	Two 420 gpm pumping units	420 gpm (0.61 MGD)	0.55 MGD
Regional	Four 1,850 gpm pumping units	5,500 gpm (8.0 MGD)	7.72 MGD

Both lift stations have adequate capacity to accommodate the ultimate peak wastewater flows.

D. WASTEWATER TREATMENT FACILITIES

As stated in Chapter I, all of the District's wastewater is conveyed through the Regional and Juan Diaz Lift Stations and Force Mains for treatment at the Riverside Regional Water Quality Control Plant, owned and operated by the City of Riverside. Currently, the District has 3.055 MGD (average daily flow) of capacity rights in the Riverside Regional Water Quality Control Plant for wastewater treatment and disposal.

Based on the projected wastewater flows (**Table II-2**), it is anticipated the District will require 0.50 MGD of additional wastewater treatment and disposal capacity between 2020 and 2025 and then an additional 0.445 MGD of wastewater treatment and disposal capacity between 2025 and 2030.

E. ESTIMATED PROJECT COST AND PROPOSED CONSTRUCTION SCHEDULE

Estimated project costs and related construction schedules for the proposed wastewater system improvements are set forth in **Table III-1**. The estimated project costs for facilities are based on 2015 costs (ENR CCI for Los Angeles for June 2015 is 10,981) and consists of construction costs, a 20% allowance for construction contingencies, and a 15% allowance for administrative, legal, and engineering fees. Proposed facilities are shown on **Plate 2**.

The construction cost for sewers includes installation of sewers, manholes, and connections to existing sewer laterals; wastewater bypass pumping; removal and disposal of existing sewers; crushed rock in the pipe zone; hauling and disposing of excess excavated material; and pavement removal and replacement (where applicable).

For the 0.5 MGD of additional wastewater treatment and disposal capacity, the cost will range between $2,500,000 (if the District continues purchasing capacity rights from the City) and $5,500,000 (if the District constructs a new wastewater treatment plant). For the 0.445 MGD of additional wastewater treatment and disposal capacity, the cost will range between $2,225,000 and $4,895,000.

TABLE III-1
PROPOSED PROJECTS
ESTIMATED PROJECT COSTS[1] AND SCHEDULE

	2015-2020	2020-2025 [2]	2025-2030	2030-2035	Total
Project 1 - Rustic Lane, Pacific Avenue, and 42nd Street (6,900± LF - 12")	$2,650,000				$2,650,000
Project 2 - Limonite Avenue and Plaza Lane (330± LF - 12")	$120,000				$120,000
Project 3 - Agua Mansa Road (2,900± LF - 12")		$1,090,000			$1,090,000
Project 4 - 20th Street (240± LF - 12")		$90,000			$90,000
Project 5 - Rubidoux Boulevard / 24th Street (2,730± LF - 15")		$1,140,000			$1,140,000
Project 6 - Hall Avenue (3,300± LF - 18")		$1,510,000			$1,510,000
Project 7 - Wallace Street (800± LF - 21")		$420,000			$420,000
Project 8 - Pontiac Avenue (Northerly of the 60 Freeway and Mission Boulevard to 34th Street (1,400± LF - 10" and 600± LF - 12")		$730,000			$730,000
Project 9 - 42nd Street (Fort Drive to Rubidoux Boulevard) (500± LF - 24")		$310,000			$310,000
Project 10 - Rubidoux Boulevard / Riverside County Flood Control and Water Conservation District Right-of-Way (42nd Street to 46th Street) (700± LF - 24" and 2,300± LF - 27")		1,650,000			$1,650,000
Additional Wastewater Treatment and Disposal Capacity		$5,500,000 [3]	$4,895,000 [3]		$10,395,000
Total:	**$2,770,000**	**$12,440,000**	**$4,895,000**	**$0**	**$20,105,000**

(1) The estimated project costs include construction costs, a 20% allowance for construction contingencies, and a 15% allowance for administration, legal, and engineering fees.

(2) It is unclear when the various projects will be required since the schedules are dependent on when and where future development projects are implemented. Therefore, for purposes of this Master Plan, all improvements to accommodate ultimate peak wastewater flows are shown for the 2020-2025 time period.

(3) For purposes of this Master Plan, it is assumed additional wastewater treatment and disposal capacity will be provided by construction of a new wastewater treatment plant.

APPENDIX A

SERVICE AREA WASTEWATER DEMANDS

APPENDIX A
SERVICE AREA WASTEWATER DEMANDS

A. EXISTING WASTEWATER FLOW

Based on a combination of District records and data from the 1997 Master Plan, existing wastewater unit flows were estimated to be as follows:

- Single Family Homes 220 gpd/dwelling unit
- Mobile Homes 100 gpd/dwelling unit
- Apartments 100 gpd/dwelling unit
- Schools 400 gpd/acre
- Churches 200 gpd/acre
- Commercial Developments 300 gpd/acre
- Industrial Developments 600 gpd/acre

In order to determine the distribution of existing wastewater flows, the District's service area was divided into 106 planning areas based on current City of Jurupa Valley Zoning Maps (obtained July 2011) as shown in **Figure A-1 (Figure A-1** indicates 107 planning areas; however, planning area 30 was not used).

Utilizing an aerial photograph of the District's service area, the number of existing residential dwelling units and the acreage of existing non-residential development were identified for each planning area. Applying the wastewater unit flow to the existing development, the existing wastewater flow was estimated for each planning area. As set forth in **Table A-1**, the total existing wastewater flow is 2.1 MGD (rounded), which compares closely with the District's records of 2.0 MGD for 2009 and 2010.

B. FUTURE WASTEWATER FLOW

Future wastewater flow within each of the 106 planning areas were projected based on ultimate development of all vacant property. The type and maximum permissible densities for future development were based on the current City of Jurupa Valley Zoning Maps.

Wastewater unit flows for future development were estimated to be as follows:

- Single Family Homes 250 gpd/dwelling unit
- Commercial Development 600 gpd/acre
- Industrial Development 1,200 gpd/acre

As set forth in **Table A-2**, future development will consist of approximately 5,050 additional residential dwelling units (for purposes of **Table A-2**, multi-family developments were converted to the equivalent number of single family homes), approximately 160 acres of additional commercial development, and approximately 320 acres of additional industrial development, resulting in an increase of wastewater flow of approximately 2.0 MGD.

C. SUMMARY

Based on data set forth in **Tables A-1 and A-2**, the number of residential dwelling units, the acreage of commercial development, the acreage of industrial development, and the average wastewater flow for both existing and ultimate conditions are summarized as follows:

	Existing Conditions	Incremental Increase	Total for Ultimate Conditions
Residential Dwelling Units (Rounded) (1)	7,800	5,050	12,850
Commercial Development (Rounded)	430 Acres (2)	160 Acres	590 Acres
Industrial Development (Rounded)	690 Acres	320 Acres	1,010 Acres
Average Daily Flow (Rounded)	2.0 MGD (3)	2.0 MGD	4.0 MGD

(1) Single Family Homes, Mobile Homes, and Apartments
(2) Includes Schools and Churches
(3) Based on District Records

APPENDIX A
TABLE A-1
EXISTING WASTEWATER FLOWS

AREA NO.	ZONING DESIGNATION	SINGLE FAMILY HOMES		MOBILE HOMES		APARTMENT UNITS		SCHOOLS		CHURCHES		COMMERCIAL DEVELOPMENT		INDUSTRIAL DEVELOPMENT		TOTAL FLOW
		DWELLING UNITS	FLOW (1) GPD	DWELLING UNITS	FLOW (2) GPD	DWELLING UNITS	FLOW (3) GPD	ACRES	FLOW (4) GPD	ACRES	FLOW (5) GPD	ACRES	FLOW (6) GPD	ACRES	FLOW (7) GPD	GPD
1	R-4	190	41,800													41,800
2	C-1/C-P											1.30	390			390
3	R-T			324	32,400											32,400
4	R-2A	76	16,720													16,720
5	R-1	6	1,320													1,320
6	R-1-80	315	69,300			4	400									69,700
7	R-5	Golf Course														0
8	R-2A	41	9,020													9,020
9	R-1-100	58	12,760													12,760
10	R-2A	88	19,360													19,360
11	R-1-100	176	38,720													38,720
12	R-1-20000	74	16,280													16,280
13	R-1-18000	2	440													440
14	R-2	23	5,060													5,060
15	R-2A	48	10,560													10,560
16	R-3	7	1,540													1,540
17	R-A	109	23,980													23,980
18	R-1-80	163	35,860													35,860
19	R-1-100															0
20	R-1-80	113	24,860													24,860
21	R-3	27	5,940			74	7,400	8.92	3,568	0.95	190					17,098
22	C-P-S											3.27	981			981
23	R-1-20															0
24	R-1	1,335	293,700					48.76	19,504							313,204
25	R-4	442	97,240									25.85	7,755			104,995
26	C-1/C-P			223	22,300											22,300
27	R-VC EAST	2	440									14.79	4,437			4,877
28	R-VC CENTER	76	16,720									30.96	9,288			26,008
29	R-VC WEST	2	440	47	4,700							21.97	6,591			11,731
30	Not Used															Not Used
31	C-1/C-P	44	9,680	212	21,200	51	5,100					88.99	26,697			62,677
32	A-1	38	8,360													8,360
33	M-SC,M-H											98.04	29,412			29,412
34	R-A	28	6,160													6,160
35	R-1	97	21,340													21,340
36	R-5															0
37	R-3															0
38	R-T															0
39	N-A															0
40	R-6	104	22,880													22,880
41	R-1	11	2,420													2,420

APPENDIX A TABLE A-1 EXISTING WASTEWATER FLOWS																
		SINGLE FAMILY HOMES		MOBILE HOMES		APARTMENT UNITS		SCHOOLS		CHURCHES		COMMERCIAL DEVELOPMENT		INDUSTRIAL DEVELOPMENT		
AREA NO.	ZONING DESIGNATION	DWELLING UNITS	FLOW (1) GPD	DWELLING UNITS	FLOW (2) GPD	DWELLING UNITS	FLOW (3) GPD	ACRES	FLOW (4) GPD	ACRES	FLOW (5) GPD	ACRES	FLOW (6) GPD	ACRES	FLOW (7) GPD	TOTAL FLOW GPD
42	R-3	125	27,500			28	2,800	14.58	5,832							36,132
43	R-1	90	19,800													19,800
44	R-2	222	48,840							0.61	122					48,962
45	R-3	37	8,140			176	17,600									25,740
46	R-3,2500,4000					48	4,800									4,800
47	R-1	36	7,920													7,920
48	M-SC													7.39	4,434	4,434
49	R-3	62	13,640	72	7,200	7	700	10.07	4,028	2.05	410					25,978
50	R-2	1	220			10	1,000									1,220
51	R-3	34	7,480													7,480
52	R-3	2	440	46	4,600	24	2,400			3.04	608					8,048
53	R-2	13	2,860													2,860
54	R-1	25	5,500			49	4,900									10,400
55	C-P-S,R-3											9.18	2,754			2,754
56	R-1	249	54,780	109	10,900											65,680
57	R-6					200	20,000									20,000
58	R-6					66	6,600									6,600
59	R-3	14	3,080	53	5,300	172	17,200					2.89	867			26,447
60	R-2	62	13,640			6	600									14,240
61	R-3	8	1,760													1,760
62	R-2	81	17,820	15	1,500	3	300	10.47	4,188	1.24	248					24,056
63	R-1	232	51,040													51,040
64	R-2	19	4,180													4,180
65	A-1	24	5,280	1	100											5,380
66	R-1	36	7,920							1.87	374					8,294
67	M-SC															0
68	R-1	199	43,780													43,780
69	A-1															0
70	M-SC															0
71	A-1															0
72	R-1	157	34,540													34,540
73	R-6	31	6,820													6,820
74	R-3															0
75	C-1/C-P											18.36	5,508			5,508
76	R-1	37	8,140													8,140
77	R-3		0													0
78	A-1	9	1,980									0.18	54			2,034
79	N-A	2	440	1	100							9.60	2,880	10.34	6,204	9,624
80	R-2	120	26,400	3	300					0.90	180					26,880
81	SP	45	9,900	23	2,300	36	3,600									15,800
82	M-M													128.43	77,058	77,058

APPENDIX A
TABLE A-1
EXISTING WASTEWATER FLOWS

AREA NO.	ZONING DESIGNATION	SINGLE FAMILY HOMES		MOBILE HOMES		APARTMENT UNITS		SCHOOLS		CHURCHES		COMMERCIAL DEVELOPMENT		INDUSTRIAL DEVELOPMENT		TOTAL FLOW
		DWELLING UNITS	FLOW [1] GPD	DWELLING UNITS	FLOW [2] GPD	DWELLING UNITS	FLOW [3] GPD	ACRES	FLOW [4] GPD	ACRES	FLOW [5] GPD	ACRES	FLOW [6] GPD	ACRES	FLOW [7] GPD	GPD
83	SP															0
84	A-1															0
85	R-5															0
86	M-SC													18.26	10,956	10,956
87	M-H															0
88	R-5															0
89	I-P															0
90	M-H													21.89	13,134	13,134
91	M-SC															0
92	R-A															0
93	M-H													20.95	12,570	112,570 [8]
94	M-H													102.40	61,440	61,440
95	M-H													52.51	31,506	31,506
96	M-H													42.46	25,476	25,476
97	M-H													36.57	21,942	21,942
98	M-SC															0
99	M-SC													4.46	2,676	2,676
100	M-SC													20.62	12,372	12,372
101	M-SC	13	2,860											38.05	22,830	25,690
102	M-SC	20	4,400											22.44	13,464	17,864
103	M-SC	12	2,640											12.54	7,524	10,164
104	M-SC	8	1,760											10.52	6,312	8,072
105	M-SC													15.66	9,396	9,396
106	A-1-5															0
107	M-H													122.85	73,710	73,710
TOTAL		**5,720**	**1,258,400**	**1,129**	**112,900**	**954**	**95,400**	**92.80**	**37,120**	**10.66**	**2,132**	**325.38**	**97,614**	**688.34**	**413,004**	**2,116,570**

(1) Average daily flow for single family homes is based on 220 gpd per dwelling unit.
(2) Average daily flow for mobile homes is based on 100 gpd per dwelling unit.
(3) Average daily flow for apartment units is based on 100 gpd per dwelling unit.
(4) Average daily flow for schools is based on 400 gpd per acre.
(5) Average daily flow for churches is based on 200 gpd per acre.
(6) Average daily flow for commercial development is based on 300 gpd per acre.
(7) Average daily flow for industrial development is based on 600 gpd per acre.
(8) Includes 100,000 gpd for Aramark Uniform Services facility.

APPENDIX A
TABLE A-2
FUTURE WASTEWATER FLOWS

AREA NO.	ZONING DESIGNATION	SINGLE FAMILY HOMES		MOBILE HOMES		APARTMENT UNITS		SCHOOLS		CHURCHES		COMMERCIAL DEVELOPMENT		INDUSTRIAL DEVELOPMENT		TOTAL FLOW
		DWELLING UNITS	FLOW [1] GPD	DWELLING UNITS	FLOW [2] GPD	DWELLING UNITS	FLOW [2] GPD	ACRES	FLOW GPD	ACRES	FLOW GPD	ACRES	FLOW [3] GPD	ACRES	FLOW [4] GPD	GPD
1	R-4															0
2	C-1/C-P															0
3	R-T															0
4	R-2A															0
5	R-1															0
6	R-1-80	4	1,000													1,000
7	R-5	275 [5]	68,750													68,750
8	R-2A	14	3,500													3,500
9	R-1-100	26	6,500													6,500
10	R-2A															0
11	R-1-100	36	9,000													9,000
12	R-1-20000	1	250													250
13	R-1-18000															0
14	R-2															0
15	R-2A															0
16	R-3															0
17	R-A	16	4,000													4,000
18	R-1-80	64	16,000													16,000
19	R-1-100															0
20	R-1-80															0
21	R-3	63	15,750													15,750
22	C-P-S															0
23	R-1-20	2	500													500
24	R-1	167	41,750													41,750
25	R-4	235 [6]	58,750													58,750
26	C-1/C-P											0.67	402			402
27	R-VC EAST											12.71	7,626			7,626
28	R-VC CENTER											5.17	3,102			3,102
29	R-VC WEST											24.40 [7]	14,640			14,640
30	Not Used															0
31	C-1/C-P											22.66	13,596			13,596
32	A-1	216 [8]	54,000													54,000
33	M-SC,M-H											8.39	5,034			5,034
34	R-A															0
35	R-1															0
36	R-5															0
37	R-3	9	2,250													2,250
38	R-T	18	4,500													4,500
39	N-A															0
40	R-6															0
41	R-1															0
42	R-3															0
43	R-1	1	250													250

APPENDIX A
TABLE A-2
FUTURE WASTEWATER FLOWS

AREA NO.	ZONING DESIGNATION	SINGLE FAMILY HOMES		MOBILE HOMES		APARTMENT UNITS		SCHOOLS		CHURCHES		COMMERCIAL DEVELOPMENT		INDUSTRIAL DEVELOPMENT		TOTAL FLOW
		DWELLING UNITS	FLOW [1] GPD	DWELLING UNITS	FLOW [2] GPD	DWELLING UNITS	FLOW [2] GPD	ACRES	FLOW GPD	ACRES	FLOW GPD	ACRES	FLOW [3] GPD	ACRES	FLOW [4] GPD	GPD
44	R-2	6	1,500													1,500
45	R-3	14	3,500													3,500
46	R-3,2500,4000	30	7,500													7,500
47	R-1															0
48	M-SC															0
49	R-3	7	1,750													1,750
50	R-2	23	5,750													5,750
51	R-3															0
52	R-3															0
53	R-2	1	250													250
54	R-1	1	250													250
55	C-P-S,R-3															0
56	R-1	1	250													250
57	R-6															0
58	R-6															0
59	R-3	4	1,000													1,000
60	R-2	11	2,750													2,750
61	R-3	2	500													500
62	R-2	1	250													250
63	R-1	17	4,250													4,250
64	R-2	2	500													500
65	A-1															0
66	R-1	49	12,250													12,250
67	M-SC	41 [9]	10,250											11.12	13,344	23,594
68	R-1	57	14,250													14,250
69	A-1	22 [10]	5,500													5,500
70	M-SC													52.80 [11]	63,360	63,360
71	A-1	6	1,500													1,500
72	R-1	9	2,250													2,250
73	R-6															0
74	R-3	20	5,000													5,000
75	C-1/C-P											15.19	9,114			9,114
76	R-1															0
77	R-3	10	2,500													2,500
78	A-1	22	5,500													5,500
79	N-A											72.75	43,650			43,650
80	R-2	24	6,000													6,000
81	SP	1,400 [12]	350,000													350,000
82	M-M													78.68	94,416	94,416
83	SP	2,100 [13]	504,150													504,150
84	A-1	8	2,000													2,000
85	R-5															0

APPENDIX A
TABLE A-2
FUTURE WASTEWATER FLOWS

AREA NO.	ZONING DESIGNATION	SINGLE FAMILY HOMES		MOBILE HOMES		APARTMENT UNITS		SCHOOLS		CHURCHES		COMMERCIAL DEVELOPMENT		INDUSTRIAL DEVELOPMENT		TOTAL FLOW
		DWELLING UNITS	FLOW [1] GPD	DWELLING UNITS	FLOW [2] GPD	DWELLING UNITS	FLOW [2] GPD	ACRES	FLOW GPD	ACRES	FLOW GPD	ACRES	FLOW [3] GPD	ACRES	FLOW [4] GPD	GPD
86	M-SC													1.57	1,884	1,884
87	M-H													17.00	20,400	20,400
88	R-5															0
89	I-P													4.63	5,556	5,556
90	M-H													3.36	4,032	4,032
91	M-SC													28.29	33,948	33,948
92	R-A	2	500													500
93	M-H													11.10	13,320	268,320 [14]
94	M-H													2.18	2,616	2,616
95	M-H													7.71	9,252	9,252
96	M-H													7.45	8,940	8,940
97	M-H													8.04	9,648	9,648
98	M-SC													7.19	8,628	8,628
99	M-SC													0.90	1,080	1,080
100	M-SC													20.49	24,588	24,588
101	M-SC													15.41	18,492	18,492
102	M-SC													24.25	29,100	29,100
103	M-SC													10.46	12,552	12,552
104	M-SC													5.89	7,068	7,068
105	M-SC													3.01	3,612	3,612
106	A-1-5	13	3,250													3,250
107	M-H															0
TOTAL		**5,050**	**1,241,650**	**0**	**0**	**0**	**0**	**0.00**	**0**	**0.00**	**0**	**161.94**	**97,164**	**321.53**	**385,836**	**1,979,650**

(1) Average daily flow for single family homes is based on 250 gpd per dwelling unit.

(2) It was assumed future development will not include mobile home parks, apartments, schools, or churches except for Emerald Meadows and Rio Vista.

(3) Average daily flow for commercial development is based on 600 gpd per acre.

(4) Average daily flow for industrial development is based on 1200 gpd per acre.

(5) Future development of Jurupa Hills Country Club could consist of 500 to 550 units for senior housing. Assume 550 units equivalent to 275 single family homes.

(6) Based on 85 single family homes for Tract No. 31503 plus development of the balance of Area 25.

(7) Mission Plaza.

(8) Based on 60 condominium units for Tract No. 34795 plus development of the balance of area 32. Equivalent to approximately 216 single family homes.

(9) Tract No. 34598.

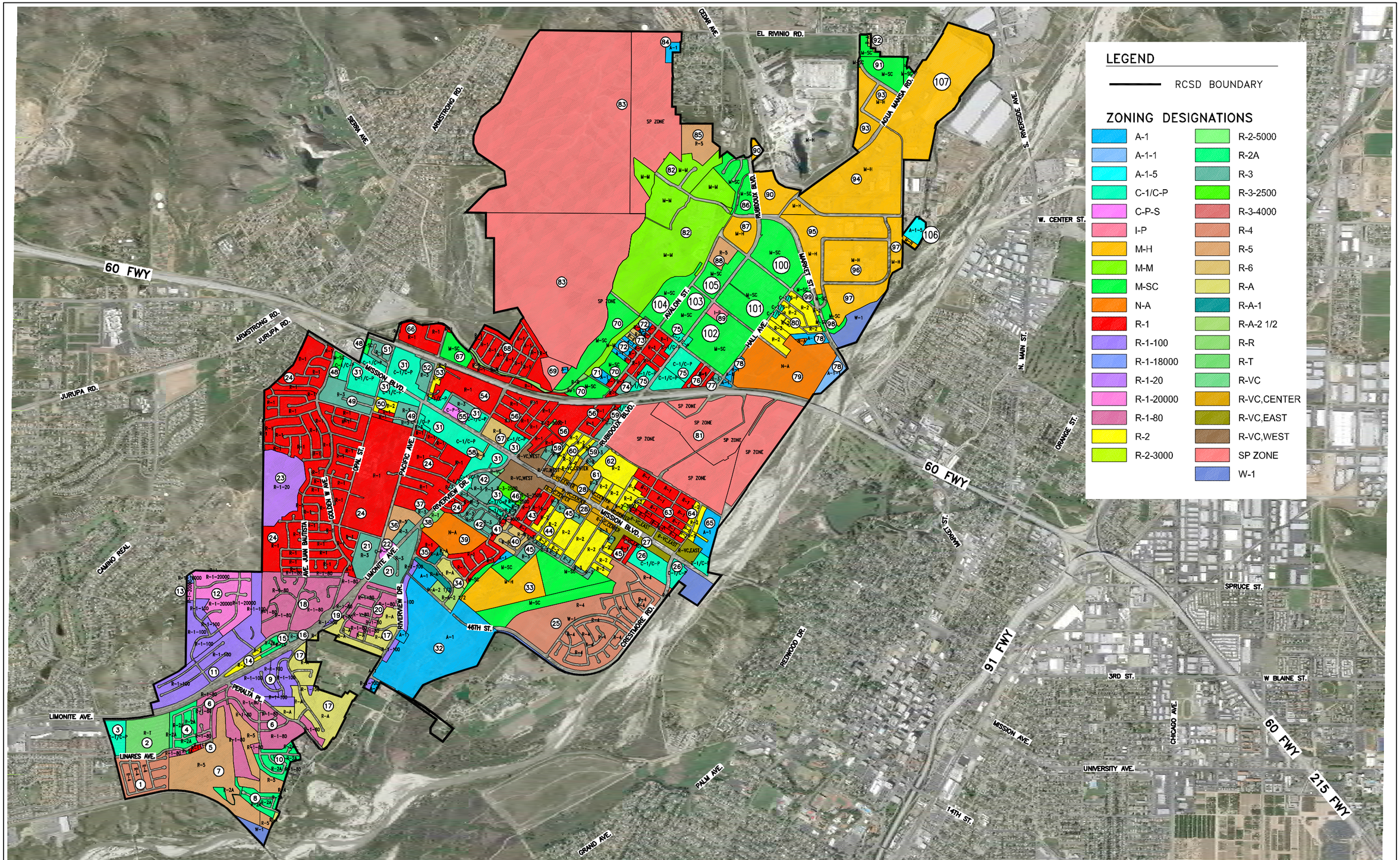
(10) Tract No. 32721.

(11) Bircher Industrial Center.

(12) Emerald Meadows
Emerald Meadows consists of 991 single family homes, 205 multiple family units, 20 acres of commercial development, 30 acres of schools and parks, and 25 acres of churches. The Emeralds Meadows development is equivalent to approximately 1,400 single family homes.

(13) Rio Vista
Rio Vista consists of 1,247 single family homes, 348 multiple family units, and approximately 80 acres of schools and parks. The Rio Vista development excludes the development in the northeasterly corner of the sub area (250 single family homes). The Rio Vista development along with the area in the northeasterly corner of the sub area is equivalent to approximately 2,100 single family homes.

(14) Includes 255,000 gpd for Aramark Uniform Services Facility.



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

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RUBIDOUX COMMUNITY SERVICES DISTRICT

WASTEWATER FACILITIES MASTER PLAN UPDATE

PLANNING AREAS

SCALE: 1"=1200' DATE: 04/24/15 DRAWN BY: JGS CHECKED BY: MEM W.O.: 587-44

FIGURE A-1

DWG. NO.: 587-44f2 FILE NO.: 587-44 UPDATE BY: SPK PROJ. ENG.: MEM PLOT DATE: 04/24/15 PLOT TIME: 10:38AM PLOT SCALE: 1=1

APPENDIX B

EXISTING AND ULTIMATE WASTEWATER FLOWS

APPENDIX B TABLE B-1 EXISTING WASTEWATER FLOWS										
SEWER REACH	FROM MANHOLE	TO MANHOLE	SEWER DIAMETER (in)	SEWER LENGTH (ft)	SEWER SLOPE	EXISTING PEAK WASTEWATER FLOW (MGD)	EXISTING AVERAGE DAILY WASTEWATER FLOW		VELOCITY (ft/s)	DEPTH OF FLOW TO SEWER DIAMETER RATIO (d/D)
							(gpm)	(MGD)		
101	MHL3131	MHL3134	12	23	0.1318	0.42	102.4	0.15	8.60	0.15
103	MHL4106	MHL4108	21	12	0.0273	3.25	1023.6	1.47	8.42	0.30
GMC71002	MHC7101	MHC7102	8	327	0.0439	0.01	2.3	0.00	2.24	0.07
GMC71003	MHC7102	MHC7103	8	376	0.0419	0.01	2.3	0.00	2.20	0.07
GMC81005	MHC8104	MHC8105	8	240	0.0078	0.37	88.9	0.13	3.12	0.52
GMC81006	MHC8105	MHC8107	8	295	0.0078	0.37	88.9	0.13	3.12	0.52
GMC91006	MHC9105	MHC9108	8	295	0.0217	0.18	39.1	0.06	3.71	0.27
GMC91010	MHC9108	MHC9110	8	338	0.0217	0.18	39.1	0.06	3.70	0.27
GMC91012	MHC9110	MHC9115	8	295	0.0217	0.18	39.1	0.06	3.71	0.27
GMC91017	MHC9115	MHC9118	8	182	0.0078	0.33	78.2	0.11	3.03	0.49
GMC91022	MHC9118	MHC9121	8	195	0.0078	0.33	78.2	0.11	3.03	0.49
GMC91023	MHC9119	MHC9120	12	45	0.0031	0.23	51.2	0.07	1.90	0.28
GMC91024	MHC9120	MHC9122	12	304	0.003	0.23	51.2	0.07	1.88	0.29
GMC91025	MHC9121	MHC8104	8	207	0.0078	0.33	78.2	0.11	3.03	0.49
GMC91026	MHC9122	MHC9123	12	338	0.003	0.23	51.2	0.07	1.88	0.29
GMD61002	MHD6101	MHD7118	12	346	0.0473	0.13	26.7	0.04	4.20	0.11
GMD71001	MHC7103	MHD7101	10	131	0.1473	0.01	2.3	0.00	3.30	0.04
GMD71003	MHD7101	MHD7106	10	250	0.0284	0.02	4.2	0.01	2.19	0.07
GMD71009	MHD7106	MHD7112	12	219	0.0032	0.02	4.2	0.01	0.99	0.10
GMD71015	MHD7112	MHD7121	12	399	0.0033	0.02	4.2	0.01	1.01	0.09
GMD71021	MHD7118	MHD7120	12	184	0.0497	0.13	26.7	0.04	4.27	0.11
GMD71023	MHD7120	MHD7123	12	148	0.0534	0.13	26.7	0.04	4.38	0.11
GMD71024	MHD7121	MHD7122	12	33	0.0009	0.03	6.1	0.01	0.71	0.15
GMD71025	MHD7122	MHD7127	10	392	0.0086	0.04	8.0	0.01	1.72	0.12
GMD71026	MHD7123	MHD7124	12	346	0.0417	0.13	26.7	0.04	4.02	0.11
GMD71027	MHD7124	MHD7125	12	181	0.035	0.13	26.7	0.04	3.78	0.12
GMD71028	MHD7125	MHD7126	12	306	0.0382	0.13	26.7	0.04	3.90	0.12
GMD71029	MHD7126	MHD7128	12	306	0.036	0.23	53.5	0.08	4.59	0.16
GMD71030	MHD7127	MHD7131	10	380	0.0086	0.05	9.9	0.01	1.82	0.14
GMD71031	MHD7128	MHD7129	12	159	0.0353	0.23	53.5	0.08	4.56	0.16
GMD71032	MHD7129	MHD7130	12	141	0.0494	0.23	53.5	0.08	5.13	0.15
GMD71033	MHD7130	MHD7131	10	114	0.0664	0.23	53.5	0.08	5.83	0.17
GMD71034	MHD7131	MHD7133	10	110	0.0446	0.27	63.4	0.09	5.29	0.20

APPENDIX B TABLE B-1 EXISTING WASTEWATER FLOWS										
SEWER REACH	FROM MANHOLE	TO MANHOLE	SEWER DIAMETER (in)	SEWER LENGTH (ft)	SEWER SLOPE	EXISTING PEAK WASTEWATER FLOW (MGD)	EXISTING AVERAGE DAILY WASTEWATER FLOW		VELOCITY (ft/s)	DEPTH OF FLOW TO SEWER DIAMETER RATIO (d/D)
							(gpm)	(MGD)		
GMD71035	MHD7136	MHD7132	12	304	0.0063	0.27	63.4	0.09	2.59	0.26
GMD71036	MHD7133	MHD7135	10	236	0.0256	0.27	63.4	0.09	4.35	0.23
GMD71037	MHD7135	MHD7136	12	428	0.0127	0.27	63.4	0.09	3.32	0.22
GMD81002	MHC8107	MHD8101	8	345	0.0045	0.37	88.9	0.13	2.53	0.62
GMD81003	MHD8101	MHD8102	8	345	0.0047	0.37	88.9	0.13	2.56	0.61
GMD81004	MHD8102	MHD8105	10	345	0.0047	0.41	99.5	0.14	2.64	0.45
GMD81007	MHD8105	MHD8106	10	345	0.0047	0.41	99.5	0.14	2.64	0.45
GMD81008	MHD8106	MHD8107	10	183	0.0047	0.41	99.5	0.14	2.64	0.45
GMD81009	MHD8107	MHD8108	10	190	0.0052	0.41	99.5	0.14	2.74	0.44
GMD81010	MHD8108	MHD8109	10	60	0.0502	0.41	99.5	0.14	6.20	0.24
GMD81011	MHD8109	MHD8118	15	320	0.0228	0.66	172.1	0.25	5.17	0.22
GMD81012	MHD8111	MHD8109	12	126	0.004	0.31	72.5	0.10	2.27	0.31
GMD81013	MHD8112	MHD8111	12	246	0.004	0.31	72.5	0.10	2.28	0.31
GMD81014	MHD8116	MHD8112	12	245	0.004	0.31	72.5	0.10	2.28	0.31
GMD81015	MHD8113	MHD8117	12	295	0.004	0.27	61.9	0.09	2.19	0.29
GMD81016	MHD8114	MHD8113	12	243	0.0075	0.27	61.9	0.09	2.74	0.25
GMD81017	MHD8115	MHD8114	12	295	0.003	0.27	61.9	0.09	1.97	0.31
GMD81018	MHD8117	MHD8116	12	345	0.004	0.31	72.5	0.10	2.28	0.31
GMD81019	MHD8118	MHD8119	15	208	0.0049	0.66	172.1	0.25	2.98	0.32
GMD81021	MHD8119	MHD8121	15	186	0.0192	0.67	174.3	0.25	4.88	0.23
GMD81023	MHD8121	MHD8122	16	320	0.0016	0.67	174.3	0.25	1.99	0.40
GMD81024	MHD8122	MHD8123	16	20	0.148	0.68	176.6	0.25	9.98	0.13
GMD81025	MHD8123	MHD8125	15	186	0.005	0.68	176.6	0.25	3.03	0.33
GMD81026	MHD7132	MHD8124	12	324	0.0064	0.28	65.7	0.09	2.62	0.26
GMD81028	MHD8124	MHD8126	15	138	0.0037	0.28	65.7	0.09	2.11	0.22
GMD81029	MHD8125	MHD8126	15	5	0.006	0.68	176.6	0.25	3.24	0.31
GMD91001	MHC9123	MHD9101	12	295	0.003	0.23	51.2	0.07	1.88	0.29
GMD91002	MHD9101	MHD9102	12	295	0.003	0.23	51.2	0.07	1.88	0.29
GMD91003	MHD9102	MHD9103	12	295	0.003	0.23	51.2	0.07	1.88	0.29
GMD91004	MHD9103	MHD9104	12	311	0.0027	0.23	51.2	0.07	1.81	0.29
GMD91005	MHD9104	MHD9105	12	345	0.0104	0.23	51.2	0.07	2.93	0.21
GMD91006	MHD9105	MHD9106	12	245	0.003	0.23	51.2	0.07	1.89	0.29
GMD91007	MHD9106	MHD9107	12	100	0.003	0.23	51.2	0.07	1.88	0.29

APPENDIX B TABLE B-1 EXISTING WASTEWATER FLOWS										
SEWER REACH	FROM MANHOLE	TO MANHOLE	SEWER DIAMETER (in)	SEWER LENGTH (ft)	SEWER SLOPE	EXISTING PEAK WASTEWATER FLOW (MGD)	EXISTING AVERAGE DAILY WASTEWATER FLOW		VELOCITY (ft/s)	DEPTH OF FLOW TO SEWER DIAMETER RATIO (d/D)
							(gpm)	(MGD)		
GMD91008	MHD9107	MHD8115	12	345	0.003	0.27	61.9	0.09	1.98	0.31
GME71003	MHE7101	MHE7103	12	515	0.0097	0.90	242.3	0.35	4.22	0.44
GME71005	MHE7103	MHE7104	12	388	0.0096	0.90	242.3	0.35	4.20	0.44
GME71008	MHE7104	MHE7107	12	401	0.0096	0.92	248.8	0.36	4.23	0.44
GME71011	MHE7107	MHE8108	12	276	0.0138	0.94	253.1	0.36	4.85	0.41
GME81001	MHD8126	MHE7101	15	404	0.0046	0.90	242.3	0.35	3.17	0.39
GME81010	MHE8108	MHE8109	12	376	0.0096	0.94	253.1	0.36	4.25	0.45
GME81011	MHE8109	MHE8115	10	376	0.0311	0.95	257.4	0.37	6.61	0.43
GME81012	MHE8110	MHF8101	8	302	0.0583	0.24	54.8	0.08	5.74	0.24
GMF51001	MHF5101	MHF5104	8	382	0.0184	0.14	30.4	0.04	3.28	0.25
GMF51006	MHF5104	MHF5113	8	382	0.0098	0.14	30.4	0.04	2.62	0.29
GMF51016	MHF5113	MHF5116	8	96	0.0832	0.14	30.4	0.04	5.59	0.17
GMF51020	MHF5116	MHF5123	8	215	0.0765	0.14	30.4	0.04	5.42	0.17
GMF51027	MHF5123	MHF5125	8	95	0.0579	0.14	30.4	0.04	4.92	0.19
GMF71003	MHF8112	MHF7103	15	272	0.0053	1.21	336.1	0.48	3.63	0.44
GMF71005	MHF7103	MHF7107	15	383	0.0055	1.26	353.5	0.51	3.72	0.44
GMF71010	MHF7107	MHF7112	15	371	0.0055	1.28	359.9	0.52	3.73	0.45
GMF71014	MHF7112	MHF7113	15	371	0.0055	1.29	364.0	0.52	3.74	0.45
GMF71015	MHF7113	MHG7101	15	371	0.0055	1.29	364.0	0.52	3.74	0.45
GMF81001	MHE8115	MHF8103	15	342	0.0058	1.14	314.1	0.45	3.67	0.41
GMF81002	MHF8102	MHE8115	10	414	0.0038	0.25	56.7	0.08	2.13	0.36
GMF81003	MHF8101	MHF8105	8	263	0.0596	0.24	54.8	0.08	5.79	0.24
GMF81004	MHF8106	MHF8102	10	414	0.0035	0.24	54.8	0.08	2.07	0.36
GMF81005	MHF8103	MHF8109	15	345	0.0055	1.14	314.1	0.45	3.60	0.42
GMF81008	MHF8105	MHF8108	8	291	0.0233	0.24	54.8	0.08	4.14	0.30
GMF81009	MHF8108	MHF8106	10	126	0.0025	0.24	54.8	0.08	1.83	0.40
GMF81011	MHF8109	MHF8112	15	271	0.0054	1.21	336.1	0.48	3.63	0.44
GMG31050	MHG3143	MHG3145	8	171	0.0086	0.32	75.6	0.11	3.12	0.46
GMG31052	MHG3145	MHG3151	8	390	0.0321	0.32	75.6	0.11	5.04	0.32
GMG31058	MHG3151	MHG3155	8	391	0.0293	0.32	75.6	0.11	4.87	0.33
GMG41029	MHG3155	MHG4127	8	316	0.0231	0.32	75.6	0.11	4.47	0.35
GMG41030	MHG4131	MHG4125	10	115	0.0107	0.58	148.1	0.21	3.93	0.44
GMG41031	MHG4125	MHG4132	10	491	0.003	0.67	173.4	0.25	2.49	0.71
GMG41034	MHG4127	MHG4131	8	306	0.019	0.32	75.6	0.11	4.16	0.37

APPENDIX B TABLE B-1 EXISTING WASTEWATER FLOWS										
SEWER REACH	FROM MANHOLE	TO MANHOLE	SEWER DIAMETER (in)	SEWER LENGTH (ft)	SEWER SLOPE	EXISTING PEAK WASTEWATER FLOW (MGD)	EXISTING AVERAGE DAILY WASTEWATER FLOW		VELOCITY (ft/s)	DEPTH OF FLOW TO SEWER DIAMETER RATIO (d/D)
							(gpm)	(MGD)		
GMG41040	MHG4132	MHG4134	10	375	0.0032 (1)	0.67	173.4	0.25	2.55	0.70
GMG41042	MHG4134	MHG4137	10	322	0.0032 (1)	0.67	173.4	0.25	2.55	0.70
GMG51001	MHF5125	MHG5104	8	303	0.0809	0.14	30.4	0.04	5.53	0.17
GMG51007	MHG5104	MHG5111	8	312	0.0577	0.14	30.4	0.04	4.91	0.19
GMG51014	MHG5111	MHG5114	8	96	0.2432	0.14	30.4	0.04	8.14	0.13
GMG51017	MHG5114	MHG5115	8	27	0.0478	0.14	30.4	0.04	4.59	0.19
GMG51018	MHG5115	MHG5116	8	185	0.0497	0.14	30.4	0.04	4.66	0.19
GMG51019	MHG5116	MHG5118	8	215	0.0132	0.14	30.4	0.04	2.91	0.27
GMG51021	MHG5118	MHG5119	8	132	0.0135	0.14	30.4	0.04	2.93	0.27
GMG51022	MHG5119	MHG5121	8	326	0.0141	0.17	36.1	0.05	3.11	0.29
GMG51024	MHG5121	MHG5122	8	166	0.0246	0.17	36.1	0.05	3.80	0.25
GMG51025	MHG5122	MHG5126	8	154	0.005 (1)	0.17	36.1	0.05	2.14	0.38
GMG51029	MHG5126	MHG5127	8	186	0.0197	0.17	36.1	0.05	3.51	0.26
GMG51030	MHG5127	MHG5130	8	126	0.0103	0.19	41.8	0.06	2.89	0.33
GMG51035	MHG5130	MHG5135	8	291	0.0183 (1)	0.19	41.8	0.06	3.55	0.29
GMG51040	MHG5135	MHG5138	8	312	0.0496 (1)	0.21	47.5	0.07	5.23	0.24
GMG51046	MHG5138	MHG5141	8	174	0.0599	0.21	47.5	0.07	5.59	0.22
GMG61009	MHG6107	MHG6118	8	623	0.0039	0.22	50.9	0.07	2.13	0.47
GMG61019	MHG6118	MHG6122	8	121	0.0395	0.22	50.9	0.07	4.91	0.26
GMG61023	MHG6122	MHG6123	10	297	0.0217	0.22	50.9	0.07	3.87	0.22
GMG61024	MHG6123	MHG6126	8	335	0.0185	0.22	50.9	0.07	3.74	0.31
GMG61027	MHG6126	MHG6130	8	124	0.1704	0.22	50.9	0.07	8.23	0.18
GMG61032	MHG6130	MHH6101	8	299	0.0341	0.25	56.6	0.08	4.78	0.28
GMG71002	MHG7101	MHG7104	15	225	0.0052	1.32	371.1	0.53	3.68	0.46
GMG71005	MHG7104	MHG7109	15	350	0.0055	1.32	371.1	0.53	3.76	0.45
GMG71012	MHG7109	MHG7113	15	107	0.0609	1.32	371.1	0.53	8.93	0.24
GMG71014	MHG7113	MHG7114	15	263	0.0088	1.32	371.1	0.53	3.50	0.25
GMG71017	MHG7114	MHG7115	18	313	0.0034	1.32	371.1	0.53	3.13	0.40
GMG71018	MHG7115	MHG7116	18	234	0.0032	1.32	371.1	0.53	3.06	0.40
GMG71019	MHG7116	MHG7117	18	293	0.0034	1.32	371.1	0.53	3.11	0.40
GMG71020	MHG7117	MHG7118	18	399	0.004	1.32	371.1	0.53	3.32	0.38
GMH41001	MHG4137	MHH4103	10	246	0.0036 (1)	0.69	179.4	0.26	2.68	0.68
GMH41006	MHH4103	MHH4111	10	232	0.008 (1)	0.69	179.4	0.26	3.68	0.52
GMH41016	MHH4111	MHH4117	10	264	0.008 (1)	0.69	179.4	0.26	3.67	0.53

APPENDIX B TABLE B-1 EXISTING WASTEWATER FLOWS										
SEWER REACH	FROM MANHOLE	TO MANHOLE	SEWER DIAMETER (in)	SEWER LENGTH (ft)	SEWER SLOPE	EXISTING PEAK WASTEWATER FLOW (MGD)	EXISTING AVERAGE DAILY WASTEWATER FLOW		VELOCITY (ft/s)	DEPTH OF FLOW TO SEWER DIAMETER RATIO (d/D)
							(gpm)	(MGD)		
GMH41026	MHH4119	MHH4122	10	356	0.0032 (1)	0.69	179.4	0.26	2.56	0.71
GMH41029	MHH4122	MHH4123	10	162	0.0032 (1)	0.69	179.4	0.26	2.56	0.71
GMH41030	MHH4123	MHH4125	10	211	0.01	0.69	179.4	0.26	4.01	0.49
GMH41035	MHH4125	MHH4129	10	18	0.145	0.69	179.4	0.26	10.53	0.24
GMH41040	MHH4129	MHH4131	8	82	0.028	0.69	179.4	0.26	5.89	0.52
GMH41042	MHH4131	MHH4135	8	248	0.0186 (1)	0.69	179.4	0.26	5.03	0.58
GMH51003	MHG5141	MHH5106	8	346	0.0312	0.21	47.5	0.07	4.43	0.26
GMH51009	MHH5106	MHH6111	8	346	0.0191	0.23	53.2	0.08	3.83	0.32
GMH51014	MHH6111	MHH5118	8	358	0.0263	0.23	53.2	0.08	4.29	0.29
GMH51022	MHH5118	MHH5127	8	356	0.0062	0.26	59.3	0.09	2.61	0.45
GMH51025	MHH5121	MHH5124	8	126	0.0406	0.32	76.8	0.11	5.50	0.31
GMH51028	MHH5124	MHH5129	8	381	0.0152	0.35	82.5	0.12	3.92	0.41
GMH51031	MHH5127	MHH5131	8	331	0.0154	0.26	59.3	0.09	3.64	0.35
GMH51033	MHH5129	MHH5132	8	385	0.0223	0.35	83.8	0.12	4.53	0.38
GMH51035	MHH5131	MHH5132	8	24	0.0066	0.26	59.3	0.09	2.67	0.44
GMH51036	MHH5132	MHH5136	15	37	0.0863	0.56	143.2	0.21	7.88	0.15
GMH51037	MHH5133	MHH5138	8	351	0.0108	0.00	0.0	0.00	0.00	0.00
GMH51040	MHH5136	MHH5139	15	320	0.0084	0.56	143.2	0.21	3.46	0.26
GMH51042	MHH6131	MHH5141	8	130	0.004 (1)	0.31	73.7	0.11	2.32	0.58
GMH51043	MHH5138	MHH5141	8	259	0.0035	0.04	6.3	0.01	1.21	0.19
GMH51044	MHH5139	MHH5143	15	290	0.0042	0.56	143.2	0.21	2.70	0.31
GMH51046	MHH5141	MHH5143	8	63	0.0147	0.34	80.0	0.12	3.84	0.41
GMH51049	MHH5143	MHH6140	15	216	0.0135	0.84	223.2	0.32	4.59	0.28
GMH51056	MHH4135	MHH5147	8	125	0.0421	0.69	179.4	0.26	6.85	0.46
GMH51057	MHH5147	MHI5102	8	319	0.0151 (1)	0.69	179.4	0.26	4.64	0.63
GMH61002	MHH6101	MHH6106	8	295	0.0215	0.25	56.6	0.08	4.06	0.31
GMH61008	MHH6106	MHH6108	8	102	0.0065	0.25	56.6	0.08	2.62	0.43
GMH61010	MHH6108	MHH6109	8	94	0.0437	0.25	56.6	0.08	5.23	0.26
GMH61011	MHH6109	MHH6115	8	292	0.0228 (1)	0.25	56.6	0.08	4.14	0.31
GMH61016	MHH6115	MHH6120	8	318	0.005	0.25	56.6	0.08	2.38	0.47
GMH61021	MHH6120	MHH6125	8	373	0.0051	0.27	61.5	0.09	2.45	0.48
GMH61026	MHH6125	MHH6131	8	371	0.0102	0.27	61.5	0.09	3.17	0.40
GMH61028	MHH6127	MHH6134	18	302	0.0044	1.35	382.1	0.55	3.44	0.38
GMH61036	MHH6134	MHH6135	21	3	0.0036	1.35	382.1	0.55	3.17	0.32

APPENDIX B TABLE B-1 EXISTING WASTEWATER FLOWS										
SEWER REACH	FROM MANHOLE	TO MANHOLE	SEWER DIAMETER (in)	SEWER LENGTH (ft)	SEWER SLOPE	EXISTING PEAK WASTEWATER FLOW (MGD)	EXISTING AVERAGE DAILY WASTEWATER FLOW		VELOCITY (ft/s)	DEPTH OF FLOW TO SEWER DIAMETER RATIO (d/D)
							(gpm)	(MGD)		
GMH61039	MHH6135	MHH6137	21	172	0.0038	1.41	399.3	0.57	3.27	0.32
GMH61040	MHH6137	MHH6145	21	172	0.0037	1.41	399.3	0.57	3.25	0.32
GMH61043	MHH6140	MHH6146	15	143	0.0069	0.84	223.2	0.32	3.60	0.33
GMH61048	MHH6145	MHI6107	21	306	0.0065	1.43	408.1	0.59	4.00	0.28
GMH61050	MHH6146	MHI5104	15	259	0.0049	0.84	223.2	0.32	3.19	0.37
GMH71001	MHG7118	MHH7101	18	502	0.0036	1.33	376.6	0.54	3.21	0.39
GMH71002	MHH7101	MHH7102	18	360	0.0035	1.33	376.6	0.54	3.16	0.40
GMH71003	MHH7102	MHH7103	18	396	0.0035	1.33	376.6	0.54	3.18	0.40
GMH71004	MHH7103	MHH7104	18	396	0.0035	1.33	376.6	0.54	3.18	0.40
GMH71005	MHH7104	MHH7105	18	396	0.0035	1.35	382.1	0.55	3.19	0.40
GMH71006	MHH7105	MHH6127	18	396	0.0035	1.35	382.1	0.55	3.19	0.40
GMI31026	MHI3120	MHI3121	8	222	0.0563	0.17	36.2	0.05	5.10	0.20
GMI31028	MHI3121	MHI3124	8	327	0.0362	0.17	36.2	0.05	4.36	0.23
GMI31035	MHI3124	MHI4112	8	326	0.0312	0.17	36.2	0.05	4.14	0.23
GMI31048	MHI3148	MHI4116	8	288	0.0258	0.17	36.2	0.05	3.87	0.25
GMI31060	MHI3150	MHI3148	8	124	0.0301	0.17	36.2	0.05	4.08	0.24
GMI31063	MHI3149	MHI3150	8	205	0.0299	0.17	36.2	0.05	4.07	0.24
GMI31065	MHI3151	MHI3149	8	41	0.2165	0.17	36.2	0.05	8.19	0.15
GMI41005	MHI4107	MHI4106	8	267	0.0035	0.03	4.9	0.01	1.13	0.17
GMI41006	MHI4106	MHI4111	8	427	0.003	0.03	4.9	0.01	1.07	0.17
GMI41007	MHI4110	MHI4107	8	265	0.0026	0.03	4.9	0.01	1.02	0.18
GMI41013	MHI4111	MHI5150	8	391	0.0088	0.03	4.9	0.01	1.57	0.13
GMI41014	MHI4116	MHI4112	8	271	0.014	0.17	36.2	0.05	3.11	0.29
GMI41015	MHI4112	MHI4113	8	373	0.0371	0.31	72.5	0.10	5.25	0.31
GMI41016	MHI4113	MHI4115	8	366	0.0445	0.33	78.4	0.11	5.72	0.30
GMI41018	MHI4115	MHI4119	8	221	0.0072	0.33	78.4	0.11	2.95	0.50
GMI41021	MHI4119	MHI4123	8	222	0.0073	0.33	79.1	0.11	2.96	0.50
GMI41023	MHI4123	MHI4121	8	61	0.0013	0.40	97.8	0.14	1.78	1.00
GMI41024	MHI4121	MHI4122	8	22	0.0139 (1)	0.40	97.8	0.14	3.95	0.46
GMI41026	MHI4122	MHI4127	8	269	0.0033	0.40	97.8	0.14	2.27	0.73
GMI41027	MHI4128	MHI4123	8	316	0.016	0.09	18.7	0.03	2.75	0.21
GMI41035	MHJ4102	MHI4128	8	281	0.0601	0.09	18.7	0.03	4.38	0.15
GMI51006	MHI5102	MHI5112	8	455	0.0165	0.73	192.0	0.28	4.87	0.63
GMI51009	MHI5104	MHI5119	18	397	0.0051	0.84	223.2	0.32	3.19	0.28

APPENDIX B TABLE B-1 EXISTING WASTEWATER FLOWS										
SEWER REACH	FROM MANHOLE	TO MANHOLE	SEWER DIAMETER (in)	SEWER LENGTH (ft)	SEWER SLOPE	EXISTING PEAK WASTEWATER FLOW (MGD)	EXISTING AVERAGE DAILY WASTEWATER FLOW		VELOCITY (ft/s)	DEPTH OF FLOW TO SEWER DIAMETER RATIO (d/D)
							(gpm)	(MGD)		
GMI51010	MHI5112	MHI5105	10	125	0.008 (1)	0.73	192.0	0.28	3.73	0.54
GMI51011	MHI5105	MHI5117	8	408	0.0142	0.73	192.0	0.28	4.58	0.67
GMI51026	MHI5117	MHI5125	8	408	0.0127	0.76	199.2	0.29	4.40	0.71
GMI51028	MHI5119	MHI5131	18	367	0.0056	0.84	223.2	0.32	3.30	0.27
GMI51035	MHI5125	MHI5132	10	252	0.0026	0.79	209.8	0.30	2.25	1.00
GMI51041	MHI6139	MHI5144	8	366	0.0055	0.20	45.5	0.07	2.35	0.41
GMI51042	MHI5131	MHI5142	18	425	0.0058	0.84	223.2	0.32	3.34	0.27
GMI51043	MHI5132	MHI5138	10	261	0.003 (1)	0.81	214.4	0.31	2.29	1.00
GMI51051	MHI5138	MHI5146	10	310	0.0103	0.85	226.3	0.33	4.26	0.55
GMI51054	MHI5142	MHI5145	18	66	0.0045	0.84	223.2	0.32	3.06	0.29
GMI51056	MHI5144	MHI5156	8	368	0.0085	0.20	45.5	0.07	2.75	0.36
GMI51057	MHI5145	MHI5146	18	5	0.5761	0.84	223.2	0.32	16.81	0.09
GMI51060	MHI5146	MHI5154	18	410	0.0059	1.56	449.5	0.65	4.00	0.37
GMI51067	MHI5150	MHI5165	8	463	0.0135	0.03	4.9	0.01	1.82	0.12
GMI51072	MHI5154	MHI5157	21	63	0.0044	1.56	449.5	0.65	3.56	0.33
GMI51073	MHI5155	MHI5160	21	82	0.0021	1.79	522.4	0.75	2.81	0.43
GMI51074	MHI5162	MHI5155	21	204	0.002	1.79	522.4	0.75	2.77	0.43
GMI51075	MHI5156	MHI5172	8	319	0.004	0.20	45.5	0.07	2.10	0.45
GMI51077	MHI5157	MHI5163	21	57	0.0028 (1)	3.10	971.9	1.40	3.61	0.54
GMI51078	MHI5160	MHI5157	18	44	0.0199	0.94	252.9	0.36	5.21	0.20
GMI51079	MHI5160	MHI5157	18	39	0.0226	0.99	269.5	0.39	5.56	0.20
GMI51083	MHI5166	MHI5162	21	202	0.002	1.79	522.4	0.75	2.76	0.43
GMI51084	MHI5163	MHI5173	21	179	0.0028 (1)	3.10	971.9	1.40	3.61	0.54
GMI51086	MHI5165	MHI5168	8	29	0.0255	0.03	4.9	0.01	2.27	0.10
GMI51087	MHI5167	MHI5166	21	13	0.0022	1.79	522.4	0.75	2.89	0.42
GMI51088	MHI5172	MHI5167	21	105	0.002	1.79	522.4	0.75	2.77	0.43
GMI51089	MHI5168	MHI5171	12	212	0.0114	0.03	4.9	0.01	1.62	0.08
GMI51093	MHI5171	MHI5175	12	111	0.0248	0.03	4.9	0.01	2.13	0.06
GMI51095	MHI5177	MHI5172	21	235	0.0029	1.65	476.9	0.69	3.10	0.37
GMI51097	MHI5173	MHI5178	21	160	0.0028 (1)	3.19	1002.0	1.44	3.64	0.55
GMI51099	MHI5175	MHI5182	12	158	0.013	0.03	4.9	0.01	1.70	0.07
GMI51101	MHI5185	MHI5177	21	235	0.0029	1.65	476.9	0.69	3.10	0.37
GMI51102	MHI5178	MHI5181	21	303	0.003 (1)	3.21	1008.8	1.45	3.74	0.54
GMI51107	MHI5181	MHI5183	24	69	0.0016 (1)	3.21	1008.8	1.45	2.95	0.53

APPENDIX B TABLE B-1 EXISTING WASTEWATER FLOWS										
SEWER REACH	FROM MANHOLE	TO MANHOLE	SEWER DIAMETER (in)	SEWER LENGTH (ft)	SEWER SLOPE	EXISTING PEAK WASTEWATER FLOW (MGD)	EXISTING AVERAGE DAILY WASTEWATER FLOW		VELOCITY (ft/s)	DEPTH OF FLOW TO SEWER DIAMETER RATIO (d/D)
							(gpm)	(MGD)		
GMI51108	MHI5182	MHI5190	8	282	0.004	0.03	4.9	0.01	1.19	0.16
GMI51110	MHI5183	MHI5188	24	244	0.0016 (1)	3.21	1008.8	1.45	2.95	0.53
GMI51112	MHI6179	MHI5185	21	213	0.0029	1.62	468.4	0.67	3.08	0.37
GMI61011	MHI6107	MHI6113	21	140	0.004	1.43	408.1	0.59	3.35	0.32
GMI61013	MHI6108	MHI6111	21	85	0.004	1.43	408.1	0.59	3.35	0.32
GMI61014	MHI6113	MHI6108	21	55	0.0038	1.43	408.1	0.59	3.30	0.32
GMI61016	MHI6111	MHI6123	21	223	0.004	1.43	408.1	0.59	3.35	0.32
GMI61022	MHI6117	MHI6131	8	289	0.0024	0.13	27.6	0.04	1.54	0.40
GMI61028	MHI6123	MHI6132	21	223	0.0262	1.43	408.1	0.59	6.54	0.20
GMI61030	MHI6125	MHI6139	8	367	0.0058	0.20	45.5	0.07	2.39	0.40
GMI61031	MHI6131	MHI6125	8	50	0.003 (1)	0.20	45.5	0.07	1.88	0.48
GMI61038	MHI6132	MHI6140	21	289	0.0108	1.49	427.0	0.61	4.84	0.25
GMI61046	MHI6140	MHI6143	21	116	0.0032	1.54	442.5	0.64	3.15	0.35
GMI61050	MHI6143	MHI6153	21	317	0.0074	1.57	451.4	0.65	4.28	0.29
GMI61061	MHI6153	MHI6160	21	317	0.0025	1.57	451.4	0.65	2.91	0.38
GMI61068	MHI6160	MHI6170	21	317	0.0025	1.57	451.4	0.65	2.91	0.38
GMI61076	MHI6170	MHI6172	21	175	0.0025	1.59	459.9	0.66	2.92	0.38
GMI61079	MHI6172	MHI6177	21	175	0.0026	1.59	459.9	0.66	2.94	0.38
GMI61084	MHI6177	MHJ6103	21	224	0.0025	1.59	459.9	0.66	2.91	0.38
GMJ31007	MHJ3119	MHJ3110	8	131	0.1098	0.09	18.7	0.03	5.41	0.13
GMJ31008	MHJ3110	MHJ3117	8	202	0.0704	0.09	18.7	0.03	4.63	0.14
GMJ41001	MHI4127	MHJ4104	8	368	0.0231	0.40	97.8	0.14	4.76	0.40
GMJ41005	MHJ4107	MHJ4102	8	221	0.1233	0.09	18.7	0.03	5.64	0.13
GMJ41006	MHJ4105	MHJ4103	8	42	0.0723	0.51	126.5	0.18	7.67	0.33
GMJ41007	MHJ4103	MHJ4109	15	222	0.0154	0.51	126.5	0.18	4.15	0.21
GMJ41008	MHJ4104	MHJ4105	8	193	0.0562	0.40	97.8	0.14	6.57	0.32
GMJ41010	MHJ4110	MHJ4107	8	237	0.0442	0.09	18.7	0.03	3.93	0.16
GMJ41012	MHJ4109	MHJ4113	15	296	0.0213	0.51	126.5	0.18	4.66	0.19
GMJ41013	MHJ3117	MHJ4110	8	211	0.0235	0.09	18.7	0.03	3.15	0.19
GMJ41016	MHJ4113	MHJ4120	15	396	0.016	0.51	128.5	0.19	4.22	0.21
GMJ41024	MHJ4120	MHJ4128	15	396	0.0077	0.51	128.5	0.19	3.26	0.25
GMJ41029	MHJ4125	MHJ4127	24	11	0.0009	3.27	1031.5	1.49	2.38	0.64
GMJ41031	MHJ4127	MHJ4136	24	260	0.0015 (1)	3.27	1031.5	1.49	2.89	0.54
GMJ41033	MHJ4128	MHJ4136	15	396	0.0074	0.51	128.5	0.19	3.21	0.26

APPENDIX B TABLE B-1 EXISTING WASTEWATER FLOWS										
SEWER REACH	FROM MANHOLE	TO MANHOLE	SEWER DIAMETER (in)	SEWER LENGTH (ft)	SEWER SLOPE	EXISTING PEAK WASTEWATER FLOW (MGD)	EXISTING AVERAGE DAILY WASTEWATER FLOW		VELOCITY (ft/s)	DEPTH OF FLOW TO SEWER DIAMETER RATIO (d/D)
							(gpm)	(MGD)		
GMJ41042	MHJ4136	MHJ4145	24	217	0.0021	3.63	1160.0	1.67	3.38	0.52
GMJ41046	MHJ4140	MHJ4141	15	37	0.0016	0.37	88.4	0.13	1.71	0.32
GMJ41047	MHJ4146	MHJ4140	12	245	0.002	0.33	78.4	0.11	1.81	0.39
GMJ41048	MHJ4141	MHJ4147	15	325	0.001	0.37	88.4	0.13	1.44	0.36
GMJ41052	MHJ4145	MHJ4150	24	225	0.0031	3.63	1160.0	1.67	3.91	0.47
GMJ41054	MHJ4147	MHJ4154	15	287	0.0009	0.37	88.4	0.13	1.40	0.37
GMJ41058	MHJ4150	MHJ4156	27	338	0.0016 (1)	3.63	1160.0	1.67	3.05	0.47
GMJ51001	MHI5188	MHJ5104	24	119	0.0016 (1)	3.21	1008.8	1.45	2.95	0.53
GMJ51002	MHI5190	MHJ5105	12	284	0.004	0.05	9.9	0.01	1.35	0.13
GMJ51007	MHJ5104	MHJ5106	24	156	0.0016 (1)	3.21	1008.8	1.45	2.95	0.53
GMJ51008	MHJ5105	MHJ5108	12	204	0.0043	0.06	10.9	0.02	1.43	0.13
GMJ51011	MHJ5106	MHJ5110	24	189	0.0016 (1)	3.21	1008.8	1.45	2.94	0.53
GMJ51014	MHJ5108	MHJ5110	12	161	0.004	0.08	15.9	0.02	1.53	0.16
GMJ51015	MHJ5110	MHJ5111	24	119	0.0016 (1)	3.27	1031.5	1.49	2.97	0.53
GMJ51016	MHJ5111	MHJ5115	24	248	0.0016 (1)	3.27	1031.5	1.49	2.98	0.53
GMJ51019	MHJ5115	MHJ4125	24	236	0.0014 (1)	3.27	1031.5	1.49	2.82	0.56
GMJ51020	MHJ5116	MHJ4146	12	357	0.0019	0.33	78.4	0.11	1.77	0.40
GMJ51021	MHJ5117	MHJ5116	12	357	0.0019	0.33	78.4	0.11	1.77	0.40
GMJ51022	MHJ5118	MHJ5117	12	196	0.0014	0.33	78.4	0.11	1.60	0.43
GMJ51023	MHJ5119	MHJ5118	12	190	0.0019	0.33	78.4	0.11	1.77	0.39
GMJ51024	MHJ5120	MHJ5119	12	7	0.2063	0.33	78.4	0.11	9.38	0.12
GMJ51029	MHJ5120	MHJ5119	12	6	0.2148	0.00	0.0	0.00	0.00	0.00
GMJ51030	MHJ5121	MHJ5120	12	278	0.0021	0.33	78.4	0.11	1.83	0.39
GMJ51031	MHK5101	MHJ5121	12	346	0.0019	0.33	78.4	0.11	1.76	0.40
GMJ61002	MHJ6104	MHI6179	21	213	0.0029	1.62	468.4	0.67	3.09	0.37
GMJ61005	MHJ6103	MHJ6110	21	224	0.0025	1.59	459.9	0.66	2.93	0.38
GMJ61006	MHJ6106	MHJ6104	21	183	0.0029	1.59	459.9	0.66	3.07	0.37
GMJ61009	MHJ6111	MHJ6106	21	183	0.0028	1.59	459.9	0.66	3.05	0.37
GMJ61012	MHJ6110	MHJ6111	21	88	0.0029	1.59	459.9	0.66	3.09	0.37
GMK21001	MHJ2134	MHK2104	8	204	0.1568	0.09	18.3	0.03	6.10	0.12
GMK21004	MHK2104	MHK2106	8	140	0.0027	0.09	18.3	0.03	1.45	0.32
GMK21006	MHK2106	MHK2107	8	50	0.0040	0.09	18.3	0.03	1.60	0.28
GMK21008	MHK2107	MHK2108	8	183	0.0508	0.09	18.3	0.03	4.11	0.15
GMK21009	MHK2108	MHK2112	8	119	0.0033	0.09	18.3	0.03	1.55	0.31

APPENDIX B TABLE B-1 EXISTING WASTEWATER FLOWS										
SEWER REACH	FROM MANHOLE	TO MANHOLE	SEWER DIAMETER (in)	SEWER LENGTH (ft)	SEWER SLOPE	EXISTING PEAK WASTEWATER FLOW (MGD)	EXISTING AVERAGE DAILY WASTEWATER FLOW		VELOCITY (ft/s)	DEPTH OF FLOW TO SEWER DIAMETER RATIO (d/D)
							(gpm)	(MGD)		
GMK21012	MHK2112	MHK2116	8	441	0.0086	0.09	18.3	0.03	2.20	0.24
GMK21018	MHK2116	MHK2123	8	426	0.0087	0.09	18.3	0.03	2.20	0.24
GMK21030	MHK2123	MHK2126	8	154	0.0767	0.15	31.8	0.05	5.49	0.18
GMK21032	MHK2133	MHK2125	8	338	0.0034	0.18	38.5	0.06	1.88	0.43
GMK21033	MHK2125	MHK2128	8	119	0.0335	0.18	38.5	0.06	4.31	0.24
GMK21035	MHK2126	MHK2133	8	261	0.0625	0.15	31.8	0.05	5.11	0.19
GMK21037	MHK2128	MHK2135	8	274	0.0346	0.25	56.6	0.08	4.81	0.28
GMK21048	MHK2135	MHK2140	8	318	0.0199	0.25	56.6	0.08	3.94	0.32
GMK21062	MHK2140	MHK2146	8	256	0.0196	0.25	56.6	0.08	3.93	0.32
GMK21070	MHK2146	MHK3128	8	136	0.019	0.25	56.6	0.08	3.91	0.32
GMK21077	MHK2151	MHK2159	8	247	0.0027	0.04	8.1	0.01	1.17	0.22
GMK31033	MHK3128	MHK3131	8	311	0.0555	0.25	56.6	0.08	5.69	0.25
GMK31036	MHK3131	MHL3101	8	267	0.0555	0.25	56.6	0.08	5.69	0.25
GMK31037	MHL3102	MHK3132	10	199	0.0056	0.10	20.0	0.03	1.88	0.21
GMK41001	MHJ4154	MHK4102	15	326	0.001	0.37	88.4	0.13	1.43	0.36
GMK41003	MHJ4156	MHK4105	27	275	0.0016 (1)	3.63	1160.0	1.67	3.05	0.47
GMK41006	MHK4102	MHK4106	15	243	0.0012	0.37	88.4	0.13	1.52	0.34
GMK41009	MHK4105	MHK4106	27	18	0.0028	3.64	1162.0	1.67	3.73	0.40
GMK41010	MHK4106	MHK4109	27	94	0.0016 (1)	3.88	1250.4	1.80	3.10	0.49
GMK41012	MHK4109	MHK4110	27	163	0.0016 (1)	3.88	1250.4	1.80	3.10	0.49
GMK41013	MHK4110	MHK4111	27	263	0.0016 (1)	3.88	1250.4	1.80	3.10	0.49
GMK41014	MHK4111	MHK4112	27	150	0.0016 (1)	3.89	1252.3	1.80	3.10	0.49
GMK41015	MHK4112	MHK4116	27	263	0.0016 (1)	3.89	1252.3	1.80	3.10	0.49
GMK41016	MHK4119	MHK4113	10	351	0.0027	0.10	20.0	0.03	1.45	0.25
GMK41017	MHK4113	MHK4114	10	275	0.0131	0.10	20.0	0.03	2.54	0.17
GMK41018	MHK4114	MHK4116	10	273	0.0134	0.10	20.0	0.03	2.56	0.17
GMK41019	MHK4120	MHK4115	10	252	0.0017	0.10	20.0	0.03	1.24	0.27
GMK41020	MHK4115	MHK4119	10	313	0.0238	0.10	20.0	0.03	3.13	0.14
GMK41021	MHK4116	NSK4101	30	17	0.0147	3.94	1272.3	1.83	6.89	0.24
GMK41022	NSK4101	MHK4118	21	17	0.0107	3.25	1023.6	1.47	5.97	0.37
GMK41023	NSK4101	MHK4117	18	22	0.0027	0.92	248.6	0.36	2.48	0.32
GMK41025	MHK4117	MHK4122	18	366	0.0026	0.92	248.6	0.36	2.59	0.35
GMK41026	MHK4118	MHK4123	21	332	0.0035	3.25	1023.6	1.47	3.97	0.52
GMK41027	MHK3132	MHK4120	10	252	0.0017	0.10	20.0	0.03	1.24	0.27

APPENDIX B TABLE B-1 EXISTING WASTEWATER FLOWS										
SEWER REACH	FROM MANHOLE	TO MANHOLE	SEWER DIAMETER (in)	SEWER LENGTH (ft)	SEWER SLOPE	EXISTING PEAK WASTEWATER FLOW (MGD)	EXISTING AVERAGE DAILY WASTEWATER FLOW		VELOCITY (ft/s)	DEPTH OF FLOW TO SEWER DIAMETER RATIO (d/D)
							(gpm)	(MGD)		
GMK51001	MHK5103	MHK5101	12	296	0.0018	0.33	78.4	0.11	1.73	0.40
GMK51003	MHK5105	MHK5103	12	346	0.0019	0.33	78.4	0.11	1.76	0.40
GMK51005	MHK5108	MHK5105	12	344	0.0022	0.33	78.4	0.11	1.86	0.38
GML21003	MHK2159	MHL2106	8	271	0.0328	0.06	11.1	0.02	3.08	0.14
GML21011	MHL2106	MHL2113	8	266	0.0326	0.07	14.1	0.02	3.28	0.15
GML21032	MHL2128	MHL2125	8	411	0.0046	0.04	8.1	0.01	1.41	0.19
GML21033	MHL2125	MHL2133	8	273	0.0589	0.04	8.1	0.01	3.48	0.10
GML21037	MHL2129	MHL2128	8	137	0.0037	0.04	8.1	0.01	1.32	0.20
GML21038	MHL2135	MHL2129	8	260	0.0043	0.04	8.1	0.01	1.39	0.20
GML21042	MHL2133	MHL2131	8	165	0.0193	0.05	9.0	0.01	2.42	0.14
GML21043	MHL2131	MHL2140	8	390	0.0197	0.31	72.4	0.10	4.18	0.36
GML21047	MHL2134	MHL2135	8	319	0.0045	0.04	8.1	0.01	1.40	0.20
GML21050	MHL2140	MHL2139	10	186	0.0091	0.31	72.4	0.10	3.11	0.32
GML21051	MHL2139	MHL2145	8	421	0.0343	0.34	80.5	0.12	5.24	0.33
GML31004	MHL3101	MHL3105	8	267	0.0555	0.25	56.6	0.08	5.69	0.25
GML31005	MHL3106	MHL3102	10	163	0.002	0.10	20.0	0.03	1.31	0.26
GML31009	MHL3105	MHL3109	8	360	0.0582	0.25	56.6	0.08	5.79	0.24
GML31010	MHL3115	MHL3106	10	360	0.002	0.10	20.0	0.03	1.30	0.27
GML31014	MHL2113	MHL3113	8	304	0.0393	0.09	17.2	0.02	3.69	0.16
GML31016	MHL3114	MHL3109	8	64	0.0538	0.15	32.3	0.05	4.87	0.19
GML31017	MHL3109	MHL3110	8	253	0.0536	0.37	88.9	0.13	6.31	0.31
GML31019	MHL3110	MHL3117	8	237	0.0337	0.37	88.9	0.13	5.34	0.35
GML31022	MHL3113	MHL3120	8	261	0.0398	0.10	20.2	0.03	3.87	0.17
GML31023	MHL3116	MHL3114	8	197	0.0602	0.14	29.3	0.04	4.93	0.18
GML31025	MHL3122	MHL3115	10	346	0.002	0.10	20.0	0.03	1.32	0.26
GML31026	MHL3119	MHL3116	8	348	0.0036	0.12	26.2	0.04	1.76	0.35
GML31027	MHL3117	MHL3121	8	178	0.0336	0.37	88.9	0.13	5.33	0.35
GML31031	MHL3127	MHL3118	12	311	0.0155	0.42	102.4	0.15	4.04	0.26
GML31032	MHL3118	MHL4124	12	230	0.0352	0.42	102.4	0.15	5.40	0.21
GML31033	MHL3120	MHL3119	8	339	0.0035	0.11	23.2	0.03	1.68	0.34
GML31036	MHL3121	MHL3124	8	219	0.0608	0.37	88.9	0.13	6.60	0.30
GML31038	MHL3126	MHL3123	12	57	0.0154	0.42	102.4	0.15	4.03	0.26
GML31039	MHL3123	MHL3128	12	201	0.0155	0.42	102.4	0.15	4.04	0.26
GML31040	MHL3124	MHL3131	12	131	0.0062	0.37	88.9	0.13	2.81	0.31

APPENDIX B TABLE B-1 EXISTING WASTEWATER FLOWS										
SEWER REACH	FROM MANHOLE	TO MANHOLE	SEWER DIAMETER (in)	SEWER LENGTH (ft)	SEWER SLOPE	EXISTING PEAK WASTEWATER FLOW (MGD)	EXISTING AVERAGE DAILY WASTEWATER FLOW		VELOCITY (ft/s)	DEPTH OF FLOW TO SEWER DIAMETER RATIO (d/D)
							(gpm)	(MGD)		
GML31043	MHL3133	MHL3126	12	140	0.0074	0.42	102.4	0.15	3.10	0.31
GML31045	MHL3128	MHL3127	12	33	0.0153	0.42	102.4	0.15	4.02	0.26
GML31054	MHL3137	MHL3133	12	100	0.0074	0.42	102.4	0.15	3.10	0.31
GML31055	MHL3134	MHL3143	12	270	0.0216	0.42	102.4	0.15	4.54	0.24
GML31058	MHL3142	MHL3137	12	171	0.0074	0.42	102.4	0.15	3.09	0.31
GML31061	MHL3147	MHL3131	12	224	0.0024	0.07	13.4	0.02	1.23	0.17
GML31063	MHL3143	MHL3142	12	92	0.0074	0.42	102.4	0.15	3.10	0.31
GML31068	MHL3149	MHL3146	12	135	0.0028	0.07	13.4	0.02	1.30	0.16
GML31069	MHL3146	MHL3148	12	462	0.0028	0.07	13.4	0.02	1.30	0.16
GML31070	MHL3148	MHL3147	8	5	0.0081	0.07	13.4	0.02	1.99	0.21
GML31075	MHL3154	MHL3149	8	135	0.0022	0.07	13.4	0.02	1.24	0.29
GML31083	MHL3158	MHL3154	8	151	0.0029	0.07	13.4	0.02	1.37	0.27
GML31090	MHL3162	MHL3158	8	103	0.0017	0.07	13.4	0.02	1.13	0.32
GML41001	MHK4122	MHL4103	18	386	0.003	0.92	248.6	0.36	2.72	0.34
GML41002	MHK4123	MHL4104	21	385	0.0085	3.25	1023.6	1.47	5.53	0.40
GML41005	MHL4103	MHL4105	18	30	0.004	0.92	248.6	0.36	2.99	0.31
GML41006	MHL4104	MHL4106	21	27	0.0042	3.25	1023.6	1.47	4.24	0.49
GML41007	MHL4105	MHL4108	18	16	0.1456	0.92	248.6	0.36	10.70	0.13
GML41008	MHL4112	MHL4107	12	177	0.0065	0.42	102.4	0.15	2.96	0.32
GML41009	MHL4107	MHL4110	12	74	0.0065	0.42	102.4	0.15	2.96	0.32
GML41010	MHL4108	MHL4111	24	132	0.0506	3.94	1272.3	1.83	10.94	0.23
GML41013	MHL4110	MHL4109	12	28	0.0113	0.42	102.4	0.15	3.61	0.28
GML41014	MHL4111	MHL4109	24	93	0.005	3.94	1272.3	1.83	4.75	0.43
GML41015	MHL4117	MHL4112	12	113	0.0065	0.42	102.4	0.15	2.97	0.32
GML41020	MHL4118	MHL4117	12	53	0.0065	0.42	102.4	0.15	2.95	0.32
GML41021	MHL4122	MHL4118	12	138	0.0065	0.42	102.4	0.15	2.95	0.32
GML41025	MHL4123	MHL4122	12	34	0.0065	0.42	102.4	0.15	2.95	0.32
GML41026	MHL4124	MHL4123	12	144	0.0065	0.42	102.4	0.15	2.96	0.32
GMM21002	MHL2145	MHM2104	8	217	0.0369	0.34	80.5	0.12	5.38	0.32
GMM21007	MHM2104	MHM2107	8	361	0.021	0.34	80.5	0.12	4.39	0.37
GMM21010	MHM2107	MHM3110	12	400	0.0023	0.35	82.5	0.12	1.94	0.38
GMM31012	MHM3110	MHM3114	12	396	0.0023	0.35	84.6	0.12	1.95	0.39
GMM31015	MHM3114	MHM3113	12	192	0.0018	0.35	84.6	0.12	1.78	0.41
GMM31016	MHM3113	MHM3115	10	55	0.0982	0.35	84.6	0.12	7.54	0.19

APPENDIX B TABLE B-1 EXISTING WASTEWATER FLOWS										
SEWER REACH	FROM MANHOLE	TO MANHOLE	SEWER DIAMETER (in)	SEWER LENGTH (ft)	SEWER SLOPE	EXISTING PEAK WASTEWATER FLOW (MGD)	EXISTING AVERAGE DAILY WASTEWATER FLOW		VELOCITY (ft/s)	DEPTH OF FLOW TO SEWER DIAMETER RATIO (d/D)
							(gpm)	(MGD)		
GMM31017	MHM3115	MHM3119	8	267	0.0508	0.35	84.6	0.12	6.11	0.30
GMM31021	MHM3119	MHM3120	8	155	0.0577	0.36	86.7	0.12	6.43	0.30
GMM31022	MHM3120	MHM3121	8	83	0.067	0.36	86.7	0.12	6.79	0.29
GMM31024	MHM3121	MHM3125	10	125	0.0050	0.36	86.7	0.12	2.60	0.42
GMM31028	MHM3125	MHM3124	10	18	0.0449	0.36	86.7	0.12	5.76	0.23
OUTLET_1	MHL4109	OUTLET1	24	27	0.0056	4.22	1374.7	1.98	5.04	0.43
OUTLET_2	MHM3124	12	10	30	0.01	0.36	86.7	0.12	3.50	0.34
P1000	MHH4117	MHH4119	10	102	0.0037	0.69	179.4	0.26	2.73	0.67

(1) Slope based on Sewer Atlas Sheets.

APPENDIX B TABLE B-2 ULTIMATE WASTEWATER FLOWS										
SEWER REACH	FROM MANHOLE	TO MANHOLE	SEWER DIAMETER (in)	SEWER LENGTH (ft)	SEWER SLOPE	ULTIMATE PEAK WASTEWATER FLOW (MGD)	ULTIMATE AVERAGE DAILY WASTEWATER FLOW		VELOCITY (ft/s)	DEPTH OF FLOW TO SEWER DIAMETER RATIO (d/D)
							(gpm)	(MGD)		
101	MHL3131	MHL3134	12	23	0.1318	0.46	114.4	0.16	8.86	0.16
103	MHL4106	MHL4108	21	12	0.0273	5.89	1997.0	2.88	9.93	0.41
GMC71002	MHC7101	MHC7102	8	327	0.0439	0.03	5.1	0.01	2.77	0.09
GMC71003	MHC7102	MHC7103	8	376	0.0419	0.03	5.1	0.01	2.73	0.09
GMC81005	MHC8104	MHC8105	8	240	0.0078	1.09	299.6	0.43	4.82	1.00
GMC81006	MHC8105	MHC8107	8	295	0.0078	1.09	299.6	0.43	4.82	1.00
GMC91006	MHC9105	MHC9108	8	295	0.0217	0.61	156.2	0.22	5.19	0.52
GMC91010	MHC9108	MHC9110	8	338	0.0217	0.61	156.2	0.22	5.18	0.52
GMC91012	MHC9110	MHC9115	8	295	0.0217	0.61	156.2	0.22	5.18	0.52
GMC91017	MHC9115	MHC9118	8	182	0.0078	1.05	288.4	0.42	4.66	1.00
GMC91022	MHC9118	MHC9121	8	195	0.0078	1.05	288.4	0.42	4.66	1.00
GMC91023	MHC9119	MHC9120	12	45	0.0031	0.23	51.2	0.07	1.90	0.28
GMC91024	MHC9120	MHC9122	12	304	0.003	0.23	51.2	0.07	1.88	0.29
GMC91025	MHC9121	MHC8104	8	207	0.0078	1.05	288.4	0.42	4.66	1.00
GMC91026	MHC9122	MHC9123	12	338	0.003	0.23	51.2	0.07	1.88	0.29
GMD61002	MHD6101	MHD7118	12	346	0.0473	1.34	378.2	0.54	8.37	0.35
GMD71001	MHC7103	MHD7101	10	131	0.1473	0.03	5.1	0.01	4.09	0.05
GMD71003	MHD7101	MHD7106	10	250	0.0284	0.04	7.3	0.01	2.54	0.09
GMD71009	MHD7106	MHD7112	12	219	0.0032	0.04	7.3	0.01	1.15	0.12
GMD71015	MHD7112	MHD7121	12	399	0.0033	0.04	7.3	0.01	1.17	0.12
GMD71021	MHD7118	MHD7120	12	184	0.0497	1.34	378.2	0.54	8.52	0.35
GMD71023	MHD7120	MHD7123	12	148	0.0534	1.34	378.2	0.54	8.75	0.34
GMD71024	MHD7121	MHD7122	12	33	0.0009	0.05	9.5	0.01	0.80	0.18
GMD71025	MHD7122	MHD7127	10	392	0.0086	0.06	11.8	0.02	1.90	0.15
GMD71026	MHD7123	MHD7124	12	346	0.0417	1.53	437.7	0.63	8.29	0.39
GMD71027	MHD7124	MHD7125	12	181	0.035	1.53	437.7	0.63	7.78	0.41
GMD71028	MHD7125	MHD7126	12	306	0.0382	1.53	437.7	0.63	8.02	0.40
GMD71029	MHD7126	MHD7128	12	306	0.036	1.63	470.5	0.68	7.99	0.42
GMD71030	MHD7127	MHD7131	10	380	0.0086	0.07	14.0	0.02	1.99	0.16
GMD71031	MHD7128	MHD7129	12	159	0.0353	1.63	470.5	0.68	7.93	0.42
GMD71032	MHD7129	MHD7130	12	141	0.0494	1.63	470.5	0.68	8.97	0.39
GMD71033	MHD7130	MHD7131	10	114	0.0664	1.63	470.5	0.68	10.08	0.47
GMD71034	MHD7131	MHD7133	10	110	0.0446	1.67	484.5	0.70	8.73	0.53

APPENDIX B TABLE B-2 ULTIMATE WASTEWATER FLOWS										
SEWER REACH	FROM MANHOLE	TO MANHOLE	SEWER DIAMETER (in)	SEWER LENGTH (ft)	SEWER SLOPE	ULTIMATE PEAK WASTEWATER FLOW (MGD)	ULTIMATE AVERAGE DAILY WASTEWATER FLOW		VELOCITY (ft/s)	DEPTH OF FLOW TO SEWER DIAMETER RATIO (d/D)
							(gpm)	(MGD)		
GMD71035	MHD7136	MHD7132	12	304	0.0063	1.71	498.7	0.72	4.10	0.77
GMD71036	MHD7133	MHD7135	10	236	0.0256	1.67	484.5	0.70	7.04	0.64
GMD71037	MHD7135	MHD7136	12	428	0.0127	1.71	498.7	0.72	5.46	0.59
GMD81002	MHC8107	MHD8101	8	345	0.0045	1.09	299.6	0.43	4.82	1.00
GMD81003	MHD8101	MHD8102	8	345	0.0047	1.09	299.6	0.43	4.82	1.00
GMD81004	MHD8102	MHD8105	10	345	0.0047	1.12	310.7	0.45	3.19	1.00
GMD81007	MHD8105	MHD8106	10	345	0.0047	1.12	310.7	0.45	3.19	1.00
GMD81008	MHD8106	MHD8107	10	183	0.0047	1.12	310.7	0.45	3.19	1.00
GMD81009	MHD8107	MHD8108	10	190	0.0052	1.12	310.7	0.45	3.19	1.00
GMD81010	MHD8108	MHD8109	10	60	0.0502	1.12	310.7	0.45	8.24	0.41
GMD81011	MHD8109	MHD8118	15	320	0.0228	1.36	384.1	0.55	6.35	0.31
GMD81012	MHD8111	MHD8109	12	126	0.004	0.31	73.4	0.11	2.28	0.31
GMD81013	MHD8112	MHD8111	12	246	0.004	0.31	73.4	0.11	2.28	0.31
GMD81014	MHD8116	MHD8112	12	245	0.004	0.31	73.4	0.11	2.29	0.31
GMD81015	MHD8113	MHD8117	12	295	0.004	0.27	62.3	0.09	2.19	0.29
GMD81016	MHD8114	MHD8113	12	243	0.0075	0.27	62.3	0.09	2.75	0.25
GMD81017	MHD8115	MHD8114	12	295	0.003	0.27	62.3	0.09	1.98	0.31
GMD81018	MHD8117	MHD8116	12	345	0.004	0.31	73.4	0.11	2.29	0.31
GMD81019	MHD8118	MHD8119	15	208	0.0049	1.38	390.5	0.56	3.63	0.48
GMD81021	MHD8119	MHD8121	15	186	0.0192	1.39	392.8	0.57	6.00	0.33
GMD81023	MHD8121	MHD8122	16	320	0.0016	1.39	392.8	0.57	2.38	0.62
GMD81024	MHD8122	MHD8123	16	20	0.148	1.39	395.1	0.57	12.35	0.18
GMD81025	MHD8123	MHD8125	15	186	0.005	1.39	395.1	0.57	3.67	0.48
GMD81026	MHD7132	MHD8124	12	324	0.0064	1.72	500.9	0.72	4.12	0.77
GMD81028	MHD8124	MHD8126	15	138	0.0037	1.72	500.9	0.72	3.45	0.60
GMD81029	MHD8125	MHD8126	15	5	0.006	1.39	395.1	0.57	3.93	0.46
GMD91001	MHC9123	MHD9101	12	295	0.003	0.23	51.2	0.07	1.88	0.29
GMD91002	MHD9101	MHD9102	12	295	0.003	0.23	51.2	0.07	1.88	0.29
GMD91003	MHD9102	MHD9103	12	295	0.003	0.23	51.2	0.07	1.88	0.29
GMD91004	MHD9103	MHD9104	12	311	0.0027	0.23	51.2	0.07	1.81	0.29
GMD91005	MHD9104	MHD9105	12	345	0.0104	0.23	51.2	0.07	2.93	0.21
GMD91006	MHD9105	MHD9106	12	245	0.003	0.23	51.2	0.07	1.89	0.29
GMD91007	MHD9106	MHD9107	12	100	0.003	0.23	51.2	0.07	1.88	0.29

APPENDIX B TABLE B-2 ULTIMATE WASTEWATER FLOWS										
SEWER REACH	FROM MANHOLE	TO MANHOLE	SEWER DIAMETER (in)	SEWER LENGTH (ft)	SEWER SLOPE	ULTIMATE PEAK WASTEWATER FLOW (MGD)	ULTIMATE AVERAGE DAILY WASTEWATER FLOW		VELOCITY (ft/s)	DEPTH OF FLOW TO SEWER DIAMETER RATIO (d/D)
							(gpm)	(MGD)		
GMD91008	MHD9107	MHD8115	12	345	0.003	0.27	62.3	0.09	1.98	0.31
GME71003	MHE7101	MHE7103	12	515	0.0097	2.89	896.0	1.29	5.68	1.00
GME71005	MHE7103	MHE7104	12	388	0.0096	2.89	896.0	1.29	5.68	1.00
GME71008	MHE7104	MHE7107	12	401	0.0096	2.91	905.1	1.30	5.74	1.00
GME71011	MHE7107	MHE8108	12	276	0.0138	2.95	917.9	1.32	5.81	1.00
GME81001	MHD8126	MHE7101	15	404	0.0046	2.89	896.0	1.29	3.64	1.00
GME81010	MHE8108	MHE8109	12	376	0.0096	2.95	917.9	1.32	5.81	1.00
GME81011	MHE8109	MHE8115	10	376	0.0311	2.98	930.8	1.34	8.47	1.00
GME81012	MHE8110	MHF8101	8	302	0.0583	0.30	70.0	0.10	6.12	0.27
GMF51001	MHF5101	MHF5104	8	382	0.0184	0.16	34.2	0.05	3.38	0.26
GMF51006	MHF5104	MHF5113	8	382	0.0098	0.16	34.2	0.05	2.70	0.31
GMF51016	MHF5113	MHF5116	8	96	0.0832	0.16	34.2	0.05	5.76	0.18
GMF51020	MHF5116	MHF5123	8	215	0.0765	0.16	34.2	0.05	5.59	0.18
GMF51027	MHF5123	MHF5125	8	95	0.0579	0.16	34.2	0.05	5.07	0.20
GMF71003	MHF8112	MHF7103	15	272	0.0053	3.31	1043.9	1.50	4.17	1.00
GMF71005	MHF7103	MHF7107	15	383	0.0055	3.40	1077.8	1.55	4.29	1.00
GMF71010	MHF7107	MHF7112	15	371	0.0055	3.48	1104.9	1.59	4.38	1.00
GMF71014	MHF7112	MHF7113	15	371	0.0055	3.51	1115.8	1.61	4.42	1.00
GMF71015	MHF7113	MHG7101	15	371	0.0055	3.51	1115.8	1.61	4.42	1.00
GMF81001	MHE8115	MHF8103	15	342	0.0058	3.21	1009.3	1.45	4.04	1.00
GMF81002	MHF8102	MHE8115	10	414	0.0038	0.33	78.6	0.11	2.31	0.43
GMF81003	MHF8101	MHF8105	8	263	0.0596	0.30	70.0	0.10	6.16	0.27
GMF81004	MHF8106	MHF8102	10	414	0.0035	0.32	76.0	0.11	2.23	0.43
GMF81005	MHF8103	MHF8109	15	345	0.0055	3.21	1009.3	1.45	4.04	1.00
GMF81008	MHF8105	MHF8108	8	291	0.0233	0.32	76.0	0.11	4.49	0.35
GMF81009	MHF8108	MHF8106	10	126	0.0025	0.32	76.0	0.11	1.98	0.47
GMF81011	MHF8109	MHF8112	15	271	0.0054	3.31	1043.9	1.50	4.17	1.00
GMG31050	MHG3143	MHG3145	8	171	0.0086	0.32	75.6	0.11	3.12	0.46
GMG31052	MHG3145	MHG3151	8	390	0.0321	0.32	75.6	0.11	5.04	0.32
GMG31058	MHG3151	MHG3155	8	391	0.0293	0.32	75.6	0.11	4.87	0.33
GMG41029	MHG3155	MHG4127	8	316	0.0231	0.32	75.6	0.11	4.47	0.35
GMG41030	MHG4131	MHG4125	10	115	0.0107	0.63	162.6	0.23	4.02	0.46
GMG41031	MHG4125	MHG4132	10	491	0.003	0.75	197.8	0.28	2.52	0.79

APPENDIX B TABLE B-2 ULTIMATE WASTEWATER FLOWS										
SEWER REACH	FROM MANHOLE	TO MANHOLE	SEWER DIAMETER (in)	SEWER LENGTH (ft)	SEWER SLOPE	ULTIMATE PEAK WASTEWATER FLOW (MGD)	ULTIMATE AVERAGE DAILY WASTEWATER FLOW		VELOCITY (ft/s)	DEPTH OF FLOW TO SEWER DIAMETER RATIO (d/D)
							(gpm)	(MGD)		
GMG41034	MHG4127	MHG4131	8	306	0.019	0.32	75.6	0.11	4.16	0.37
GMG41040	MHG4132	MHG4134	10	375	0.0032 (1)	0.75	197.8	0.28	2.59	0.77
GMG41042	MHG4134	MHG4137	10	322	0.0032 (1)	0.75	197.8	0.28	2.59	0.77
GMG51001	MHF5125	MHG5104	8	303	0.0809	0.16	34.2	0.05	5.71	0.18
GMG51007	MHG5104	MHG5111	8	312	0.0577	0.16	34.2	0.05	5.06	0.20
GMG51014	MHG5111	MHG5114	8	96	0.2432	0.20	44.2	0.06	8.99	0.15
GMG51017	MHG5114	MHG5115	8	27	0.0478	0.20	44.2	0.06	5.06	0.23
GMG51018	MHG5115	MHG5116	8	185	0.0497	0.20	44.2	0.06	5.14	0.23
GMG51019	MHG5116	MHG5118	8	215	0.0132	0.20	44.2	0.06	3.20	0.32
GMG51021	MHG5118	MHG5119	8	132	0.0135	0.20	44.2	0.06	3.22	0.32
GMG51022	MHG5119	MHG5121	8	326	0.0141	0.22	49.9	0.07	3.38	0.33
GMG51024	MHG5121	MHG5122	8	166	0.0246	0.22	49.9	0.07	4.12	0.29
GMG51025	MHG5122	MHG5126	8	154	0.005 (1)	0.22	49.9	0.07	2.31	0.44
GMG51029	MHG5126	MHG5127	8	186	0.0197	0.22	49.9	0.07	3.81	0.30
GMG51030	MHG5127	MHG5130	8	126	0.0103	0.24	55.6	0.08	3.10	0.38
GMG51035	MHG5130	MHG5135	8	291	0.0183 (1)	0.24	55.6	0.08	3.81	0.33
GMG51040	MHG5135	MHG5138	8	312	0.0496 (1)	0.27	61.3	0.09	5.58	0.26
GMG51046	MHG5138	MHG5141	8	174	0.0599	0.27	61.3	0.09	5.97	0.25
GMG61009	MHG6107	MHG6118	8	623	0.0039	0.49	122.6	0.18	2.18	1.00
GMG61019	MHG6118	MHG6122	8	121	0.0395	0.49	122.6	0.18	6.12	0.39
GMG61023	MHG6122	MHG6123	10	297	0.0217	0.49	122.6	0.18	4.85	0.33
GMG61024	MHG6123	MHG6126	8	335	0.0185	0.49	122.6	0.18	4.63	0.48
GMG61027	MHG6126	MHG6130	8	124	0.1704	0.49	122.6	0.18	10.35	0.26
GMG61032	MHG6130	MHH6101	8	299	0.0341	0.51	128.3	0.18	5.86	0.41
GMG71002	MHG7101	MHG7104	15	225	0.0052	3.58	1141.6	1.64	4.51	1.00
GMG71005	MHG7104	MHG7109	15	350	0.0055	3.58	1141.6	1.64	4.51	1.00
GMG71012	MHG7109	MHG7113	15	107	0.0609	3.58	1141.6	1.64	11.84	0.41
GMG71014	MHG7113	MHG7114	15	263	0.0088 (1)	3.58	1141.6	1.64	2.80	0.75
GMG71017	MHG7114	MHG7115	18	313	0.0034	3.58	1141.6	1.64	3.95	0.74
GMG71018	MHG7115	MHG7116	18	234	0.0032	3.58	1141.6	1.64	3.83	0.76
GMG71019	MHG7116	MHG7117	18	293	0.0034	3.58	1141.6	1.64	3.92	0.75
GMG71020	MHG7117	MHG7118	18	399	0.004	3.58	1141.6	1.64	4.23	0.69
GMH41001	MHG4137	MHH4103	10	246	0.0036 (1)	0.77	203.8	0.29	2.73	0.75

APPENDIX B TABLE B-2 ULTIMATE WASTEWATER FLOWS										
SEWER REACH	FROM MANHOLE	TO MANHOLE	SEWER DIAMETER (in)	SEWER LENGTH (ft)	SEWER SLOPE	ULTIMATE PEAK WASTEWATER FLOW (MGD)	ULTIMATE AVERAGE DAILY WASTEWATER FLOW		VELOCITY (ft/s)	DEPTH OF FLOW TO SEWER DIAMETER RATIO (d/D)
							(gpm)	(MGD)		
GMH41006	MHH4103	MHH4111	10	232	0.008 (1)	0.77	203.8	0.29	3.78	0.56
GMH41016	MHH4111	MHH4117	10	264	0.008 (1)	0.77	203.8	0.29	3.77	0.56
GMH41026	MHH4119	MHH4122	10	356	0.0032 (1)	0.77	203.8	0.29	2.60	0.79
GMH41029	MHH4122	MHH4123	10	162	0.0032 (1)	0.77	203.8	0.29	2.60	0.79
GMH41030	MHH4123	MHH4125	10	211	0.01	0.77	203.8	0.29	4.12	0.53
GMH41035	MHH4125	MHH4129	10	18	0.145	0.77	203.8	0.29	10.88	0.26
GMH41040	MHH4129	MHH4131	8	82	0.028	0.77	203.8	0.29	6.05	0.55
GMH41042	MHH4131	MHH4135	8	248	0.0186 (1)	0.77	203.8	0.29	5.16	0.63
GMH51003	MHG5141	MHH5106	8	346	0.0312	0.27	61.3	0.09	4.73	0.30
GMH51009	MHH5106	MHH6111	8	346	0.0191	0.29	67.0	0.10	4.05	0.35
GMH51014	MHH6111	MHH5118	8	358	0.0263	0.29	67.0	0.10	4.55	0.32
GMH51022	MHH5118	MHH5127	8	356	0.0062	0.31	73.1	0.11	2.73	0.50
GMH51025	MHH5121	MHH5124	8	126	0.0406	0.44	106.9	0.15	5.97	0.36
GMH51028	MHH5124	MHH5129	8	381	0.0152	0.46	112.6	0.16	4.22	0.48
GMH51031	MHH5127	MHH5131	8	331	0.0154	0.31	73.1	0.11	3.83	0.39
GMH51033	MHH5129	MHH5132	8	385	0.0223	0.46	114.0	0.16	4.87	0.44
GMH51035	MHH5131	MHH5132	8	24	0.0066	0.31	73.1	0.11	2.80	0.49
GMH51036	MHH5132	MHH5136	15	37	0.0863	0.72	187.1	0.27	8.45	0.16
GMH51037	MHH5133	MHH5138	8	351	0.0108	0.00	0.0	0.00	0.00	0.00
GMH51040	MHH5136	MHH5139	15	320	0.0084	0.72	187.1	0.27	3.71	0.29
GMH51042	MHH6131	MHH5141	8	130	0.004 (1)	0.58	148.1	0.21	2.58	1.00
GMH51043	MHH5138	MHH5141	8	259	0.0035	0.04	6.3	0.01	1.21	0.19
GMH51044	MHH5139	MHH5143	15	290	0.0042	0.72	187.1	0.27	2.89	0.35
GMH51046	MHH5141	MHH5143	8	63	0.0147	0.60	154.4	0.22	4.45	0.58
GMH51049	MHH5143	MHH6140	15	216	0.0135	1.22	341.5	0.49	5.11	0.34
GMH51056	MHH4135	MHH5147	8	125	0.0421	0.77	203.8	0.29	7.05	0.49
GMH51057	MHH5147	MHI5102	8	319	0.0151 (1)	0.77	203.8	0.29	4.74	0.68
GMH61002	MHH6101	MHH6106	8	295	0.0215	0.51	128.3	0.18	4.95	0.47
GMH61008	MHH6106	MHH6108	8	102	0.0065	0.52	130.2	0.19	3.12	0.69
GMH61010	MHH6108	MHH6109	8	94	0.0437	0.52	130.2	0.19	6.44	0.39
GMH61011	MHH6109	MHH6115	8	292	0.0228 (1)	0.52	130.2	0.19	5.07	0.46
GMH61016	MHH6115	MHH6120	8	318	0.005	0.52	130.2	0.19	2.79	0.77
GMH61021	MHH6120	MHH6125	8	373	0.0051	0.54	135.2	0.19	2.83	0.78

APPENDIX B TABLE B-2 ULTIMATE WASTEWATER FLOWS										
SEWER REACH	FROM MANHOLE	TO MANHOLE	SEWER DIAMETER (in)	SEWER LENGTH (ft)	SEWER SLOPE	ULTIMATE PEAK WASTEWATER FLOW (MGD)	ULTIMATE AVERAGE DAILY WASTEWATER FLOW		VELOCITY (ft/s)	DEPTH OF FLOW TO SEWER DIAMETER RATIO (d/D)
							(gpm)	(MGD)		
GMH61026	MHH6125	MHH6131	8	371	0.0102	0.54	135.2	0.19	3.77	0.60
GMH61028	MHH6127	MHH6134	18	302	0.0044	4.28	1395.6	2.01	4.48	0.78
GMH61036	MHH6134	MHH6135	21	3	0.0036	4.28	1395.6	2.01	4.27	0.61
GMH61039	MHH6135	MHH6137	21	172	0.0038	4.33	1412.8	2.03	4.38	0.61
GMH61040	MHH6137	MHH6145	21	172	0.0037	4.33	1412.8	2.03	4.35	0.61
GMH61043	MHH6140	MHH6146	15	143	0.0069	1.22	341.5	0.49	3.99	0.41
GMH61048	MHH6145	MHI6107	21	306	0.0065	4.35	1421.7	2.05	5.40	0.51
GMH61050	MHH6146	MHI5104	15	259	0.0049	1.22	341.5	0.49	3.53	0.45
GMH71001	MHG7118	MHH7101	18	502	0.0036	3.93	1268.6	1.83	4.09	0.79
GMH71002	MHH7101	MHH7102	18	360	0.0035	3.93	1268.6	1.83	4.00	0.80
GMH71003	MHH7102	MHH7103	18	396	0.0035	3.93	1268.6	1.83	4.04	0.80
GMH71004	MHH7103	MHH7104	18	396	0.0035	3.93	1268.6	1.83	4.04	0.80
GMH71005	MHH7104	MHH7105	18	396	0.0035	4.28	1395.6	2.01	3.75	1.00
GMH71006	MHH7105	MHH6127	18	396	0.0035	4.28	1395.6	2.01	3.75	1.00
GMI31026	MHI3120	MHI3121	8	222	0.0563	0.17	36.6	0.05	5.11	0.20
GMI31028	MHI3121	MHI3124	8	327	0.0362	0.17	36.6	0.05	4.37	0.23
GMI31035	MHI3124	MHI4112	8	326	0.0312	0.17	36.6	0.05	4.15	0.24
GMI31048	MHI3148	MHI4116	8	288	0.0258	0.22	50.7	0.07	4.21	0.29
GMI31060	MHI3150	MHI3148	8	124	0.0301	0.22	50.7	0.07	4.45	0.27
GMI31063	MHI3149	MHI3150	8	205	0.0299	0.22	50.7	0.07	4.44	0.28
GMI31065	MHI3151	MHI3149	8	41	0.2165	0.22	50.7	0.07	8.95	0.17
GMI41005	MHI4107	MHI4106	8	267	0.0035	0.09	17.4	0.03	1.56	0.29
GMI41006	MHI4106	MHI4111	8	427	0.003	0.10	20.6	0.03	1.55	0.33
GMI41007	MHI4110	MHI4107	8	265	0.0026	0.09	17.4	0.03	1.41	0.32
GMI41013	MHI4111	MHI5150	8	391	0.0088	0.10	20.6	0.03	2.28	0.25
GMI41014	MHI4116	MHI4112	8	271	0.014	0.22	50.7	0.07	3.39	0.33
GMI41015	MHI4112	MHI4113	8	373	0.0371	0.36	87.3	0.13	5.50	0.33
GMI41016	MHI4113	MHI4115	8	366	0.0445	0.39	93.3	0.13	5.97	0.33
GMI41018	MHI4115	MHI4119	8	221	0.0072	0.39	93.3	0.13	3.06	0.55
GMI41021	MHI4119	MHI4123	8	222	0.0073	0.39	94.0	0.14	3.07	0.55
GMI41023	MHI4123	MHI4121	8	61	0.0013	0.48	118.2	0.17	2.11	1.00
GMI41024	MHI4121	MHI4122	8	22	0.0139 (1)	0.48	118.2	0.17	4.12	0.51
GMI41026	MHI4122	MHI4127	8	269	0.0033	0.48	118.2	0.17	2.11	1.00

APPENDIX B TABLE B-2 ULTIMATE WASTEWATER FLOWS										
SEWER REACH	FROM MANHOLE	TO MANHOLE	SEWER DIAMETER (in)	SEWER LENGTH (ft)	SEWER SLOPE	ULTIMATE PEAK WASTEWATER FLOW (MGD)	ULTIMATE AVERAGE DAILY WASTEWATER FLOW		VELOCITY (ft/s)	DEPTH OF FLOW TO SEWER DIAMETER RATIO (d/D)
							(gpm)	(MGD)		
GMI41027	MHI4128	MHI4123	8	316	0.016	0.12	24.2	0.03	2.94	0.23
GMI41035	MHJ4102	MHI4128	8	281	0.0601	0.12	24.2	0.03	4.69	0.17
GMI51006	MHI5102	MHI5112	8	455	0.0165	0.81	216.4	0.31	4.97	0.68
GMI51009	MHI5104	MHI5119	18	397	0.0051	1.22	341.5	0.49	3.55	0.34
GMI51010	MHI5112	MHI5105	10	125	0.008 (1)	0.81	216.4	0.31	3.82	0.58
GMI51011	MHI5105	MHI5117	8	408	0.0142	0.81	216.4	0.31	4.66	0.72
GMI51026	MHI5117	MHI5125	8	408	0.0127	0.84	223.6	0.32	4.46	0.78
GMI51028	MHI5119	MHI5131	18	367	0.0056	1.22	341.5	0.49	3.67	0.33
GMI51035	MHI5125	MHI5132	10	252	0.0026	0.93	249.6	0.36	2.62	1.00
GMI51041	MHI6139	MHI5144	8	366	0.0055	0.22	50.4	0.07	2.41	0.43
GMI51042	MHI5131	MHI5142	18	425	0.0058	1.22	341.5	0.49	3.72	0.33
GMI51043	MHI5132	MHI5138	10	261	0.003 (1)	0.94	254.4	0.37	2.67	1.00
GMI51051	MHI5138	MHI5146	10	310	0.0103	0.98	266.3	0.38	4.40	0.60
GMI51054	MHI5142	MHI5145	18	66	0.0045	1.25	350.0	0.50	3.42	0.36
GMI51056	MHI5144	MHI5156	8	368	0.0085	0.22	50.4	0.07	2.82	0.38
GMI51057	MHI5145	MHI5146	18	5	0.5761	1.25	350.0	0.50	18.97	0.11
GMI51060	MHI5146	MHI5154	18	410	0.0059	2.07	616.2	0.89	4.32	0.44
GMI51067	MHI5150	MHI5165	8	463	0.0135	0.10	20.6	0.03	2.65	0.22
GMI51072	MHI5154	MHI5157	21	63	0.0044	2.07	616.2	0.89	3.85	0.38
GMI51073	MHI5155	MHI5160	21	82	0.0021	4.70	1551.0	2.23	3.02	1.00
GMI51074	MHI5162	MHI5155	21	204	0.002	4.70	1551.0	2.23	3.02	1.00
GMI51075	MHI5156	MHI5172	8	319	0.004	0.22	50.4	0.07	2.15	0.47
GMI51077	MHI5157	MHI5163	21	57	0.0028 (1)	6.33	2167.2	3.12	4.07	1.00
GMI51078	MHI5160	MHI5157	18	44	0.0199	2.47	750.7	1.08	6.88	0.33
GMI51079	MHI5160	MHI5157	18	39	0.0226	2.61	800.3	1.15	7.34	0.33
GMI51083	MHI5166	MHI5162	21	202	0.002	4.70	1551.0	2.23	3.02	1.00
GMI51084	MHI5163	MHI5173	21	179	0.0028 (1)	6.33	2167.2	3.12	4.07	1.00
GMI51086	MHI5165	MHI5168	8	29	0.0255	0.10	20.6	0.03	3.32	0.19
GMI51087	MHI5167	MHI5166	21	13	0.0022	4.70	1551.0	2.23	3.57	0.79
GMI51088	MHI5172	MHI5167	21	105	0.002	4.70	1551.0	2.23	3.02	1.00
GMI51089	MHI5168	MHI5171	12	212	0.0114	0.10 (2)	20.6	0.03	2.38	0.14
GMI51093	MHI5171	MHI5175	12	111	0.0248	0.10 (2)	20.6	0.03	3.12	0.11
GMI51095	MHI5177	MHI5172	21	235	0.0029	4.57	1500.5	2.16	3.97	0.69

APPENDIX B TABLE B-2 ULTIMATE WASTEWATER FLOWS										
SEWER REACH	FROM MANHOLE	TO MANHOLE	SEWER DIAMETER (in)	SEWER LENGTH (ft)	SEWER SLOPE	ULTIMATE PEAK WASTEWATER FLOW (MGD)	ULTIMATE AVERAGE DAILY WASTEWATER FLOW		VELOCITY (ft/s)	DEPTH OF FLOW TO SEWER DIAMETER RATIO (d/D)
							(gpm)	(MGD)		
GMI51097	MHI5173	MHI5178	21	160	0.0028 (1)	6.41	2197.3	3.16	4.12	1.00
GMI51099	MHI5175	MHI5182	12	158	0.013	0.10 (2)	20.6	0.03	2.49	0.13
GMI51101	MHI5185	MHI5177	21	235	0.0029	4.57	1500.5	2.16	3.97	0.69
GMI51102	MHI5178	MHI5181	21	303	0.003 (1)	6.43	2204.1	3.17	4.14	1.00
GMI51107	MHI5181	MHI5183	24	69	0.0016 (1)	6.43	2204.1	3.17	3.17	1.00
GMI51108	MHI5182	MHI5190	8	282	0.004	0.10	20.6	0.03	1.72	0.31
GMI51110	MHI5183	MHI5188	24	244	0.0016 (1)	6.43	2204.1	3.17	3.17	1.00
GMI51112	MHI6179	MHI5185	21	213	0.0029	4.54	1492.0	2.15	3.95	0.69
GMI61011	MHI6107	MHI6113	21	140	0.004	4.35	1421.7	2.05	4.48	0.60
GMI61013	MHI6108	MHI6111	21	85	0.004	4.35	1421.7	2.05	4.48	0.60
GMI61014	MHI6113	MHI6108	21	55	0.0038	4.35	1421.7	2.05	4.40	0.61
GMI61016	MHI6111	MHI6123	21	223	0.004	4.35	1421.7	2.05	4.47	0.60
GMI61022	MHI6117	MHI6131	8	289	0.0024	0.14	30.1	0.04	1.57	0.42
GMI61028	MHI6123	MHI6132	21	223	0.0262	4.35	1421.7	2.05	9.00	0.35
GMI61030	MHI6125	MHI6139	8	367	0.0058	0.22	50.4	0.07	2.45	0.42
GMI61031	MHI6131	MHI6125	8	50	0.003 (1)	0.22	50.4	0.07	1.92	0.51
GMI61038	MHI6132	MHI6140	21	289	0.0108	4.41	1444.0	2.08	6.54	0.45
GMI61046	MHI6140	MHI6143	21	116	0.0032	4.46	1459.8	2.10	4.11	0.66
GMI61050	MHI6143	MHI6153	21	317	0.0074	4.49	1474.0	2.12	5.69	0.51
GMI61061	MHI6153	MHI6160	21	317	0.0025	4.49	1474.0	2.12	3.74	0.72
GMI61068	MHI6160	MHI6170	21	317	0.0025	4.49	1474.0	2.12	3.74	0.72
GMI61076	MHI6170	MHI6172	21	175	0.0025	4.52	1483.5	2.14	3.73	0.73
GMI61079	MHI6172	MHI6177	21	175	0.0026	4.52	1483.5	2.14	3.77	0.72
GMI61084	MHI6177	MHJ6103	21	224	0.0025	4.52	1483.5	2.14	3.73	0.73
GMJ31007	MHJ3119	MHJ3110	8	131	0.1098	0.12	24.2	0.03	5.80	0.14
GMJ31008	MHJ3110	MHJ3117	8	202	0.0704	0.12	24.2	0.03	4.96	0.16
GMJ41001	MHI4127	MHJ4104	8	368	0.0231	0.48	118.2	0.17	4.98	0.44
GMJ41005	MHJ4107	MHJ4102	8	221	0.1233	0.12	24.2	0.03	6.04	0.14
GMJ41006	MHJ4105	MHJ4103	8	42	0.0723	0.58	147.0	0.21	7.96	0.36
GMJ41007	MHJ4103	MHJ4109	15	222	0.0154	0.58	147.0	0.21	4.32	0.23
GMJ41008	MHJ4104	MHJ4105	8	193	0.0562	0.48	118.2	0.17	6.89	0.35
GMJ41010	MHJ4110	MHJ4107	8	237	0.0442	0.12	24.2	0.03	4.21	0.18
GMJ41012	MHJ4109	MHJ4113	15	296	0.0213	0.58	147.0	0.21	4.84	0.21

APPENDIX B TABLE B-2 ULTIMATE WASTEWATER FLOWS										
SEWER REACH	FROM MANHOLE	TO MANHOLE	SEWER DIAMETER (in)	SEWER LENGTH (ft)	SEWER SLOPE	ULTIMATE PEAK WASTEWATER FLOW (MGD)	ULTIMATE AVERAGE DAILY WASTEWATER FLOW		VELOCITY (ft/s)	DEPTH OF FLOW TO SEWER DIAMETER RATIO (d/D)
							(gpm)	(MGD)		
GMJ41013	MHJ3117	MHJ4110	8	211	0.0235	0.12	24.2	0.03	3.37	0.21
GMJ41016	MHJ4113	MHJ4120	15	396	0.016	0.63	161.4	0.23	4.48	0.23
GMJ41024	MHJ4120	MHJ4128	15	396	0.0077	0.63	161.4	0.23	3.45	0.28
GMJ41029	MHJ4125	MHJ4127	24	11	0.0009	6.53	2242.4	3.23	3.22	1.00
GMJ41031	MHJ4127	MHJ4136	24	260	0.0015 (1)	6.53	2242.4	3.23	3.22	1.00
GMJ41033	MHJ4128	MHJ4136	15	396	0.0074	0.63	161.4	0.23	3.40	0.28
GMJ41042	MHJ4136	MHJ4145	24	217	0.0021	6.95	2403.8	3.46	3.42	1.00
GMJ41046	MHJ4140	MHJ4141	15	37	0.0016	0.53	132.7	0.19	1.89	0.38
GMJ41047	MHJ4146	MHJ4140	12	245	0.002	0.49	122.7	0.18	2.01	0.49
GMJ41048	MHJ4141	MHJ4147	15	325	0.001	0.53	132.7	0.19	1.58	0.44
GMJ41052	MHJ4145	MHJ4150	24	225	0.0031	6.95	2403.8	3.46	4.52	0.71
GMJ41054	MHJ4147	MHJ4154	15	287	0.0009	0.53	132.7	0.19	1.54	0.45
GMJ41058	MHJ4150	MHJ4156	27	338	0.0016 (1)	6.95	2403.8	3.46	3.52	0.72
GMJ51001	MHI5188	MHJ5104	24	119	0.0016 (1)	6.43	2204.1	3.17	3.17	1.00
GMJ51002	MHI5190	MHJ5105	12	284	0.004	0.12	25.5	0.04	1.74	0.20
GMJ51007	MHJ5104	MHJ5106	24	156	0.0016 (1)	6.43	2204.1	3.17	3.17	1.00
GMJ51008	MHJ5105	MHJ5108	12	204	0.0043	0.13	26.6	0.04	1.80	0.20
GMJ51011	MHJ5106	MHJ5110	24	189	0.0016 (1)	6.43	2204.1	3.17	3.17	1.00
GMJ51014	MHJ5108	MHJ5110	12	161	0.004	0.15	31.5	0.05	1.84	0.21
GMJ51015	MHJ5110	MHJ5111	24	119	0.0016 (1)	6.53	2242.4	3.23	3.22	1.00
GMJ51016	MHJ5111	MHJ5115	24	248	0.0016 (1)	6.53	2242.4	3.23	3.22	1.00
GMJ51019	MHJ5115	MHJ4125	24	236	0.0014 (1)	6.53	2242.4	3.23	3.22	1.00
GMJ51020	MHJ5116	MHJ4146	12	357	0.0019	0.49	122.7	0.18	1.96	0.50
GMJ51021	MHJ5117	MHJ5116	12	357	0.0019	0.49	122.7	0.18	1.96	0.50
GMJ51022	MHJ5118	MHJ5117	12	196	0.0014	0.49	122.7	0.18	1.77	0.54
GMJ51023	MHJ5119	MHJ5118	12	190	0.0019	0.49	122.7	0.18	1.97	0.49
GMJ51024	MHJ5120	MHJ5119	12	7	0.2063	0.49	122.7	0.18	10.56	0.15
GMJ51029	MHJ5120	MHJ5119	12	6	0.2148	0.00	0.0	0.00	0.00	0.00
GMJ51030	MHJ5121	MHJ5120	12	278	0.0021	0.48	119.2	0.17	2.02	0.48
GMJ51031	MHK5101	MHJ5121	12	346	0.0019	0.48	119.2	0.17	1.94	0.49
GMJ61002	MHJ6104	MHI6179	21	213	0.0029	4.54	1492.0	2.15	3.98	0.69
GMJ61005	MHJ6103	MHJ6110	21	224	0.0025	4.52	1483.5	2.14	3.75	0.72
GMJ61006	MHJ6106	MHJ6104	21	183	0.0029	4.52	1483.5	2.14	3.96	0.69

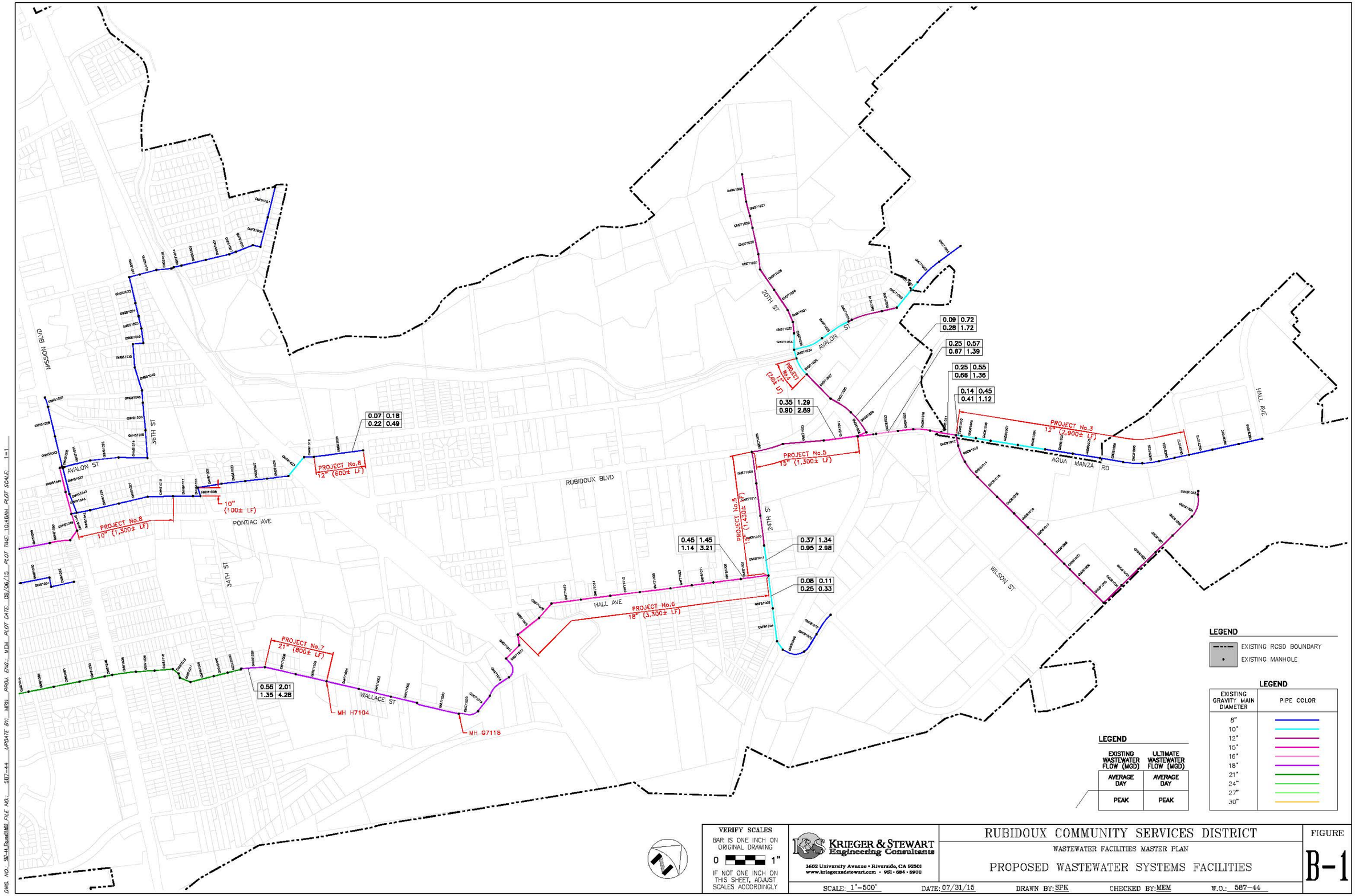
APPENDIX B TABLE B-2 ULTIMATE WASTEWATER FLOWS										
SEWER REACH	FROM MANHOLE	TO MANHOLE	SEWER DIAMETER (in)	SEWER LENGTH (ft)	SEWER SLOPE	ULTIMATE PEAK WASTEWATER FLOW (MGD)	ULTIMATE AVERAGE DAILY WASTEWATER FLOW		VELOCITY (ft/s)	DEPTH OF FLOW TO SEWER DIAMETER RATIO (d/D)
							(gpm)	(MGD)		
GMJ61009	MHJ6111	MHJ6106	21	183	0.0028	4.52	1483.5	2.14	3.93	0.69
GMJ61012	MHJ6110	MHJ6111	21	88	0.0029	4.52	1483.5	2.14	3.99	0.68
GMK21001	MHJ2134	MHK2104	8	204	0.1568	0.09	18.5	0.03	6.11	0.12
GMK21004	MHK2104	MHK2106	8	140	0.0027	0.09	18.5	0.03	1.46	0.32
GMK21006	MHK2106	MHK2107	8	50	0.0040 (1)	0.09	18.5	0.03	1.60	0.28
GMK21008	MHK2107	MHK2108	8	183	0.0508	0.09	18.5	0.03	4.12	0.15
GMK21009	MHK2108	MHK2112	8	119	0.0033	0.09	18.5	0.03	1.56	0.31
GMK21012	MHK2112	MHK2116	8	441	0.0086	0.09	18.5	0.03	2.20	0.24
GMK21018	MHK2116	MHK2123	8	426	0.0087	0.09	18.5	0.03	2.21	0.24
GMK21030	MHK2123	MHK2126	8	154	0.0767	0.15	31.9	0.05	5.50	0.18
GMK21032	MHK2133	MHK2125	8	338	0.0034	0.18	38.7	0.06	1.89	0.43
GMK21033	MHK2125	MHK2128	8	119	0.0335	0.20	44.9	0.06	4.48	0.25
GMK21035	MHK2126	MHK2133	8	261	0.0625	0.15	31.9	0.05	5.11	0.19
GMK21037	MHK2128	MHK2135	8	274	0.0346	0.29	68.6	0.10	5.05	0.30
GMK21048	MHK2135	MHK2140	8	318	0.0199	0.29	68.6	0.10	4.14	0.35
GMK21062	MHK2140	MHK2146	8	256	0.0196	0.29	68.6	0.10	4.12	0.35
GMK21070	MHK2146	MHK3128	8	136	0.019	0.29	68.6	0.10	4.10	0.35
GMK21077	MHK2151	MHK2159	8	247	0.0027	0.04	8.1	0.01	1.17	0.22
GMK31033	MHK3128	MHK3131	8	311	0.0555	0.29	68.6	0.10	5.98	0.27
GMK31036	MHK3131	MHL3101	8	267	0.0555	0.29	68.6	0.10	5.98	0.27
GMK31037	MHL3102	MHK3132	10	199	0.0056	0.13	27.2	0.04	2.04	0.24
GMK41001	MHJ4154	MHK4102	15	326	0.001	0.53	132.7	0.19	1.58	0.44
GMK41003	MHJ4156	MHK4105	27	275	0.0016 (1)	6.95	2403.8	3.46	3.52	0.72
GMK41006	MHK4102	MHK4106	15	243	0.0012	0.53	132.7	0.19	1.68	0.42
GMK41009	MHK4105	MHK4106	27	18	0.0028	6.98	2418.3	3.48	4.40	0.59
GMK41010	MHK4106	MHK4109	27	94	0.0016 (1)	7.32	2551.0	3.67	3.54	0.75
GMK41012	MHK4109	MHK4110	27	163	0.0016 (1)	7.32	2551.0	3.67	3.54	0.75
GMK41013	MHK4110	MHK4111	27	263	0.0016 (1)	7.32	2551.0	3.67	3.54	0.75
GMK41014	MHK4111	MHK4112	27	150	0.0016 (1)	7.36	2565.5	3.69	3.54	0.75
GMK41015	MHK4112	MHK4116	27	263	0.0016 (1)	7.36	2565.5	3.69	3.54	0.75
GMK41016	MHK4119	MHK4113	10	351	0.0027	0.13	27.2	0.04	1.57	0.28
GMK41017	MHK4113	MHK4114	10	275	0.0131	0.13	27.2	0.04	2.75	0.19
GMK41018	MHK4114	MHK4116	10	273	0.0134	0.13	27.2	0.04	2.78	0.19

APPENDIX B TABLE B-2 ULTIMATE WASTEWATER FLOWS										
SEWER REACH	FROM MANHOLE	TO MANHOLE	SEWER DIAMETER (in)	SEWER LENGTH (ft)	SEWER SLOPE	ULTIMATE PEAK WASTEWATER FLOW (MGD)	ULTIMATE AVERAGE DAILY WASTEWATER FLOW		VELOCITY (ft/s)	DEPTH OF FLOW TO SEWER DIAMETER RATIO (d/D)
							(gpm)	(MGD)		
GMK41019	MHK4120	MHK4115	10	252	0.0017	0.13	27.2	0.04	1.34	0.32
GMK41020	MHK4115	MHK4119	10	313	0.0238	0.13	27.2	0.04	3.40	0.16
GMK41021	MHK4116	NSK4101	30	17	0.0147	7.43	2592.7	3.73	8.26	0.33
GMK41022	NSK4101	MHK4118	21	17	0.0107	5.89	1997.0	2.88	6.96	0.52
GMK41023	NSK4101	MHK4117	18	22	0.0027	2.01	595.7	0.86	3.07	0.49
GMK41025	MHK4117	MHK4122	18	366	0.0026	2.01	595.7	0.86	3.17	0.54
GMK41026	MHK4118	MHK4123	21	332	0.0035	5.89	1997.0	2.88	4.45	0.79
GMK41027	MHK3132	MHK4120	10	252	0.0017	0.13	27.2	0.04	1.34	0.32
GMK51001	MHK5103	MHK5101	12	296	0.0018	0.48	119.2	0.17	1.90	0.50
GMK51003	MHK5105	MHK5103	12	346	0.0019	0.48	119.2	0.17	1.94	0.49
GMK51005	MHK5108	MHK5105	12	344	0.0022	0.48	119.2	0.17	2.05	0.47
GML21003	MHK2159	MHL2106	8	271	0.0328	0.06	11.1	0.02	3.08	0.14
GML21011	MHL2106	MHL2113	8	266	0.0326	0.07	14.1	0.02	3.28	0.15
GML21032	MHL2128	MHL2125	8	411	0.0046	0.11	24.0	0.03	1.87	0.32
GML21033	MHL2125	MHL2133	8	273	0.0589	0.12	24.7	0.04	4.68	0.17
GML21037	MHL2129	MHL2128	8	137	0.0037	0.11	24.0	0.03	1.74	0.33
GML21038	MHL2135	MHL2129	8	260	0.0043	0.11	24.0	0.03	1.84	0.32
GML21042	MHL2133	MHL2131	8	165	0.0193	0.19	41.5	0.06	3.61	0.28
GML21043	MHL2131	MHL2140	8	390	0.0197	0.43	104.9	0.15	4.57	0.43
GML21047	MHL2134	MHL2135	8	319	0.0045	0.11	24.0	0.03	1.86	0.32
GML21050	MHL2140	MHL2139	10	186	0.0091	0.43	104.9	0.15	3.41	0.39
GML21051	MHL2139	MHL2145	8	421	0.0343	0.46	113.0	0.16	5.70	0.39
GML31004	MHL3101	MHL3105	8	267	0.0555	0.29	68.6	0.10	5.98	0.27
GML31005	MHL3106	MHL3102	10	163	0.002	0.13	27.2	0.04	1.42	0.30
GML31009	MHL3105	MHL3109	8	360	0.0582	0.29	68.6	0.10	6.08	0.27
GML31010	MHL3115	MHL3106	10	360	0.002	0.13	27.2	0.04	1.40	0.31
GML31014	MHL2113	MHL3113	8	304	0.0393	0.09	17.2	0.02	3.69	0.16
GML31016	MHL3114	MHL3109	8	64	0.0538	0.15	32.3	0.05	4.87	0.19
GML31017	MHL3109	MHL3110	8	253	0.0536	0.41	100.9	0.15	6.51	0.32
GML31019	MHL3110	MHL3117	8	237	0.0337	0.41	100.9	0.15	5.51	0.37
GML31022	MHL3113	MHL3120	8	261	0.0398	0.10	20.2	0.03	3.87	0.17
GML31023	MHL3116	MHL3114	8	197	0.0602	0.14	29.3	0.04	4.93	0.18
GML31025	MHL3122	MHL3115	10	346	0.002	0.13	27.2	0.04	1.42	0.30

APPENDIX B TABLE B-2 ULTIMATE WASTEWATER FLOWS										
SEWER REACH	FROM MANHOLE	TO MANHOLE	SEWER DIAMETER (in)	SEWER LENGTH (ft)	SEWER SLOPE	ULTIMATE PEAK WASTEWATER FLOW (MGD)	ULTIMATE AVERAGE DAILY WASTEWATER FLOW		VELOCITY (ft/s)	DEPTH OF FLOW TO SEWER DIAMETER RATIO (d/D)
							(gpm)	(MGD)		
GML31026	MHL3119	MHL3116	8	348	0.0036	0.12	26.2	0.04	1.76	0.35
GML31027	MHL3117	MHL3121	8	178	0.0336	0.41	100.9	0.15	5.50	0.37
GML31031	MHL3127	MHL3118	12	311	0.0155	0.46	114.4	0.16	4.15	0.27
GML31032	MHL3118	MHL4124	12	230	0.0352	0.46	114.4	0.16	5.56	0.22
GML31033	MHL3120	MHL3119	8	339	0.0035	0.11	23.2	0.03	1.68	0.34
GML31036	MHL3121	MHL3124	8	219	0.0608	0.41	100.9	0.15	6.81	0.31
GML31038	MHL3126	MHL3123	12	57	0.0154	0.46	114.4	0.16	4.15	0.27
GML31039	MHL3123	MHL3128	12	201	0.0155	0.46	114.4	0.16	4.15	0.27
GML31040	MHL3124	MHL3131	12	131	0.0062	0.41	100.9	0.15	2.90	0.32
GML31043	MHL3133	MHL3126	12	140	0.0074	0.46	114.4	0.16	3.18	0.33
GML31045	MHL3128	MHL3127	12	33	0.0153	0.46	114.4	0.16	4.13	0.27
GML31054	MHL3137	MHL3133	12	100	0.0074	0.46	114.4	0.16	3.18	0.33
GML31055	MHL3134	MHL3143	12	270	0.0216	0.46	114.4	0.16	4.68	0.25
GML31058	MHL3142	MHL3137	12	171	0.0074	0.46	114.4	0.16	3.18	0.33
GML31061	MHL3147	MHL3131	12	224	0.0024	0.07	13.4	0.02	1.23	0.17
GML31063	MHL3143	MHL3142	12	92	0.0074	0.46	114.4	0.16	3.19	0.33
GML31068	MHL3149	MHL3146	12	135	0.0028	0.07	13.4	0.02	1.30	0.16
GML31069	MHL3146	MHL3148	12	462	0.0028	0.07	13.4	0.02	1.30	0.16
GML31070	MHL3148	MHL3147	8	5	0.0081	0.07	13.4	0.02	1.99	0.21
GML31075	MHL3154	MHL3149	8	135	0.0022	0.07	13.4	0.02	1.24	0.29
GML31083	MHL3158	MHL3154	8	151	0.0029	0.07	13.4	0.02	1.37	0.27
GML31090	MHL3162	MHL3158	8	103	0.0017	0.07	13.4	0.02	1.13	0.32
GML41001	MHK4122	MHL4103	18	386	0.003	2.01	595.7	0.86	3.34	0.52
GML41002	MHK4123	MHL4104	21	385	0.0085	5.89	1997.0	2.88	6.43	0.57
GML41005	MHL4103	MHL4105	18	30	0.004	2.01	595.7	0.86	3.69	0.48
GML41006	MHL4104	MHL4106	21	27	0.0042	5.89	1997.0	2.88	4.81	0.73
GML41007	MHL4105	MHL4108	18	16	0.1456	2.01	595.7	0.86	13.48	0.19
GML41008	MHL4112	MHL4107	12	177	0.0065	0.46	114.4	0.16	3.04	0.34
GML41009	MHL4107	MHL4110	12	74	0.0065	0.46	114.4	0.16	3.04	0.34
GML41010	MHL4108	MHL4111	24	132	0.0506	7.43	2592.7	3.73	13.12	0.32
GML41013	MHL4110	MHL4109	12	28	0.0113	0.46	114.4	0.16	3.71	0.29
GML41014	MHL4111	MHL4109	24	93	0.005	7.43	2592.7	3.73	5.54	0.63
GML41015	MHL4117	MHL4112	12	113	0.0065	0.46	114.4	0.16	3.05	0.34

APPENDIX B TABLE B-2 ULTIMATE WASTEWATER FLOWS										
SEWER REACH	FROM MANHOLE	TO MANHOLE	SEWER DIAMETER (in)	SEWER LENGTH (ft)	SEWER SLOPE	ULTIMATE PEAK WASTEWATER FLOW (MGD)	ULTIMATE AVERAGE DAILY WASTEWATER FLOW		VELOCITY (ft/s)	DEPTH OF FLOW TO SEWER DIAMETER RATIO (d/D)
							(gpm)	(MGD)		
GML41020	MHL4118	MHL4117	12	53	0.0065	0.46	114.4	0.16	3.03	0.34
GML41021	MHL4122	MHL4118	12	138	0.0065	0.46	114.4	0.16	3.04	0.34
GML41025	MHL4123	MHL4122	12	34	0.0065	0.46	114.4	0.16	3.03	0.34
GML41026	MHL4124	MHL4123	12	144	0.0065	0.46	114.4	0.16	3.05	0.34
GMM21002	MHL2145	MHM2104	8	217	0.0369	0.46	113.0	0.16	5.85	0.38
GMM21007	MHM2104	MHM2107	8	361	0.021	0.46	113.0	0.16	4.76	0.44
GMM21010	MHM2107	MHM3110	12	400	0.0023	0.52	131.8	0.19	2.16	0.48
GMM31012	MHM3110	MHM3114	12	396	0.0023	0.53	134.7	0.19	2.17	0.49
GMM31015	MHM3114	MHM3113	12	192	0.0018	0.53	134.7	0.19	1.98	0.52
GMM31016	MHM3113	MHM3115	10	55	0.0982	0.53	134.7	0.19	8.51	0.23
GMM31017	MHM3115	MHM3119	8	267	0.0508	0.53	134.7	0.19	6.86	0.38
GMM31021	MHM3119	MHM3120	8	155	0.0577	0.54	137.6	0.20	7.22	0.37
GMM31022	MHM3120	MHM3121	8	83	0.067	0.54	137.6	0.20	7.62	0.35
GMM31024	MHM3121	MHM3125	10	125	0.0050 (1)	0.54	137.6	0.20	2.88	0.53
GMM31028	MHM3125	MHM3124	10	18	0.0449	0.54	137.6	0.20	6.48	0.29
OUTLET_1	MHL4109	OUTLET1	24	27	0.0056	7.72	2707.1	3.90	5.83	0.62
OUTLET_2	MHM3124	12	10	30	0.01 (1)	0.54	137.6	0.20	3.60	0.44
P1000	MHH4117	MHH4119	10	102	0.0037	0.77	203.8	0.29	2.78	0.74

(1) Slope based on Sewer Atlas Sheets.


MISSION BLVD
36TH ST
AVALON ST
PROJECT No.8
10" (1,300± LF)
PROJECT No.8
12" (600± LF)
10"
(100± LF)
PONTIAC AVE
0.07 0.18
0.22 0.49
RUBIDOUX BLVD
34TH ST
PROJECT No.7
21" (800± LF)
WALLACE ST
MH H7104
MH G7118
0.55 2.01
1.35 4.28
HALL AVE
PROJECT No.6
18" (3,300± LF)
0.45 1.45
1.14 3.21
PROJECT No.5
15" (1,300± LF)
PROJECT No.5
15" (1,430± LF)
24TH ST
0.37 1.34
0.95 2.98
0.08 0.11
0.25 0.33
20TH ST
AVALON ST
PROJECT No.4
12" (240± LF)
0.35 1.29
0.90 2.89
0.09 0.72
0.28 1.72
0.25 0.57
0.87 1.39
0.25 0.55
0.66 1.36
0.14 0.45
0.41 1.12
PROJECT No.3
12" (2,900± LF)
AGUA MANZA RD
WILSON ST
HALL AVE
LEGEND
EXISTING RCSD BOUNDARY
EXISTING MANHOLE
LEGEND
EXISTING WASTEWATER FLOW (MGD)
ULTIMATE WASTEWATER FLOW (MGD)
AVERAGE DAY
AVERAGE DAY
PEAK
PEAK
LEGEND
EXISTING GRAVITY MAIN DIAMETER
PIPE COLOR
8"
10"
12"
15"
16"
18"
21"
24"
27"
30"
VERIFY SCALES
BAR IS ONE INCH ON ORIGINAL DRAWING
0 1"
IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY
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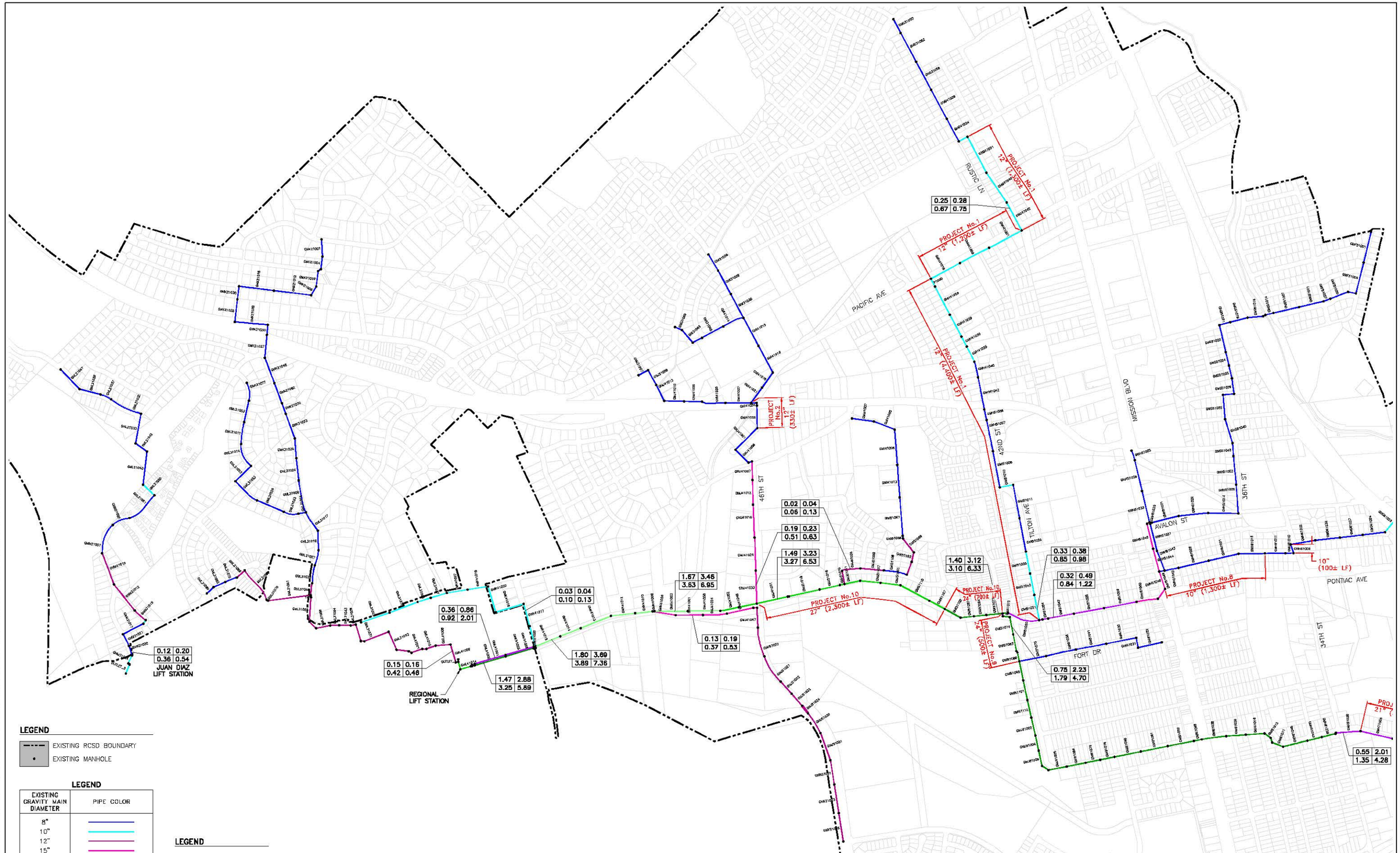
RUBIDOUX COMMUNITY SERVICES DISTRICT
WASTEWATER FACILITIES MASTER PLAN
PROPOSED WASTEWATER SYSTEMS FACILITIES
FIGURE
B-1
SCALE: 1"=500'
DATE: 07/31/15
DRAWN BY: SFK
CHECKED BY: MEM
W.O.: 587-44



LEGEND

EXISTING RCSD BOUNDARY

EXISTING MANHOLE

LEGEND

EXISTING GRAVITY MAIN DIAMETER	PIPE COLOR
8"	
10"	
12"	
15"	
16"	
18"	
21"	
24"	
27"	
30"	

LEGEND

EXISTING WASTEWATER FLOW (MGD)	ULTIMATE WASTEWATER FLOW (MGD)
AVERAGE DAY	AVERAGE DAY
PEAK	PEAK

VERIFY SCALES

BAR IS ONE INCH ON ORIGINAL DRAWING

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WASTEWATER FACILITIES MASTER PLAN

PROPOSED WASTEWATER SYSTEMS FACILITIES

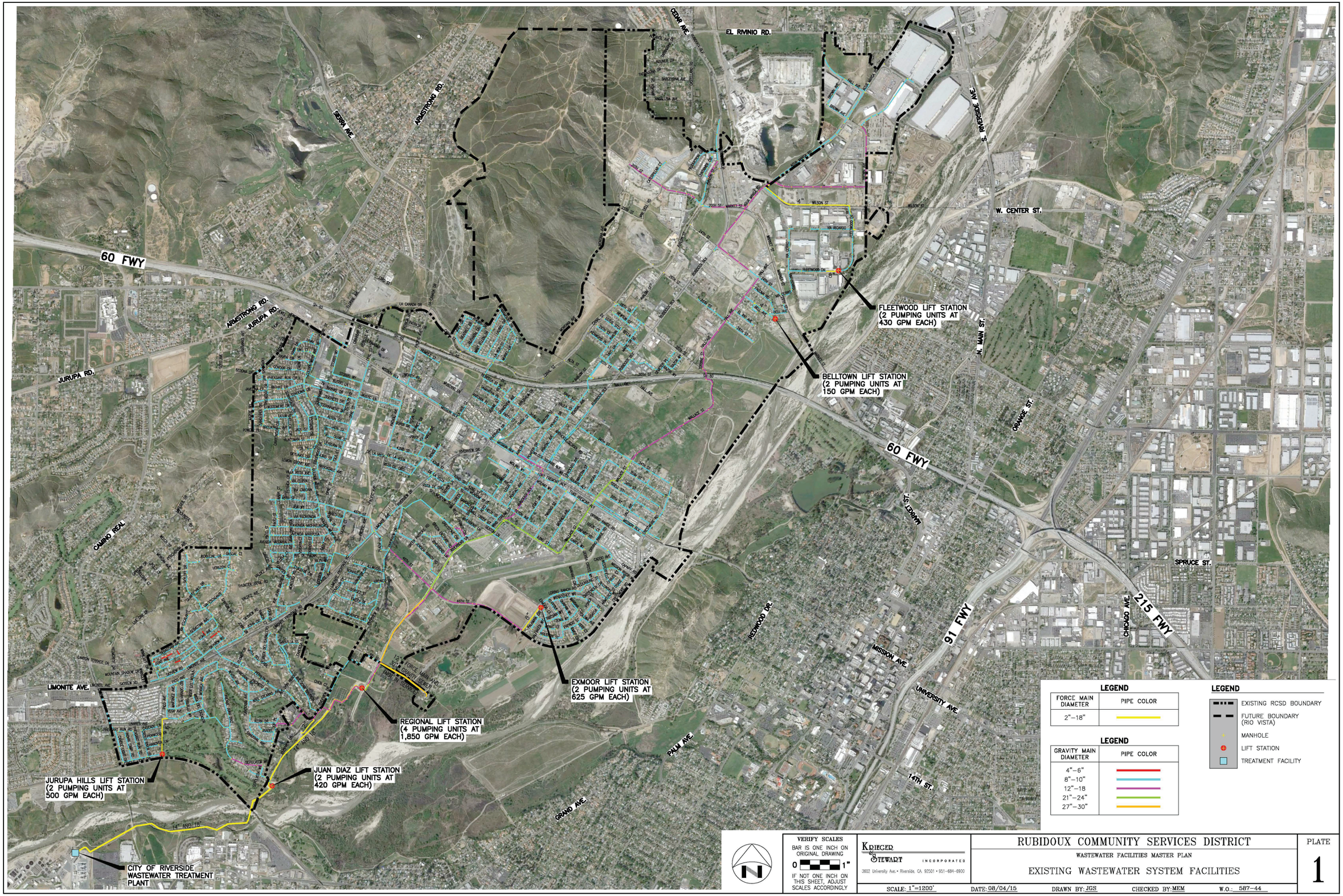
SCALE: 1"=500' DATE: 08/04/15 DRAWN BY: SPK CHECKED BY: MEM W.O.: 587-44

FIGURE

B-2

DWG. NO.: 587-44 FILE NO.: 587-44 UPDATE BY: MRH PROJ. ENG.: MEM PLOT DATE: 08/06/15 PLOT TIME: 10:41AM PLOT SCALE: 1=1

Plates



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

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RUBIDOUX COMMUNITY SERVICES DISTRICT

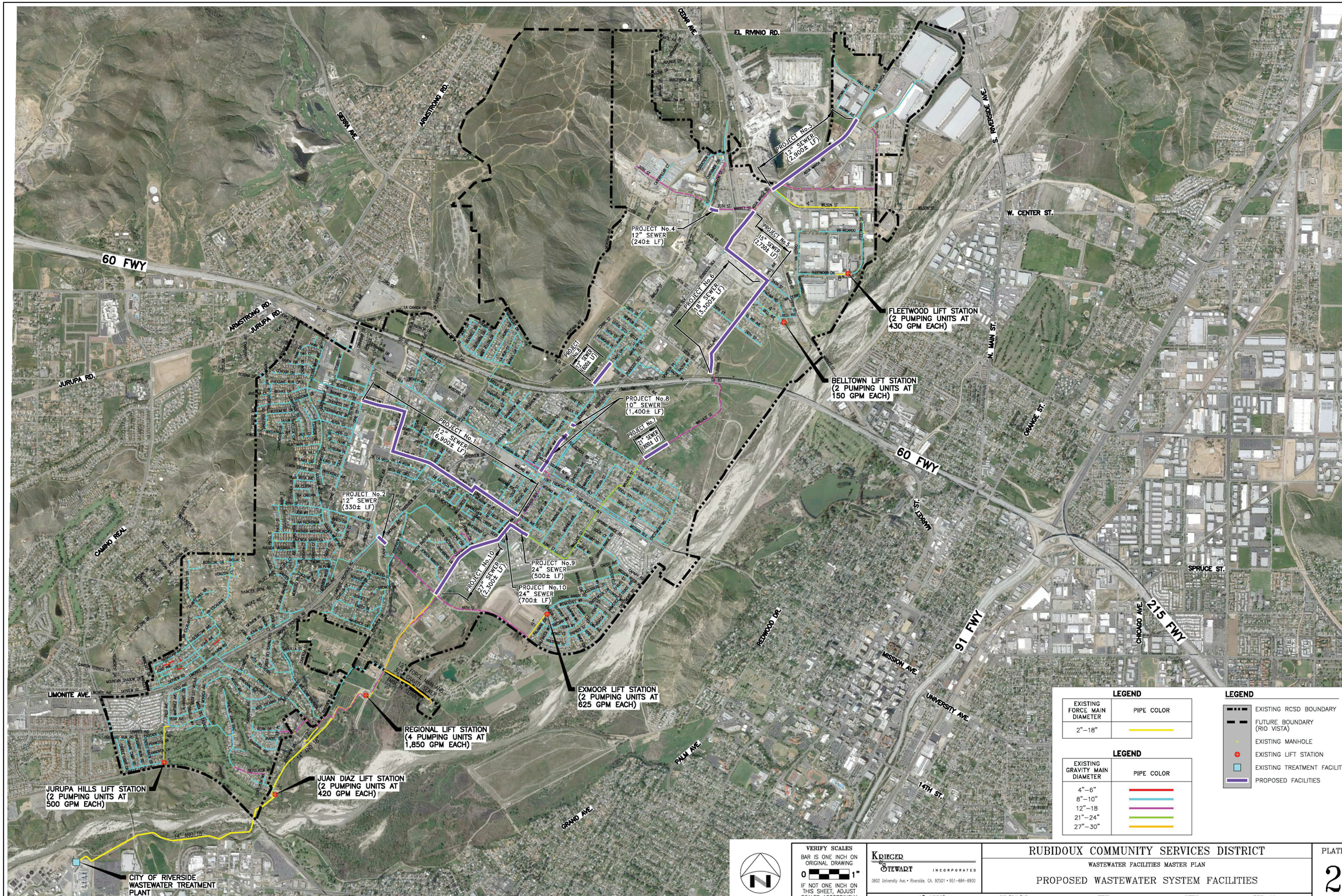
WASTEWATER FACILITIES MASTER PLAN

EXISTING WASTEWATER SYSTEM FACILITIES

PLATE 1

SCALE: 1"=1200' | DATE: 08/04/15 | DRAWN BY: JGS | CHECKED BY: MEM | W.O.: 587-44

DWG. NO.: 587-44.Dwg FILE NO.: 587-44 UPDATE BY: SPK PROJ. ENG.: MEM PLOT DATE: 08/04/15 PLOT TIME: 8:54AM PLOT SCALE: 1=1



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

KRIEGER & STEWART INCORPORATED
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RUBIDOUX COMMUNITY SERVICES DISTRICT

WASTEWATER FACILITIES MASTER PLAN

PROPOSED WASTEWATER SYSTEM FACILITIES

SCALE: 1"=1200' | DATE: 08/04/15 | DRAWN BY: SPK | CHECKED BY: MEM | W.O.: 587-44

PLATE 2

DWG. NO.: 587-44.Plot2 FILE NO.: 587-44 UPDATE BY: SPK PROJ. ENG.: MEM PLOT DATE: 08/04/15 PLOT TIME: 9:15AM PLOT SCALE: 1=1

Appendix 3B.9

2008 EDGEMONT COMMUNITY SERVICES DISTRICT MASTER SEWER SYSTEM EVALUATION PLAN

EDGEMONT COMMUNITY SERVICES DISTRICT
RIVERSIDE COUNTY, CALIFORNIA

MASTER SEWER SYSTEM
EVALUATION PLAN

September, 2008

Prepared by:
ALBERT A. WEBB ASSOCIATES
3788 McCray Street
Riverside, CA 92506

EDGEMONT COMMUNITY SERVICES DISTRICT
RIVERSIDE COUNTY, CALIFORNIA

MASTER SEWER SYSTEM
EVALUATION PLAN

September, 2008

REGISTERED PROFESSIONAL ENGINEER
SINNARO YOU
9/25/08
NO. 68607
EXP. 09-30-09
CIVIL
STATE OF CALIFORNIA

Prepared by:
ALBERT A. WEBB ASSOCIATES
3788 McCray Street
Riverside, CA 92506

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SECTION 1 - INTRODUCTION

The following document is an update of the November 9, 1995 Proposed Improvements to the Sewer Collection System for the Edgemont Community Services District (District). The District is a 2.35 square mile community services district located within the easterly portion of the City of Riverside and the westerly portion of the City of Moreno Valley (**Figure 1-1**).

During the late 1980's and early 1990's, Albert A. Webb Associates conducted a study to review the District's wastewater collection and conveyance system capacity. This study was necessitated by the City of Moreno Valley March 1989 General Land Use Plan which consisted of higher density uses than what the sewer system was originally constructed for in the late 1950's. The study area focused primarily on the southeast portion of the District because the portion northwest of Eucalyptus Avenue and Old Interstate 215 was relatively new and was sized based on more recent land use general plans at the time. As a result of this study, the District implemented the November 9, 1995 Edgemont Community Services District Proposed Improvements to The Sewer Collection System Report (1995 ECSD Sewer Report), which provided the District with a planning document for improvements to their wastewater collection and conveyance system. Since 1995, the District has implemented various improvements to their system, such as the Old I-215, Alessandro Boulevard and Day Street sewer line replacements and these projects have been constructed and in service for several years now. It is noted that the majority of the proposed improvements identified in the 1995 ECSD Sewer Report have been implemented, though various improvements have not been made.

The City of Moreno Valley recently updated their General Land Use Plan which was adopted by the City on July 11, 2006. Subsequently, the City is in the process of updating its zoning atlas to be consistent with the recently adopted General Land Use Plan. The updated land use data for some portions of the District's service area is found to be different from the data utilized in the 1995 ECSD Sewer Report. Subsequent updates to the City's zoning atlas further differentiate the land use designation. One zoning atlas update in particular is the City's proposed redevelopment within the area served by the Box Springs Mutual Water Company which is within the District's boundary (**Figure 1-2**). The zoning atlas within the area was updated and would potentially impact the District's wastewater generation, line sizing and treatment plant capacity requirements.

With the land use changes being adopted by the City of Moreno Valley, the District has authorized Albert A. Webb Associates to review how these changes affect the District's existing and ultimate collection systems. Webb Associates has utilized the City of Moreno Valley's G.I.S. data base for current City zoning in concurrence with the latest land use designations.

EDGEMONT COMMUNITY SERVICES DISTRICT

REGIONAL LOCATION MAP

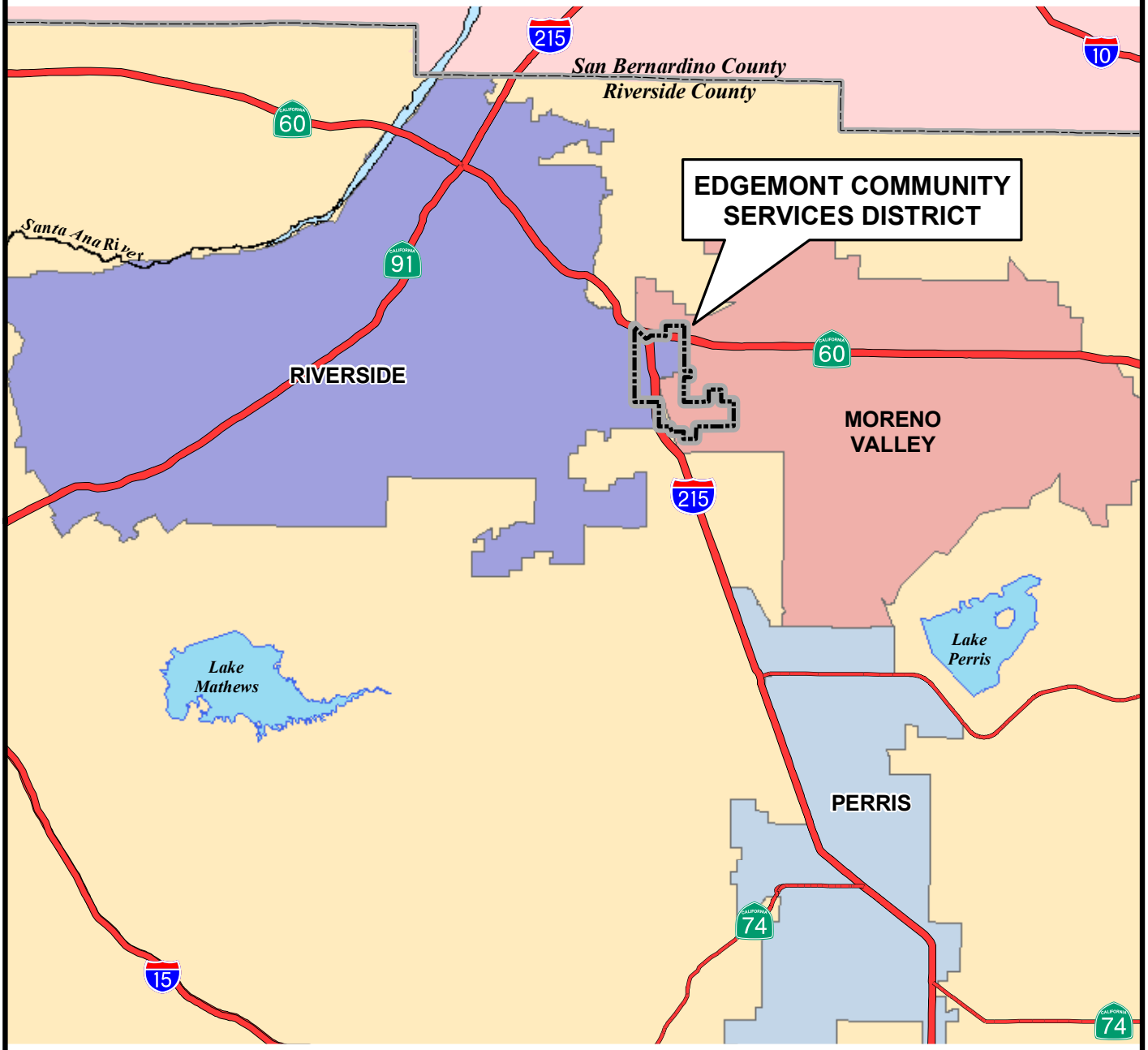

FIGURE 1-1

Not to Scale

ALBERT A. WEBB ASSOCIATES

Map revised October 23, 2007. G:\2006\06-0352\Gis\Location.mxd

EDGEMONT COMMUNITY SERVICES DISTRICT

BOUNDARY MAP

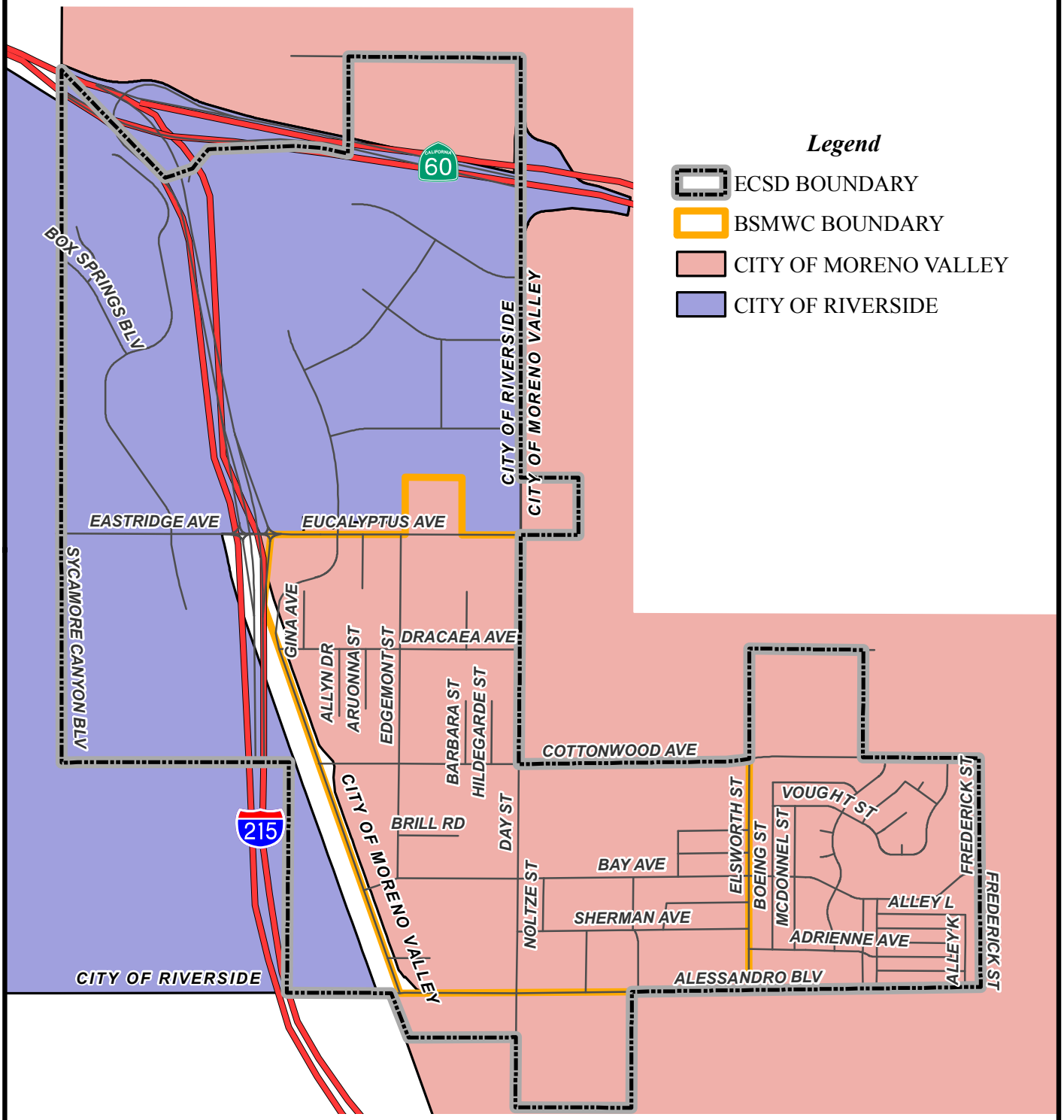

FIGURE 1-2

Not to Scale

ALBERT A. WEBB ASSOCIATES

Map revised October 23, 2007. G:\2006\06-0352\Gis\Boundary.mxd

The objective of this study is to update the District's 1995 ECSD Sewer Report, evaluate the District's existing wastewater collection system to convey existing and projected sewage flows, and evaluate possible increased wastewater contributions due to the City of Moreno Valley's planned redevelopment of the area served by the Box Springs Mutual Water Company. If portions of the system are found to be inadequate, the necessary improvements and related costs will be determined and the District will be provided with criteria to schedule implementation of such improvements.

SCOPE OF WORK

In order to accomplish the objectives of this report, the scope of the study includes the following:

1. Research and data collection
2. Review of existing and projected study area characteristics
3. Sewer System Management Plan (SSMP)
4. Development of design criteria and basis of cost estimates
5. Evaluation of existing facilities
6. Determination of projected wastewater flows
7. Hydraulic analysis of existing system
8. Hydraulic analysis of design year system
9. Development of capital improvements required and estimated costs associated therewith

SECTION 2 - EXISTING AND PROJECTED STUDY AREA CHARACTERISTICS

The purpose of this section is to provide background information on the area and population characteristics of Edgemont Community Services District (District).

STUDY AREA BOUNDARIES AND COMPOSITION

Edgemont Community Services District is located within a portion of the City of Riverside and a portion of the City of Moreno Valley (**Figures 1-1 and 1-2**) and encompasses approximately 1,500 acres of land.

EXISTING LAND USE ANALYSIS

Figure 2-1 provides an aerial view of the District. Dense residential developments are generally located within the center and eastern portions of the District's service area. The areas to the north and western portions are occupied by industrial warehouses. Sewer within these areas is serviced by facilities owned by the City of Riverside. The undeveloped area in the northern portion of the District and south of the I-60 Freeway is planned for commercial development; however, wastewater generated within the undeveloped area will be serviced by the City of Riverside.

PROJECTED LAND USE ANALYSIS

Figure 2-2, which is based on the July 2006 City of Moreno Valley General Plan, depicts the different land uses for ultimate buildout conditions within the District. As discussed in Section 1, the City of Moreno Valley is in the process of updating their Zoning Atlas Map. To determine projected ultimate buildout flows based on more current data, the land use within the District's boundaries will be based on the City of Moreno Valley's September 2007 zoning atlas map (**Figure 2-3**). It is noted that ultimate buildout conditions yield ultimate wastewater flows, which will be discussed in later sections. **Table 2-1** tabulates the projected land uses based the City's September 2007 zoning atlas map within the District's service area.

EDGEMONT COMMUNITY SERVICES DISTRICT

AERIAL VIEW MAP

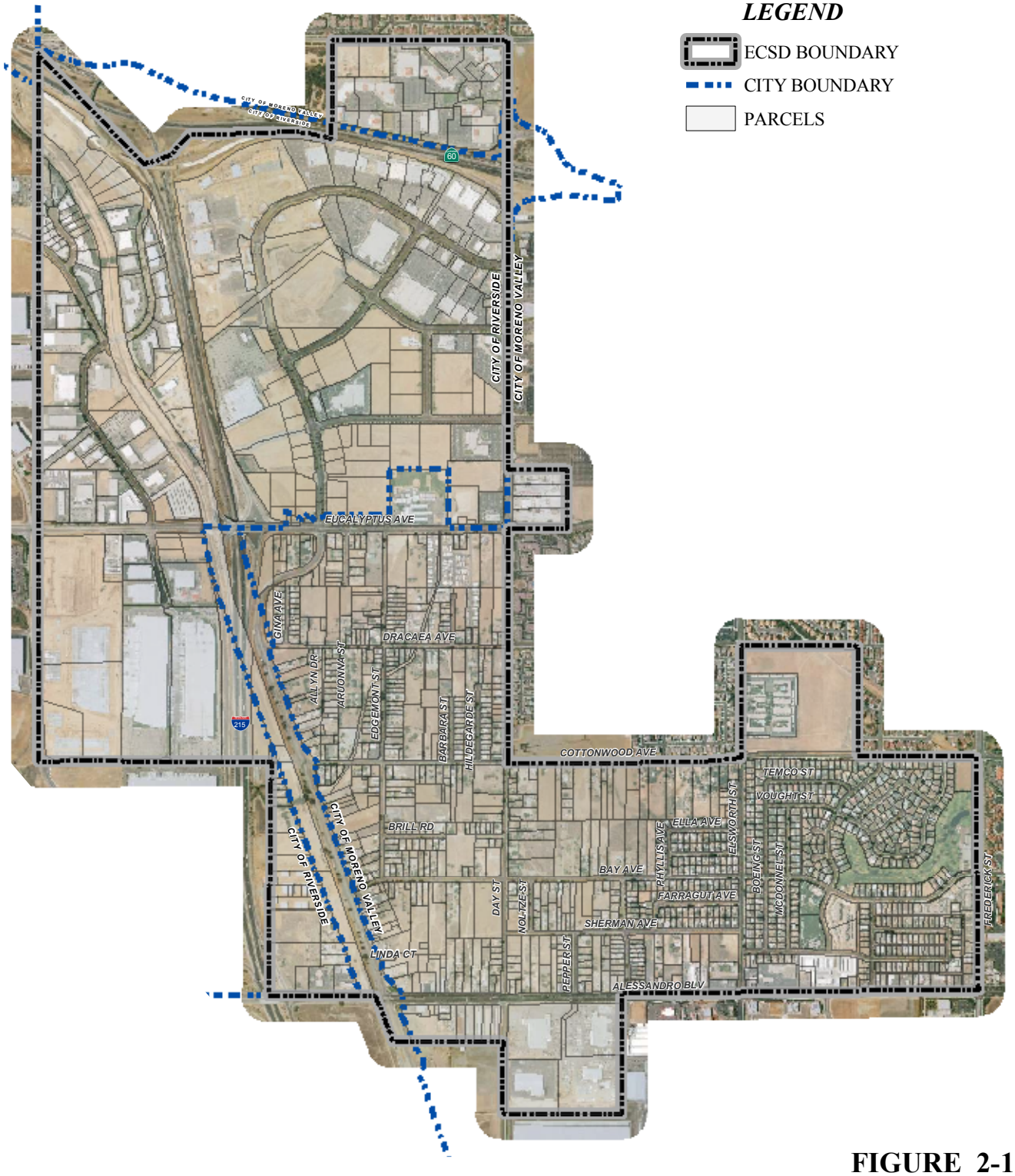

FIGURE 2-1

0 1,000 2,000
Feet

Source: Riverside County 2007
AirPhoto USA 2007

ALBERT A. WEBB ASSOCIATES

Map revised March 17, 2008. G:\2006\06-0352\Gis\Aerial_8x11.mxd

EDGEMONT COMMUNITY SERVICES DISTRICT

LAND USE MAP*
JULY 2006

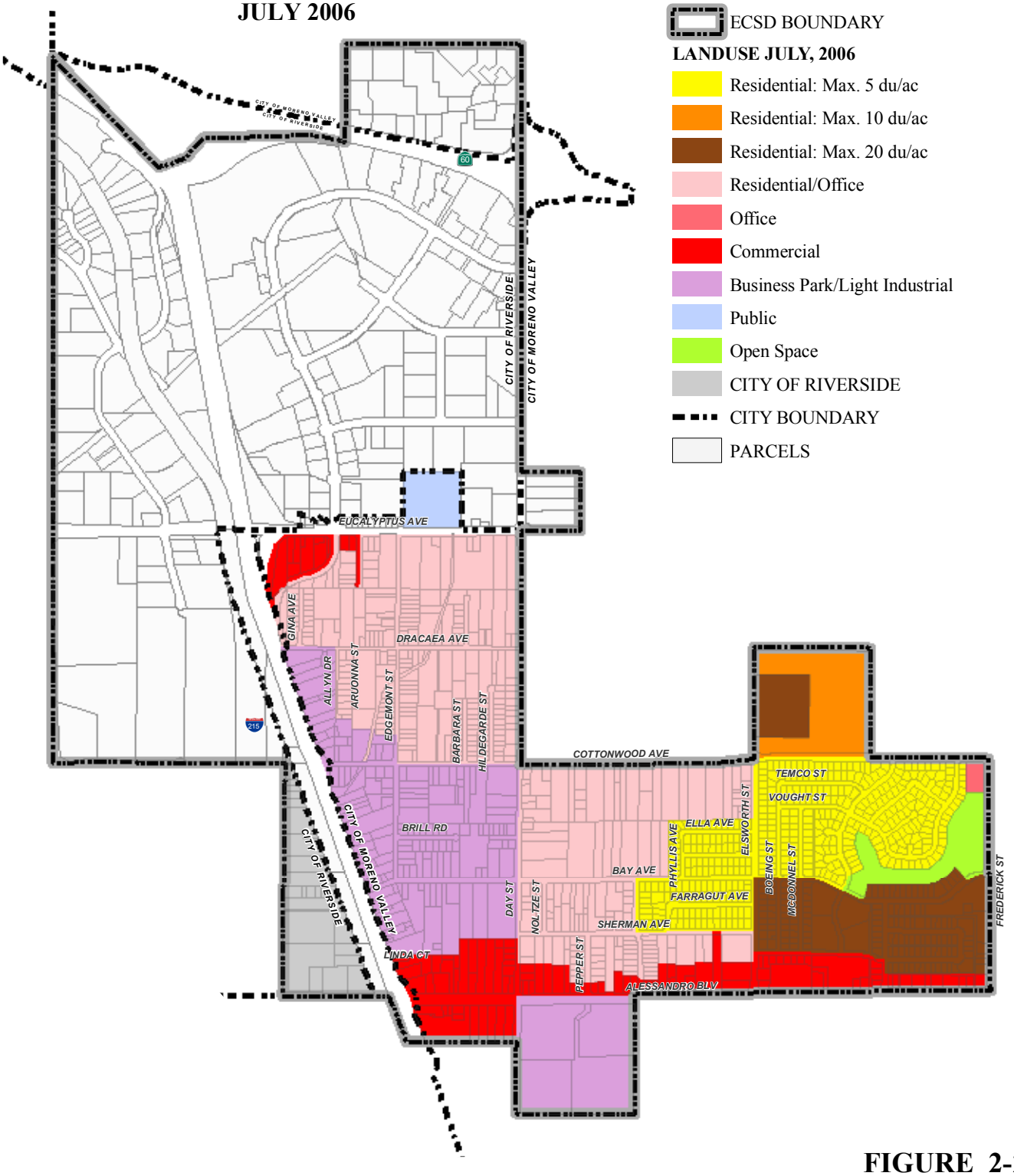

FIGURE 2-2

0 1,000 2,000
Feet

Source: Riverside County 2007

* FROM CITY OF MORENO VALLEY GIS - GENERAL PLAN LAND USE, JULY 2006

ALBERT A. WEBB ASSOCIATES

Map revised March 17, 2008. G:\2006\06-0352\Gis\Land_Use_8x11.mxd

EDGEMONT COMMUNITY SERVICES DISTRICT

ZONING MAP*
SEPTEMBER 2007

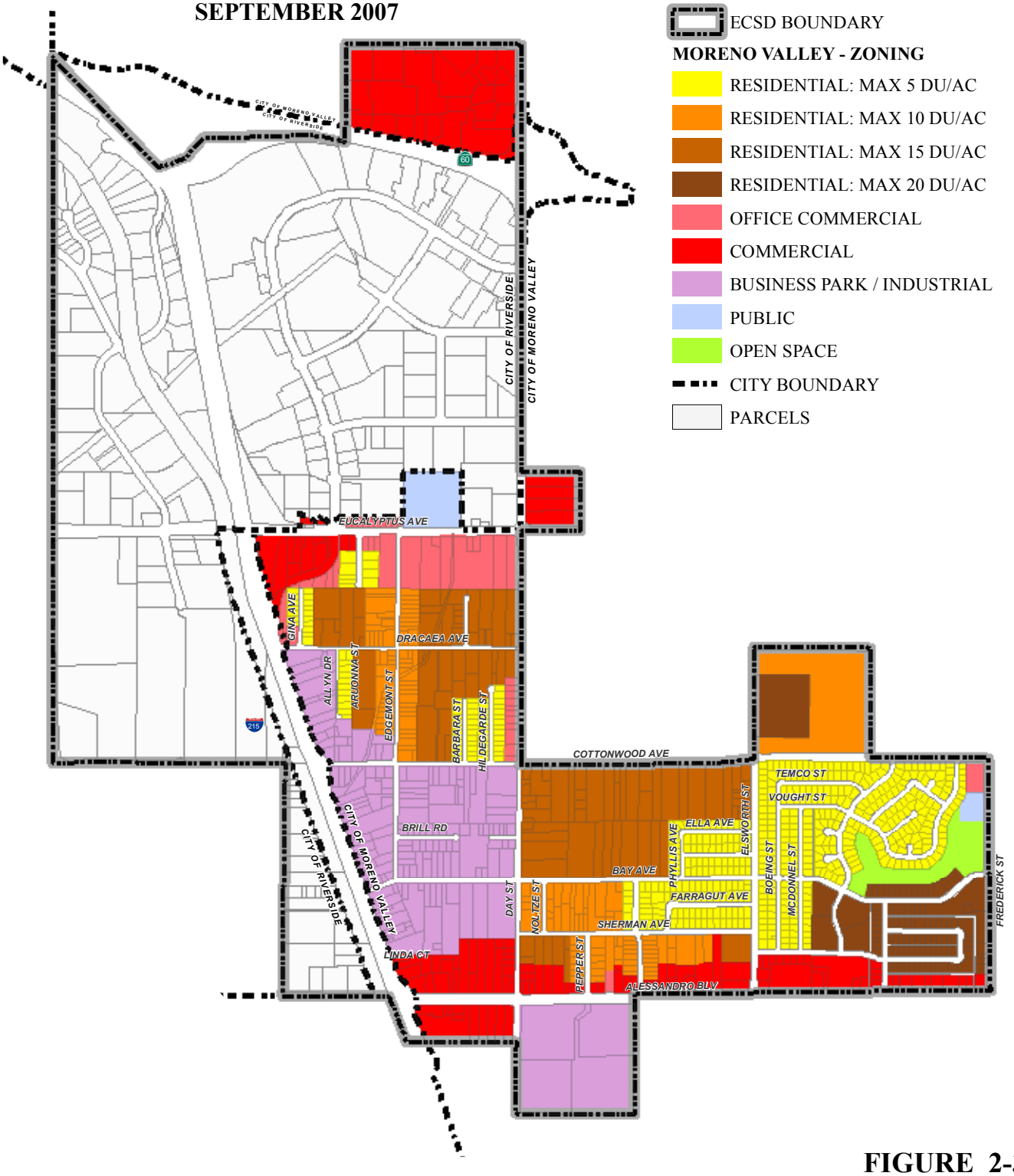

FIGURE 2-3

0 1,000 2,000
Feet

Source: Riverside County 2007

* FROM CITY OF MORENO VALLEY GIS - ZONING LAYER, SEPT. 2007

ALBERT A. WEBB ASSOCIATES

Map revised March 17, 2008. G:\2006\06-0352\Gis\Gen_Plan_8x11.mxd

Table 2-1: Edgemont Community Services District Land Use Summary based on September 2007 Zoning Map

Land Use Characteristics	City of Moreno Valley Area (Acres)	City of Riverside Area (Acres)
Residential		
Residential: Max 5 DU/AC	103.4	
Residential: Max 10 DU/AC	72.8	
Residential: Max 15 DU/AC	118.1	
Residential: Max 20 DU/AC	42.5	
Commercial & Industrial		
Office Commercial	30.16	
Commercial	108.7	32.9[1]
Business Park/ Industrial	133.5	
Open Space		
Public	11.5	
Open Space	12.9	
Totals:	**633.56**	**32.9**

[1] It is noted that the land use within City of Riverside Area (west of I-215, north of Alessandro Boulevard and south of Cottonwood Avenue) is serviced by ECSD sewerlines. However, ECSD is credited for this sewer service at 20,000 gpd.

SECTION 3 - ANALYSIS CRITERIA

This section discusses the following criteria used to evaluate the District's wastewater system:

- Wastewater Generation
- Facility Design

It should be noted that the following criteria incorporated the November 1995 ECSD Sewer Collection System Plan (1995 ECSD Sewer Plan). In addition, a review of flow and equivalent dwelling units (EDU) data from the 2007-2008 ECSD Fiscal Year Sewer Charges Report and the 2006 ECSD monthly treatment services invoices (**Appendix A**) was conducted to further evaluate and develop generation factors.

WASTEWATER GENERATION

Domestic Wastewater

The domestic wastewater generation factor utilized in the November 1995 ECSD Sewer Plan in terms of equivalent dwelling units was 280 gallons per day per equivalent dwelling unit (gpd/EDU). A review of District data for current sewer service accounts and current flow data was conducted to further evaluate and develop generation factors. This flow data was obtained from the flow metering facility readings (**Plate 1**) prior to sewer entering the City of Riverside Water Quality Control Plant (WQCP). Based on the 2007-2008 ECSD Fiscal Year Sewer Charges Report and the 2006 ECSD monthly treatment services invoices (**Appendix A and F**), the calculated ECSD wastewater generation factor per equivalent dwelling unit was approximately 240 gpd/EDU. For the purposes of this report, domestic wastewater generation factor of 240 gpd/EDU for single family (5 to 10 DU/AC) and 160 gpd/EDU for high density residential (15 to 20 DU/AC) will be utilized to determine wastewater treatment capacity. For pipeline design purposes, the original generation factors of 280 gpd/EDU for single family and 160 gpd/EDU for high density residential will be utilized.

Commercial/Industrial Wastewater

Per the November 1995 ECSD Sewer Plan, the Commercial/Industrial wastewater generation factor was 2000 gpd/AC. To further evaluate and develop these types of generation factors, an analysis of several commercial and industrial areas within the District was conducted, particularly in the southern and western regions of the District. The generation factors within these areas ranged from 400 gpd/AC to as high as 900 gpd/AC. This calculation was based on the 2007-2008 Fiscal Year Sewer Charges Report of all existing commercial and industrial areas within ECSD (**Appendix A and F**). Due to the wide range of generation data, a generation factor of 1000 gpd/AC will be utilized in this report for wastewater treatment capacity. For pipeline design purposes, the original generation factor of 2000 gpd/EDU will be utilized.

Miscellaneous Land Use Sewage

Miscellaneous land use areas discussed in this section include areas for public use and open spaces. The public use area within the District is the Edgemont Elementary School. According to the 2007-2008 Fiscal Year Sewer Charges, this area is generating approximately 525 gpd/AC of wastewater. For planning purposes, a generation factor of 1000 gpd/AC will be used as its standard for public use areas.

Due to the minimal open spaces (such as golf courses) within the District, the wastewater generated by these open spaces are considered to be negligible.

Dry Weather Flow

Dry weather sewage flows generated within the study area include domestic, commercial, and industrial wastes. As the majority of the sewers constructed in the study area will lie above the groundwater table, infiltration during dry weather periods has been assumed to be negligible.

Infiltration/Inflow

In order to design pipeline improvements, it is necessary to establish values for the peak flows, which also entails an allowance for infiltration/inflow. For this report, the infiltration/inflow allowance for wastewater generated within the District is assumed to be similar to that adopted by other local sewer districts such as Jurupa Community Services District. Jurupa Community Services District utilizes an infiltration/inflow allowance of 160 gpd/AC for existing developed areas and 50 gpd/AC for current and future development areas.

Wet Weather Flow

Wet weather flow are included in the design of the system in order to determine the maximum hydraulic loading on pipelines and various appurtenances, though dry weather infiltration is considered to be negligible. Wet weather infiltration in addition to direct storm inflow is added to the dry weather flows to obtain the total wet weather flow. Direct storm inflow is distinguished from wet weather infiltration by the rapidity with which inflow begins and ends after a period of rainfall. Infiltration, on the other hand, may persist for an extended period after the cessation of rainfall.

For this study, it is assumed that the domestic, commercial and industrial wastewater generation factors include a wet weather flow component.

Waste Water Generation Factor

Table 3-1 summarizes the wastewater generation factors as well as infiltration and inflow to be utilized for evaluating the District's overall wastewater system.

Table 3-1: Summary of Wastewater Generation Factors

Land Use	Wastewater Generation Factor
Residential Wastewater (low density: 5 to 10 edu/acre)	280 gpd/edu (pipeline design purposes)
Residential Wastewater (low density: 5 to 10 edu/acre)	240 gpd/edu (treatment capacity purposes)
Residential Wastewater (high density: 15 to 20 edu/acre)	160 gpd/edu (both pipeline design and treatment)
Commercial/Industrial	2,000 gpd/acre (pipeline design purposes)
Commercial/Industrial	1,000 gpd/acre (treatment capacity purposes)
Public Uses	1,000 gpd/acre (both pipeline design and treatment)
Open Space	Not applicable
Infiltration/Inflow	160 gpd/acre (existing development areas)
Infiltration/Inflow	50 gpd/acre (current and future development areas)

Wastewater Peak Factors

The flow used for the design capacity for sewers and sewage lift stations is the "computed peak flow," or facility "design flow," which is determined on the basis of projected land use area, the unit wastewater generation factor assigned to the particular land use designation and a peak factor to account for the diurnal flow rate variations.

The District uses the following wastewater peak flow equation to obtain peak flows.

$Q_{PK} = 2.5\ Q_{ADF}^{(0.91)}$, where
Q_{PK} = peak flow, in mgd
Q_{ADF} = average daily flow, in mgd

FACILITY DESIGN

Transport Facilities

Collection sewers in this report are considered to be pipes less than 10 inches in diameter. These pipes should be designed to be one-half full under peak flow conditions. Collection sewers are typically designed to flow one-half full for maintenance purposes and since collection pipelines serve smaller areas, they can experience high peak factors. Collection sewer diameters are determined using Manning's equation and a roughness coefficient (n) of 0.013.

Trunk and Interceptor Sewers

Generally, trunk sewers are considered to be pipes 10 inches and larger in diameter. There may be sewer mains less than 10-inch diameter that will be evaluated as a trunk sewer. The capacity to be provided in each section of a trunk sewer is based on the peak rate of flow calculated for the area tributary to that section. For each area this rate is the summation of peak domestic, commercial,

and industrial rates plus storm water inflow which is known as the "peak wet weather flow" or "design flow."

A summary of design criteria for gravity flow sewer pipelines is as follows:

Trunk sewer lines are typically designed to carry wastewater at a minimum velocity of 2 ft/sec when flowing with a maximum depth to diameter ratio (D/d) of 0.75, and are sized to carry peak flows without surcharge. A roughness coefficient (n) of 0.013 is used for new pipe sizing. A safety factor should be included in the design of all gravity flow pipelines to account for the variability of the initial approximation of flow and partial clogging of the sewer. The method of accounting for the inherent variables is to limit the depth of flow. **Table 3-2** shows the design depth of flow ratio.

Table 3-2: Maximum Depth of Flow to Pipeline Diameter Rates

Pipe Diameter (In Inches)	Ratio of Depth of Sewage Flow to Diameter of Sewer
8	0.50±
10 and greater	0.75±

Low velocities in the sewers causes deposition of solids and results in accumulation of hydrogen sulfide, minimum slopes should be set to maintain a flow velocity of not less than 2 feet per second during maximum flows. **Table 3-3** provides a list of the minimum allowable slopes.

Table 3-3: Minimum Pipeline Slope Criteria

Pipe Diameter (In Inches)	Minimum Slope (Feet/100 Feet)
8	0.40
10	0.32
12	0.24
15	0.16
18	0.14
21	0.12
24	0.10
27	0.08
30 and larger	0.07

Whenever possible, the pipelines should be designed to flow by gravity. Sewage pump stations should be installed only when existing topography prevents gravity flow and when excessive trench depths are encountered.

Manholes should be located at all junctions, all changes in grade, all changes in direction, and all changes in pipe size. Where the distance between manholes required for the foregoing reasons exceeds 350 feet, good judgment should be used in placing intermediate manholes at points of probable sewer intersections, or lacking other criteria, at approximately equal intervals. In general, the maximum of 350 feet should be observed.

Manhole diameters are determined based upon pipeline diameters as shown in **Table 3-4**.

Table 3-4: Minimum Manhole Diameter Summary

Largest Pipe Diameter	Minimum Manhole Diameter
8" – 12"	48"
15" – 30"	60"

Vitrified clay pipe (VCP) material, unless otherwise indicated, is assumed to be used in future construction for purposes of comparative cost evaluation. However, final recommendation of any specific sewer pipe material will be made at the time of final design.

In addition to the above mentioned manhole design criteria, the following design considerations should be taken into account.

- Manholes will be constructed of precast reinforced concrete riser and top sections in compliance with ASTM C478. Additionally, there may exist the possibility of using watertight manhole covers.
- Manholes in pipelines where excessive hydrogen sulfide may be encountered should be lined with PVC lining to minimize chemical deterioration. Manhole bases should be lined with PVC lining or a special protective coating.
- All manholes deeper than 25 feet, plus or minus, may require safety platforms installed.
- Where future sewerlines will likely be connected into the trunk sewer manholes, an appropriately sized stub will need to be installed.

Initially, some of the new trunk sewers or interceptors may not have sufficient velocity (greater than 2 fps) to prevent deposition of solids. These lines may require special preventive maintenance or other control procedures for the first few years to minimize the formation of hydrogen sulfide gases, which could damage the sewer system.

In general, large trunk and interceptor sewers should be designed for long-term requirements. Gravity flow pipelines should be designed with the latest pipe materials, providing rubber or plastic ring joints to assure permanent water tightness. Final recommendation of any specific sewer pipe material, however, will be made at the time of final design.

Inverted Siphons

The purpose of an inverted siphon is to carry the flow under an obstruction such as a stream or depressed highway and to regain as much elevation as possible after the obstruction has been passed. Self-cleaning velocities (2 to 3 fps) should be obtained at least once a day, even during the early years of operation. To ensure adequate minimum velocities, it may be necessary to use multiple diameter pipelines. Flow in these lines can be regulated by control structures such as overflow weirs. Inverted siphons may require cleaning more often than gravity sewers.

A conservative Hazen-Williams roughness coefficient (C) of 100 (equivalent to Manning's n of between 0.014 and 0.018) should be used to calculate head loss. Material that would be considered for siphons include VCP and lined ductile iron pipe. Final selection of pipe materials would be made during the detailed design phase.

Wastewater Treatment Plants

The primary considerations in the design of a wastewater treatment plant are the required capacity and the degree of treatment. Plant capacity is usually expressed in terms of average dry weather flow. Degree of treatment is based on requirements established in the waste discharge permit issued by the California Regional Water Quality Control Board. Plants are designed with sufficient capacity to handle peak organic, as well as peak hydraulic loads and are planned for enlargement to handle future increases.

The District does not own a wastewater treatment plant. The sewage generated within the District is currently conveyed to the City of Riverside WQCP by existing connection and metering facilities located at the Canyon Springs Shopping Center near the north boundary of ECSD, south of I-60 Freeway and on Cottonwood Avenue at the west boundary of ECSD, east of I-215 Freeway (**Plate 1**). These two (2) metering facilities provide for measurement of wastewater generated within the District for billing purposes.

SECTION 4 - EXISTING FACILITIES

Edgemont Community Services District has nearly 17 miles of sewer pipelines within their jurisdiction (**Plate 1**). With the exception of sewer improvements on Cottonwood Avenue and Alessandro Boulevard and recent developments, the majority of the District consists of sewers that are at least 20 years old. The sewer systems are generally capable of providing service to the community at the present time, though there are areas in need of improvements as will be discussed in this section.

TRUNK/INTERCEPTOR SYSTEM

Review of the November 1995 ECSD Sewer Plan indicated the District has identified the following trunk lines within the system:

1. Alessandro Trunk Sewer
2. I-215 Trunk Sewer
3. Cottonwood Trunk Sewer

Alessandro Trunk Sewer

The Alessandro Trunk Sewer (**Figure 4-1**) begins at Courage Street as a 10-inch diameter line, increases to a 12-inch diameter line as it continues west along Alessandro Boulevard to Old Frontage Road (I-215 Freeway). Additionally, an 8-inch diameter line in Alessandro Boulevard parallels the 12-inch diameter line and will connect to the 12-inch diameter line at Day Street. Due to limited capacity of the 8-inch diameter line, the District constructed an additional 8-inch line, approximately 500 feet west of Elsworth Street to connect to the 12-inch diameter line to relieve 8-inch diameter sewer.

I-215 Trunk Sewer

The I-215 Trunk Sewer (**Figure 4-1**) begins at Alessandro Boulevard as a 12-inch diameter line and increases to a 15-inch diameter for approximately 800 feet south of Cottonwood Avenue where the line parallels the existing flood control channel and continues to connect to the Cottonwood Trunk Sewer on Cottonwood Avenue.

Cottonwood Trunk Sewer

The Cottonwood Trunk Sewer (**Figure 4-1**) begins at Elsworth Street as an 8-inch diameter line, traverses west on Cottonwood Avenue and connects to the City of Riverside wastewater line. The 8-inch diameter line increases to a 12-inch diameter line at Edgemont Street and then increases to an 18-inch diameter line where it connects to the I-215 Trunk Sewer. The 18-inch diameter line traverses westerly where the pipeline crosses a 5' x 5' box owned by Riverside County Flood Control via an 18-inch diameter D.I.P. sewer siphon system. The pipeline continues westerly across the Old

EDGEMONT COMMUNITY SERVICES DISTRICT

TRUNK SEWER SYSTEM

LEGEND

- ECSD BOUNDARY
- PARCELS
- CITY BOUNDARY
- ALESSANDRO TRUNK SEWER
- COTTONWOOD TRUNK SEWER
- OLD 215 TRUNK SEWER
- MISCELLANEOUS TRUNK SEWER
- METERING FACILITY FOR CONNECTION TO CITY OF RIVERSIDE

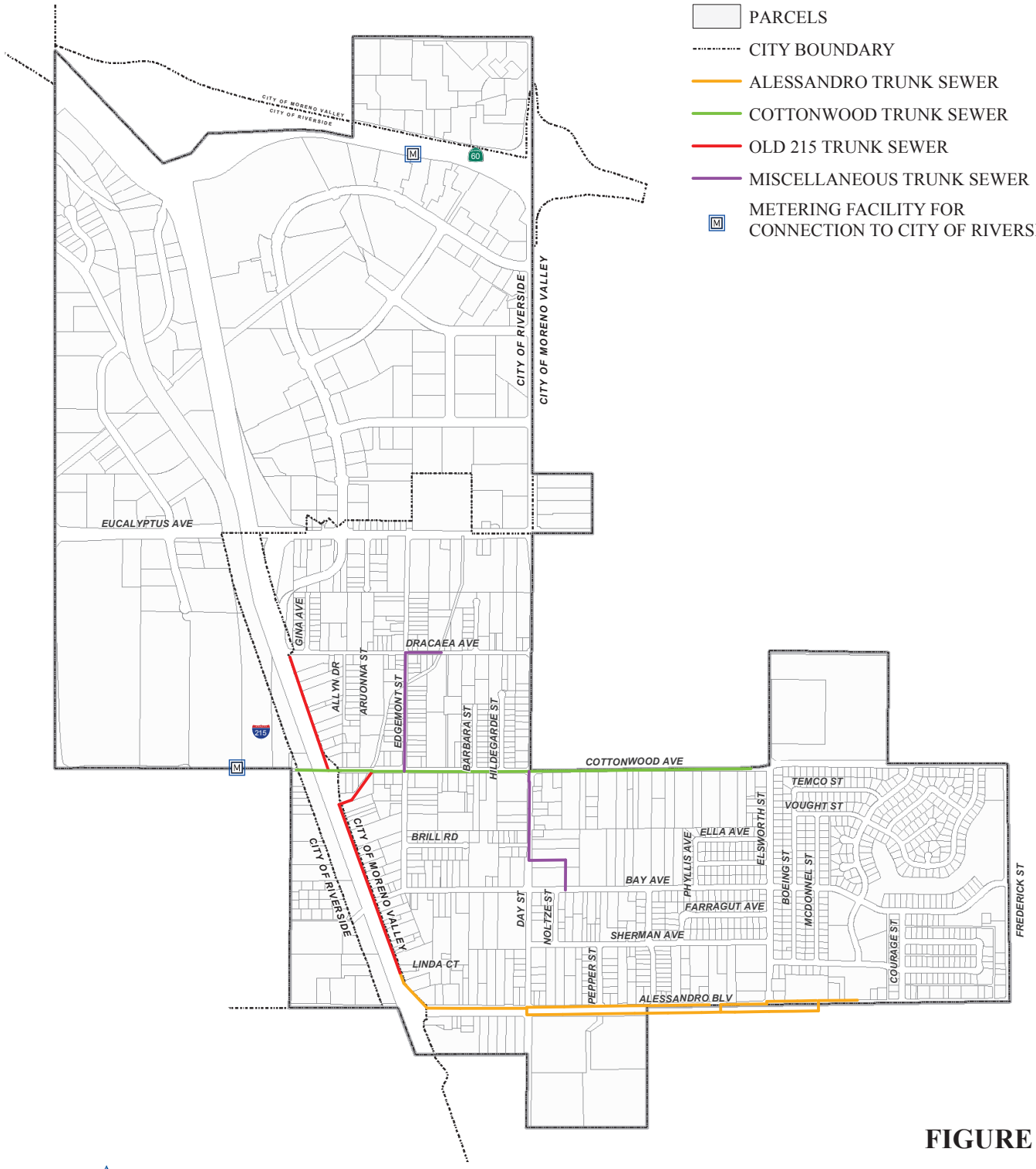

FIGURE 4-1

0 1,000 2,000
Feet

Source: Riverside County 2007

ALBERT A. WEBB ASSOCIATES

Map revised July 29, 2008. G:\2006\06-0352\Gis\Trunk_Reach_36x30.mxd

Interstate 215 to outlet to a manhole prior to crossing the I-215 Freeway. At this point, a 4-barrel pipeline system crosses the I-215 Freeway to the City of Riverside metering station. Miscellaneous trunk sewerlines will also be considered in Section 7, as flow input locations (concentration points) are diverted to these pipe reaches (**Figure 4-1**).

COLLECTION SYSTEM

Collection pipes are those having a diameter of 8 inches or less. The District has over 13.5 miles of pipeline which are categorized as such.

Many of the older collection pipes have been constructed at grades less than the current minimum standards. At low flows, velocities may not be high enough to prevent deposition of solids and potentially increasing operations and maintenance of the system. An additional concern to sewerlines at less than minimum grades is the potential for surcharging during peak flows.

There are sewer collection pipes within the District's system that have sustained damage by ingrown tree roots. There are also pipes that contain grease deposits in certain areas. An example would be the 6-inch diameter sewerline along Day Street which was observed to have ingrown roots and has experienced surcharging.

SECTION 5 - PROJECTED WASTEWATER FLOWS

TRIBUTARY SEWAGE FLOW AREAS

The tributary sewage flow areas are based on the following criteria as used in the 1995 ECSD Sewer Plan. In undeveloped areas of the District, tributary sewage flow areas are based upon Riverside County Flood Control District's topographical maps. Therefore, in the undeveloped areas, the wastewater was assumed to flow based on the natural drainage patterns of the existing topography. In the developed areas of the District, the tributary sewage flow areas are based on the layout of the existing collection system.

The tributary sewage flow areas (**Figure 5-1**) are divided into the previously determined nineteen (19) areas in addition to three (3) newly developed areas. Each of these areas has a concentration point to which all flows within the area converge. The three (3) newly developed areas incorporated into this study area are located in the northern and central region of the District (**Figure 5-1**) and will be designated as Tributary Area Q_{17}, Q_{18} and Q_{19}. Tributary Area Q_{17} is the Edgemont Elementary School, Tributary Area Q_{18} is a newly developed commercial area and Tributary Area Q_{19} is the Canyon Springs Shopping Center.

TOTAL DESIGN FLOWS

Appropriate wastewater generation factors (developed in Section 3) were applied to calculate projected flows for each land use (detailed in Section 2) for each tributary sewage area within the District. For residential land use, the total number of equivalent dwelling units (EDU's) per tributary area was determined prior to applying generation factors. The details of each tributary area are summarized in spreadsheet format in **Appendix B**. Each row within this spreadsheet represents a tributary sewage flow area. Each sewage flow area is broken up into the corresponding land use designations. The areas are multiplied with the corresponding wastewater generation factors to obtain the average daily flows. The flows are summarized at the end of each row to totalize the flow generated in that tributary area. The summation of the total flows from each tributary area was conducted to determine the total design flow for the entire District.

The projected average daily flows are used in the following sections of this report to determine: (1) the capacity of the existing system to convey future growth within the sewer service areas; (2) the diameters and locations of pipelines necessary to convey the projected "buildout" wastewater flows; and (3) the wastewater treatment capacity for "buildout" conditions.

Table 5-1 and **Table 5-2** summarize the projected buildout average daily flows within the District for pipeline design and wastewater treatment capacity respectively. The total projected average daily flow for pipeline design for the District is approximately 1.42 mgd and will be utilized in the hydraulic analysis for the design of a trunk sewer system to convey the ultimate flow conditions. The projected average daily flow for treatment capacity for the District is approximately 1.05 mgd and will be utilized to determine ultimate wastewater treatment capacity.

EDGEMONT COMMUNITY SERVICES DISTRICT

TRIBUTARY SEWAGE FLOW AREAS

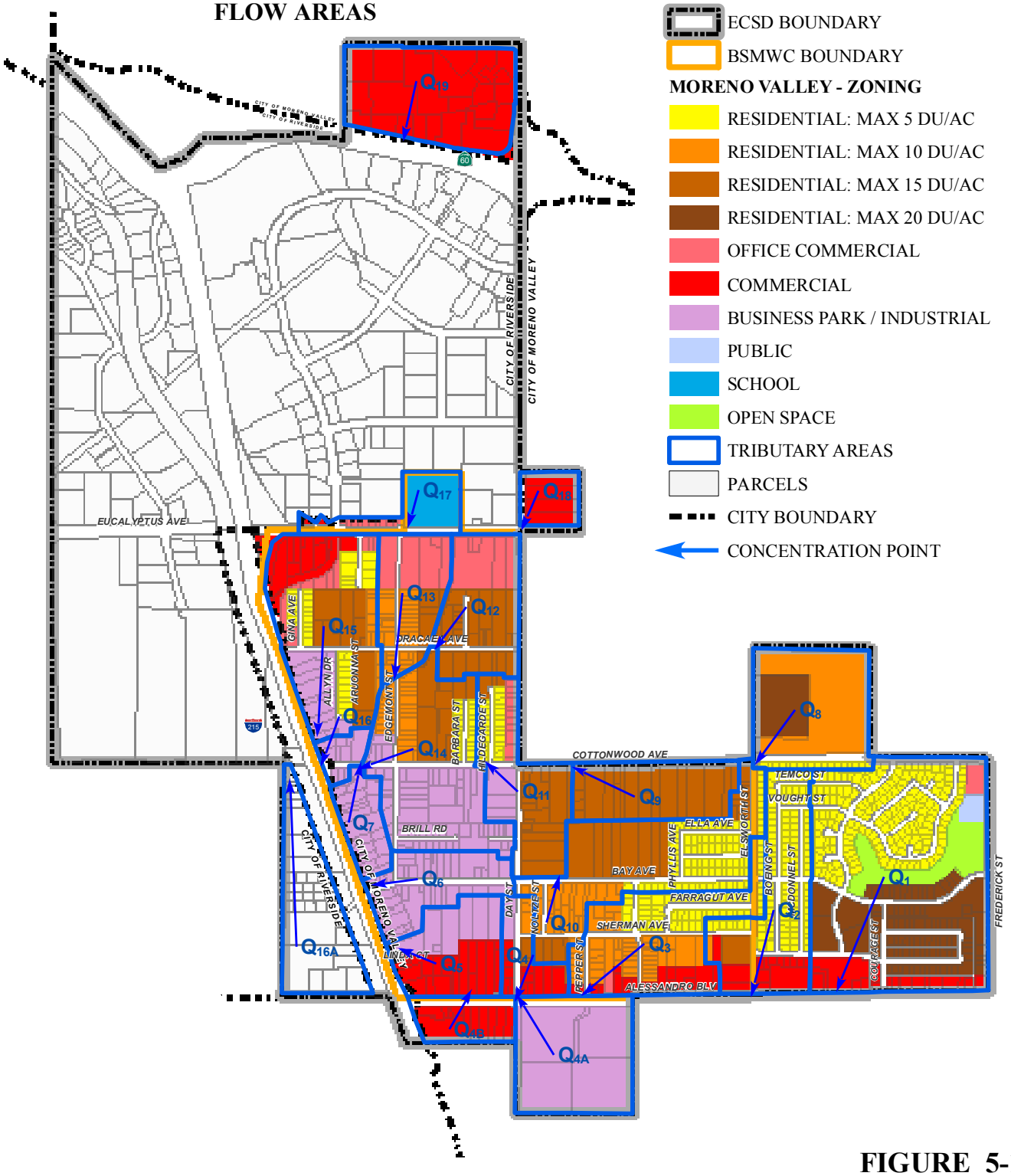

FIGURE 5-1

Source: Riverside County 2007

* FROM CITY OF MORENO VALLEY GIS - ZONING LAYER

ALBERT A. WEBB ASSOCIATES

Map revised July 29, 2008. G:\2006\06-0352\Gis\Gen_Plan_Trib_8x11.mxd

Table 5-1: Projected "Buildout" Average Daily Flows For Ultimate Trunk Sewer Design

Tributary Sewage Flow Area	Commercial/Industrial Average Daily Flow (gpd)[1]	Residential Average Daily Flow (gpd)[2]	Public/Open space Average Daily Flow (gpd)	Total Average Daily Flow (gpd)
Q_1	23,000	149,820	2,000	174,820
Q_2	17,200	35,820	0	53,020
Q_3	16,800	62,860	0	79,660
Q_4	14,800	8,320	0	23,120
Q_{4A}	73,800	0	0	73,800
Q_{4B}	20,600	0	0	20,600
Q_5	52,600	0	0	52,600
Q_6	24,800	0	0	42,800
Q_7	24,800	0	0	24,800
Q_8	0	106,160	0	106,160
Q_9	0	63,600	0	63,600
Q_{10}	0	103,900	0	103,900
Q_{11}	16,400	47,820	0	64,220
Q_{12}	20,800	45,360	0	66,160
Q_{13}	16,200	33,400	0	49,600
Q_{14}	56,800	53,900	0	110,700
Q_{15}	51,200	57,080	0	108,280
Q_{16}	9,600	0	0	9,600
Q_{16A}	65,800	0	0	65,800
Q_{17}	4,520	0	9,500	14,020
Q_{18}	17,000	0	0	17,000
Q_{19}	94,000	0	0	94,000
Total	**638,720**	**768,040**	**11,500**	**1,418,260**

[1] Commercial and industrial wastewater generation of 2000 gpd/acre was utilized based on factors set forth in Section 3.
[2] A wastewater generation factor for residential dwelling units of 280 gpd/EDU for low density and 160 gpd/EDU for high density was utilized for projecting flows for ultimate trunk sewer design.

Table 5-2: Projected "Buildout" Average Daily Flows for Wastewater Treatment Capacity

Tributary Sewage Flow Area	Commercial/Industrial Average Daily Flow (gpd)[1]	Residential Average Daily Flow (gpd)[2]	Public/Open space Average Daily Flow (gpd)	Total Average Daily Flow (gpd)
Q_1	11,500	143,320	2,000	156,820
Q_2	8,600	31,560	0	40,160
Q_3	8,400	53,880	0	62,280
Q_4	7,400	7,680	0	15,080
Q_{4A}	36,900	0	0	36,900
Q_{4B}	10,300	0	0	10,300
Q_5	26,300	0	0	26,300
Q_6	21,400	0	0	21,400
Q_7	12,400	0	0	12,400
Q_8	0	95,520	0	95,520
Q_9	0	63,600	0	63,600
Q_{10}	0	96,600	0	96,600
Q_{11}	8,200	46,920	0	55,120
Q_{12}	10,400	45,360	0	55,760
Q_{13}	8,100	30,000	0	38,100
Q_{14}	28,400	50,040	0	78,440
Q_{15}	25,600	53,760	0	79,360
Q_{16}	4,800	0	0	4,800
Q_{16A}	32,900	0	0	32,900
Q_{17}	2,260	0	9,500	11,760
Q_{18}	8,500	0	0	8,500
Q_{19}	47,000	0	0	47,000
Total	**319,360**	**718,240**	**11,500**	**1,049,100**

[1] Commercial and industrial wastewater generation of 1000 gpd/acre was utilized based on factors set forth in Section 3.
[2] A wastewater generation factor for residential dwelling units of 240 gpd/EDU for low density and 160 gpd/EDU for high density was utilized for projecting flows for ultimate trunk sewer design.

As a result of applying the City of Moreno Valley's September 2007 updated atlas map (**Figure 2-3**), the District's total projected "buildout" average daily flow increased by approximately 176,000 gpd when compared to estimates based on November 1995 ECSD Sewer Report. The majority of this increase was based on a significant rezoning of commercial land use to high density residential within District service area. **Table 5-3** below summarizes results detailed in **Appendix C**.

Table 5-3: Projected "Buildout" Average Daily Flows for Wastewater Treatment Capacity

November 1995 ECSD Sewer Report Average Daily Flow (gpd)	September 2007 Zoning Atlas Map "Adjusted" Average Daily Flow (gpd)	Average Daily Flow Increase (gpd)
872,780[(1)]	1,049,100	176,320

[(1)] Based on Table 2: Projected Ultimate Wastewater Flow, of the ECSD Proposed Improvements to the Sewer Collection System. Table was updated for the additional tributary areas (Q_{17}, Q_{18} and Q_{19}) and flows were adjusted applying commercial generation factor of 1,000 gpd/AC and residential generation factor of 240 gpd/EDU.

SECTION 6 - EXISTING SYSTEM ANALYSIS

SEWER VIDEO INSPECTION

With the exception of a few recent sewer improvements, the majority of the existing ECSD sewer system is 20 - 50 years old. Some of the existing pipes were constructed at sizes less than the current minimum standards. In anticipation for potential operational and maintenance concerns and to determine the current physical standing of these older sewerlines, the District videotaped all existing 6-inch diameter sewerlines within the District with the exception of the sewerline on Pan-Am Boulevard (as this is serving only one property). **Table 6-1** and corresponding **Figure 6-1** summarizes this video inspection.

Table 6-1: ECSD Sewer Videotape Inspection

Street Name	Approximate Quantity (linear feet)	Location
Allyn Drive	700	From Dracaea Avenue to south end of Allyn Drive
Barbara Street	1,200	From Cottonwood Avenue to north end of Barbara Street and from Dracaea Avenue to north end of Barbara Street
Hildegarde Street	900	From Cottonwood Avenue to north end of Hildegrade Street
Brill Road	1,250	From Edgemont Street to east end of Brill Road
Edgemont Street	1,270	From Cottonwood Avenue to Bay Avenue
Bay Avenue	1,700	From Day Street to Old I-215 Road and sewer adjacent to Bay Avenue
Linda Court	1,560	From Old I-215 Road to east end of Linda Court and sewer adjacent to Linda Court
Nolze Street	1,000	From Day Street to Pepper Street, including portion of sewer on Sherman Avenue and Bay Avenue
Grant Street	1,110	From Alessandro Boulevard to Sherman Avenue
Sherman Avenue	1,000	From Elsworth Street to Farragut Avenue
Bertie Avenue	800	From Phyllis Avenue to Elsworth Street
Arvonna Street	750	From Dracaea Avenue to south and Arvonna Street
Lancaster Lane	1,000	From Eucalyptus Avenue to Dracaea Avenue and approximately 100 ft. of sewer east of Lancaster Lane on Dracaea Avenue
Day Street	1,000	From Alessandro Boulevard to Bay Avenue

EDGEMONT COMMUNITY SERVICES DISTRICT

SEWER VIDEO INSPECTION

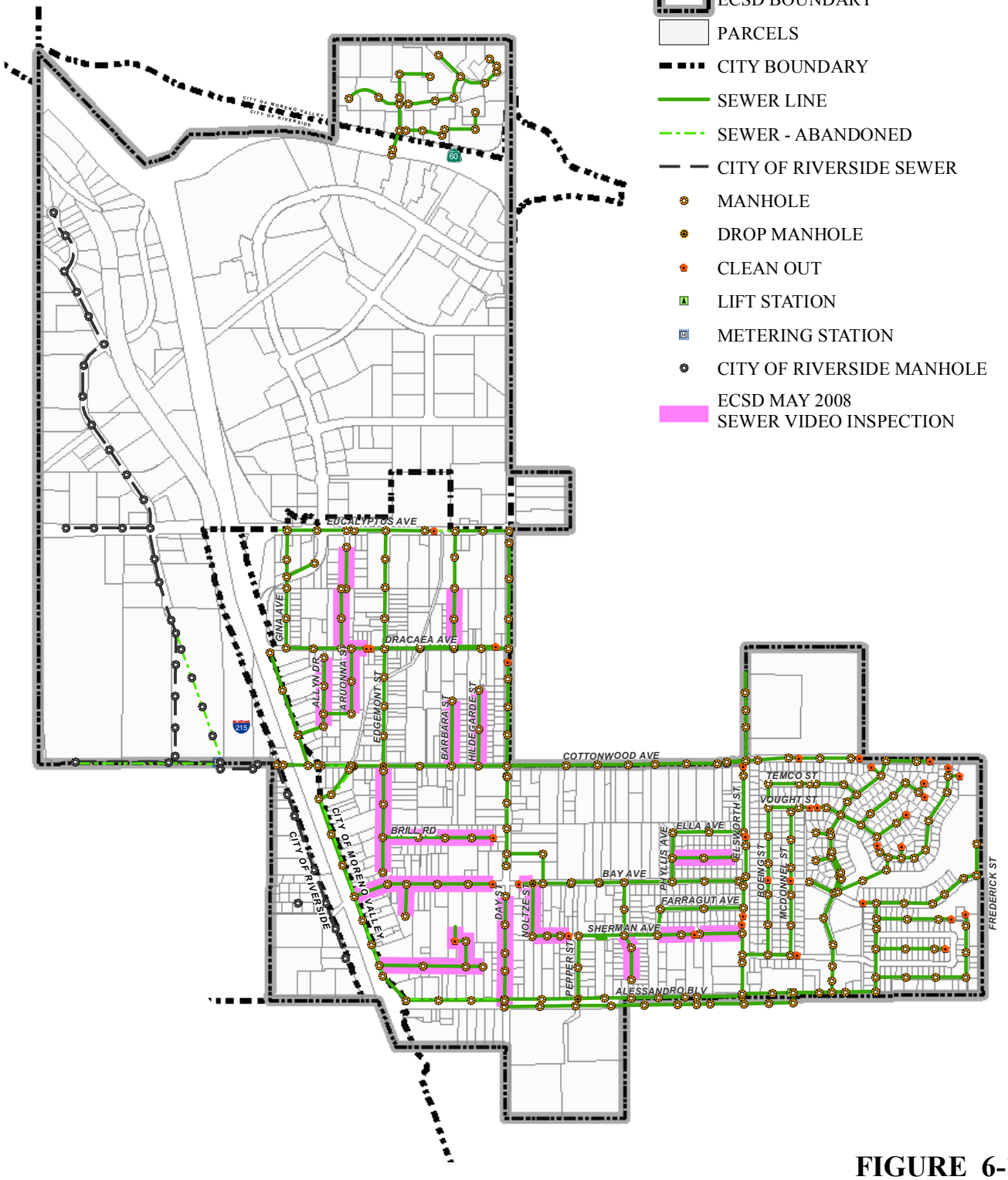

FIGURE 6-1

Source: Riverside County 2007

ALBERT A. WEBB ASSOCIATES

Map revised July 11, 2008. G:\2006\06-0352\Gis\Sewer_Video_8x11.mxd

The observations made per review of District's sewer video inspection included cracks, offset joints at main line and laterals, tree root in growth, sag, grease build-up, etc. As a result of these observations, various improvements are recommended such as miscellaneous point repairs, sewerline replacement and sewer lateral replacements. At certain locations the majority of the existing sewerline does not require repair, though portions do; therefore, only the repair locations require remedy. These locations would constitute miscellaneous point repairs and internal rehabilitation/replacement without having to replace entire sewer line. For other sewerlines, the repair locations were close together and would be more economical to replace the entire section of sewer affected. **Figure 6-2** shows all necessary sewer replacements and miscellaneous maintenance improvements per District videotape review. Cost for these improvements is included in the proposed "Design" sewer system.

FIELD VISIT WITH DISTRICT REPRESENTATIVE

In addition to the sewer video inspection, a field visit was conducted with the District Representative on October 29, 2007 to further review the physical conditions of the existing sewer system.

Cottonwood Sewer Siphon System

The District currently utilizes an 18-inch diameter ductile iron pipe (D.I.P.) sewer siphon to convey wastewater flows under an existing 5' x 5' concrete box culvert on Cottonwood Avenue, east of Old Interstate 215 (**Figure 6-1**). It is our understanding that the County of Riverside Flood Control owned the 5' x 5' concrete box culvert, although is currently not in service and has been abandoned. Although the siphon is adequately sized to covey ultimate flows, it is recommended that the sewer siphon be replaced with standard gravity system to minimize maintenance and clean up issues. It is noted, prior to the replacement of the siphon system, a written confirmation is required from the County of Riverside Flood Control confirming the abandonment of the 5' x 5' concrete box culvert as this structure would require demolition. Cost for this improvement is included in the proposed "Design" Sewer System.

8-Inch Diameter Canyon Springs Shopping Center Sewer

Canyon Springs Shopping Center is located at the north boundary of ECSD, north of the 60 Freeway (**Figure 6-1**). Currently wastewater flows generated within this area are conveyed across the 60 Freeway to the City of Riverside metering station located in the rear parking area of the shopping center south of the 60 Freeway. Sewer videos show that the joint is offset near the manhole south of the 60 Freeway. This offset was also identified during the October 2007 field visit with the District representative. Photos taken on July 4, 2008 by the District Representative show significant joint offset and build-up **(Appendix I)**. It is recommended that this offset joint be repaired and the cost for this improvement is included in the proposed "Design" Sewer System.

Manhole Improvements

During the October 2007 field visit with the District representative, it was observed that multiple manholes, cleanouts, and concrete aprons require repairs such as raised to match the surrounding

grade. It is recommended that the District implement a program to rehabilitate/replace manholes. Cost for this program is included in the proposed "Design" Sewer System.

EDGEMONT COMMUNITY SERVICES DISTRICT

EXISTING SEWER IMPROVEMENTS

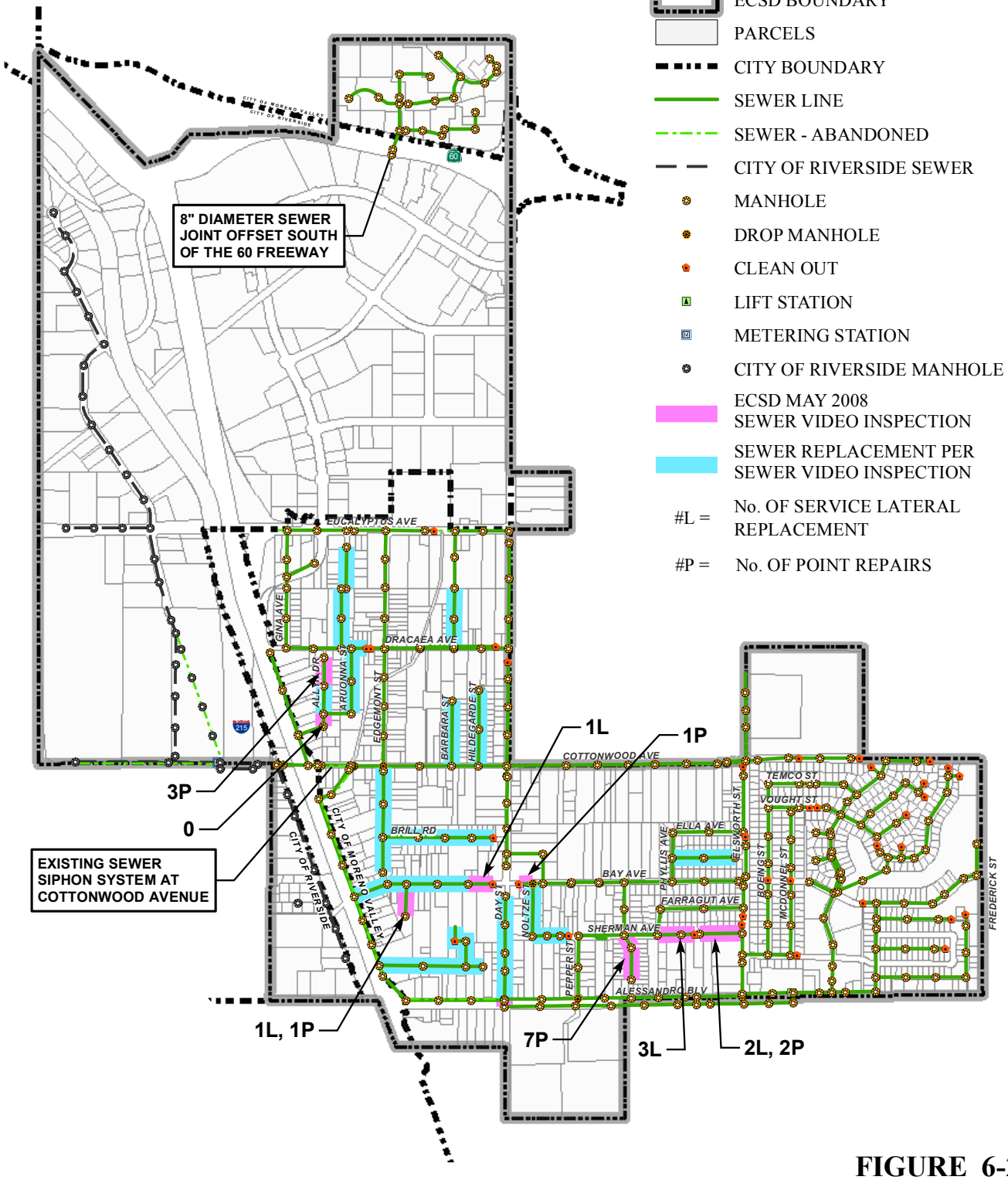

FIGURE 6-2

Source: Riverside County 2007

Map revised July 11, 2008. G:\2006\06-0352\Gis\Sewer_Replace_8x11.mxd

SECTION 7 - HYDRAULIC ANALYSIS

HYDRAULIC ANALYSIS

Based on tributary drainage areas discussed in previous sections and pipeline layouts, hydraulic analysis was performed to determine the adequacy of the existing trunk sewer lines to convey wastewater for the ultimate buildout conditions.

To analyze the existing ECSD system, it was necessary to identify the size of the pipes and slopes. This information, obtained from the District's Atlas Map records, was analyzed using Mannings equation for gravity flow in pipes to determine the pipe capacity. Based on the layout of the existing sewer pipelines within the District, reaches were established at various points within each tributary sewage flow area to denote major wastewater concentration points. The tributary sewage flow areas were developed in Section 5 while the locations of these concentration points corresponded to existing manhole locations within the District's trunk systems.

The flow data at these concentration points were based on wastewater generation values tabulated in **Table 3-1**. The peaking factors as well as wet weather infiltration rates were applied to the flow data to determine the adequacy of each pipeline to convey the ultimate wastewater flows.

INPUT DATA

A spreadsheet was utilized to perform the hydraulic analysis. Much of the inputted data utilized in this spreadsheet were derived from the criteria and standards discussed in Section 3.

Pipe Design Criteria

Evaluation of system performance is subjective and is based on several factors such as flow generation characteristics, peaking factors, infiltration rates, and pipe characteristics. Pipe characteristics such as slope, length and roughness of the pipe can greatly affect the analysis. Some referenced points are evaluated to determine if the design is within reasonable tolerance of the standards established.

Wastewater Concentration Points and Reaches

A flow concentration point is required for each tributary flow area. The concentration points were obtained from the November 1995 ECSD Sewer Plan and are utilized in this report. Wastewater flows generated by each tributary area are diverted to the corresponding concentration point. At each concentration point, the corresponding pipe reach was analyzed for pipe capacity.

The pipe capacity calculations are based on pipe slope, Manning's "n" value and D/d ratio. Minimum pipe diameters and slopes are utilized at each reach to determine the maximum flow capacity.

The identifying prefixes corresponding to each reach utilized in the analysis corresponds to the Trunk Sewer System as described in Section 4 (**Figure 4-1**). In addition to these Trunk Sewer Systems, the hydraulic analysis also analyzed lines which convey tributary flows to the corresponding trunk sewers. These prefixes were utilized in the model to identify the trunk system in which it is a part of:

Prefix	**Trunk System**
A	Alessandro Trunk Sewer System (**Figure 7-2)**
I	I-215 Trunk Sewer System (North and South) (**Figure 7-3**)
C	Cottonwood Trunk Sewer System (**Figure 7-4**)
M	Miscellaneous Sewer lines (**Figure 7-4**)

Flow Data

Once the trunk systems and reaches were established and entered into the hydraulic analysis, the flow data was entered. The flow data was determined by reviewing the tributary drainage areas to determine the contributing tributary areas that correspond to each reach concentration point of a specific drainage area.

Flow input designations are shown in **Figure 7-1** as the wastewater collection point. As previously discussed, flow input is based on wastewater generation factors developed in Section 3 while quantities are based on the values tabulated in **Appendix B** and **Appendix C**.

The following summarizes the tributary areas along with the designated Trunk Systems (**Figure 5-1**):

Trunk System	**Tributary Flow Areas**
Alessandro Trunk System	Q_1 - Q_4, Q_{4A}, Q_{4B}
I-215 Trunk System (South)	Q_1 - Q_4, Q_{4A}, Q_{4B}, Q_5 - Q_7
I-215 Trunk System (North)	Q_{15}
Cottonwood Trunk System	Q_1 - Q_4, Q_{4A}, Q_{4B}, Q_5 - Q_{16}, Q_{16A} , Q_{17}, Q_{18}
Miscellaneous (M1)	Q_{10}
Miscellaneous (M2)	Q_{12}
Miscellaneous (M3)	$Q_{12,}$ Q_{13}

Peaking Factor

It is important to consider diurnal flow rate variations and these variations can be accounted for by introducing a peaking factor. The peaking factor is calculated by utilizing the peaking factor equation discussed in Section 3. The peak flow value will be utilized to evaluate the sewerline capacity (refer to **Appendix D** for a detailed breakdown of peak flow values).

EDGEMONT COMMUNITY SERVICES DISTRICT

TRUNK SEWER SYSTEM

LEGEND

- ECSD BOUNDARY
- TRIBUTARY AREAS
- PARCELS
- CITY BOUNDARY
- CONCENTRATION POINT
- ALESSANDRO TRUNK SEWER
- COTTONWOOD TRUNK SEWER
- OLD 215 TRUNK SEWER
- MISCELLANEOUS TRUNK SEWER

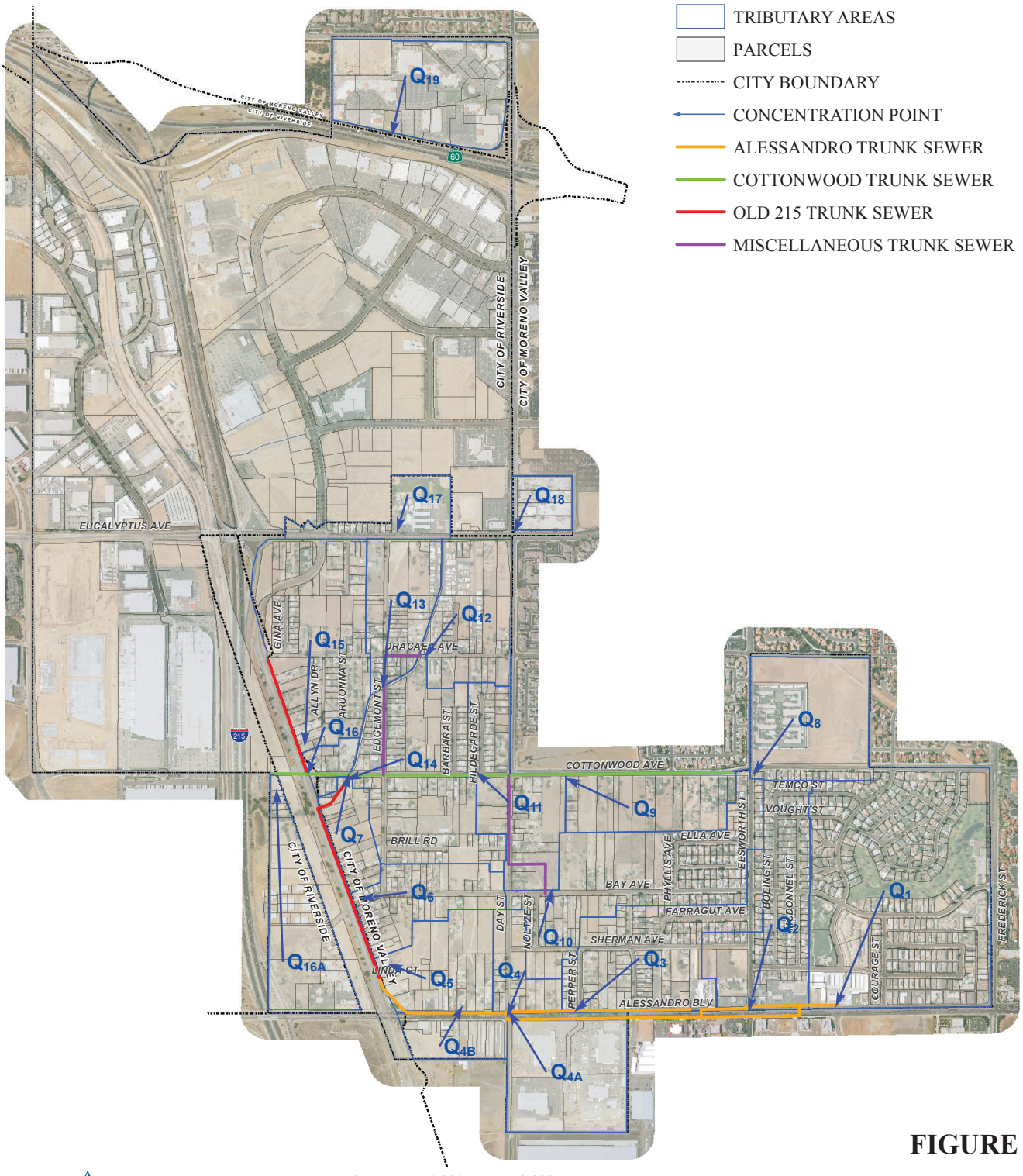

FIGURE 7-1

Source: Riverside County 2007

Map revised July 29, 2008. G:\2006\06-0352\Gis\Aerial_Trunk_Reach_36x30.mxd

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ALESSANDRO TRUNK SEWERS

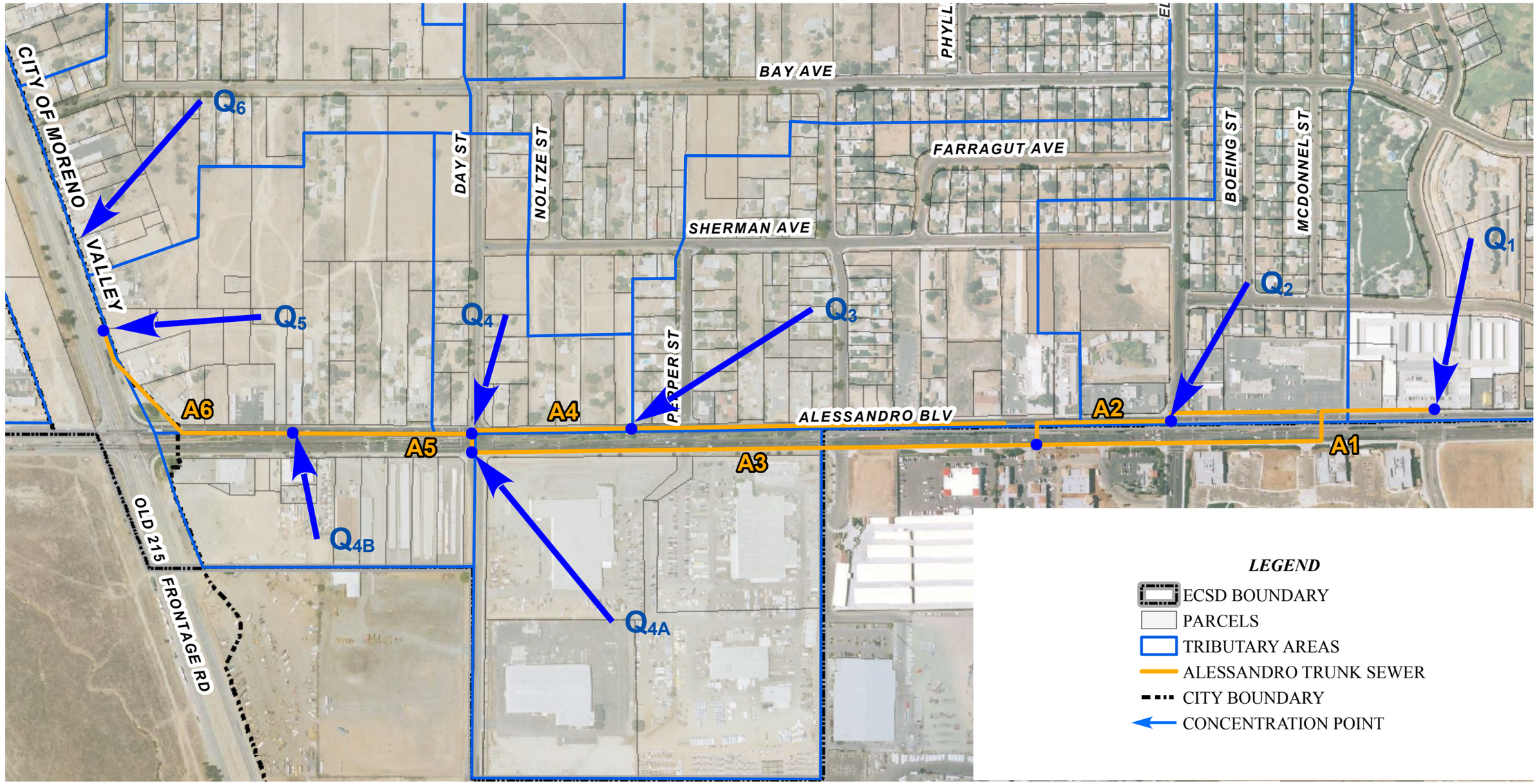

FIGURE 7-2

0 400 800
Feet

Source: Riverside County 2007

ALBERT A. WEBB ASSOCIATES

Map revised October 9, 2007. G:\2006\06-0352\Gis\Trunk-Alessandro_8x11.mxd

EDGEMONT COMMUNITY SERVICES DISTRICT

OLD 215 TRUNK SEWERS

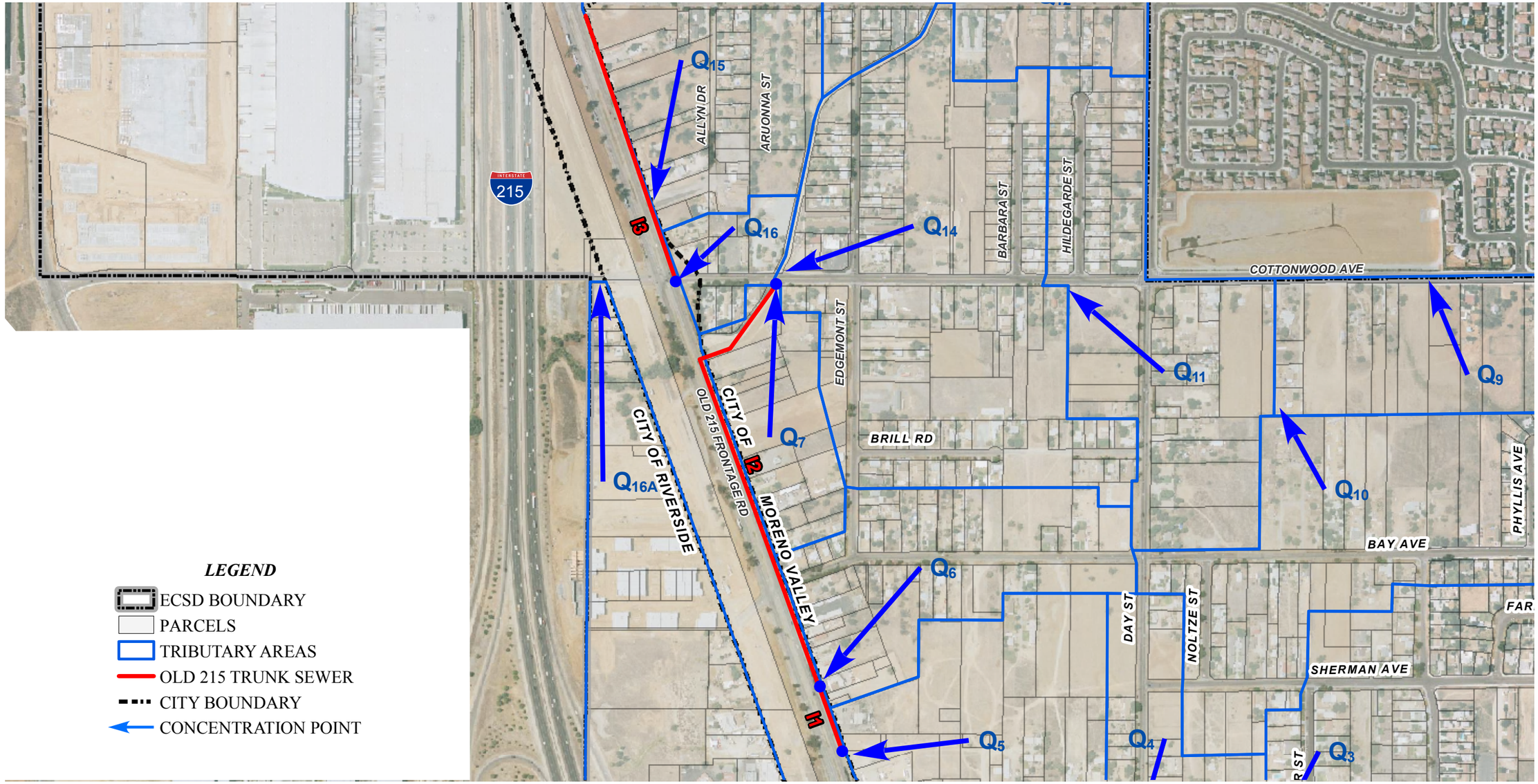

FIGURE 7-3

Source: Riverside County 2007

ALBERT A. WEBB ASSOCIATES

Map revised October 11, 2007. G:\2006\06-0352\Gis\Trunk-Old215_8x11.mxd

EDGEMONT COMMUNITY SERVICES DISTRICT

COTTONWOOD TRUNK SEWERS

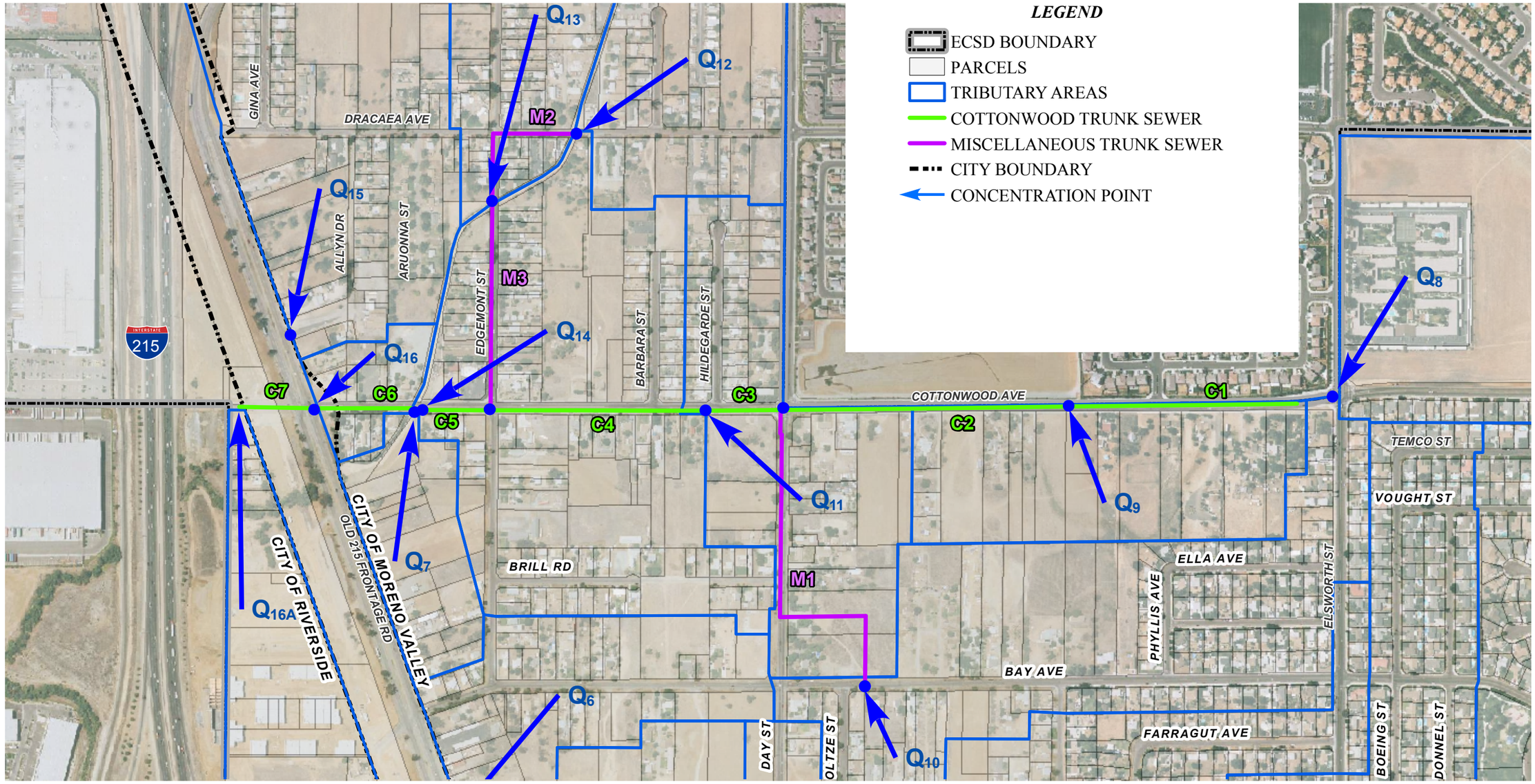

FIGURE 7-4

Source: Riverside County 2007

ALBERT A. WEBB ASSOCIATES

Map revised October 1, 2007. G:\2006\06-0352\Gis\Trunk-Cottonwood_8x11.mxd

ANALYSIS RESULTS

Table 7-1 summarizes the results obtained from the hydraulic analysis (refer to **Appendix G** for a detailed breakdown of this table).

Table 7-1: Summary of Results from Hydraulic Analysis

Reach	Average Daily Flow (MGD)	Peak Daily Flow (MGD)	Maximum Flow Capacity (MGD)
A1	0.175	0.511	1.327
A2	0.053	0.173	0.157
A3	0.215	0.617	1.327
A4	0.080	0.250	0.247
A5	0.404	1.097	1.327
A6	0.425	1.148	1.259
I1	0.478	1.276	1.259
I2	0.520	1.380	1.513
I3	0.108	0.331	1.087
C1	0.106	0.325	0.247
C2	0.170	0.498	0.247
C3	0.274	0.769	0.247
C4	0.338	0.931	0.251
C5	0.454	1.218	1.704
C6	1.110	2.748	2.766
C7	1.227	3.013	3.092
M1	0.104	0.318	0.271
M3	0.116	0.351	0.285

As previously stated, the criteria outlined in Section 3 was used to determine the peak daily flow for ultimate buildout conditions in comparison to the existing systems maximum flow capacity at each critical reach. Wastewater flow exceeding the capacity of the existing pipe would be considered as potentially deficient and therefore, would need further evaluation to determine if replacement is recommended. An example of this type of deficiency can be observed in Reach C1 as shown in **Table 7-1**. This reach is an 8-inch diameter pipe and has a maximum flow capacity of 0.247 MGD based on a specified slope, roughness factor and D/d. The amount of flow that this pipe is required to convey is 0.325 MGD based on buildout conditions. This value is "above" the allowable pipe capacity by 0.078 MGD and can be defined as a hydraulic deficiency. **Table 7-2** outlines all the hydraulic deficiencies observed within the District's system requiring further evaluation.

Table 7-2: Potential Hydraulic Deficiencies

Reach	Pipe Diameter (in)	Slope (%)	Average Daily Flow (MGD)	Peak Daily Flow (MGD)	Maximum Flow Capacity (MGD)	Actual D/d[1]
A2	8	0.00160	0.053	0.173	0.157	0.54
A4	8	0.00400	0.080	0.250	0.247	0.52
I1	12	0.00360	0.478	1.276	1.259	0.76
C1	8	0.00400	0.106	0.325	0.247	0.61
C2	8	0.00400	0.170	0.489	0.247	0.80
C3	8	0.00400	0.247	0.796	0.247	>1
C4	8	0.00410	0.338	0.931	0.251	>1
M1	8	0.00480	0.104	0.318	0.271	0.56
M3	8	0.00530	0.116	0.361	0.285	0.57

As shown in **Table 7-2**, there is a close proximity between the existing pipe capacities and the ultimate peak wastewater flows for the majority of reaches. If the D/d ratio is increased the pipe capacity is also increased. For the purposes of this evaluation, if the D/d ratio is adjusted to 0.60 for 8-inch and 0.80 for 10-inch and greater diameter pipe, the number of hydraulically deficient reaches was reduced. **Table 7-3** summarizes the adjusted list of pipe reaches that are now deficient under this criterion.

Table 7-3: Hydraulic Deficiencies

Reach	Pipe Diameter (in)	Slope (%)	Average Daily Flow (MGD)	Peak Daily Flow (MGD)	Maximum Flow Capacity (MGD)	Actual D/d[1]
C1	8	0.00400	0.106	0.325	0.247	0.61
C2	8	0.00400	0.170	0.498	0.247	0.80
C3	8	0.00400	0.247	0.769	0.247	>1
C4	8	0.00400	0.338	0.931	0.251	>1

Summary

A review of the locations of hydraulically deficient pipes was conducted (**Figure 7-5**). The pipes that fall under the Hydraulic Deficiencies definition are 8-inch diameter pipe and are located on Cottonwood Avenue.

It should be noted that the existing ECSD Collection system was analyzed with current wastewater flows generated within the ECSD boundary using data from the 2007-2008 ECSD Fiscal Year Sewer Charges Report to identify any current hydraulically deficient reaches. **Table 7-4** below summarizes the results of this analysis and shows that reaches C3 and C4 are currently hydraulically deficient; and should be prioritized over other replacement lines.

[1] Actual D/d represents the actual D/d ratio necessary to convey peak daily flow through the reach.

EDGEMONT COMMUNITY SERVICES DISTRICT

HYDRAULICALLY DEFICIENT REACHES OF TRUNK SEWERS

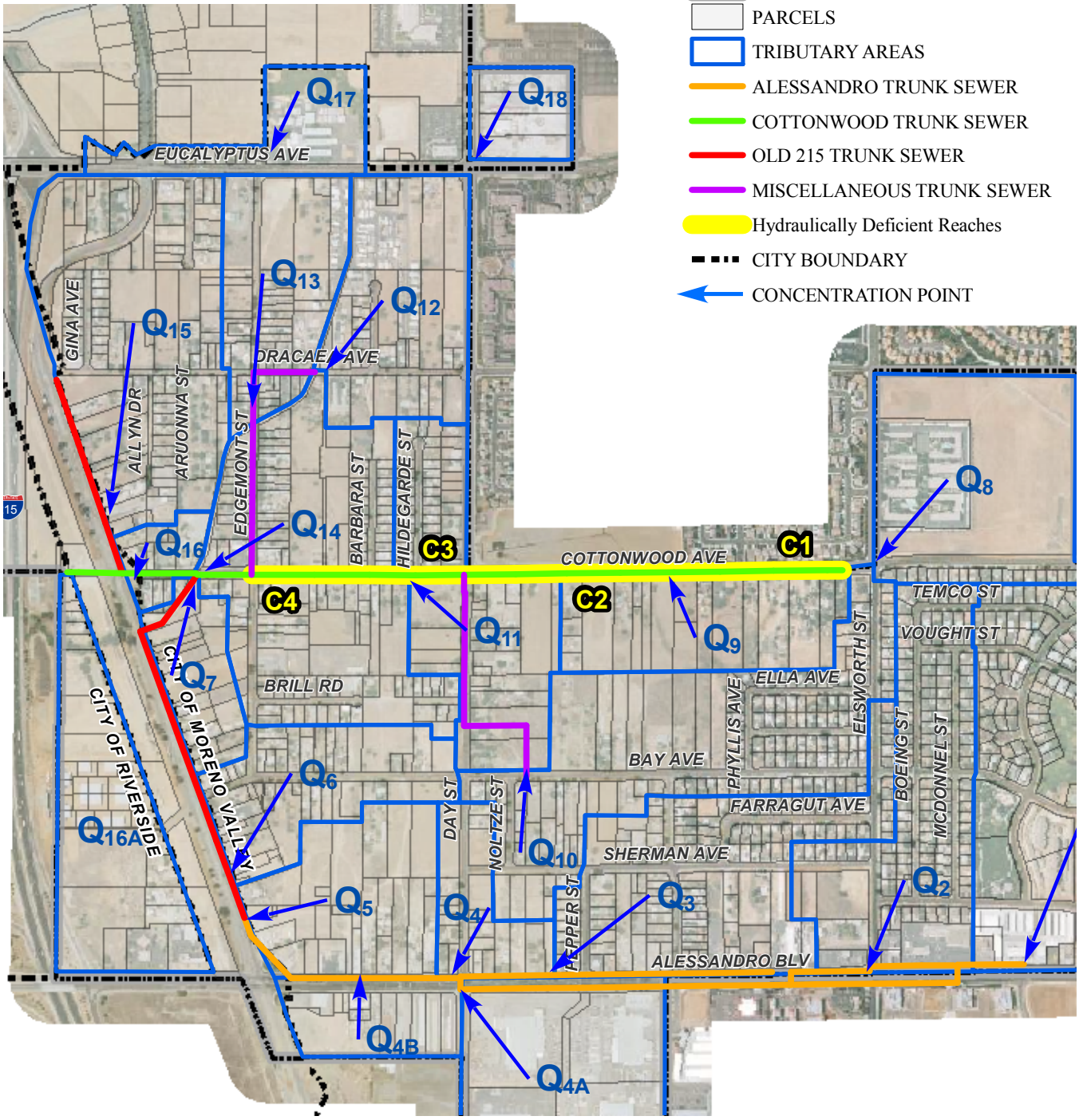

FIGURE 7-5

0 1,000 2,000
Feet

Source: Riverside County 2007
AirPhoto USA 2007

ALBERT A. WEBB ASSOCIATES

Map revised March 26, 2008. G:\2006\06-0352\Gis\Aerial_Trunk-Fail_8x11.mxd

Table 7-4: Hydraulically Deficient Reaches Based on Current Wastewater Flows

Reach	Pipe Diameter (in)	Slope (%)	Current Existing Flow (MGD)	Peak Daily Flow (MGD)	Maximum Flow Capacity (MGD)	Actual D/d
C3	8	0.00400	0.105	0.322	0.247	0.59
C4	8	0.00400	0.127	0.382	0.251	0.66

SECTION 8 - PROPOSED SYSTEM IMPROVEMENT

As a result of the ultimate wastewater flows on the existing trunk sewer system, various sewers required replacement, relief or rerouting to provide for adequate flow conveyance and minimize hydraulic deficiencies as described in Section 7 of this report.

In addition to evaluating the pipelines based on hydraulic analysis, the pipelines were also evaluated based on the sewer video inspection to assess any physical damage. The damaged pipelines shall require replacement, even if the corresponding pipe reaches are hydraulically sufficient, and will be incorporated into the required improvements to the District's Sewer System.

GRAVITY SYSTEM EVALUATION

Pipe reaches falling under the definition of "Hydraulic Deficiency" can either be replaced with a larger diameter pipe, relieved or rerouted in order to convey ultimate wastewater flow as detailed herein.

The District's Existing Trunk System consists of mostly vitrified clay pipe (V.C.P.) with some exceptions. It is assumed that the replaced, relieved and rerouted sewers will be V.C.P. as well. The hydraulically deficient pipe reaches defined in Section 7 (**Figure 7-5**) shall be identified and in accordance to their respective street names. **Table 8-1** summarizes the hydraulically deficient pipe reaches required to convey ultimate wastewater flows (see **Appendix H** for detailed proposed system analysis).

Table 8-1: Proposed Improvements to Existing ESCD Sewer System per Hydraulic Analysis

Street Name	Location	Project Type
Cottonwood Avenue	From Elsworth Street to Day Street	Existing 8" dia. sewer to be replaced with 10" dia. sewer due to ultimate buildout flows
Cottonwood Avenue	From Elsworth Street to Edgemont Street	Existing 8" dia. sewer to be replaced with 12" dia. sewer due to ultimate buildout flows

Replacement of Sewers

This method requires the replacement of the existing sewer pipe with a "new" sewer pipe of larger diameter to provide for adequate flow conveyance. For planning purposes, it is

assumed that the "new" sewer pipe will have the same slope and flowline elevations as the existing sewer pipe to be replaced.

Relief Sewers

This method requires an additional sewer pipe such as a parallel system to "relieve" an existing sewer main of its hydraulic deficiencies. The relief sewer may discharge back into the same trunk line downstream at a point where there are no hydraulic deficiencies or discharge into another trunk line with sufficient capacity for additional flows.

Rerouting of Sewers

This method requires the abandonment of portions of the existing sewer with hydraulic deficiencies and rerouting the trunk line along a new alignment. This may also include upgrading the sewer pipe to a larger diameter pipe.

DISTRICT VIDEO

As discussed in Section 6 of this report, the District has videotaped various sewer lines within the District that may need replacement. Such lines include the District's 6-inch diameter sewer lines, 8-inch diameter Canyon Springs Shopping Center pipeline, and the 8-inch diameter Arvonna Street Pipeline. Observations made in the videotape review included cracks, separated joints, sag, grease build-up and damages caused by tree root in growth. **Table 8-2** and corresponding **Figure 6-2** summarizes the pipelines requiring replacement based on these observations.

Table 8-2: Proposed Improvements to Existing ECSD Sewer System per Video and Field Visit

Street Name	Approx. Quantity (linear feet)	Location	Project Type
Allyn Drive	400	From Dracaea Avenue to south end of Allyn Drive	Existing 6" dia. sewer to be replaced with 8" dia. sewer due to excessive damage observed in videotape.
Barbara Street	1,325	From Cottonwood Avenue to north end of Barbara Street and from Dracaea Avenue to north end of Barbara Street	Existing 6" dia. sewer to be replaced with 8" dia. sewer due to excessive damage observed in videotape.
Hildegarde Street	900	From Cottonwood Avenue to north end of Hildegrade Street	Existing 6" dia. sewer to be replaced with 8" dia. sewer due to excessive damage observed in videotape.
Brill Road	1,250	From Edgemont Street to east end of Brill Road	Existing 6" dia. sewer to be replaced with 8" dia. sewer due to excessive damage observed in videotape.
Edgemont Street	1,250	From Cottonwood Avenue to Bay Avenue	Existing 6" dia. sewer to be replaced with 8" dia. sewer due to excessive damage observed in videotape.
Bay Avenue	1,250	From Day Street to Old I-215 Road and sewer adjacent to Bay Avenue	Existing 6" dia. sewer to be replaced with 8" dia. sewer due to excessive damage observed in videotape.
Linda Court	1,550	From Old I-215 Road to east end of Linda Court and sewer adjacent to Linda Court	Existing 6" dia. sewer to be replaced with 8" dia. sewer due to excessive damage observed in videotape.
Nolze Street	1,000	From Day Street to Pepper Street, including portion of sewer on Sherman Avenue and Bay Avenue	Existing 6" dia. sewer to be replaced with 8" dia. sewer due to excessive damage observed in videotape.
Bertie Avenue	800	From Phyllis Avenue to Elsworth Street	Existing 6" dia. sewer to be replaced with 8" dia. sewer due to excessive damage observed in videotape.
Arvonna Street	800	From Dracaea Avenue to south and Arvonna Street	Existing 8" dia sewer to be replaced due to excessive damage observed in videotape.
Lancaster Lane	1,200	From Eucalyptus Avenue to Dracaea Avenue and approximately 100 ft. of sewer east of Lancaster Lane on Dracaea Avenue	Existing 8" dia sewer to be replaced due to excessive damage observed in videotape.
Day Street	1,000	From Alessandro Boulevard to Bay Avenue	Existing 6" dia sewer to be replaced with 8" dia sewer due to excessive damage observed in videotape.

GRAVITY SYSTEM IMPROVEMENT LOCATIONS

The following **Table 8-3** summarizes the locations of improvements (**Figure 8-1**) from the observations made in the hydraulic analysis and video inspection.

Table 8-3: Summary of ECSD Gravity Sewer System Improvements

Project No.	Project Location	Project Type	Proposed Pipe Replacement (feet)	Proposed Sewer Main Sizes
CA-1 & CA-2	Cottonwood Ave.	Sewer Replacement	3,800	10 and 12-inch
ES-1	Edgemont St.	Sewer Replacement	1,250	8-inch
BS-1	Barbara St.	Sewer Replacement	1,325	8-inch
LL-1	Lancaster Ln.	Sewer Replacement	1,200	8-inch
BA-1	Bay Ave.	Sewer Replacement	1,250	8-inch
AS-1	Arvonna St.	Sewer Replacement	800	8-inch
DS-1	Day St.	Sewer Replacement	1,000	8-inch
AD-1	Allyn Dr.	Sewer Replacement	400	8-inch
HS-1	Hildegarde St.	Sewer Replacement	900	8-inch
BR-1	Brill Rd.	Sewer Replacement	1,250	8-inch
LC-1	Linda Ct.	Sewer Replacement	1,550	8-inch
NS-1	Nolze St.	Sewer Replacement	1,000	8-inch
BE-1	Bertie Ave.	Sewer Replacement	800	8-inch

EDGEMONT COMMUNITY SERVICES DISTRICT

PROPOSED ECSD SEWER CAPITAL IMPROVEMENT PROJECTS

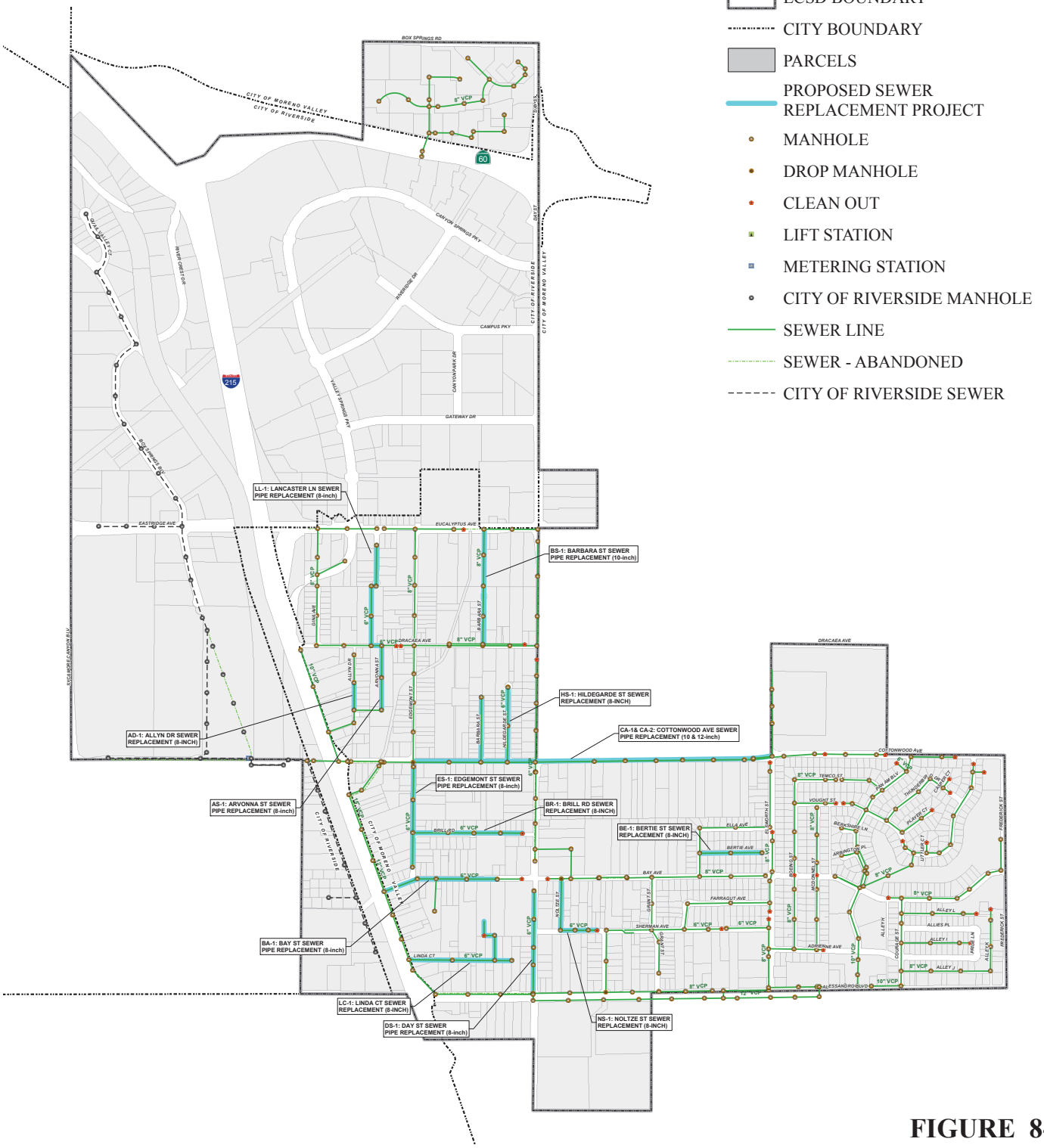

FIGURE 8-1

Source: Riverside County 2007

ALBERT A. WEBB ASSOCIATES

Map revised June 26, 2008. G:\2006\06-0352\Gis\Sewer_CIP_ECSD_36x30.mxd

Based on the overall system, the number of pipes which need to be replaced is relatively low. The total length of pipe needing replacement is 16,525 L.F. or about 17% of the total pipes within the ECSD system.

MAINTENANCE IMPROVEMENTS

The majority of the pipelines observed in the video inspection would require replacements. However, at certain locations, sewer replacement can be avoided if miscellaneous improvements to the existing sewerline are performed. Therefore, maintenance improvement programs should be developed to replace/rehabilitate existing ECSD facilities. These improvements include rehabilitating approximately 10 to 20 manholes, approximately 14-20 point repairs to existing gravity sewer system and replacing approximately 7-10 sewer service laterals.

TREATMENT SYSTEM EVALUATION AND PLANNING

Wastewater generated by the District is ultimately conveyed to the City of Riverside WQCP for treatment. The District's wastewater enters the City of Riverside's collection system at two locations: (1) the metering facility at Cottonwood Avenue and (2) the metering facility for the Canyon Springs Shopping Center south of the 60-Freeway.

The projected ultimate "buildout" wastewater flow to the City of Riverside WQCP is approximately 1.05 MGD for dry weather average daily flow (**Table 5-2**). ECSD currently owns 0.89 MGD of treatment capacity from the City of Riverside. Therefore, ECSD does not presently have rights for the projected ultimate treatment plant capacity of 1.05 MGD. Rights for an additional 0.16 MGD of treatment plant capacity is required from the City of Riverside to accommodate the projected "buildout" average daily flow.

SECTION 9 - COST ANALYSIS

COST ESTIMATION

Proper and consistent cost estimation is essential in determining the feasibility of a proposed project. Construction costs for all plans are based upon preliminary layouts of proposed facilities. For estimating purposes, the prices of comparative work were obtained from a variety of available sources of current information such as recent project bid data, literature, publications, telephone and personal contacts with manufacturers and suppliers of equipment. It should be noted that the unit prices applied to sewer pipelines in the estimates take into account the costs of A.C. pavement removal, disposal, replacement, and cap where these lines occur in paved roads and clearing, grubbing and 12-feet wide access road, construction costs where these lines occur outside of paved streets.

In reviewing the cost estimates presented herein for the proposed projects, it is essential to realize that changes in estimates during final design will alter the totals to some degree. Furthermore, future changes in the cost of material, labor, and equipment certainly will cause comparable changes in the cost summarized herein. Some of the specific cost estimating factors are discussed in the following subsections. The cost data presented are comprised of two primary components: (1) estimated construction costs, and (2) estimated project costs (incidental costs).

Estimated Construction Costs

The basic estimated construction costs apply to preliminary design and layout of major facilities required for the proposed facilities. In such layouts, detailed construction drawings and specifications are not required. Instead, reasonably close approximations of the size, location, route and cost of the various facilities were developed in sufficient detail to permit cost estimates to be made. Estimated construction costs were based upon what one might expect of a "low bid" price to construct the required improvements.

Construction Contingencies

A contingency allowance is made for uncertainties associated with preliminary design. Such factors as differences in final lengths and exact topography associated with the pipelines, unknown underground substructures, and changes made during construction, are a few of the many items which may increase contract costs and for which some allowance must be made in preliminary design estimates.

Cost Index and Price Escalation

Construction costs can be expected to undergo long-term changes in keeping with corresponding changes in the national economy. The best available barometer of these changes is the Engineering News-Record Construction Cost Index (ENR-CCI), which is

computed from prices of construction materials and labor. For purposes of this report, cost data are based on an ENR-CCI Los Angeles. By reference to the ENR-CCI at any future date, the estimated construction costs included herein can be adjusted to match the current costs at that future date. This allows the estimated costs to be updated to the time when actual construction is undertaken.

Engineering Costs

The cost of engineering services for major construction projects may include special investigations, pre-design reports, surveys, foundation explorations, location of interfering utilities, detailed design, preparation of contract drawings and specifications, construction inspection, materials testing, and final inspection of the completed work. Depending on the size and type of the project, the total engineering costs may range from 7 to 20 percent of the contract cost. The lower percentage applies to large projects and to those which do not require a large amount of preliminary investigation. The higher percentage applies to smaller projects or to those which require a relatively large amount of preliminary work.

Legal and Administrative Costs

Legal costs would include items such as assistance in R-O-W acquisition, specification review, construction contract review and approval, coordination during construction, etc. Administrative costs would be those associated with contract administration, progress payments to the Contractor, change orders, notice of completion, etc. Finally, it should be noted that assessment engineering and financing costs are not included in these costs. Assessment engineering and financing costs are those associated with securing funds to pay for the proposed improvements and determination of equitable method(s) of sharing the costs (i.e., costs to benefits). Environmental documentation includes those basic services necessary to obtain environmental clearance to perform the construction. However, extensive environmental services such as those that would be necessary for an environmental impact report and/or environmental impact statement are not included.

PROPOSED CAPITAL IMPROVEMENT PROJECTS

The components used to develop unit construction costs for the trunk sewerlines include pipeline material and installation costs, manhole costs, and asphalt concrete removal, disposal, and replacement costs. Construction costs were determined by reviewing historical bids of similar projects. Road reconstruction was assumed to be 25 feet wide with 4 inches of AC pavement over 8 inches of Class II base. The average depth of the pipe was assumed to be 10-feet and would require Class B-2 bedding. It was assumed nine, 5-ft diameter manholes would be installed for each project. These costs were then updated to correlate with recent bid results that are about 25 percent higher than the "generic bid" results. Not included in the unit cost estimates are extraordinary construction items such as bore casings, dewatering, rock removal, etc. A summary of these estimated unit costs are as shown in **Table 9-1**.

Table 9-1: Estimated Unit Cost of Trunk Sewer Pipelines

Sewer Line Dia. (in.)	Construction Cost	Project Cost[1]
8	$200.00	$280.00
10	$215.00	$300.00
12	$245.00	$345.00
15	$260.00	$365.00
18	$290.00	$405.00

The unit costs shown in **Table 9-1** were applied to the proposed capital improvement projects shown in **Table 8-3** to develop project cost estimates as summarized in **Table 9-2**. The total estimated project cost for gravity flow pipelines is $4,760,000. **Plate 2** shows the project locations.

Table 9-2: Cost Analysis for Proposed Capital Improvement Projects

Item	Quantity	Unit	Unit Price	Total Cost
CA-1: 10" Dia. Cottonwood Sewer Replacement	2,500	LF	$215	$537,500
CA-2: 12" Dia. Cottonwood Sewer Replacement	1,300	LF	$245	$318,500
ES-1: 8" Dia Edgemont Sewer Replacement	1,250	LF	$200	$250,000
BS-1: 8" Dia Barbara Sewer Replacement	1,325	LF	$200	$265,000
LL-1: 8" Dia Lancaster Sewer Replacement	1,200	LF	$200	$240,000
BA-1: 8" Dia. Bay Sewer Replacement	1,250	LF	$200	$250,000
AS-1: 8" Dia. Arvonna Sewer Replacement	800	LF	$200	$160,000
DS-1: 8" Dia. Day Sewer Replacement	1,000	LF	$200	$200,000
AD-1: 8" Dia. Allyn Sewer Replacement	400	LF	$200	$80,000
HS-1: 8" Dia. Hildegarde Sewer Replacement	900	LF	$200	$180,000
BR-1: 8" Dia. Brill Sewer Replacement	1,250	LF	$200	$250,000
LC-1: 8" Dia. Linda Sewer Replacement	1,550	LF	$200	$310,000
NS-1: 8" Dia. Nolze Sewer Replacement	1,000	LF	$200	$200,000
BE-1: 8" Dia. Bertie Sewer Replacement	800	LF	$200	$160,000
			Total Estimated Construction Cost	$3,401,000
			Total Estimated Project Cost	$4,760,000[2]

[1] Project cost is 1.4 times construction cost rounded up to nearest $5. Project cost includes: construction cost, construction contingencies, design engineering including plans and specifications; design and construction surveying and mapping; geotechnical evaluation and report; engineering contract administration; field inspection and basic environmental documentation. Costs are based on Engineering New Record (E.N.R.). The Engineering news Record Construction Cost Index for the Los Angeles Areas for July 2008 was utilized. This value is 9,335.69. Escalation, financing, interest during construction, legal, land, R.O.W. agent, and environmental impact report costs are not included in construction costs. Additionally, not included in the unit cost estimates are extraordinary construction items such as bore casings, dewatering, rock removal etc.

[2] Project cost is 1.4 times construction cost rounded up to nearest $10,000. Project cost, includes: construction cost, construction contingencies, design engineering including plans and specifications; design and construction surveying and mapping; geotechnical evaluation and report; engineering contract administration; field inspection and basic environmental documentation.

RECOMMENDED SEWER SYSTEM REHABILITATION/REPLACEMENT PROJECTS

Section 6 outlined recommended rehabilitation/replacement projects that the District should consider due to conditions that create operation and maintenance problems. These conditions include existing sewer siphon system at Cottonwood Avenue and offset joint at Canyon Springs Shopping Center. A summary of these recommended sewer system rehabilitation/replacement projects and estimated project cost are shown in **Table 9-3**.

Table 9-3: Recommended Sewer System Rehabilitation/Replacement Projects

Project	Quantity	Unit	Unit Price	Total
Recommended Sewer System Replacement				
18" Dia. Cottonwood Siphon Replacement	100	LF	$600	$60,000
8" Dia. Canyon Springs Shopping Center Sewer Replacement	1	LS	$40,000	$40,000
			Total Estimated Construction Cost	$100,000
			Total Estimated Project Cost	$140,000[1]

MAINTENANCE IMPROVEMENT PROGRAM

As previously discussed in Section 8, there are various maintenance improvements within the District boundary that are recommended. The improvements were categorized into three (3) programs: 1) manhole replacement program, 2) sewer line point repair program and 3) sewer service lateral replacement program. The estimated construction and project cost for these programs is approximated to be $200,000 for the manhole replacement program, $150,000 for the sewerline point repair program and $36,000 for the sewer service lateral replacement program. It is noted that this is a lump sum estimate utilized for planning purposes only and may vary on a case by case basis.

CITY OF RIVERSIDE WATER QUALITY CONTROL PLANT CAPACITY PURCHASE

The purchase of treatment plant capacity at the City of Riverside WQCP is assumed to reflect the current costs to construct a wastewater treatment plant. Presently, due to the increasing costs of solids treatment and disposal, and due to the amount of treatment capacity being constructed, typical unit project cost is approximately $12/gallon/day. The District currently owns 0.89 mgd of treatment capacity at the City of Riverside's facility. As discussed in Section 8 of this report, the District would be required to obtain an additional 0.16 mgd of treatment capacity from the City of Riverside. Applying the unit cost factor as

[1] Project is 1.4 times the construction cost rounded to the nearest $1,000. Project cost includes: construction cost, construction contingencies, design engineering including plans and specifications; design and construction surveying and mapping; geotechnical evaluation and report; engineering contract administration; field inspection and basic environmental documentation. Costs are based on Engineering New Record (E.N.R.).

listed above to this capacity increase results in an estimated projected treatment cost of $1,920,000.

A summary of the estimated project costs for the ECSD Sewer System Improvements are shown in **Table 9-4** with corresponding **Figure 9-1** (see **Plate 2** for full size). As shown in **Table 9-4**, the total project cost estimate of the updated sewer system improvements is approximately $7,360,000.

EDGEMONT COMMUNITY SERVICES DISTRICT

PROPOSED ECSD SEWER IMPROVEMENT

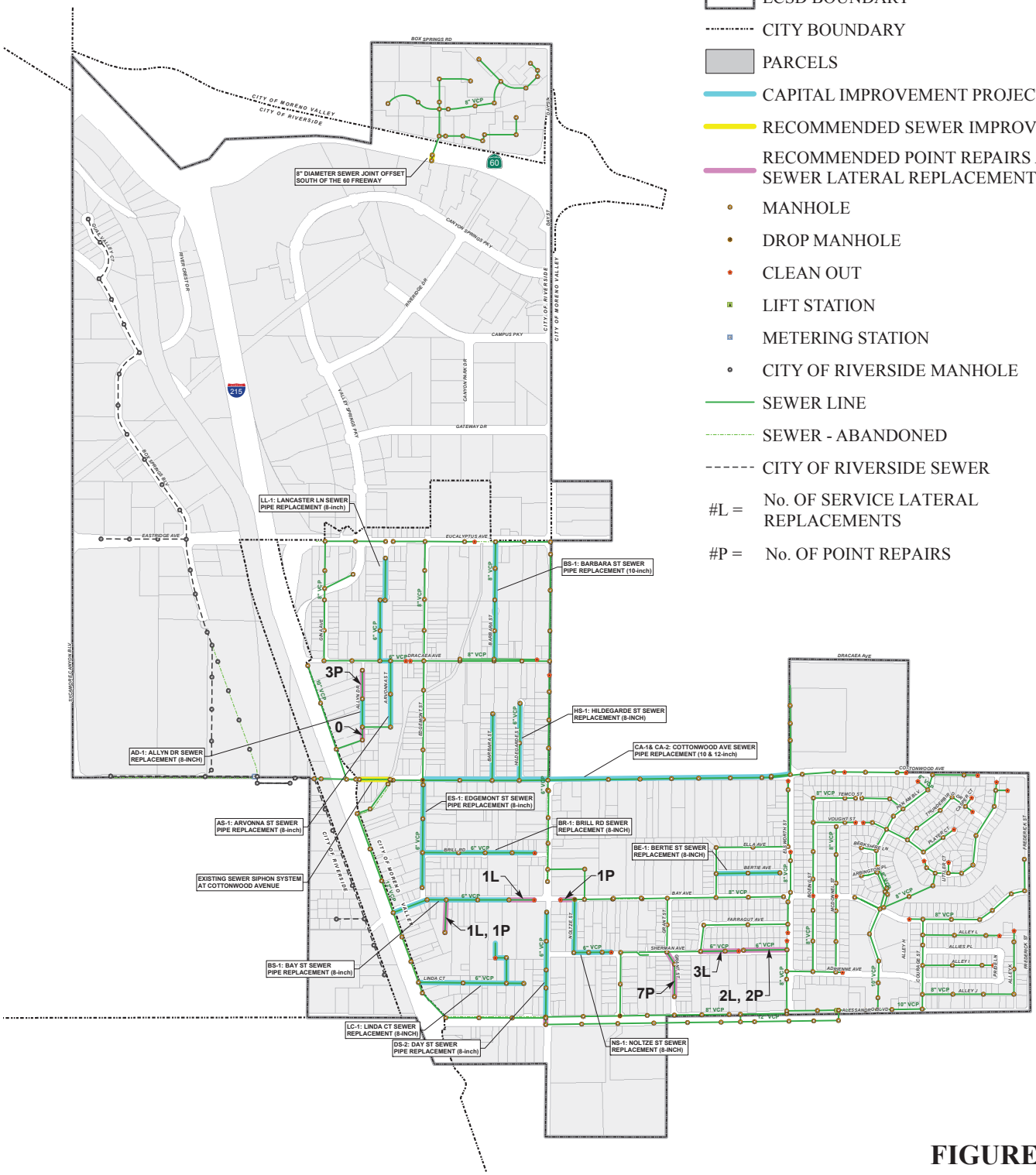

FIGURE 9-1

0 1,000 2,000
Feet

Source: Riverside County 2007

ALBERT A. WEBB ASSOCIATES

Map revised July 29, 2008. G:\2006\06-0352\Gis\Sewer_Prop_ECSD_36x30.mxd

Table 9-4: Edgemont Community Services District Design System Improvements

Item No.	Location	Sewer Replacement Line Size	Quantity	Unit	Unit Cost	Total Cost
Capital Improvement Projects						
Required Upsizing						
CA-1	Cottonwood	10-inch	2500	LF	$215	$537,500
CA-2	Cottonwood	12-inch	1300	LF	$245	$318,500
ES-1	Edgemont	8-inch	1250	LF	$200	$250,000
BS-1	Barbara	8-inch	1325	LF	$200	$265,000
LL-1	Lancaster	8-inch	1200	LF	$200	$240,000
BA-1	Bay	8-inch	1250	LF	$200	$250,000
AS-1	Arvonna	8-inch	800	LF	$200	$160,000
DS-1	Day	8-inch	1000	LF	$200	$200,000
AD-1	Allyn	8-inch	400	LF	$200	$80,000
HS-1	Hildegarde	8-inch	900	LF	$200	$180,000
BR-1	Brill	8-inch	1250	LF	$200	$250,000
LC-1	Linda	8-inch	1550	LF	$200	$310,000
NS-1	Nolze	8-inch	1000	LF	$200	$200,000
BE-1	Bertie	8-inch	800	LF	$200	$160,000
					Total Construction Cost:	**$3,401,000**
					Total Project Cost:	**$4,761,400**
Additional Treatment Cost[1]						**$1,920,000**
					Total Cost:	**$6,681,400**
Recommended Sewer System Replacement						
18-inch Siphon Sysytem Replacement	Cottonwood	18-inch	100	LF	$600	$60,000
8-inch Offset Joint Replacement	Canyon Springs	8-inch	1	LS	$40,000	$40,000
					Total Construction Cost:	**$100,000**
					Total Project Cost:	**$140,000**
Maintenance Improvement Programs						
Manhole Replacement	n/a	n/a	20	EA	$10,000	$200,000
Sewerline Point Repair	n/a	n/a	20	EA	$7,500	$150,000
Sewer Lateral Replacement	n/a	n/a	10	EA	$3,600	$36,000
					Total Construction Cost:	**$386,000**
					Total Project Cost:	**$540,400**
					Total Construction Cost:	**$3,887,000**
					Total Project Cost[2]:	**$5,440,000**
					Additional Treatment Cost[1]:	**$1,920,000**
					Total Cost:	**$7,360,000**

[1] District currently owns 0.89 MGD of treatment capacity at the City of Riverside WQCP. The projected wastewater generated based on ultimate buildout flows is 1.05 MGD. The District would be required to purchase an additional 0.16 MGD at the City of Riverside WQCP. The cost for additional treatment plant capacity is $12 per gallon per day.

[2] Project cost is 1.4 times construction cost rounded up to nearest $10,000. Project cost includes: construction cost, construction contingencies, design engineering including plans and specifications; design and construction surveying and mapping; geotechnical evaluation and report; engineering contract administration; field inspection and basic environmental documentation. Costs are based on Engineering New Record (E.N.R.). The Engineering news Record Construction Cost Index for the Los Angeles Areas for July 2008 was utilized. This value is 9335.69. Escalation, financing, interest during construction, legal, land, R.O.W. agent, and environmental impact report costs are not included in construction costs. Additionally, not included in the unit cost estimates are extraordinary construction items such as bore casings, dewatering, rock removal etc.

SECTION 10 - SEWER SYSTEM MANAGEMENT PLAN (SSMP)

In November 2004, the State Water Resources Control Board (SWRCB) adopted Resolution 2004-80, requiring staff to develop a regulatory means for reducing sanitary sewage overflows (SSO's) as California's wastewater collection system infrastructure begins to age. Treatment plants, including pretreatment programs, have been regulated for some time; however, collection systems were yet to be regulated.

The SWRCB adopted the statewide General Waste Discharge Requirement (GWDR) on May 2, 2006 requiring that all federal and state agencies, municipalities, counties, districts, and other public entities that own or operate sanitary sewer system greater than one mile in length that collect and/or convey untreated or partially treated wastewater to a publicly owned treatment facility to prepare a Sewer System Management Plan (SSMP).

An SSMP is a document that, required by all agencies, describes the activities that each agency uses to manage their wastewater collection system effectively to minimize the number and impact of SSO's. The required elements of an SSMP include:

1. Collection system management goals
2. Organization of personnel, including the chain of command and communications
3. Legal authority for permitting flows into the system, inflow/infiltration control as well as for new and rehabilitated sewers
4. Operations and maintenance activities to maintain the wastewater collection system
5. Design and performance provisions
6. Overflow emergency response plan
7. Fats, oils, and grease (FOG) control program
8. System evaluation and capacity assurance program
9. Monitoring, measurement, and modifications plan for SSMP program effectiveness
10. Periodic internal SSMP audits
11. SSMP communication program

The District is currently in the process of self-certifying each section of the SSMP. Following the deadlines developed by the SWRCB, the SSMP shall be completed by August 2, 2009.

Appendix A
Summary of 2006 ECSD Treatment Services Invoices

Edgemont Community Services District
Appendix A
Summary of City of Riverside WQCP Wastwater Treatment Invoices to the District [1]

Month	Monthly Total (mg)	Daily Minimum (mg)	Daily Maximum (mg)	Daily Average (mg)
Jan-06	16.54	0.45	0.61	0.54
Feb-06	15.25	n/a	n/a	0.52
Mar-06	15.87	n/a	n/a	0.52
Apr-06	15.86	0.42	0.61	0.54
May-06	17.81	0.50	0.71	0.58
Jun-06	17.79	0.46	0.66	0.60
Jul-06	19.18	0.55	0.76	0.63
Aug-06	19.28	0.48	0.74	0.63
Sep-06	18.76	0.60	0.72	0.64
Oct-06	18.23	0.57	0.71	0.60
Nov-06	16.47	0.47	0.66	0.56
Dec-06	16.24	0.44	0.67	0.53
			Daily Average (mg)=	**0.574166667**
			Daily Average (gpd)=	**574,000**

*Total Sewer EDU's per the ECSD Fiscal Year Sewer Charges Report = **2357**

$$\frac{574{,}000\,\text{gpd}}{2{,}357\,\text{EDU}} \approx 240\ \text{gpd/EDU}$$

(1) Data provided by ECSD Monthly Billing from the City of Riverside WQCP for wastewater treatment services.

Appendix B
Projected "Design" Ultimate Wastewater Flows
Based on City of Moreno Valley September 2007 Zoning Land Use Map

Edgemont Community Services District
Appendix B
Projected "Design" Ultimate Wastewater Flows
Based on City of Moreno Valley September 2007 Zoning Land Use Map

	City of Moreno Valley Land Use Designations (Acre)										Average Daily Flow per Designated Land Use (gpd)									
				Residential										Residential						
Tributary Drainage Area	Commercial	Office Commercial	Business Park/Industrial	R-5	R-10	R-15	R-20	Public	Open Space[6]	Total Acres (AC)	Commercial[1]	Office Commercial[1]	Business Park/Industrial[1]	R-5[2]	R-10[3]	R-15[4]	R-20[5]	Public[6]	Open Space[7]	Projected Average Daily Flow (gpd)
Q_1	9.8	1.7		32.5			32.6	2	12.9	91.5	19,600	3,400		45,500			104,320	2,000	0	174,820
Q_2	8.6			20.5	0.4	2.5				32	17,200			28,700	1,120	6,000				53,020
Q_3	7.9	0.5		12.3	16.3					37	15,800	1,000		17,220	45,640					79,660
Q_4	5.9		1.5		1.6	1.6				10.6	11,800		3,000		4,480	3,840				23,120
Q_{4A}			36.9							36.9			73,800							73,800
Q_{4B}	10.3									10.3	20,600									20,600
Q_5	13.9		12.4							26.3	27,800		24,800							52,600
Q_6			21.4							21.4			42,800							42,800
Q_7			12.4							12.4			24,800							24,800
Q_8				3.2	25		9.9			38.1				4,480	70,000		31,680			106,160
Q_9						26.5				26.5						63,600				63,600
Q_{10}				16.5	10	22				48.5				23,100	28,000	52,800				103,900
Q_{11}		3.3	4.9	4.5		17.3				30		6,600	9,800	6,300		41,520				64,220
Q_{12}		10.4				18.9				29.3		20,800				45,360				66,160
Q_{13}		8.1			8.5	4				20.6		16,200			23,800	9,600				49,600
Q_{14}			28.4	4.1	7.6	11.2				51.3			56,800	5,740	21,280	26,880				110,700
Q_{15}	10.4	4.4	10.8	9.8	3.4	14.1				52.9	20,800	8,800	21,600	13,720	9,520	33,840				108,280
Q_{16}			4.8							4.8			9,600							9,600
Q_{16A}	32.9									32.9	65,800									65,800
Q_{17}	0.5	1.76						9.5		11.76	1,000	3,520						9,500		14,020
Q_{18}	8.5									8.5	17,000									17,000
TOTAL	**108.7**	**30.16**	**133.5**	**103.4**	**72.8**	**118.1**	**42.5**	**11.5**	**12.9**	**633.56**	**217,400**	**60,320**	**267,000**	**144,760**	**203,840**	**283,440**	**136,000**	**11,500**	**0**	**1,324,260**
TOTAL AC.	**633.56**																			

[1] Based upon 2,000 gpd/AC
[2] Based upon R-5 = 5 DU/AC x 280 gpd/DU = 1,400 gpd/AC
[3] Based upon R-10 = 10 DU/AC x 280 gpd/DU = 2,800 gpd/AC
[4] Based upon R-15 = 15 DU/AC x 160 gpd/DU = 2,400 gpd/AC
[5] Based upon R-20 = 20 DU/AC x 160 gpd/DU = 3,200 gpd/AC
[6] Based upon 1000 gpd/AC.
[7] Assumed to generate neglible wastewater flow.

Appendix C
Projected Ultimate Wastewater Flows for Treatment Plant Capacity
Based on City of Moreno Valley September 2007 Zoning and Land Use Map

Edgemont Community Services District
Appendix C
Projected "Adjusted" Ultimate Wastewater Flows
Based on City of Moreno Valley September 2007 Zoning Land Use Map

		City of Moreno Valley Land Use Designations (Acre)										Average Daily Flows per Designated Land Use (gpd)									
					Residential										Residential						
Tributary Drainage Area		Commercial	Office Commercial	Business Park/Industrial	R-5	R-10	R-15	R-20	Public	Open Space[6]	Total Acres (AC)	Commercial[1]	Office Commercial[1]	Business Park/Industrial[1]	R-5[2]	R-10[3]	R-15[4]	R-20[5]	Public[6]	Open Space[7]	Projected Average Daily Flow (gpd)
Q_1		9.8	1.7		32.5			32.6	2	12.9	91.5	9,800	1,700		39,000			104,320	2,000		156,820
Q_2		8.6			20.5	0.4	2.5				32	8,600			24,600	960	6,000				40,160
Q_3		7.9	0.5		12.3	16.3					37	7,900	500		14,760	39,120					62,280
Q_4		5.9		1.5		1.6	1.6				10.6	5,900		1,500		3,840	3,840				15,080
Q_{4A}				36.9							36.9			36,900							36,900
Q_{4B}		10.3									10.3	10,300									10,300
Q_5		13.9		12.4							26.3	13,900		12,400							26,300
Q_6				21.4							21.4			21,400							21,400
Q_7				12.4							12.4			12,400							12,400
Q_8					3.2	25		9.9			38.1				3,840	60,000		31,680			95,520
Q_9							26.5				26.5						63,600				63,600
Q_{10}					16.5	10	22				48.5				19,800	24,000	52,800				96,600
Q_{11}			3.3	4.9	4.5		17.3				30		3,300	4,900	5,400		41,520				55,120
Q_{12}			10.4				18.9				29.3		10,400				45,360				55,760
Q_{13}			8.1			8.5	4				20.6		8,100			20,400	9,600				38,100
Q_{14}				28.4	4.1	7.6	11.2				51.3			28,400	4,920	18,240	26,880				78,440
Q_{15}		10.4	4.4	10.8	9.8	3.4	14.1				52.9	10,400	4,400	10,800	11,760	8,160	33,840				79,360
Q_{16}				4.8							4.8			4,800							4,800
Q_{16A}		32.9									32.9	32,900									32,900
Q_{17}		0.5	1.76						9.5		11.76	500	1,760						9,500		11,760
Q_{18}		8.5									8.5	8,500									8,500
Q_{19}		47									47	47,000									47,000
TOTAL		**155.7**	**30.16**	**133.5**	**103.4**	**72.8**	**118.1**	**42.5**	**11.5**	**12.9**	**680.56**	**155,700**	**30,160**	**133,500**	**124,080**	**174,720**	**283,440**	**136,000**	**11,500**	**0**	**1,049,100**
TOTAL AC.	**680.56**																				

[1] Based upon 1,000 gpd/AC
[2] Based upon R-5 = 5 DU/AC x 240 gpd/DU = 1,200 gpd/AC
[3] Based upon R-10 = 10 DU/AC x 240 gpd/DU = 2,400 gpd/AC
[4] Based upon R-15 = 15 DU/AC x 160 gpd/DU = 2,400 gpd/AC
[5] Based upon R-20 = 20 DU/AC x 160 gpd/DU = 3,200 gpd/AC
[6] Based upon 1000 gpd/AC.
[7] Assumed to generate neglible wastewater flow.

Appendix D
Projected "Design Buildout" Peak and Wet Weather Flows
Based on City of Moreno Valley September 2007 Zoning and Land Use Map

Edgemont Community Services District
Appendix D
Projected "Design" Peak and Wet Weather Flows
Based on City of Moreno Valley September 2007 Zoning Land Use Map

Tributary Drainage Area	Acres(AC)	Commercial/Industrial Average Daily Flow (gpd)	Residential Average Daily Flow (gpd)	Public/Open space Average Daily Flow (gpd)	Total Average Daily Flow (gpd)	Peak Dry Weather Flow (gpd)	Wet Weather Infiltration (gpd)	Peak Wet Weather Flow (gpd)
Q_1	91.5	23,000	149,820	2,000	174,820	-	14,640	-
Q_2	32	17,200	35,820	0	53,020	-	5,120	-
Q_3	37	16,800	62,860	0	79,660	-	5,920	-
Q_4	10.6	14,800	8,320	0	23,120	-	1,696	-
Q_{4A}	36.9	73,800		0	73,800	-	5,904	-
Q_{4B}	10.3	20,600		0	20,600	-	1,648	-
Q_5	26.3	52,600		0	52,600	-	4,208	-
Q_6	21.4	42,800		0	42,800	-	3,424	-
Q_7	12.4	24,800		0	24,800	-	1,984	-
Q_8	38.1	0	106,160	0	106,160	-	6,096	-
Q_9	26.5	0	63,600	0	63,600	-	4,240	-
Q_{10}	48.5	0	103,900	0	103,900	-	7,760	-
Q_{11}	30	16,400	47,820	0	64,220	-	4,800	-
Q_{12}	29.3	20,800	45,360	0	66,160	-	4,688	-
Q_{13}	20.6	16,200	33,400	0	49,600	-	3,296	-
Q_{14}	51.3	56,800	53,900	0	110,700	-	8,208	-
Q_{15}	52.9	51,200	57,080	0	108,280	-	8,464	-
Q_{16}	4.8	9,600		0	9,600	-	768	-
Q_{16A}	32.9	65,800		0	65,800	-	5,264	-
Q_{17}	11.76	4,520		9,500	14,020	-	1,882	-
Q_{18}	8.5	17,000		0	17,000	-	1,360	-
Total	**633.56**	**544,720**	**768,040**	**11,500**	**1,324,260**	**3,228,016**	**101,370**	**3,329,386**

Appendix E
Hydraulic Analysis

Edgemont Community Services District
Appendix E
Hydraulic Analysis

Reach	Tributary Areas Contributing Flows	Average Daily Flow (MGD)	Peak Daily Flow (MGD)	Peak Wet Weather Flow (MGD)	Pipe Diameter (in)	D/d[1]	K'	Slope	Maximum Flow Capacity (MGD)
A1	Q_1	0.209	0.601	0.616	12	0.75	0.42200	0.00400	1.327
A2	Q_2	0.043	0.143	0.148	8	0.50	0.23200	0.00160	0.157
A3	Q_1, Q_2	0.252	0.714	0.733	12	0.75	0.42200	0.00400	1.327
A4	Q_3	0.062	0.200	0.206	8	0.50	0.23200	0.00400	0.247
A5	Q_1, Q_2, Q_3, Q_4, Q_{4A}	0.368	1.007	1.041	12	0.75	0.42200	0.00400	1.327
A6	Q_1, Q_2, Q_3, Q_4, Q_{4A}, Q_{4b}	0.379	1.033	1.068	12	0.75	0.42200	0.00360	1.259
I1	Q_1, Q_2, Q_3, Q_4, Q_{4A}, Q_{4b}, Q_5	0.405	1.098	1.137	12	0.75	0.42200	0.00360	1.259
I2	Q_1, Q_2, Q_3, Q_4, Q_{4A}, Q_{4b}, Q_5, Q_6	0.426	1.151	1.193	12	0.75	0.42200	0.00520	1.513
I3	Q_{15}	0.096	0.297	0.306	10	0.75	0.42200	0.00710	1.087
C1	Q_8	0.111	0.339	0.345	8	0.50	0.23200	0.00400	0.247
C2	Q_8, Q_9	0.207	0.596	0.606	8	0.50	0.23200	0.00400	0.247
C3	Q_8, Q_9, Q_{10}	0.330	0.911	0.929	8	0.50	0.23200	0.00400	0.247
C4	Q_8, Q_9, Q_{10}, Q_{11}	0.406	1.100	1.123	8	0.50	0.23200	0.00410	0.251
C5	Q_8, Q_9, Q_{10}, Q_{11}, Q_{12}, Q_{13}	0.527	1.396	1.427	12	0.75	0.42200	0.00660	1.704
C6	Q_1, Q_2, Q_3, Q_4, Q_{4A}, Q_{4b}, Q_5, Q_6, Q_7, Q_8, Q_9, Q_{10}, Q_{11}, Q_{12}, Q_{13}, Q_{14}	1.058	2.631	2.714	18	0.75	0.42200	0.00200	2.766
C7	Q_1, Q_2, Q_3, Q_4, Q_{4A}, Q_{4b}, Q_5, Q_6, Q_7, Q_8, Q_9, Q_{10}, Q_{11}, Q_{12}, Q_{13}, Q_{14}, Q_{15}, Q_{16}	1.159	2.859	2.951	18	0.75	0.42200	0.00250	3.092
M1	Q_{10}	0.123	0.371	0.379	8	0.50	0.23200	0.00480	0.271
M2	Q_{12}	0.078	0.247	0.251	8	0.50	0.23200	0.00400	0.247
M3	Q_{12}, Q_{13}	0.121	0.367	0.375	8	0.50	0.23200	0.00530	0.285

(1) D/d shall be 0.75 for pipes and 10-inches or greater in diameter and 0.50 for pipes 8-inches or less in diameter

Appendix F
Existing Generation Factors

ECSD Master Sewer Plan,
Existing Generation Factors per September 2007 Zoning Land

1EDU = 240GPD, per Appendix A

Residential: Max 5DU/AC
558.00 EDU x 240gpd/1EDU = 133,920 gpd/103.90 AC
=> 1,290 gpd/AC

Residential: Max 10DU/AC
160.69 EDU x 240gpd/1EDU = 38,565.6gpd/72.72AC
=> 530gpd/AC

Residential: Max 15DU/AC
149.00 EDU x 240gpd/1EDU = 35,760gpd/118.04AC
=> 300gpd/AC

Residential: Max 20DU/AC
350.00EDU x 240gpd/1EDU = 132,000gpd/42.5AC
=> 3,100gpd/AC

Office Commercial
56.00EDU x 240gpd/1EDU = 13,440gpd/32.84AC
=> 410gpd/AC

Commercial
284.29EDU x 240gpd/1EDU = 68,229.6/310AC
=> 220gpd/AC

Business Park/Industrial
185.07EDU x 240gpd/1EDU = 44,416.8/132.90AC
=> 335gpd/AC

Public
21.83EDU x 240gpd/1EDU = 5,239.2/11.50AC
=> 455gpd/AC

W.O. No. 2006-0352
By: J.N. 10-23-07
Checked by: S.Y. 9-23-08

Appendix G
Hydraulic Analysis Based on Current Wastewater Flows

Edgemont Community Services District
Appendix G
Hydraulic Analysis for Current Wastewater Flows

Reach	Tributary Areas Contributing Flows	Average Daily Flow (MGD)	Peak Daily Flow (MGD)	Peak Wet Weather Flow (MGD)	Pipe Diameter (in)	D/d	K'	Slope	Maximum Flow Capacity (MGD)
A1	Q_1	0.176	0.515	0.530	12	0.75	0.42200	0.00400	1.327
A2	Q_2	0.042	0.141	0.146	8	0.50	0.23200	0.00160	0.157
A3	Q_1, Q_2	0.219	0.627	0.647	12	0.75	0.42200	0.00400	1.327
A4	Q_3	0.034	0.116	0.122	8	0.50	0.23200	0.00400	0.247
A5	Q_1, Q_2, Q_3, Q_4, Q_{4A}	0.262	0.739	0.773	12	0.75	0.42200	0.00400	1.327
A6	Q_1, Q_2, Q_3, Q_4, Q_{4A}, Q_{4b}	0.265	0.746	0.781	12	0.75	0.42200	0.00360	1.259
I1	Q_1, Q_2, Q_3, Q_4, Q_{4A}, Q_{4b}, Q_5	0.273	0.768	0.807	12	0.75	0.42200	0.00360	1.259
I2	Q_1, Q_2, Q_3, Q_4, Q_{4A}, Q_{4b}, Q_5, Q_6	0.284	0.795	0.838	12	0.75	0.42200	0.00520	1.513
I3	Q_{15}	0.026	0.091	0.100	10	0.75	0.42200	0.00710	1.087
C1	Q_8	0.059	0.189	0.195	8	0.50	0.23200	0.00400	0.247
C2	Q_8, Q_9	0.064	0.204	0.214	8	0.50	0.23200	0.00400	0.247
C3	Q_8, Q_9, Q_{10}	0.105	0.322	0.340	8	0.50	0.23200	0.00400	0.247
C4	Q_8, Q_9, Q_{10}, Q_{11}	0.127	0.382	0.404	8	0.50	0.23200	0.00410	0.251
C5	Q_8, Q_9, Q_{10}, Q_{11}, Q_{12}, Q_{13}	0.171	0.501	0.532	12	0.75	0.42200	0.00660	1.704
C6	Q_1, Q_2, Q_3, Q_4, Q_{4A}, Q_{4b}, Q_5, Q_6, Q_7, Q_8, Q_9, Q_{10}, Q_{11}, Q_{12}, Q_{13}, Q_{14}	0.502	1.336	1.419	18	0.75	0.42200	0.00200	2.766
C7	Q_1, Q_2, Q_3, Q_4, Q_{4A}, Q_{4b}, Q_5, Q_6, Q_7, Q_8, Q_9, Q_{10}, Q_{11}, Q_{12}, Q_{13}, Q_{14}, Q_{15}, Q_{16}	0.534	1.413	1.505	18	0.75	0.42200	0.00250	3.092
M1	Q_{10}	0.042	0.138	0.146	8	0.50	0.23200	0.00480	0.271
M2	Q_{12}	0.025	0.089	0.093	8	0.50	0.23200	0.00400	0.247
M3	Q12, Q13	0.044	0.146	0.154	8	0.50	0.23200	0.00530	0.285

Appendix H
Proposed Sewer System Analysis

Edgemont Community Services District
Appendix H
Proposed Sewer System Analysis

Reach	Tributary Areas Contributing Flows	Average Daily Flow (MGD)	Peak Daily Flow (MGD)	Peak Wet Weather Flow (MGD)	Pipe Diameter (in)	D/d	K'	Slope	Flow Capacity (MGD)
C1	Q_8	0.175	0.511	0.526	10	0.75	0.23200	0.00400	0.816
C2	Q_8, Q_9	0.228	0.651	0.670	10	0.75	0.23200	0.00400	0.816
C3	Q_8, Q_9, Q_{10}	0.308	0.855	0.881	12	0.75	0.23200	0.00400	1.327
C4	Q_8, Q_9, Q_{10}, Q_{11}	0.331	0.913	0.940	12	0.75	0.23200	0.00410	1.343

Appendix I
July 4, 2008 Photos of Canyon Springs 8” Dia. Pipe taken by District Representative

Photo #1: Canyon Springs - Joint Offset

Photo #2: Canyon Springs - Joint Offset

Photo #3: Canyon Springs - Joint Offset

Photo #3: Canyon Springs - Joint Offset

EDGEMONT COMMUNITY SERVICES DISTRICT

SEWER MAP

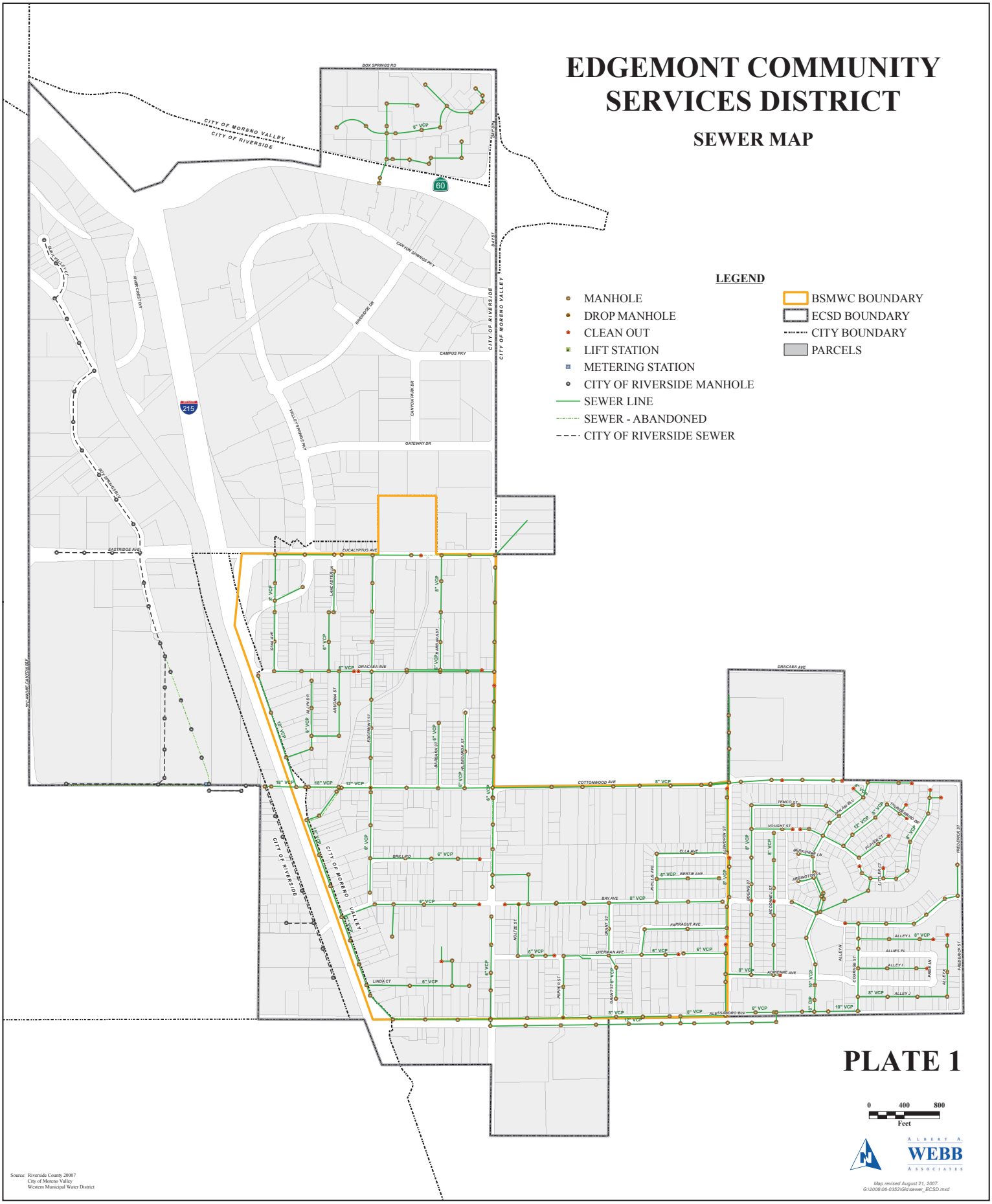

PLATE 1

0 400 800
Feet

ALBERT A. WEBB ASSOCIATES

Map revised August 21, 2007.
G:\2006\06-0352\Gis\sewer_ECSD.mxd

Source: Riverside County 20007
City of Moreno Valley
Western Municipal Water District

EDGEMONT COMMUNITY SERVICES DISTRICT

PROPOSED ECSD SEWER IMPROVEMENTS

LEGEND

- ECSD BOUNDARY
- CITY BOUNDARY
- PARCELS
- PROPOSED 6" SEWER REPLACEMENT PROJECT
- PROPOSED SEWER REPLACEMENT PROJECT
- MANHOLE
- DROP MANHOLE
- CLEAN OUT
- LIFT STATION
- METERING STATION
- CITY OF RIVERSIDE MANHOLE
- SEWER LINE
- SEWER - ABANDONED
- CITY OF RIVERSIDE SEWER

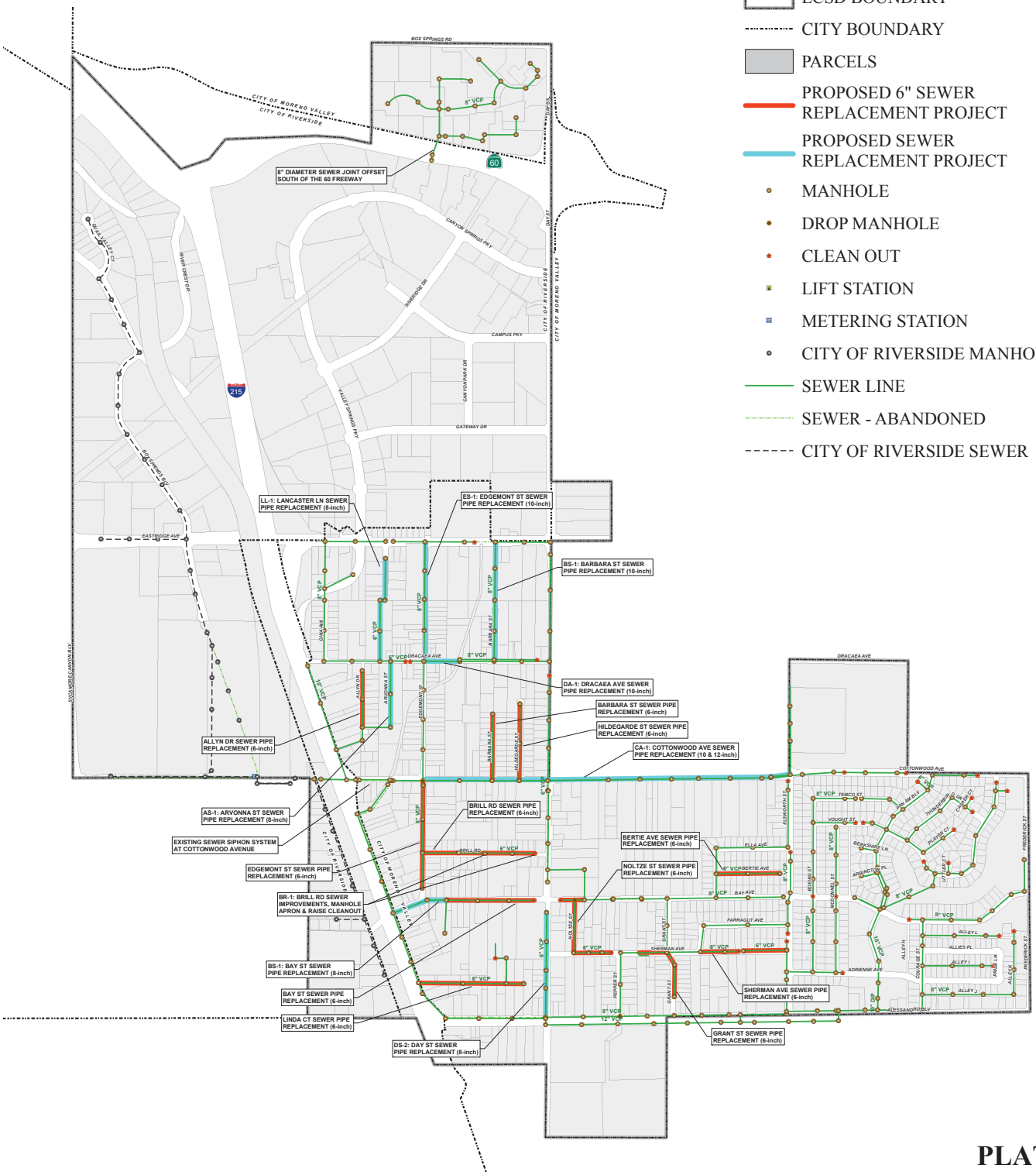

PLATE 2

0 1,000 2,000

Feet

Source: Riverside County 2007

ALBERT A. WEBB ASSOCIATES

Map revised March 18, 2008. G:\2006\06-0352\Gis\Sewer_Prop_ECSD_36x30_Plate.mxd

City of Riverside Public Works Department

UPDATE OF THE INTEGRATED

MASTER PLAN FOR THE WASTEWATER COLLECTION AND TREATMENT FACILITIES

VOL. 2

CHAPTER 4

Basis of Planning

Basis of Cost Estimates

Engineers...Working Wonders With Water®

City of Riverside Public Works Department

Update of the Integrated Master Plan for the Wastewater Collection and Treatment Facilities

VOLUME 2: BASIS OF PLANNING

CHAPTER 4: BASIS OF COST ESTIMATES

FINAL | June 2019

City of Riverside Public Works Department
Update of the Integrated Master Plan for the Wastewater Collection and Treatment Facilities

VOLUME 2: BASIS OF PLANNING

CHAPTER 4: BASIS OF COST ESTIMATES

Carollo Project No. 10495A00

Digitally signed by Graham J.G. Juby
Contact Info: Carollo Engineers, Inc.
Date: 2019.08.24 15:37:15-07'00'

REGISTERED PROFESSIONAL ENGINEER
GRAHAM J. G. JUBY
No. 67217
CIVIL
STATE OF CALIFORNIA

Contents

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4.6 Life-Cycle Costs 4-3

Appendices

APPENDIX 4A AACE CLASSIFICATION SYSTEM

APPENDIX 4B ENGINEERING NEWS RECORD CONSTRUCTION COST INDEX HISTORICAL VALUES FOR LOS ANGELES

Chapter 4

BASIS OF COST ESTIMATES

4.1 Purpose

The purpose of this chapter is to summarize the procedures and guidelines for estimating O&M and capital costs for the update of the Master Plan. In addition, procedures for applying the O&M and capital costs in a life-cycle cost analysis to compare alternatives are summarized.

4.2 Background

The update of the Master Plan, when completed, will present an updated plan that will meet the expansion and replacement needs of the City's collection system and RWQCP facilities through 2037. In order to complete this plan, consistent assumptions and criteria for development of O&M and capital costs and life-cycle cost analyses are necessary.

4.3 Level of Accuracy

The costs shown herein are estimates and are prepared as guidance for project evaluation and planning purposes using limited information available at the time of the estimate. More accurate and detailed cost estimates should be prepared during the preliminary design phase of each project in which alternative analyses would be conducted to determine the best alternative for the City using the most up-to-date information at the time. The criteria presented in this Chapter were used to develop total costs for each project. However, the initial facilities identified throughout this update of the Master Plan were determined with limited available details such that cost estimates can be considered only as budget estimates. For this reason, based on the Association for the AACE International's definitions of the five "class estimates" in AACE International Recommended Practice No. 18R-97 (Appendix 4A), the classification of costs presented in this update of the Master Plan are Class 4 estimates. The expected accuracy of any estimates included herein is 30 percent over the estimate to 15 percent under the estimate.

4.4 Operations and Maintenance Costs

O&M costs include the labor, supplies, and utility costs for operations, preventive and corrective maintenance, inspections, and repair and replacement of parts. O&M costs are based on the information provided by the following:

- Historical costs from recent Carollo projects.
- Vendor supplied costs.
- Costs supplied by RWQCP staff (i.e., power, labor, chemicals, and natural gas).
- Calculations as necessary to supplement other sources.

The cost estimates are generally based on applying the above information to flow diagrams for main process systems, plant schematic layouts, and equipment lists that will be developed for the integrated update of the Master Plan. O&M costs are escalated for inflation as described in the capital cost section that follows.

4.5 Capital Costs

Capital costs consist of all the items that will be constructed/purchased for the projects that are being evaluated for the update of the Master Plan. The direct cost of each equipment item or process area will be based on the following:

- Vendor-quoted information.
- Cost curves based on historical costs from other Carollo Projects or scale up or scale down of similar sized projects.
- Scale-up of costs to account for inflation, using a base ENR value of 11,555 (Los Angeles, February 2017).
- Quantity take-off and unit prices when applicable information is necessary and available.

For most projects, depending on applicability, general factors will be added to the direct costs derived from the information listed above. These factors include the following:

- The costs of Site Work and Electrical and Instrumentation are estimated as percentages of the subtotal direct cost. Typical percentages are 10 percent and 15 percent, respectively.
- The contingency is an amount added to the construction cost estimate to provide for undefined project elements and to reduce the risk for underestimation. The contingency usually ranges from 0 to 30 percent. The contingency is estimated as 30 percent of the total direct cost in the update of the Master Plan.
- The added amount for General Conditions includes the costs of mobilization/ demobilization, bonds and insurance, contractor temporary project facilities and supervisory personnel, testing, start-up, and other constraints. A General Conditions allowance of 10 percent of the total direct cost plus contingency is added.
- General Contractor Overhead and Profit refers to the general contractor's home office overhead and profit. It is estimated to be 15 percent of the subtotal of the above costs.
- The cost of the project at approximate mid-point of construction is predicted by escalating February 2017 costs. Over the last 20 years, the average inflation rate is 2.8 percent based on the ENR CCI values for Los Angeles (Appendix 4B). For this update of the Master Plan, we will use a value of 3 percent.
- Based on the sales tax rate for Riverside County, sales tax is estimated at 8.75 percent on materials, based on material cost equaling 50 percent of the total direct cost and contingency.
- Bid Market Allowance is an escalation factor intended to account for unfavorable bidding conditions due to the current construction market. In the previous planning study, a 15-percent allowance was incorporated. However, the market does not appear to be or is foreseen to become as turbulent as it was in the mid- to late-2000s and as such, no bid market allowance will be included.
- Engineering, Management, and Legal are also included to determine the total project cost. This covers Engineering, Planning, design and construction oversight costs, legal fees, as well as City administration expenses to oversee the project from planning through construction. For this project, a factor of 30 percent of the total construction cost is used, including all above items.

4.6 Life-Cycle Costs

In order to evaluate different alternatives for upgrading or replacement of the lift station and RWQCP facilities, life-cycle cost analyses will be performed to distinguish which alternative is the best from an economic standpoint. Life-cycle cost analyses determine the present worth of both capital costs and annual O&M costs for each alternative over a 20-year period. Factors considered in the life-cycle costs include the escalation rate, cost of capital (discount rate), capital loan period, and the life-cycle period. These values are as follows:

- Escalation rate used to estimate the cost at mid-point of construction based on the above discussed inflation rate of 3 percent.
- Discount rate of 6 percent for computing present worth values. This is based on the average 20-year bond borrowing rate index over the last 30 years.
- Life-cycle period from 2018 to 2037.

Appendix 4A

AACE CLASSIFICATION SYSTEM

AACE International Recommended Practice No. 18R-97

COST ESTIMATE CLASSIFICATION SYSTEM – AS APPLIED IN ENGINEERING, PROCUREMENT, AND CONSTRUCTION FOR THE PROCESS INDUSTRIES

TCM Framework: 7.3 – Cost Estimating and Budgeting

Acknowledgments:

Peter Christensen, CCE (Author)
Larry R. Dysert, CCC (Author)
Jennifer Bates, CCE
Dorothy J. Burton
Robert C. Creese, PE CCE
John K. Hollmann, PE CCE
Kenneth K. Humphreys, PE CCE
Donald F. McDonald, Jr. PE CCE
C. Arthur Miller
Bernard A. Pietlock, CCC
Wesley R. Querns, CCE
Don L. Short, II

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AACE International Recommended Practice No. 18R-97

COST ESTIMATE CLASSIFICATION SYSTEM – AS APPLIED IN ENGINEERING, PROCUREMENT, AND CONSTRUCTION FOR THE PROCESS INDUSTRIES

TCM Framework: 7.3 – Cost Estimating and Budgeting

February 2, 2005

PURPOSE

As a recommended practice of AACE International, the Cost Estimate Classification System provides guidelines for applying the general principles of estimate classification to project cost estimates (i.e., cost estimates that are used to evaluate, approve, and/or fund projects). The Cost Estimate Classification System maps the phases and stages of project cost estimating together with a generic maturity and quality matrix, which can be applied across a wide variety of industries.

This addendum to the generic recommended practice provides guidelines for applying the principles of estimate classification specifically to project estimates for engineering, procurement, and construction (EPC) work for the process industries. This addendum supplements the generic recommended practice (17R-97) by providing:

- a section that further defines classification concepts as they apply to the process industries;
- charts that compare existing estimate classification practices in the process industry; and
- a chart that maps the extent and maturity of estimate input information (project definition deliverables) against the class of estimate.

As with the generic standard, an intent of this addendum is to improve communications among all of the stakeholders involved with preparing, evaluating, and using project cost estimates specifically for the process industries.

It is understood that each enterprise may have its own project and estimating processes and terminology, and may classify estimates in particular ways. This guideline provides a generic and generally acceptable classification system for process industries that can be used as a basis to compare against. It is hoped that this addendum will allow each user to better assess, define, and communicate their own processes and standards in the light of generally-accepted cost engineering practice.

INTRODUCTION

For the purposes of this addendum, the term process industries is assumed to include firms involved with the manufacturing and production of chemicals, petrochemicals, and hydrocarbon processing. The common thread among these industries (for the purpose of estimate classification) is their reliance on process flow diagrams (PFDs) and piping and instrument diagrams (P&IDs) as primary scope defining documents. These documents are key deliverables in determining the level of project definition, and thus the extent and maturity of estimate input information.

Estimates for process facilities center on mechanical and chemical process equipment, and they have significant amounts of piping, instrumentation, and process controls involved. As such, this addendum may apply to portions of other industries, such as pharmaceutical, utility, metallurgical, converting, and similar industries. Specific addendums addressing these industries may be developed over time.

This addendum specifically does not address cost estimate classification in nonprocess industries such as commercial building construction, environmental remediation, transportation infrastructure, “dry” processes such as assembly and manufacturing, “soft asset” production such as software development, and similar industries. It also does not specifically address estimates for the exploration, production, or transportation of mining or hydrocarbon materials, although it may apply to some of the intermediate processing steps in these systems.

The cost estimates covered by this addendum are for engineering, procurement, and construction (EPC) work only. It does not cover estimates for the products manufactured by the process facilities, or for research and development work in support of the process industries. This guideline does not cover the

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significant building construction that may be a part of process plants. Building construction will be covered in a separate addendum.

This guideline reflects generally-accepted cost engineering practices. This addendum was based upon the practices of a wide range of companies in the process industries from around the world, as well as published references and standards. Company and public standards were solicited and reviewed by the AACE International Cost Estimating Committee. The practices were found to have significant commonalities that are conveyed in this addendum.

COST ESTIMATE CLASSIFICATION MATRIX FOR THE PROCESS INDUSTRIES

The five estimate classes are presented in figure 1 in relationship to the identified characteristics. Only the level of project definition determines the estimate class. The other four characteristics are secondary characteristics that are generally correlated with the level of project definition, as discussed in the generic standard. The characteristics are typical for the process industries but may vary from application to application.

This matrix and guideline provide an estimate classification system that is specific to the process industries. Refer to the generic standard for a general matrix that is non-industry specific, or to other addendums for guidelines that will provide more detailed information for application in other specific industries. These will typically provide additional information, such as input deliverable checklists to allow meaningful categorization in those particular industries.

	Primary Characteristic	***Secondary Characteristic***			
ESTIMATE CLASS	**LEVEL OF PROJECT DEFINITION** Expressed as % of complete definition	**END USAGE** Typical purpose of estimate	**METHODOLOGY** Typical estimating method	**EXPECTED ACCURACY RANGE** Typical variation in low and high ranges [a]	**PREPARATION EFFORT** Typical degree of effort relative to least cost index of 1 [b]
Class 5	0% to 2%	Concept Screening	Capacity Factored, Parametric Models, Judgment, or Analogy	L: -20% to -50% H: +30% to +100%	1
Class 4	1% to 15%	Study or Feasibility	Equipment Factored or Parametric Models	L: -15% to -30% H: +20% to +50%	2 to 4
Class 3	10% to 40%	Budget, Authorization, or Control	Semi-Detailed Unit Costs with Assembly Level Line Items	L: -10% to -20% H: +10% to +30%	3 to 10
Class 2	30% to 70%	Control or Bid/ Tender	Detailed Unit Cost with Forced Detailed Take-Off	L: -5% to -15% H: +5% to +20%	4 to 20
Class 1	50% to 100%	Check Estimate or Bid/Tender	Detailed Unit Cost with Detailed Take-Off	L: -3% to -10% H: +3% to +15%	5 to 100

Notes: [a] The state of process technology and availability of applicable reference cost data affect the range markedly. The +/- value represents typical percentage variation of actual costs from the cost estimate after application of contingency (typically at a 50% level of confidence) for given scope.

[b] If the range index value of "1" represents 0.005% of project costs, then an index value of 100 represents 0.5%. Estimate preparation effort is highly dependent upon the size of the project and the quality of estimating data and tools.

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Figure 1. – Cost Estimate Classification Matrix for Process Industries

CHARACTERISTICS OF THE ESTIMATE CLASSES

The following charts (figures 2a through 2e) provide detailed descriptions of the five estimate classifications as applied in the process industries. They are presented in the order of least-defined estimates to the most-defined estimates. These descriptions include brief discussions of each of the estimate characteristics that define an estimate class.

For each chart, the following information is provided:

- **Description:** a short description of the class of estimate, including a brief listing of the expected estimate inputs based on the level of project definition.
- **Level of Project Definition Required:** expressed as a percent of full definition. For the process industries, this correlates with the percent of engineering and design complete.
- **End Usage:** a short discussion of the possible end usage of this class of estimate.
- **Estimating Methods Used:** a listing of the possible estimating methods that may be employed to develop an estimate of this class.
- **Expected Accuracy Range:** typical variation in low and high ranges after the application of contingency (determined at a 50% level of confidence). Typically, this results in a 90% confidence that the actual cost will fall within the bounds of the low and high ranges.
- **Effort to Prepare:** this section provides a typical level of effort (in hours) to produce a complete estimate for a US$20,000,000 plant. Estimate preparation effort is highly dependent on project size, project complexity, estimator skills and knowledge, and on the availability of appropriate estimating cost data and tools.
- **ANSI Standard Reference (1989) Name:** this is a reference to the equivalent estimate class in the existing ANSI standards.
- **Alternate Estimate Names, Terms, Expressions, Synonyms:** this section provides other commonly used names that an estimate of this class might be known by. These alternate names are not endorsed by this Recommended Practice. The user is cautioned that an alternative name may not always be correlated with the class of estimate as identified in the chart.

CLASS 5 ESTIMATE	
Description: Class 5 estimates are generally prepared based on very limited information, and subsequently have wide accuracy ranges. As such, some companies and organizations have elected to determine that due to the inherent inaccuracies, such estimates cannot be classified in a conventional and systemic manner. Class 5 estimates, due to the requirements of end use, may be prepared within a very limited amount of time and with little effort expended—sometimes requiring less than an hour to prepare. Often, little more than proposed plant type, location, and capacity are known at the time of estimate preparation. **Level of Project Definition Required:** 0% to 2% of full project definition. **End Usage:** Class 5 estimates are prepared for any number of strategic business planning purposes, such as but not limited to market studies, assessment of initial viability, evaluation of alternate schemes, project screening, project location studies, evaluation of resource needs and budgeting, long-range capital planning, etc.	**Estimating Methods Used:** Class 5 estimates virtually always use stochastic estimating methods such as cost/capacity curves and factors, scale of operations factors, Lang factors, Hand factors, Chilton factors, Peters-Timmerhaus factors, Guthrie factors, and other parametric and modeling techniques. **Expected Accuracy Range:** Typical accuracy ranges for Class 5 estimates are - 20% to -50% on the low side, and +30% to +100% on the high side, depending on the technological complexity of the project, appropriate reference information, and the inclusion of an appropriate contingency determination. Ranges could exceed those shown in unusual circumstances. **Effort to Prepare (for US$20MM project):** As little as 1 hour or less to perhaps more than 200 hours, depending on the project and the estimating methodology used. **ANSI Standard Reference Z94.2-1989 Name:** Order of magnitude estimate (typically -30% to +50%). **Alternate Estimate Names, Terms, Expressions, Synonyms:** Ratio, ballpark, blue sky, seat-of-pants, ROM, idea study, prospect estimate, concession license estimate, guesstimate, rule-of-thumb.

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Figure 2a. – Class 5 Estimate

CLASS 4 ESTIMATE	
Description: Class 4 estimates are generally prepared based on limited information and subsequently have fairly wide accuracy ranges. They are typically used for project screening, determination of feasibility, concept evaluation, and preliminary budget approval. Typically, engineering is from 1% to 15% complete, and would comprise at a minimum the following: plant capacity, block schematics, indicated layout, process flow diagrams (PFDs) for main process systems, and preliminary engineered process and utility equipment lists. **Level of Project Definition Required:** 1% to 15% of full project definition. **End Usage:** Class 4 estimates are prepared for a number of purposes, such as but not limited to, detailed strategic planning, business development, project screening at more developed stages, alternative scheme analysis, confirmation of economic and/or technical feasibility, and preliminary budget approval or approval to proceed to next stage.	**Estimating Methods Used:** Class 4 estimates virtually always use stochastic estimating methods such as equipment factors, Lang factors, Hand factors, Chilton factors, Peters-Timmerhaus factors, Guthrie factors, the Miller method, gross unit costs/ratios, and other parametric and modeling techniques. **Expected Accuracy Range:** Typical accuracy ranges for Class 4 estimates are -15% to -30% on the low side, and +20% to +50% on the high side, depending on the technological complexity of the project, appropriate reference information, and the inclusion of an appropriate contingency determination. Ranges could exceed those shown in unusual circumstances. **Effort to Prepare (for US$20MM project):** Typically, as little as 20 hours or less to perhaps more than 300 hours, depending on the project and the estimating methodology used. **ANSI Standard Reference Z94.2-1989 Name:** Budget estimate (typically -15% to + 30%). **Alternate Estimate Names, Terms, Expressions, Synonyms:** Screening, top-down, feasibility, authorization, factored, pre-design, pre-study.

Figure 2b. – Class 4 Estimate

CLASS 3 ESTIMATE	
Description: Class 3 estimates are generally prepared to form the basis for budget authorization, appropriation, and/or funding. As such, they typically form the initial control estimate against which all actual costs and resources will be monitored. Typically, engineering is from 10% to 40% complete, and would comprise at a minimum the following: process flow diagrams, utility flow diagrams, preliminary piping and instrument diagrams, plot plan, developed layout drawings, and essentially complete engineered process and utility equipment lists. **Level of Project Definition Required:** 10% to 40% of full project definition. **End Usage:** Class 3 estimates are typically prepared to support full project funding requests, and become the first of the project phase "control estimates" against which all actual costs and resources will be monitored for variations to the budget. They are used as the project budget until replaced by more detailed estimates. In many owner organizations, a Class 3 estimate may be the last estimate required and could well form the only basis for cost/schedule control.	**Estimating Methods Used:** Class 3 estimates usually involve more deterministic estimating methods than stochastic methods. They usually involve a high degree of unit cost line items, although these may be at an assembly level of detail rather than individual components. Factoring and other stochastic methods may be used to estimate less-significant areas of the project. **Expected Accuracy Range:** Typical accuracy ranges for Class 3 estimates are -10% to -20% on the low side, and +10% to +30% on the high side, depending on the technological complexity of the project, appropriate reference information, and the inclusion of an appropriate contingency determination. Ranges could exceed those shown in unusual circumstances. **Effort to Prepare (for US$20MM project):** Typically, as little as 150 hours or less to perhaps more than 1,500 hours, depending on the project and the estimating methodology used. **ANSI Standard Reference Z94.2-1989 Name:** Budget estimate (typically -15% to + 30%). **Alternate Estimate Names, Terms, Expressions, Synonyms:** Budget, scope, sanction, semi-detailed, authorization, preliminary control, concept study, development, basic engineering phase estimate, target estimate.

Figure 2c. – Class 3 Estimate

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CLASS 2 ESTIMATE	
Description: Class 2 estimates are generally prepared to form a detailed control baseline against which all project work is monitored in terms of cost and progress control. For contractors, this class of estimate is often used as the "bid" estimate to establish contract value. Typically, engineering is from 30% to 70% complete, and would comprise at a minimum the following: process flow diagrams, utility flow diagrams, piping and instrument diagrams, heat and material balances, final plot plan, final layout drawings, complete engineered process and utility equipment lists, single line diagrams for electrical, electrical equipment and motor schedules, vendor quotations, detailed project execution plans, resourcing and work force plans, etc. **Level of Project Definition Required:** 30% to 70% of full project definition. **End Usage:** Class 2 estimates are typically prepared as the detailed control baseline against which all actual costs and resources will now be monitored for variations to the budget, and form a part of the change/variation control program.	**Estimating Methods Used:** Class 2 estimates always involve a high degree of deterministic estimating methods. Class 2 estimates are prepared in great detail, and often involve tens of thousands of unit cost line items. For those areas of the project still undefined, an assumed level of detail takeoff (forced detail) may be developed to use as line items in the estimate instead of relying on factoring methods. **Expected Accuracy Range:** Typical accuracy ranges for Class 2 estimates are -5% to -15% on the low side, and +5% to +20% on the high side, depending on the technological complexity of the project, appropriate reference information, and the inclusion of an appropriate contingency determination. Ranges could exceed those shown in unusual circumstances. **Effort to Prepare (for US$20MM project):** Typically, as little as 300 hours or less to perhaps more than 3,000 hours, depending on the project and the estimating methodology used. Bid estimates typically require more effort than estimates used for funding or control purposes. **ANSI Standard Reference Z94.2-1989 Name:** Definitive estimate (typically -5% to + 15%). **Alternate Estimate Names, Terms, Expressions, Synonyms:** Detailed control, forced detail, execution phase, master control, engineering, bid, tender, change order estimate.

Figure 2d. – Class 2 Estimate

CLASS 1 ESTIMATE	
Description: Class 1 estimates are generally prepared for discrete parts or sections of the total project rather than generating this level of detail for the entire project. The parts of the project estimated at this level of detail will typically be used by subcontractors for bids, or by owners for check estimates. The updated estimate is often referred to as the current control estimate and becomes the new baseline for cost/schedule control of the project. Class 1 estimates may be prepared for parts of the project to comprise a fair price estimate or bid check estimate to compare against a contractor's bid estimate, or to evaluate/dispute claims. Typically, engineering is from 50% to 100% complete, and would comprise virtually all engineering and design documentation of the project, and complete project execution and commissioning plans. **Level of Project Definition Required:** 50% to 100% of full project definition. **End Usage:** Class 1 estimates are typically prepared to form a current control estimate to be used as the final control baseline against which all actual costs and resources will now be monitored for variations to the budget, and form a part of the change/variation control program. They may be used to evaluate bid checking, to support vendor/contractor negotiations, or for claim evaluations and dispute resolution.	**Estimating Methods Used:** Class 1 estimates involve the highest degree of deterministic estimating methods, and require a great amount of effort. Class 1 estimates are prepared in great detail, and thus are usually performed on only the most important or critical areas of the project. All items in the estimate are usually unit cost line items based on actual design quantities. **Expected Accuracy Range:** Typical accuracy ranges for Class 1 estimates are -3% to -10% on the low side, and +3% to +15% on the high side, depending on the technological complexity of the project, appropriate reference information, and the inclusion of an appropriate contingency determination. Ranges could exceed those shown in unusual circumstances. **Effort to Prepare (for US$20MM project):** Class 1 estimates require the most effort to create, and as such are generally developed for only selected areas of the project, or for bidding purposes. A complete Class 1 estimate may involve as little as 600 hours or less, to perhaps more than 6,000 hours, depending on the project and the estimating methodology used. Bid estimates typically require more effort than estimates used for funding or control purposes. **ANSI Standard Reference Z94.2 Name:** Definitive estimate (typically -5% to + 15%). **Alternate Estimate Names, Terms, Expressions, Synonyms:** Full detail, release, fall-out, tender, firm price, bottoms-up, final, detailed control, forced detail, execution phase, master control, fair price, definitive, change order estimate.

Figure 2e. – Class 1 Estimate

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COMPARISON OF CLASSIFICATION PRACTICES

Figures 3a through 3c provide a comparison of the estimate classification practices of various firms, organizations, and published sources against one another and against the guideline classifications. These tables permits users to benchmark their own classification practices.

INCREASING PROJECT DEFINITION

AACE Classification Standard	ANSI Standard Z94.0	AACE Pre-1972	Association of Cost Engineers (UK) ACostE	Norwegian Project Management Association (NFP)	American Society of Professional Estimators (ASPE)
Class 5	Order of Magnitude Estimate -30/+50	Order of Magnitude Estimate	Order of Magnitude Estimate Class IV -30/+30	Concession Estimate Exploration Estimate Feasibility Estimate	Level 1
Class 4	Budget Estimate -15/+30	Study Estimate	Study Estimate Class III -20/+20	Authorization Estimate	Level 2
Class 3		Preliminary Estimate	Budget Estimate Class II -10/+10	Master Control Estimate	Level 3
Class 2	Definitive Estimate -5/+15	Definitive Estimate	Definitive Estimate Class I -5/+5	Current Control Estimate	Level 4
Class 1		Detailed Estimate			Level 5 Level 6

Figure 3a. – Comparison of Classification Practices

INCREASING PROJECT DEFINITION

AACE Classification Standard	Major Consumer Products Company (Confidential)	Major Oil Company (Confidential)	Major Oil Company (Confidential)	Major Oil Company (Confidential)
Class 5	Class S Strategic Estimate	Class V Order of Magnitude Estimate	Class A Prospect Estimate Class B Evaluation Estimate	Class V
Class 4	Class 1 Conceptual Estimate	Class IV Screening Estimate	Class C Feasibility Estimate Class D Development Estimate	Class IV
Class 3	Class 2 Semi-Detailed Estimate	Class III Primary Control Estimate	Class E Preliminary Estimate	Class III
Class 2	Class 3 Detailed Estimate	Class II Master Control Estimate	Class F Master Control Estimate	Class II
Class 1		Class I Current Control Estimate	Current Control Estimate	Class I

Figure 3b. – Comparison of Classification Practices

INCREASING PROJECT DEFINITION

AACE Classification Standard	J.R. Heizelman, 1988 AACE Transactions [1]	K.T. Yeo, The Cost Engineer, 1989 [2]	Stevens & Davis, 1988 AACE Transactions [3]	P. Behrenbruck, Journal of Petroleum Technology, 1993 [4]
Class 5	Class V	Class V Order of Magnitude	Class III*	Order of Magnitude
Class 4	Class IV	Class IV Factor Estimate	Class II	Study Estimate
Class 3	Class III	Class III Office Estimate		Budget Estimate
Class 2	Class II	Class II Definitive Estimate		
Class 1	Class I	Class I Final Estimate	Class I	Control Estimate

[1] John R. Heizelman, ARCO Oil & Gas Co., 1988 AACE Transactions, Paper V3.7
[2] K.T. Yeo, The Cost Engineer, Vol. 27, No. 6, 1989
[3] Stevens & Davis, BP International Ltd., 1988 AACE Transactions, Paper B4.1 (* Class III is inferred)
[4] Peter Behrenbruck, BHP Petroleum Pty., Ltd., article in Petroleum Technology, August 1993

Figure 3c. – Comparison of Classification Practices

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ESTIMATE INPUT CHECKLIST AND MATURITY MATRIX

Figure 4 maps the extent and maturity of estimate input information (deliverables) against the five estimate classification levels. This is a checklist of basic deliverables found in common practice in the process industries. The maturity level is an approximation of the degree of completion of the deliverable. The degree of completion is indicated by the following letters.

- None (blank): development of the deliverable has not begun.
- Started (S): work on the deliverable has begun. Development is typically limited to sketches, rough outlines, or similar levels of early completion.
- Preliminary (P): work on the deliverable is advanced. Interim, cross-functional reviews have usually been conducted. Development may be near completion except for final reviews and approvals.
- Complete (C): the deliverable has been reviewed and approved as appropriate.

	ESTIMATE CLASSIFICATION				
General Project Data:	**CLASS 5**	**CLASS 4**	**CLASS 3**	**CLASS 2**	**CLASS 1**
Project Scope Description	General	Preliminary	Defined	Defined	Defined
Plant Production/Facility Capacity	Assumed	Preliminary	Defined	Defined	Defined
Plant Location	General	Approximate	Specific	Specific	Specific
Soils & Hydrology	None	Preliminary	Defined	Defined	Defined
Integrated Project Plan	None	Preliminary	Defined	Defined	Defined
Project Master Schedule	None	Preliminary	Defined	Defined	Defined
Escalation Strategy	None	Preliminary	Defined	Defined	Defined
Work Breakdown Structure	None	Preliminary	Defined	Defined	Defined
Project Code of Accounts	None	Preliminary	Defined	Defined	Defined
Contracting Strategy	Assumed	Assumed	Preliminary	Defined	Defined
Engineering Deliverables:					
Block Flow Diagrams	S/P	P/C	C	C	C
Plot Plans		S	P/C	C	C
Process Flow Diagrams (PFDs)		S/P	P/C	C	C
Utility Flow Diagrams (UFDs)		S/P	P/C	C	C
Piping & Instrument Diagrams (P&IDs)		S	P/C	C	C
Heat & Material Balances		S	P/C	C	C
Process Equipment List		S/P	P/C	C	C
Utility Equipment List		S/P	P/C	C	C
Electrical One-Line Drawings		S/P	P/C	C	C
Specifications & Datasheets		S	P/C	C	C
General Equipment Arrangement Drawings		S	P/C	C	C
Spare Parts Listings			S/P	P	C
Mechanical Discipline Drawings			S	P	P/C
Electrical Discipline Drawings			S	P	P/C
Instrumentation/Control System Discipline Drawings			S	P	P/C
Civil/Structural/Site Discipline Drawings			S	P	P/C

Figure 4. – Estimate Input Checklist and Maturity Matrix

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ANSI Standard Z94.2-1989. **Industrial Engineering Terminology: Cost Engineering**.
AACE International Recommended Practice No.17R-97, **Cost Estimate Classification System**.

CONTRIBUTORS

Peter Christensen, CCE (Author)
Larry R. Dysert, CCC (Author)
Jennifer Bates, CCE

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Dorothy J. Burton
Robert C. Creese, PE CCE
John K. Hollmann, PE CCE
Kenneth K. Humphreys, PE CCE
Donald F. McDonald, Jr. PE CCE
C. Arthur Miller
Bernard A. Pietlock, CCC
Wesley R. Querns, CCE
Don L. Short, II

Appendix 4B

ENGINEERING NEWS RECORD CONSTRUCTION COST INDEX HISTORICAL VALUES FOR LOS ANGELES

ENR CCI Historical Data - Los Angeles

Year	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Annual Average
1996	6520	6520	6521	6523	6522	6522	6524	6499	6555	6543	6542	6558	6529
1997	6522	6528	6535	6599	6619	6622	6634	6631	6632	6656	6653	6631	6605
1998	6664	6671	6673	6679	6691	6691	6694	6693	6709	6865	6859	6852	6728
1999	6852	6844	6832	6833	6827	6823	6824	6818	6822	6827	6884	6826	6834
2000	6828	6842	7058	7059	7066	7066	7064	7063	7069	7072	7067	7068	7027
2001	7068	7072	7073	7273	7276	7247	7234	7235	7228	7227	7228	7227	7199
2002	7432	7432	7440	7420	7419	7420	7421	7416	7416	7403	7403	7403	7419
2003	7401	7566	7572	7557	7561	7542	7543	7543	7544	7544	7539	7532	7537
2004	7529	7691	7694	7776	7804	7844	7846	7857	8168	8169	8184	8192	7896
2005	8193	8236	8232	8267	8267	8299	8290	8278	8485	8506	8540	8567	8347
2006	8573	8558	8552	8555	8554	8547	8563	8570	8572	8868	8893	8879	8640
2007	8871	8871	8873	8875	8889	8855	8861	8863	9215	9216	9179	9182	8979
2008	9183	9183	9200	9205	9224	9266	9336	9342	9394	9895	9876	9823	9411
2009	9811	9797	9799	9794	9790	9777	9764	9766	9765	9761	9761	9764	9779
2010	9762	9764	9770	9772	9945	9962	9969	9969	9949	9999	10008	10004	9906
2011	10000	10032	10035	10045	10046	10051	10063	10076	10077	10083	10088	10089	10057
2012	10092	10092	10284	10285	10300	10300	10296	10281	10280	10283	10282	10271	10254
2013	10277	10285	10284	10289	10299	10305	10307	10304	10305	11321	10741	10739	10455
2014	10736	10734	10732	10735	10736	10739	10737	10737	10738	10748	10760	10756	10741
2015	10999	11004	10995	10989	10995	10981	10981	10981	11121	11628	11116	11117	11076
2016	11115	11147	11158	11159	11150	11148	11155	11155	11178	11526	11527	11555	11248

1996 to 2016 ENR CCI average % increase

$= ((\text{Annual Average ENR in 2016}/\text{Annual Average ENR in 1996})^{(1/20\ \text{years})}) - 1 =$ **2.76%**

City of Riverside Public Works Department

UPDATE OF THE INTEGRATED

MASTER PLAN FOR THE WASTEWATER COLLECTION AND TREATMENT FACILITIES

VOL. 2

CHAPTER 5

Basis of Planning

Organizational Review

Engineers...Working Wonders With Water®

City of Riverside Public Works Department

Update of the Integrated Master Plan for the Wastewater Collection and Treatment Facilities

VOLUME 2: BASIS OF PLANNING

CHAPTER 5: ORGANIZATIONAL REVIEW

FINAL | June 2019

City of Riverside Public Works Department
Update of the Integrated Master Plan for the Wastewater Collection and Treatment Facilities

VOLUME 2: BASIS OF PLANNING

CHAPTER 5: ORGANIZATIONAL REVIEW

Carollo Project No. 10495A00

Digitally signed by Graham J.G. Juby
Contact Info: Carollo Engineers, Inc.
Date: 2019.08.24 16:02:20-07'00'

REGISTERED PROFESSIONAL ENGINEER
GRAHAM J. G. JUBY
No. 67217
CIVIL
STATE OF CALIFORNIA

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Chapter 5

ORGANIZATIONAL REVIEW

5.1 Purpose

The purpose of this chapter is to provide information to help structure the work performed by the primary work groups at the RWQCP, with the intent having a staff that can proactively meet the challenges through 2037.

5.2 Conclusions and Recommendations

Section managers and higher-level representatives of each work group were interviewed. Information from each of these interviews is synthesized into SOC format. Tables 5.1 through 5.8 provide a summary of the SOCs and recommendations for the various Sections within the Wastewater Division. These Tables are high-level summaries and do not contain all the context for each bullet.

A comparison between the City and other organizations was conducted using data from the 2018 NACWA financial survey which aims to provide utilities, government officials, and the public with a comprehensive knowledge base on financing, rates, staffing, and key utility management initiatives. This information was used to develop a high-level assessment of the current staffing utilization in five areas: Operations, Maintenance, Collections, Environmental Compliance, and Administration.

Based on the results of this evaluation, the City appears to be adequately staffed in the Operations, Maintenance, and Environmental Compliance Sections. Administration may be slightly understaffed while the Collections section appears to be significantly understaffed. A detailed investigation should be done to determine the necessary staffing levels to meet the City's expanding requirements.

Table 5.1 Overall Public Works – Wastewater Division Summary Snapshot

Strengths, Opportunities, Concerns , and Recommendations	
Strengths • Desire to do a good job. • Desire to do the right job. • Willingness to reduce operating costs with better tools and procedures. **Opportunities** • Tailored orientation and marketing material establishes focus on work, goals, and missions of RWQCP. • Section specific comprehensive training programs managed by a Safety and Training Coordinator. • Evaluate and implement technology to improve response times such as plant-wide Wi-Fi and Toughbook tablets. • Evaluate a Public Works administrative position to transfer 311 Work Orders to ArcGIS Work Orders to improve efficiency in the Division. • Computer drives maintenance can be standardized and scheduled. • A collaboration seminar between the Purchasing Department and the Wastewater Department could streamline workflows and deliverables. • O&M knowledge transfer from veterans into databases for facility-wide knowledge share. • A succession plan of Section leadership to provide continuity and structure helps build local talent and development. **Concerns** • Inconsistent training and supervisory follow-up. • Inconsistent enforcement of methods and software utilization.	**Concerns (continued)** • Long-term vacancies in electrical and instrumentation positions affects morale. • Pay inequities affect morale and deter promotions. • CMMS is not uniformly utilized. Buy-in is needed from all Sections. • Wastewater infrastructure needs to be continually updated to prevent repetitive incidents such as SSO's. • LOTO tracking software is under-utilized. **Recommendations** • Provide a facility-wide orientation for all new hires. Develop a plant brochure with goals/objectives/plant layout, etc. • Establish a comprehensive training program for each Section managed by a Safety and Training Coordinator. • Formalize data review for NPDES, connector, and unit process data. • Standardize computer drives. • Conduct a seminar including Purchasing and Wastewater to identify efficiency avenues to meet requirements. • Establish succession planning for Section leadership. • Achieve buy-in from all Sections on the utilization of the CMMS system. • Standardize critical incident investigation and follow-up. • Develop staff engagement plan to collaborate front-line staff with project studies and designs with input from all Sections.

Table 5.2 Operations Summary Snapshot

Strengths, Opportunities, Concerns, and Recommendations	
Strengths • NPDES permit requirements are consistently met. • Plant operators are cross-trained in each process area. • Dashboarding tools, data management systems, and automation have drastically improved knowledge share, decision-making strategies, strategic planning, and collaboration between Operations and the rest of the Department. **Opportunities** • Operations is working toward unmanned facility operation by increasing the amount of process automation, however it is still a work in progress. • Use pan-tilt-zoom cameras to monitor work spaces. • Duplicate jobs by section, such as Planners, could become globalized serving all sections rather than just one.	**Opportunities (continued)** • Consider cross-training O&M personnel in an effort to increase response times on critical incidents, such as pump repair and troubleshooting. **Concerns** • Dispatch lacks a generic script and list of standard questions leading to missing information. **Recommendations** • Utilize Operations Supervisors for facility operation and personnel development. • Continue to work towards unmanned operation as automation continues to improve. • Formalize data review for NPDES, connector, and unit process data. • Continue to update all SOPs and revise annually.

Table 5.3 Maintenance Summary Snapshot

Strengths, Opportunities, Concerns, and Recommendations	
Strengths • Mechanical - Pride of ownership. • Mechanical - Desire to do each job properly, with the correct parts. • Mechanical - Strong leadership. • Electrical - Cross-training throughout the plant and pump stations. • Electrical - SCADA hardware and software training provided. • SCADA - Extremely competent. • SCADA - Provide superior support to end users. **Opportunities** • Maintenance heavily utilizes the CMMS software and could facilitate training for all RWQCP employees stressing the importance of the software in budgetary planning and justification. • A collaboration seminar between the Purchasing Department and the Wastewater Department could streamline workflows and deliverables. • Consider combined electrician and instrument technician job duties. • Consider cross-training O&M personnel. **Concerns** • Purchasing policies are obstructive and cumbersome. • Hiring new staff with adequate maintenance skills (includes mechanical, electrical, and SCADA skill sets) is difficult. • Backfilling items missed during construction project detracts from Preventative and Corrective tasks.	**Concerns (continued)** • Maintenance is the champion of CMMS utilization, but needs buy-in from other Sections to fully realize its benefits. • Separate electricians and instrument technical job titles creates disconnects when completing repairs or upgrades. • Staff engagement in project design is requested, but comments provided were largely ignored. • As-built and red-lined drawings delivered from recent project are inferior. Information is missing or incorrectly presented in the drawings. • Quality of many of the vendor O&M manuals is suspect. • Asset management is not a focus and is out-of-date. The City is in the process of updating the asset management database. • Lack of a trainee position means new hires come from outside. • Morale suffers due to pay inequity between electricians and instrument technicians. **Recommendations** • Develop a periodic work order training program for all employees and enforce utilization of the CMMS tool. • Conduct a seminar including Purchasing and Wastewater to identify efficiency avenues to meet requirements. • Create Electrical Instrument Technician position by combining electrician and instrument technician duties. • Enforce maintenance related deliverable quality from construction projects. • Develop a training program to further staff skills by utilizing the certification and training programs available.

Table 5.4 Collections Summary Snapshot

Strengths, Opportunities, Concerns, and Recommendations	
Strengths • Desire to achieve award winning performance, as measured by CWEA or NACWA award criteria. • Recognized with two Awards in 2018. • Staff enjoys special projects such as short-term construction and cross training opportunities. • Section continues to respond to an average of 500 custom service requests per year in addition to routine O&M activities. **Opportunities** • Utilize SSMP to achieve award winning performance and focus on the Section's priorities. • Create a guidance document to manage expectations and frame team work. • Use pan-tilt-zoom cameras to monitor lift stations. • Utilize ArcGIS to facilitate and/or derive efficiencies in scheduling, monitoring, and reporting work. • Upgrade Toughbook's capabilities to utilize existing architecture. • Evaluate resource sharing with Streets. **Concerns** • Develop protocol for addressing private lateral inspections. • The CMMS is not maintenance friendly. • Repetitive incidents that require immediate attention (e.g., SSO from the same location). • No defined procedure for attaching third-party video to asset or identified mass storage solution for video files. • An additional CCTV truck is needed, including lateral inspection capabilities. • No SCADA trends from some Lift Stations. • Some SOPs are outdated.	**Concerns (continued)** • GIS information is not well integrated with other software or systems. • Construction and spill response activities could be expedited with a construction outfitted truck (or trailer). **Recommendations** • Utilize the SSMP to guide Section's actions and activities. • Transition to a proactive private lateral inspection and maintenance program; likely requires another crew. • Conduct a daily work load study to assess current staffing levels in the areas of Operation, Maintenance, and Engineering specific to the Collection System management. • Consider assigning only sewer construction projects to Collection System Engineers and assess current staffing and work load allocation. • Consider improving performance accountability by assigning crews to specific regions within the City. • Use the results from CCTV inspections to adjust and prioritize collection system maintenance activities. • Modernize the Section's use of GIS technology to document work, plan routes, and track performance and outfit staff with technology necessary to do so. • Update all SOPs and establish a protocol to revise annually. • Use pan-tilt-zoom cameras to monitor lift stations. • Streamline spill reporting processes. • Define responsibilities with SSO notifications and procedures. • Enforce maintenance related deliverable quality from construction projects.

Table 5.5 Laboratory Summary Snapshot

Strengths, Opportunities, Concerns, and Recommendations	
Strengths • Current staff is certified, meticulous, dedicated, self-driven to optimize work. **Opportunities** • Software utilization can facilitate QA/QC for all samples. • Illustrated work flows for various monthly, periodic, and annual reports are suggested. **Concerns** • Additional samples will be required due to food waste and FOG receiving.	**Concerns (continued)** • Post-recession economic recovery is creating an increase in pre-treatment sampling by Environmental Compliance. • Non-comprehensive QA/QC on low risk/high frequency or medium risk/medium frequency analyses. **Recommendations** • Carefully evaluate current and projected workloads as food waste and FOG receiving sampling increases.

Table 5.6 Environmental and Regulatory Compliance Summary Snapshot

Strengths, Opportunities, Concerns, and Recommendations	
Strengths • Section strives for consistently high quality and continual improvement. • Staff is self-motivated and well-educated. • Tablets are used to download field information to databases. • Work has been streamlined by standardization of plan-check details and summaries. **Opportunities** • The Regulatory Section should create illustrated work flows for various monthly, periodic, and annual reports.	**Concerns** • Repetitive incidents that require immediate attention (e.g., SSO from the same location). • SSO response is delayed by overtime compensation and managerial approval requirement. **Recommendations** • Streamline or offload tasks to reduce impractical workload. • Formalize data review for NPDES, connector, and unit process data. • Graphically display work flows for various monthly, periodic, and annual reports to ensure timeliness. • Pre-approve a designated SSO overtime limit to improve SSO response times with approval from the City. Develop a policy for more/less overtime once the severity of the SSO is understood.

Table 5.7 Administration Summary Snapshot

Strengths, Opportunities, Concerns, and Recommendations	
Strengths • Staff works well together and fills in for each other when needed. • Principal Management Analyst provides leadership that results in a cohesive team. • Financial and Audit background of current Senior Administrative Analysts. • Willingness of staff to learn. • All staff use the same directory for document filling. **Opportunities** • A collaboration seminar between the Purchasing Department and the Wastewater Department could streamline workflows and deliverables.	**Concerns** • Maintenance of computer drives can be standardized and scheduled. • Management of electronic and paper documentation. • Ability to provide correct version when documents are requested by outside agencies. • Retain quality staff within the plant. • Losing quality staff to other City jobs (job description and pay differences). **Recommendations** • Conduct a seminar including Purchasing and Wastewater to identify efficiency avenues to meet requirements. • Normalize the inequities between facility and City jobs to retain trained staff.

Table 5.8 Engineering Summary Snapshot

Strengths, Opportunities, Concerns, and Recommendations	
Strengths • Understanding specifications and executing designs. • Knowledgeable in the City's accounting system Oracle and OneSolution. **Opportunities** • Consider the use of one software between design and construction groups to take a project from design through close-out seamlessly. • Engineering staff should periodically attend national conferences in the wastewater field to update knowledge base and produce a formalized report to transfer that knowledge to other staff. • Streamline policies and procedures to execute work. **Concerns** • There is no formal "debrief" mechanism to summarize lessons learned at project conclusion. • The priority ranking of existing projects changes. • Impacts of new projects on current priorities. • "Screaming Need" projects may slip. • Piggybacking wastewater treatment-specific equipment into blanket purchases with unpredictable results.	**Concerns (continued)** • The GIS database may be outdated and Engineering has not been trained on its utilization. • Engineering and Construction staff tasks or expectations are not outlined in the Emergency Response Plan. • There are no defined work responsibilities between the various Engineering Departments throughout the City (e.g., City Hall Engineering, RWQCP Engineering, Collections, Contract Administration, etc.) concerning design/bid/build and design/build projects. • Contract Administration should be integrated into the Engineering Section to oversee design and contract administration in a single place. **Recommendations** • Develop a formalized report or process for transferring knowledge learned at conferences or during construction to increase the knowledge base throughout the Section. • Streamline policies and procedures to execute work. • Engage Engineering in the optimization of unit processes. • Outline Engineering's tasks and expectations in the Emergency Response Plan.

5.3 Background

The Master Plan presents an updated plan that will meet the expansion and replacement needs of the City's collection system and RWQCP facilities through 2037. Recent upgrades to the treatment footprint, additional work added to the collection system, growth in the service area, and the increased use of software, automation, and instrumentation are some of the drivers that must be considered to ensure that the various work groups are positioned to effectively meet the demands of daily work.

Goals moving forward can be synthesized into:

- Improve efficiency.
- Reduce operating costs.
- Embrace technology.
- Put people where they can do the best work.

5.4 Baseline Information

The primary work groups at the RWQCP include Operations, Maintenance, Collections, Laboratory, Environmental Compliance, Administration, and Engineering, with the spring 2019 staffing organization shown on Figure 5.1. The work and structure of these work groups were evaluated. Section managers and higher-level representatives of each work group were interviewed. Information from each of these interviews is synthesized into a SOC format. Potential options for structuring the work and work groups that consider the SOC information are provided, but are by no means all inclusive.

Common themes surfaced in each interview. These themes are discussed in the Overall Summary section. More detail on each theme is located in the section discussions and interview notes.

In Section 5.15, comparisons to other wastewater utilities are provided based on NACWA data. These data compare and contrast the staffing levels against other cities and agencies both in California and in the equivalent "peer" group across the country. The information is representative only, due to anomalies in reporting techniques or responses.

5.5 Overall Summary

Feedback and observations with common themes from the Section interviews follow. These are items that were mentioned by several staff members, meaning that the topics are important to, or apply to multiple work groups.

5.5.1 Strengths

- Desire to do a good job.
- Desire to do the right job.
- Willingness to reduce operating costs through better tools and procedures.

5.5.2 Opportunities

- Providing an orientation session for new hires would establish focus on the work, goals, and mission of the RWQCP. These sessions would be held periodically to orient new workers and revised as needed to help welcome new people to the organization. Additionally, it may be beneficial to develop a plant tour brochure which can be used to introduce new hires and plant guests to the goals, objectives, and the plant layout of the RWQCP.
- Establishing the learning criteria and a comprehensive training program for each Section, including the metrics used to monitor and optimize each Section, would focus improvement and optimization efforts. Establishing training methods tied to documenting on-the-job training would raise awareness, allowing a new person to integrate into the daily work flow more efficiently. The existing Emergency Services Coordinator could be renamed the Safety and Training Coordinator and manage the training and orientation of all employees.
- Evaluating and implementing specific tools, such as cameras in remote locations, could improve response and reduce hours spent in transit. Plant-wide Wi-Fi and the implementation of ToughBook Tablets could be used by all field staff to streamline data entry and improve quality directly. Additionally, Wi-Fi access would allow the use of important resources like record drawings and O&M manuals in the field improving accuracy and efficiency.
- Standardization of Section drives to a single file structure is recommended. Note: Various public and private drives in use (Public Works, S: G: and H: drives) are each structured by the responsible Section.
- Developing and participating in a joint seminar between Purchasing and Wastewater

could streamline workflows to meet the needs of both departments. A collaborative session could help define deliverables from both sides and establish a standard time expectance for all classifications of projects such that priority projects are handled at an expedited rate on both sides.

5.5.3 Concerns

- Some positions, such as instrument technician and electrician are extremely difficult to fill. Vacancies in these and other positions is affecting morale.
- The CMMS system is not uniformly utilized within the Department. It appears that training in the software's capabilities varies widely between the Sections. To utilize the software to its full potential, it may be necessary to provide an in-depth training program as to what can be done as well as *why* it should be done. Getting buy-in from all Sections would improve and automate reporting of personnel, record-keeping, and materials.
- At the time of this review, it appears that there is no formal bridge between the City's GIS system and the CMMS system. The City could more easily track field assets based on key performance indicators, condition assessments, maintenance history, etc. if the two systems were linked in some way.
- Wastewater infrastructure needs to be continually updated to prevent repetitive incidents such as SSO's. The City has a procedure in place for the investigation of SSO's, but may be lacking a procedure for other critical incidents. A formalized procedure could help identify the cause of such incidents.
- Current maintenance of computer drives and version control is inconsistent. Some drives are Section-specific, and file structures between locations can vary significantly.
- LOTO tracking software is under-utilized and may be outdated.
- Table 5.9 displays recommendations that address shortcomings voiced in staff interviews.

Table 5.9 Overall Recommendations

Recommendations
Provide overall facility orientation for new hires
Establish a comprehensive training program for each Section under the management of a Safety and Training Coordinator.
Formalize data review to ensure that electronically stored NPDES, connector, and unit process data accurately reflects facility operation
Standardize the computer drives
Conduct a seminar including Purchasing and Wastewater to identify efficiency avenues to meet requirements
Achieve buy-in from all Sections on the utilization of the CMMS system
Standardize critical incident investigation and follow-up; maintain infrastructure needs to prevent repetitive incidents such as SSO's.
Establish means such as a staff engagement plan to capture the input from front-line staff into project studies and designs. Strengthen the partnership between front-line Operations, Maintenance, and Collections staff and Engineering to improve the overall quality for any project from study through commissioning.

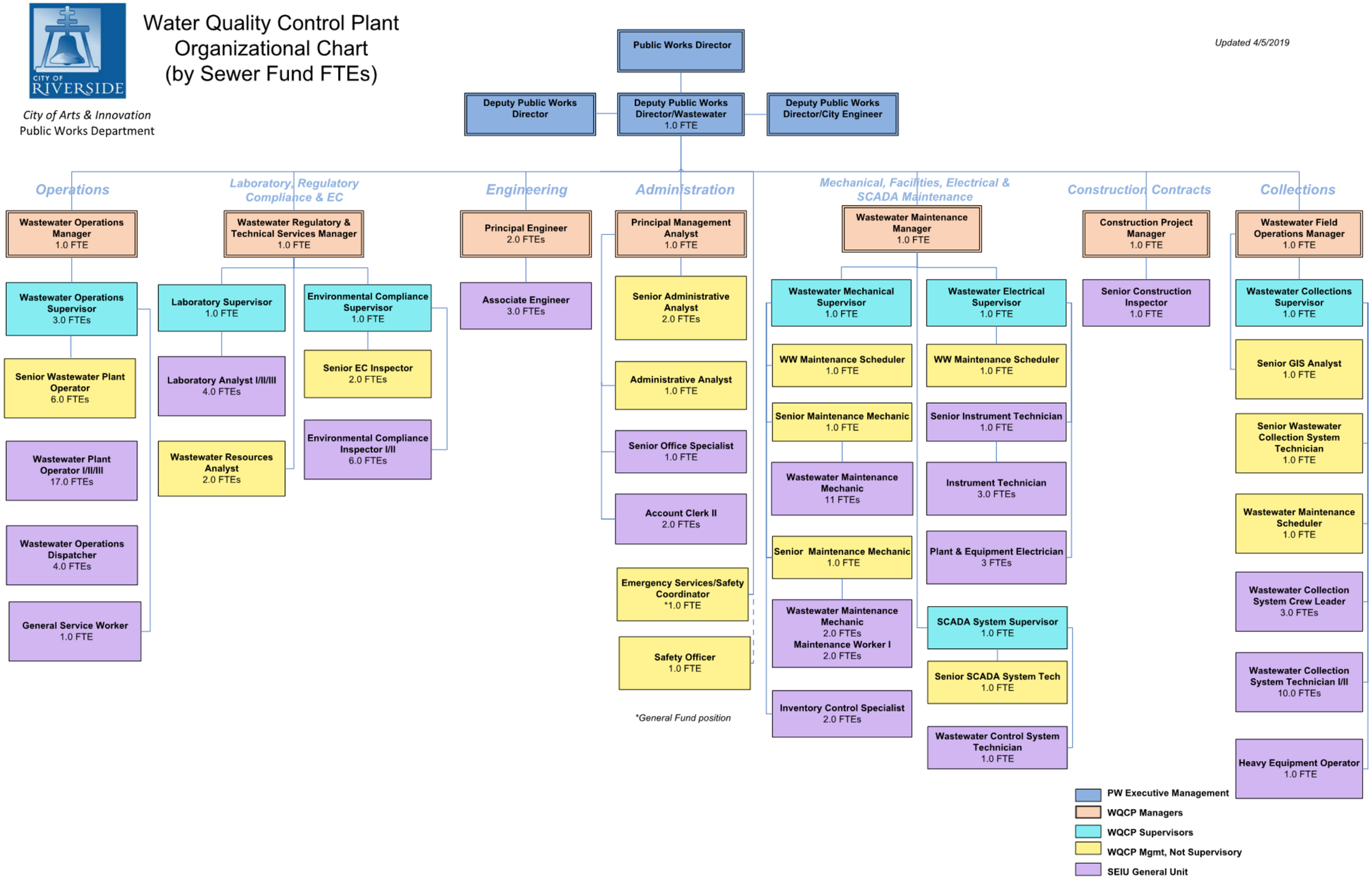

Figure 5.1 Riverside Water Quality Control Plant Organizational Chart

5.6 Operations

The Operations Section is integral to wastewater treatment. The comprehensive changes in the plant's operational footprint require the Operations section to take the lead for overall facility optimization, which will reduce annual operating costs. Since the completion of the MBR treatment train (Plant 1) Phase I Expansion, significant changes have been made within the Operations Section as well as the mindset of staff throughout the plant.

5.6.1 Strengths

- NPDES permit requirements are consistently met.
- Plant operators are cross-trained in each process area.
- Dashboarding tools, data management systems, and automation facilitate knowledge share, decision making strategies, strategic planning, and collaboration throughout the Department.

5.6.2 Opportunities

- The Section is in the process of installing various equipment to achieve full automation throughout the facility. Rate payer cost savings may be possible in the future should unmanned facility operation become feasible. This should be evaluated in the future as automation and remote access capabilities continues to expand.
- Pan-tilt-zoom cameras can be used to monitor work spaces; uses include process adjustments, optimization, and safety.
- Consider evaluating job duties and descriptions that may be redundant between multiple Sections and "globalizing" these jobs such that the individual would serve all the Sections rather than a select few.
- Consider cross-training O&M personnel in an effort to increase response times on critical incidents, such as pump repair and troubleshooting.

5.6.3 Concerns

- The Dispatcher responds and supports SSOs and other Emergency Response activities. A generic script and list of questions (instantly accessible and completed live) would ensure that appropriate information is gathered and disseminated.

Focused recommendations to the Operations Section are listed in Table 5.10.

Table 5.10 Operations-Focused Recommendations

Recommendations
Evaluate unmanned operation to reduce operating costs and improve plant operator working hours
Formalize data review to ensure that electronically stored NPDES, connector, and unit process data accurately reflects facility operation
Continue to update all SOPs and revise annually.

5.7 Mechanical Maintenance

Ongoing maintenance by well-trained and qualified staff is crucial to maintain permit compliance, keeping critical systems working, and maintaining capacity and redundancy to free up components. In general, the maintenance staff exudes pride of ownership, and has strong

leadership in the decision-making positions. Interviews were conducted with Mechanical, Electrical, and SCADA personnel. The results are provided for each focused area.

5.7.1 Strengths

- Pride of ownership.
- Desire to do each job properly, with the correct parts.
- Strong leadership.
- Staff are cross-trained on all areas within the Plant.
- Staff has a good technical background.

5.7.2 Opportunities

- O&M: Strengthen work order approval process to improve quality of content and prioritizations.
- Establish and institutionalize periodic (i.e., quarterly) work order training for all users and new hires.
- Developing and participating in a joint seminar between Purchasing and Wastewater could streamline workflows to meet the needs of both departments. A collaborative session could help define deliverables from both sides and establish a standard time expectance for all classifications of projects such that priority projects are handled at an expedited rate on both sides. As purchasing requirements significantly impact the Maintenance Section, representatives from this Section should be included in the seminar.
- Maintenance personnel are currently not required to hold certifications as a condition of employment or advancement within the City. Maintenance certifications provide the necessary documentation that staff have developed the skills and ability to safely perform their duties. The City has a general obligation to perform due diligence in ensuring the competency of personnel. Wastewater certification provides the City with evidence that the certificate holder has demonstrated a certain level of job-related knowledge, skills, and abilities. Furthermore, it provides a documented level of assurance that employees are competent in safe work practices. Certification provides concrete evidence to Board Members and citizens that the City is staffed with people who know what they are doing and is competitive in any comparison of quality of service.
- Consider cross-training O&M personnel in an effort to increase response times on critical incidents, such as pump repair and troubleshooting.

5.7.3 Concerns

- Purchasing policies are obstructive and cumbersome. The ability to get the equipment that fits best is hindered. All purchases or work order requests must go through the City's Purchasing Department which can take weeks or months, even for small task orders (e.g., less than $5,000 work orders). Additionally, the burden of labor is put on the Maintenance Manager rather than the Purchasing Department. Morale is affected when necessary equipment or work order requests are delayed. This demonstrates a lack of urgency to the front-line staff. A joint seminar between the two Departments could help define deliverables and responsibilities by each group in an effort to streamline the process for the more pressing requests.

- Hiring new staff that has adequate mechanical maintenance skills is challenging. RWQCP has no trainee position to transition other City staff into the role, so new hires come from the outside.
- Maintenance personnel are currently not required to hold certifications as a condition of employment or advancement within the City.
- Staff spends time dealing with items missed during construction projects, which detracts from completing Preventive and Corrective tasks.
- Section has embraced the CMMS system. However, other Sections are not required to use it and therefore, the reports produced represent only a portion of the information. For example, the CMMS system has the ability to track all labor and expenses for a particular asset producing a report to demonstrate how much that asset costs the City. However, if Operations, for example, does not use the CMMS tool to track their labor associated with that asset, then the costs shown in that report do not include Operations costs.
- Documenting critical incident causes, and the means to prevent them, by using an Investigation form is suggested (for all Sections).

5.8 Electrical Maintenance

5.8.1 Strengths

- Cross-training throughout plant and pump stations.
- SCADA hardware and software training is provided.

5.8.2 Opportunities

- Establishing and institutionalizing periodic (i.e., quarterly) work order training for all users and new hires will reduce rework.
- Many treatment plants have combined the electrician and instrument technician jobs into Electrical Instrument Technicians. This approach draws on both skills, and allows more flexibility to conduct daily work and respond to emergencies, while reducing the on-call pay.
- Developing and participating in a joint seminar between Purchasing and Wastewater could streamline workflows to meet the needs of both departments. A collaborative session could help define deliverables from both sides and establish a standard time expectance for all classifications of projects such that priority projects are handled at an expedited rate on both sides. As purchasing requirements significantly impact the Maintenance Section, representatives from this Section should be included in the seminar.
- Maintenance personnel are currently not required to hold certifications as a condition of employment or advancement within the City. Maintenance certifications provide the necessary documentation that staff have developed the skills and ability to safely perform their duties. The City has a general obligation to perform due diligence in ensuring the competency of personnel. Wastewater certification provides the City with evidence that the certificate holder has demonstrated a certain level of job-related knowledge, skills, and abilities. Furthermore, it provides a documented level of assurance that employees are competent in safe work practices. Certification provides concrete evidence to City Council and citizens that the City is staffed with people who know what they are doing and is competitive in any comparison of quality of service.

5.8.3 Concerns

- Separate electricians and instrument technician job titles creates a disconnect when completing repairs or upgrades.
- Staff engagement in project design is requested, but comments provided were largely ignored.
- As-built and red-lined drawings delivered from recent projects are not to a high standard.
- The quality of many of the vendor O&M manuals from the recent Phase 1 Expansion project are questionable. This is an industry trend, but leaves the front-line staff with poor documentation.
- Staff spends time addressing items missed during construction projects, which detracts from completing Preventive and Corrective tasks.
- Asset management is not a focus and is falling further behind due to recent projects.
- Hiring new staff that has adequate electrical and instrumentation maintenance skills is a challenge. RWQCP has no trainee position to transition other City staff into the role, so new hires come from the outside. Competition is fierce for instrument technicians.
- Maintenance personnel are currently not required to hold certifications as a condition of employment or advancement within the City.
- Morale suffers due to pay inequity between electricians and instrument technicians.
- With Operations' goal to provide more automation and move towards an unmanned facility, more pressure will be placed on electrical and instrumentation technicians, and hiring new staff is already a challenge.

5.9 SCADA

The SCADA system is crucial for monitoring and adjusting plant processes. Feedback from new instruments and analyzers are making it an even more valuable tool. The Historian retains plant operations and LIMS data, which serves as an analytical tool to evaluate past events and, possibly, to proactively meet future challenges. Optimization strategies would have to be well planned and coordinated to allow this staff to participate.

5.9.1 Strengths

- Extremely competent, provides superior support to end users.

5.9.2 Opportunities

- The SCADA system is unmanned during off hours. Outdated equipment should be updated to maintain remote troubleshooting capabilities.
- Maintenance personnel are currently not required to hold certifications as a condition of employment or advancement within the City. Maintenance certifications provide the necessary documentation that staff have developed the skills and ability to safely perform their duties. The City has a general obligation to perform due diligence in ensuring the competency of personnel. Wastewater certification provides the City with evidence that the certificate holder has demonstrated a certain level of job-related knowledge, skills, and abilities. Furthermore, it provides a documented level of assurance that employees are competent in safe work practices. Certification provides concrete evidence to Board Members and citizens that the City is staffed with people who know what they are doing and is competitive in any comparison of quality of service.

5.9.3 Concerns

- Hiring new staff with adequate skills in the following areas is a challenge: programming, operation, maintenance skills (system, electrical, and instrumentation). Because knowledge of the operational dynamics of the plant is essential, there may be an opportunity to repurpose and train a plant operator.
- Developing a comparable replacement for the Senior Supervisor prior to his retirement.

Table 5.11 presents the recommendations for the Maintenance Section, which includes mechanical maintenance, electrical maintenance, and SCADA.

Table 5.11 Maintenance-Focused Recommendations

Recommendations
Use this Section to champion and train other Sections in the utilization of the CMMS system. Enforce its use by all Sections. Get buy-in from other Sections in how the CMMS system should streamline holistic RWQCP asset and labor management.
Establish and institutionalize work order training for all users and new hires.
Conduct a seminar including Purchasing and Wastewater to identify efficiency avenues to meet requirements.
Combine the electrician and instrument technician jobs into one job description - Electrical Instrument Technician.
Evaluate means to improve the maintenance related deliverables from construction projects such as as-built drawings and vendor O&M manuals.
Require maintenance certification and training programs as a condition of employment and advancement.

5.10 Collections

The Collections Section is charged with maintaining the service area's sewage piping and lift stations. Operational and maintenance skills are required and must be available at all times to respond to sewage overflows, maintenance needs, and customer service requests.

A major concern is how to address private lateral inspections appropriately. A scope is needed which defines City expectations to align staffing, equipment, budgeting, and overall management of the City-owned portion of sewer laterals.

There may be better ways to use the Collections staff. For example, other organizations assign one fully-certified technician and one general worker to assist the technician on each daily-use work truck. Furthermore, the City may be able to improve performance accountability within the Section by dividing the City into regions and assigning specific crews to those regions. Therefore, the Crew Leaders within a region could be held accountable for the completed work within that region. Additional crews along with possible crew restructuring may improve the Sections ability to complete necessary tasks as they align with the City's expectations.

The City should conduct an efficiency study and determine how technicians can be more appropriately utilized, possibly to the effect of increasing the number of crews, increasing productivity, and decreasing operating costs. It is important to conduct a daily work load study to determine the amount of time required and ideal time of day or week to complete each task. This information would provide an overview of the amount of time required to adequately maintain

the City's collections system, which should then be compared to the City's staffing levels. Current indications from within the Section along with external sources (see Section 5.15.3) suggested that the City's Collections Division (including operations, maintenance, and engineering personnel) is understaffed.

Furthermore, the addition of the "Lateral Program," which aims at appropriately addressing private lateral inspections as they pertain to City-owned portions of the lateral, further exasperates the work balance within the Section. Additional consideration should be given to determining the necessary staffing levels to effectively operate and maintain the City's collection system, appropriately implement the Lateral Program, and effectively manage future collection system construction projects such as those recommended in Volume 3, Chapter 10, Capital Improvement Program, for the Collection System.

5.10.1 Strengths

- Desire to achieve award-winning performance, as measured by CWEA or NACWA award criteria. The City's Collections Division recently applied for and won awards for their performance.
- Staff enjoys special projects such short-term construction and cross-training opportunities. These divert them from addressing the typical work load but increase morale.
- The Section continues to respond to an average of 500 customer service requests per year in addition to routine O&M activities.

5.10.2 Opportunities

- Use the SSMP to publish the goals to achieve award winning performance and focus the Section's priorities.
- Use the SSMP to define the means to maintain staff morale, define daily work and measures of accomplishment, recruitment initiatives, and training programs.
- A guidance document for new employee orientation, operators in training, training refreshers, and individual and overall expectations would help frame the work of the team.
- Use pan-tilt-zoom cameras to monitor lift station work spaces; uses include optimization, vandalism, and safety. These cameras support daily or weekly inspections by staff.
- Utilize the ArcGIS software currently employed to facilitate and/or derive efficiencies in scheduling, monitoring, and reporting work. Consider additional software programs similar to those used in the City's Public Utilities division to produce "dashboards" with real-time information to facilitate immediate action on service requests, spill reports, and other operation/maintenance tasks.
- Streamline spill reporting using ArcGIS (a proprietary mobile software platform). Reporting becomes active, eliminating the current practice of manually duplicating spill information after the event.
- Upgrade the Toughbook's ability by making the snap shot interactive (spill reporting). Enable VPN access to the web to obtain information in the field (i.e., vendor manuals, how-to videos). Oracle access is in place - use it for work orders and parts ordering.
- Evaluate resource sharing with the Streets department, who complete Stormwater duties and response.

5.10.3 Concerns

- Addressing the private lateral inspections appropriately. A scope is needed that defines City expectations to align staffing, equipment and budgeting.
- The City's CMMS system is used throughout every Department within the City and incorporates tasks from time sheet management to work order requests and everything in between. It is widely used, but currently has a limitation that strongly impacts the Collections Section. The CMMS system is not currently integrated with available GIS software meaning work orders are currently being duplicated in both systems. The City is currently investigating a bridge between the two systems. However, at the time of this review, data retrieval, display, trending, and information publication are cumbersome activities with the CMMS system as it relates to the Collections Section. A map-based system with a globalized visualization of problem areas, maintenance history, design limitations, etc. would streamline work tasks and allow the Collections staff to make informed decisions more quickly and easily.
- There are repetitive incidents that require immediate attention. Documenting critical incident causes and means to reduce them using an Investigation form is suggested (for all Sections).
- There is no defined procedure for attaching video from a third party to the asset televised. While additional geocaching technology has recently been employed to address this issue, there is no identified or implemented solution in place for the mass storage and retrieval of video files at this time. Currently, external hard drives are used and remain inaccessible in the field. The City should consider mass storage solutions such as "cloud" storage technologies, which provide strict security, redundancy, and archival protocols along with in the field accessibility to valuable information.
- An additional CCTV truck is needed, especially due to the private lateral initiative.
- No SCADA trends from some Lift Stations are provided, only start/stop notifications.
- Some SOPs are outdated. Suggest a plan to bring these up to today's duties and expectations.
- GIS information is not well integrated with other software or systems.
- A construction-outfitted truck (or trailer) would expedite construction and spill response activities.
- The engineering division associated with the Collection System Section are highly understaffed. At present, there is one engineer and one senior technician responsible for managing all engineering projects associated with the collection system, collaborating with the Land Development Group of Public Works, and responsible for other engineering projects. An evaluation should be conducted to determine the appropriate level of staffing that is required to effectivity performing the duties and responsibilities of collection system engineering and should take into consideration future projects such as those proposed in Volume 3, Chapter 10, Capital Improvement Program for the Collection System.

Table 5.12 presents the recommendations for the Collections Section.

Table 5.12 Collections-Focused Recommendations

Recommendations
Use the SSMP to guide the Sections actions and activities.
Transition to a proactive private lateral inspection and maintenance program ("Lateral Program"), which likely requires another crew.
Conduct a daily work load study to assess current staffing levels in the areas of Operation, Maintenance, and Engineering specific to the Collection System management.
Consider improving performance accountability be assigning crews to specific regions within the City.
Use the results from CCTV inspections to adjust and prioritize collection system maintenance activities.
Modernize the Section's use of GIS technology to document work, plan routes, and track performance and outfit staff with technology necessary to do so.
Update all SOPs. Establish a means to add, review, and revise annually.
Use pan-tilt-zoom cameras to monitor lift station work spaces; uses include optimization, vandalism, and safety
Streamline spill reporting processes.
SSO notification and procedures are inadequately documented. Define responsibilities.
Evaluate means to improve the deliverables from construction projects such as as-built drawings and vendor O&M manuals.

5.11 Laboratory

The Laboratory Section completes a large number and variety of analyses required to document permit compliance and evaluate process performance. Some analyses serve as the charge basis for sewer connections and significant industrial users. Additional analyses to optimize unit processes would be an additional burden. Optimization strategies would have to be well planned and coordinated to allow the laboratory staff to participate in such studies.

5.11.1 Strengths

Current staff is:

- Certified.
- Meticulous.
- Dedicated.
- Self-driven to optimize work.

5.11.2 Opportunities

- Use of software for QA/QC of all samples.

5.11.3 Concerns

- Staff anticipates that the initiative to receive food waste and FOG will result in more samples, and there is a concern about the laboratory staff's ability to handle additional analyses.
- Post-recession economic recovery is creating an increase in pre-treatment sampling by Environmental Compliance, adding to the sample load.
- Non-comprehensive QA/QC on low-risk/high-frequency or medium-risk/medium-frequency analyses.

Table 5.13 presents the recommendations for the Laboratory Section.

Table 5.13 Laboratory-Focused Recommendations

Recommendations
Evaluate the current sampling and analyses requested by Operations, Collections, and through projects. Determine if samples can be reduced or eliminated (legacy relics) to free up analysts' time. Consider adding staff to deal with future sampling loads, if necessary.
Consider using a dedicated administrative staff to perform data QA/QC on analyses results exported to Hach WIMS
Formalize data review to ensure that electronically stored NPDES, connector, and unit process data accurately reflects facility operation
Graphically display the work flows for the various monthly, periodic, and annual reports to ensure timeliness

5.12 Environmental and Regulatory Compliance

The Environmental Compliance Section is charged with a variety of duties including sewer interceptor unit inspections, billing, plan checks, new business evaluations, stormwater inspections, and user permit drafting, tracking, and enforcement. The Regulatory Compliance Section evaluates and prepares the compliance documents provided to the various State and Regional regulatory boards. In short, the Environmental Compliance section handles compliance for all things coming into the plant whereas the Regulatory Compliance section handles compliance for all things leaving the plant. The Sections complete and submit a large variety of regulatory reports and are expected to submit on time and without errors.

5.12.1 Strengths

- Sections strives for consistently high quality and continual improvement.
- Staff is self-motivated and well-educated.
- Staff is efficiently using tablets to download field information to the database.
- Standardized details for plan-checks and standardized summaries have streamlined work.

5.12.2 Opportunities

- The Regulatory Compliance section should create illustrated work flows for the various monthly, periodic, and annual reports. These would help a new employee predict work load and gauge progress.

5.12.3 Concerns

- Documenting critical incident causes and means to reduce them using an Investigation form is suggested (for all Sections).
- While it is the City's policy to require managerial approval for all overtime, SSOs pose a significant risk to the City, its residents, and the environment. It is recommended that overtime policies be addressed in the SSO procedures and approved by the City to a specific degree. For example, say the average SSO response clean-up takes four hours. As part of the SSO procedure, receive blanket authorization for on-call personnel to work four hours of overtime. Should the spill be larger or more complex, the staff will need to

notify their supervisor and authorization for additional overtime could be given at that time. This practice would reduce SSO response times and damages from contamination.
- Grease trap maintenance was shifted to the owner. Language is in place to enforce this, but owners will take shortcuts.

Table 5.14 presents the recommendations for the Environmental and Regulatory Compliance Section.

Table 5.14 Environmental and Regulatory Compliance-Focused Recommendations

Recommendations
Continue to streamline or offload tasks to reduce impractical workload.
Formalize data review for NPDES, connector, and unit process data.
Graphically display work flows for various monthly, periodic, and annual reports to ensure timeliness.

5.13 Administration

The Administration Section is the business arm of the plant.

An opportunity to offload data input and management work from other Sections may free up the supervisors and specialists. Allowing the more highly skilled staff members to focus on their direct duties should result in more efficient and effective efforts, while reducing consternation and effects on morale.

5.13.1 Strengths

- The staff works well together and fills in for each other when needed.
- The Principal Management Analyst provides the leadership that results in a cohesive team.
- Financial and Audit background of current Senior Administrative Analysts.
- Willingness of staff to learn.
- All staff uses the same directory for document filing.

5.13.2 Opportunities

- The City has recently assigned Public Works with a dedicated Purchasing officer. However, there still seems to be a mismatch between the City's standard policies and the needs associated with wastewater treatment and construction. Developing and participating in a joint seminar between Purchasing and Wastewater could streamline workflows to meet the needs of both departments. A collaborative session could help define deliverables from both sides and establish a standard time expectance for all classifications of projects such that priority projects are handled at an expedited rate on both sides.

5.13.3 Concerns

- Document management - Standardization of computer drives is required in order to facilitate locating items. Public and private drives in use include Public Works, S: G: and H: drives. Drive maintenance and version control is inconsistent.
- Management of electronic and paper documentation is a concern.

- Procedures should be developed so that the correct version of documents can be provided when requested by outside agencies.
- The ability to retain quality staff within the plant is difficult, due to job description and pay differences with comparable City jobs.

Table 5.15 presents the recommendations for the Administration Section.

Table 5.15 Administration-Focused Recommendations

Recommendations
Conduct a seminar including Purchasing and Wastewater to identify efficiency avenues to meet requirements.
Normalize the inequities between facility and City jobs to retain trained staff

5.14 Engineering

The Engineering Section is comprised of three sub-sections: Plant Engineering, Construction Contract Administration, and Collections Engineering (offsite). During the interviews, the Emergency Services/Safety Coordinator joined in.

The Phase 1 Expansion project forced the evaluation of many protocols, procedures, and work flows. It is recommended that staff from each sub-section formally identify shortcomings and how they were overcome, and systematically revise the processes that improve productivity.

Engineering could collaborate with Operations to optimize the treatment plant, including upgrading the necessary tools and equipment required. These tools include the SCADA system and installation of process-specific automation and analyzers.

5.14.1 Strengths

- Strong understanding of specifications and executing designs from the planning stages to award by City Council and providing engineering support during construction.
- Knowledgeable in the City's accounting system Oracle and OneSolution.

5.14.2 Opportunities

- Consider the use of consistent software between design and construction groups to take a project from planning stages through close-out seamlessly.
- Developing and participating in a joint seminar between Purchasing and Wastewater could streamline workflows to meet the needs of both departments. A collaborative session could help define deliverables from both sides and establish a standard time expectance for all classifications of projects such that priority projects are handled at an expedited rate on both sides.
- Engineering staff should periodically attend national conferences in the wastewater field to update knowledge base and produce a formalized report to transfer that knowledge to other staff.
- Streamline policies and procedures to execute work. Examples include:
  - Contract "boilerplate" through the Green Book does not fit wastewater plant and collections construction well. Staff suggests focused specifications would improve project delivery.

  - O&M efficiency and economy through standardized design guidelines that strive for comparable equipment. Economy comes from reduced variability of parts, consistent run times between maintenance activities, known reliability, and consistent skill sets.
  - Flexibility in purchasing approaches to rapidly address unforeseen project needs.
- Consider a risk analysis study to prioritize repairs and replacement based on pipe size, condition, age, etc.
- Use the cooperative purchase agreements with vendors (Sourcewell and US Communities).
- Associate engineers should be trained in the use of ACAD.
- Future consultants and contractor's panel could become a five-year term.

5.14.3 Concerns

- The completion of the recent $190 million Phase 1 Expansion construction project resulted in countless "lessons learned." However, there is no formal "debrief" mechanism to summarize these lessons at project conclusion.
- The priority ranking of existing projects changes.
- Impacts of new projects on current priorities.
- "Screaming Need" projects that may slip, i.e., Pierce Lift Station.
- Piggybacking wastewater treatment- specific equipment into blanket purchases, with unpredictable results.
- The GIS database may be outdated, and Engineering has not been trained on its utilization.
- Engineering and Construction staff tasks or expectations are not outlined in the Emergency Response Plan.
- There are no defined work responsibilities between the various Engineering Departments throughout the City (e.g., City Hall Engineering, RWQCP Engineering, Collections, Contract Administration, etc.) concerning design/bid/build and design/build projects.
- Contract Administration should be integrated into the Engineering Section to oversee design and contract administration in a single place.

Table 5.16 presents the recommendations for the Engineering Section.

Table 5.16 Engineering-Focused Recommendations

Recommendations
Develop a formalized report or process for transferring knowledge learned at conferences or during construction to increase the knowledge base throughout the Section.
Streamline policies and procedures to execute work. Formally identify shortcomings of protocols, procedures, and work flows and how they were overcome. Systematically revise the processes that improve productivity.
Engage Engineering in the optimization of the treatment processes with the goals of reducing variability and operational costs.
Outline Engineering and Construction Services tasks and expectations in the Emergency Response Plan.

5.15 Comparison with Other Organizations

Data provided in NACWA's 2018 Financial Survey were used to compare and contrast the staffing of Operations, Maintenance, Collections, Environmental Compliance, and Administration against other cities and agencies both in California and in the equivalent "peer" group across the country. Administration and Engineering are difficult to illustrate, as various utilities report these staffing differently. A variety of categories, such as Administration, Engineering, Finance, Human Resources, may be reported as Administration.

The utilities vary by focus. For O&M and Administration, comparable design capacity and actual daily average flows were used. For Collections, comparable collection systems lengths are shown. For Environmental Compliance, comparable service areas are shown.

For each comparison, the ratio between the metric (flow, collection system length, or service area) was divided by the reported number of workers (FTEs). The intent is to show how each agency staffs the work it completes, but details of that work for each agency are unknown.

Each California agency that provided survey data is shown. It is important to note that not all California plants are comparable to the City in terms of treatment capacity, average daily flows, service area, or collection system sizing. However, every California organization that participated in the survey is included in each evaluation. As Figure 5.2 demonstrates, all organizations are required to treat the wastewater, however California has more stringent regulatory requirements which likely increase the staffing necessary to achieve compliance. Therefore, when considering Operations, Maintenance, Environmental Compliance, and Administration, California plants likely have more FTE's than their equivalent nationwide counter-parts. However, in the Collections system, the regulatory requirements do not play as much of a factor. Therefore, Collections should be compared more heavily against its equivalent nationwide peer group. In addition, not all data may have been provided by the California or nationwide respondents.

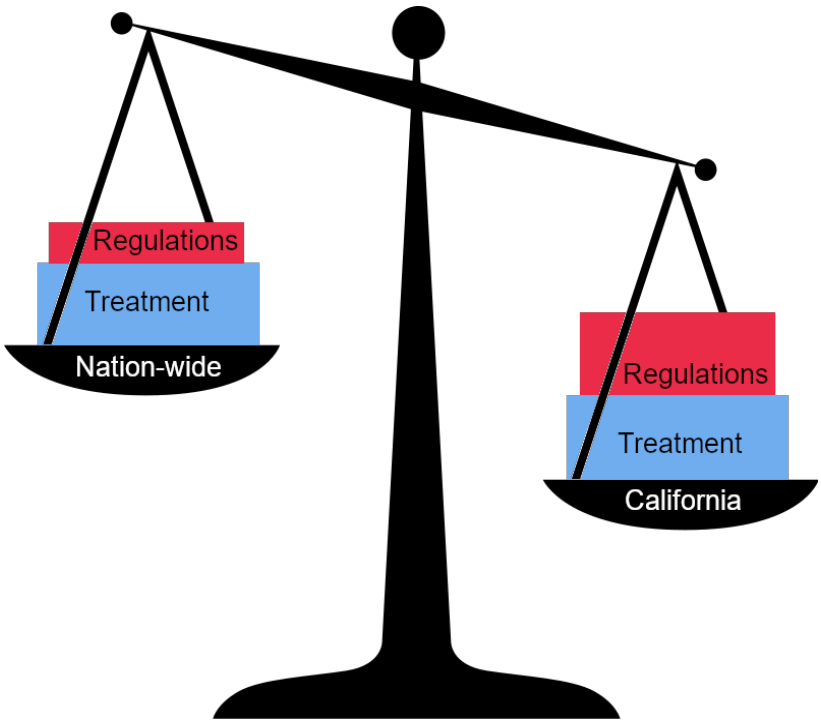

Figure 5.2 Considerations when Comparing RWQCP Against Other Agencies

Figure 5.3 explains how to interpret Figures 5.4 through 5.9. As stated above, each benchmark is divided by the number of FTE's employed by each agency. However, there are ambiguities in how the survey numbers were reported. For example, one agency may include supervisors under the Administration section instead of their assigned field (e.g., Collections) while others may have reported their supervisors in both locations. Figure 5.3 shows a "Goldilocks" region that encompasses most of the facilities. This represents a collectively employed balance between the benchmark (e.g. treatment capacity) and the number of FTE's to manage that level of flow.

Figure 5.3 Interpreting the Comparison Figures

5.15.1 Operations

Benchmarks for the operations of comparably-sized wastewater treatment plants nationwide and California are shown on Figure 5.4. The plants displayed have similar treatment processes, design capacity and daily flows, but the staffing structures may vary from the RWQCP. California plants are shown in cyan, and plants in other states are shown in grey. Note: The dispatchers are not added into either Operations or Administrative totals. The operations structure is typical of California treatment plants.

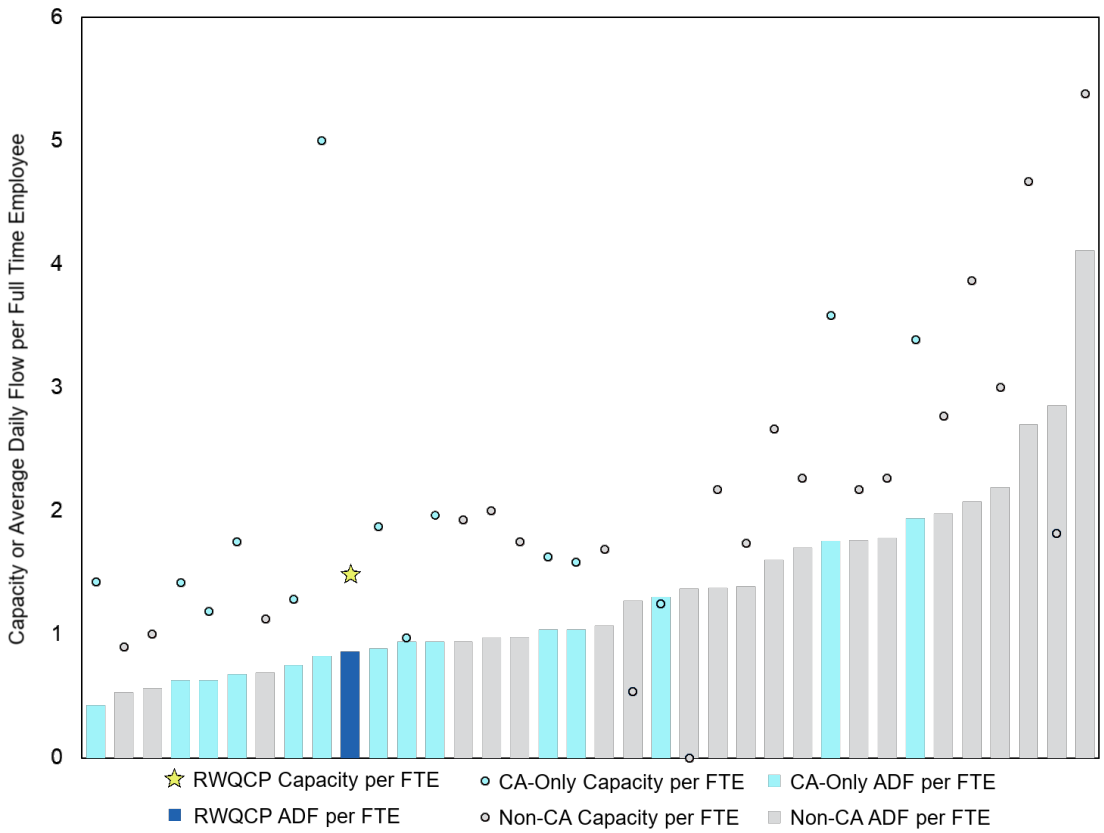

Figure 5.4 Operations Staffing Utilization Comparison to Other Agencies

Figure 5.4 demonstrates the staffing utilization on a design capacity (bullet icons) or average daily flow (columns) basis. In this Figure, the left side represents a low average daily flow to FTE ratio while the right represents a high average daily flow to FTE ratio. Based on Figure 5.4, the Operations Section appears to have an appropriate staffing level (indicated by the dark blue column) compared to the average daily flow and staffing levels of other plants. However, if the City feels the Operations Section is over or under-staffed, a study should be done to determine the appropriate number of operators.

5.15.2 Maintenance

Benchmarks for the maintenance of comparably-sized wastewater treatment plants nationwide were considered. Data for California plants are provided to represent the more stringent regulatory obligations of the State. The plants displayed have comparable treatment processes, design capacity and daily flows, but the staffing structures may vary from the RWQCP. Maintenance comparisons are shown on Figure 5.5.

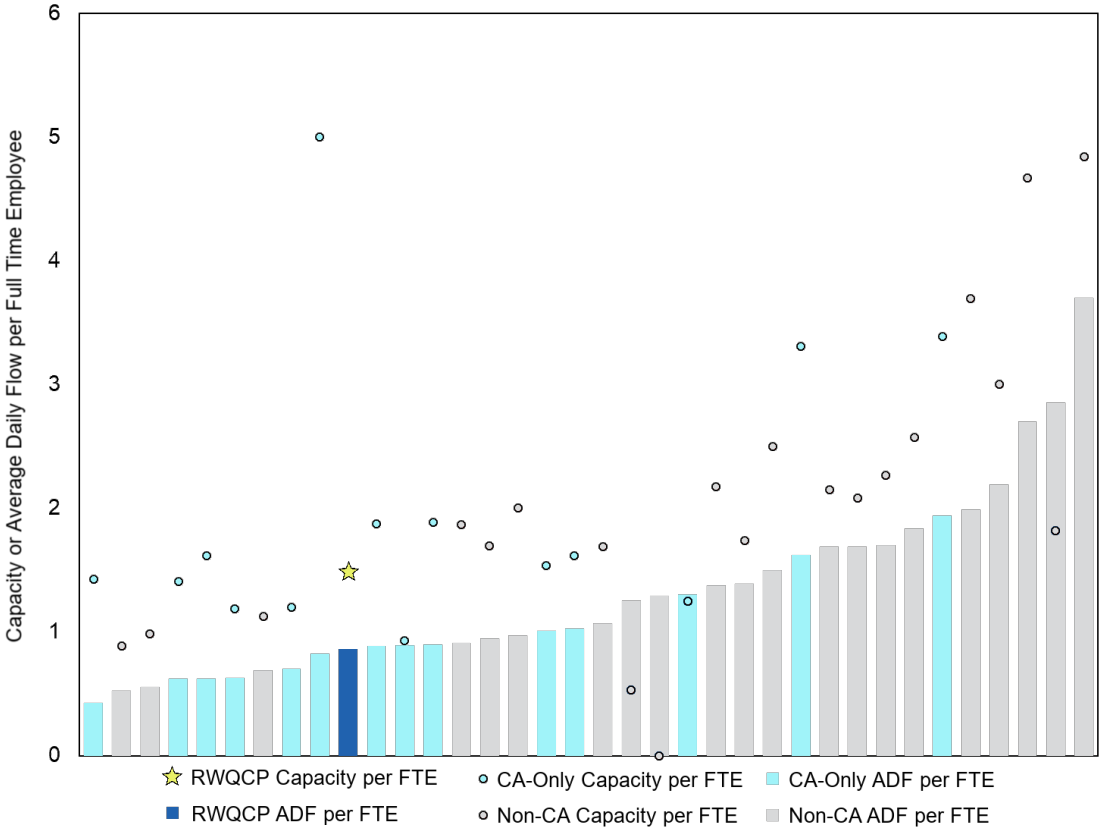

Figure 5.5 Maintenance Staffing Utilization Comparison to Other Agencies

Similar to Operations, Maintenance appears to be typical of California plants with a good distribution of Maintenance staff to average daily flow.

5.15.3 Collections

Benchmarks for comparably-sized collection systems were used to contrast Collections staffing and are shown on Figure 5.6. The systems displayed have comparable lengths of sewers, but the staffing structures may vary from those of the City.

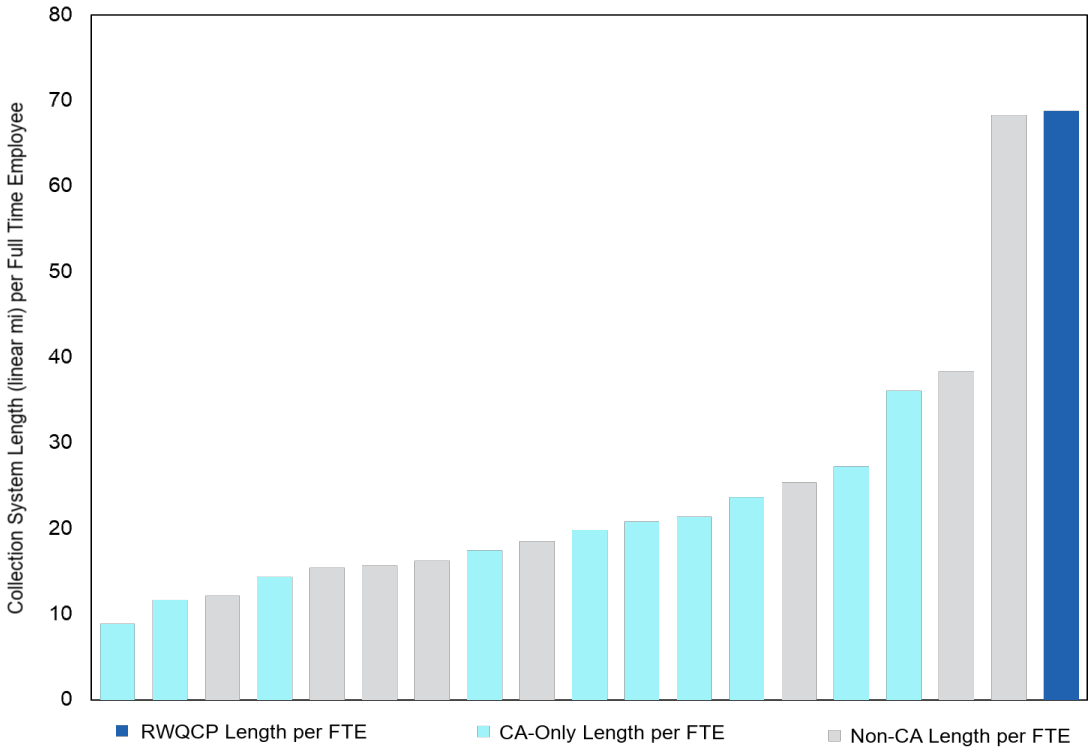

Figure 5.6 Collection System Staffing Utilization Comparison to Other Agencies

As Figure 5.6 demonstrates, the City has almost 70 linear miles of pipe per FTE, which is the highest ratio of all California plants that responded to the survey along with the comparable organizations nationwide.

After discussion with the City, it became apparent that when the City responded to the NACWA survey, the City under-represented the number of people assigned to work on Collections system O&M. The City has 19 technicians and 2 engineers dedicated to the Collection System specifically. Additionally, the maintenance of Collection System assets, like force mains and lift stations, are handled by the RWQCP Maintenance staff. They do not have dedicated Maintenance personnel exclusively assigned to the Collection System infrastructure. The City, therefore, estimates a total of 23 staff associated with the Collection System maintenance, which differs from the 16 people

reported in the survey. Figure 5.7 shows the revised graphic using the City's current estimate of Collections System staff.

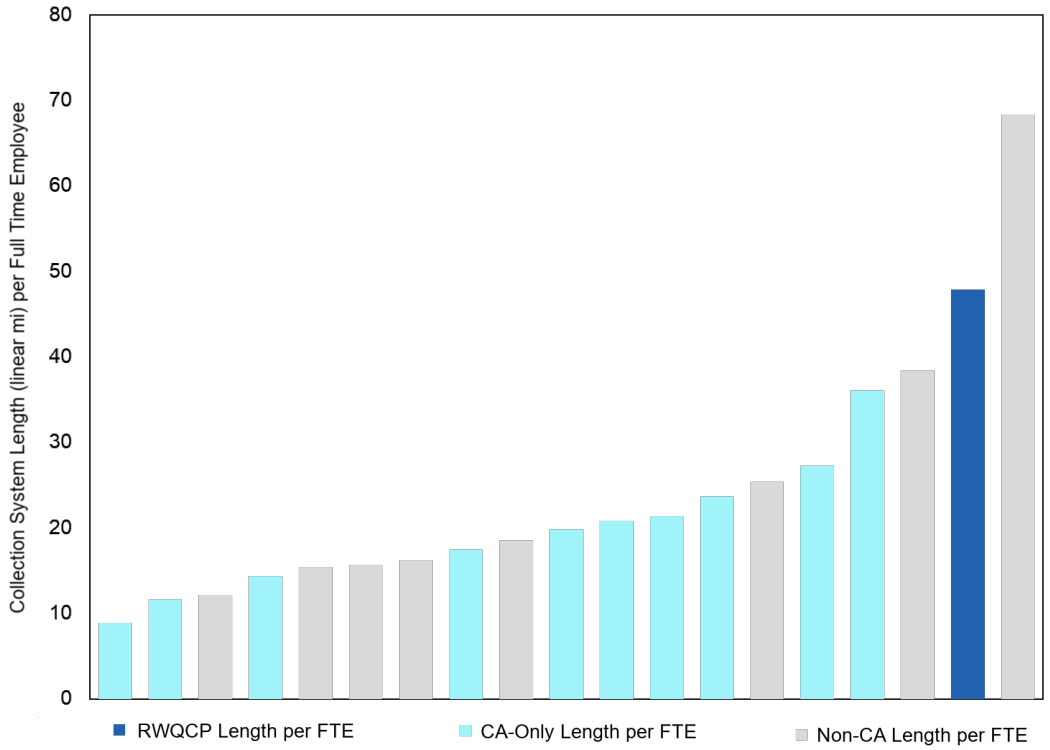

Figure 5.7 Collection System Staffing Utilization Comparison to Other Agencies

Despite the changes to reported staffing levels as shown on Figure 5.7, the City still appears to be understaffed for a collection system of this size. In particular, the Collections Engineering group is unlikely to be able to keep up with upcoming infrastructure projects, such as those recommended in Volume 3, Chapter 10, Capital Improvement Program. A study should be conducted to determine the adequate level of staffing to meet current and future needs.

5.15.4 Environmental Compliance

Benchmarks for comparably-sized service areas were used to contrast Environmental Compliance staffing and are shown on Figure 5.8. The national agencies displayed in grey have similar sized service areas, but the staffing structures may vary from those of the City of Riverside.

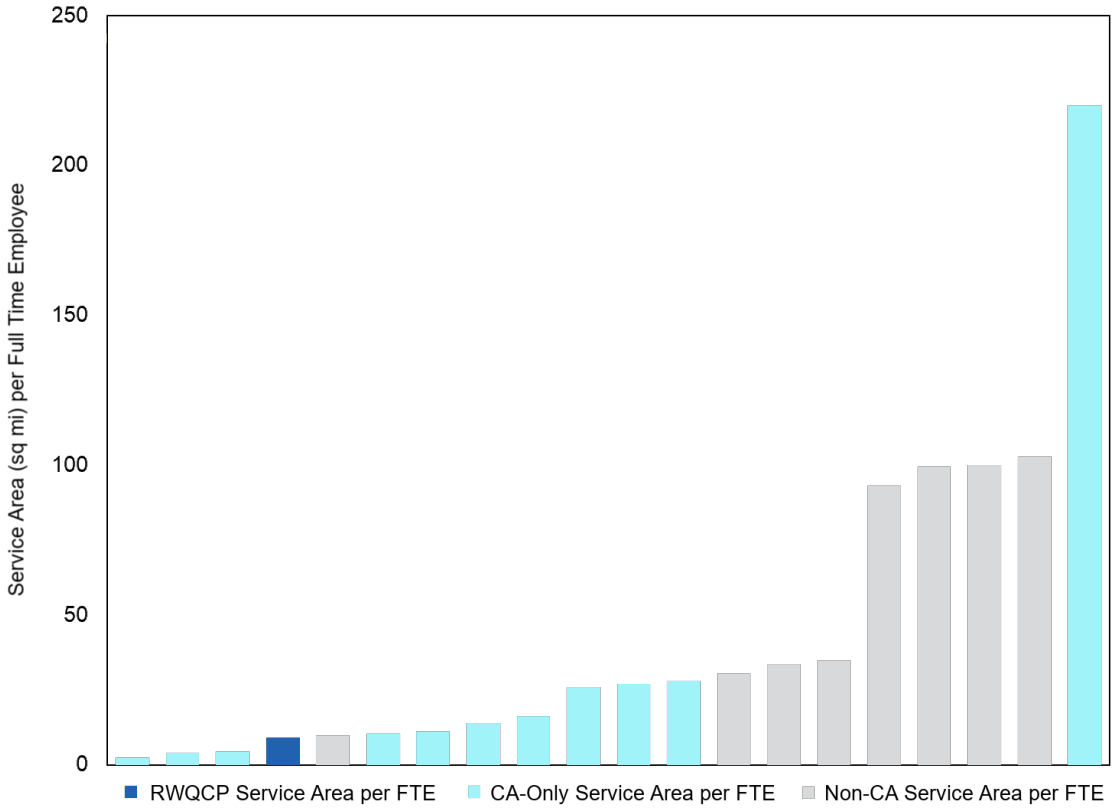

Figure 5.8 Environmental Compliance Staffing Utilization Comparison to Other Agencies

Comparing the nationwide facilities with similar sized service areas (grey bars), the City appears to have higher than average staffing levels; that is a smaller ratio of service area to FTEs. However, compared with the California plants, of various service area size (cyan bars), the City appears to be adequately staffed in this area.

Although the City's Environmental Compliance staff appears to be adequate based on Figure 5.8, the NACWA survey does not take into consideration the number of samples collected or processed by each survey recipient. Based on the City's comments, the Environmental Compliance Section should evaluate the necessity of the current sampling schedule and discontinue unnecessary sampling protocols. Furthermore, a detailed investigation may be useful to determine how each of the reporting agencies staff their environmental compliance programs.

5.15.5 Administrative Services

Benchmarks for comparably-sized nationwide treatment plants (grey bars) were used to contrast Administrative Services staffing and are shown on Figure 5.9. The staffing structures may vary from those of the City, and results may include services provided by others within the City or Engineering. Separate engineering staff data was not published.

From Figure 5.9, the Administrative Section is above average meaning that there are fewer employees per treatment flow and capacity, compared with similarly sized plants nationwide, as well as when compared to other California plants (cyan bars). However, based on input from the City, the staffing appears to be adequate considering the current services provided. Additional staffing may be needed if more services are required in the future.

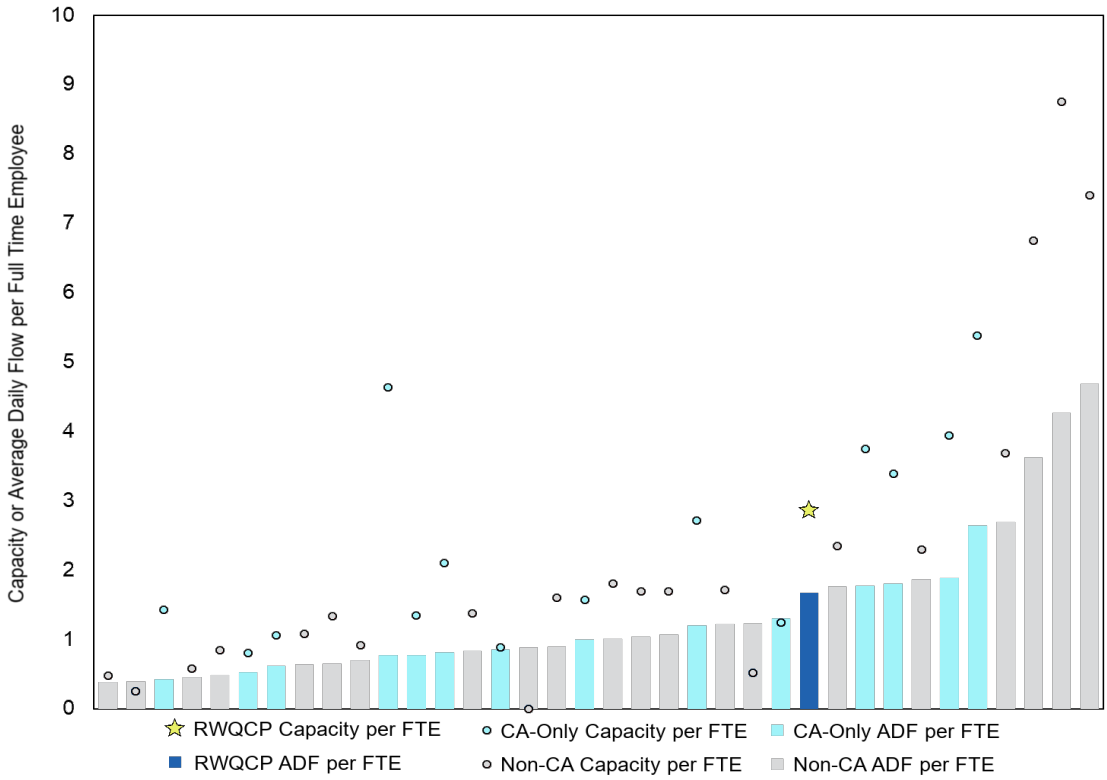

Figure 5.9 Administration Staffing Utilization Comparison to Other Agencies