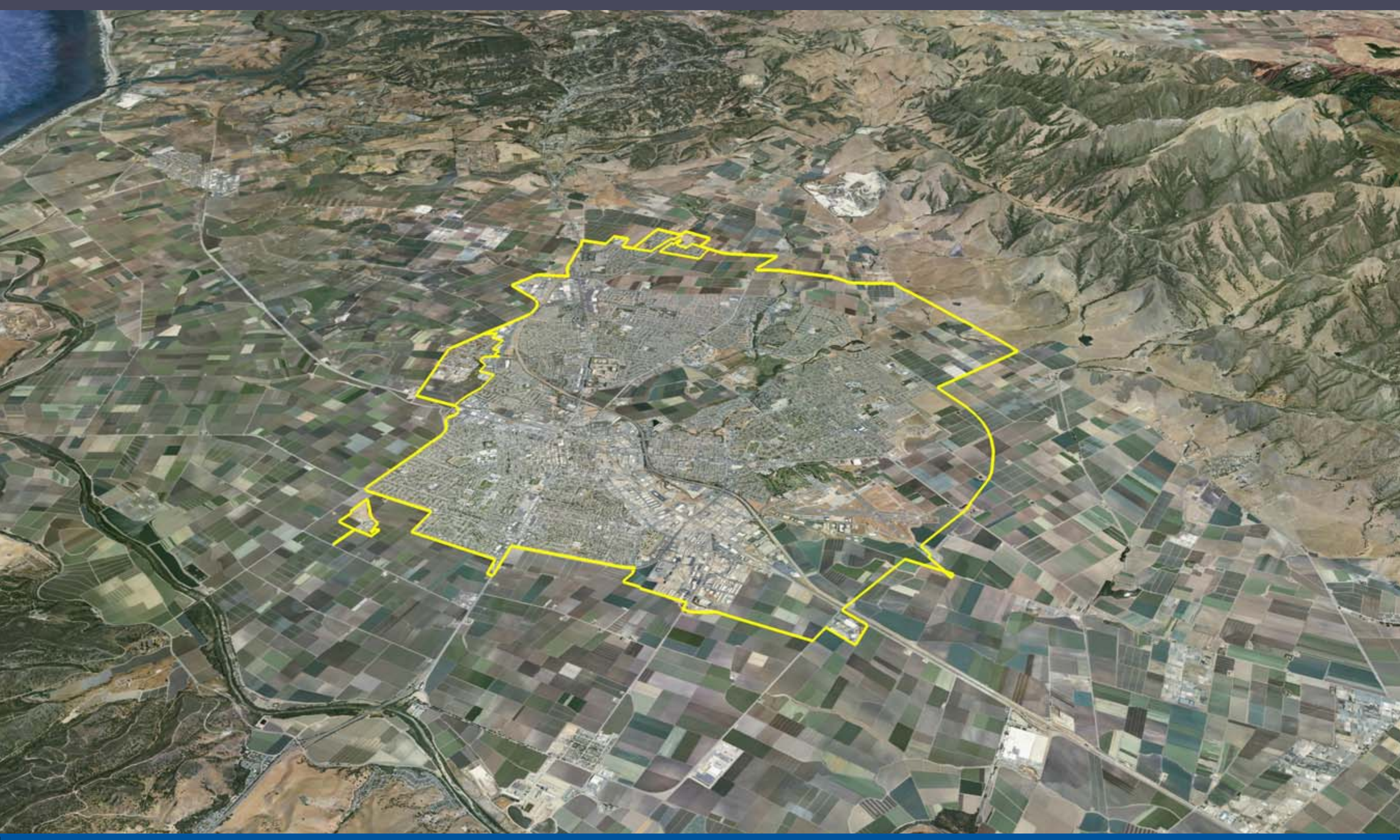
CDM

FINAL REPORT

City of Salinas

Sanitary Sewer System Master Plan

August 2011



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Acronyms and Abbreviations

CCI	Construction Cost Index
CDM	Camp Dresser & McKee Inc.
CIP	Capital Improvement Program
City	City of Salinas
County Plan	2010 Monterey County General Plan
CSO	combined sewer overflows
d/D	depth of flow in the pipe relative to the pipe diameter
ENR	Engineering News Records
FEA	future expansion area
FGA	future growth area
ft	feet
ft/sec	feet per second
GIS	geographic information system
gpd	gallons per day
gpd/acre	gallons per acre per day
gpm	gallons per minute
GWI	groundwater infiltration
HGL	hydraulic gradeline
HP	horsepower
I/I	infiltration and inflow
LDD/CD	Land Development Desktop/Civil Design
mgd	million gallons per day
MRWPCA	Monterey Regional Water Pollution Control Agency
RDII	rainfall-dependent inflow and infiltration
RTC	real time control
SSO	sanitary sewer overflows
SWMM	Stormwater Management Model

Executive Summary

Purpose of the Master Plan

The City of Salinas (City) owns and operates a municipal sanitary sewer collection system for the residents and businesses within its service area. The City periodically conducts studies to plan for current and future sanitary sewage collection needs.

This document provides a comprehensive Sanitary Sewer Master plan update for the City of Salinas, based on the City's 2002 General Plan, development planning, and preliminary planning information from the current housing element update. The study area includes the ultimate system area that will be served by the sewer facilities owned and operated by the City, according to its current General Plan. In addition, two County areas in west Boronda and Bolsa Knolls are included that discharge to the City's system.

Section 2 describes the study area and land uses.

The master plan includes development of a city-wide sanitary sewer system model (10-inch and greater diameter) for existing and projected future development, development of wastewater flow projections, use of the model to identify and analyze required improvements, and development of capital improvement program recommendations based on the analysis results.

This Master Plan addresses the City's sanitary sewer system only, and does not include the City's industrial waste system or any wastewater facilities owned or operated by the Monterey Regional Water Pollution Control Agency (MRWPCA).

Existing Sanitary Sewer System

Section 3 describes the existing sewer system and the updated hydraulic model.

The City of Salinas owns and operates the wastewater collection system within its service area. The existing system comprises approximately 289 miles of sewer pipe ranging in size from 6 inches to 72 inches in diameter, 11 pump stations, and 7 flow split structures. Flow in the City system is primarily by gravity, with low-head pump stations located at low spots due to the City's flat topography. All sanitary wastewater collected by the City's system flows to the MRWPCA's Salinas Pump Station located at the southwestern boundary of the City.

An updated hydraulic model of the City's sanitary sewer system was developed and used for the sanitary sewer system analyses. The hydraulic model includes existing system facilities, and proposed major sewers to serve the Future Growth Area.

Wastewater Flow Projections

Section 4 provides information on wastewater flow projections.

Existing and future flow projections were developed using a land use based approach, using unit flow factors developed from City flow meter data. The system-wide flow projections, in million gallons per day (mgd), presented in Table ES-1 are the base case, based on flow factors derived from existing meter data. The unit flow factors for all land use types, other than industrial, are the same for existing and future areas. For future industrial areas, a higher unit flow factor is used for future areas to account for more intensive future industrial development than indicated by the existing industrial development.

In addition, a sensitivity analysis was conducted to determine the impact of potential future flows from an area north of the future North Boronda Future Growth Area that is outside the current master plan study area. The maximum buildout flow for sensitivity analysis shown in the last column of Table ES-1 includes these additional flows.

Table ES-1
Summary of System-Wide Wastewater Flow Projections

Condition	Existing Flow (mgd)	Buildout Flow [2] (mgd)	Maximum Buildout Flow - Sensitivity Analysis [3] (mgd)
Average Dry Weather Flow (Base Wastewater Flow)	14.4	21.7	22.1
Peak Dry at 1.6 times average for existing and 1.55 times average for buildout (from peaking curve).	23.0	33.6	34.2
Peak Wet Weather Flow (Average Dry Weather plus RDII for 10-Year, 6-Hour Design Storm) [1]	32.5	44.1	47.0

(1) The 10-year design storm was selected for evaluation of existing system and sizing of improvements based on sensitivity analysis discussed in Section 6.

(2) The buildout flow projections discussed in Section 4 are based on flow factors derived from existing meter data. The unit flow factors for all land use types, other than industrial, are the same for existing and future areas. For existing industrial areas, the existing unit flow factor is 500 gallons per day per acre (gpd/acre). For incremental future industrial areas, a higher unit flow factor of 2,000 gpd/acre is used to account for more intensive future industrial development than indicated by the existing industrial development.

(3) The maximum buildout flow shown in the last column of Table ES-1 is based on sensitivity analyses discussed in Section 6 that investigated the potential impacts of potential future flows from an area north of the future North Boronda Future Growth Area that is outside the current master plan study area. The additional flows due to this assumption are: 0.4 mgd average dry weather; 0.6 mgd peak dry weather; 2.5 mgd 10-year, 6-hour rainfall-dependent inflow and infiltration (RDII); and 2.9 mgd total peak weather flow (average dry plus 10-year RDII).

Sewer System Analysis

Section 5 summarizes the hydraulic criteria for the sewer system analysis. Section 6 describes the analysis results.

The updated hydraulic model and the wastewater flow projections were used to analyze existing and buildout conditions, to determine where the system is deficient and the need for system improvements. The collection system analysis included pipeline capacity evaluation, pumping capacity evaluation and force main capacity evaluation.

The results for the dry peak and wet peak (dry average plus 10-year storm) simulations were compared to the hydraulic criteria for depth of flow (d/D) and allowable surcharge. Locations not meeting the criteria were identified as deficiency locations. The locations that did not meet the criteria were then subject to a detailed analysis to determine the need for improvements.

Not all existing pipes not meeting the criteria (i.e., identified as system deficiencies) require improvement. The ultimate need for a system improvement is dictated by the level of surcharge, the possibilities of diverting flow upstream to a different existing pipe, and existing pipe characteristics such as slope and diameter, and whether it is impacted by backwater that will be eliminated by a downstream improvement.

Plan Recommendations

Table ES-2 summarizes the major categories of recommended projects for the City's Capital Improvement Program (CIP).

Section 7 presents the plan recommendations and cost estimates.

Table ES-2
Summary of Recommended Sanitary Sewer System Improvements

Type	***Quantity***	***Unit***	***Capital Cost (2010 $ Million)***		
			Existing	***Future***	***Total***
Capacity Improvements					
Gravity Sewers	37,400	Feet	$2.1	$21.0	$23.1
Force Mains	1,260	Feet	$0.0	$0.5	$0.5
Pump Station Upgrades	185	horsepower	$0.0	$2.2	$2.2
		Subtotal	*$2.1*	*$23.7*	*$25.8*
Rehabilitation/Replacement Improvements					
Sewers	2,290	Feet	$0.3	$0.0	$0.3
Emergency Bypasses at Pump Stations	7	Each	$2.5	$0.0	$2.5
		Subtotal	*$2.8*	*$0.0*	*$2.8*
Grand Total			$4.9	$23.7	$28.6

Table 7-1 (in Section 7) provides a detailed description of the recommended CIP projects to provide the required capacity to convey buildout flows. Figure 7-1 (in Section 7) shows the conceptual locations of the recommended capacity projects. All projects are sized to convey buildout flows.

Figure 7-1 also shows conceptual alignments for the future major sewers to serve the Future Growth Area. The CIP projects do not include future sewers to serve future growth areas. The sewer facilities required in the new development areas will be constructed as part of the new development. The master plan provides guidance for the City on sizing of the future facilities, which would be confirmed and verified by the specific plan of the area.

The City provided available information on existing sewers that require replacement/rehabilitation due to poor condition, and other existing needs. Table 7-2 (in Section 7) lists specific problem locations requiring pipeline/manhole improvements, as identified based on available maintenance history. These replacement/rehabilitation projects should be included in the City's CIP budget.

Section 1
Introduction

This section describes the purpose, organization and scope of the master plan, and lists acknowledgments.

1.1 Purpose of Master Plan

The City of Salinas, the county seat and largest city in Monterey County, is located in the northwest part of the Salinas Valley about 60 miles south of San Jose and 10 miles inland from Monterey Bay. Figure 1-1 shows Salinas' general location.

Figure 1-1
Location Map

The City of Salinas (City) owns and operates a municipal sanitary sewer collection system for the residents and businesses within its service area. The City periodically conducts studies to plan for current and future sanitary sewage collection needs.

This report provides a comprehensive update of the City of Salinas Sanitary Sewer System Master Plan prepared in 1998. The update is based on the City's 2002 General Plan and current development planning information, including information from the City's current housing element update.

The master plan includes development of a city-wide sanitary sewer system model (10-inch and greater diameter) for existing and projected future development, use of the model to identify and analyze required improvements, and development of capital improvement program recommendations based on the analysis results.

The master plan is for the City sanitary sewer system and does not include any facilities operated by the Monterey Regional Water Pollution Control Agency (MRWPCA), or the City's industrial wastewater system.

1.2 Organization of Master Plan Report

This report highlights the key master plan findings. The report is organized into seven sections, as described in Table 1-1. Detailed technical information is in appendices.

Table 1-1
Report Organization

Section	*Description*
1 – Introduction	Overview of the purpose, organization, and scope of the Master Plan.
2 - Study Area and Land Uses	Pertinent information on the study area, and its existing and future land uses.
3 - Existing Sanitary Sewer System	Overview of the existing system and key facilities; summary description of hydraulic model.
4 – Wastewater Flow Projections	Development of dry weather and wet weather wastewater flows to determine peak design flows for the system evaluation.
5 - Hydraulic Criteria for System Analysis	Hydraulic criteria used for the Master Plan evaluation.
6 – Sanitary Sewer System Analysis	Results of the analysis to identify pipeline and pumping improvements required to convey existing and future flows.
7 – Recommended Sanitary Sewer System Improvements	Sanitary sewer system improvement recommendations, including costs and phasing.

1.3 Scope of Services

The City of Salinas retained Camp Dresser & McKee Inc. (CDM) to prepare the Sanitary Sewer System Master Plan. The scope of work included the following major elements:

- Evaluate hydraulic modeling software and select preferred software.
- Determine existing and future land use information for the study area.

- Develop dry weather and wet weather wastewater flow projections.
- Develop a sewer system hydraulic model using the selected software.
- Utilize the hydraulic model to analyze the sewer system under existing and future conditions based on established hydraulic criteria.
- Develop capital improvement recommendations for the system.

1.4 Acknowledgments

This report would not have been possible without the valuable assistance of City staff. In particular, the following staff provided comprehensive information, significant input and important insights throughout the master plan development:

- Rob Russell, City Engineer
- Carl Niizawa, (Former) Deputy City Engineer
- Frank Aguayo, Senior Engineer, Public Works Department
- Josie Lantaca, Assistant Engineer, Public Works Department
- Denise Estrada, Former Maintenance Services Director
- Ron Cole, Wastewater Manager, Public Works Department

Section 2
Study Area and Land Uses

This section identities the master plan study area, and the current and future land uses within the study area. This information is used in Section 4 to develop the wastewater flow projections.

2.1 Master Plan Study Area

The master plan study area is shown on Figure 2-1. Only sewer flows from the areas shown on Figure 2-1 are included in the master plan analysis. The two main areas are:

- City Sewer System Area: This is the ultimate system area that will be served by sewer facilities owned and/or operated by the City. Within this boundary, the City's sewer system will be analyzed in detail in this master plan to determine required sewer improvements. The future City sewer system area encompasses:
  - Current service area;
  - Area in Bolsa Knolls that is part of a City special assessment district;
  - Future Growth Areas (FGA) including North Boronda FGA, West Boronda FGA, East FGA, and Southeast FGA; and
  - Future industrial (agriculture-related) area of about 257 acres at the southeast corner near Abbott Street and Highway 101.
- Outside Areas: These are outside areas where the sewer system is owned by others. The City will not own or maintain the sewer systems in these areas. The master plan will not analyze facilities within these areas. These outside areas include:
  - County area in Bolsa Knolls (future connection); that is outside the City special assessment district. For analysis purposes, the sewer flows from this outside area are added to the hydraulic model only as inflows to the City sewer system at the appropriate location to determine potential impacts on the City system.
  - County Boronda Area (existing connection). For analysis purposes, the sewer flows from this outside area are added to the hydraulic model only as inflows to the City sewer system at the appropriate location to determine impacts on the City system.

The Figure 2-1 study area is assumed to be the ultimate area that will be served by the City's system under its General Plan buildout. Future development areas currently outside the City boundary will become part of the City upon annexation.

The Salinas Sewer Collection System Study (Kennedy/Jenks Consultants, 1998) presented a larger future contributing area. The most significant in size was an area north of the North Boronda FGA and Bolsa Knolls, bounded approximately by San

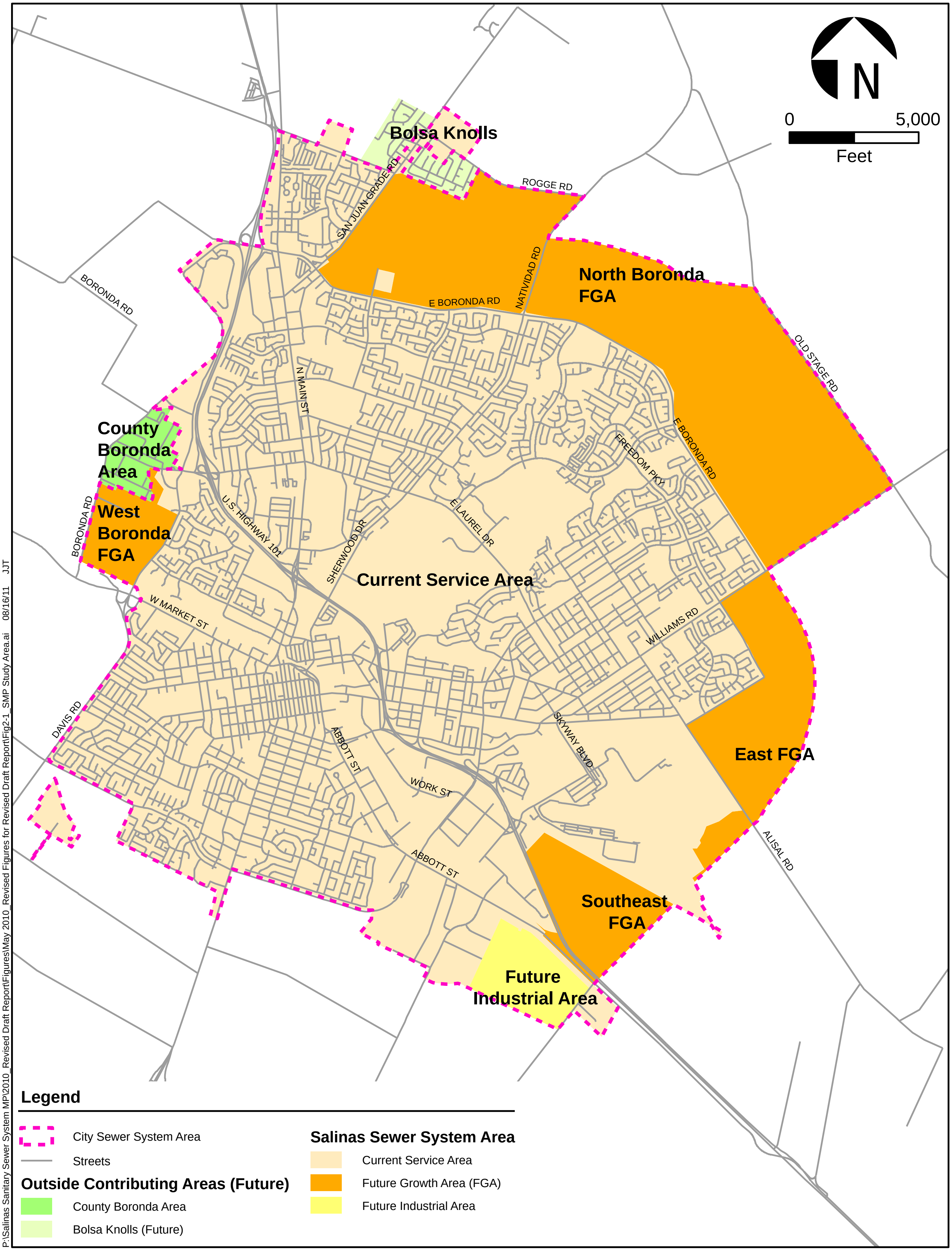

Figure 2-1
Plan Study Area
Salinas Sewer System Master Plan

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Juan Grade Road and Old Stage Road. Based on the planning information provided to date, these areas are no longer part of the Master Plan study area, and are not shown on Figure 2-1. However, the Section 6 analysis includes a sensitivity analysis of the impact of future flows from potential future development north of the study area limit shown on Figure 2-1.

2.2 Sources of Land Use Information

To determine future and existing land uses within the study area, as described in this section, GIS shape files provided by the City, the City and County General Plans, and previous studies were used.

Table 2-1 summarizes the information sources that were reviewed for each specific service area, and notes the source that was used as basis for the development of a comprehensive GIS Land Use Map for the master plan. For each specific area, the land use information for the comprehensive GIS land use map was obtained from the latest source or from the source recommended by the City.

Subsequent to the draft report (dated July 2009), the City provided additional land use information that has been incorporated into the land use database and a revised analysis. This information included: adding mixed use areas (commercial and residential) at locations provided by the City including preliminary information from the housing element update currently in progress; and adding some infill and redevelopment projects including Alisal Marketplace, Haciendas Plaza, and Tresor Family Apartments.

Table 2-1
Sources of Buildout Land Use Information

Area	*Sources*
City Sewer System Areas	
Current City Service Area	• City's GIS database/Zoning Map, November 2006 (used as basis for land use map) • City of Salinas General Plan, September 2002
North Boronda FGA	• Land use figure provided by the City via e-mail on November 29, 2007 (used as basis for the land use map) • City of Salinas, North Future Growth Area, Sewer System Study, P&D Consultants, August 2006
Area in Bolsa Knolls that is part of a City special assessment district	• San Juan Grade/Rogge Road Sanitary Sewer Model Limits, Kennedy Jenks Consultants, 2004 (used as basis for land use map) • City's GIS database/Zoning Map, November 2006
East FGA, Southeast FGA	• City's GIS database/Zoning Map, November 2006 (used as basis for land use map) • City of Salinas General Plan, September 2002
West Boronda FGA	• General Development Plan for Boronda Meadows – overall lotting plan, Draft 2009 prepared by RJA
Future Industrial Area (agriculture-related) in vicinity of Abbott Street and Highway 101 ("Fresh Express")	• Information provided by City staff via e-mail on November 14, 2007 and updated Engineer's Report provided March 2009 (used as basis for land use map)

Table 2-1
Sources of Buildout Land Use Information

Area	***Sources***
Infill and Redevelopment Areas	• Alisal Marketplace – Mixed uses from preliminary planning information provided by City in October 21, 2009 transmittal and e-mails in November and December 2009 • Haciendas Plaza – replacement of 76 multi-family units with mixed use project of commercial and 151 multi-family units at Sherwood Drive and Calle Cebu (e-mail from City, December 1, 2009 • Tresor Family Apartments – infill 81 unit apartment project at 1041 Buckhorn Drive (e-mail from City, November 18, 2009) • Tynan Village – redevelopment with mixed uses based on land use information in the Technical Memorandum “Tynan Village Pipe Capacity Evaluation” prepared by CDM, November 2006. • Other mixed use areas per preliminary information from City’s housing element update that is currently in progress, as discussed below in Section 2.4.
Outside Areas	
County area in Bolsa Knolls that is outside the City special assessment district	• San Juan Grade/Rogge Road Sanitary Sewer Model Limits, 2004 (used as basis for land use map) • City’s GIS database/Zoning Map, November 2006
County Boronda Area	• Monterey County General Plan, 2006 (used as basis for land use map)

2.3 Master Plan Land Use Types

The land use information sources used various land use classifications. To be consistent and to facilitate the master plan analysis, the various classifications were grouped into seven general types for the master plan land use map. Table 2-2 summarizes the master plan land use types, their descriptions, and the relationship to the various City land use classifications.

Table 2-2
Master Plan Land Use Types

Master Plan Land Use Type	***Description***	***City Zoning and General Plan Land Use Designations***
A	Agriculture	Agriculture
C	Commercial	Commercial, General Commercial, Commercial-Residential, Commercial – Retail, Commercial Thoroughfare, Arterial Frontage, Mixed Use, Business Park, Office, Retail
I	Industrial	Industrial/Business Park, General Industrial, Light Industrial, Industrial/Commercial
MU	Mixed Use	Mixed Commercial and Residential
OS	Open Space	Open Space
P	Parks	Parks
PS	Public/Semipublic	Public, Public/Semipublic

Table 2-2
Master Plan Land Use Types

Master Plan Land Use Type	Description	City Zoning and General Plan Land Use Designations
RL	Residential - Low Density	Residential Low Density, R-L-5.5
RM	Residential - Medium Density	Residential Medium Density, R-M-2.9, R-M-3.6
RH	Residential - High Density	Residential High Density, R-H-1.8, R-H-2.1

2.4 Existing and Future Land Uses for Master Plan

Based on the information sources in Table 2-1 and using the master plan land use types in Table 2-2, a master shape file was created with the updated land use information for each specific area for existing and build-out conditions. This existing and build-out land use information was used to develop the master plan flow projections in Section 4.

Figure 2-2 shows the comprehensive GIS land use map for the master plan study area for build-out conditions. Figure 2-3 shows the vacant areas for future development and other areas not currently contributing to the sewer system, as well as areas that will remain unsewered in the future, including open spaces, parks, and agricultural areas. Table 2-3 presents the acreages of each of the master plan land use types within the various master plan areas.

Figure 2-2 identifies a number of future mixed use areas that may have both commercial and residential development. These mixed use areas are located primarily in the North Boronda FGA, and in the metropolitan high density zoning areas under consideration in the current housing element update. The mixed use areas are assumed to be commercial development at street level with residential units on upper stories. For these areas, the master plan flows include the commercial flows plus the additional residential flows. The primary mixed use areas with additional residential units include:

- North Boronda FGA mixed use areas – 300 units in the mixed use area near Sanborn Road; 91 units in the mixed use area near El Dorado Drive; and 86 units in the mixed use area near Hemingway Drive.

- Other mixed use areas including Haciendas Plaza with up to 151 multi-family units; and an area near Constitution and Independence Boulevards with up to 170 multi-family units.

- Redevelopment areas identified as MX (mixed use) in the City's current housing element update, which would allow metropolitan high density residential (up to 30 units per acres) in addition to commercial development in certain areas. These areas and potential number of additional units include:

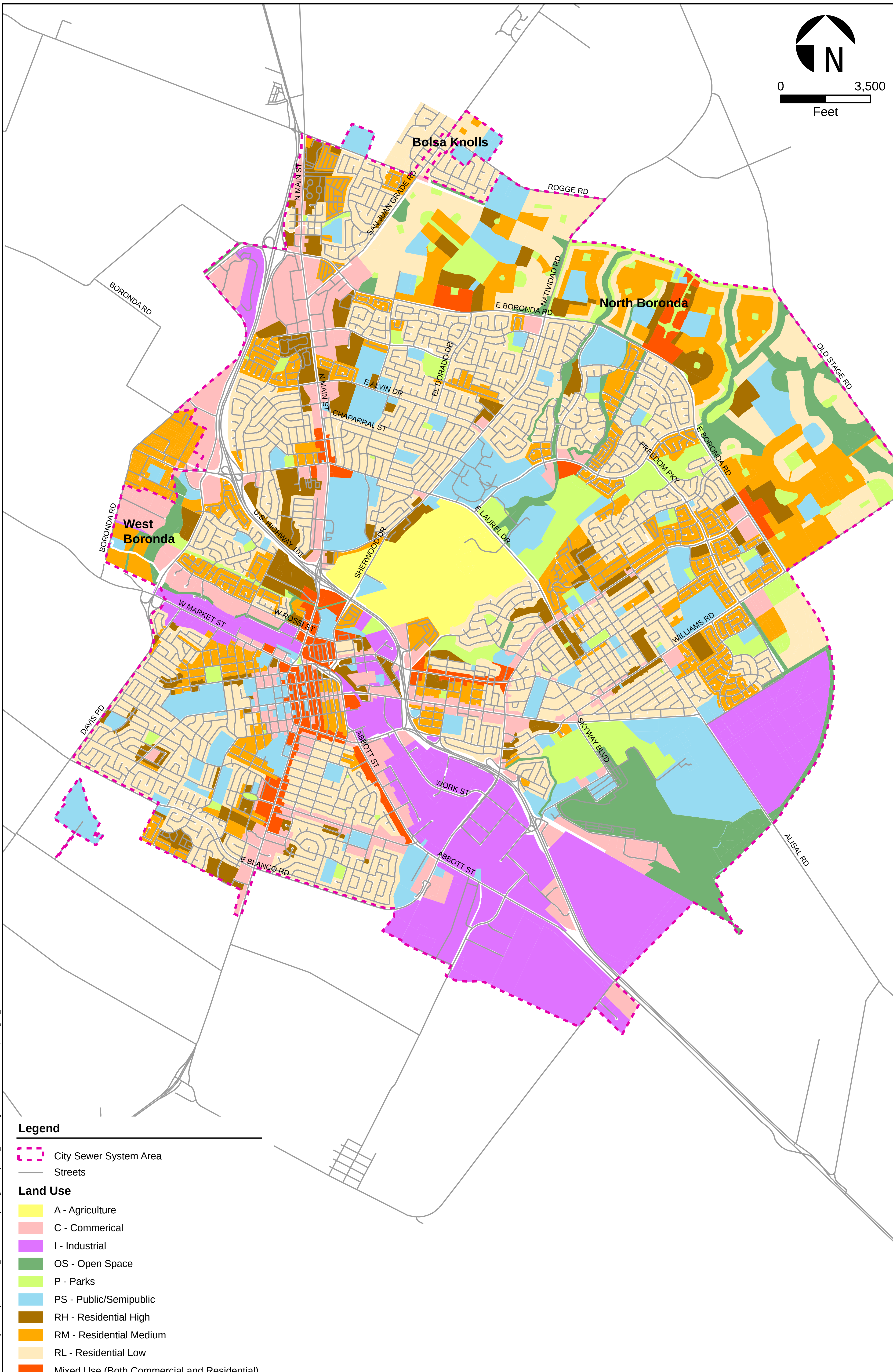

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Figure 2-2
Buildout Land Use Map
Salinas Sewer System Master Plan

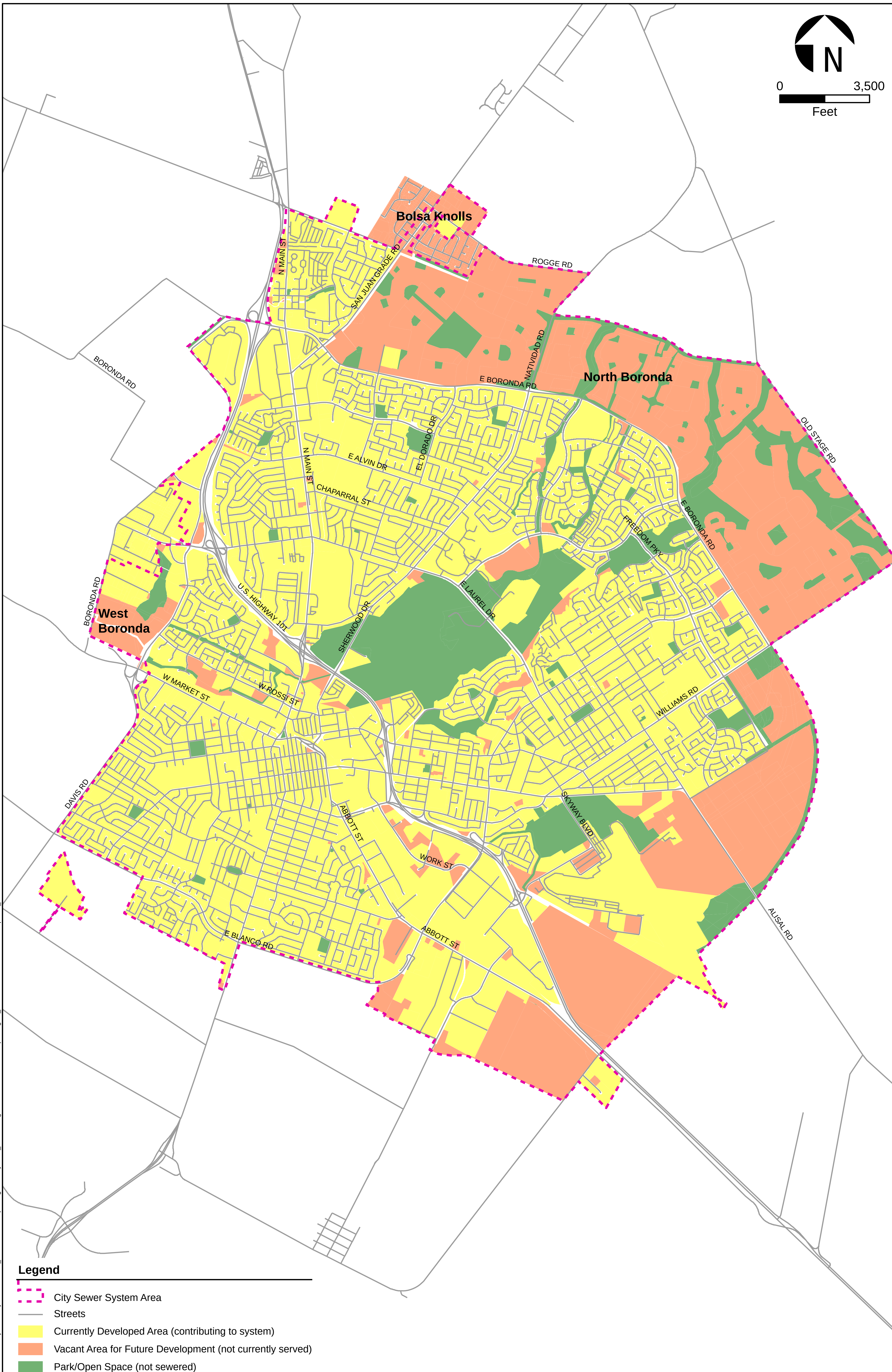

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Figure 2-3
Vacant Areas for Future Development
Salinas Sewer System Master Plan

- Based on the available conceptual information, the master plan assumes a potential maximum of 3,784 total units, which is the maximum allowable for all the redevelopment areas. Specific locations for the additional units have not yet been identified. The master plan assumes the following general locations for the additional units based on the available information: downtown core – up to 391 units; outside the downtown core but within the central city – up to 484 units; and outside the central city but within focused areas – up to 2909 units. The units were allocated to these mixed use areas based on the general location and size of the tributary subareas.

- Using the maximum number of 3,784 units is a conservative assumption for the master plan, and assumes that every underutilized parcel is redeveloped. The City's housing element update has a minimum requirement to provide at least 1,230 units for low and very low income units. Preliminary City planning information has identified underutilized parcels that have sufficient land for redevelopment of up to 2,821 units, which would more than meet the minimum requirement, but is below the conservative master plan total.

- The Alisal Marketplace and Tynan Village residential units are included as part of the total 3,784 units. Figure 2-2 shows the Tynan Village area as mixed use. Figure 2-2 shows the larger Alisal Marketplace area with the planned conceptual land uses (residential, commercial, public) based on its preliminary master plan.

For build-out conditions, it is assumed that every parcel within the study area will be served to its full potential. The following land use types are assumed to remain unsewered and not contribute flows to the system: agriculture; open space; and parks.

For existing conditions, those portions of the study area were identified that are currently vacant or are not currently served by the City system (e.g., Bolsa Knolls area is currently on septic tanks), but are expected to be served in the future. The starting point for this identification was information provided by the City for the 2004 Stormwater Master Plan on vacant areas within the City, which had been developed for the 2002 General Plan. This previous information was checked using available aerial photographs (2002) and public domain information (online satellite images, 2004, and road maps 2005), in order to determine current vacant areas. The majority of the vacant areas are future growth areas and small infill parcels.

Table 2-3
Land Use Acreages for Master Plan Areas [1]

Land Use Types Within Each Service Area			Currently Developed, Contributing Within Current Service Area	Vacant for Future Development, Not Currently Contributing, or Outside Service Area	Future Re-Development [2]	Open Space and Parks (not sewered)	Total at Buildout
Service Area	***Land Use Type***	***Description***	***Area (Acres)***	***Area (Acres)***	***Area (Acres)***	***Area (Acres)***	***Area (Acres)***
City Sewer System Areas							
CURRENT SERVICE AREA (including Bolsa Knolls Special Assessment District)	OS	Open Space (including Carr Lake agricultural area)	-	-	-	755	755
	P	Parks	-	-	-	644	644
	C	Commercial	1,426	122	(216)	-	1,332
	I	Industrial	1,238	120	(32)	-	1,326
	MU	Mixed Use	-	23	227	-	250
	PS	Public/Semipublic	1,829	436	5	-	2,270
	RH	Residential - High Density	743	22	27	-	792
	RL	Residential - Low Density	3,615	45	(11)	-	3,649
	RM	Residential - Medium Density	1,270	21	-	-	1,292
		Total - Current Service Area	*10,122*	*789*	*0*	*1,399*	*12,310*
ALL FUTURE GROWTH AREAS (Including Future Industrial Area)	OS	Open Space[1]	-	-	-	441	441
	P	Parks	-	-	-	283	283
	C	Commercial	-	101	-	-	101
	I	Industrial	-	1,058	-	-	1,058
	MU	Mixed Use	-	104	-	-	104
	PS	Public/Semipublic	-	255	-	-	255
	RH	Residential - High Density	-	187	-	-	187
	RL	Residential - Low Density	-	836	-	-	836
	RM	Residential - Medium Density	-	666	-	-	666
		Total - Future Growth Areas	*0*	*3,208*	*0*	*724*	*3,932*
Subtotal - City Sewer System Areas			**10,122**	**3,997**	**0**	**2,123**	**16,242**

Table 2-3
Land Use Acreages for Master Plan Areas (1)

Land Use Types Within Each Service Area			Currently Developed, Contributing Within Current Service Area	Vacant for Future Development, Not Currently Contributing, or Outside Service Area	Future Re-Development (2)	Open Space and Parks (not sewered)	Total at Buildout
Service Area	**Land Use Type**	**Description**	**Area (Acres)**	**Area (Acres)**	**Area (Acres)**	**Area (Acres)**	**Area (Acres)**
Outside City Areas							
COUNTY BORONDA AREA	OS	Open Space	-	-	-	-	-
	P	Parks	-	-	-	-	-
	C	Commercial	-	8	-	-	8
	I	Industrial	-	-	-	-	-
	MU	Mixed Use	-	-	-	-	-
	PS	Public/Semipublic	-	8	-	-	8
	RH	Residential - High Density	-	-	-	-	-
	RL	Residential - Low Density	-	-	-	-	-
	RM	Residential - Medium Density	-	114	-	-	114
		Total - County Boronda Area	*0*	*130*	*0*	*0*	*130*
BOLSA KNOLLS (Outside City's Special Assessment District)	OS	Open Space	-	-	-	-	-
	P	Parks	-	-	-	-	-
	C	Commercial	-	-	-	-	-
	I	Industrial	-	-	-	-	-
	MU	Mixed Use	-	-	-	-	-
	PS	Public/Semipublic	-	2	-	-	2
	RH	Residential - High Density	-	-	-	-	-
	RL	Residential - Low Density	-	2	-	-	2
	RM	Residential - Medium Density	-	130	-	-	130
		Total - Bolsa Knolls	*0*	*134*	*0*	*0*	*134*
Subtotal - Outside Areas			***0***	***264***	***0***	***0***	***264***
GRAND TOTAL - City System Areas and Outside Areas			**10,122**	**4,261**	**0**	**2,123**	**16,506**

(1) Land areas are in gross acres.

(2) Some existing developed parcels in the current service area will be redeveloped in the future. The redevelopment areas primarily allow mixed use (commercial/industrial plus residential) or in some cases shift from low density to high density residential.

Section 3
Existing Sanitary Sewer System

This section provides an overview of the existing sanitary sewer system, and describes the hydraulic model developed for the sewer system.

3.1 Overview of Existing System

The Salinas Sanitary Sewer System comprises approximately 289 miles of sewer pipe, 11 pump stations, and 7 flow split structures. Flow in the City system is primarily by gravity, with low-head pump stations located at low spots due to the City's flat topography.

Figure 3-1 provides an overview of the City's existing sanitary sewer collection system. The figure shows the sewer network, the main trunks, and other system facilities such as sewer lift stations and flow splits (diversions). The main system facilities are summarized herein.

3.1.1 MRWPCA Salinas Pump Station

All sanitary wastewater collected by the City's system flows to the MRWPCA's Salinas Pump Station located at the southwestern boundary of the City. The MRWPCA is a regional authority that owns and operates the regional wastewater treatment facility serving the City and other member agencies in the Monterey vicinity. MRWPCA's Salinas Pump Station conveys sanitary wastewater discharges to the regional treatment facility via a MRWPCA force main.

This master plan does not include evaluation of the MRWPCA Salinas Pump Station or conveyance to the regional treatment facility. MRWPCA is conducting its own study of the Salinas Pump Station capacity and ability to meet existing and future needs. According to MRWPCA, the existing pump station capacity ranges from 32.8 to 35.4 million gallons per day (mgd(with 3 pumps operating; and from 35.2 to 38.5 mgd with all 4 pumps operating.

3.1.2 Salinas Sanitary Sewer Collection System

The City owns and operates the wastewater collection system within its service area. The City's collection system has about 289 miles of sewer pipe ranging in size from 6 inches to 72 inches in diameter. Table 3-1 summarizes the pipeline lengths by diameter. Figure 3-2 shows the distribution by diameter.

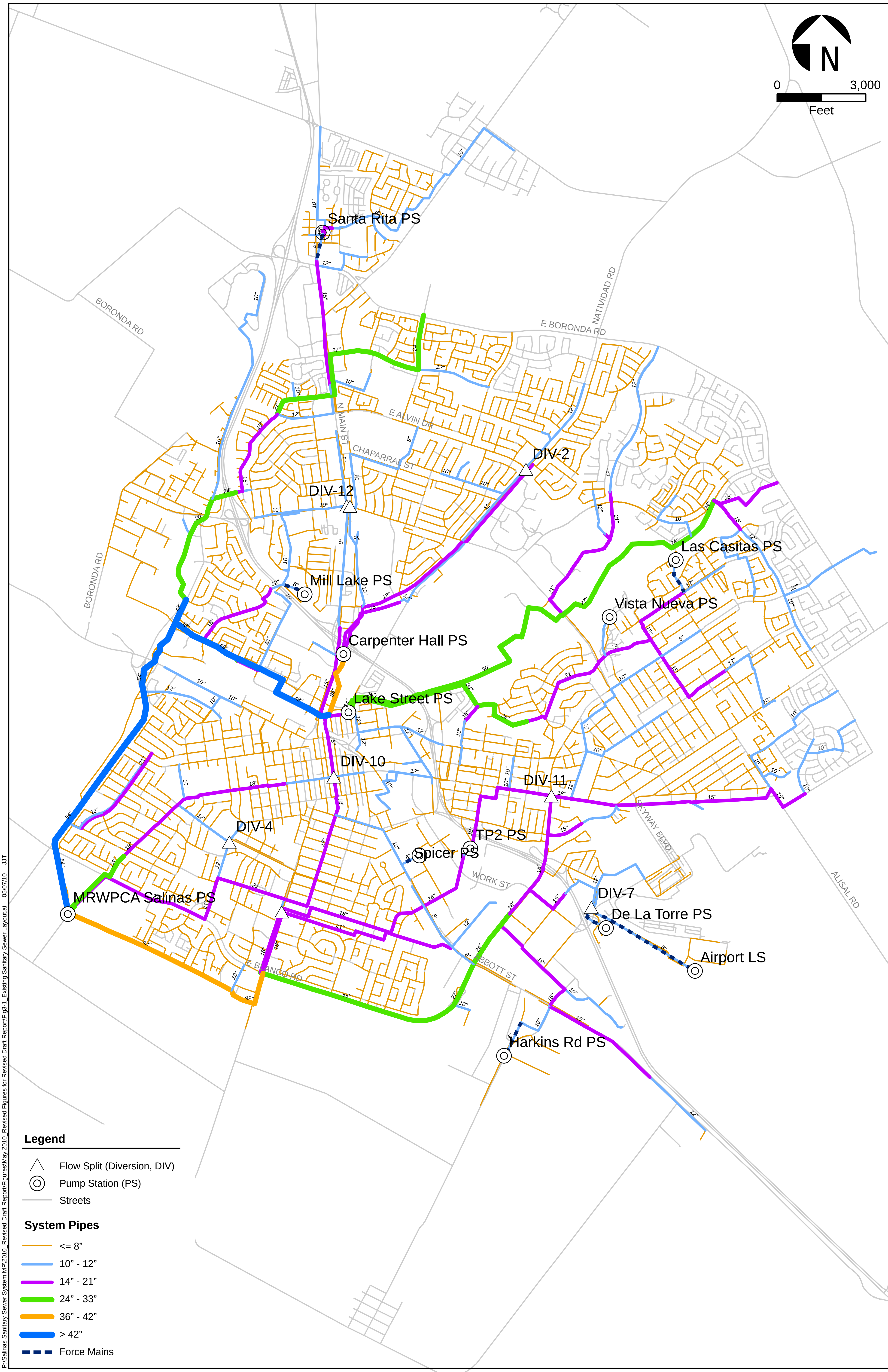

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Figure 3-1
Existing Sanitary Sewer System Layout
Salinas Sewer System Master Plan

Table 3-1
Salinas Sanitary Sewer System –
Existing Gravity Sewers

Diameter (inches)	*Length (miles)*	*% in System*
< 8	212.0	73%
10	24.2	8%
12	13.2	5%
15	9.7	3%
18	9.2	3%
21	5.4	2%
24	3.8	1%
27	2.2	1%
30	2.5	1%
33	1.2	0%
36	0.4	0%
42	1.5	1%
48	1.4	0%
54	2.1	1%
66	0.02	0.01%
72	0.03	0.01%
Total	289.0	

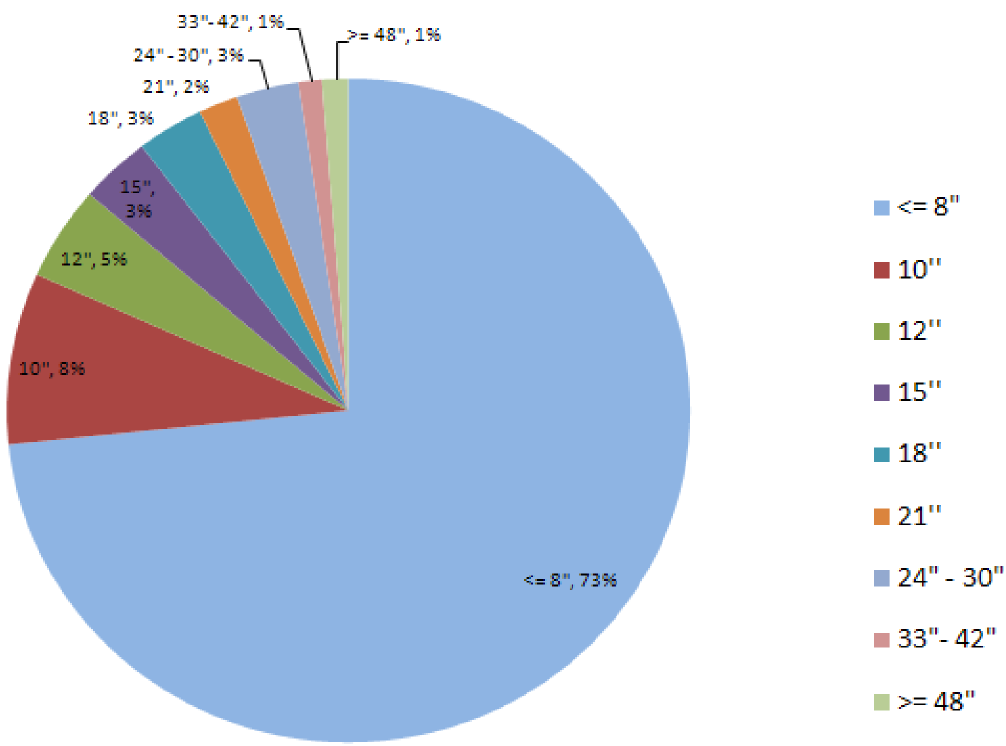

Figure 3-2
Sanitary Sewer System
Pipe Length by Diameter

The City has made extensive efforts over the past years to identify and correct collection system deficiencies that may result in system overflow. Based on the 1998 Master Plan recommendations, the City implemented significant sewer improvements to both replace poor condition sewers and increase capacity of those sewers. Since 1999, the City has implemented $30 million of sewer system improvement projects involving replacement or rehabilitation of about 69,000 feet of major sewers greater than 10-inches diameter and pump station improvements.

A separate City industrial wastewater system serves some industries in the southeastern portion of the City. This master plan does not include the industrial wastewater system; and industrial wastewater facilities are not shown on Figure 3-1.

3.1.3 Pump Stations

The City's collection system has 11 pump stations, as shown on Figure 3-1. Seven of the pump stations (the larger stations) have permanent backup power generators. The City also maintains 5 portable towable diesel powered generators to provide emergency power to stations not equipped with permanent on-site electrical generators. Table 3-2 presents the hydraulic information for the pump stations in the Salinas Sanitary Sewer System.

In all cases, the pump stations and associated force mains convey wastewater a short distance prior to it entering a gravity sewer for continued conveyance to the Salinas Pump Station. The two largest stations, Lake Street Station and Carpenter Hall Station, lift flows from the north at approximately the location of the Carr Lake low point in the center of the City, for continued gravity flow to the southwest. The third largest station, Santa Rita Station, lifts wastewater flows from the northwestern part of the City for continued gravity conveyance south. The remaining lift stations are much smaller and serve localized low areas.

3.1.4 Flow Splits

The City's collection system has 7 major flow splits (diversions). The location and available hydraulic information for these structures is summarized in Table 3-3. The flow splits are shown in Figure 3-1.

Table 3-2
Salinas Sanitary Sewer System - Pump Stations

Pump Station Name	***Number of Pumps***	***HP per Pump***	***Type (Speed)***	***Capacity per Pump (gallons per minute)***	***Wet Well Dimensions (feet)***			***Pump Level Settings (on/off levels for pump operation)***
					Diameter or Width (feet)	***Length, if applicable (feet)***	***Depth from Bottom to Maximum Level (feet)***	
Airport (Moffett)	2	10	Constant	550	8	NA	16	60% / 0%
Carpenter Hall	2	30	Variable	2,250	8	NA	16	7.0 / 4.0
De La Torre	2	5	Constant	200	4	NA	11	3.5 / 1.5
Harkins Road	2	5	Constant	350	4	NA	12	2.5 / 1.5
Lake Street	3	30	Variable	2,850	5.3	24.7	25	3.5 / 2.8
Las Casitas	2	10	Constant	150	4	NA	20	3.5 / 1.6
Mill Lake	2	15	Constant	500	4	NA	16	3.0 / 1.5
Santa Rita	2	30	Constant	1,530	8	NA	16	6.5 / 4.0
Spicer	2	7.5	Constant	400	4	NA	21	3.7 / 2.0
TP2	2	10	Variable	400	6	NA	21	3.4 / 1.5
Vista Nueva	2	7.5	Constant	175	6	NA	13	60% / 0%

Source: City of Salinas

Table 3-3
Salinas Sanitary Sewer System – Flow Splits

Flow Split ID [(1)]	***Location***	***Main Flow Pipe Diameter (inches)***	***Main Flow Pipe Invert Elevation (feet)***	***Overflow Pipe Diameter (inches)***	***Overflow Pipe Invert Elevation (feet)***	***Description***
DIV-02	Natividad Rd and E Alvin Dr	15	73.8	12	73.8	Parallel overflow
DIV-04	College Dr and Iverson St	12	37.4	12	37.9	Overflow along Iverson St
DIV-05	Main St, between Orange Dr and Katherine Ave	18	35.3	18	35.6	Overflow directed north along Main St
DIV-07	Carol Dr, East of Hwy 101, downstream of De La Torre PS	10	54.9	10	56	Parallel overflow
DIV-10	Alisal St and Pajaro St	18	42.0	10	42.3	Overflow along Alisal St
DIV-11	N Sanborn Rd and E Alisal St	18	60.8	15	61.7	Overflow along Alisal St
DIV-12	E Laurel Dr, between Main St and Noice Dr	8	64.0	8	66.7	Overflow on line parallel to Main St, directed south

(1) Flow Split ID used in hydraulic model.

3.2 Sewer System Hydraulic Model

As part of the master plan, an updated hydraulic model of the City's sanitary sewer system has been developed and used for the sewer system analyses. The hydraulic model includes existing system facilities, and proposed major sewers to serve the Future Growth Areas.

Figure 3-3 shows the modeled sewer system facilities overlain on an aerial photograph. The model simulates a skeletonized system with all the major trunk sewers, 10-inch diameter pipes and larger, as well as all 11 pump stations and associated force mains. Some smaller diameter lines were also included if needed to keep the topology of the main trunk system or to keep the tributary areas at a reasonable size. The model includes about 83 miles of pipelines. The locations of the facilities are at a planning-level of detail consistent with the model accuracy.

Below is a summary overview of the model software, the modeled system network, and the modeled subareas.

3.2.1 Model Software

The City's previous sanitary sewer model was developed in Pizer's HYDRA software, as part of the Salinas Sewer Collection Master Study in 1998. As part of this master plan, CDM evaluated several model software packages, as described in Appendix A. Based on the evaluation results and model demonstrations, the City selected InfoSewer as the model software for this master plan.

The City's HYDRA model network was initially converted to InfoSewer by MWHSoft by transferring pipes, manholes, and modeled pump stations along with their attributes. The converted model was reviewed by CDM to identify missing data and resolve apparent inconsistencies in pipe slopes, diameters, and diversion structure configuration. Other than missing or inconsistent data, the data in the previous model for existing sewers (locations, sizes, inverts) was assumed accurate and not verified.

The original HYDRA model had no known coordinate system or known projection, i.e., was not geo-referenced to any real coordinate system. The City's GIS parcel map and 2002 aerial photos are geo-referenced to the State Plane coordinate system (in feet) with NAD83 projection. Using these layers as a background, necessary adjustments were made to the sewer system layout in the converted model to follow the street alignments. With these adjustments, the converted model facilities are approximately geo-referenced to the same State Plane coordinate system as the City's GIS.

The model facilities are in a GIS database, ESRI Arc-GIS, which is the same as the City's GIS. The locations of the facilities are at a planning-level of detail consistent with the model accuracy. The GIS mapping shows sewers within the correct streets, but the locations within the street right-of-way is not accurate for design purposes.

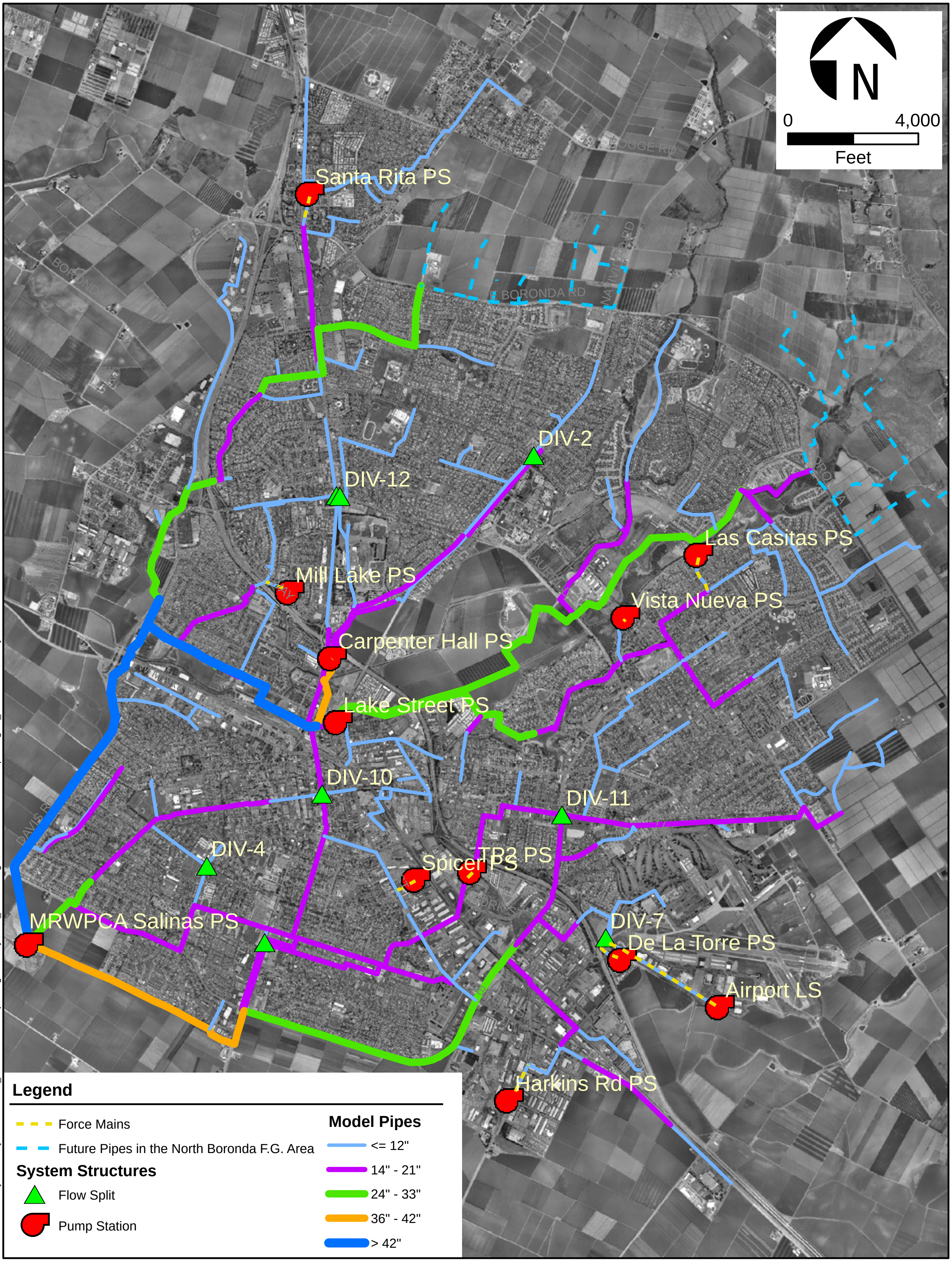

Figure 3-3
Modeled Sewer System Facilities
Salinas Sewer System Master Plan

Where there are parallel sewers within the same right-of-way, the sewer locations have been adjusted (separated) so that the two lines are legible at the map scale.

3.2.2 Model Network Update

The converted hydraulic model was updated to incorporate information provided by the City on recent improvements, and input from City staff to correct missing or inconsistent data in the previous model.

As-built drawings for the following projects were provided by the City: Independence Blvd Sewer Improvements; Boronda Crossing Place; E Blanco Road Trunk Line; Kipling Sewer Trunk Line Improvements; Salinas Auto Center Sewer Line; Davis Sewer Trunk Line Improvements (Direct Bury and Recondition Existing Main); West Rossi Street; Lake Street/Bridge Street Sewer Improvements; Monte Bella, Phases 1, 2, 2A, 3, and 4; California Rodeo Sports Complex Sewer Line; Alisal Outfall Connection; New line at Manchester Drive; and New line at Regency Circle.

Based on the above information, pipe diameter, pipe alignment, or inlet and outlet inverts were revised for various areas of the system. Future sewer alignments were obtained from the P&D Sewer Study for the North Boronda FGA. Slopes for future sewers were assumed based on minimum slope criteria.

The updated model includes all pump stations, in order to analyze the system more accurately. In the updated model, the pump stations are modeled as fixed capacity pumps.

The City also provided information about the location of flow splits (flow diversions) and its configuration. Based on field checking, some diversion locations in the previous model were eliminated and other locations were modified to reflect actual conditions.

3.2.3 Model Subareas

After updating the model network, the model tributary subareas were also updated. Each tributary subarea loads to a corresponding manhole in the modeled network. Figure 3-4 shows the updated model subareas and the corresponding loading manholes. The load point (manhole) was selected based on where most of the flow from each subarea enters the sewer system.

For the subarea update, first the subarea layer from the previous HYDRA model was imported into InfoSewer. Then the subareas were shifted as needed to overlay the City’s georeferenced GIS parcel layer and 2002 aerial photo, and be consisted with the updated sewer system map. This information was used as the starting point for the subarea update.

For existing developed areas, subarea boundaries were checked against existing sewer pipe layouts and modified as needed. Future subarea boundaries were checked and

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Figure 3-4
Hydraulic Model Subareas
Salinas Sewer System Master Plan

modified based on anticipated flow directions, using a 2-foot elevation contour map that was provided by the City. The layout of sewers in the North Boronda FGA as proposed by P&D was used to delineate the boundaries of those tributary subareas.

Section 4
Wastewater Flow Projections

This section summarizes the system-wide wastewater flow projections for existing and future conditions and the key findings of the dry weather and wet weather flow analyses. The estimated peak design flows are used in Section 6 for the hydraulic analysis. Appendix B contains a detailed discussion of the development of the flow projections.

4.1 Summary of System-Wide Flow Projections

Table 4-1 summarizes the system-wide flow projections for existing and buildout conditions. This section then provides a detailed description of the development of the flow projections.

System-wide flows are shown in Table 4-1 for the following:

- Dry weather flows calculated using unit flow factors developed from dry weather flow meter data. These unit flow factors were applied to the contributing land uses described in Section 2, in order to estimate existing and future dry weather flows. The unit flow factors for all land use types, other than industrial, are the same for existing and future areas. For future industrial areas, a higher unit flow factor is used for future areas to account for more intensive future industrial development than indicated by the existing industrial development. The average dry weather flow is assumed to include the groundwater infiltration component. Peak dry weather flow was determined using a peaking curve.

- Peak rainfall-dependent inflow and infiltration (RDII) flows for the 5-year, 6-hour design storm and the 10-year, 6-hour design storm. To estimate the wet weather RDII peak flows, wet weather flow parameters were developed, and then applied to a design storm to determine the peak RDII unit flow rates. Various RDII peak unit flow rates were developed for various areas of the City based on the flow meter data. As discussed in Section 6, a sensitivity analysis of the 5-year and 10-year design storm was conducted as part of the hydraulic analysis to determine the recommended design storm; the 10-year storm was selected for the master plan.

- Total wet weather peak flows consisting of the average dry weather base flow plus the RDII component. The peak design flows for the master plan analysis are the higher of the peak dry weather flow or the peak wet weather flow calculated as the average dry weather base flow plus the peak RDII flow. It is overly conservative to estimate peak wet weather flows as the sum of the peak dry weather base flow plus the peak RDII.

The flow projections in Table 4-1 and discussed in Section 4 are the base case for the planned future service area identified in Section 2. In addition, as discussed in Section 6, a sensitivity analysis was conducted to determine the impact of potential future flows from an area north of the future North Boronda FGA that is outside the current master plan study area. The maximum buildout flow for sensitivity analysis shown in the last column of Table 4-1 includes these additional flows.

Table 4-1
Summary of System-Wide Wastewater Flow Projections

Condition	*Existing Flow (mgd)*	*Buildout Flow* [2] *(mgd)*	*Maximum Buildout Flow - Sensitivity Analysis* [3] *(mgd)*
Dry Weather Flows			
Average Dry Weather Flow (Base Wastewater Flow)	14.4	21.7	22.1
Peak Dry at 1.6 times average for existing and 1.55 times average for buildout (from peaking curve).	23.0	33.6	34.2
RDII Peak Flow Component			
5-Year, 6-Hour Design Storm	14.2	18.0	20.0
10-Year, 6-Hour Design Storm (selected design storm) [1]	17.8	22.4	24.9
Total Peak Weather Flows			
Average Dry Weather plus RDII for 5-Year, 6-Hour Design Storm	28.6	39.7	42.1
Average Dry Weather plus RDII for 10-Year, 6-Hour Design Storm (selected design storm) [1]	32.2	44.1	47.0

(1) The 10-year design storm was selected for evaluation of existing system and sizing of improvements based on sensitivity analysis discussed in Section 6.

(2) The buildout flow projections discussed in Section 4 are the base case, based on flow factors derived from existing meter data. The unit flow factors for all land use types, other than industrial, are the same for existing and future areas. For existing industrial areas, the existing unit flow factor is 500 gallons per day per acre (gpd/acre). For incremental future industrial areas, a higher unit flow factor of 2,000 gpd/acre is used to account for more intensive future industrial development than indicated by the existing industrial development.

(3) The maximum buildout flow shown in the last column of Table 4-1 is based on sensitivity analyses discussed in Section 6 that investigated the potential impacts of potential future flows from an area north of the North Boronda FGA that is outside the current master plan study area. The additional flows due to this assumption are: 0.4 mgd average dry weather; 0.6 mgd peak dry weather; 2.5 mgd 10-year, 6-hour RDII; and 2.9 mgd total peak weather flow (average dry plus 10-year RDII).

As discussed in Appendix B, the flow projections have been developed using a land use based approach, using unit flow factors developed from City meter data. In Appendix B, the existing flow projections were compared with historic flow data from the MRWPCA Salinas Pump Station. Due to flow metering inaccuracies (flattening at high flow rates) at the Salinas Pump Station meter, it is recommended the City conduct its own metering of flows to the station in the future.

4.2 Wastewater Flow Components

The three main wastewater flow components are described below. Figure 4-1 shows a generic schematic of the wastewater flow components (not specific to Salinas system).

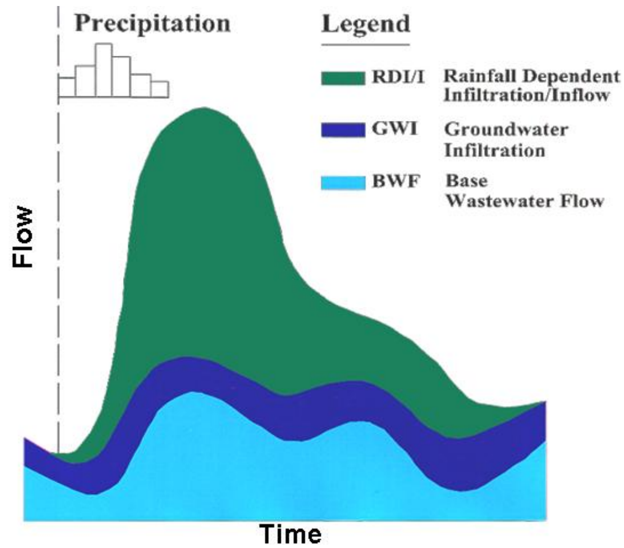

Figure 4-1
Generic Schematic of Wastewater Flow Components

Base Wastewater Flow is domestic wastewater from residential, commercial, and institutional (e.g., schools, churches, hospitals) sources, plus industrial wastewater that is not discharged to the City's separate Industrial Waste System. It is affected by the population and land uses in an area, and varies throughout the day in response to personal habits and business operations. Base wastewater flow is the primary component of dry weather flow.

Groundwater Infiltration (GWI) is defined as groundwater entering the collection system that is not related to a specific rain event. GWI occurs when groundwater is above the sewer pipe invert and infiltrates through defective pipes, pipe joints, and manhole walls. The magnitude of the groundwater infiltration depends on the depth of the groundwater table above the pipelines, the percentage of the system that is submerged and the physical condition of the system. GWI is seasonal and typically declines during dry weather periods as groundwater levels drop.

Rainfall-Dependent Infiltration/Inflow (RDII) is stormwater that enters the collection and trunk sewer system in direct response to the intensity and duration of individual rainfall events. RDII is comprised of storm water inflow and rainfall-dependent infiltration. Stormwater inflow reaches the collection system by direct connections rather than by first percolating through the soil. Stormwater inflow sources may include roof downspouts illegally connected to the sanitary sewers, yard and area drains, holes in manhole covers, or cross-connections with storm drains or catch basins. Rainfall-dependent infiltration includes all other rainfall-dependent flow that enters the collection system, including stormwater that enters defective pipes, pipe joints, and manhole walls after percolating through the soil.

4.3 Rainfall and Flow Meter Data

Rainfall and flow data was metered by the City at sixteen locations throughout the sanitary sewer collection system. Data was collected for the following periods: winter 2007 (January through April 2007); summer 2007 (July through September 2007), and winter 2008 (January through March 2008 at all sixteen locations, and re-monitoring of three locations in April 2008).

The City's meters covered an area of approximately 12,589 acres, 76% the total service area (16,640 acres). Out of the total area, 8,383 acres are contributing to the sewer system; the rest are parks, open space, or undeveloped. About 67% of the contributing area is from residential land uses.

Figure 4-2 shows the location of the meters and the discrete contributing area for each meter. The metered data was used in developing dry and wet weather unit flow and peaking factors, as discussed in the remainder of this section.

4.4 Dry Weather Flow Analysis Summary

This section summarizes the key findings of the dry weather flow analysis. Appendix B provides detailed information on the development of the dry weather flow factors.

Dry weather flows are comprised of the following two components:

- Base wastewater flow from customers. The base wastewater flow is estimated by applying a unit flow factor for each contributing land use type based on acreage, in order to calculate a contributing flow for each land use type. The total base flow is the sum of all the contributing land use types.
- GWI during dry weather. The regional groundwater table in Salinas is fairly deep, about 40 feet or more deep below top of ground; therefore, groundwater infiltration is not expected to be significant. However, there may be localized areas of shallower or perched groundwater.

The base wastewater flow component was estimated using land use and unit flow factors. A unit flow factor is the average contribution of sewer flow per acre, expected from each land use type. The estimated unit flow factors were applied to existing and future land uses to generate existing and future flows.

Table 4-2 shows unit flow factors for each land use type that contributes base flows to the collection system. The unit flow factors are those that better fit the metered dry weather flow. Land uses assumed not to contribute base flows are not shown in Table 4-2, such as open space, undeveloped, parks, agricultural.

Table 4-3 shows the existing and future dry weather flows, the estimated flow for each contributing land use type based on acreages and unit flow factors, and the estimated total system-wide flow from all contributing areas. The land use acreages for each land use type were obtained from the updated land use master shape file developed as part of the land use maps in Section 2.

As indicated in Table 4-3, the total system-wide flow is estimated at 14.4 mgd for existing land uses, and 21.7 mgd for buildout land uses.

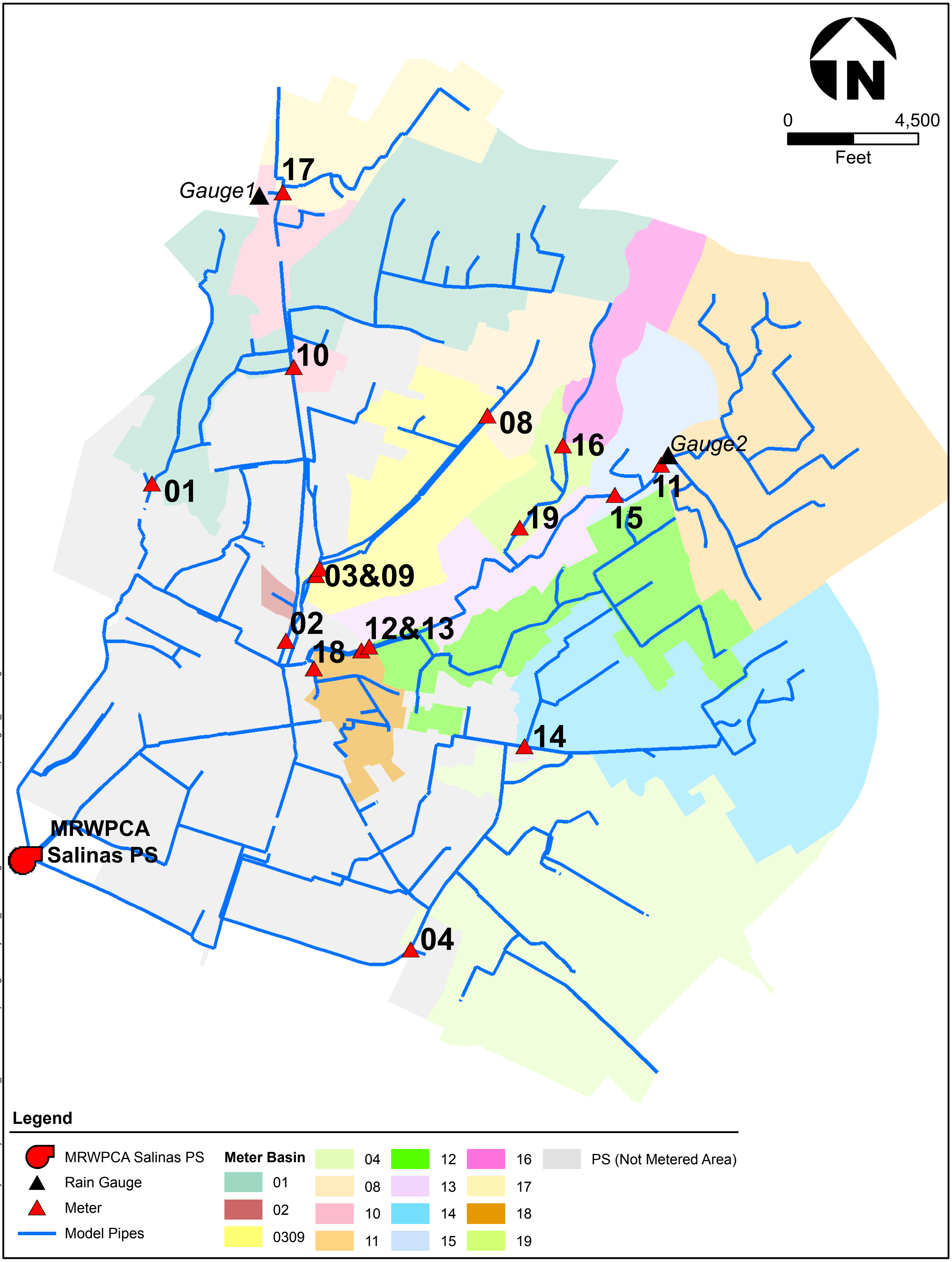

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Figure 4-2
Rain Gauge and Meter Locations
Salinas Sewer System Master Plan

Table 4-2
Average Dry Weather Unit Flow Factors

Land Use Type [1]	Unit Flow Rate (gpd/acre)
Commercial	1,200
Industrial	500 for existing conditions; 2,000 for future conditions [2]
Public/Semipublic	1,000
Residential - High Density	3,500
Residential - Low Density	1,400
Residential - Medium Density	2,000

(1) Unsewered areas (agricultural, open space, parks, undeveloped) do not contribute base flow to the system, i.e., zero unit flow rates.

(2) For industrial areas, the existing unit flow factor based on the flow metering data is 500 gpd/acre. For future industrial areas, a higher factor of 2,000 gpd/acre is recommended to account for more intensive industrial development in the future.

Table 4-3
Estimated Dry Weather Flows for Existing and Future Conditions Using Average Dry Weather Unit Flow Factors

Land Use Type	Description	Existing Contributing Sewered Areas [1] (acres)	Incremental Future Contributing Sewered Areas [1] (acres)	Existing Unit Flow Rate (gpd/acre)	Existing Flow (mgd)	Future Unit Flow Rate for Incremental Future Areas (gpd/acre)	Future Flow (mgd)
C and MU	Commercial and Mixed Use (mixed commercial and residential) [2]	1,427	369	1,200	1.7	1,200	2.2
I	Industrial	1,238	1,146	500	0.6	2,000	2.9
PS	Public/Semipublic	1,829	706	1,000	1.8	1,000	2.5
RH	Residential - High Density	743	236	3,500	2.6	3,500	3.4
RL	Residential - Low Density	3,615	872	1,400	5.1	1,400	6.3
RM	Residential - Medium Density	1,270	932	2,000	2.5	2,000	4.4
TOTAL FOR ALL CONTRIBUTING AREAS		**10,122**	**4,261**		**14.4**		**21.7**

(1) Areas are gross sewered acres (including roads/streets in contributing sewered areas). The contributing sewered areas do not include unsewered areas such parks, open spaces, or undeveloped parcels.

(2) Some existing commercial properties are redeveloped as future mixed use (total 354 acres mixed use at buildout). Flows for the mixed use areas estimated as commercial flow using unit flow rate per acre plus additional residential flows at 210 gpd per unit.

The dry weather (base flow) varies throughout the day in response to the personal habits of the general population and special events. Dry weather peaking factors are used to determine the peak design base flow.

Figure 4-3 shows the peaking factor curve for the Salinas sewer system, developed using the available meter data. For the master plan, the peaking curve in Figure 4-3 is used to estimate peak dry weather flows in the model, with a maximum value of 2.5, and a minimum value of 1.5. As indicated by the curve, portions of the system conveying smaller flows (i.e., with smaller tributary areas) are subject to higher peaking factors than portions of the system conveying larger flows (i.e., larger tributary areas).

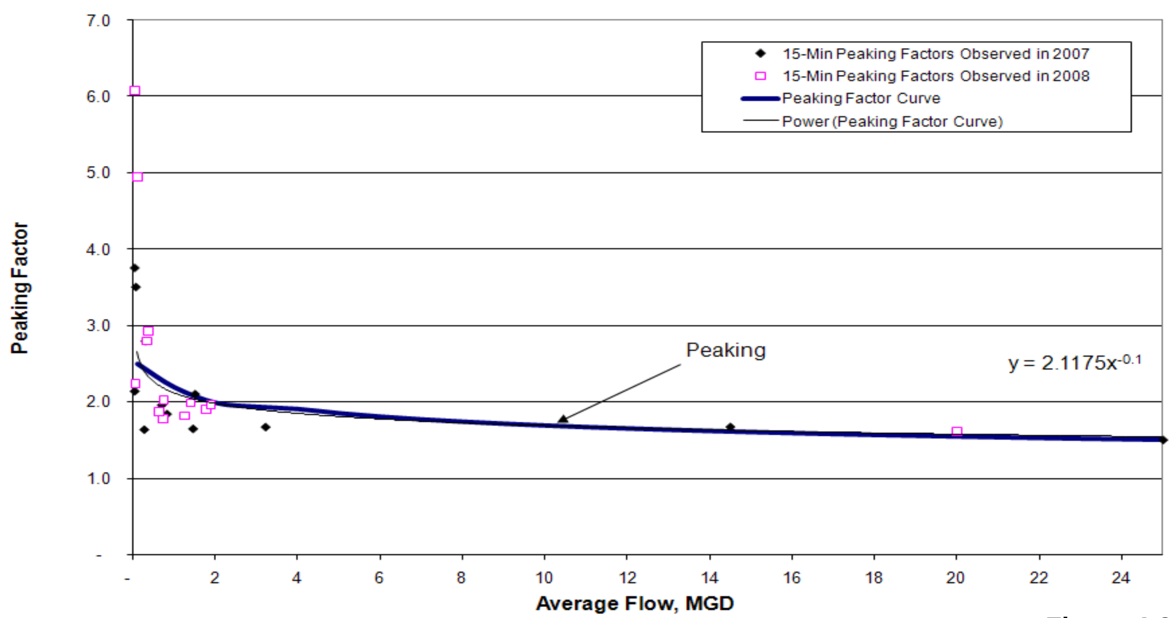


Figure 4-3
Dry Weather Peaking Curve

4.5 Wet Weather Flow Estimation Summary

This section summarizes the key findings of the wet weather flow analysis. Appendix B provides detailed information on the development of the wet weather flow factors.

The RDII (wet weather) flow portion of the wastewater flow is generated by storm events. For system analysis, the system must be able to collect and convey the peak RDII flow generated by a design storm event, in addition to the average dry weather flow. The available meter data was used to determine wet weather parameters for each metered basin. These parameters were then applied to selected storm events to compute the corresponding expected peak flows.

Tables 4-4 and 4-5 show the peak RDII factors for the 5-year, 6-hour storm and the 10-year, 6-hour storm respectively. Figure 4-4 shows the existing peak RDII factors for both design storms for the various areas in the system. For the existing sewered areas in the system that were not metered, a system-wide average rate is recommended: 1,600 gpapd for the 5-year, 6-hour storm and 2,000 gpapd for the 10-year, 6-hour storm.

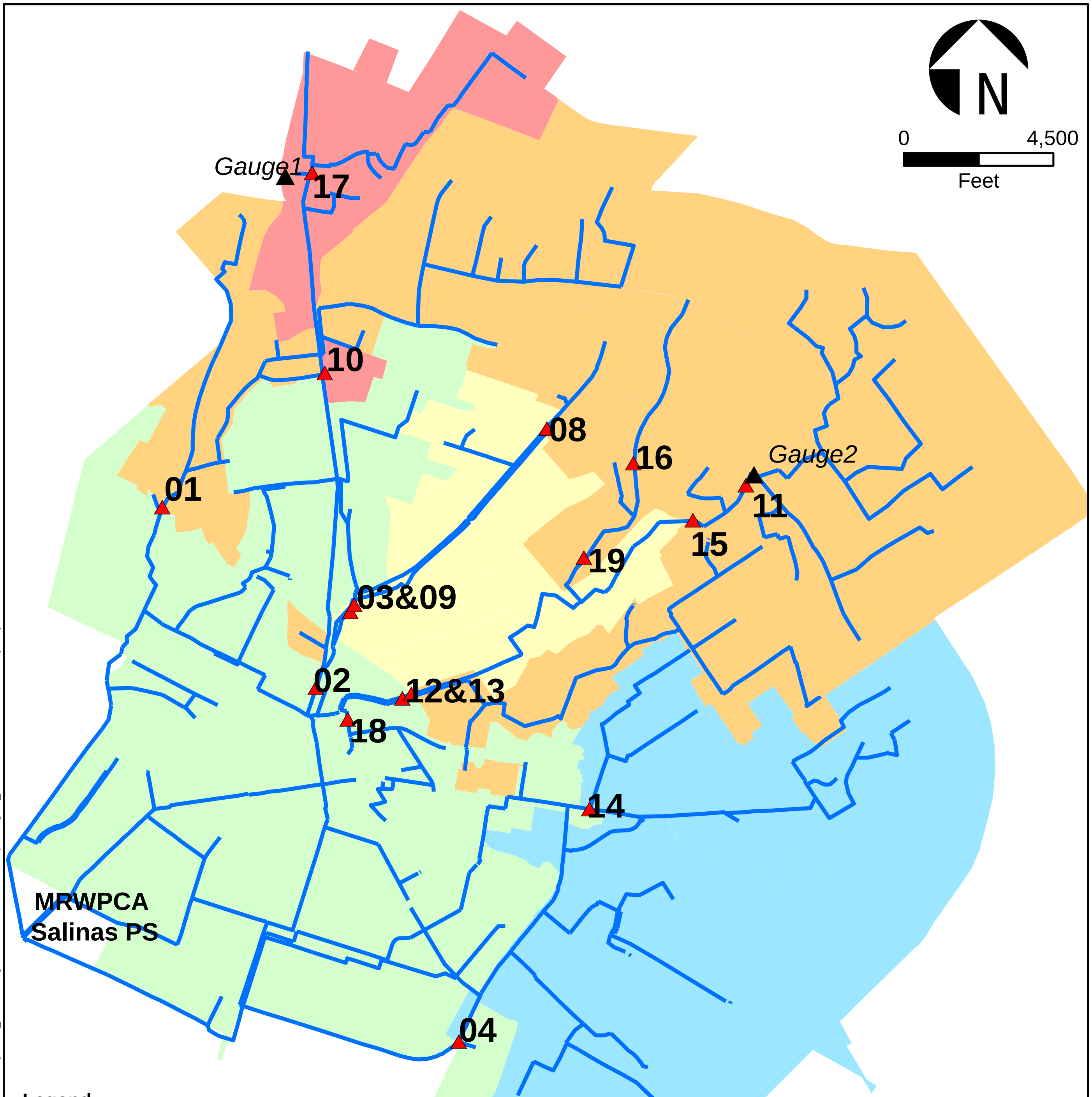
For new pipes in new development areas, it would be expected to have lower rates, on the order of 900 gpd/acre for the 5-year design storm and 1,100 gpd/acre for the 10-year design storm, for very tight plastic systems. These lower rates were used for the incremental future growth areas. A minimum peak RDII flow of 500 gpd/acre is recommended for any area, e.g., for areas where existing peak RDII flow is lower.

The RDII unit flow rates are applied only to the contributing sewered area, i.e., the area within the tributary drainage area that generates sewer flows. The RDII flows do not include unsewered areas such as open space, agricultural or parks.

To determine the peak wet weather flows for the master plan analysis, the RDII peak flow is added to the average dry weather flow. For the 5 year, 6-hour design storm, the total existing RDII peak flow for the entire system is 14.2 mgd, and the total buildout RDII peak flow is 18.07 mgd. For the 10-year, 6-hour design storm, the total existing RDII peak flow for the entire system is 17.8 mgd, and the total buildout RDII peak flow is 22.4 mgd.

For meter basins 11, 15, and 16, the recommended unit flow rate is lower than calculated at Meter 13 (downstream meter), because these areas are recently developed or currently vacant.

The peak design flows for the master plan analysis were loaded to the hydraulic model subareas and corresponding loading manholes described in Section 3. The procedure to calculate the flows per subarea is described in Appendix B.



Legend

		5yr-6hr Storm	10yr-6hr Storm
▲	Rain Gauge	Existing Peak RDII Unit Flow	Existing Peak RDII Unit Flow
▲	Meter	500 gpapd	600 gpapd
—	Model Pipes	600 - 900 gpapd	700 - 1,200 gpapd
		1,200 - 1,600 gpapd	1,600 - 2,000 gpapd
		1,700 - 1,800 gpapd	2,200 - 2,400 gpapd
		2,200 - 2,300 gpapd	2,900 - 3,000 gpapd

All Incremental Future Developed Areas:

- 5yr-6hr Storm
- Peak RDII Unit Flow: 900 gpapd

- 10yr-6hr Storm
- Peak RDII Unit Flow:1,100 gpapd

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Figure 4-4

Recommended Peak RDII Unit Flow Factors
for 5-Year and 10-Year Design Storms

Table 4-4
Peak RDII Unit Rates and Flow Estimates for 5-year, 6-hour Design Storm

Meter Basin	Existing Peak RDII Flow			Incremental Future Peak RDII Flow			Total Buildout Peak RDII Flow	
	Existing Sewered Area[(1)] (acres)	Recommended Existing Peak RDII Unit Flow (gpd/acre)	Existing Peak RDII Flow[(2)] (mgd)	Incremental Future Sewered Area (acres)	Recommended Future Peak RDII Unit Flow (gpd/acre)	Incremental Future Peak RDII Flow[(3)] (mgd)	Total Buildout Sewered Area (acres)	Total Buildout Peak RDII Flow[(4)] (mgd)
1	800	900	0.72	820	900	0.74	1,620	1.46
2	26	900	0.02	4	900	0.00	30	0.02
03 & 09	1,016	2,300	2.34	8	900	0.01	1,024	2.35
4	1,391	1,700	2.36	785	900	0.71	2,176	3.07
8	338	600	0.2	4	600	0.00	342	0.20
10	297	500	0.15	2	500	0.00	299	0.15
11	363	900	0.33	1,035	900	0.93	1,398	1.26
12	774	900	0.7	27	900	0.02	801	0.72
13	50	2,200	0.11	4	900	0.00	54	0.11
14	752	1,800	1.35	615	900	0.55	1,367	1.90
15	283	900	0.25	7	900	0.01	290	0.26
16	149	900	0.13	140	900	0.13	289	0.26
17	538	500	0.27	44	500	0.02	582	0.29
18	231	1,600	0.37	4	900	0.00	235	0.37
19	91	900	0.08	46	900	0.04	137	0.12
Not Metered Areas	3,023	1,600	4.84	716	900	0.64	3,739	5.48
Grand Total	**10,122**		**14.23**	**4,261**		**3.82**	**14,383**	**18.04**

(1) Sewered Area does not include Agriculture, Open Spaces, Parks, or Undeveloped land use areas. The sewered areas are gross acres including streets.
(2) Existing RDII peak flow equals the existing peak RDII unit flow times the exiting sewered area.
(3) Incremental RDII peak flow equals the future peak RDII unit flow times the incremental sewered area.
(4) Buildout RDII peak flow equals existing peak RDII flow plus incremental future peak RDII flow.

Table 4-5
Peak RDII Unit Rates and Flow Estimates for 10-year, 6-hour Design Storm

Meter Basin	Existing Peak RDII Flow: Existing Sewered Area [(1)] (acres)	Existing Peak RDII Flow: Recommended Existing Peak RDII Unit Flow (gpd/acre)	Existing Peak RDII Flow: Existing RDII Peak Flow [(2)] (mgd)	Incremental Future Peak RDII Flow: Incremental Future Sewered Area[(1)] (acres)	Incremental Future Peak RDII Flow: Recommended Future Peak RDII Unit Flow (gpd/acre)	Incremental Future Peak RDII Flow: Incremental Future Peak RDII Flow [(3)] (mgd)	Total Buildout Peak RDII Flow: Total Buildout Sewered Area[(1)] (acres)	Total Buildout Peak RDII Flow: Total Buildout RDII Peak Flow [(4)] (mgd)
1	800	1,200	0.96	820	1,100	0.90	1,620	1.86
2	26	1,200	0.03	4	1,100	0.00	30	0.03
03 & 09	1,016	3,000	3.05	8	1,100	0.01	1,024	3.06
4	1,391	2,100	2.92	785	1,100	0.86	2,176	3.78
8	338	700	0.24	4	700	0.00	342	0.24
10	297	500	0.15	2	500	0.00	299	0.15
11	363	1,200	0.44	1,035	1,100	1.14	1,398	1.58
12	774	1,100	0.85	27	1,100	0.03	801	0.88
13	50	2,900	0.15	4	1,100	0.00	54	0.15
14	752	2,100	1.58	615	1,100	0.68	1,367	2.26
15	283	1,200	0.34	7	1,100	0.01	290	0.35
16	149	1,200	0.18	140	1,100	0.15	289	0.33
17	538	500	0.27	44	500	0.02	582	0.29
18	231	2,000	0.46	4	1,100	0.00	235	0.46
19	91	1,100	0.1	46	1,100	0.05	137	0.15
Not Metered Areas	3,023	2,000	6.05	716	1,100	0.79	3,739	6.83
Grand Total	**10,748**		**17.75**	**4,261**		**4.66**	**14,383**	**22.41**

(1) Sewered Area does not include Agriculture, Open Spaces, Parks, or Undeveloped land use areas. The sewered areas are gross acres including streets.
(2) Existing RDII peak flow equals the existing peak RDII unit flow times the existing sewered area.
(3) Incremental RDII peak flow equals the future peak RDII unit flow times the incremental sewered area.
(4) Buildout RDII peak flow equals existing peak RDII flow plus incremental future peak RDII flow.

Section 5
Hydraulic Criteria

This section presents the hydraulic criteria used for the system analysis discussed in Section 6.

5.1 Summary of Hydraulic Criteria

Table 5-1 summarizes the hydraulic criteria for the analyses of the Salinas sewer system. Preliminary criteria discussed with the City have been revised based on City input. In Section 6, the hydraulic model results are compared to these criteria to identify capacity deficiencies and improvements.

The City prefers a conservative approach for determining required improvements and sizes of new facilities, due to uncertainties inherent in future planning. The marginal cost of upsizing a new pipe is generally small compared with the potential future cost if it is undersized. The criteria provide a conservative approach for analyzing pipe capacity with respect to the maximum allowable depth of flow.

Table 5-1
Summary of Criteria for Hydraulic Analysis

Element	***Recommended Value***
Manning's 'n' Factor (for gravity lines)	0.013 for all pipes
Minimum Pipe Size	8 inches
Maximum Allowable Flow Depth	Future pipes in new development areas: d/D = 0.75 under peak design flow conditions (10-year, 6-hour design storm). Existing pipes: d/D = 0.9 under peak design flow conditions (10-year, 6-hour design storm). For evaluating and prioritizing whether existing pipes require improvement, surcharge is allowed as long as the hydraulic gradeline (HGL) remains at least 5 feet below the rim elevation under peak design flow conditions. This criterion is only for evaluating whether existing pipes require replacement or relief. Sensitivity analysis is done for existing pipes to determine extent of required improvements to existing pipes and whether improvements are needed due to increase in future flows due to future growth. The more stringent criteria apply to improvements needed for future growth. The less stringent criteria apply to existing pipes not affected or negligibly affected by future growth. All new pipe improvements and replacement projects are sized to convey the peak design flow without any surcharge.
Velocity Criteria for Gravity Lines	<u>Minimum</u>: 2.0 feet per second (ft/sec) at peak dry weather flow; 1.75 ft/sec at average dry weather flow Note: The minimum velocity criteria are used for designing new pipe improvements. These criteria are not used for evaluating whether existing pipes require replacement. The key criterion for evaluating existing pipes is whether capacity is adequate to convey the peak design flow.
	<u>Maximum</u>: 8.0 ft/sec

Table 5-1
Summary of Criteria for Hydraulic Analysis

Element	Recommended Value
Minimum Slopes for Gravity Lines	6-inch diameter: 1% 8-inch diameter: 0.4% 10-inch diameter: 0.26% 12-inch and larger diameter: 0.2% Note: The minimum slope criteria are used for designing new pipe improvements. These criteria are not used for evaluating whether existing pipes require replacement. The key criterion for evaluating existing pipes is whether capacity is adequate to convey the peak design flow.
Force Main Hydraulic Criteria	Maximum velocity: 6 ft/sec for new pipes, 8 ft/sec for existing pipes Minimum velocity : 3.5 ft/sec Hazen-Williams Headloss Coefficient: range of C=100 to120 depending on pipe size, material, and age.
Pump Station Capacity	Firm Capacity, with largest pump as a standby unit, for peak design flows (peak wet weather flows).

Below is a discussion of each element including relevant standards, typical criteria used by other agencies, and recommended values. The hydraulic criteria consider the City of Salinas Standard Specifications, Design Standards and Standard Plans (2008 Edition) (referred to herein as Salinas Standards); and criteria used in previous City master plans and studies. The criteria also consider generally accepted industry standards, based on experience with similar projects.

5.2 Manning's 'n' Factor

Manning's 'n' roughness coefficient is the friction factor utilized in the Manning's Equation for gravity flow to describe the roughness of a particular pipe material or condition. Manning's 'n' value generally ranges from 0.01 for plastic pipe to 0.016 for unlined concrete pipe with vitrified clay pipe between the two values. The Salinas Standards state that a Manning's n of 0.013 must be used for Vitrified Clay Pipe.

For the hydraulic model and master plan, it is recommended that an 'n' value of 0.013 be used for all pipe materials. This design value is widely accepted in the industry and is a reasonably conservative value for planning purposes, since it accounts for aging and buildup of material inside pipes over time. Although the City is now using plastic pipe for its sewer system, there will be buildup of material inside the plastic pipes over time that will increase the Manning's 'n' coefficient over time.

5.3 Minimum Pipe Diameter for Gravity Sewers

The Salinas Standards indicate that no sewer mains less than 8-inch in diameter shall be used. This is also generally accepted as the industry standard. Under certain conditions, if approved by the City Engineer, 6-inch minimum pipe may be permitted if serving fewer than 10 homes; however, this situation is not applicable for the master plan level of analysis.

5.4 Maximum Allowable Flow Depth

The depth of flow in the pipe (d) relative to the pipe diameter (D) is a typically used parameter for evaluating capacity needs. For the master plan analysis, the following criteria are used:

- Pipe improvements for new development: Design peak flows to be conveyed with d/D = 0.75 under peak flow design conditions (10-year, 6-hour design storm for peak wet weather flow). This criterion is used for sizing all new improvements.
- Existing pipes: d/D = 0.9 under peak design flow conditions (10-year, 6-hour design storm), which is the depth of flow providing the maximum discharge rate for circular pipes. This criterion will be used for the initial identification of capacity deficiencies in the existing system. [Note: There is a lower discharge rate at d/D =1.0 (full pipe) due to friction losses, which is equivalent to the discharge rate at d/D = 0.82.]
- For evaluating and prioritizing whether existing pipes require improvement, surcharge is allowed as long as the HGL remains at least 5 feet below the rim elevation at the upstream manhole under peak design flow conditions. Under surcharged conditions, the pipe flows at greater than full pipe flow and the HGL is above the top of the pipe (pressurized flow). This criterion is only for evaluating whether existing pipes require replacement. All new pipe improvements and replacement projects are sized to convey the peak design flow without any surcharge.
- Sensitivity analysis is done for existing pipes to determine extent of required improvements to existing pipes and whether improvements are needed due to increases in future flows due to future growth. The more stringent criteria apply to improvements needed for future growth. The less stringent criteria apply to existing pipes not affected or negligibly affected by future growth.
- All new pipe improvements and replacement projects are sized to convey the peak design flow without any surcharge, at d/D = 0.75.

Salinas Standards specify that sewers be designed to discharge the expected peak flow when the pipe is running full. The previous Salinas Sanitary Sewer Collection Master Study (1998) used the following two criteria for determining whether pipes required replacement based on conveying the peak design flow: 1) d/D ratio of 0.9; and 2) HGL at least 5 feet below the rim elevation at the upstream manhole. Both of these criteria were required to be met before a pipe was replaced. Therefore, some surcharging of existing pipes was allowed if there was adequate depth of cover. New pipe improvements were sized to meet both criteria. These criteria are consistent with those used for the 1992 Salinas Sewage and Drainage Master Plan.

The North Boronda Future Growth Area Sewer System Study (P&D Consultants (2006) used the following criteria for sizing sewers: 1) 8-inch pipes at d/D of 0.5 for peak design flow conditions; and 2) 10-inch and greater pipes at d/D of 0.75 for peak design flow conditions.

Depending on the pipe size, the following three criteria concerning the allowable depth of flow are generally being used by sewer agencies in California:

- For smaller pipes, usually up to 10 or 12 inches in diameter, a depth of flow to pipe diameter (d/D) ratio of 0.5 to 0.75 is often used for the peak design flow. This lower (d/D) ratio is more conservative and used to help prevent flow blockages in smaller pipes due to debris and avoid potential backup into connected service laterals.
- Larger pipes of 12 or 15 inches and larger are generally designed to flow between d/D of 0.75 to d/D of 1.0 full at peak design flow conditions.
- In order to save costs, some agencies allow surcharging of large diameter gravity flow sewers under peak flows associated with infrequent (long return period) storm events.

5.5 Minimum Pipe Velocity

The Salinas Standards specify a minimum velocity of 2.0 ft/sec when the pipe is running full, and a minimum velocity of 1.75 ft/sec under average flow conditions. These criteria will be used for the master plan.

The minimum velocity criteria are used for designing new pipe improvements. These criteria are not used for determining whether existing pipes require replacement. The key criterion for evaluating existing pipes is whether capacity is adequate to convey the peak design flow. Existing pipes that have minimum velocities below the criteria can be flagged to provide information for City staff regarding pipelines that may require more monitoring or cleaning of solids deposition.

For municipal wastewater, 2 ft/sec has been commonly used as the minimum design velocity at full or half full pipe flow conditions, in order to minimize deposition of solids. When the sewers are less than half full, velocities will drop below 2 ft/sec, and some deposition of solids will occur. Re-suspension of solids occurs when the depth of sewage is greater than half full, and the velocity increases above 2 ft/sec until a maximum velocity is reached at approximately 94 percent of full pipe depth. From 94 percent depth to full pipe, the velocity decreases back to 2 ft/sec.

5.6 Maximum Pipe Velocity

The Salinas Standards specify a maximum velocity criterion of 8 ft/sec be used for gravity sewers. Excessive velocities due to steep pipe slopes may cause abrasion of the pipe material and have a hydraulic impact on the receiving system. Typically, the maximum velocity criterion used by various agencies ranges from 8 to 15 ft/sec.

5.7 Minimum Slope

The Salinas Standards specify the following minimum slopes for gravity sewers:

6-inch	Min. S = 1%
8-inch	Min. S = 0.4% (0.5% desired)
10-inch	Min. S = 0.26% (0.3% desired)
12-inch and larger	Min. S = 0.2%

The minimum slope criteria are used for designing new pipe improvements. These criteria are not used for evaluating whether existing pipes require replacement. The key criterion for evaluating existing pipes is whether capacity is adequate to convey the peak design flow.

5.8 Force Main Capacity

Various agencies use different design criteria for minimum and maximum velocities in force mains. The maximum velocity in a force main is usually determined by balancing a number of factors relating to the costs of facility improvements versus the cost of power usages (higher velocity results in higher head loss).

The design flow rate for sewer force mains, which is typically the peak wet weather flow at buildout, occurs infrequently. Therefore, it is generally cost effective to set the maximum velocity under peak design conditions at a relatively high velocity, since the daily peak flow rate is typically much lower and typical velocities will be less.

For the master plan, the following maximum velocity criteria are recommended for force mains under peak design flow conditions:

- 6 ft/sec for sizing new force mains
- 8 ft/sec for evaluating whether existing force mains may require improvement.

Pump stations may operate intermittently and the solids in the force mains can settle out during low flow periods as the wet well fills. To re-suspend the solids, a minimum velocity of 3.5 ft/sec for force mains is recommended for the master plan.

The Hazen-Williams formula is used for calculating the friction head loss of force mains. The Hazen-Williams roughness coefficient, C, varies with pipe material, velocity, size, and age. For this master plan, a roughness coefficient of C = 100 to 120 is proposed depending on pipe sizes and materials.

5.9 Pump Station Capacity

Pump stations should have firm capacity that matches or exceeds the peak design flows for current and future conditions. Firm capacity is defined as the capacity with the largest pump as a standby unit.

Section 6
Sewer System Analysis

This section presents the findings of the sewer system analysis to identify the need for additional system capacity under existing and future conditions.

The updated hydraulic model described in Section 3 and the flow projections developed in Section 4, were used to analyze existing and buildout conditions, to determine where the system is deficient and the need for system improvements. The hydraulic criteria in Section 5 were used for the evaluation. Section 7 presents the recommended improvements based on this analysis.

6.1 Collection System Analysis Approach

The collection system analysis included pipeline capacity evaluation, pumping capacity evaluation and force main capacity evaluation. The updated hydraulic model (described in Section 3) was used to perform simulations for existing and buildout conditions. Figure 6-1 shows the modeled collection system facilities.

The analysis assumes that all sanitary sewer flows will continue to be conveyed to the MRWPCA Salinas Pump Station for conveyance to the MRWPCA wastewater treatment plant, and that the Salinas Pump Station will be capable of conveying the flows reaching the plant. This master plan does not include analysis of improvements that may be required to MRWPCA facilities.

6.1.1 Model Scenarios

The Salinas collection system model was evaluated under various combinations (scenarios) of base flow (dry weather flow) and RDII flow (wet weather flow) under existing and buildout conditions. The base scenarios for determining the recommended improvements are summarized below. Some additional sensitivity analysis scenarios were also evaluated as discussed in Section 6.4.

- Existing Scenarios
  - Existing average dry weather conditions. Average dry weather flows estimated based on existing land use from Section 2 and dry weather unit flow factors from Section 4. Under existing conditions, all developed industrial uses have a 500 gpd/acre unit flow factor. Existing conditions include flows from developed lands within the existing City service area as shown in Section 2.
  - Existing peak dry weather conditions. The model uses the peaking curve in Section 4 and the average dry weather flows to simulate peak dry weather conditions.

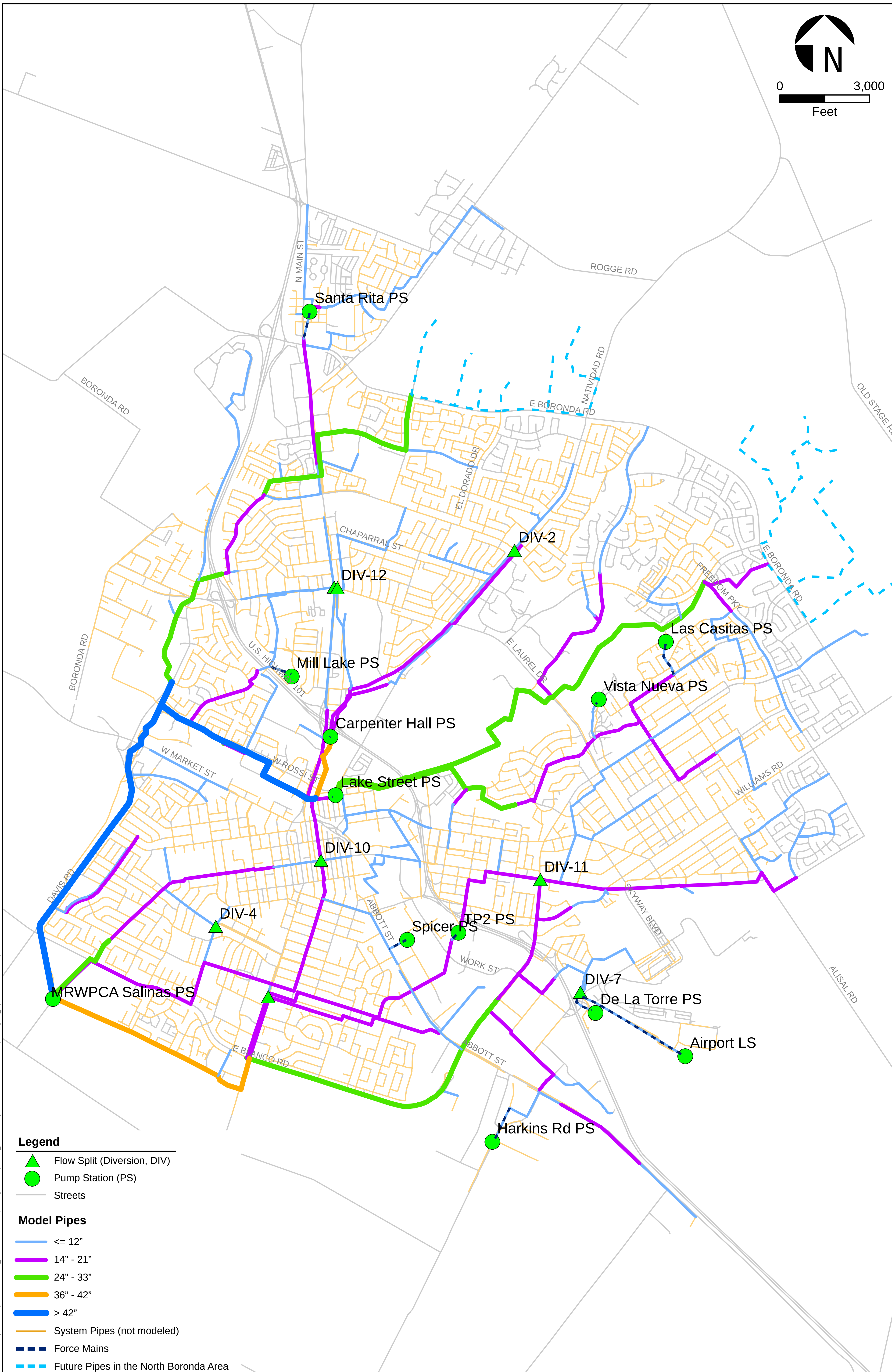

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Figure 6-1
Hydraulic Model Layout
Salinas Sewer System Master Plan

- Existing peak wet weather conditions. Peak wet weather flows calculated as the existing average dry weather flow plus the RDII flow for the selected 10-year, 6-hour design storm from existing contributing sewered areas.

- Buildout Scenarios

  - Build-out average dry weather flows. Average dry weather flows estimated based on future land use from Section 2 and dry weather unit flow factors from Section 4. For the buildout dry weather scenario, a unit flow factor of 500 gpd/acre is used for existing industrial development; however, a higher unit flow factor of 2,000 gpd/acre is used for the incremental future industrial areas to account for more intensive future industrial development than the average existing industrial development. Future conditions include flows within the projected ultimate service area identified in Section 2.

  - Build-out peak dry weather conditions. The model uses the peaking curve in Section 4 and average dry weather flows to simulate peak dry weather conditions.

  - Build-out peak wet weather conditions. Peak wet weather flows calculated as the buildout average dry weather flow plus the RDII flow for the selected 10-year, 6-hour design storm from buildout contributing sewered areas.

6.1.2 Evaluation Approach

The existing average dry and existing peak dry runs were used to verify the model flow allocations and the flow split configuration and assumptions. The results for the existing and buildout dry peak and wet peak (dry average plus 10-year storm RDII) simulations were compared to the hydraulic criteria for d/D and allowable surcharge as established in Section 5. Locations that did meet the criteria were identified as deficiency locations, as summarized in Section 6.2.

The deficiency locations that did not meet the criteria were then subject to a detailed analysis to determine the need for improvements. A hydraulic profile of each deficiency location was analyzed individually to determine the level of surcharge (if it comes within 5 feet from the manhole rim) and the occurrence of backflow conditions from downstream pipes.

Not all existing pipes not meeting the criteria (i.e., identified as deficiency locations) require improvement. The ultimate need for a system improvement is dictated by the level of surcharge, the possibility of diverting flow upstream to a different existing pipe, existing pipe characteristics such as slope and diameter, and whether it is impacted by backwater that will be eliminated by a downstream improvement. Section 6.3 provides a detailed discussion of the preliminary improvement locations identified in the detailed analysis.

6.2 Model Analysis Results (Deficiency Locations)

The model results summarized in this section show all the gravity sewer deficiency locations, i.e., locations where existing gravity sewers could not convey the peak design flows according to the criteria established in Section 5. More detailed analysis was then conducted to determine if improvements were required for the individual deficiency locations.

The key criteria for identifying capacity deficiencies of existing sewers were a d/D of 0.9 under peak design flow conditions, and a surcharge level that is within 5 feet of the manhole rim elevation. Both criteria must be exceeded for a deficiency location to require improvement. For evaluating and prioritizing whether existing pipes require improvement, surcharge is allowed as long as the hydraulic gradeline remains at least 5 feet below the rim elevation under peak design flow conditions. At some locations in the system, there are shallow pipeline segments where the pipe crown is within 5 feet of the ground surface, but pipes have adequate capacity to convey the peak design flows with no surcharge; such locations are not identified as deficiencies.

Figures 6-2 and 6-3 show pipes color-coded where the criteria of a d/D ratio = 0.9 is exceeded, for dry peak and wet peak (dry average plus 10-year storm) loading conditions. Manholes are color-coded to show where the surcharge criterion is exceeded, i.e., the hydraulic gradeline is within 5 feet of the rim elevation. Figure 6-2 presents results for the existing scenario; and Figure 6-3 for the buildout scenario.

The deficiencies shown in Figures 6-2 and 6-3 are color-coded according to the loading condition first causing the deficiency, even if the severity is greater under the other loading conditions. If a pipe/manhole is deficient under dry peak flows, it is color-coded as such on the figures, even though the severity may be higher under peak wet weather flows. Locations on the figures that are color-coded as deficient for peak wet weather flows are not deficient for peak dry weather flows. All improvements are sized for the highest peak flow condition. The information on the loading condition first causing the deficiency is used only for prioritizing improvements.

Figure 6-4 summarizes deficiency locations in the system where the pipe capacity hydraulic criteria are exceeded, and the loading condition first causing the deficiency. The color-coding for timeframe is based on the when either of the criteria (either d/D and/or surcharge) are exceeded. However, the need for and timing of improvements is based on exceeding both criteria, as discussed later in this section.

Table 6-1 provides a general description for each deficiency location shown in Figure 6-4. Key findings from Table 6-1 include:

- Shaded rows in Table 6-1 are the locations where improvements will be needed. These locations are discussed individually in more detail in Section 6.3.
  - Locations L01, L04, L05, L06, L15, L17, L18, and L20 need pipe improvements.

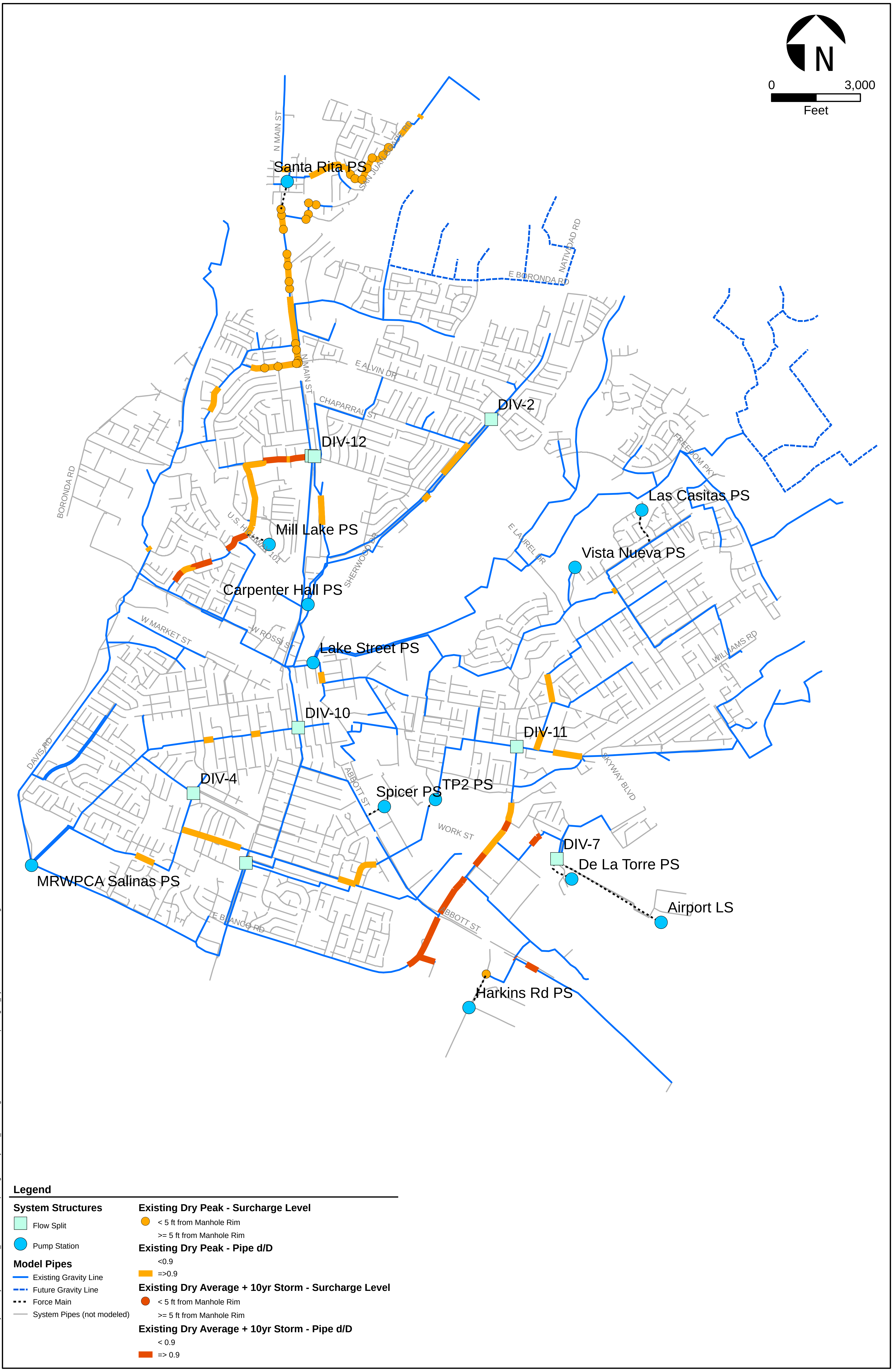

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Figure 6-2
Hydraulic Model Results for Existing Conditions
Salinas Sewer System Master Plan

Legend

System Structures
- Flow Split
- Pump Station
- Force Main

Model Pipes
- Existing Gravity Line
- Future Gravity Line
- System Pipes (not modeled)
- Streets

Buildout Dry Peak - Surcharge Level
- < 5 ft from Manhole Rim
- >= 5 ft Manhole Rim

Buildout Dry Peak - Pipe d/D
- < 0.9
- =>0.9

Buildout Dry Average + 10yr Storm - Surcharge Level
- < 5 ft Manhole Rim
- >= 5 ft Manhole Rim

Buildout Dry Average + 10yr Storm - Pipe d/D
- < 0.9
- =>0.9

Notes:
1. Deficiencies are color-coded by the loading condition first causing the deficiency, even if the severity is greater under the other loading condition, i.e., flows may be higher under the other loading condition. A location deficient for both peak dry and peak wet flows is shown as peak dry. Only locations deficient only for peak wet, but not peak dry, flows are color-coded as a peak wet deficiency.
2. Deficiencies shown are with the proposed re-configuration at diversion structure DIV-11, which eliminates pipeline deficiencies downstream of TP2 pump station.

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Figure 6-3
Hydraulic Model Results Buildout Conditions
Salinas Sewer System Master Plan

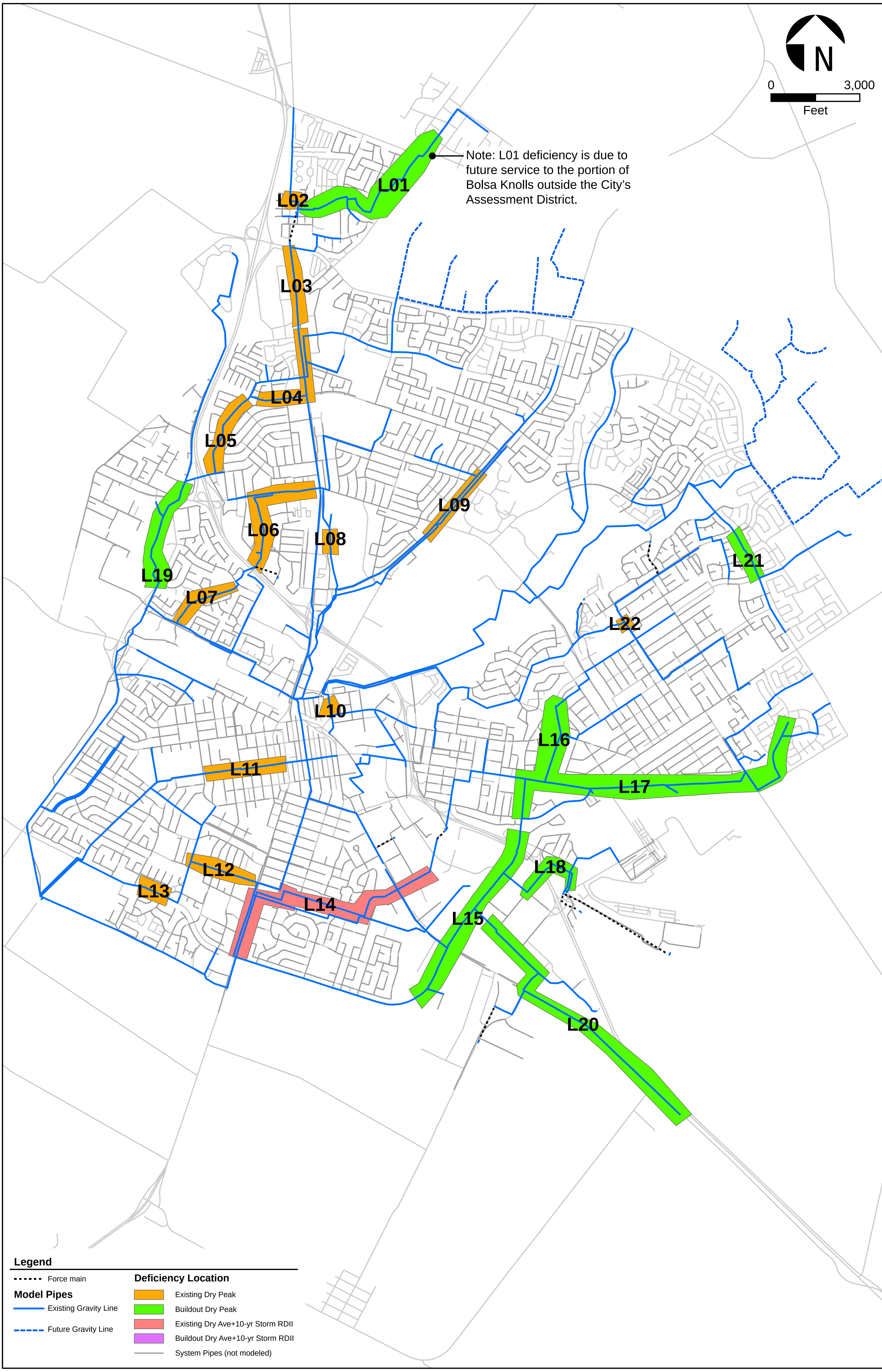

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Figure 6-4
Hydraulic Model Results Deficiency Locations
Salinas Sewer System Master Plan

  - In two locations, L08 and L14, an upstream flow diversion to a different existing pipe is recommended which will eliminate the deficiency at those locations, while consolidating pipeline improvements.

- Unshaded rows in Table 6-1 are locations that will not require improvement based on the detailed analysis.
  - At locations L03 and L16, downstream improvements corrected the deficiency, i.e., the deficiency was due to backwater effects.
  - At locations L02, L07, L09, L10, L11, L12, L13, L14, L19, L21, and L22, only the d/D criterion was exceeded in some pipe segments due to flat pipe slope; however, surcharge levels did not come within 5 feet of the manhole rim elevations for the peak design flows.

Table 6-1
Salinas Sewer System – Location of System Deficiencies
(locations that do not meet hydraulic criteria for existing or buildout conditions)

Location	Description	Comments
L01	10-inch and 8-inch pipelines on E Bolivar St, Lenny St, Louise St, and Souza Way	**Improvement recommended.**
L02	10-inch pipeline upstream of Santa Rita PS, south of Prado St	Flat slope (only d/D exceeded, not surcharge criterion), no improvement recommended.
L03	15-inch pipeline along N Main St, south of Boronda Rd	Downstream improvement at L04 takes care of this location.
L04	18-inch pipeline along N Main St, south of Madrid St and 12-inch along W Alvin Dr	**Improvement recommended.**
L05	18-inch pipeline along Cherokee Dr, north of Tulane St	**Improvement recommended.**
L06	10-inch pipeline along Tyler St, South of W Laurel Dr, and along W Laurel Dr to N Main St	**Improvement recommended.**
L07	15-inch segment along Victor St	Only d/D exceeded, not surcharge criterion, no improvement recommended.
L08	10-inch segment west of Rodeo grounds	**Upstream flow diversion recommended** at N Main St and Laurel Dr to divert excess flow to the Location L06 pipe line. This consolidates all improvements at one location, the L06 location.
L09	12-inch segments along Natividad Rd, north of Sorrentini Dr	Flat slope (only d/D exceeded, not surcharge criterion), no improvement recommended.
L10	12-inch segment along Sherwood Dr, north of Market Way	Flat slope (only d/D exceeded, not surcharge criterion), no improvement recommended. The d/D is only slightly over 1.0; and the minor surcharge level is more than 13 feet below the manhole rim elevation.
L11	18-inch and 15-inch segments along W Alisal St, east of Lorimer St	Only d/D exceeded, not surcharge criterion, no improvement recommended. The d/D is only slightly over 1.0; and the minor surcharge level is more than 9 to 12 feet below the manhole rim elevation.
L12	21-inch pipeline along W Romie Ln, east of Iverson St	Flat slope (only d/D exceeded, not surcharge criterion), no improvement recommended.
L13	21-inch segment along W Blanco Rd, east of San Vicente Ave	Flat slope (only d/D exceeded, not surcharge criterion), no improvement recommended.
L14	18-inch pipeline along E Romie Ln and Malarin St, downstream of TP2 pump station	**Upstream flow diversion recommended** at E Alisal St & Sanborn Road to divert all flow to the L15 location. This consolidates all improvements at one location, the L15 location.
L15	24-inch and 18-inch pipelines along S Sanborn Rd	**Improvement recommended.**

Table 6-1
Salinas Sewer System – Location of System Deficiencies
(locations that do not meet hydraulic criteria for existing or buildout conditions)

Location	Description	Comments
L16	12-inch and 10-inch pipelines along Eucalyptus Dr	Downstream improvement at L15 takes care of this location.
L17	15-inch pipeline along E Alisal St, east of N Sanborn Rd	**Improvement recommended.**
L18	15-inch and 12-inch pipelines along Vertin Ave and Jean Ave	**Improvement recommended.**
L19	30-inch segments parallel to N Davis Rd, south of W Laurel Dr	Only d/D exceeded, not surcharge criterion, no improvement recommended.
L20	15-inch and 10-inch pipelines along Industrial St and Harkins Rd, from Sanborn Rd to the connection to the Harkins PS force main	**Improvement recommended.**
L21	12-inch segment along Freedom Pky, south of Rider Ave	Only d/D exceeded, not surcharge criterion, no improvement recommended.
L22	15-inch segment along Acosta Plaza, west of Garner Ave	Flat slope (only d/D exceeded, not surcharge criterion), no improvement recommended.

6.3 Evaluation of Capacity Improvement Needs

This section summarizes the key findings of the system capacity evaluation for gravity sewers, pump stations, and force mains. The major gravity sewers for future service to the North Boronda FGA are also presented in this section.

The improvement needs identified in this section are based on the selected 10-year design storm. The unit flow rates for future industrial development areas are assumed to be 2,000 gpd/acre, while existing industrial areas remain at a unit flow rate of 500 gpd/acre; in order to account for more intensive industrial development in the future. All other unit flow rates are the same for both existing and future land uses, as developed from the flow monitoring data in Section 4.

As discussed in Section 6.4, the following sensitivity analyses evaluated the potential impact on the sizes or extent of the improvement recommendations:

- Impact of using 5-year storm for wet weather flows instead of selected 10-year design storm.
- Impact of flows from contributing areas outside the City: County Boronda area; and the portion of Bolsa Knolls that is outside the City Assessment District.
- Impact of potential future flows from the area to the north of the current planned future North Boronda FGA in a potential Future Expansion Area.

6.3.1 Existing Gravity Sewer Capacity

For existing pipes, at deficiency locations where the level of surcharge reached the maximum level allowed (5-ft below the rim), during existing or buildout conditions, pipeline improvements are recommended.

The replacement or parallel diameter was determined using a design criteria of d/D=0.9 for the largest flow through the pipe, either buildout dry peak or buildout wet peak (dry average plus 10 yr storm). The proposed pipes were assumed to have the same slope as the existing pipes. If a steeper slope is an option, the size could decrease.

Figure 6-5 shows the preliminary locations requiring gravity sewer improvements; these improvement locations are further described below. The highest design flows for sizing improvements were: peak dry weather flows at Locations L01, L04 and L05; peak wet weather flows at Locations L06, L08, L14 and L15, L17, L20; and at Location L18 peak dry and peak wet flows were similar.

Location L01: Replacement of existing 8-inch and 10-inch pipes, with a 15-inch (or parallel with a 12-inch) along E Bolivar St from Soto Place to Van Buren Ave (approximately 1,500 feet of 15-inch pipe), then with 12-inch (or parallel with a 10-inch) south along Van Buren Ave to the southern property line of the house at 18635 Van Buren Avenue, then along the south property line to Louise Street, then south along Louise St and then Lenny St to Souza Way, then north along Souza Way to Hoover St, then along the southern property line of house at 18951 Hoover St (approximately 3,200 feet of 12-inch pipe).

- Location L01 is one of the main lines conveying flows from the San Juan Grade Rd and Rogge Rd area (including La Joya Elementary School and Santa Rita Middle School) to Santa Rita Pump Station. This improvement will be required when the Bolsa Knolls area currently on septic tanks, which is outside the Assessment District, is connected to the sewer system. As discussed in Section 6.4.2 sensitivity analysis, if the Bolsa-Knolls area outside the Assessment District is not connected, this improvement is not necessary; i.e., the need is due to the area outside the City's Assessment District.

Location L04: Replacement of existing 12-inch with a new 18-inch (or parallel with a 15-inch) along W Alvin Dr from Cherokee Dr to Main St, then north along Main St up to 500 ft south of Cherokee Dr (total length approximately 2,900 feet). Model results for this location show surcharge during existing dry peak conditions, as high as 5-feet below the rim. However, these results are not consistent with the flow meter data (Meter 10) analyzed in Section 4, which were within 12 percent of the modeled flow. The meter data did not show any surcharge or pressurized pipe during dry conditions, which is not consistent with model results; therefore, it is recommended that the existing pipe diameters be field verified. The diameter information available for this area is conflicting, the existing diameter was assumed 12-inch for all the segments included in the replacement project. Before implementing this improvement, a field verification of the existing diameter should be conducted to determine if replacement is needed for all the segments identified.

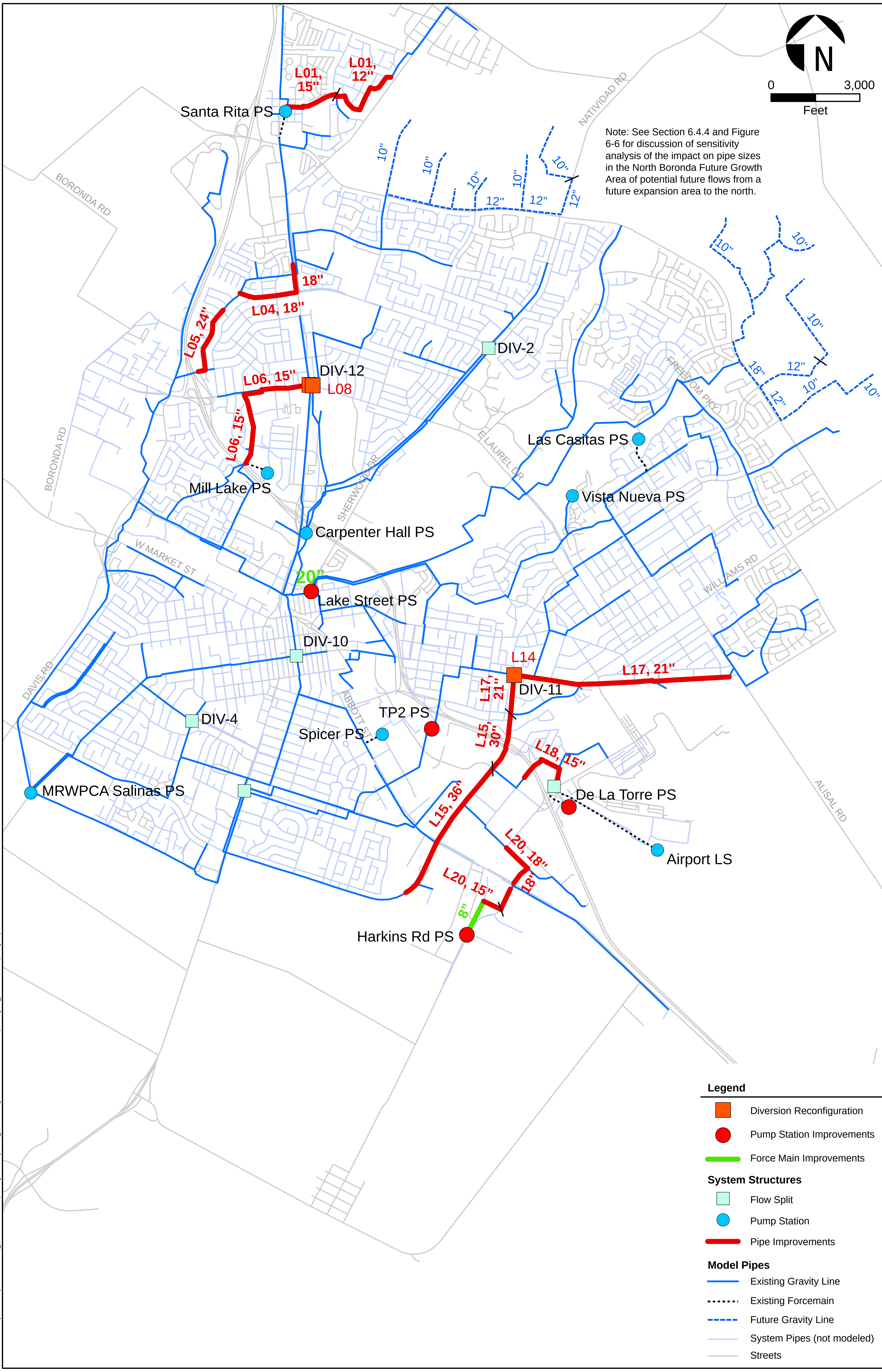

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Figure 6-5
Locations Requiring Improvement
Salinas Sewer System Master Plan

Location L05: Replacement of existing 18-inch with a new 24-inch (or parallel with a 15-inch) from 250-feet west to the intersection of Tulane St and Cherokee Dr, and then along Cherokee Dr from Tulane St to 70 feet north of Inca Way (total length approximately 2,500 feet). This location shows surcharge during buildout dry peak conditions, as high as 1-foot below the rim.

Location L06: Replacement of existing 10-inch with a new 15-inch (or parallel with a 12-inch) along Tyler St from the east side of Hwy 101 to W Laurel Dr, then east along W Laurel Dr to Main St (total length approximately 5,700 feet). Under existing peak flow conditions, some segments exceed the d/D criterion; however, surcharge levels are greater than 5 feet below the rim elevation. Only under future conditions are both criteria exceeded, including surcharge within 5 feet of the rims. This replacement is also sized to relieve the deficiency location L08 (discussed below), conveying flows from the diversion at Main St and Laurel Dr.

Location L08: Connect overflow from flow diversion at Main St and Laurel Dr to proposed L06 (15-inch), to relieve two parallel pipes along Main St (8-inch each) from Laurel Dr to Bernal Dr and the Natividad Rd interceptor. This connection will decrease the flow to the existing lines lowering the d/D to acceptable levels. Without this diversion, this location shows surcharge during peak wet weather buildout conditions, as high as 1-foot below the rim.

Locations L14 and L15 (flow diversion eliminates L14 deficiency): Replacement of existing 18-inch, 24-inch, and 27-inch with two new segments, 30-inch and 36-inch (or parallel with a 24-inch). The 36-inch segment runs along Blanco Rd from 500 feet west of Blanco Cir to Terven Ave (approximate length 5,200 feet). The 30-inch segment runs along Sanborn Rd from Terven Ave to John St (approximate length 2,000 feet). For buildout conditions, this deficiency also affects areas L17, L18, and L20 (discussed below), as L14 and L15 are downstream of those locations. The L15 improvement must be implemented prior to or along with the upstream improvements at L17, L18 and L 20. Under existing peak flow conditions, some segments exceed the d/D criterion; however, surcharge levels are more than 5 feet below the rim elevation. Only under future conditions are both criteria exceeded, including surcharge within 5 feet of the rims. This improvement is sized assuming that the flow split located at E Alisal St and Sanborn Rd does not send any flow to the TP2 pump station, through the 15-in overflow line, relieving the deficiency location L14.

Location L17: Replacement of existing 18-inch pipe along Sanborn Road, from John Street to E Alisal Street, and the existing 15-inch along E Alisal Street, from Sanborn Road to Margaret Street, with a new 21-inch pipe (total length approximately (8,300 feet). This location shows surcharge during buildout peak wet weather flow conditions that is within 5 feet of the manhole rims.

Location L18: Replacement of existing 10-inch and 12-inch with a new 15-inch (or parallel with a 12-inch) along Vertin Ave from the connection point to the existing 15-inch sewer about 200 feet southwest of Hwy 101 to Jean Ave, then along Jean Ave to Carol Dr, and then to the connection to the force mains from De La Torre and

Airport pump stations (approximate length 2,700 feet). This location shows surcharge during buildout peak wet weather flow conditions, as high as 1-foot below the rim.

Location L20: This location will serve a future 250+acre agricultural-industrial project area. The recommended system improvement is the replacement of the existing 10-inch with a new 15-inch (or parallel with a 12-inch) from the discharge of Harkins PS to Harkins Road (approximately 700 feet), and the replacement of the existing 12-inch and 15-inch with a new 18-inch (or parallel with a 15-inch) along Harkins Rd to Industrial Street, and then along Industrial Street about 1,000 feet to connect to the existing 18-inch (approximate length 2,700 feet). This location shows surcharge during buildout peak wet weather flows, as high as 1-foot below the rim.

6.3.2 Future Gravity Sewers for North Boronda FGA

Figure 6-5 shows the major gravity sewers for future service to the North Boronda FGA (shown as dashed lines). The alignments are based on the information in the P&D Sewer Study for the North Boronda FGA (August 2006). The diameters shown on Figure 6-5 for these future sewers are based on the model analysis for buildout peak wet weather flows (average dry weather plus 10-year, 6-hour RDII flows), to meet the design criteria for future pipes of d/D=0.75.

For the model analysis, slopes for future sewers were assumed based on the minimum slope criteria described in this document. A minimum manhole depth of 10-feet was assumed for modeling purposes. Based on the model analysis and assumptions, the approximate lengths for the major new gravity sewers in this area are summarized below, as shown on Figure 6-5:

Diameter (inches)	*Length (feet)*
10	27,000
12	11,000
15	3,000
18	1,000
Total	42,000

This conceptual master plan information on the future sewers in the North Boronda FGA is a guideline for the City. This conceptual information should be confirmed by detailed analyses conducted as part of the Specific Plans for the area.

As discussed in Section 6.4.4, a sensitivity analysis was also conducted to determine the impact on the recommended pipe sizes in the North Boronda FGA, if potential future development to the north of this area were to occur in a potential Future Expansion Area. Figure 6-6 shows future interceptors through the North Boronda FGA to serve the Future Expansion Area.

6.3.3 Pumping Capacity Evaluation

Table 6-2 compares existing pump station capacities with existing and buildout pumping requirements, for peak dry and peak wet weather flows (dry average plus 10-year storm). The table shows the total existing capacity and the firm capacity with the largest pump out of service. The pump station must have firm capacity to meet the largest buildout flow (peak dry conditions or peak wet conditions). Firm capacity is the capacity of the pump station assuming the largest pump out of service.

Key results of the pumping capacity evaluation shown in Table 6-2 are:

- Existing Scenario: All pump stations have adequate firm capacity to meet existing requirements. This assumes that the recommended diversion modifications at location L15 (E Alisal St and Sanborn Rd) are implemented, which eliminates the need for TP2 pump station improvements under existing conditions. Without the diversion modifications, both pumps must operate to meet the estimated existing peak flows, i.e., no standby pump under peak conditions.
- Buildout Scenario: To meet future needs, capacity increases will be needed at De La Torre, Harkins, Lake Street, and TP2 pump stations to meet buildout requirements. The location of these pump stations are shown in Figure 6-5.

The pump stations requiring additional capacity are discussed below:

- De La Torre Pump Station serves the industrial area in the southeast part of the City, where future industrial growth is anticipated, and will require additional capacity to meet buildout needs. The timing for the additional capacity will depend on the timing for future industrial projects in its tributary areas. To meet the required firm capacity, this pump station will require additional 290 gallons per minute (gpm). The force main for this pump station will not need to be upgraded.
- Harkins Rd Pump Station: The existing firm capacity of Harkins Rd Pump Station is 350 gpm, the total future peak flow through the pump station will be 820 gpm, including flows from the 250+ acre future agricultural-industrial project area. To convey the additional flows of 470 gpm, the Harkins pump station will need upgrades.
- Lake Street Pump Station: The largest amount of additional capacity will be needed to convey buildout flows through the Lake Street Pump Station. The existing firm capacity is 5,700 gpm, the total buildout peak flow through the pump station will be 7,070. To convey the additional flows of 1,370 gpm, the Lake Street station will need upgrades.
- TP2 Pump Station: Even with the proposed diversion at Location L15, TP2 pump station will require additional capacity to meet future needs, due to anticipated future mixed use development that will be tributary to this location. For buildout, additional pumping capacity of 170 gpm will be needed. To convey the additional flows, the TP2 station will need upgrades.

Table 6-2
Pump Station Capacity Evaluation [1]

Pump Station Name	Number of Pumps	Capacity per Pump (gpm)	HP per Pump	Pump Station Firm Capacity (gpm)	Peak Flows [2] Existing Dry (gpm)	Peak Flows [2] Buildout Dry Weather (gpm)	Peak Flows [2] Existing Wet Weather (10-year Storm) (gpm)	Peak Flows [2] Buildout Wet Weather (10-year Storm) (gpm)	Additional Capacity Required for Buildout Peak Flows (gpm)	Priority
Airport	2	550	10	550	130	380	150	370	-	
Carpenter Hall	2	2,250	30	2,250	780	810	790	830	-	
De La Torre	2	200	5	200	30	490	30	370	290	Buildout
Harkins Road [3]	2	350	5	350	140	820	260	820	470	Buildout
Lake Street	3	2,850	30	5,700	4,090	7,070	3,800	6,580	1,370	Buildout
Las Casitas	2	150	10	150	120	140	80	90	-	
Mill Lake	2	500	15	500	240	250	170	180	-	
Santa Rita	2	1,530	30	1,530	1,330	1,450	830	930	-	
Spicer	2	400	7.5	400	140	160	230	250	-	
Vista Nueva	2	175	7.5	175	60	70	30	60	-	
TP2 [4]	2	400	10	400	440	570	460	510	170 [4]	Buildout [4]

(1) For industrial areas, the unit flow factors are: 500 gpd/acre for existing industrial development; and 2,000 gpd/acre for the incremental future industrial development.

(2) At some pump stations, peak dry weather flows are higher than or similar to peak wet weather flows. Several factors affect this including application of the dry weather peaking curve (stations with smaller tributary areas tend to have higher dry weather peaking factors), the amount of future development within the tributary area (future development areas have lower RDII factors than existing areas), and the amount of future industrial within the tributary area (future industrial development has a higher unit dry weather flow factor than existing industrial development.

(3) Harkins Rd Pump Station will need to be upgraded to convey the future 250+acre ag-industrial project area. The priority of this improvement depends on the construction timing of the developer project.

(4) The existing flows through Pump Station TP2 were computed assuming current configuration at the flow split located at E Alisal St and Sanborn Rd; while the buildout peak flows assume implementation of the recommended reconfiguration for the flow split at E Alisal St and Sanborn Rd. With the recommended reconfiguration of the diversion, additional capacity is not required at TP2 until the future scenario.

6.3.4 Force Main Capacity Evaluation

The hydraulic criterion for force mains is not to exceed a maximum velocity of 8 ft/sec under the largest flow, either peak wet weather flow (dry average plus 10 yr storm flow) or peak dry flow. Table 6-3 shows the results of the force main capacity analysis. Key results of the evaluation include:

- All existing force mains have adequate capacity for the existing peak flows. The Lake Street Force Main is at the upper limit of the maximum velocity criterion. All other force mains have velocities well below the maximum criterion under existing peak flow conditions.

- Under buildout peak flow conditions, the two force mains below require improvement to meet the maximum velocity criterion. The force main improvements would be done as part of the pump station upgrades at these locations.

  - Harkins Road Force Main: The recommended size for the future force main at Harkins Road is 8-inch, and the location is shown on Figure 6-4.

  - Lake Street Force Main: The recommended size for the force main at Lake Street is 20-inch. The location of this force main is shown in Figure 6-4. The existing velocity marginally meets the criterion; improvement would only be needed for the higher buildout flows due to future development.

6.4 Sensitivity Analyses of Improvement Evaluations

One of the advantages of hydraulic models is the ability to investigate what-if scenarios to observe the impact of changes in the key modeling assumptions, in the estimated parameters, or in the hydraulic criteria. The following sensitivity analyses were performed for the Salinas Sewer System to identify potential impacts on the extent of deficiencies and required improvements:

- Impact of using 5-year storm to determine peak wet weather flows instead of using the selected 10-year design storm.

- Impact of flows from contributing areas outside the City: County Boronda area; and the portion of Bolsa Knolls that is outside the City Assessment District.

- Impact of potential future flows from a potential Future Expansion Area to the north of the planned North Boronda FGA.

Table 6-3
Force Main Capacity Analysis [1]

Pump Station	***Forcemain Diameter (in)***	***Existing Scenario***				***Buildout Scenario***			
		Flow (cubic feet per second)		***Velocity (ft/sec)***		***Flow (cubic feet per second)***		***Velocity (ft/sec)***	
		Existing Dry Peak	***Existing Peak Wet Weather (10-year Storm)***	***Existing Dry Peak***	***Existing Peak Wet Weather (10-year Storm)***	***Buildout Dry Peak***	***Buildout Peak Wet Weather (10-year Storm)***	***Buildout Dry Peak***	***Buildout Peak Wet Weather (10-year Storm)***
Airport	8	0.3	0.3	0.8	1.0	0.8	0.8	2.4	2.4
Carpenter Hall	12	1.7	1.8	2.2	2.2	1.8	1.8	2.3	2.4
De La Torre	6	0.1	0.1	0.3	0.3	1.1	0.8	5.6	4.2
Harkins Rd	6	0.3	0.6	1.6	2.9	1.8	1.8	**9.3**	**9.3**
Lake Street	14	9.1	8.5	**8.5**	**7.9**	15.7	14.7	**14.7**	**13.7**
Las Casitas	8	0.3	0.2	0.8	0.5	0.3	0.2	0.9	0.6
Mill Lake	6	0.5	0.4	2.7	1.9	0.6	0.4	2.8	2.0
Santa Rita	10	3.0	1.8	5.4	3.4	3.2	2.1	5.9	3.8
Spicer	6	0.3	0.5	1.6	2.6	0.4	0.6	1.8	2.8
Vista Nueva	4	0.1	0.1	1.5	0.8	0.2	0.1	1.8	1.5
TP2	6	1.0	1.0	5.0	5.2	1.3	1.1	6.5	5.8

[1] For industrial areas, the unit flow factors are: 500 gpd/acre for existing industrial development; and 2,000 gpd/acre for the incremental future industrial development.

6.4.1 Sensitivity Analysis of Using 5-year Storm for Peak Wet Weather Analysis

A sensitivity analysis was conducted using peak wet weather flows for a 5-year design storm and the results compared with those of the 10-year design storm to assess the incremental impact on required improvements. If improvements were sized using the 5-year storm, the recommended size for improvements at most locations would remain the same. At a few locations, improvements would still be required, although the pipe diameter would be smaller and for a shorter length.

Since the difference in required improvements is not significant, the 10-year design storm was selected to develop improvements. All improvement recommendations are based on a 10-year design storm, which is more conservative and provides a higher level of service.

6.4.2 Sensitivity Analysis of Flow from County Boronda and Bolsa Knolls Areas outside the City

A sensitivity analysis of buildout conditions was conducted to determine the impact on required improvements in the City's system due to flow contributed by the following two areas outside the City's service area:

- County Boronda Area, and
- Portion of Bolsa Knolls outside the City' service area (outside the Assessment District).

Future flows for these two areas were generated using future land use from Section 2 and dry weather unit flow factors from Section 4. The model was run with and without these areas and the need of improvements downstream was evaluated. The results are summarized below:

- County Boronda Area: The model results show that the connection of the County Boronda area does not impact any recommended improvement. This is because the County Boronda area is tributary to major (large diameter) trunk sewers and contributes a relatively small amount of flow to these sewers compared with the other flow from the City.

- Bolsa Knolls outside Assessment District: The model results show that if the Bolsa Knolls area is not connected to the system, Location L01 would not exceed the hydraulic criteria. Therefore, the pipeline replacement recommended to address this location would not be necessary. The Location L01 improvement is due to the Bolsa Knolls flows from outside the City.

6.4.3 Sensitivity Analysis of Potential Future Expansion Area to North

For planning purposes, the City has determined its ultimate future growth and service area, as described in Section 2, which was the basis for the model flow projections. A sensitivity analysis was performed to conceptually determine the impact of having additional flow contributions from the area north of the North Boronda FGA, i.e., from a potential future expansion area (FEA) that is outside the current master plan study area, but within the Monterey County Planning Area. The FEA assumption included all of that certain area designated as Development Limited to Lots of Record per Policy GS-1.13, as shown on Figure #LU7 of the 2010 Monterey County General Plan (County Plan). The Board of Supervisors adopted the County Plan and certified the Environmental Impact Report on October 26, 2010. The assumptions were limited to the number of dwelling units that could potentially be built based on the County Plan.

For the sensitivity analysis, the City requested to include in the analysis the impact of an additional flow contribution from 1,686 low density residential units in the North Boranda FGA. The wet weather flows were computed based on the assumption that the future growth area will be developed at a lower density that will cover the entire FGA. The average dry weather and wet weather flows were loaded into the sewer system at the four manholes shown on Figure 6-6. The percentages of the total flow loaded to each of the four manholes were provided by the City as: 40 percent at McKinnon Street; 30 percent at Independence Blvd; 20 percent at New Hampshire Court; and 10 percent at Rider. The total additional flow from the potential future northern expansion area was assumed equal to: 0.4 mgd average dry weather flow; 0.6 mgd peak dry weather flow; and 2.9 mgd peak wet weather flow (10-year design storm).

This sensitivity analysis is intended to help guide the City's development of future sewers in the North Boronda FGA, connecting with the existing system, and also, to alert the City to what existing interceptors may be affected if those additional flows from the FEA are to be conveyed. The system was analyzed for peak dry flows and peak wet flows with 10-year design storm conditions based on the conceptual flow assumptions. More detailed analysis will be needed to evaluate specific improvement needs when more information is available on the potential FEA.

With the additional flows from the FEA, four interceptors in the North Boronda FGA would require larger diameters and be considered interceptors from future areas to the north, as shown on Figure 6-6, based on the modeling results:

- Future North Boronda Interceptor 1 – New 15-inch pipe along Boronda Rd from McKinnon St to Abbey Way (approximately 2,300 ft), then a new 12-inch pipe north up to Rogge Rd (approximately 6,000 ft).

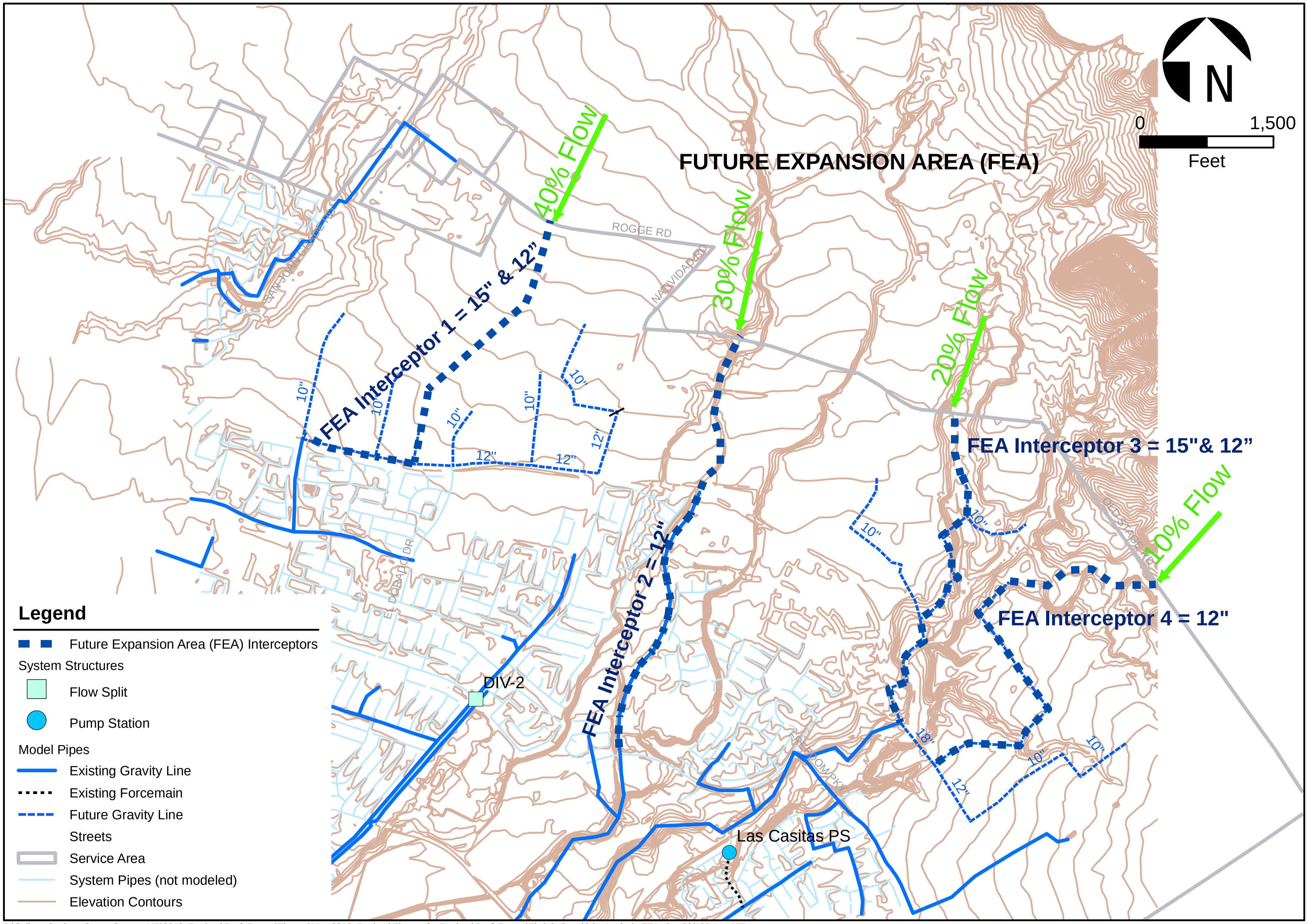

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Figure 6-6
Sensitivity Analysis of Future Expansion Area (FEA) to North
Salinas Sewer System Master Plan

- Future North Boronda Interceptor 2 –New 12-inch pipe along Independence Blvd from the end of the 12-inch pipe at East Boronda Rd to the current planning limit (approximately 3,500 feet).

- Future North Boronda Interceptor 3 – New 15-inch pipe from the end of the existing 18-inch sewer along Boronda Rd to Constitution Blvd (700 feet), then north 1,800 feet; then a new 12-inch pipe north up to the City's current planning limit (approximately 6,000 feet).

- Future North Boronda Interceptor 4 – New 12-inch pipe from Boronda Rd (from a proposed 18-inch pipeline in the North Boronda area) along Rider Avenue, east up to the City's current planning limit (9,000 feet).

With the assumed additional flows from the potential FEA north of North Boronda FGA, the following additional improvements will be needed for the existing system:

For the assumed flows, the Lake Street pump station will receive an additional 800 gpm beyond peak buildout estimates at the pump station of 7,100 gpm. Proposed Lake Street PS improvements would provide 9,000 gpm of firm capacity, which is adequate to accommodate buildout peak flows plus FEA flows. The future 20-inch force main would also be adequate to handle the flows from the additional area.

The existing City sewers that would convey flows from the potential future area to the Salinas Pump Station did not show additional deficiencies caused by the additional flow from this area. However, more detailed hydraulic analysis should be conducted when more detailed flow information is available to determine if improvements may be needed to this portion of the City's existing system.

These conceptual sensitivity analysis results are based on the conceptual-level flow assumptions described above for the potential FEA. These sensitivity results should be re-evaluated and a more detailed flow and hydraulic analysis performed when more information becomes available on the potential FEA.

Section 7
Recommended Improvements

This section presents the recommended sanitary sewer system improvements, based on the hydraulic criteria in Section 5 and the sewer system analysis in Section 6.

7.1 Recommended Sewer System Capacity Improvements

Table 7-1 shows the recommended Capital Improvement Program (CIP) projects to provide the required sanitary sewer system capacity to convey buildout flows. Figure 7-1 shows the conceptual locations of the projects. At this conceptual master planning level, the conceptual locations are assumed to be in the same alignments as the existing facilities.

For conservative budgeting purposes, CIP costs shown in Table 7-1 are based on replacement rather than relief sewers, in order to provide more flexibility for the City in implementing projects. The costs for pump station upgrades are based on the total pumping capacity and horsepower (HP) required for future flows, assuming that stations will be replaced when upgraded. The basis for the capital cost estimates is provided in Section 7.5.

The projects in Table 7-1 are grouped by the timeframe when the improvement is needed, either existing or future. All future projects will be needed by buildout; the specific timing for future projects will depend on future development needs. All projects for existing and future timeframes are sized for buildout flows.

Projects within each timeframe are prioritized according to the criteria discussed later in this document. Higher priority projects would be implemented before lower priority projects, unless there are other factors affecting the schedule such as coordination with other City projects, e.g., street improvements.

The projects identified in Table 7-1 were based on the capacity evaluations discussed in Section 6. During the capacity evaluation, deficient sewers that did not meet the hydraulic capacity criteria were identified under both dry and peak wet weather conditions for the existing and buildout timeframes. After identifying the deficient sewers, a more detailed analysis was conducted to determine required improvements. The recommended improvements were sized to convey the maximum potential build-out flow based on the flow projections and sensitivity analyses discussed in Section 6.

The improvements are grouped into projects based on location and to minimize public disruption. As appropriate, projects combine deficient reaches in the same vicinity into a single project based on average slope and consistent diameters in contiguous reaches, e.g., pipe diameters progressively increase in a downstream direction. Each project has been analyzed under buildout conditions to convey the buildout peak flow while meeting the established hydraulic criteria.

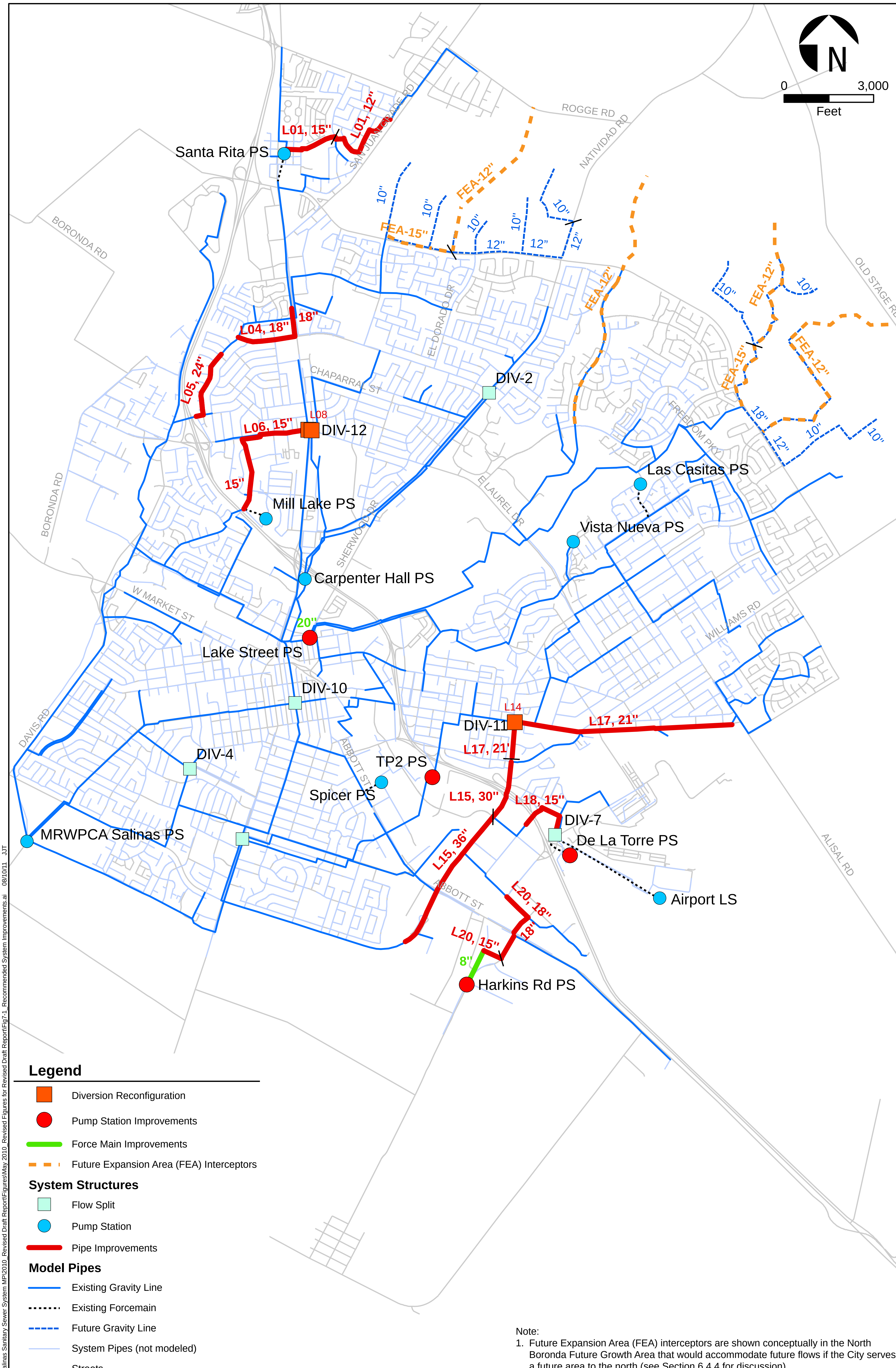

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Figure 7-1
Recommended Sanitary Sewer System Improvements
Salinas Sewer System Master Plan

Table 7-1
Summary of Recommended Sanitary Sewer Improvements

Location	Description	Improvements Needed			Capital Cost (2010 $)	Time Frame
Gravity Sewer Projects [1]		**Replacement Diameter (inches)**	**Parallel Diameter (inches)**	**Length (feet)**		
L04	Replacement of existing 12-in with an 18-in along W Alvin Dr from Cherokee Dr to Main St, then north along Main St to 500 ft south of Cherokee Dr	18	15	2,900	$1,537,000	Existing
L08	Connect overflow from flow diversion at Main St and Laurel Dr, to convey flows west to the existing 10-inch and proposed 15-inch (see Recommended Improvement L06).				$300,000	Existing
L14	Disconnect overflow from flow diversion at Sanborn Rd and E Alisal St, to direct all flow south (Sanborn Rd). Overflow currently directing flows west (E Alisal St). This will reduce existing flows reaching TP2 PS and its downstream pipelines (L14). Diversion is also needed for future improvement L15 below.				$300,000	Existing
L05	Replacement of existing 18-in with a 24-in from 250-feet west of the intersection of Tulane St and Cherokee Dr, and then along Cherokee Dr from Tulane St to 70 ft north of Inca Way	24	15	2,500	$1,700,000	Future
L01 [1]	Replacement of existing 8-in and 10-in pipes, with a 15-in along E Bolivar St from Soto Place to Van Buren Ave, then with a 12-in south along Van Buren Ave to the southern property line of house at 18635 Van Buren Ave, then along south property line to Louise St, then south along Louise St and then Lenny St to Souza Way, then north along Souza Way to Hoover St, then along southern property line of house at 18951 Hoover St. This improvement is only needed if the City serves the part of Bolsa Knolls outside the City Assessment District.	15 12	12 10	1,500 3,200	$1,899,000	Future [1]
L06	Replacement of existing 10-in with a 15-in along Tyler St from the east side of Hwy 101 to W Laurel Dr, then east along W Laurel Dr to Main St.	15	12	5,700	$2,594,000	Future

Table 7-1
Summary of Recommended Sanitary Sewer Improvements

Location	Description	Improvements Needed			Capital Cost (2010 $)	Time Frame
Gravity Sewer Projects [1]		**Replacement Diameter (inches)**	**Parallel Diameter (inches)**	**Length (feet)**		
L15	Replacement of existing 18-in, 24-in, and 27-in along Sanborn Rd, with two segments, one in 30-in and the other 36-in. The 36-in segment runs from 500 ft west of Blanco Cir to Terven Avenue. The 30-in segment runs from Terven Avenue to John Street.	36 30	27 24	5,200 2,000	$6,756,000	Future [2]
L17 [2]	Replacement of existing 18-in pipe along Sanborn Road, from John Street to E Alisal Street, and the existing 15-inch along E Alisal Street, from Sanborn Road to Margaret St, with a new 21-inch pipe.	21	12	8,300	$5,022,000	Future [2]
L18 [2]	Replacement of existing 10- and 12-in with an 15-in along Vertin Ave from the existing 15-inch sewer about 200 ft southwest of Hwy 101 to Jean Ave, then along Jean Ave to Carol Dr, and then to the connection to the force mains from the De La Torre and Airport Pump Stations.	15	12	2,700	$1,229,000	Future [2]
L20 [2]	Replacement of existing 10-in with a 15-in from the discharge of Harkins Rd Pump Station to Harkins Rd, and replacement of existing 12-in and 15-in with 18-in along Harkins Rd to Industrial St, and then along Industrial St about 1,000 ft to connect to existing 18-inch.	18 15	15 12	2,700 700	$1,750,000	Future [2]
Subtotal - Gravity Sewer Improvements				**37,400**	**$23,087,000**	
Location	**Description**	**Improvements Needed**			**Capital Cost (2010 $)**	**Time Frame**
Force Main Projects		**Existing Diameter (inches)**	**Replacement Diameter (inches)**	**Length (feet)**		
FM01	Replace existing 14-in force main with a new 20- when Lake Street PS expanded.	14	20	120	$108,000	Future
FM02	Replace existing 6-inch force main with a new 8-inch force main when Harkins PS expanded.	6	8	1,140	$411,000	Future
Subtotal – Force Main Improvements				**1,260**	**$519,000**	

Table 7-1
Summary of Recommended Sanitary Sewer Improvements

Location	Description	Improvements Needed			Capital Cost (2010 $)	Time Frame
Pump Station Upgrade Projects		**Existing Firm Capacity (HP)**	**Required Firm Capacity (HP)**	**Required Total HP [3]**		
PS01	Increase the capacity of De La Torre Pump Station, replacing the two existing 5 HP with new 10 HP pumps (each new pump capacity of 500 gpm).	5	10	20	$367,000	Future
PS02	Increase the capacity of Harkins Rd Pump Station, replacing the two existing 5 HP pumps with new 15 HP pumps (each new pump capacity of 850 gpm).	5	15	30	$477,000	Future [4]
PS03	Increase the capacity of Lake Street Pump Station, replacing the three existing 30 HP pumps with new 40 HP pumps for a total station capacity of 120 HP (new pump station firm capacity of 13,500,000 gpm).	60	80	120	$897,000	Future
PS04	Increase the capacity of TP2 Pump Station, replacing the two existing 10 HP pumps with new 15 HP pumps (each new pump capacity of 600 gpm).	10	15	30	$477,000	Future
Subtotal - Pump Station Improvements				**185**	**$2,200,000**	
Total Cost - Existing Recommended Improvements					**$2,137,000**	
Total Cost - Future Recommended Improvements					**$23,669,000**	
Grand Total Recommended Improvements Cost					**$25,806,000**	

(1) Improvement L01 will be required when the portion of Bolsa Knolls outside the City, currently served by septic tanks, is connected to the system.
(2) Improvement L15 will be required before improvements L17, L18, and L20 are implemented, as L15 is downstream of the other locations.
(3) Total capacity (HP) to provide the required minimum firm capacity, with a standby pump.
(4) Harkins Rd Pump Station upgrade will be required when the future Uni-Kool Project is constructed.

The CIP projects do not include future sewers to serve future development areas, such as the North Boronda FGA. Conceptual alignments for the future major sewers to serve the North Boronda FGA are shown on Figure 7-1. In addition, Figure 7-1 shows conceptual alignments for future major interceptors to potentially serve a future expansion area to the north of the North Boronda FGA. The sewer facilities required in the new development areas will be constructed as part of the new development. The master plan provides guidance for the City on sizing of the future facilities, which would be confirmed and verified by the specific plans for the area.

7.2 Replacement/Rehabilitation Needs

The capacity improvements in Section 7.1 address the larger diameter sewers (10-inch and greater). Since 1999, the City has implemented $30 million of replacement/ rehabilitation improvements involving the larger diameter sewers. The replacement/ rehabilitation needs discussed herein focus on the smaller diameter sewers.

The City provided available information on existing sewers that require improvement due to poor condition, and other existing needs. Table 7-2 lists specific problem locations requiring pipeline/manhole improvements, as identified based on available maintenance history. These replacement/rehabilitation projects should be included as part of the City's CIP budgeting.

It is recommended that the City consider including an annual budget amount in its CIP for repair/replacement needs in general for the smaller sewers, with specific projects to be determined on a case-by-case (as-needed) basis. For example, assuming replacement of one-half to 1 mile of 8-inch sewer per year would result in an annual budget amount of $0.7 to $1.4 million.

The City is planning to conduct future condition assessments of the sewer system, e.g., video inspections, as part of its Sanitary Sewer Management Plan to meet the requirements of the Statewide General Waste Discharge Permit for Sanitary Sewer Systems. When conducted, the results of the condition assessments can be used by City staff to identify specific repair/replacement projects in future years.

Table 7-2 also includes installation of emergency bypasses at 7 pump stations, as identified by the City. The emergency bypasses would include a portable sewage pumping unit to bypass flows from the wet well to the force main, if the station pumps were not operating. A bypass may consist of a vault/standpipe with appropriate piping and valves to isolate the station pumps and re-direct flow to the portable pumping unit; with quick connect couplings for connection to the force main. The specific configuration for the bypass would be determined during preliminary/final design based on the site-specific characteristics of each pump station. The portable pumping unit could be moved from the affected pump station when needed.

Table 7-2
Sanitary Sewer System Replacement/Rehabilitation Needs

Location	*From*	*To*	*Size (inches)*	*Length (feet)*	*Replacement/Rehabilitation Need*	*Estimated Capital Cost (2010 $)*
S. Main Street	Near East Romie	To East Acacia Street	8	400	Pipeline cracked in multiple locations. Pipeline leaks into nearby P.G.&E vault. Replace/Re-line	$106,000
Adjacent to N. Main Street	Along Eucalyptus Trees	Inside Rodeo Grounds	8	400	Pipeline in poor condition. Cracks and tree roots in multiple joints from row of eucalyptus trees. Possible pipe re-line to seal joints.	$106,000
Miscellaneous Locations:						
Pajaro Street	Near intersection of Oak Street		8	50	Minor pipe repair. Dye test of storm line above the sewer resulted in dye showing up in sanitary sewer. Cause unknown. Dig and Repair.	
Lang	At Riker		8	100	Hole in bottom of pipe. Dig and repair.	
Subtotal - Miscellaneous Locations				150		$40,000
SUBTOTAL FOR ALL PIPELINE REPLACEMENT/REHABILITATION PROJECTS				950		$252,000
Pump Stations[1]:						
	Santa Rita Lake Street Mill Lake De la Torre Las Casitas Harkins Road Spicer		Emergency Bypass needed at these pump stations to bypass flows if pumps are not operating, e.g., during an emergency or pump station maintenance. The bypass would convey sewage from the wet well bypassing the existing pumps, utilizing a portable pumping unit. It is assumed that the City would have one or two portable pumping units that could be taken to the affected location(s). The cost does not include purchase of portable pumps, and assumes the portable pumping unit would be connected to the existing force main.			$2,500,000
Subtotal - Pump Station Bypasses						
TOTAL FOR ALL REPLACEMENT/REHABILITATION PROJECTS						**$2,752,000**

[1] Includes flow meter installation at all pump stations.

7.3 Types of Improvements

The sewer system capacity improvements could be accomplished by implementing either replacement or relief sewers. For CIP budgeting purposes, the costs assume that replacement sewers are implemented. When projects are implemented, more detailed alignment and predesign investigations should be conducted to determine the specific features of each project on a case-by-case basis, prior to final design and preparation of construction documents.

- Relief sewers may be constructed parallel to an existing trunk sewer, or along an alternate route designed to bypass areas which are hydraulically limited. Relief sewers may be designed as on-line or off-line systems. Relief sewers increase sewer maintenance flexibility by allowing one line to be removed from service without bypass pumping.

  - On-line relief sewers convey flows in parallel pipes, either in the same street alignment or an alternate alignment.

  - Off-line relief sewers provide temporary storage during peak flows, with the stored flow re-entering the system after the peak has passed. Off-line relief sewers can be controlled hydraulically via a fixed weir or junction box, or mechanically using a power-operated gate, valve, or other control device.

- Replacement sewers are advantageous if the existing trunk sewer is in poor condition, or if right-of-way and construction easement limitations preclude cost-effective relief sewer construction. Replacement sewer material costs are typically higher than relief sewer costs, since the replacement sewers need to be sized larger to offer equivalent capacity as parallel sewers (existing and relief). Typically, the marginal cost increase is not significant if the increase in diameter between a relief and replacement diameter is only one or two standard diameters. During construction of replacement sewers, sewer flow must be maintained, requiring special construction procedures, such as bypass pumping, which can increase costs.

For sewers in poor condition, rehabilitation could be accomplished by various methods. Non-structural repairs may be adequate if the pipe is sound, and would typically involve sealing leaking joints in pipes and manholes. Structural repairs would involve either replacement of all or a portion of a sewer line, or the lining of the sewer. These repairs could be done using typical trench excavation techniques or trenchless technologies to limit excavation.

Trenchless technologies include slip lining in which a smooth plastic liner is pulled through the existing pipe; cured-in-place pipe technologies in which a resin-soaked felt liner is placed in the existing pipe and cured in place; and fold-and-form technologies in which a heated plastic liner is folder, pulled into place and then expanded and allowed to harden. A variation of slip lining is pipe bursting, in which a bursting head is pulled through the existing pipe, bursting it, and at the same time pulling a continuous replacement pipe through the resulting hole. A benefit of pipe bursting is that it can be used to increase the diameter of the new pipe, if needed. Although slip-lining may also increase the hydraulic capacity by reducing friction losses; which may more than offset the reduced diameter due to the lining process.

Pump station improvements to increase capacity could be accomplished in several ways:

- Replacing existing pump(s) with larger pumps if the pump station piping and building are adequately sized.
- Adding an additional pump at the existing pump station building, if site investigation determines there is adequate space.
- Building a parallel (relief) facility to the existing facility if there is not adequate space at the existing facility; or
- Replacing an existing facility with a larger capacity station if the existing facility is in poor condition.

The recommended pump station projects will require site-specific evaluations during predesign and design to determine specific improvements recommendations.

Other alternatives for providing additional pump station capacity could be considered, such as the option to divert some flow from the Lake Street Station to the Carpenter Hall Station, which has excess capacity. However, the Carpenter Hall Station is at a higher elevation than the Lake Street Station. Therefore it would require pumping to lift water from the Lake Street vicinity up to the Carpenter Hall Station, which would eliminate the benefit of using the excess capacity at Carpenter Hall. A gravity diversion would have to occur further north (north of Highway 101). The feasibility of such a diversion will depend on the inverts of the two pipes, availability of right-of-way for a diversion pipe, and length/size of diversion pipe that would be required. As the diversion point moves farther north of Highway 101, the length of diversion pipe between the Lake Street upstream sewers and the Carpenter Hall upstream sewers increases significantly.

7.4 Prioritization Criteria for Phasing

The projects in Table 7-1 were grouped for implementation by timeframe: existing and buildout. Within each timeframe, the projects prioritized for implementation using the following criteria:

- Threat of overflow: the projects were ranked depending on the threat of overflow or how much freeboard remained. Freeboard is the amount of space between the water surface elevation and the ground surface.

- Flow scenario: higher priority for those projects that show capacity deficiency under peak dry weather; lower priority for projects with deficiency under average dry weather plus 10-year storm conditions.

- Impact on more than one problem area: Some projects will affect other recommended improvements because of their location; these projects are given a higher priority.

The prioritization of projects in Table 7-1 is intended to serve as a guideline for City staff in its CIP planning. City staff will review individual projects for implementation as part of the development of the City's 5-year CIPs. The specific priority for implementation of individual projects will depend on the City's needs and funding availability, as determined over time.

7.5 Basis for Capital Cost Estimates

Conceptual planning-level capital cost estimates have been developed for the recommended improvements. All costs are in 2010 dollars and indexed to a Engineering News Records (ENR) "Twenty Cities" Construction Cost Index (CCI) of 8700 (estimated average as of May 2010).

Table 7-3 shows the unit capital costs used for this master plan. The components of the unit capital costs are described below. The unit capital costs include construction costs plus a total compounded markup of 1.89 for a 35% design and construction contingency and a 40% project implementation allowance.

- Construction cost: calculated using unit construction costs based on other CDM projects and general information from public projects bid in California.
  - Unit capital costs for replacement sewers are for sewers up to an average invert depth of placement of 25 feet, including manholes and other appurtenances, and assume construction within existing streets with traffic control and normal correction of utility interferences, and potential use of trenchless construction methods in some locations.
  - Pump station unit construction costs are based on an aboveground structure with standby pump, telemetry, and standby generator for backup power.

- Design and construction contingency: markup of 35 percent of the construction cost, intended to account for additional work that may be identified during final design and bidding (25%), and change orders during construction (10%).

Table 7-3
Salinas Sanitary Sewer Master Plan
Unit Capital Costs [(1)]

Gravity Sewer Unit Cost	
Diameter (inches)	***Unit Capital Cost ($/foot)***
8	265
10	320
12	380
15	455
18	530
21	605
24	680
27	755
30	830
33	910
36	980

PUMP STATIONS (including standby pump and standby generator)		
HP	***Unit Capital Cost***	***Total Capital Cost [(2) (3)]***
	($ per HP)	***($ per station)***
20	18,330	367,000
30	15,900	477,000
40	13,470	539,000
60	11,690	701,000
80	9,540	764,000
100	8,330	833,000
120	7,522	879,000
150	6,310	947,000
200	5,520	1,104,000

(1) Unit capital costs include construction costs times 1.89 total markup for contingencies (35% of construction cost) and project implementation (40% of total construction cost with contingencies). Unit costs are in 2010 dollars, ENR CCI of 8700 for “Twenty Cities”.

(2) Costs for pump station upgrade projects shown in Table 7-1 are based on replacement of the total capacity needed to meet future flow requirements, and assume stations will be replaced when upgraded, to provide flexibility in project implementation. Pump station costs are based on total required HP, including standby pump.

(3) For estimating pump station replacement improvements, the following percentages of the total cost for a new pump station may be used as approximate estimates: pumps and motors – 20%; pump (no motor) – 5%; electrical/instrumentation – 30%; pipes, fittings, valves – 20%; building and site work – 20%.

- Project implementation allowance: allowance of 40 percent of the total construction cost (construction cost plus construction contingency) to cover the following items:
  - Feasibility and/or siting/routing studies (4%)
  - Preliminary and final design engineering, preparation of construction plans and specifications (12%)
  - Environmental documentation and permitting (4%)
  - Construction services including construction management, construction inspection, engineering support during construction, construction surveying, and as-built drawings (10%).
  - City overhead, legal and administration (10%).

No land costs are included. It is assumed that all improvements will be constructed within existing rights-of-way or City-owned site.

Appendix A

Hydraulic Model Software Evaluation – Technical Memorandum

CDM

Technical Memorandum

To: *Carl Niizawa, City of Salinas Deputy City Engineer*

From: *Youssif Hussein, Lisa House*

Date: *August 31, 2007; Revised November 2007*

Subject: *Salinas Sanitary Sewer System Master Plan*
Task 2 - Evaluation of Hydraulic Modeling Software

The purpose of this memorandum is to summarize the results of CDM's Task 2 review of available hydraulic modeling programs and to recommend the most appropriate sewer system hydraulic model for use in developing the Sanitary Sewer System Master Plan and continued use by City staff after completion of the master plan.

A HYDRA model of the sewer system was originally developed for the 1998 Master Plan, and has been used for recent analyses conducted for the Northern Future Growth Area. The City's stormwater model is also in HYDRA.

After the City's review of the model rankings and recommendations presented herein, CDM arranged for a demonstration of the following top two modeling packages for the City: 1) InfoSewer (semi-dynamic model); and 2) InfoSWMM (fully dynamic model). Subsequent to the demonstration, the City selected InfoSewer for the master plan. The City selected the InfoSewer model, as it is easier to learn and use than the fully dynamic model, and conservatively estimates flows while still providing full analysis capabilities for the elements of concern to the City. The City preferred a conservative approach for the analysis to provide some cushion for future uncertainties.

The following topics are addressed herein:

- Purpose of Memorandum
- Modeling Objectives
- Model Evaluation Criteria
- Available Sewer Modeling Software
- Key Evaluation Findings and Model Rankings
- Recommendation
- Appendix: Detailed Descriptions of Model Software

Modeling Objectives

Determining the City's objectives for using the model is the first step towards identifying the best software to meet the City's needs. This section discusses the City's objectives as discussed at the kickoff meeting and potential uses of the model.

The City wants the following from a modeling package:

- Easy to learn and use
- Flexible and easy to use tool to answer questions from developers. The City will use the model to run scenarios for developers requesting service.
- Ability to allow the City to expand the model database in the future to add 8-inch and smaller lines to GIS and mapping, and then import into the model. The City's ultimate goal is to have comprehensive up-to-date maps of all the sewer facilities.
- In the future, the City may want use the software to set up a simple model and analyze the industrial wastewater system.
- Compatibility with the City's GIS platform, ESRI ArcGIS.
- Ability to easily communicate with the City's design software (AutoCAD Civil 3D).
- Capability of updating the software as technology changes.

In general, hydraulic models may be used to support a diverse array of uses including:

- Facilities master planning and capital improvement program planning
- Planning and evaluation of repair/rehabilitation projects
- Evaluation of development improvements
- Evaluation of potential hydrogen sulfide generation and corrosion issues
- Linkage to maintenance management databases

Model Evaluation Criteria

Models were selected for evaluation based on the modeling objectives discussed earlier. The following criteria were considered in the evaluation:

- Software Vendor Stability and Technical Support
  - Vendor stability
  - Technical support

- Ease of Use
  - Level of effort required to input and modify source data
  - Ease of calibrating model to flow monitoring data

  - Ease of analyzing proposed changes to existing system or proposed development improvements (steady state analysis ability, ability to easily isolate and analyze small areas)
  - Graphical presentation and GIS capabilities
  - Compatibility with City's GIS platform

- Model Capabilities
  - Solution(routing) technique (static or steady-state, dynamic, and/or ability for either mode)
  - Ability to generate base sanitary flow and inflow/infiltration flows
  - Ability to model conduits in both open-channel (free surface or full pipe) and pressurized pipe flow conditions
  - Ability to handle surcharged conditions and predict sewer overflow locations and volumes
  - Ability to model structures/manholes with weirs, diversions or multiple outlets
  - Ability for real-time control analysis

- Other Features for Flexibility in Future Uses
  - Ability to model flow equalization basins (or detention basins for stormwater systems)
  - Ability to predict hydrogen sulfide generation and impacts
  - Ability to link to maintenance management software
  - Ability to link to other software, such as AutoCAD Civil 3D

A key model feature is the solution technique for routing flows through the sewer system. There are two basic types: static (or steady state) models and dynamic models.

Static (steady state) models estimate hydraulic conditions at a specific point in time (usually peak flow). Static (steady state) models require only that the upstream boundary condition (flow input) be described, and they are typically easier to understand and use. Dynamic routing models have the ability to describe the elevation of the hydraulic grade line over time as flow conditions change, and require information on both upstream and downstream boundary conditions. Dynamic models provide a more accurate analysis of the relative timing of peaks from multiple network branches and complex hydraulic conditions. However, dynamic models are significantly more complicated to set up and use than static (steady state) models.

Available Sewer Modeling Software

The term "model" has come to be used in several ways. "Model" can refer to the program code that solves the various algorithms that describe the modeled processes; this is often (and more precisely) referred to as the "model engine". "Model" can also be used to refer to the datasets that comprise the unique values for each modeled parameter associated with each modeled element (e.g. pipes, catchments, unit flow rates). During the past few years, the term "model" has also been used to describe the software developed to take advantage of modern microcomputer advances and combine sophisticated graphical interfaces and other support tools (e.g. relational databases) with the program code. In the model evaluation described herein, the complete modeling package is considered.

Five modeling packages were evaluated for this project as called for in the scope of work. The models considered are based on CDM's knowledge of the currently available models, and on the objectives discussed earlier in this memorandum.

All the models evaluated have an established user base and application history for large sewer modeling projects, and an established entity for user support. This helps ensure product reliability, and eliminates research-oriented models with little or no practical application history and no viable user support mechanisms. The modeling packages considered are listed below:

- **HYDRA** - Stand-alone modeling package developed by Pizer Inc. The City's current sanitary sewer and stormwater models are in HYDRA Version 6.0. This GIS package includes a proprietary hydraulic engine for steady-state (static) analysis, and an EXTRAN (Extended Transportation Analysis) module that is part of EPA's Stormwater Management Model (SWMM) for dynamic analysis if desired. This is a stand-alone package with built-in proprietary GIS tools, i.e., it cannot be directly linked to the City's GIS system, although information can be transferred by shape files.

- **InfoSWMM** – GIS-based modeling package created by MWH Soft. This package uses EPA's Stormwater Management Model (SWMM) as its hydraulic engine which has been in use since the 1980's. This software package works within an ESRI Arc-GIS environment, which is the City's GIS platform, providing direct linkage between the model and the GIS.

- **InfoSewer** – GIS-based modeling package that is a simplified version of InfoSWMM, and also works within an ESRI ArcGIS environment. InfoSewer provides more simplified routing solutions than InfoSWMM, and is less complicated to use. (Note: H2OMap Sewer is similar to InfoSewer, except H2OMapSewer includes stand-alone GIS tools while InfoSewer operates within a GIS platform.)

- **Sewer Cad/SewerGEMS** – Stand-alone modeling package with GIS tools developed by Haestad Methods. Haestad's SewerGEMS is the most recent version of SewerCAD, which provide fully dynamic modeling capability. SewerCAD was created to work within AutoCAD, Sewer GEMS works within a GIS environment.

- **XP-SWMM** – Stand-alone modeling package developed by XP Software. This package uses the EPA hydraulic engine from the Stormwater Management Model (SWMM). This package has stand-alone GIS tools utilizing shape files that are similar in look and feel to ArcGIS, but cannot be directly linked to the City's ArcGIS system.

Detailed descriptions of each of the above modeling packages are provided in the Appendix to this memorandum.

There are many other available modeling packages that were not evaluated. For example, proprietary steady-state models have been developed for specific applications, such as an agency-specific model, which do not have widespread use or support. There are also complex dynamic modeling packages, such as the InfoWorks Collection System (CS), a product of Wallingford Software of England, and MIKE-URBAN with MOUSE, a product of the Danish Hydraulic Institute (DHI of Denmark), that are very complicated to use.

Key Evaluation Findings and Rankings

This technical memorandum evaluates several hydraulic models with respect to their appropriateness for use in this master plan and subsequently by the City. The key factors considered in the evaluation include: software vendor stability and technical support; ease of use; modeling capabilities; and flexibility for future uses.

All the model vendors provide websites for customer service and technical support. MWHSoft and Pizer are located on the west coast; the other vendors are headquartered on the east coast or overseas. InfoSWMM and InfoSewer are supported by MWHSoft, a company well known for their high quality customer support and technical products, with offices in Arcadia California (Operations Center) and Broomfield Colorado (Headquarters). HYDRA is supported by the Pizer office in Seattle, Washington, a family business in operation since the 1980's. The XP-SWMM vendor is headquartered in Australia, with offices in Portland Oregon and Ontario Canada. The SewerGEMS vendor is now Bentley who recently purchased Haestad Methods, with an office located in Watertown Connecticut. Due to the recent change in ownership, the SewerGEMS vendor not as well established as the other vendors.

All of the models evaluated can accept either fixed inflows or input hydrographs, and all can simulate both base flows and infiltration/inflow. All the models evaluated are GIS-based. InfoSWMM and InfoSewer operate within an Arc-GIS platform, which is the City's GIS and can be directly linked to the model which simplifies data transfer. HYDRA and XP-SWMM, are stand-alone model packages with built-in GIS tools, and cannot be linked directly to the City's GIS, although information can be transferred in the form of shape files. SewerCAD is stand-alone, while the SewerGEMS version can work within an Arc-GIS platform.

InfoSWMM and XP-SWMM utilize the Stormwater Management Model (SWMM) as its hydraulic engine. SWMM was initially developed by EPA in the 1970's and has been continually in use since that time, undergoing numerous upgrades and being tested by many users/projects. HYDRA uses a proprietary hydraulic engine developed by Pizer for steady state analysis, and the SWMM EXTRAN module for dynamic analysis. SewerGEMS (Haestad) uses a proprietary hydraulic engine developed by the individual vendor.

All the models evaluated except InfoSewer are fully dynamic and solve the complete St. Venant's equations in routing flows, which provides a more accurate simulation of backwater, surcharge, and flow diversions in branched and looped sewer systems. InfoSewer is a "semi-dynamic" model that uses a simplified method to simulate peak flow damping effects throughout the system, but does not provide the more detailed solution for the complete dynamic routing equations as in the fully dynamic models. InfoSWMM and HYDRA have the flexibility to provide both dynamic and steady-state analyses.

InfoSewer is the easiest modeling package to learn, set-up, and use. The other fully dynamic models are much more complex and complicated to use, since the data setup and model calculations required for a fully dynamic model are commensurately more complex.

Table 1 provides cost comparisons for the modeling software. These costs assume one seat license with unlimited links. These costs include all discounts available to CDM. Typically there are no maintenance costs for the first year of operation.

Table 1
Cost Comparison of Modeling Software

Models	***User (1-seat) License Cost (1)***	***Annual (1-seat) Maintenance Cost (2)***
HYDRA (Pizer)	$5,000	$1,250
InfoSewer (MWHSoft)	$14,000 - $15,000 (3)	$1,000
InfoSWMM (MWHSoft)	$18,000	$2,000
SewerGEMS (Haestad/Bentley)	$14,000	$3,600
XP-SWMM (XP Software)	$21,000	$3,200

(1) License costs are list price for one seat license with unlimited links.
(2) Annual maintenance cost typically start in the second year (the first year of purchase has no maintenance cost).
(3) The standard InfoSewer package is $14,000. The PRO version that allows modeling of runoff hydrographs for stormwater system analysis is $15,000. The City could either purchase the PRO version immediately or wait and upgrade to the PRO version in the future when the stormwater master plan is updated.

Based on the evaluation, the modeling packages are ranked as shown in Table 2 from most favorable, i.e., that meets the most requirements, to least favorable, i.e., that meets the least requirements.

Table 2		
Model Evaluation Rankings		
Ranking	***Model***	***Basis for Ranking***
1 – Most Favorable	InfoSewer	Best meets City's objectives/requirements. See recommendation section below for a detailed discussion of the reasons for selecting InfoSewer.
2	InfoSWMM	InfoSWMM offers all of InfoSewer's capabilities plus more, and is fully integrated with ArcGIS. However, it is a fully dynamic model which would be significantly more complicated to setup and use than InfoSewer; although it does offer a higher level of accuracy in modeling due to its dynamic modeling capabilities. This package was ranked second due to the City's objectives of ease of use and conservative analysis.
3	HYDRA	City's sanitary and storm models are already in HYDRA, lowest cost, can operate in steady state mode only as well as dynamic. Major drawbacks: not integrated within ArcGIS although can transfer information using shape files, not as easy to use as InfoSewer, more limited user base and breadth/depth of software support.
4	SewerGEMS	Highest annual maintenance cost, no advantages over InfoSWMM, vendor recently changed ownership so track record of new owner not well established.
5 – Least Favorable	XP-SWMM	Highest initial purchase cost and second highest annual maintenance cost, no advantages over InfoSWMM, not integrated with ArcGIS.

CDM's contract scope calls for CDM to demonstrate or arrange to have demonstrated up to two modeling packages for the City. It is assumed that the InfoSewer and InfoSWMM models will be demonstrated, since they are the two top ranked models. MWHSoft will conduct the demonstration with CDM in attendance, so that City staff can have their questions answered directly by the vendor. We would like the City's input on the model rankings and the software that the City would like to have demonstrated.

Recommendation

It is recommended that InfoSewer be selected for the following reasons:

Ease of Use. InfoSewer, as a semi-dynamic model, is the easiest modeling package to learn and use, while providing significant modeling capabilities.

Ability to Analyze Developer Improvements and Proposed Changes in the Sewer System. InfoSewer is the simplest modeling package for analysis of such items as proposed changes to sewers, e.g., pipe size changes due to replacement/improvement projects, adding a sewer extension, sizing new pipes to serve new development areas, or determining the impact on downstream facilities from adding a new sewer inflow.

Ability to Easily Analyze Portions of System. With InfoSewer, it will be possible to easily isolate and analyze portions of the system, such as proposed development areas, without requiring simulations to be performed on the entire system.

Conservative Hydraulic Analysis for Pipe Sizing. InfoSewer's "semi-dynamic" routing will provide a somewhat conservative analysis of the system based on peak flow conditions and a simplified method for peak flow routing and attenuation. A more detailed fully dynamic routing analysis that would be possible with a fully dynamic model may allow for some downsizing of improvements by more accurate analysis of flow attenuation effects in large systems. However, as discussed at the kickoff meeting, a somewhat conservative approach for pipe sizing will provide more flexibility to handle future uncertainties in development patterns and flows.

Built-in Tools to Simplify Data Input and Analysis. InfoSewer provides built-in tools and features to help simplify data input and analysis, as described in the detailed description in the appendix.

Compatibility with ArcGIS and AutoCAD Civil 3D. InfoSewer operates completely within the ArcGIS environment, so will be fully compatible with the City's objectives of integration with other City software and future expansion of the database to include all sewer facilities.

Flexibility for Future Uses. With InfoSewer, the facilities database can be easily expanded to add all sewer facilities in the future and can be linked to future software, such as maintenance management software. InfoSewer also can be used to predict hydrogen sulfide generation and corrosion potential. InfoSewer can also be used for the industrial wastewater and stormwater systems. The current HYDRA model of the City's stormwater system could be converted to InfoSewer (PRO version) in the next stormwater master plan update.

Vendor Support. MWH Soft has a very good reputation for customer service and software support. On the many projects that CDM has used MWHSoft products, the technical support has been very good and responsive.

Cost. InfoSewer is a reasonably priced package compared with the others for both initial purchase and annual maintenance. HYDRA is the lowest cost of those evaluated, but does not provide the ease of use and GIS integration compatibility that InfoSewer does. HYDRA also does not have as large an established user base and breadth/depth of company technical support as does InfoSewer.

CDM

APPENDIX

Detailed Descriptions of Models

HYDRA

InfoSewer

InfoSWMM

SewerCAD/SewerGEMS

XP-SWMM

HYDRA

HYDRA consists of several modules for the hydrologic and hydraulic analysis of sewer systems. It is a proprietary package developed and distributed by Pizer, Inc. The modules include a graphical interface to prepare data for analysis and view analysis results, a hydraulic analysis engine to perform the hydrologic and hydraulic computations, and a GIS tool to facilitate graphical data transfer between AutoCAD and HYDRA.

The current version of HYDRA is Version 6.4. The City's current sanitary sewer and stormwater models were created in HYDRA 6.0. If this model package is selected, the City will need to upgrade to the current version.

Model Development

HYDRA is used to develop link-node and spatially distributed models that are used for analysis, design and simulation of both wastewater collection and storm drainage systems. HYDRA includes stand-alone CAD and GIS tools that allow the user to create and modify the network interactively on the screen using a mouse and graphic tools.

HYDRA has data input checking tools to prevent incorrect or inconsistent network structures or data from being created. It supports importing backgrounds, a variety of file types including AutoCAD and ArcView coverages. HYDRA also has tools to facilitate model building by using data from other previous projects, other models and external sources.

Modeling Capability

HYDRA offers the following features for analysis of municipal sewer systems:

- Sanitary sewer flows – Tools to organize data and estimate flows using a variety of methods including land use characteristics, service area basins, and parcels. Flows are then loaded into the conveyance system on a pipe by pipe basis.

- Stormwater runoff – Flexible tools to simulate rain events, both for design storms and actual storms, including intensity-duration-frequency curves, rain gauges, radar data, or synthetic rain events. There are three methods available to calculate storm runoff.

- Infiltration and inflow (I&I) – HYDRA tracks each type of flow separately through the collection system, including sanitary flow, groundwater infiltration, rainfall-derived infiltration, and stormwater inflow. I&I can also be simulated for actual rain events.

- Hydraulic analysis for either steady-state (static) peak flow conditions or dynamic analysis using an add-on module, as described further below.

- System design – In addition to modeling existing pipelines, HYDRA is able to design (size) new sewers and provide construction cost estimates. The user provides basic design criteria, such as allowable depth of flow and allowable velocities, and the program automatically finds an optimal solution for the conditions.

- Worst-case scenario analysis – HYDRA can shift the timing of the storm so that the peak sanitary flow coincides with the maximum peak storm flows, in order to simulate worst case conditions for wet weather flows.

HYDRA's basic hydraulic engine performs a steady-state (static) analysis. It uses a simple technique of routing hydrographs through a system and computes a hydraulic grade line for the peak flow condition encountered. The basic engine is not dynamic, in that the equations of continuity and momentum are not solved and hydraulic grade lines are computed statically (at one point in time). HYDRA has features to perform backwater calculations and generate hydraulic gradeline profiles. Storage, such as equalization or detention basins, can be modeled using a user-specified volume-discharge curve.

There is an optional add-on module that allows HYDRA users to model portions of the sewer collection system with SWMM EXTRAN. This SWMM EXTRAN module can be used for dynamic analysis of portions of the system where there are extensive overflows or surcharging in the system. Therefore, HYDRA can function as either a steady-state (static) model only and/or as a dynamic model for those portions of the system analyzed with the SWMM EXTRAN module.

Results/Output Features

The HYDRA package includes an AutoCAD software add-on tool called GISMaster to create and edit drawings for use with HYDRA. HYDRA provides a variety of tabular reports, graphics and other output formats. Exampled of pre-formatted results reports include system summary report, existing pipe report, and pump report. The individual user can also create customized report formats by exporting HYDRA input and results data into an external spreadsheet, database or report program.

GIS Integration

HYDRA is a stand-alone product which exchanges data with standard GIS and CAD programs. Graphical data and associated records can be exchanged using:

- Shapefiles (.SHP/.DBF) – exchange data with ESRA products including ArcGIS, ArcView, ArcInfo and others.

- Drawing Exchanges Files (.DXF) – Exchange data with AutoDesk products including AutoCAD and AutoDeskMap, as well as other CAD programs.

Data from external sources is mapped to specific HYDRA database fields, and then can be manipulated within HYDRA.

InfoSewer

InfoSewer, developed by MWH Soft, is a fully ArcGIS integrated, comprehensive hydrologic, hydraulic, and water quality simulation model for management of wastewater collection and urban storm water systems. It is built atop ESRI ArcGIS using the latest Microsoft .NET and ESRI ArcObjects component technologies. The minimum system requirements to run this model are a Pentium II 450 MHz or equivalent CPU, 128 MB RAM (256 MB recommended).

Model Development

InfoSewer is integrated within the ArcGIS environment allowing for unique access to GIS data sources. InfoSewer models can be developed using a variety of different sources. For example, network components can be directly imported from an ArcGIS, ARC/INFO, or MapInfo GIS, or can be interactively created using a mouse by pointing and clicking. Scanned TIFF or BMP aerial images or maps, or DXF maps of streets, parcels, and buildings can be displayed as a background image, which would allow the digitizing of a network model and confirmation of the network layout. InfoSewer has data exchange functionality that allows data import and export in multiple formats that are compatible with GIS, CAD, and spreadsheets.

InfoSewer's GIS Gateway tool provides functionality to create and manage Exchange Clusters. This technology stores model development rules for future use. Once the user creates an Exchange Clusters it can be reused. This technology supports existing workflows and existing databases, rather than forcing a new workflow or database on the user.

InfoSewer provides a comprehensive set of tools for thoroughly evaluating data in the model. The range of tools includes geometry checks (overlapping nodes, missed connections, pipe split candidates, etc.), object checks (orphan nodes, orphan links, etc.), tracing (trace upstream, trace downstream), engineering validation (invalid pump curve, etc.), network reviews (short pipes, incorrect slopes), and many more. All of these tools show results graphically.

InfoSewer can model many separate systems within the same model. It can activate and deactivate network objects--enabling a single project file to include any number of different systems—gravity systems, force mains, receiving streams, and treatment plants. Model runs for these can be maintained separately and/or combined.

InfoSewer has a set of extendable information tables that can host any amount of data for each pipe, manhole, pump, etc. It is possible to manage asset data utilizing this feature. Furthermore, these fields can be installed to maintain data quality or data source fields.

InfoSewer provides other useful tools to simplify model development including:

- Load Allocator calculates dry weather loading rates based on water usage billing records, landuse planning, zoning, population and/or buildout information.
- Detailed engineering reviewer to ensure data consistency with expected engineering values based on engineering standards or any user-defined set of validation rules
- Comprehensive network auditor to validate proper connectivity and report missing data
- Provides automated adverse slope correction
- Automatically identifies inappropriate flow circulating loops (cycles)
- Automatically calculates pipe invert elevations from pipe slope data
- Automatically evaluates invert data at manholes to locate out-of-tolerance drops

Modeling Capability

InfoSewer is a link-node based model that performs hydraulic and water quality analysis of wastewater collection systems. Typical applications of InfoSewer include predicting locations of sanitary sewer overflows (SSO), open and closed conduit flow analysis, design of new site developments, analysis of existing sanitary sewer systems, and infiltration and inflow (I/I) assessment.

InfoSewer provides steady-state analysis using various peaking factors and automated system design, along with simplified solutions of the St. Venant's equations considering flow attenuation. The InfoSewer Pro package provides rainfall-runoff modeling (runoff hydrograph generation using several methods) for routing of combined sanitary and/or stormwater flows through the collection system.

InfoSewer modeling features include:

- InfoSewer models both dry weather and wet weather flows, and analyzes sanitary, storm and combined sewers. InfoSewer Pro can generate storm runoff hydrographs and peak flows from design rainfall using several methods.
- Supports various methods of loading conditions including contributing population, service area, peakable or unpeakable flows, or any other user-defined loading types. Considers multiple loading categories at any manholes, each with its own pattern of time variation (e.g. hydrographs).
- Accounts for infiltration/inflow effects using several methods including: count-based (e.g., defect-based), pipe surface area-based, pipe length-based, and pipe diameter length-based.
- Accommodates multiple outlets, supports any number of loops and parallel pipes, models flow-splitting (bifurcation) diversions.

- Performs steady-state and extended period (dynamic) simulations, simulates unsteady flow conditions. Analyzes both pressurized (force mains) and partial (free surface) flow conditions; uses the Hazen-Williams (pressure) and Manning (open channel) friction formulas; accounts for local headlosses for manholes and junctions.

- Peaks flows with commonly used peaking equations using flow based and population based peaking curves. Simulates complex flow (hydrograph) attenuation (peak flow damping effect) throughout the collection system using advanced Muskingum-Cunge explicit diffusion (dynamic) wave model. It implements a dynamic flow routing model based on the industry standard Muskingum-Cunge explicit diffusion wave algorithm (a simplified form of the full one-dimensional Saint Venant equations neglecting inertial terms) to accurately track spatial and temporal variation of sewage flows throughout collection system.

- Carries out accurate HGL calculations under surcharge conditions, models surcharges, satisfies conservation of mass during a surcharged extended period simulation.

- Pumping facilities: Allows multiple series and parallel pumps and lift-stations to be modeled using capacity flow (pump or wet-well capacity), two-point design flow exponential curve, or multiple (3 points) head-flow pump characteristic curve ; models constant speed pumps; models variable speed pumps (fixed flow pumps) - pump speed is automatically adjusted to meet user specified targeted discharge flow; controls on-off status of pumps based on time or wet well levels/volumes; allows for both constant diameter or variable area wet-wells at pump stations.

- Automatically designs the entire network based on user specified system performance criteria (e.g., depth-of-flow to diameter ratio, minimum and maximum velocities); calculates sanitary sewer network replacement/improvement costs.

- Models any number of system conditions and compare them graphically, generates animated profiles, creates graphs of time-varying network parameters (velocity, flow, etc.). Automatically compares multiple scenarios to instantly identify and review differences in input data sets, ability to view model results from multiple simulations

- Calculates the age of sewage (time of concentration throughout a network.

- Ability to model hydrogen sulfide buildup and corrosion potential in sewer systems.

- Models deposition and transport of sediments with time throughout the sewer collection system

Results/Output Features

InfoSewer's graphical capability includes horizontal plan plots, profile plots, and time series plots; viewing animated extended period simulation (dynamic) results sequentially using

VCR style controls directly in ArcGIS; and generating contours, graphs, and tables of modeling results within ArcGIS. Output results for pipes can be plotted with variable pipe widths and nodes with variable radius to identify those areas of the network experiencing the most surcharge, flow, pollutant concentration, etc.

GIS Integration

InfoSewer offers direct ArcGIS integration enabling engineers and GIS professionals to work simultaneously on the same integrated platform. It provides a GIS analysis and hydraulic modeling in a single environment using a single dataset. InfoSewer allows you to create, edit, modify, run, map, analyze, design and optimize sewer network models and review, query and display simulation results from within ArcGIS.

Since InfoSewer built atop of ArcGIS, it takes advantage of its capabilities and functionality. As an ESRI business partner and certified by the National Association of GIS Centric Software (www.nagcs.com), InfoSewer is always current with latest versions of ArcGIS.

InfoSWMM

InfoSWMM, developed by MWH Soft, is a fully ArcGIS integrated, comprehensive hydrologic, hydraulic, and water quality simulation model for management of wastewater collection and urban storm water systems. It is built atop ESRI ArcGIS using the latest Microsoft .NET and ESRI ArcObjects component technologies.

Model Development

InfoSWMM is integrated within the ArcGIS environment allowing for unique access to GIS data sources. InfoSWMM models can be developed using a variety of different sources. For example, network components can be directly imported from an ArcGIS, ARC/INFO, or MapInfo GIS, or can be interactively created using a mouse by pointing and clicking. Scanned TIFF or BMP aerial images or maps, or DXF maps of streets, parcels, and buildings can be displayed as a background image, which would allow the digitizing of a network model and confirmation of the network layout. InfoSWMM has data exchange functionality that allows data import and export in multiple formats that are compatible with GIS, CAD, and spreadsheets.

InfoSWMM's GIS Gateway tool provides functionality to create and manage Exchange Clusters. This technology stores model development rules for future use. Once the user creates an Exchange Cluster it can be reused. This technology supports existing workflows and existing databases, rather than forcing a new workflow or database on the user.

InfoSWMM provides a comprehensive set of tools for thoroughly evaluating data in the model. The range of tools includes geometry checks (overlapping nodes, missed connections, conduit split candidates, etc.), object checks (orphan nodes, orphan links, etc.), tracing (trace upstream, trace downstream), engineering validation (orifice setting too large, invalid pump curve, etc.), network reviews (short conduits, incorrect slope), and many more. All of these tools show results graphically.

InfoSWMM can model many separate systems within the same model. It can activate and deactivate network objects--enabling a single project file to include any number of different systems—gravity systems, force mains, receiving streams, and treatment plants. Model runs for these can be maintained separately and/or combined.

InfoSWMM has a set of extendable information tables that can host any amount of data for each pipe, manhole, pump, etc. It is possible to manage asset data utilizing this feature. Furthermore, these fields can be installed to maintain data quality or data source fields.

InfoSWMM offers many useful tools including:

- Dry Weather Flow Allocation calculates dry weather loading rates based on water usage billing records, land use planning, zoning, population and/or build out information.

- Subcatchment Manager can directly import or graphically create subcatchment boundaries utilizing TIN, raster, grid, point or vector feature classes. This provides a geographical representation of the contributing area for each manhole and allows automatic calculation of the total area, impervious area, soil types, water quality buildup and washoff functions. This feature provides significant time savings when compared with the manual process.

- Calibrator uses genetic algorithm optimization to automatically adjust sewer parameters to match any combination of flow, depth, and velocity measurements. Parameters can include any combination of subcatchment, soil, aquifer, RDII, and conduit properties.

- Designer uses genetic algorithm optimization to automatically determine the most cost-effective combination of pipe slope and size, storage volume, pumping capacity and new piping to best convey sewer flows without surcharging, overflows, flooding, and backups.

- Risk Assessment Manager can automatically compute the extent of sewer overflows and flooding (volume and reach), calculate population at risk, pinpoint sources overloading the system, locate system capacity limitations and blockages, and estimate property damage costs. Overland flow pathways can also be quickly examined, showing the lateral routes and spreading of floodwaters.

- Conduit Storage Synthesizer accurately determines storage capacity in a conduit network (stage storage relationship) based on a dynamic analysis of the wastewater system volume under changing heads when analyzing large and complex gravity-pumped systems.

Modeling Capability

InfoSWMM is a link-node based model that performs hydrology, hydraulic, and water quality analysis of wastewater and storm water systems, including sewage treatment plants and water quality control devices. Typical applications include predicting combined sewer overflows (CSO), sanitary sewer overflows (SSO), interconnected pond analysis, open and closed conduit flow analysis, design of new site developments, analysis of existing storm water and sanitary sewer systems, infiltration and inflow (I/I) assessment, and real time control (RTC) operational studies.

InfoSWMM utilizes the EPA SWMM 5 hydraulic engine. The engine solves the complete St. Venant (dynamic flow) equations throughout the drainage network and includes modeling of backwater effects, flow reversal, surcharging, looped connections, pressure flow, tidal outfalls, and interconnected ponds. Flow can also be routed through a variety of different storage elements, such as detention ponds, settling ponds, and lakes.

Key additional modeling tools include:

- Ability to model hydrogen sulfide buildup and corrosion potential in sewer systems.
- Continuous Simulation Module for detailed, continuous modeling of the complete land phase of the hydrologic cycle which allows for continuous, long-term analysis to look at periods of both wet and dry weather, as well as inflows and infiltration to the sewer network.
- An advanced RTC rule that could be used to effectively simulate the operation of pumps and flow regulating structures such as weirs, orifices, and outlets. Unlike Simple Controls, RTC rules allow for the creation of multiple conditions to be satisfied before a control action is performed. Each regulator or pump operates under the control logic encapsulated into a set of simple logical rules and control functions.

Results/Output Features

InfoSWMM's graphical capability includes horizontal plan plots, profile plots, and time series plots; viewing animated extended period simulation (dynamic) results sequentially using VCR style controls directly in ArcGIS; and generating contours, graphs, and tables of modeling results within ArcGIS. Output results for pipes can be plotted with variable pipe widths and nodes with variable radius to identify those areas of the network experiencing the most surcharge, flow, pollutant concentration, etc. Statistics Manager can summarize entire model runs for just about any output parameter, like total outfall volumes, total flood volumes, maximum flood levels, etc.

GIS Integration

InfoSWMM offers direct ArcGIS integration enabling engineers and GIS professionals to work simultaneously on the same integrated platform. It provides a GIS analysis and hydraulic modeling in a single environment using a single dataset. InfoSWMM allows you to create, edit, modify, run, map, analyze, design and optimize sewer network models and review, query and display simulation results from within ArcGIS.

Since InfoSWMM built atop of ArcGIS, it takes advantage of its capabilities and functionality. As an ESRI business partner and certified by the National Association of GIS Centric Software (www.nagcs.com), InfoSWMM is always current with latest versions of ArcGIS.

Sewer CAD/Sewer GEMS

Sewer CAD/Sewer GEMS was developed by Haestad Methods, a Connecticut based firm that is best known for Cybernet/WaterCAD, water distribution modeling software. Haestad Methods was recently purchased by Bentley. Sewer GEMS is the most recently released version.

Sewer CAD/Sewer GEMS can be run using a stand-alone Windows interface or directly inside AutoCAD or ArcGIS. Projects can be completed in the exact same fashion, whether through the Stand-Alone graphical editor or the graphical user interface is used.

Model Development

Networks can be digitized in Sewer CAD directly to scale if there is a DXF background base map or schematically. Scaled and schematic sections in the same project can be mixed and matched, which can be convenient in tight areas of a drawing (such as at pump stations or other complicated piping areas). A network can be imported from various sources: databases and spreadsheets, including Jet (Microsoft Access), dBase, Paradox, BTrieve, FoxPro, Excel, and Lotus; or use ODBC to connect to Oracle, SQL Server, and other popular database applications, AutoCAD, AutoCAD Land Development Desktop / Civil Design (LDD/CD) and ArcView. Sewer CAD can handle different unit systems, different data types, and multiple data sources. Another useful feature of Sewer CAD is the ability to undo and redo an unlimited number of actions.

Model Capability

Sewer CAD allows for the development and computation of sanitary loads and simulation of the hydraulic response of the entire system including gravity collection piping and pressure force mains. It is capable of analyzing pressure or partial (free surface) flow conditions automatically, including transitions. Gravity-based hydraulic grade lines are calculated using standard-step gradually varied flow algorithms. Using these algorithms, Sewer CAD solves for subcritical, critical, and supercritical conditions, even for complex composite profiles.

Sewer CAD's comprehensive Scenario Manager and wizards enables the tracking of design alternatives and multiple "what-if" conditions. Scenario management can be used to see how the system reacts to different conditions, including all of the extended modeling capabilities. Errors in data entry can be minimized with scenario management's full data inheritance. This allows for changes to be made easily, and lets the changes cascade through the inheritance tree. This is called a parent-child relationship: if a part of the system changes, just revise the appropriate "parent" data and let the "children" automatically update to reflect the change.

Sewer CAD features comprehensive design capabilities for sizing and locating sewer system pipes on either a system-wide or pipe-by-pipe basis. Any number of separate sanitary sewer networks can be combined into a single project file.

SewerGEMS gives users the ability to have the option of performing fully dynamic simulations with either the SWMM algorithm or the implicit solution of the full Saint-Venant equations.

Results/Output Features

For results presentation, a sequence of pipes can be selected to profile for elevation, hydraulic grade, pressure, etc. Hydraulic bottlenecks in the system can be pinpointed and possible locations for pump installations can be selected. Profiles can be generated from any manhole or junction chamber in the system. Input and output data from different scenarios can be compared with tools like comparative annotation. Sewer CAD has recently added animated profiles that show the changes to the hydraulic grade line over time.

GIS Integration

Sewer CAD/Sewer GEMS allows for sewer networks to be built and maintained directly inside ArcInfo or ArcView and native GIS commands can be used to manipulate data. If changes are made to the network in Sewer CAD, the Synchronize Shape File function in the Shapefile Connection Wizard will automatically update the linked network contained in ArcView and vice versa. Sewer CAD can function as stand-alone software or can work directly within ArcGIS.

XPSWMM

XPSWMM is a product of XP Software. XP software has its headquarters in Australia and offices in Portland, Oregon, and Ontario Canada. XPSWMM is fully dynamic model, integrates SWMM modeling concepts into a comprehensive modeling and data management system. XPSWMM is a stand-alone interface that has a similar look and feel to ArcGIS

Model Development

XPSWMM is used to develop link-node and spatially distributed models that are used for analysis, design and simulation of storm and wastewater systems. XPSWMM's graphical environment allows the modeler to create and modify the network interactively on the screen using a mouse and graphic tools. It has graphical wizard guide through a range of optional data. It has a data input checker to prevent incorrect or inconsistent network structures or data from being created. It supports importing backgrounds, a variety of file types including AutoCAD, Image Files and other ArcView coverages. XPSWMM also contains a variety of tools to jump-start model building by using data from other previous projects, other models and external sources.

Model Capability

XPSWMM simulates the complete hydrologic cycle in rural and urban watersheds. Including single or multiple rainfall events and dry weather flows, it models through collection, conveyance and treatment systems to the final outfalls. XPSWMM can generate flow hydrographs using different method such as non-linear EPA SWMM and other hydrograph methods such as SCS, SBUH, Rational method etc. XPSWMM allows loading and simulating hydraulics in both separate and combined sewers. Temporal variation of both sanitary and groundwater infiltration are fully accommodated.

The XPSWMM hydraulics engine solves for the complete St. Venant (Dynamic Flow) equation for gradually varied, one dimensional, unsteady flow throughout the drainage network. The calculation accurately models backwater effects, flow reversal, surcharging, pressure flow and tidal outfalls and interconnected ponds. The model allows for looped networks, multiple outfalls and accounts for storage in conduits. Flow can be routed using the USEPA EXTRAN solution and with kinematic or diffused wave methods.

XPSWMM's Real Time Control (RTC) optional module expands the control capabilities for gates, flow regulators, moveable weirs and telemetry-controlled pumps. It extends RTC to a comprehensive management and design tool. It has sensors can be any combination of velocity, flow and water levels at nodes, conduits, pumps weirs or orifices in the network.

Results/Output Features

XPSWMM's graphical capabilities include providing horizontal plan plots, profile plots, and time series plots. XPSWMM provides automatic color-coding of links and nodes based upon any input or output property—allowing the network to be color-coded based upon pipe sizes, flow rates, velocities, hydraulic grades, water quality concentrations, and any other attribute. Model results for the entire simulation can be viewed in any profile, plan or section view. The display of the animation is controlled by a set of VCR like buttons. At any time step the animation may be printed or exported as a graphic file. The results may also be replayed on a multi-panel view presenting a profile, cross section and hydrographs. XPSWMM has a perspective view that allows viewing results in 3 dimensions. User may navigate the view by zooming or changing the viewing locations.

XPSWMM has tools to generate customized tables for both input and output results. The report can be for either node or link data. Tables may be easily formatted and exported to other format.

GIS Integration

XPSWMM allows the user to import information from GIS, Asset Management, CAD package or other database. Data can be linked to AutoCAD, ArcGIS, MapInfo, Microstation, Excel, dBase, Access or any other ODBC compliant database. Results may be exported to these packages or other GIS database. XPSWMM allows ESRI and MapInfo graphic files to act as backgrounds.

Appendix B

Development of Wastewater Flow Projections – Detailed Technical Information

Appendix B
Development of Wastewater Flow Projections – Detailed Technical Information

This appendix provides detailed information on the development of the flow projections summarized in Section 4. The following topics are covered:

B.1 Dry Weather Flow Estimation Methodology and Results

Dry weather flows are comprised of the following two components:

- Base wastewater flow from customers. The base wastewater flow is estimated by applying a unit flow factor for each contributing land use type based on acreage, in order to calculate a contributing flow for each land use type. The total base flow is the sum of all the contributing land use types.
- Groundwater infiltration during dry weather. The regional groundwater table in Salinas is fairly deep, about 40 feet or more deep below top of ground; therefore, groundwater infiltration is not expected to be significant. However, there may be localized areas of shallower or perched groundwater.

B.1.1 Methodology for Development of Unit Flow Factors

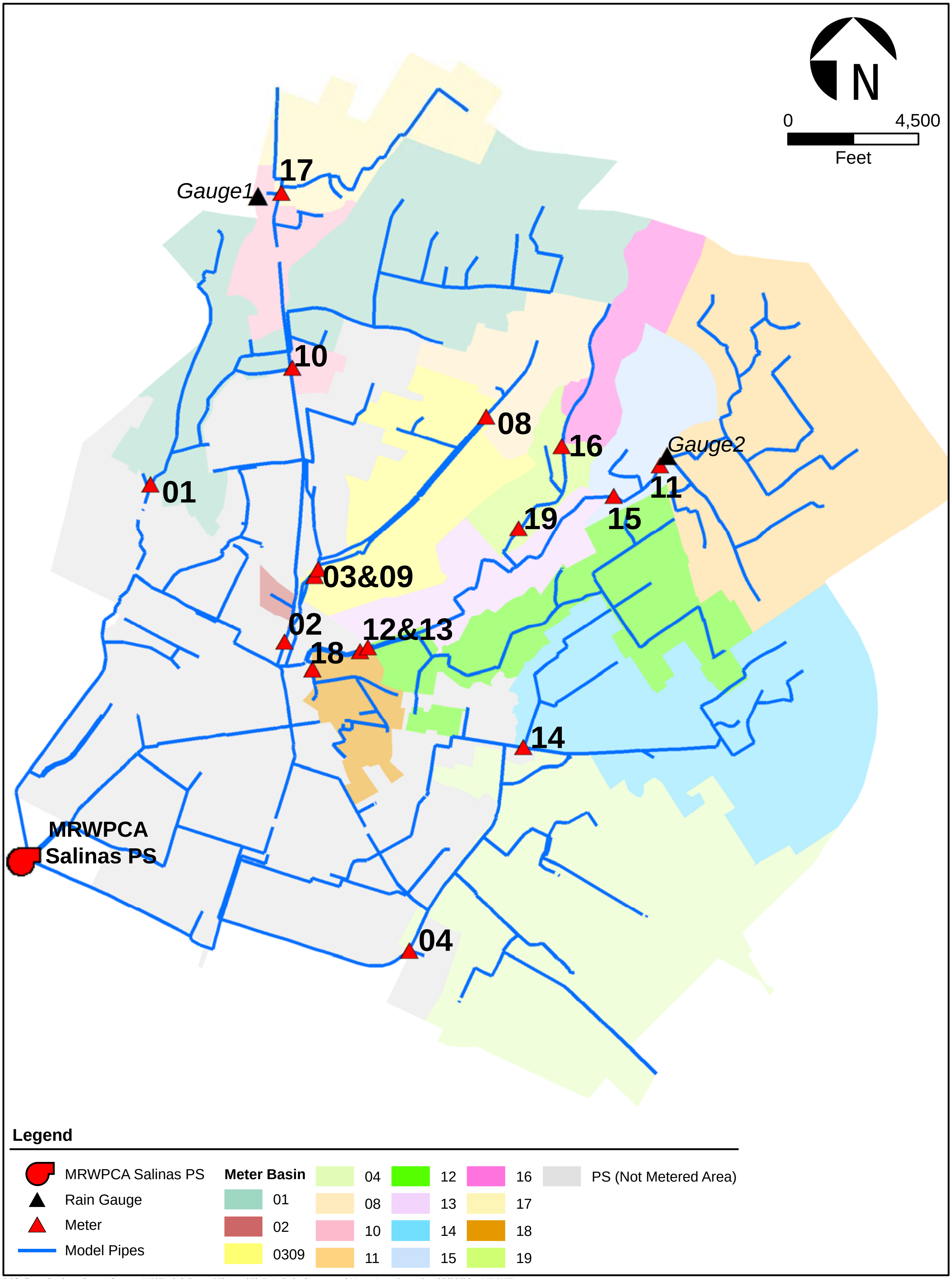
The base wastewater flow component was estimated using land use and unit flow factors. A unit flow factor is the average contribution of sewer flow per acre, expected from each land use type.

Below is the process used to develop the unit flow factor for contributing land uses:

1. For every meter, the tributary area was determined based on available pipe layout, trunk network interconnection, parcel information, and topography. These meter basins are shown on Figure B-1.
2. The meter basin areas were intersected with the master plan land use map (existing land uses) described in Section 2, to determine the total area of each land use type contributing to each meter.
3. The available flow meter data for each basin area was analyzed, using flow data for periods when no rainfall occurred, during winter and summer months, to determine the dry weather average flow at each meter location.
4. For each meter basin, different combinations of unit flow factors were tried until the calculated flow from the contributing areas per land use and the metered dry weather average flows matched within 10 percent. These unit flow factors were average dry weather base flow. Basins with a predominate land use type were analyzed first and those values were used as starting point, adjusting them to best match the measured flows for the majority of the meters. The final unit flow factors were compared to those typically used in the industry, and with those used by CDM in similar projects.
5. The final unit flow factors were applied to the total service area, to estimate the total system-wide flow expected at the downstream discharge point to the MRWPCA Salinas Pump Station.
6. The total system-wide flow developed using the average unit flow factors was compared with available meter records provided by MRWPCA for the Salinas Pump Station from 2003-2007.
7. Other methods of sewer flow estimation were used to compare the total system flow predicted using the unit flow factors developed from the meter data. These methods were based on water consumption information from California Water Service Company, projections from the data reported in the 1998 Salinas Sanitary Sewer Collection Master Study, and population information.

B.1.2 Unit Flow Factor Analysis Results

Table B-1 shows unit flow factors for each land use type that contributes base flows to the collection system. The unit flow factors are those that better fit the metered dry weather flow. Land uses assumed not to contribute base flows are not shown in Table B-1, such as open space, undeveloped, parks, agricultural. Table B-2 shows the predominant land use for each meter basin. Table B-3 shows the tributary area, the flow computed with the unit flow factors, and the flow from meter data.



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CDM

Figure B-1

City of Salinas - Rain Gauge and Meter Locations

Table B-1
Average Dry Weather Unit Flow Factors

Land Use Type [(1)]	Unit Flow Rate (gpd/acre)
Commercial	1,200
Industrial	500 for existing conditions; 2000 for future conditions [(2)]
Public/Semipublic	1,000
Residential - High Density	3,500
Residential - Low Density	1,400
Residential - Medium Density	2,000

(1) Unsewered areas (agricultural, open space, parks, undeveloped) do not contribute base flow to the system, i.e., zero unit flow rates.

(2) For industrial areas, the existing unit flow factor based on the flow metering data is 500 gpd/acre. For future industrial areas, a higher factor of 2000 gpd/acre is recommended to account for more intensive industrial development in the future..

Table B-2
Predominant Land Use per Meter Basin

Meter	Predominant Land Use	Meter	Predominant Land Use
1	C, RL	12 & 13	RL, RM
2	C, RH	14	PS, RL
03 & 09	PS, RL	15	RL, RM
4	I, RL	16	PS, RL
8	RL	17	PS, RH, RL, RM
10	C, RH, RL, RM, PS	18	C, I, RL, RH, RM
11	RM	19	PS, RL, C

C: Commercial
I: Industrial
PS: Public/Semipublic
RH: Residential – High Density
RM: Residential – Medium Density
RL: Residential – Low Density

Table B-3
Computed and Metered Minimum Dry Weather Flows

Meter	***Upstream Meters***	***AVERAGE DRY WEATHER WEEK Flow (gpm)***		
		Calculated Flow from Unit Flow Factors	***Average Flow From Meter Data***	***Difference %***
01	10, 17	1,006	1,214	-17%
02		162	161	1%
03 & 09	08	957	993	-4%
04		1,461	1,243	18%
08		402	417	-4%
10	17	1,115	1,133	-2%
11		489	445	10%
12 & 13	11,15,16,19	2,178	2,171	0%
14		883	928	-5%
15	11	828	525	58%
16		119	117	1%
17		700	688	2%
18		160	100	60%
19	16	195	195	0%

A total of 14 meter basins are shown on the tables including two locations that combined two meters. For analysis purposes, Meters 03 and 09 were combined; as were Meters 12 and 13. For the purpose of this analysis, flow and tributary areas for meters 03 and 09 were combined. There is a diversion connecting the two parallel lines upstream of the meters on these parallel lines. Downstream of the meters, only the 21-inch line discharges into the Carpenter Hall PS, the 15-inch bypasses it. A similar situation occurs for Meters 12 and 13. The calculated flow at Meter 12 under predicts the measured flow and the opposite occurs in Meter 13. When the flow from both meters is combined, the calculated flow matches the measured flow. The pipelines for both Meters 12 and 13, even if not connected, convey flows into the Lake Street Pump Station. Table B-3 shows the results for the combined area.

As indicated on Table B-3, the flow estimated using the unit flow factors is predicted within 10 to 18 percent of the metered flow at 12 of the 14 analysis locations. The computed flow did not agree with the measured flow for meters 15 and 18. Meter 18 is measuring flow from a local commercial area where the flow unit factor may be different than the global estimated factor. The quality of the data for Meter 15 is suspected, due to the agreement of Meters 11 (upstream of Meter 15, in the same trunk pipe) and Meters 12 and 13 (downstream of Meter 15). Another possible explanation is the possibility of developments already built but not yet occupied in the tributary area of Meter 15.

B.1.3 Estimated Existing and Future Average Dry Weather Flows

Table B-4 shows the existing and future dry weather flows, the estimated flow for each contributing land use type based on acreages and unit flow factors, and the estimated total system-wide flow from all contributing areas. The land use acreages for each land use type were obtained from the land use information discussed in Section 2.

As indicated in Table B-4, the total system-wide flow is estimated at 14.4 mgd for existing land uses, and 21.7 mgd for buildout land uses.

Table B-4
Estimated Dry Weather Flows for Existing and Future Conditions
Using Average Dry Weather Unit Flow Factors

Land Use Type	Description	Existing Contributing Sewered Areas (1) (Acres)	Incremental Future Contributing Sewered Areas (1) (Acres)	Existing Unit Flow Rate (gpd/acre)	Existing Flow (mgd)	Future Unit Flow Rate for Incremental Future Areas (gpd/acre)	Future Flow (mgd)
C and MU	Commercial and Mixed Use (mixed commercial and residential) (2)	1,427	369	1,200	1.7	1,200	2.2
I	Industrial	1,238	1,146	500	0.6	2,000	2.9
PS	Public/Semipublic	1,829	706	1,000	1.8	1,000	2.5
RH	Residential - High Density	743	236	3,500	2.6	3,500	3.4
RL	Residential - Low Density	3,615	872	1,400	5.1	1,400	6.3
RM	Residential - Medium Density	1,270	932	2,000	2.5	2,000	4.4
TOTAL FOR ALL CONTRIBUTING AREAS		**10,122**	**4,261**		**14.4**		**21.7**

(1) Areas are gross sewered acres (including roads/streets in contributing sewered areas). The contributing sewered areas do not include unsewered areas such parks, open spaces, or undeveloped parcels.

(2) Some existing commercial properties are redeveloped as future mixed use (total 354 acres mixed use at buildout). Flows for the mixed use areas estimated as commercial flow using unit flow rate per acre plus additional residential flows at 210 gpd/unit.

B.1.4 Dry Weather Peaking Curve

The dry weather (base flow) varies throughout the day in response to the personal habits of the general population and special events. Dry weather peaking factors are used to determine the peak design base flow. The dry weather peaking factors are calculated by dividing the peak 15-minute dry weather flow by the average daily dry weather flow. The values generally range from 1.5 to 3.0 with the higher values associated with the lower flows, i.e., smaller tributary areas have higher peak factors.

Figure B-2 shows the peaking factor curve for the Salinas sewer system, developed using the available meter data. For the master plan, the peaking curve in Figure 3 will be used to estimate peak dry weather flows in the model, with a maximum value of 2.5, and a minimum value of 1.5. For comparison, the current Salinas Standards specify dry weather peaking factors based on population served, as follows:

Service Population	***Peaking Factor***
1,000	2.5
3,000	2.1
10,000	1.8
35,000	1.6
100,000	1.5

For the total service area, with all flows contributing at the Salinas Pump Station, the peaking factor reaches its lowest value. Based on MRWPCA data for the Salinas Pump Station, the dry weather peaking factor at the pump station is 1.6 times the current average dry weather flow of about 13-14 mgd. It is assumed that the peaking factor will become somewhat lower and approach 1.5 as flows increase in the future.

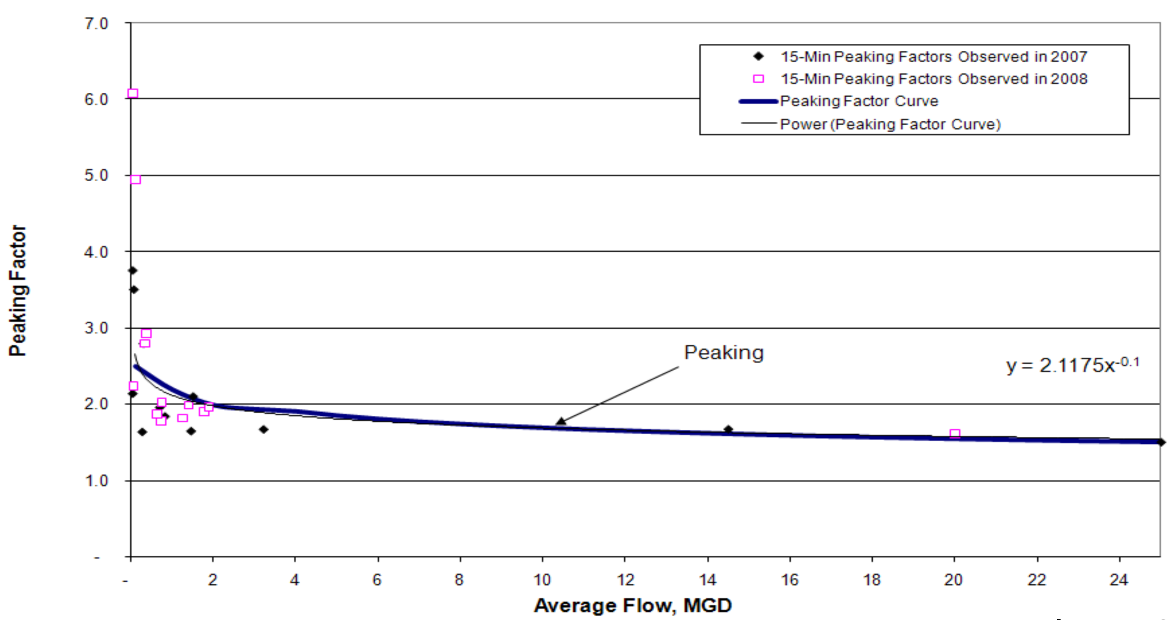


Figure B-2
Dry Weather Peaking Curve

B.1.5 Comparison with Other Flow Estimates

A) MRWPCA Pump Station Flow Data

Table B-5 shows the maximum and average daily flows for years 2002 to 2007 from the available flow records provided by MRWPCA.

Table B-5
MRWPCA Salinas Pump Station Daily Flows

Condition	2002	2003	2004	2005	2006	2007	Average for 2002-2007
Maximum Daily Flow (mgd)	13.5	14.1	14.0	13.9	15.6	12.6	14.0
Average Daily Flow (mgd)	12.5	13.6	12.5	12.0	11.9	11.6	12.5

Source: MRWPCA pump station records

The average daily flows at the Salinas Pump Station have ranged from 11.6 to 13.6 over the last 6 years (average 12.5 mgd); and the maximum daily flows have ranged from 12.6 to 15.6 mgd (average 14.0 mgd). The peak dry weather flow at the Pump Station is about 1.6 times the average dry weather flow. The peak hourly wet weather flow has ranged from 22 mgd to 25 mgd, which is about 2 times the average flow.

As shown in Table B-5, the total average daily flow at the Salinas Pump Station predicted by the unit flow factors is 14.4 mgd. The flows calculated using the unit flow factors are over-predicting the total average daily flow at the Salinas Pump Station, based on MRWPCA flow data; although are fairly close to the maximum daily flow.

The average flow reported in the City's1998 Sanitary Sewer Collection Master Study (11.9 mgd from pump station records), indicating no increase in flows but a slight decrease in 9 years; which is not consistent with population growth records that show an increase of at least 18 percent. This appears suspect, especially as the City meter data within the collection system indicates higher flows. City staff indicates that the flow meter at the pump station is located on the downstream side of the pumps, and that the meter "peaks out" at a certain discharge rate and does not accurately measure the higher flows. Therefore, it is not surprising that CDM's flow estimates do not match the MRWPCA data.

CDM has recommended that the City locate its own meters in the main inflow lines to the Salinas Pump Station, during wet and dry weather periods, in order to collect its own data to confirm MRWPCA data.

Due to the difference between the estimated flows calculated and the flow data provided by MRWPCA at the Salinas Pump Station, several other flow estimates were also made to corroborate the flow estimates using the unit flow factors with other methods. These other methods included:

- Sewer flow estimation based on water demand records
- Review of projections from meter data from the 1998 Sanitary Sewer Master Study
- Sewer flow estimation based on population and average density

The results of these other methods are summarized below, and compared to the estimates derived from the unit flow factors. The results of the other estimates indicate the unit flow factors are reasonable. The average unit flow factors provide a reasonably conservative basis for future planning in the master plan analysis.

B) Sewer Flow Estimated as Percentage of Water Demands

The total flow predicted for the service area using the unit flow factors was also compared to estimates based on water consumption records. Based on planning data from the California Water Service Company, Salinas District, the average annual water demand in 2007 was 24.6 mgd for the portion of the water service area contributing to the City sewer system. The water service area comprising the Salinas and Bolsa Knolls Divisions corresponds to about 70 percent of the sewer service area.

An accepted method to estimate sewer flows is to compute them as 85 percent of the lowest monthly average water consumption or as 75 percent of the annual average water consumption. For the portion of the Salinas and Bolsa Knolls water service area that contribute flows to the sewer system, the expected sewer flow would range from approximately 15 mgd based on 85 percent of the lowest monthly average (at approximately 0.7 times the average daily demand); or up to 18 mgd based on 75 percent of the average annual demand.

C) Sanitary Sewer Collection Master Study, 1998 (Kennedy/Jenks Consultants)

Another source of information used to compare the flow estimates developed using the unit flow factors, was the 1998 Sanitary Sewer Collection Master Plan. For the 1998 master plan, flow monitoring was conducted. Seven meters were used to determine unit flow factors and the total expected flow from the service area was compared to MRWPCA Salinas PS records. The total flow calculated based on the meter data was 13.7 mgd.

The estimated flow was projected to 2007 based on the increase in population from 135,000 in 1998 to approximately 160,000 now, which is an increase of about 18.5 percent. The adjusted total flow using the same percentage increase as for population would be about 16.2 mgd based on the 1998 meter flow estimate.

D) Existing Population and Average Density Approach

Population and average density per land use were used to compute residential flow contribution on a per capita basis using an average flow per person of 70 gallons per day per capita. The computations for the population-based approach are shown in

Table B-6, with an estimated residential flow of 11.1 mgd for an estimated population of about 158,000. The estimated residential flow calculated using the unit flow is 11.0 mgd for the residential areas only. The population-based estimate matches the estimated residential flow computed using the unit flow factors.

Table B-6
Population-Based Estimate of Flows from Existing Residential Areas

Land Use	Average Density (1) (units/acre)	Existing Area (2) (acres)	People per Unit (3)	Estimated Population	Flow per Person (gpcpd)	Total Residential Flow (mgd)
Residential Low	6.5	3,034	3.67	72,3764	70	5.1
Residential Medium	11.75	1,117	3.67	48,168	70	3.4
Residential High	16.75	607	3.67	37,314	70	2.6
TOTAL		4,758		157,858		11.1

(1) Density based on 2002 General Plan, land use element, applicable to net land use area.
(2) Net land use area (does not include roads/streets).
(3) Inhabitants per unit based on 2002 General Plan, land use element.

B.2 Wet Weather Flow Estimation Methodology and Results

The RDII (wet weather) flow portion of the wastewater flow is generated by storm events. The system must be able to collect and convey the peak RDII flow generated by a design storm event, in addition to the average dry weather flow.

B.2.1 Methodology for Development of Wet Weather Flow Parameters

The available meter data was used to determine wet weather parameters for each metered basin. These parameters were then applied to four design storm events to compute the corresponding expected peak flows. This analysis was done using two different methods, and the results from both methods were compared to recommend a design RDII flow per metered basin.

Three wet weather flow parameters for each metered location were estimated for use in the two methods discussed below.

<u>Method 1</u> is based on the relationship between the peak RDII flow and the RDII Volume. This method uses the following parameters: percentage of a storm flow that enters the sewer system (R); and ratio between RDII peak flow and RDII volume. The first parameter (R) is applied to a design storm, to compute the RDII volume that enters the sewer system. The second parameter is applied to the RDII volume, to compute the expected peak flow that will enter the sewer system under the design storm.

Method 2 is based on the relationship between the peak RDII flow and the rainfall intensity. This method uses a parameter for a Runoff Coefficient (C) related to RDII. The parameter C is applied to the rainfall intensity of the design storm to compute the expected peak flow.

The process to estimate the wet weather parameters and the peak RDII flows at each meter location during a design storm was as follows:

1. Review and analysis of rainfall and meter data:
   - From the metered rainfall data, representative storms, with a comparable duration, were selected. For each selected rainfall event, the total volume of rainfall and the peak intensity were computed.
   - From the metered rainfall data, a no-rainfall period was selected to represent dry weather conditions. The no-rainfall period selected started one week after the last day of rainfall. For this period, the meter flow data was used to estimate the base flow at each meter location. Two dry weather diurnal curves were developed for each meter: one for weekdays and another for weekends.
   - For each metered rainfall event, the portion of the sewer flow that comes from the rainfall (RDII flow) was calculated as the metered flow minus the base flow from the dry weather diurnal curves.
2. Calculate wet weather parameters and flows for Method 1:
   - At each meter location, for each metered storm event, the total storm volume was calculated and compared to the metered RDII volume to calculate R, the percentage of the storm volume that will eventually reach the sewer system.
   - The peak flow during each metered rainfall event was compared to the RDII volume. From this comparison, a RDII peak flow/RDII volume ratio was computed for each meter.
   - The expected peak intensity and storm volume was calculated for four different design storm events: 2yr-6hr, 5yr-6hr, 10yr-6hr, and 20yr-6hr.
   - The RDII peak flow/RDII volume ratio was applied to the anticipated storm volume for each design storm, to calculate the expected RDII peak flow for Method 1.
3. Calculate wet weather parameters and flows for Method 2:
   - In a different approach, for each metered storm event, the measured RDII peak flow was compared to the measured rainfall peak intensity at each meter location, to compute the RDII peak flow/Rainfall Intensity ratio, and the corresponding runoff coefficient (C) factor for RDII. The runoff coefficient is similar to that used in the Rational Method, but it relates the peak RDII discharge of the area and the rainfall intensity.
   - The calculated runoff coefficient (C) for RDII was applied to the peak intensity of each design storm, to estimate the expected peak RDII flow (Method 2).

B.2.2 Wet Weather Flow Parameters Analysis

A) Field Metered Storms Events

From the available field meter data, the selected storm events for the analysis are listed in Table B-7. For each storm, Table B-7 shows the storm duration, the total metered volume, and the peak intensity that occurred during the storm event.

The rainfall and flow meter data for the eight selected storm events was analyzed, and used to estimate the wet weather parameters. For each metered basin, the metered RDII volume, the total storm volume (acre-ft), and the peak flow rate (peak flow in gallons per acre per day) were calculated.

Table B-7
Metered Storm Events

Storm Event	***Date***	***Duration (hr)***	***Volume (in)***	***Peak Intensity (in/hr)***
1	2/10/2007	8	0.36	0.14
2	2/22/2007	5	0.66	0.28
3	2/26/2007	6	0.36	0.16
4	2/27/2007	11	0.52	0.18
5	1/3/2008	13	1.47	0.25
6	1/23/2008	3	0.39	0.31
7	2/19/2008	3	0.20	0.16
8	2/23/2008	6	0.43	0.20

B) Computation of Wet Weather Parameters

The wet weather parameters were computed as follows:

1) Percentage of a storm flow that enters the sewer system (R):

   For each metered basin, the total storm volume was calculated and compared to the metered RDII volume. A linear regression was applied to the metered rainfall events and the calculated slope was the wet weather parameter R (percentage of the storm volume that reaches the sewer collection system).

2) Ratio between RDII peak flow and RDII volume:

   For each metered basin, the measured RDII peak flow was compared to the measured RDII volume. A linear regression was applied to the metered rainfall events and the calculated slope was RDII peak flow/RDII volume ratio.

3) Runoff Coefficient C for RDII:

   For each metered basin, the measured RDII peak flow was compared to the measured rainfall intensity. A linear regression was applied to the eight measured rainfall events and using the Rational Method principles, the calculated slope divided by the area is the Runoff Coefficient for RDII for each meter basin.

Table B-8 presents the estimated wet weather parameters for each metered basin.

Table B-8
Wet Weather Parameters for Metered Basins

Meter	Method 1		Method 2
	R	RDII Peak Flow/RDII Volume Ratio(1)	C for RDII
1	0.42%	4,663	0.27%
03 & 09	0.52%	9,707	0.71%
4	0.67%	4,921	0.50%
8	0.24%	11,232	0.10%
10	0.05%	5,259	0.04%
12	0.40%	5,199	0.25%
13	1.66%	2,508	0.70%
14	0.56%	7,651	0.51%

(1)RDII Peak Flow/RDII Volume Ratio in gpapd/acre-ft

B.2.3 Estimated Peak RDII Flow Rates from Existing Metered Data

The City of Salinas Storm Water Master Plan (2004) and City Storm Drainage Design Standards (2008) specify a minimum of 5-year 6-hour (5yr-6hr) event for design of the City's storm drain facilities. Various design storm events were investigated for the sanitary sewer system design.

For this analysis, the wet weather parameters were applied to the 2yr-6hr, 5yr-6hr, 10yr-6hr, and the 20yr-6hr events. The total storm volume and peak intensity of each design storm are shown in Table B-9.

Table B-9
Design Storm Characteristics

Design Storm	Storm Duration (hr)	Storm Volume (in)	Peak Intensity (in/hr)
2 year	6	0.9	0.60
5 year	6	1.2	0.70
10 year	6	1.4	0.90
20 year	6	1.6	1.05

Source: City of Salinas Storm Drainage Design Standards, 2008 (for the 5yr, 10yr, and 20yr storms); Monterey County Rainfall Intensity-Duration-Frequency Curves for the Salinas Country Club Station (for the 2yr storm, obtained from MWRA).

Table B-10 presents the calculated peak RDII unit flow rates (in gallons/day/acre) for each metered basin, using the four design storms shown in Table B-9. The peak unit flow rates were calculated using the two methods described above. The RDII unit flow rates are based only on the contributing existing sewered area, i.e., the area within the tributary drainage area that generates sewer flows, and does not include unsewered areas such as open space, agricultural, parks, or vacant. The contributing areas are in gross acres including streets.

Table B-10
Existing RDII Peak Unit Flow Rates for Various Design Storms

Meter	RDII Peak Unit Flow Rate (gpapd)							
	DESIGN STORM 1 2-year, 6-hour		DESIGN STORM 2 5-year, 6-hour		DESIGN STORM 3 10-year, 6-hour		DESIGN STORM 4 20-year, 6-hour	
	Method 1	Method 2	Method 1	Method 2	Method 1	Method 2	Method 1	Method 2
1	700	800	900	900	1,000	1,200	1,200	1,300
3 & 9	1,900	2,000	2,300	2,300	2,700	3,000	3,100	3,400
4	1,400	1,400	1,700	1,600	1,900	2,100	2,200	2,400
8	500	300	600	400	600	400	700	500
10	200	200	200	200	200	200	200	300
12	800	700	1,000	900	1,100	1,100	1,200	1,300
13	1,800	2,000	2,200	2,300	2,600	2,900	2,900	3,400
14	1,500	1,400	1,800	1,600	2,100	2,100	2,400	2,400

Method 1: computed using the RDII Peak Flow/RDII Volume ratio
Method 2: computed using the RDII Peak Flow/Rainfall Intensity ratio

As Table B-10 shows, the results from both methods were reasonably similar to each other, for all the meter locations. The existing peak RDII unit flow rates are within 10% of each other on average. The existing peak RDII flow rate recommended for each metered basin is the higher from the two methods. As indicated in Table B-10, there are differences in the anticipated RDII peak unit flows throughout the City. Therefore, the master plan will use different wet weather factors for various areas for the analysis, as discussed later in this memorandum.

The calculated RDII peak unit flow rates were compared to the following sources:

- City of Salinas, Storm Drainage Design Standards, 2008 specifies 500 gallons/day/acre as infiltration and storm water inflow allowance for the design of sewer mains.
- City of Salinas 1998 Sanitary Sewer Collection Master Study used a wet weather peak flow of 420 gallons/day/acre.
- City of Salinas 1992 Sewage and Drainage Master Plan used a RDII peak flow rate of 850 gpdpa, and a groundwater infiltration rate of 150 gpdpa, which is a total of 1,000 gpdpa.

The RDII peak flow rates from these other sources are based on the total tributary area, including both contributing sewered areas and non-contributing areas, such as open space, agricultural and park. In general, these other sources specify lower RDII flow rates than computed for this master plan using the recent meter data. None of the other sources identify a design storm that corresponds to the specified rate. The recommended peak RDII unit flow rates are for specific design storm events, and will provide a more conservative basis for facilities planning.

B.2.4 Wet Weather Analysis Conclusions

Tables B-11 and B-12 show the peak RDII factors for the 5-year, 6-hour storm and the 10-year, 6-hour storm respectively. The recommended existing peak RDII unit flows are the highest value calculated using the two methods. For the existing sewered areas in the system that were not metered, a system-wide average rate is recommended: 1,600 gpapd for the 5-year, 6-hour storm and 2,000 gpapd for the 10-year, 6-hour storm.

For new pipes in new development areas, it would be expected to have lower rates, on the order of 900 gpapd for the 5-year design storm and 1,100 gpapd for the 10-year design storm, for very tight plastic systems. These lower rates were used for the incremental future growth areas. A minimum peak RDII flow of 500 gpapd is recommended for any area, e.g., for areas where existing peak RDII flow is lower.

The RDII unit flow rates are applied only to the contributing sewered area, i.e., the area within the tributary drainage area that generates sewer flows. The RDII flows do not include unsewered areas such as open space, agricultural or parks.

To determine the peak wet weather flows for the master plan analysis, the RDII peak flow is added to the average dry weather flow. For the 5 year, 6-hour design storm, the total existing RDII peak flow for the entire system is 14.2 mgd, and the total buildout RDII peak flow is 18.0 mgd. For the 10-year, 6-hour design storm, the total existing RDII peak flow for the entire system is 17.8 mgd, and the total buildout RDII peak flow is 22.4 mgd.

For meter basins 11, 15, and 16, the recommended unit flow rate is lower than calculated at Meter 13 (downstream meter), because these areas are recently developed or currently vacant.

Table B-11
Peak RDII Unit Rates and Flow Estimates for 5-year, 6-hour Design Storm

Meter Basin	***Existing Peak RDII Flow***			***Incremental Future Peak RDII Flow***			***Total Buildout Peak RDII Flow***	
	Existing Sewered Area[(1)] (acres)	***Recommended Existing Peak RDII Unit Flow (gpapd)***	***Existing Peak RDII Flow[(2)] (mgd)***	***Incremental Future Sewered Area (acres)***	***Recommended Future Peak RDII Unit Flow (gpapd)***	***Incremental Future Peak RDII Flow[(3)] (mgd)***	***Total Buildout Sewered Area (acres)***	***Total Buildout Peak RDII Flow[(4)] (mgd)***
1	800	900	0.72	820	900	0.74	1,620	1.46
2	26	900	0.02	4	900	0.00	30	0.02
03 & 09	1,016	2,300	2.34	8	900	0.01	1,024	2.35
4	1,391	1,700	2.36	785	900	0.71	2,176	3.07
8	338	600	0.20	4	600	0.00	342	0.20
10	297	500	0.15	2	500	0.00	299	0.15
11	363	900	0.33	1,035	900	0.93	1,398	1.26
12	774	900	0.70	27	900	0.02	801	0.72
13	50	2,200	0.11	4	900	0.00	54	0.11
14	752	1,800	1.35	615	900	0.55	1,367	1.90
15	283	900	0.25	7	900	0.01	290	0.26
16	149	900	0.13	140	900	0.13	289	0.26
17	538	500	0.27	44	500	0.02	582	0.29
18	231	1,600	0.37	4	900	0.00	235	0.37
19	91	900	0.08	46	900	0.04	137	0.12
Not Metered Areas	3,023	1,600	4.84	716	900	0.64	3,739	5.48
Grand Total	**10,122**		**14.23**	**4,261**		**3.82**	**14,383**	**18.04**

(1) Sewered Area does not include Agriculture, Open Spaces, Parks, or Undeveloped land use areas. The sewered areas are gross acres including streets.
(2) Existing RDII peak flow equals the existing peak RDII unit flow times the exiting sewered area.
(3) Incremental RDII peak flow equals the future peak RDII unit flow times the incremental sewered area.
(4) Buildout RDII peak flow equals existing peak RDII flow plus incremental future peak RDII flow.

Table B-12
Peak RDII Unit Rates and Flow Estimates for 10-year, 6-hour Design Storm

Meter Basin	Existing Peak RDII Flow			Incremental Future Peak RDII Flow			Total Buildout Peak RDII Flow	
	Existing Sewered Area [1] (acres)	Recommended Existing Peak RDII Unit Flow (gpapd)	Existing RDII Peak Flow [2] (mgd)	Incremental Future Sewered Area[1] (acres)	Recommended Future Peak RDII Unit Flow (gpapd)	Incremental Future Peak RDII Flow [3] (mgd)	Total Buildout Sewered Area[1] (acres)	Total Buildout RDII Peak Flow [4] (mgd)
1	800	1,200	0.96	820	1,100	0.90	1,620	1.86
2	26	1,200	0.03	4	1,100	0.00	30	0.03
03 & 09	1,016	3,000	3.05	8	1,100	0.01	1,024	3.06
4	1,391	2,100	2.92	785	1,100	0.86	2,176	3.78
8	338	700	0.24	4	700	0.00	342	0.24
10	297	500	0.15	2	500	0.00	299	0.15
11	363	1,200	0.44	1,035	1,100	1.14	1,398	1.58
12	774	1,100	0.85	27	1,100	0.03	801	0.88
13	50	2,900	0.15	4	1,100	0.00	54	0.15
14	752	2,100	1.58	615	1,100	0.68	1,367	2.26
15	283	1,200	0.34	7	1,100	0.01	290	0.35
16	149	1,200	0.18	140	1,100	0.15	289	0.33
17	538	500	0.27	44	500	0.02	582	0.29
18	231	2,000	0.46	4	1,100	0.00	235	0.46
19	91	1,100	0.10	46	1,100	0.05	137	0.15
Not Metered Areas	3,023	2,000	6.05	716	1,100	0.79	3,739	6.83
Grand Total	**10,122**		**17.75**	**4,261**		**4.66**	**14,383**	**22.41**

(1) Sewered Area does not include Agriculture, Open Spaces, Parks, or Undeveloped land use areas. The sewered areas are gross acres including streets.
(2) Existing RDII peak flow equals the existing peak RDII unit flow times the existing sewered area.
(3) Incremental RDII peak flow equals the future peak RDII unit flow times the incremental sewered area.
(4) Buildout RDII peak flow equals existing peak RDII flow plus incremental future peak RDII flow.

B.3 Model Flow Allocations

B.3.1 Procedure for Allocating Flows to Model

The peak design flows for the master plan analysis were loaded to the hydraulic model subareas and corresponding loading manholes described in Section 3. To calculate and allocate the flow from one specific subarea, the following procedure was used:

1) Determine the existing base wastewater flow per subarea: the area per currently developed sewered land use type within the subarea was multiplied by the corresponding dry unit flow factor from Table B-1.

2) Determine the existing RDII flow per subarea: the total area from currently developed contributing land uses (land uses that are served by the sewer system: residential, commercial, industrial, or public/semipublic) was multiplied by the wet unit flow factor of the correspondent meter. This was done using the RDII wet unit flow factors for the 5-year storm and the 10-year storm, as shown in Tables B-11 and B-12

3) Determine the buildout base wastewater flow per subarea: the area per buildout land use type within the subarea was multiplied by the corresponding dry unit flow factor from Table B-1. Each parcel was assumed to be developed to its full potential.

4) Determine the incremental RDII flow per subarea: the incremental area (area that will be sewered) from buildout contributing land uses (land uses that are served by the sewer system: residential, commercial, industrial, or public/semipublic) was multiplied by the wet unit flow factor recommended for new developments: 900 gpapd for the 5-year storm, and 1,000gpapd for the 10-year storm. Each parcel was assumed to be developed to its full potential.

5) The calculated flows (dry and wet, existing and buildout) were assigned to the subarea's loading manhole in the hydraulic model, for each model scenario in the required combination.

The flow allocation process is illustrated in Figure B-3.

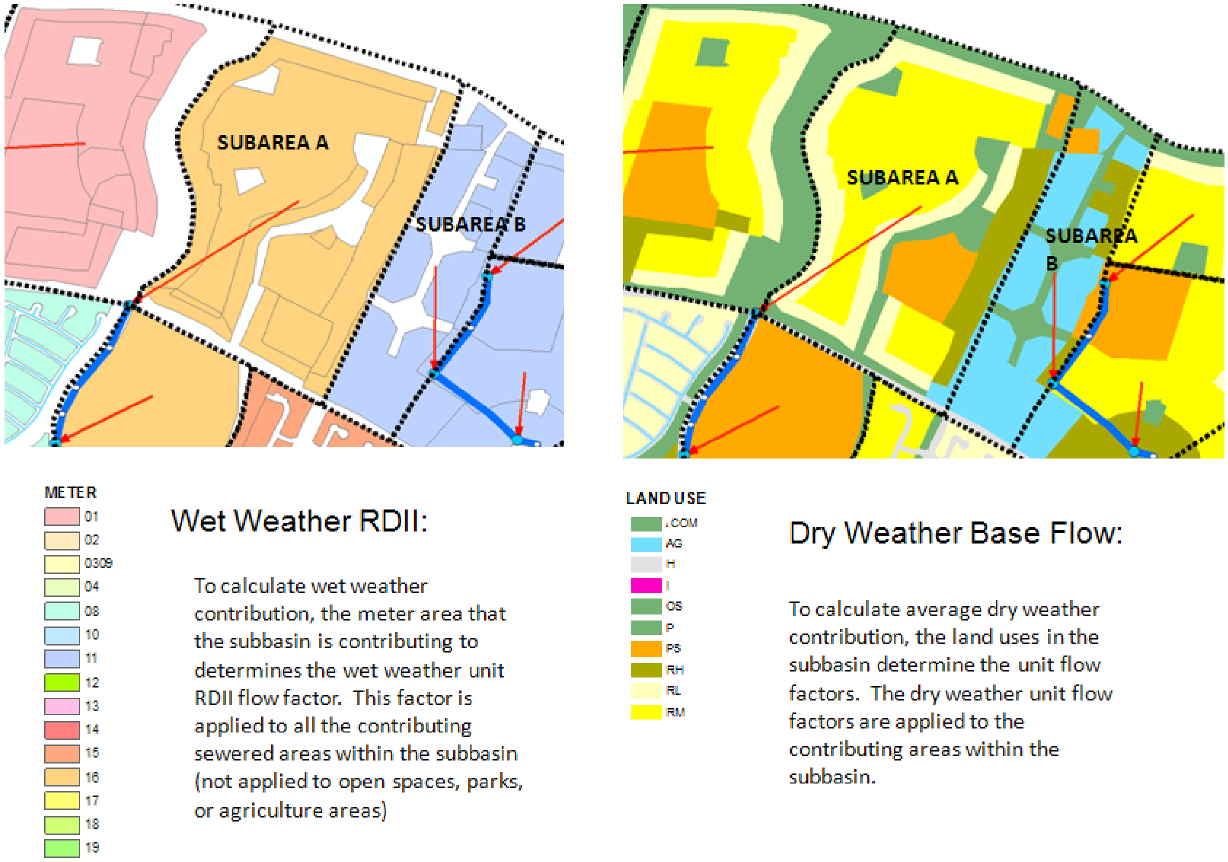


Figure B-3
Example Schematic of Model Subarea Flow Estimation Process

The InfoSewer suite includes a specific tool for loading allocation. This tool (Load Allocator) uses land use and subarea shape files and unit flow factors as input data. The tool computes the areas, applies the average dry weather unit flow factor for each subbasin, and then allocates the flow to the correspondent loading manhole in the field (in the manhole table) designated by the user. The same tool was used to generate and allocate RDII flows, using the corresponding meter basin and the wet weather unit flow factor. For the Salinas collection system model, the flows were allocated as follows for each model scenario:

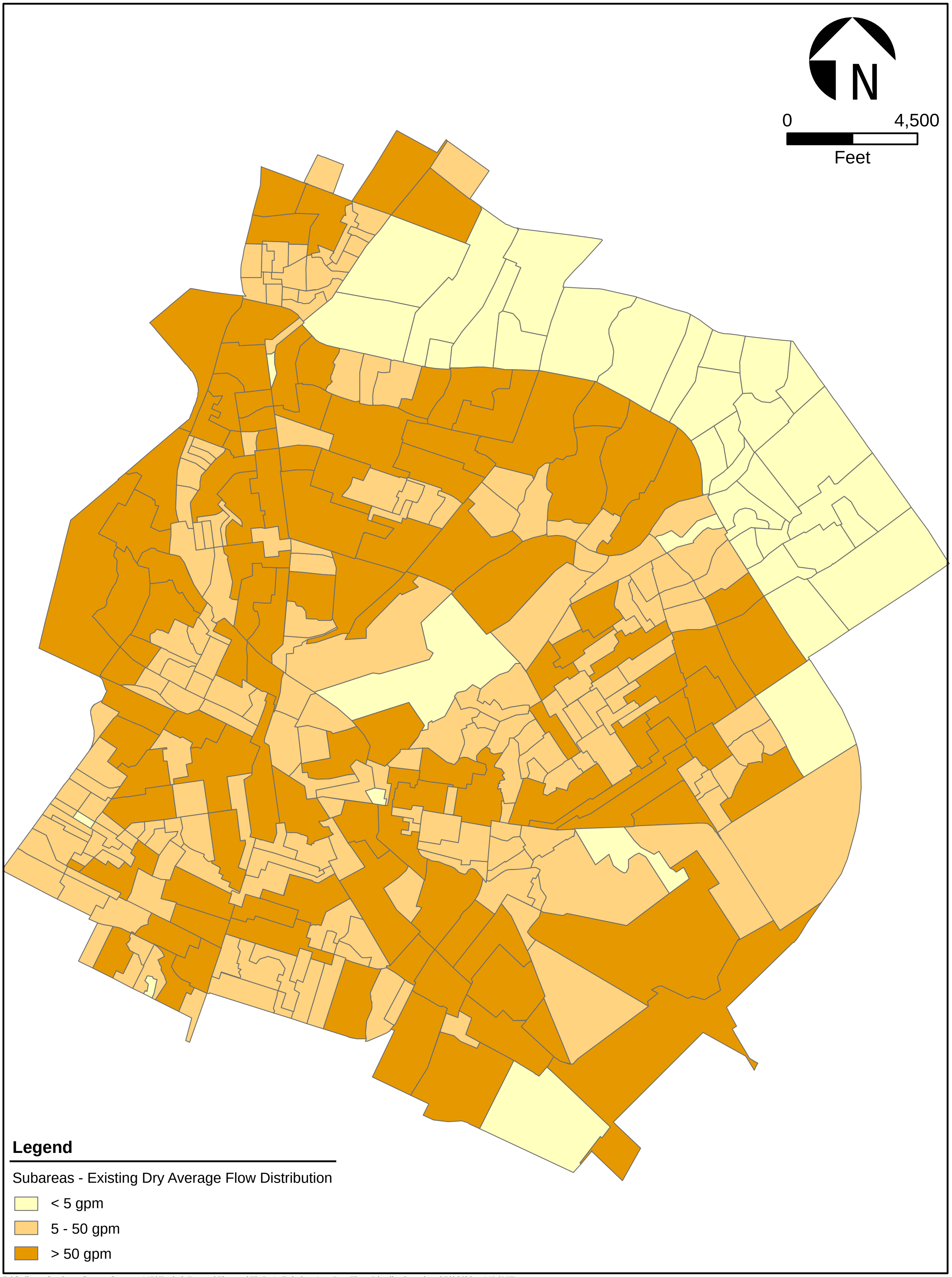
Land Use and Flow Type	***Assigned to Model Field (in manhole table)***
Residential Low Density – Average Dry Weather Baseflow	Load01
Residential Medium Density - Average Dry Weather Baseflow	Load02
Residential High Density – Average Dry Weather Baseflow	Load03
Commercial – Average Dry Weather Baseflow	Load04
Industrial – Average Dry Weather Baseflow	Load05
Public/Semipublic – Average Dry Weather Baseflow	Load06
I/I Flow for all contributing land uses (total RDII flow)	Load10

The peak dry weather flow for each subarea was calculated by the model using the dry weather peaking curve shown in Figure B-2.

B.3.2 Initial Model Calibration and Distribution of Base Flows

After the loads were allocated in the hydraulic model, the average dry flows at meter locations were compared to those measured during field tests. The results were consistent with those calculated using land use data; therefore, the model is considered reasonable calibrated for existing average dry flow conditions.

Figures B-4 and B-5 show the base flow distribution for existing and buildout conditions respectively, for the Salinas sewer system service area. The change in color intensity shows if the base flow contribution from the subbasin area is high (existing base flow average of more than 50 gpm), medium (between 5 gpm and 50 gpm) or low (less than 5 gpm). These figures illustrate graphically how the base flow will change between existing (Figure B-4) and buildout (Figure B-5) conditions. For example, the Northern Boronda Future Growth area is in the <5 gpm category under existing conditions (Figure B-4), while at buildout (Figure B-5), most of the area is in the >50 gpm category.



P:\Salinas Sanitary Sewer System MP\Task 8 Report\Figures\FigB-4_Existing Avg Dry Flow Distribution.ai 07/22/09 MD/JJT

Figure B-4

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City of Salinas - Hydraulic Model Existing Average Dry Flow Distribution

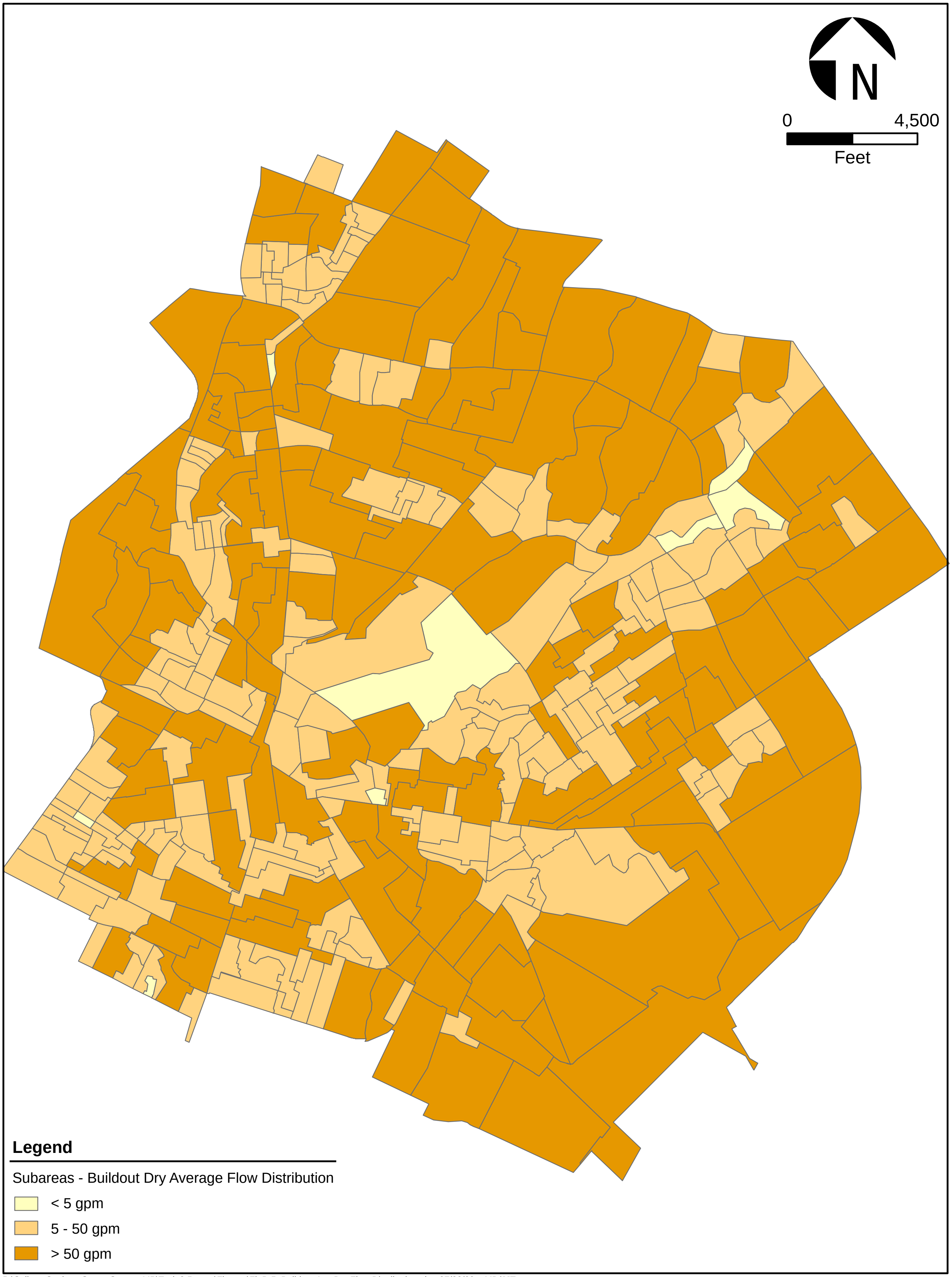

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Figure B-5

City of Salinas - Hydraulic Model Buildout Average Dry Flow Distribution

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