LIVERMORE
CALIFORNIA

CITY OF LIVERMORE

Sewer Master Plan

FINAL REPORT

DECEMBER 2017

WEST YOST ASSOCIATES

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Sewer Master Plan

Prepared for

City of Livermore

Project No. 438-12-15-05

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Table of Contents

Executive Summary

Chapter 1. Introduction

Chapter 2. Existing System Description

Chapter 3. Service Area Sewer Flows

Chapter 6. Operational Analysis

Chapter 7. Prioritized Capital Improvement Program

List of Tables

List of Figures

List of Acronyms and Abbreviations

2015 UWMP	City of Livermore 2015 Urban Water Management Plan
ABS	Acrylonitrile butadiene styrene
ADWF	Average Dry Weather Flow
BART	Bay Area Rapid Transit
BSF	Base Sanitary Flow
CalWater	California Water Service Company
CCI	Construction Cost Index
cfs	Cubic Feet Per Second
CIP	Capital Improvement Program
CIPP	Cured-in-Place Pipe
City	City of Livermore
DI	Ductile Iron
EBDA	East Bay Dischargers Authority
ENR	Engineering News Record
fps	Feet Per Second
ft	Feet
GIS	Geographic Information System
gpcd	Gallons Per Capita Per Day
gpd	Gallons Per Day
gpm	Gallon Per Minute
GWI	Groundwater infiltration
HDPE	High-Density Polyethylene
I-580	Interstate 580
ID	Identifier
in	Inches
INP	Isabel Neighborhood Plan
LAVWMA	Livermore Amador Valley Water Management Agency
LLNL	Lawrence Livermore National Laboratory
mgd	Million Gallons Per Day
PDWF	Peak Dry Weather Flow
PVC	Polyvinyl Chloride
PWWF	Peak Wet Weather Flow
q	Design Flowrate
Q	Full Pipe Flow
q/Q	Ratio

RDII	Rainfall Dependent Inflow and Infiltration
SCADA	Supervisory Control and Data Acquisition
SFPUC	San Francisco Public Utilities Commission
SNL	Sandia National Laboratory
TRUSS	Thermoplastic PVC
UGB	Urban Growth Boundary
UV	Ultraviolet
VCP	Vitrified Clay Pipe
West Yost	West Yost Associates
WRP	Water Reclamation Plant

List of Appendices

ES.1 OVERVIEW AND NEED FOR SEWER MASTER PLAN UPDATE

The City of Livermore (City) sewer collection system serves the incorporated limits of the City, which includes a population of approximately 87,000 people in eastern portion of Alameda County. In addition to the area within the City limits, the sewer service area includes small areas that are outside of the City limits but within the City's Urban Growth Boundary (UGB), as well as the Ruby Hill portion of the City of Pleasanton.

While the City is continually planning and designing collection system improvements to ensure a safe and reliable system, a comprehensive review of the City's collection system facilities has not been completed since 2004. With changes in customer's water use in response to recent on-going drought conditions, and corresponding changes in wastewater flows, and several new development projects proposed throughout the City's sewer service area, there is a need for an updated Sewer Master Plan to evaluate the City's collection system's ability to meet existing and projected future flows and identify improvements needed to address system deficiencies.

The City's existing collection system and sewer service area can be seen on Figure ES-1.

ES.2 SEWER MASTER PLAN GOALS AND OBJECTIVES

The objective of this Sewer Master Plan is to clearly define the City's long-term collection system infrastructure capacity needs, and to develop a plan that will provide the flexibility and system reliability that the City needs to accommodate changing future capacity needs. Specific objectives are listed in Table ES-1 with references to specific chapters and appendices of this Sewer Master Plan.

It is important to note that the focus of this Sewer Master Plan is to recommend capacity-related improvement projects for the City's sewer system. It is not the intent for this Sewer Master Plan to be the sole source of all recommended sewer system projects for inclusion in the City's Capital Improvement Plan (CIP). Other sources include the Water Resource Division's asset management program (which focuses on the renewal or replacement of sewer system assets based on age and condition), regulations and code compliance, operations and maintenance staff input, and coordination with other roadway improvements. The City utilizes and coordinates all sources in the development of the City's overall CIP for the sewer system.

The development of this Sewer Master Plan included working closely with staff from the City's Water Resources Division, Engineering Division, and Planning Division to evaluate wastewater flow trends and future development plans and their impact on projected future wastewater flows and future collection system infrastructure needs.

The update of the City's Sewer Master Plan will guide the City's implementation of required collection system improvement projects.

Table ES-1. Sewer Master Plan Objectives	
Sewer Master Plan Objective	Report Location
Evaluate and review available information on the existing wastewater collection system that defines its current capabilities	**Chapter 2** Existing System Description
Confirm the City's standard collection system performance criteria and re-evaluate and better define specific collection system performance criteria that establish the foundation of the City's wastewater collection system planning	**Chapter 4** Collection System Design and Performance Criteria
Establish existing wastewater flow factors, peaking factors and Rainfall Dependent Inflow and Infiltration factors so that Average Dry Weather Flow, Peak Dry Weather Flow, and Peak Wet Weather Flow values for existing and for buildout (based on the City's adopted General Plan) conditions can be developed.	**Chapter 3** Service Area Sewer Flows
Update and validate the City's existing H2OMAP Sewer wastewater collection system hydraulic model to accurately reflect the existing collection system configuration and have a 1:1 correlation with the City's wastewater system Geographic Information System (GIS), and to be used as a planning tool to evaluate the need for future collection system improvements	**Chapter 5** Hydraulic Model Update and Capacity Evaluation Refer to Appendix A for information on the update and validation of the City's wastewater collection system hydraulic model
Use the updated hydraulic model of the City's collection system to analyze and identify improvements that provide appropriate capacity for the existing system and future system at buildout design flows	**Chapter 5** Hydraulic Model Update and Capacity Evaluation Refer to Appendix B for an evaluation of the potential impacts of the proposed Isabel Neighborhood Plan, including an extension of BART to Isabel Avenue, on the City's recommended collection system improvements
Recommend future programs to better evaluate the condition and day-to-day operation of the City's collection system.	**Chapter 6** Operational Analysis
Develop a plan that identifies and prioritizes required wastewater collection system improvements to meet estimated existing rebounded and buildout flows	**Chapter 7** Prioritized Capital Improvement Program

ES.3 EXISTING AND PROJECTED SEWER FLOWS

In this Sewer Master Plan, the capacity of the City's collection system is evaluated versus design sewer flow requirements under existing and buildout conditions. As is typical, the design flow for the City's collection system is defined to be the Peak Wet Weather Flow (PWWF) for existing and future conditions in the collection system. PWWF is developed using Average Dry Weather Flow (ADWF), Peak Dry Weather Flow (PDWF), and Rainfall Dependent Infiltration and Inflow (RDII) components.

A summary of the projected design flows for Existing Rebounded and Buildout conditions developed in this Sewer Master Plan are summarized in Table ES-2, and are described below.

Table ES-2. Projected Collection System Design Flows

Year	ADWF, mgd	PDWF, mgd	RDII, mgd	PWWF, mgd	Wet Weather Peak Factor
Existing Rebounded	6.712	9.058	8.61	17.66	2.63
Buildout	8.14	10.99	15.10	26.09	3.20

mgd = million gallons per day

Between the years 2013 to 2016, California experienced a severe three-year drought. This drought significantly impacted water demand patterns and sanitary sewer generation patterns throughout the state, and has made it difficult to establish a true "baseline" water demand or sewer flow for this time period. This difficulty in establishing a baseline complicates the development of reliable future projections. The City's Water Master Plan invested considerable effort into studying the water demand patterns during the drought to develop an existing baseline. The Water Master Plan established that demands in 2013 (high point of demand during the drought) and 2015 (low point of demand during the drought) were critical to development of the baseline demand. Because water demand that is utilized indoors drives sanitary sewer generation, existing ADWF was developed using 2013 and 2015 data, consistent with the development of demands in the City's Water Master Plan.

Building upon the water demand analysis performed for the Water Master Plan, a baseline ADWF independent of drought impacts was calculated for this Sewer Master Plan projected by applying a Return-to-Sewer ratio to average day water demands. This non-drought baseline for existing flows is identified as the existing rebounded ADWF, analogous to the existing rebounded average dry demand projected for the Water Master Plan. Buildout ADWF projections were developed using the baseline existing rebounded ADWF projections as a starting point. Projected flows from reasonably foreseeable development projects, as identified by City planning staff, were added to the existing rebounded ADWF projections, in addition to projected flows from other vacant areas.

Historical PDWF was determined based on daily hydrographs for flows entering the City's Water Reclamation Plant (WRP) during non-precipitation days in 2013 and 2015. A dry weather peaking factor of 1.35 was observed, and since the dry weather peaking factor is not expected to vary significantly in the future, that same factor was used to project future PDWF.

Because of the lack of wet weather flow monitoring data and because of the few wet weather events captured in flow data at the WRP, it was most appropriate to retain the Rainfall Dependent Inflow and Infiltration (RDII) factor of 800 gallons per acre per day (gpad) established for the 2004 Master Plan. However, because of evidence of increased winter flows seen in the billing data for the Lawrence Livermore National Laboratory (LLNL) and Sandia National Laboratory (SNL) areas, reduced RDII factors were established for these areas, whereas the 2004 Master Plan excluded the RDII calculations entirely. RDII factors of existing infrastructure at buildout conditions was also increased to 1,250 gpad to account for aging. It is estimated that these RDII values correspond to a 5-year return frequency storm. A priority recommendation of this Sewer Master Plan will be implementation of a comprehensive flow monitoring program to establish RDII characteristics by basin and sub-basin throughout the City's sewer service area.

A completion description of the development of the ADWF, PDWF and PWWF for the City's collection system is described in Chapter 3.

ES.4 REVIEW AND CONFIRMATION OF DESIGN AND PERFORMANCE CRITERIA

This Sewer Master Plan utilizes existing rebounded and future design flows described above to evaluate the capacity requirements of the City's collection system. Design flow factors and the performance criteria by which the collection system performance is evaluated is described in Chapter 4. The performance criteria address the gravity mains, lift stations, and force mains. Where the performance evaluation identifies recommended improvements, these improvements shall be designed with the goal of being in accordance with the City's current facility planning guidelines, standard specifications and details, and development plan check and proceeding manual.

ES.5 HYDRAULIC MODEL UPDATE AND VALIDATION

The hydraulic model developed for the 2004 Master Plan was a skeletonized model that contained only the trunk gravity mains from the City's collection system. Small diameter gravity mains were excluded from the hydraulic model. For this Sewer Master Plan, the City desired a more comprehensive evaluation of collection system capacity, including the small diameter gravity mains that predominate the collection system. Further, the City desired that a clear link be developed between individual parcel flows and their connection to the collection system. Such a link requires that all gravity mains, regardless of diameter, be included in the hydraulic model. Therefore, as part of this Sewer Master Plan, the hydraulic model has been updated to include a network that contains all collection system gravity mains.

As described in Chapter 5, a gap analysis was performed to identify gaps in the existing GIS information (such as invert elevations) that were needed for the purposes of modeling. For these gaps, modeling assumptions were made and documented in Appendix A. It is a recommendation of this Sewer Master Plan that in the future the City perform field verification of the higher priority gap analysis findings to improve the accuracy of the model.

Use of the City's updated model was then used for the evaluation of the City's collection system under existing and buildout conditions and to identify deficiencies as described in Chapter 5.

ES.6 OPERATIONAL ANALYSIS

Maintaining the condition of the collection system and providing effective operation of the collection system are equally important to providing adequate hydraulic capacity in meeting the needs of the City and its customers. Chapter 6 provides recommendations for additional flow monitors as part of the City's overall flow monitoring program, and more detailed evaluations to assess performance of the City's lift stations.

ES.7 RECOMMENDED COLLECTION SYSTEM IMPROVEMENTS

Recommended improvements were developed for existing and buildout conditions as part of the Sewer Master Plan.

ES.7.1 Existing and Buildout Collection System Evaluations

The City's collection system was evaluated to assess the system's ability to meet the recommended collection system planning and design criteria under existing rebounded and buildout flow conditions and to identify needed improvements. The findings and recommendations of these evaluations are summarized below.

Chapter 5 of this Sewer Master Plan presents the evaluation of the City's existing and buildout collection system, and its ability to meet recommended collection system planning criteria under existing rebounded and buildout flow conditions. Collection system capacity for gravity mains, lift stations, and force mains was assessed with respect to the system's performance under the existing rebounded and buildout PWWF design flow conditions described in Chapter 3, using the design and performance criteria described in Chapter 4. Recommended improvements are provided in Chapter 7 and a summary of the results is as follows:

- Gravity Mains:
  - Under existing rebounded flow conditions, gravity mains in the City's collection system exceed the performance criteria in some locations. The recommended improvement projects are displayed on Figure ES-2.
  - Under buildout flow conditions, gravity mains in the City's collection system exceed the performance criteria in some locations. The recommended improvement projects are displayed on Figure ES-3.
- Lift Stations:
  - Under existing rebounded flow conditions, the hydraulic model indicates that all of the collection system lift stations currently have sufficient firm capacity.
  - Under buildout flow conditions, the hydraulic model indicates that the firm capacity of the Airport Lift Station has a deficiency of 335 gallons per minute (gpm). The City's other lift stations have sufficient capacity to meet buildout flow conditions.
- Force Mains:
  - Under existing rebounded flow conditions, there are no force mains that fail to meet the City's performance criteria.
  - Under buildout flow conditions, the 8-inch diameter portion of the Airport Lift Station Force Main requires upsizing due to the recommended increased capacity of the lift station.

It should be noted that the hydraulic analysis of the City's gravity mains identifies every incidence of the design and performance criteria being exceeded. In the large majority of these incidences, the performance criteria are exceeded in an isolated gravity main that has a low or even flat slope. In most cases, these low and flat slope gravity mains are small diameter gravity mains that were brought into the model for the first time as part of this Sewer Master Plan, and which have poorly verified invert elevation data. It is anticipated that these identified gravity mains do not represent true hydraulic bottlenecks in the collection system, and therefore have not been included in this Sewer Master Plan as recommended projects. However, it is recommended that in the future the City perform field verification of these isolated mains so their true capacity can be determined and the assumption of no hydraulic bottleneck confirmed.

ES.7.2 Collection System Evaluation for the Isabel Neighborhood Plan

The Isabel Neighborhood Plan (INP) is a proposed development area located in the northwest portion of the City which is contingent upon the extension of Bay Area Rapid Transit (BART) to this location. The INP planning area is entirely within the City's urban growth boundary and lies entirely within the City's sewer service area.

Proposed land uses for the INP are different from those currently included in the City's General Plan, and evaluated in this Sewer Master Plan. Sewer flows have been projected for the proposed INP land uses to determine if the additional sewer flows associated with the INP trigger additional improvements to the City's collection system, beyond those improvements identified in this Sewer Master Plan under buildout sewer flow conditions. The projected ADWF for the INP planning area assuming the INP land uses is 714,000 gallons per day (gpd), which is 195,000 gpd (or about 37 percent) higher than the ADWF for the INP planning area assuming current General Plan land uses.

Existing collection system infrastructure is in place within the INP planning area to serve the existing developed areas. Based on the sewer flow projections for the INP land uses, the following additional collection system improvements would be required to serve future planned development under the proposed INP:

- Additional gravity main improvements (beyond those required for buildout conditions); and
- Additional capacity required at the City's Airport Lift Station (deficiency in firm capacity increases from 335 gpm under buildout conditions to 365 gpm with the INP included).

The additional improvements required for potential INP flows are displayed on Figure ES-4. Additional information on the INP proposed land uses, projected sewer flows, and collection system evaluation is provided in *Appendix B Isabel Neighborhood Plan Analysis*.

ES.8 OPINION OF PROBABLE PROJECT COSTS

Chapter 7 of this Sewer Master Plan provides a summary of recommended collection system improvements, along with an opinion of probable project costs for the recommended collection system improvements to support the City's existing and buildout wastewater flows.

The total opinion of probable project costs for collection system improvements to support the City's existing and buildout sewer flows is $8,055,000. Of this amount, approximately $1,911,000 is required to address existing system deficiencies, and approximately $6,144,000 is required to support future planned growth. The potential INP flows would add approximately $540,000 in probable construction costs to the total project costs.

Table ES-3 summarizes the opinion of probable project costs by project type. It should be noted that any in-tract pipelines required to be installed as part of new development projects will be fully funded and installed by the project proponents. Therefore, these facilities and corresponding costs are not included.

Table ES-3. Opinion of Probable Project Costs for Recommended Collection System Capital Improvements by Project Type[a,b]			
Collection System Improvement Type	Existing (Near-Term)	Buildout	Total
Gravity Main Improvements	$1,636,000	$4,260,000	$5,896,000
Lift Station Improvements	-	$1,884,000	$1,844,000
Collection System Planning Studies	$275,000	-	$275,000
Opinion of Probable Project Costs	$1,911,000	$6,144,000	$8,055,000

(a) Costs shown are based on the March 2017 SF ENR CCI of 11609.

(b) Total Project Costs include the Estimated Construction Costs which include an estimating contingency of 30 percent of the Base Construction Cost, and Design and Construction Period Services equal to 50 percent of the Estimated Construction Costs.

Existing collection system improvements to address existing system deficiencies should be completed as funding permits. The construction of capital improvements for the buildout demand conditions should be coordinated with the proposed schedules of new development to ensure that required collection system infrastructure will be in place as needed to serve future customers.

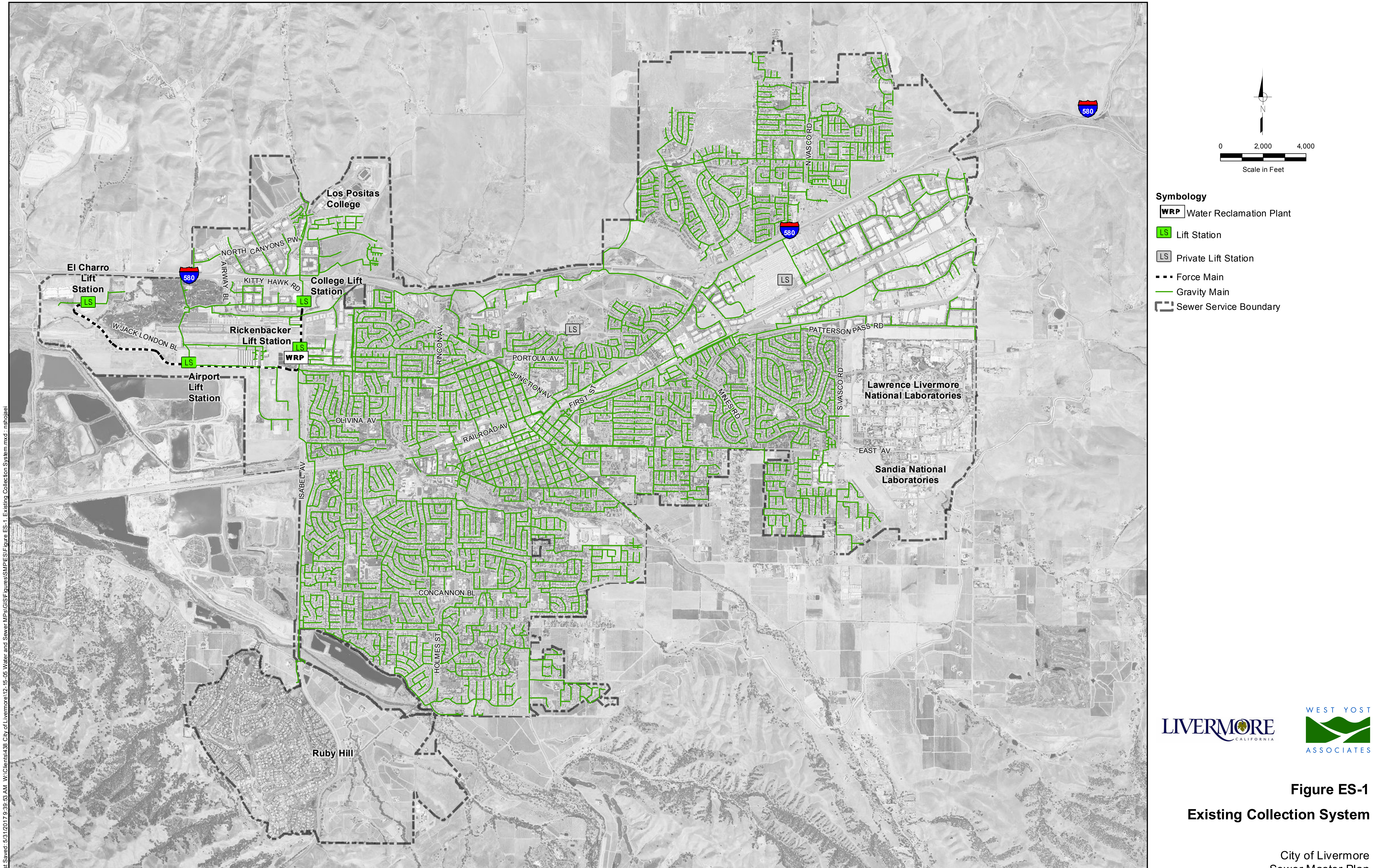
ES.9 CONSIDERATIONS FOR NEXT SEWER MASTER PLAN UPDATE

The following lists additional recommendations and observations related to future planning and operations of the City's collection system:

- The analysis in this Sewer Master Plan was based on the City's collection system facilities as of January 2017. The next Sewer Master Plan update should address and incorporate any changes to the City's service area zone boundaries and any facility changes (i.e., equipment, pipeline modifications) and update the City's collection system hydraulic model accordingly.
- In this Sewer Master Plan, Average Dry Weather Flow (ADWF) factors were calculated or assumed for the various land uses. While it should be understood that ADWF factors are average values, and that the sewer flows for each parcel with a particular land use will likely not match with the ADWF factor exactly, it is recommended that the City monitor actual water usage by customers to identify large increases in water demand, and hence corresponding sewer flows, that may affect the collection system. In particular, ADWF factors should be confirmed for the following land uses:
  - Residential (UH-4): ADWF factors in this Sewer Master Plan are much lower than in the 2004 Sewer Master Plan. Actual unit water use for UH-4 land uses should be compared to the factors used in the Water Master Plan to determine if the estimated ADWF factors are appropriate.
  - Point Demands: Actual sewer flows for Ruby Hills should be monitored to determine if estimated sewer flows are appropriate.

  - Commercial/Business and Commercial Park/Industrial: ADWF factors in this Sewer Master Plan are much lower than in the 2004 Sewer Master Plan. Actual unit water use for these land uses should be compared to the factors used in the Water Master Plan to determine if the estimated ADWF factors are appropriate.

- It is recommended that the City monitor development proposals to confirm and, if needed, update planning assumptions for reasonably foreseeable development projects, including both extent and timing.
- One of the projects identified in this Sewer Master Plan is the installation of permanent flow monitoring locations in the collection system. It is recommended that the City use data from these locations to better establish RDII and PDWF factors, and assess PWWF for 5-, 10- and 20-year storms. Comparing data both pre- and post-major rehabilitation projects will help the City to determine if rehabilitation projects are effective in managing RDII. The flow monitoring data can also be used to get more accurate estimations of return-to-sewer ratios based on land use.
- It is recommended that the City conduct a Lift Station Operational Assessment. This study will consist of operational evaluations to identify the condition and performance characteristics of the City's four lift stations. The study will include a report that prioritizes an improvement plan based upon the evaluations.
- It is recommended that the City perform field verifications of infrastructure identified in the Gap Analysis described in Chapter 5, as well as for gravity main segments that were identified as low slope during the hydraulic modeling. Field verifications should be incorporated into the hydraulic model for the next Sewer Master Plan update.



Symbology

- WRP Water Reclamation Plant
- LS Lift Station
- LS Private Lift Station
- Force Main
- Gravity Main
- Sewer Service Boundary

LIVERMORE CALIFORNIA

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Figure ES-1

Existing Collection System

City of Livermore
Sewer Master Plan

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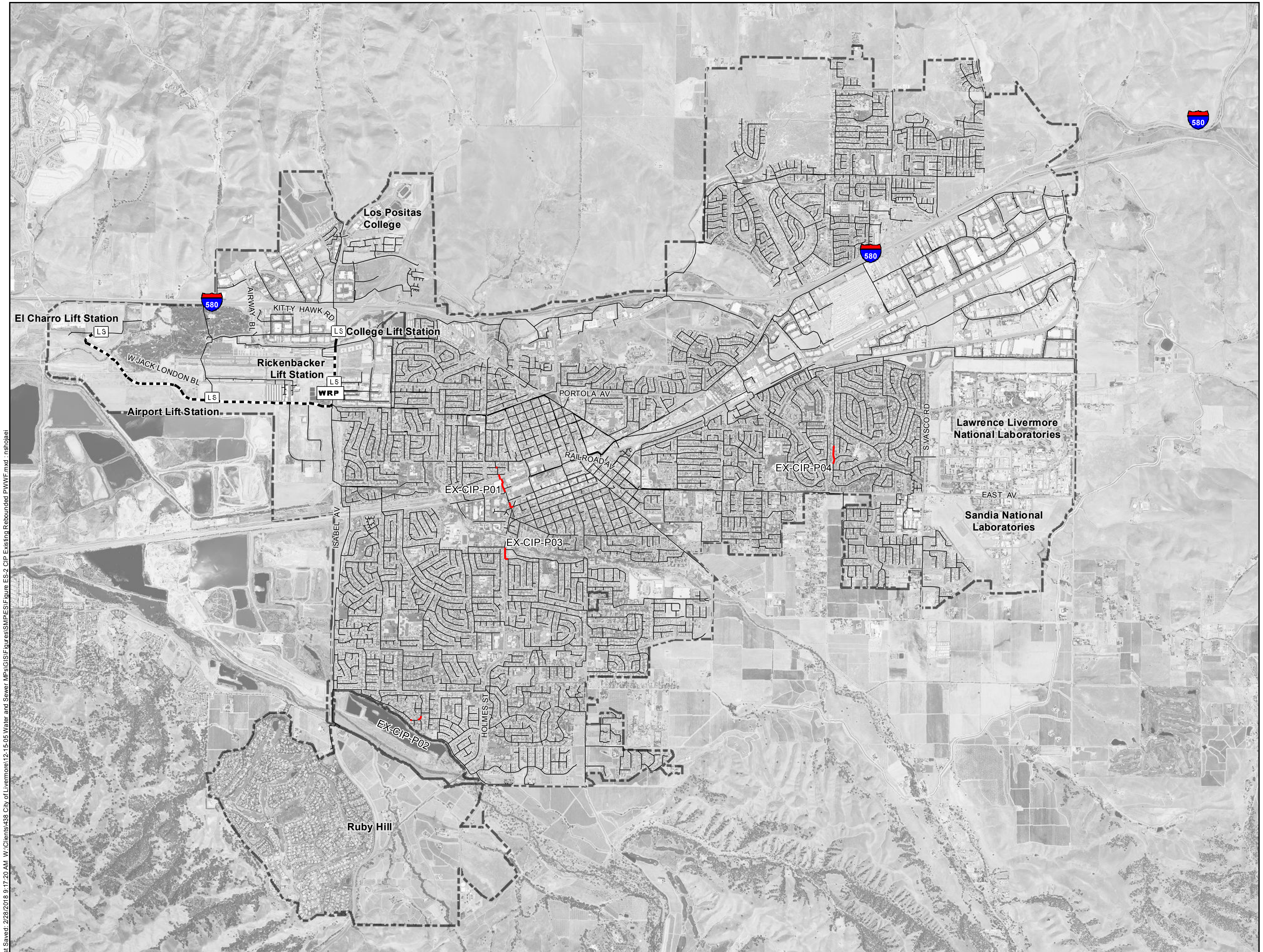

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Scale in Feet

Symbology

WRP Water Reclamation Plant

LS Lift Station

Replace Existing Gravity Main

Gravity Main

Force Main

Sewer Service Boundary

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Figure ES-2

Recommended Capital Improvement Program Existing Rebounded PWWF

City of Livermore
Sewer Master Plan

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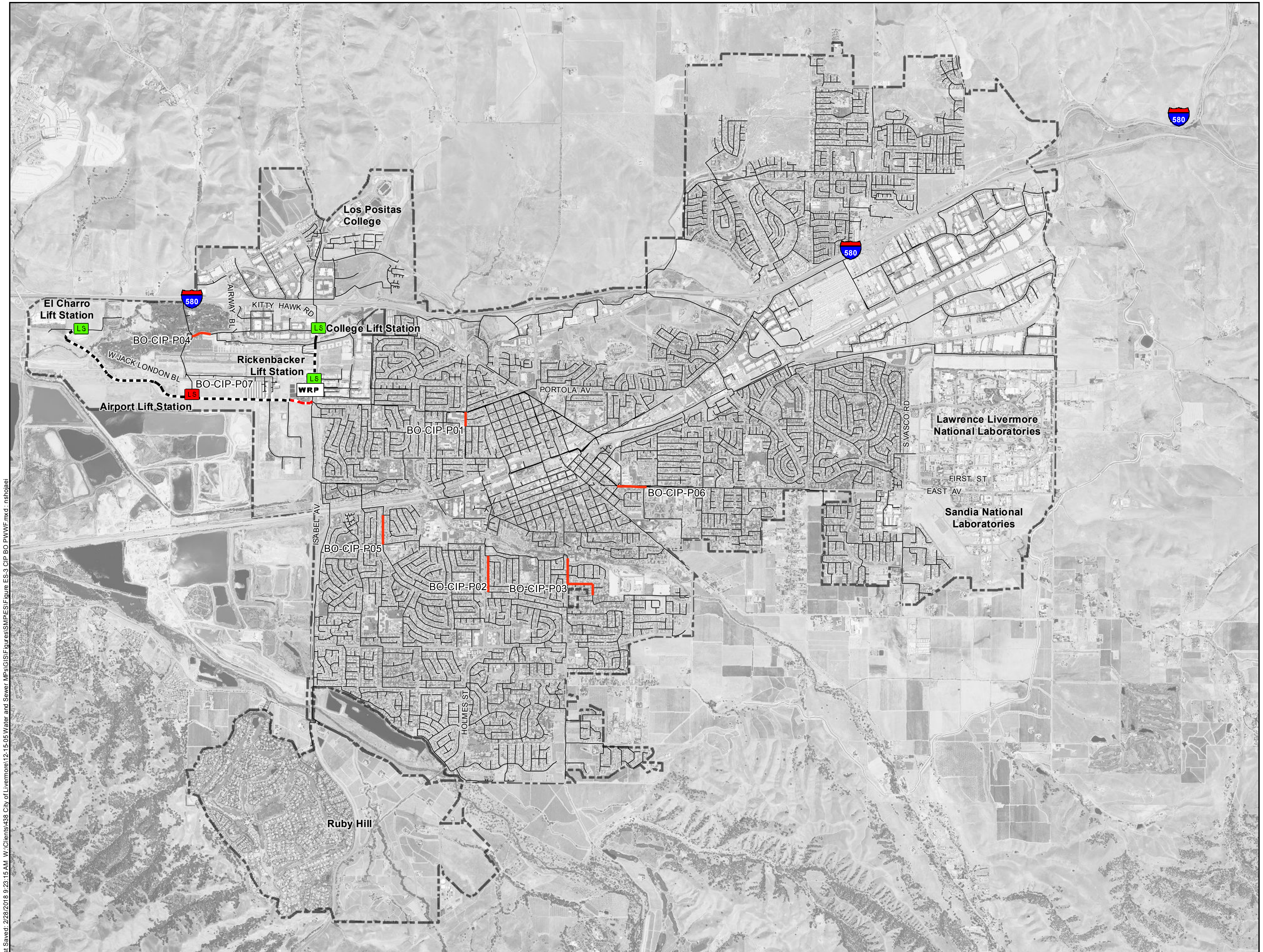

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Scale in Feet

Symbology

- WRP Water Reclamation Plant
- LS Replace Existing Lift Station
- LS Lift Station
- Replace Existing Force Main
- Force Main
- Replace Existing Gravity Main
- Gravity Main
- Sewer Service Boundary

LIVERMORE CALIFORNIA

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Figure ES-3

Recommended Capital Improvement Program Buildout PWWF

City of Livermore
Sewer Master Plan

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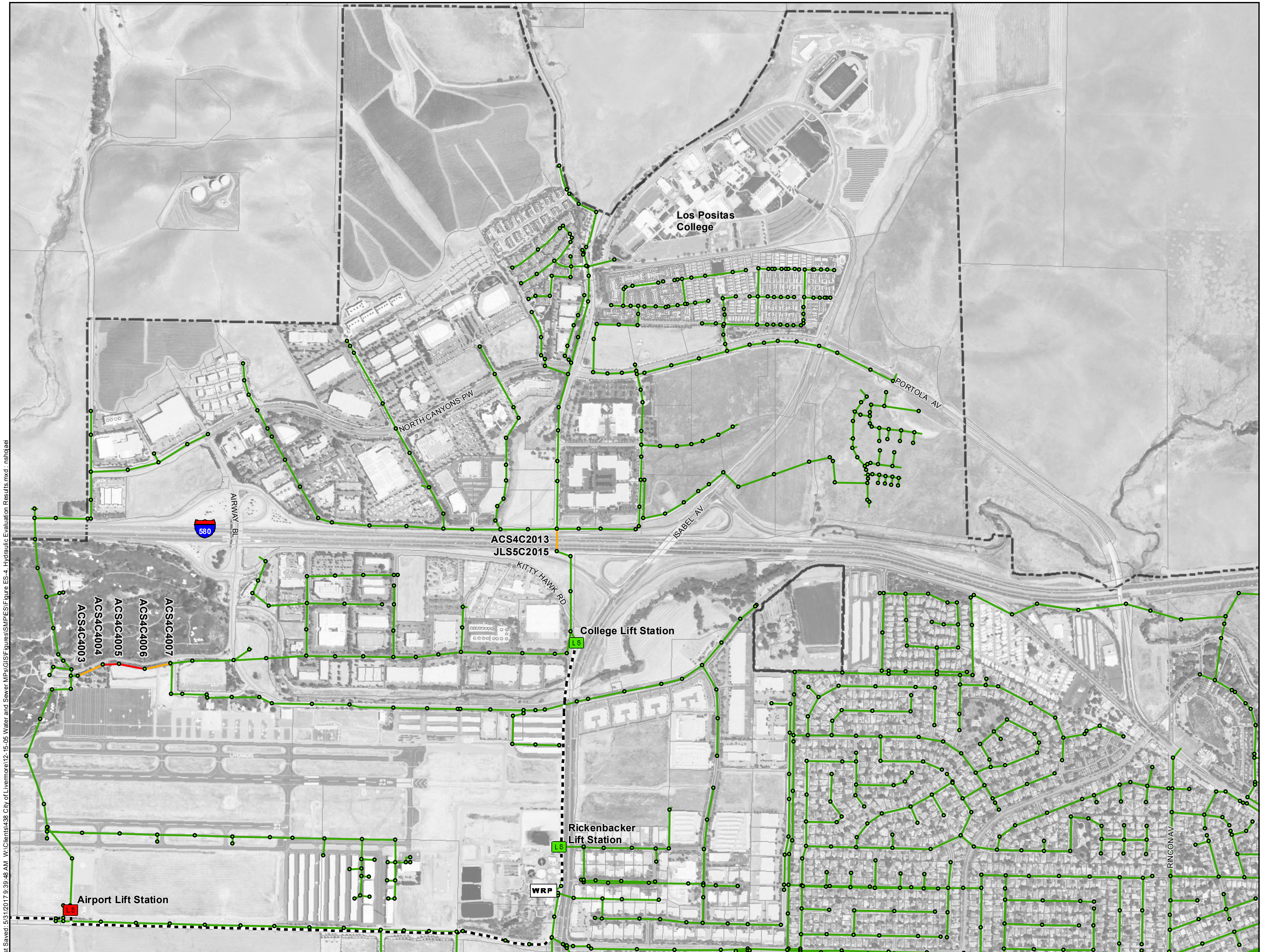

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0 500 1,000

Scale in Feet

Symbology

WRP Water Reclamation Plant

Lift Station Capacity Results

LS No Capacity Deficiency

LS Capacity Deficiency Under Both General Plan Build-Out and INP Scenarios

Manhole

Gravity Main Capacity Results

No Deficiency

Deficiency Under INP Scenario Only

Deficiency Under Both General Plan Build-out and INP Scenarios

Force Main

Sewer Service Boundary

Note:
1. Labels shown are upstream and downstream manholes' ID of gravity main capacity deficiencies.

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Figure ES-4

INP Hydraulic Evaluation Results

City of Livermore
Sewer Master PLan

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1.1 OVERVIEW AND NEED FOR SEWER MASTER PLAN

The City of Livermore (City) sewer collection system serves the incorporated limits of the City, which includes a population of approximately 87,000 people in eastern portion of Alameda County. In addition to the area within the City limits, the sewer service area includes small areas that are outside of the City limits but within the City's Urban Growth Boundary (UGB), as well as the Ruby Hill portion of the City of Pleasanton. The City's sewer service area comprises approximately 28 square miles and the collection system consists of approximately 296 miles of gravity mains, three miles of force mains and four pump stations.

While the City is continually planning and designing collection system improvements to ensure a safe and reliable system, a comprehensive review of the City's collection system facilities has not been completed since 2004. With changes in customer's water use in response to recent on-going drought conditions, and corresponding changes in wastewater flows, and several new development projects proposed throughout the City's sewer service area, there is a need for an updated Sewer Master Plan to evaluate the City's collection system's ability to meet existing and projected future flows and identify improvements needed to address system deficiencies.

1.2 SEWER SYSTEM MASTER PLAN OBJECTIVES AND TASKS

The objective of this Sewer Master Plan is to clearly define the City's long-term collection system infrastructure needs, and to develop a plan that will provide the flexibility and system reliability that the City needs to accommodate changing future needs. The development of this Sewer Master Plan included working closely with staff from the City's Water Resources Division, Engineering Division, and Planning Division to evaluate wastewater flow trends and future development plans and their impact on projected future wastewater flows and future collection system infrastructure needs. The update of the City's Sewer Master Plan will guide the City's implementation of required collection system improvement projects.

It is important to note that the focus of this Sewer Master Plan is to recommend capacity-related improvement projects for the City's sewer system. It is not the intent for this Sewer Master Plan to be the sole source of all recommended sewer system projects for inclusion in the City's Capital Improvement Plan (CIP). Other sources include the Water Resource Division's asset management program (which focuses on the renewal or replacement of sewer system assets based on age and condition), regulations and code compliance, operations and maintenance staff input, and coordination with other roadway improvements. The City utilizes and coordinates all sources in the development of the City's overall CIP for the sewer system.

To accomplish these objectives, seven primary tasks were conducted. These are outlined below:

- Task S1. Data Collection and Review
- Task S2. Review and Update Wastewater Collection System Planning Criteria
- Task S3. Develop Wastewater Flow Projections
- Task S4. Wastewater Collection System Hydraulic Model Update

- Task S5. Existing and Future Capacity Analysis
- Task S6. Develop Capital Improvement Plan
- Task S7. Prepare Sewer System Master Plan

With the completion of these tasks, this resulting Sewer Master Plan provides a comprehensive road map for the City for future planning for its collection system.

1.3 AUTHORIZATION

The City authorized West Yost Associates (West Yost) to prepare this Sewer Master Plan in November 2015. It should be noted that an update of the City's Water Master Plan was also included in the same authorization. An updated Water Master Plan was prepared by West Yost in parallel and in coordination with this Sewer Master Plan, and is included in a separate report.

1.4 REPORT ORGANIZATION

This Sewer Master Plan is organized into the following chapters:

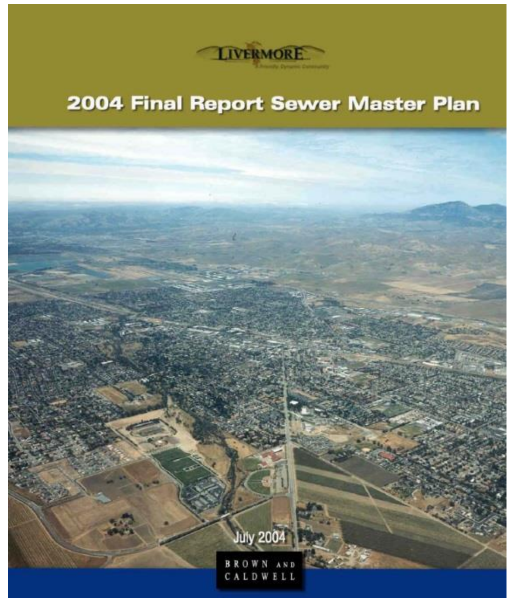
- Executive Summary
- Chapter 1. Introduction
- Chapter 2. Existing System Description
- Chapter 3. Service Area Sewer Flows
- Chapter 4. Collection System Design and Performance Criteria
- Chapter 5. Hydraulic Model Update and Capacity Evaluation
- Chapter 6. Operational Analysis
- Chapter 7. Prioritized Capital Improvement Program

The following appendices to this Sewer Master Plan contain additional technical information, assumptions and calculations:

- Appendix A: Collection System Hydraulic Model Modeler's Notebook
- Appendix B: Isabel Neighborhood Plan Sewer System Evaluation
- Appendix C: Cost Estimating Assumptions

1.5 RELATED PLANS AND REPORTS

1.5.1 2004 Sewer Master Plan



The City's last Sewer Master Plan was completed in 2004[1]. The City's existing (2003) average dry weather flow (ADWF) was 6.52 million gallons per day (mgd), and was projected to increase to 9.11 mgd at buildout of the City's sewer service area (not including BART development). This compares to a current (2015) ADWF of 6.02 mgd, now projected to increase to about 8.27 mgd at buildout of the City's sewer service area (not including BART development). BART development is analyzed in Appendix B of this Sewer Master Plan.

It is interesting to note that the 2015 ADWF is slightly less than the 2003 ADWF despite a slight increase in population. It also interesting to note that the current projected buildout ADWF is about 13 percent less than what was projected in the 2004 Sewer Master Plan. This is the result of many changes which have occurred both within the City's sewer service area and throughout California since the 2004 Sewer Master Plan was completed.

Drought conditions have impacted water resources throughout the state from 2007 to 2009, and again from 2011 to 2016. All but two years of the last decade have been dry in California. The most recent prior drought in Water Years 2007 to 2009 was followed by the current five years of drought (Water Years 2012 to 2016), and four of those years set a record for the driest four consecutive water years in California history since record-keeping began. These dry conditions prompted unprecedented State mandates for water conservation and efficient water use. And although much of the water conservation was due to reduced outdoor water use, indoor water use was also significantly reduced resulting in corresponding reductions in wastewater flows.

As described in Chapter 3, unit sewer generation factors have been reviewed and updated for this Sewer Master Plan to account for changes in sewer generation for different land uses based on recent water consumption and sewer flow data. These changes include an assumed demand rebound to account for increases in water use as the City's water customers return to some of their pre-drought water use habits, which will result in a rebound in sewer generation as well. In many instances, the resulting revised unit sewer generation factors are lower than those used in the City's 2004 Sewer Master Plan, contributing to the lower sewer flow projections in this Sewer Master Plan for buildout of the City's sewer service area.

[1] City of Livermore 2004 Final Report Sewer Master Plan, prepared by Brown and Caldwell, July 2004.

Many collection system improvements have been implemented since the completion of the 2004 Sewer Master Plan; however, with many changes in planned new development projects within the City's sewer service area, and reduced ADWF projected at buildout, there is a need to re-evaluate the City collection system's ability to meet existing and projected future flow conditions and identify improvements needed to address system deficiencies.

1.5.2 Water Master Plan Update

In parallel with this update to the City's Sewer Master Plan, West Yost has also prepared an update to the City's Water Master Plan. While the City's sewer service area encompasses the entire City of Livermore, the City's water service area is limited to only a portion of the City of Livermore (remaining portions are served by the California Water Service Company). Where applicable, the preparation of the City's Water Master Plan and Sewer Master Plan have been coordinated. Areas of coordination have included coordination with future development plans within the City's water service area and coordination between projected water demands and projected return-to-sewer flows within the City's water service area.

The purpose of this chapter is to describe the City's existing sewer service area, collection system, and treatment infrastructure. The City's collection system infrastructure has been evaluated as part of this Sewer Master Plan.

2.1 SEWER SERVICE AREA

The City's collection system serves the incorporated limits of the City. It also serves small areas outside of the incorporated limits, as well as a portion of the City of Pleasanton. The sewer service area, its population, and its land use are described below.

2.1.1 Service Area Description

The sewer service area includes the approximate area within the incorporated City limits. In addition to the area within the City limits, the service area includes small areas that are outside of the City limits but within the City's UGB, as well as the Ruby Hill portion of the City of Pleasanton. The western portion of the sewer service area is relatively flat, necessitating the use of the four lift stations to convey flow from this area to the Water Reclamation Plant (WRP). The eastern portion of the service area slopes from the hills of the Altamont Pass in the east to the west. The existing sewer service area encompasses approximately 18,000 acres, or 28 square miles. This area includes open space and right-of-way areas that are not relevant to sewer generation and are not considered in the land use descriptions provided later in this chapter.

The sewer service area is provided with potable water by four different water providers. A portion of the sewer service area is provided with potable water by the City. The central portion of the City is provided potable water by the California Water Service Company (Cal Water). Lawrence Livermore National Laboratory (LLNL) and Sandia National Laboratory (SNL) receive water directly from the San Francisco Public Utilities Commission (SFPUC) Hetch Hetchy system. Finally, the Ruby Hill Development receives potable water service from the City of Pleasanton. The sewer service area, categorized by the potable water provider, is shown on Figure 2-1.

2.1.2 Service Area Population

Historical population for the City's sewer service area is presented in Table 2-1. As shown in Table 2-1, the population of the City's sewer service area increased from 73,050 people in 2000 to 86,877 people in 2015 according to data received from the City, representing an almost 19 percent increase.

Table 2-1. Historical Sewer Service Area Population (2000-2015)

Year	City of Livermore Sewer Service Area Historical Population[a]
2000	73,050
2001	73,844
2002	75,049
2003	76,393
2004	77,923
2005	80,560
2006	81,263
2007	81,576
2008	81,496
2009	82,221
2010	82,953
2011	83,783
2012	84,620
2013	85,467
2014	86,321
2015	86,877

(a) The 2000-2008 and 2015 population data are taken from the City's and Cal Water's 2015 Urban Water Management Plans (SBX7-7 Table 3 in Appendix E-1 and Chapter 5, respectively). For 2009-2014, the City's population data was estimated based on number of residential connections for those years multiplied by the number of persons per residential connection for 2015. The Cal Water service area population was estimated based on the average annual growth rates provided in the CalWater 2015 Urban Water Management Plan (Chapter 3.4).

2.1.3 Sewer Service Area Land Use

The City provided GIS General Plan land use maps for the entire City. The existing land use map for the sewer service area is presented on Figure 2-2. The total acreages by General Plan land use designation for the parcels within the City's sewer service area in 2015 are summarized in Table 2-2. The land uses are grouped into the same categories that are shown in the City's General Plan. Furthermore, the land uses are categorized by whether they are in the City's water service area or Cal Water's water service area.

Chapter 3 provides an evaluation of the sewer generation for the parcels within the City's sewer service area which are designated as reasonably foreseeable development projects or vacant parcels to be developed in the future.

Table 2-2. Sewer Service Area Existing Land Use[(a)]

General Plan Land Use[(b)]	Land Use Code	Total Acreage: Cal Water Service Area	Total Acreage: City Municipal Service Area	Total Acreage: Total Area [(d)]
Residential				
Rural Residential	RR	186	29	215
Urban Low Residential – 1 (1.0 - 1.5 du/acre)	UL-1	73	119	192
Urban Low Residential – 2 (1.5 - 2.0 du/acre)	UL-2	415	26	441
Urban Low Medium Residential (2.0 - 3.0 du/acre)	ULM	601	384	985
Urban Medium Residential (3.0 - 4.5 du/acre)	UM	1,338	546	1,884
Urban Medium High Residential (4.5 - 6.0 du/acre)	UMH	453	341	793
Urban High Residential – 1 (6 - 8 du/acre)	UH-1	54	35	88
Urban High Residential – 2 (8 - 14 du/acre)	UH-2	240	105	345
Urban High Residential – 3 (14 - 18 du/acre)	UH-3	79	-	79
Urban High Residential – 4 (18 - 22 du/acre)	UH-4	1	63	64
Subtotal		3,439	1,647	5,086
Commercial / Industrial				
Neighborhood Commercial	NC	42	25	67
Service Commercial	SC	65	132	196
Highway Commercial	HC	22	28	49
Office Commercial	OC	44	-	44
Community Serving General Commercial	CSGC	110	38	148
Neighborhood Mixed Low Density	NML	7	-	6.60
Neighborhood Mixed Medium Density	NMM	6	0.26	6.26
Neighborhood Mixed High Density	NMH	-	128.99	128.99
Business and Commercial Park	BCP	23	721	745
Low Intensity Industrial	LII	149	380	529
High Intensity Industrial	HII	-	1,080	1,080
Subtotal		467	2,533	3,000
Community Facility				
Elementary School	CF-E	79	46	125
Intermediate School	CF-I	60	10	70
High School	CF-H	74	-	74
Community College	CF-JC	-	147	147
School General	CF-S	14	-	14
Research and Development	CF-R&D	-	-	-
Fire Station	CF-FS	2	-	2
Hospital	CF-HOSP	5	-	5
Civic Center	CF-CC	33	-	33
Cemetery	CF-CE	25	-	25
Government Service	CF	6	141	147
Airport	CF-AIR	36	528	564
Subtotal		335	871	1,206
Downtown				
Downtown	DA	180	-	180
Subtotal		180	-	180
Public / Semi-Public / Open Space				
BART	BART	-	51	51
Parks, Trailways, Recreation Areas	OSP	587	1,012	1,599
Large Parcel Agriculture	LPA	0	21	21
Limited Agriculture	LDAG	21	373	394
Agriculture/Viticulture	AGVT	107	5	112
Hillside Conservation	HLCN	-	195	195
Subtotal		715	1,658	2,373
South Livermore Valley Specific Plan				
Agricultural Preserve	SV-AP	7	103	110
Residential Development Area	SV-RDA	380	233	614
Vineyard Commercial	SV-VC	28	23	51
Subtotal		415	359	774
Total Acres		**5,550**	**7,068**	**12,618**

[(a)] Developed based on data received from the City of Livermore on December 18, 2015. It is not included the Ruby Hill Developments, SNL and LLNL area.
[(b)] Dual land use areas are considered under primary land use area and/or larger land use area per City's Land use changes by APN excel sheet received in November 2016.
[(c)] Total acreage does not include street rights-of-way in subdivided areas. Therefore, the total acreage is less than the total area within Service Areas.

2.2 EXISTING COLLECTION SYSTEM

The City's sewer infrastructure includes the Water Reclamation Plant (WRP) and the sewer collection system that is tributary to the WRP. The collection system conveys wastewater primarily by gravity to the WRP, which is located at the northwest corner of Isabel Avenue and Jack London Boulevard, in the western portion of the City. Generally, wastewater flows by gravity from the east to the west in the sewer service area. Therefore, the small portions of the service area west of the WRP are served via lift stations. The collection system consists of approximately 299 miles of gravity mains, three miles of force mains and four lift stations. An overview of the City's collection system is shown on Figure 2-3. The gravity mains, force mains, and lift stations that comprise the collection system are described in more detail in the sections below.

2.2.1 Existing Gravity Mains

The existing gravity mains in the collection system, which range in size from 4-inch to 60-inch diameter, are summarized in Table 2-3. As noted in the table, approximately 79 percent of these gravity mains are 8-inch diameter or smaller, approximately 6 percent are 10-inch diameter, and approximately 14 percent are larger than 10-inch diameter. The gravity main diameters are shown on Figure 2-4.

Table 2-3. Livermore Existing Gravity Mains by Diameter

Diameter, inches (in)	Length, feet (ft)	Length, miles	Percentage
4	1,405	0.27	0.09
6	61,718	11.69	3.91
8	1,186,388	224.69	75.14
10	103,108	19.53	6.53
12	74,357	14.08	4.71
15	24,061	4.56	1.52
18	42,626	8.07	2.70
21	11,714	2.22	0.74
24	21,948	4.16	1.39
27	8,845	1.68	0.56
30	13,738	2.60	0.87
33	7,017	1.33	0.44
36	7,295	1.38	0.46
39	3,837	0.73	0.24
42	7,844	1.49	0.50
48	2,478	0.47	0.16
60	622	0.12	0.04
Total	1,579,000	299.05	**100%**

Source: City Geographical Information system (GIS) updated in November 2017.

The existing collection system gravity main material is summarized in Table 2-4. Approximately 54 percent of the existing collection system gravity mains are constructed of vitrified clay pipe (VCP), and about 39 percent are constructed of polyvinyl chloride (PVC). Other materials, which compose a small amount of the existing gravity mains, include reinforced concrete, thermoplastic PVC (TRUSS), asbestos cement, ductile iron, high-density polyethylene (HDPE), acrylonitrile butadiene styrene (ABS), reinforced plastic mortar, and cured-in-place pipe (CIPP). The existing pipeline materials in the collection system are presented on Figure 2-5.

Table 2-4. Livermore Existing Gravity Mains by Pipeline Material

Material	Length, ft	Length, miles	Percentage
Vitrified Clay Pipe (VCP)	850,756	161.13	53.88
Polyvinyl Chloride (PVC)	618,656	117.17	39.18
Reinforced Concrete	37,675	7.14	2.39
Thermoplastic PVC (TRUSS)	27,906	5.29	1.77
Asbestos Cement	12,080	2.29	0.77
Ductile Iron	8,342	1.58	0.53
Reinforced Plastic Mortar	14,914	2.82	0.94
High-Density Polyethylene (HDPE)	2,523	0.48	0.16
Acrylonitrile Butadiene Styrene (ABS)	1,661	0.31	0.11
Cured-in-Place Pipe (CIPP)	84	0.02	0.01
Unknown	4,404	0.83	0.28
Total	1,579,000	299.05	**100%**

Source: City GIS updated in November 2017.

2.2.2 Existing Force Mains

The existing collection system includes approximately three miles of force mains. The existing force mains range in size from 8-inch to 12-inch diameter. The location of the force mains is discussed in more detail below in conjunction with discussion of the lift stations.

2.2.3 Existing Lift Stations

The City has four collection system lift stations located in the western portion of collection system. The lift stations and their configurations in the overall collection system are described below.

2.2.3.1 El Charro Lift Station

In 2011, the El Charro Lift Station was constructed at Livermore Outlets Drive, adjacent to West Jack London Avenue. The El Charro Lift Station pumps wastewater from the San Francisco Premium Outlets and Tri-Valley Golf Center. The 6,578 linear feet of 8-inch diameter force main discharges wastewater directly into the Airport Lift Station. This lift station has an emergency generator.

2.2.3.2 Airport Lift Station

The Airport Lift Station, located on West Jack London Boulevard, was upgraded in 2003. The lift station serves Doolan Road, the area located southwest of the Interstate 580 (I-580) and Kitty Hawk Road, Livermore Municipal Airport, Las Positas Golf Course, Airway Boulevard, and the area located south of West Jack London Boulevard between Discovery Drive and Voyager Street. The wastewater is discharged through 4,300 linear feet of 10-inch diameter force main and 1,023 linear feet of 8-inch diameter force main. Wastewater from the force main discharges into the gravity system and is conveyed to the WRP. This lift station does not have an emergency generator.

2.2.3.3 College Lift Station

The College Lift Station, located in Branson Way adjacent to Isabel Avenue, was upgraded and relocated in 2012. The lift station serves the areas located north of I-580. The 2,148 linear feet of 12-inch diameter force main discharges wastewater immediately upstream of the WRP. This lift station has an emergency generator.

2.2.3.4 Rickenbacker Lift Station

The Rickenbacker Lift Station, which is in Isabel Avenue and adjacent to the WRP, was upgraded and relocated in 2012 as part of the same project that upgraded and relocated the College Lift Station. The Rickenbacker Lift Station serves the small area located east of Isabel Avenue and Rutan Drive. The Rickenbacker Lift Station has a short 12-inch diameter force main that ties into the College Lift Station force main. Wastewater from the Rickenbacker Lift Station discharges with wastewater from the College Lift Station immediately upstream of the WRP. This lift station has an emergency generator.

The existing capacity of each lift station is provided in Table 2-5. The area of the collection system tributary to each lift station is displayed on Figure 2-6.

Table 2-5. Lift Station Capacity

Lift Station Name	Pump Number	Pump Capacity, gallons per minute (gpm)	Design Head, ft	Firm Capacity, gpm
College Lift Station	1 2	1,180 1,180	52	1,180
Airport Lift Station	1 2	1,145 1,145	125	1,145
Rickenbacker Lift Station	1 2	400 400	31	400
El Charro Lift Station	1 2	320 320	65	320

In addition to the four lift stations owned by the City, there are two private lift stations serving a small residential and commercial development at Portola Avenue and Naylor Avenue. These lift stations are not evaluated in this Sewer Master Plan.

2.3 WASTEWATER TREATMENT AND DISPOSAL

The WRP is located on about 35 acres in the western portion of the City. The first wastewater treatment facilities were constructed at this site in 1958. The original facility provided primary treatment and had a capacity of about 2.5 mgd. After several expansions and upgrades, the WRP currently has a permitted ADWF of 8.5 mgd. The current average daily dry weather flow during the summer is 6 mgd. The WRP includes primary, secondary, and tertiary treatment processes. Treatment plant solids undergo thickening, stabilization, and dewatering prior to transport offsite for use as landfill cover.

The WRP is equipped with the emergency holding basin that can hold influent during severe storm events and during routine maintenance of the influent pumps. The basin is normally utilized on a daily basis for flow equalization. All influent flow up to the pump limit of approximately 12 mgd is sent through primary treatment and then sent to equalization during peak hours. It is brought back downstream of the influent flow meter during low flow hours and mixed with sewer influent. Flow above approximately 12 mgd goes straight to equalization and does not get metered by the influent meter.

Approximately 4 to 7 mgd of treated wastewater is sent through the Livermore Amador Valley Water Management Agency (LAVWMA) pipeline for ultimate disposal by the East Bay Dischargers Authority (EBDA) in San Francisco Bay. The City also has a recycled water program that provides treated effluent up to 6 mgd for landscape irrigation and fire protection applications. The City’s wastewater treatment and disposal infrastructure is not evaluated as part of this Sewer Master Plan.

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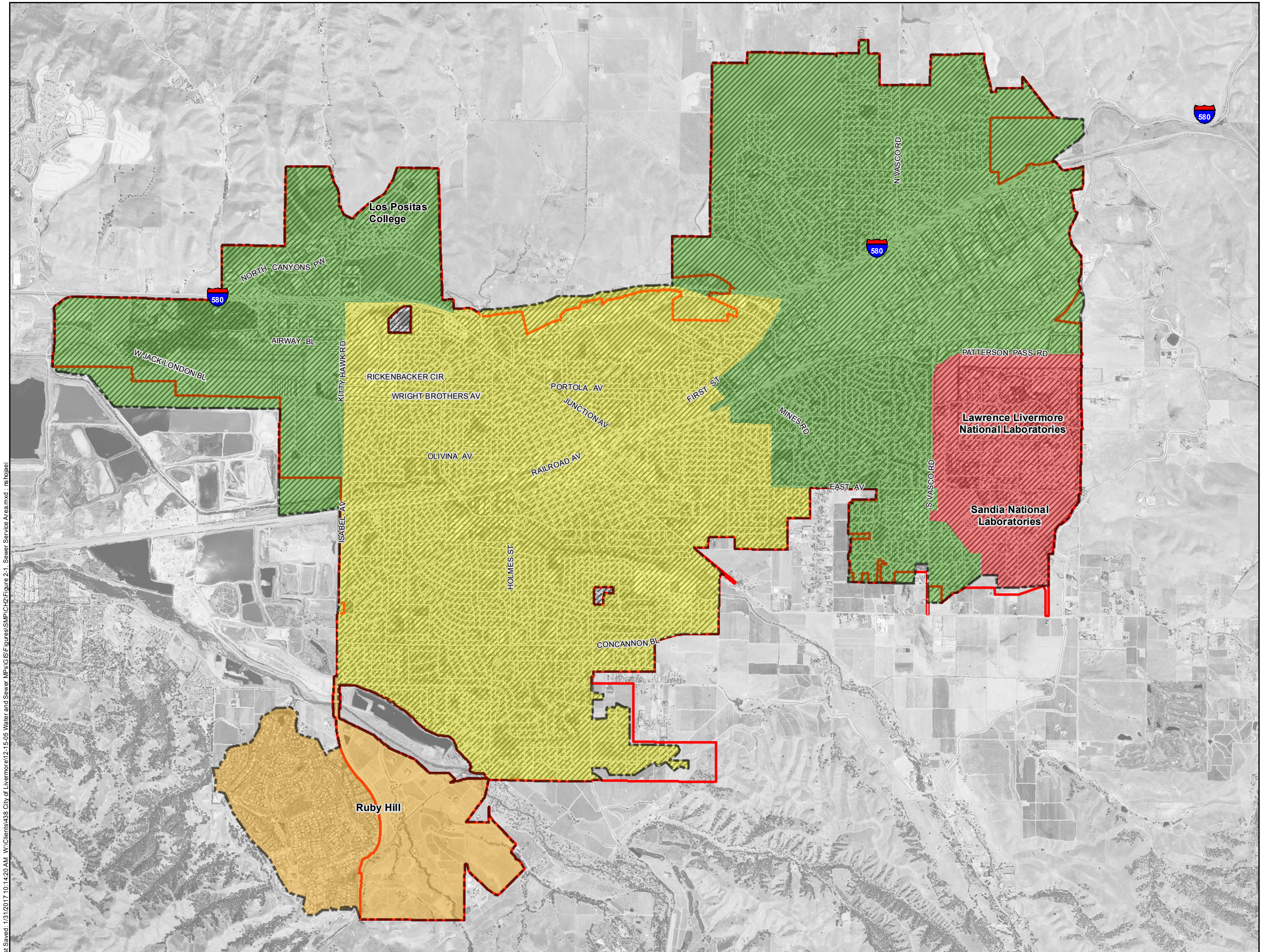

N

0 2,000 4,000

Scale in Feet

Symbology

- City of Livermore
- Cal Water
- City of Pleasanton
- SFPUC
- Sewer Service Boundary
- City Limits
- Urban Growth Boundary

Notes:
1. SFPUC refers to San Francisco Public Utilities Commission.

LIVERMORE CALIFORNIA

WEST YOST ASSOCIATES

Figure 2-1

Sewer Service Boundary and Potable Water Providers

City of Livermore
Sewer Master Plan

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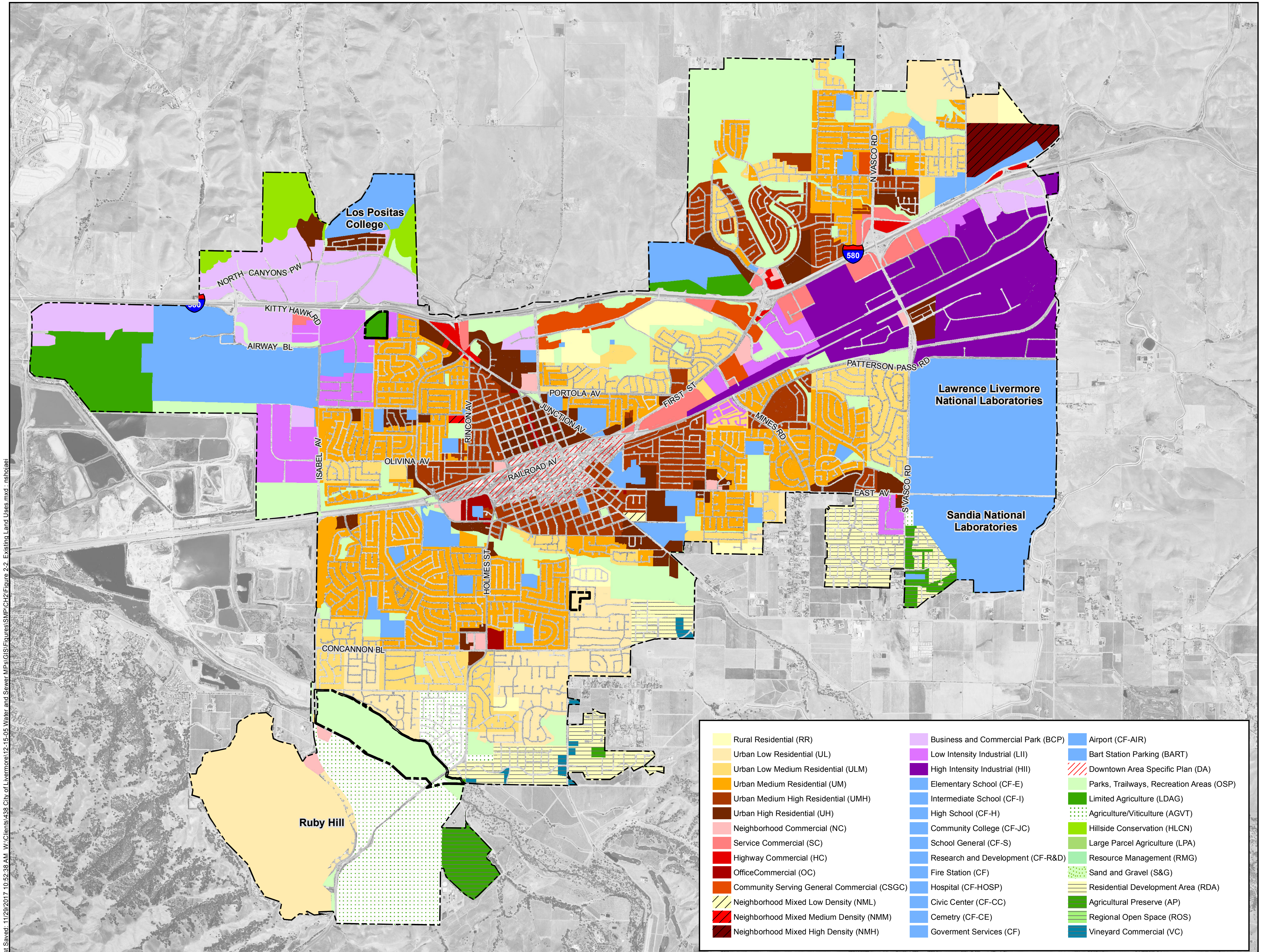

Last Saved: 11/29/2017 10:52:38 AM W:\Clients\438 City of Livermore\12-15-05 Water and Sewer MPs\GIS\Figures\SMP\CH2\Figure 2-2 Existing Land Uses.mxd : nshojaei

N

0 2,000 4,000

Scale in Feet

Symbology

Sewer Service Boundary

Notes:

1. Residential Land Use Area/Density:

RR	1.0-5.0 Acre Site
UL#1	1.0-1.5 du/acre
UL#2	1.5-2.0 du/acre
ULM	2.0-3.0 du/acre
UM	3.0-4.5 du/acre
UMH	4.5-6.0 du/acre
UH#1	6.0-8.0 du/acre
UH#2	8.0-14.0 du/acre
UH#3	14.0-18.0 du/acre
UH#4	18.0-22.0 du/acre
UH#5	22.0-38.0 du/acre
UH#5a	22.0-30.0 du/acre
UH#5b	30.0-38.0 du/acre
UH#6	38.0-55.0 du/acre

2. City of Pleasanton provides potable water for Ruby Hill developments.

3. San Francisco Public Utilities Commission provides potable water for National Laboratories.

LIVERMORE CALIFORNIA

WEST YOST ASSOCIATES

Figure 2-2

Existing Land Uses

City of Livermore
Sewer Master Plan

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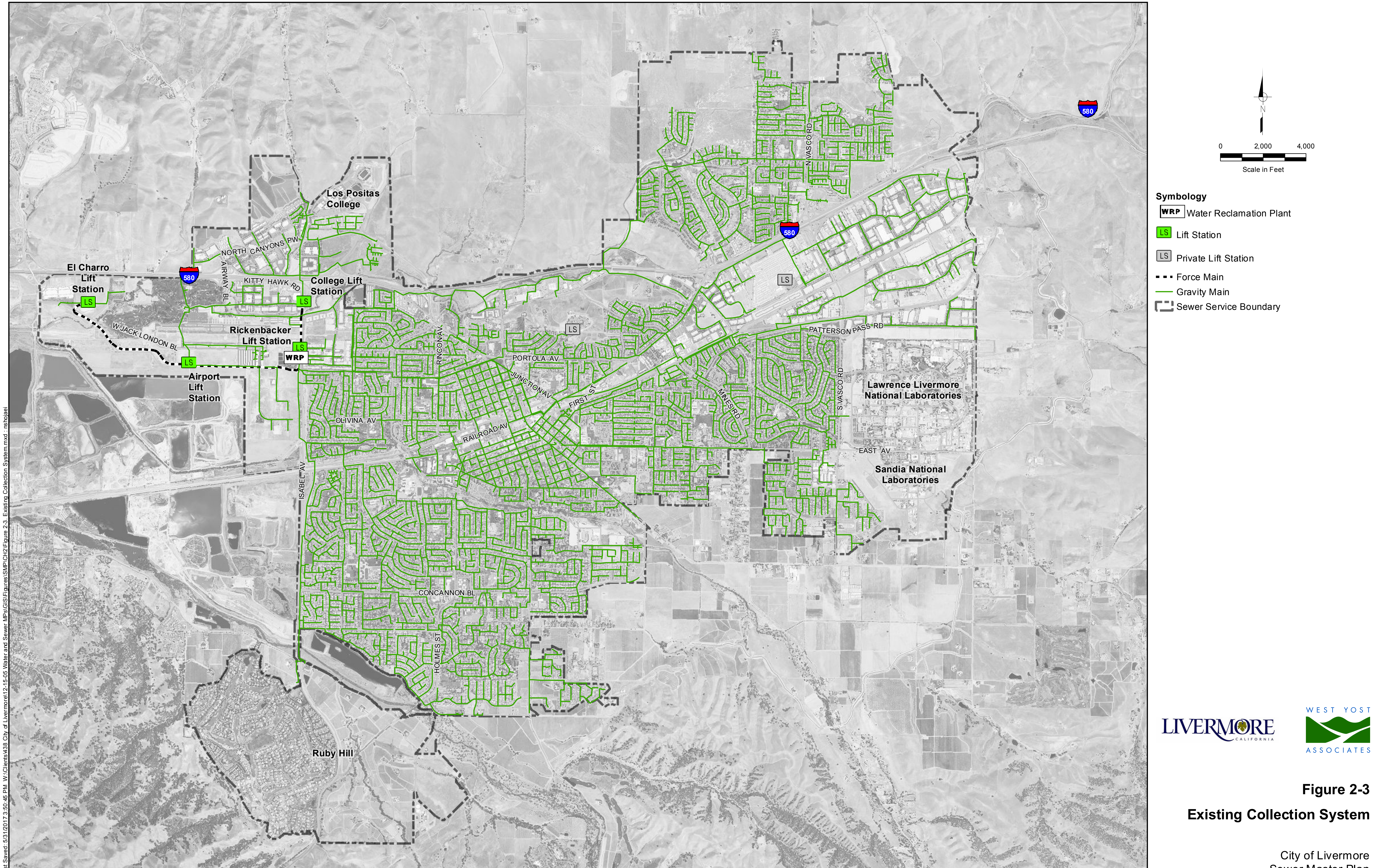

LIVERMORE CALIFORNIA

WEST YOST ASSOCIATES

Figure 2-3

Existing Collection System

City of Livermore
Sewer Master Plan

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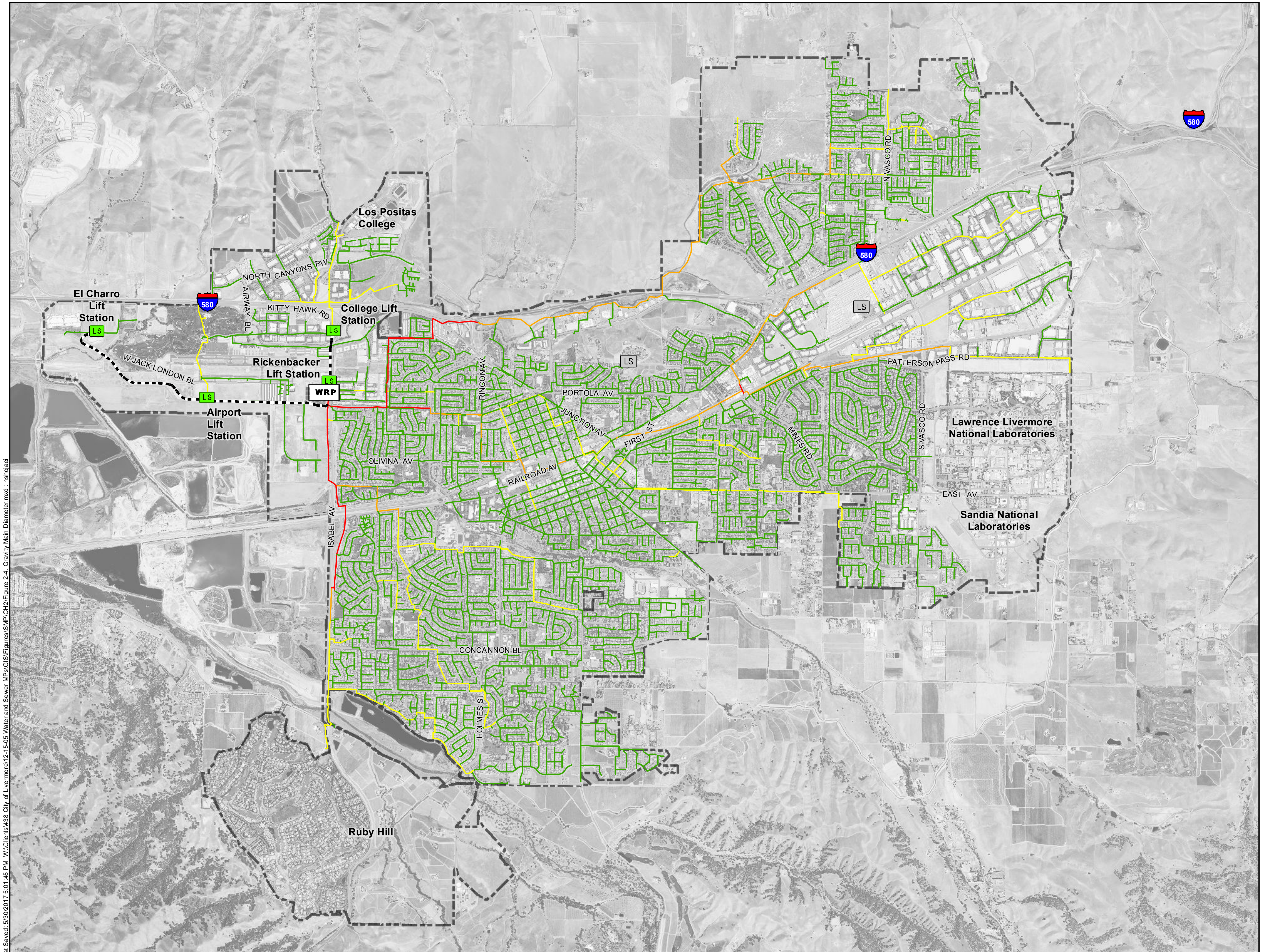

Last Saved: 5/30/2017 5:01:45 PM W:\Clients\438 City of Livermore\12-15-05 Water and Sewer MPs\GIS\Figures\SMP\CH2\Figure 2-4 - Gravity Main Diameter.mxd : nshojaei

N

0 2,000 4,000
Scale in Feet

Symbology

- WRP Water Reclamation Plant
- LS Lift Station
- LS Private Lift Station
- Force Main

Gravity Main - Diameter

- 4-inch - 8-inch
- 10-inch - 18-inch
- 21-inch - 33-inch
- 36-inch - 60-inch
- Sewer Service Boundary

LIVERMORE CALIFORNIA

WEST YOST ASSOCIATES

Figure 2-4

Gravity Main Diameter

City of Livermore
Sewer Master Plan

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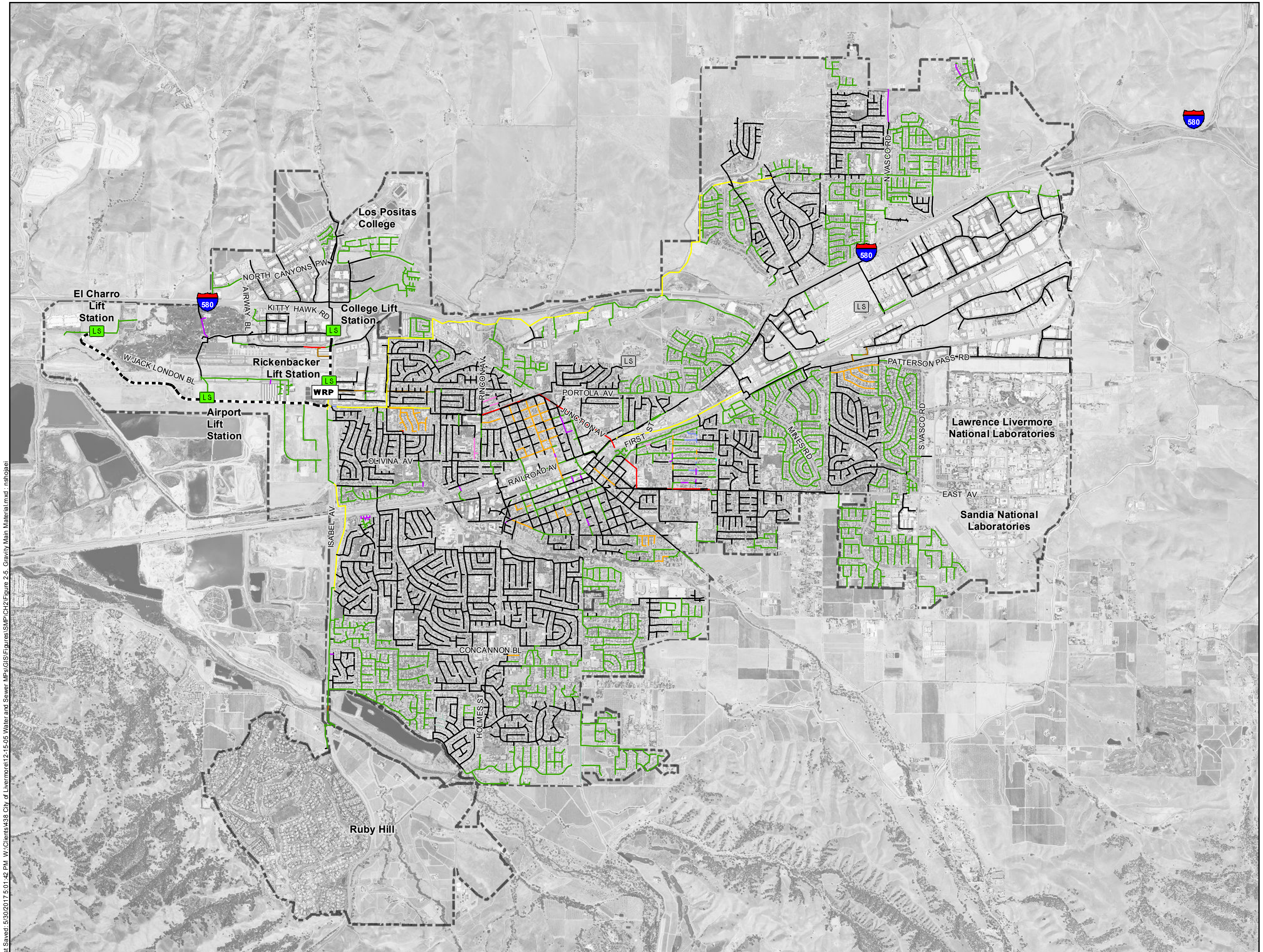

0 2,000 4,000
Scale in Feet

Symbology

- WRP Water Reclamation Plant
- LS Lift Station
- LS Private Lift Station
- Force Main

Gravity Main - Material

- Vitrified Clay
- Polyvinyl Chloride (PVC)
- Reinforced Concrete
- Thermoplastic PVC (TRUSS)
- Asbestos Cement
- Ductile Iron (DI)
- Reinforced Plastic Mortar
- High-density Polyethylene
- Acrylonitrile Butadiene Styrene (ABS)
- Cured-in-place Pipe (CIPP)
- Unknown
- Sewer Service Boundary

LIVERMORE CALIFORNIA

WEST YOST ASSOCIATES

Figure 2-5

Gravity Main Material

City of Livermore
Sewer Master Plan

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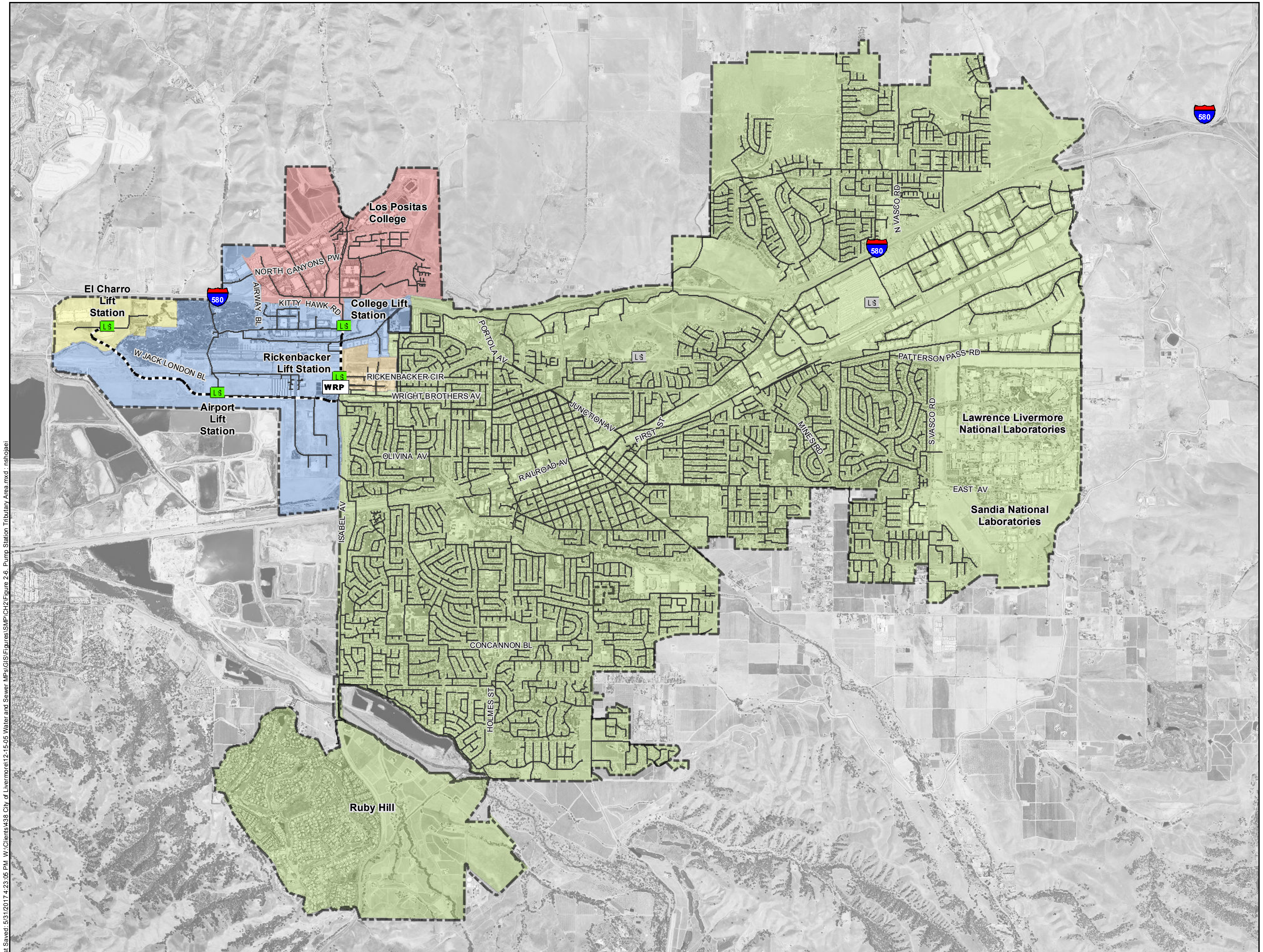

0 2,000 4,000
Scale in Feet

Symbology

- WRP Water Reclamation Plant
- LS Lift Station
- LS Private Lift Station
- Force Main
- Gravity Main

Pump Station Tributary Area

- Airport Pump Station
- College Pump Station
- El Charro Pump Station
- Rickenbacker Pump Station
- Water Reclamation Plant
- Sewer Service Boundary

LIVERMORE CALIFORNIA

WEST YOST ASSOCIATES

Figure 2-6

Lift Station Tributary Area

City of Livermore
Sewer Master Plan

Last Saved: 5/31/2017 4:23:05 PM W:\Clients\438 City of Livermore\12-15-05 Water and Sewer MPs\GIS\Figures\SMP\CH2\Figure 2-6, Pump Station Tributary Area.mxd : nshojaei

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Chapter 3 describes the development of existing and future design flows for use in hydraulic evaluation of the City's collection system. This development builds upon the sewer service area land use data that was presented in Chapter 2.

3.1 SEWER FLOW COMPONENT OVERVIEW

In this Sewer Master Plan, the capacity of the collection system is evaluated versus design sewer flow requirements. As is typical, the design flow for the City's collection system is defined to be the Peak Wet Weather Flow (PWWF) for existing and future conditions in the collection system. PWWF is developed using ADWF and Peak Dry Weather Flow (PDWF) components. The design flow components are described in more detail in the sections below.

3.1.1 Average Dry Weather Flow

ADWF is generally accepted to include two components: base sanitary flow (BSF) and groundwater infiltration (GWI). BSF represents the sanitary and process flow contributions from residential, commercial, institutional, and industrial users of the collection system. GWI is groundwater that infiltrates into defects in sewer pipes and manholes, particularly in winter and springtime in low-lying areas. GWI is typically seasonal in nature and can remain relatively constant over periods of several days or months. However, rainfall clearly has long-term impacts on GWI rates, as evidenced by measurable increases in GWI after prolonged periods of rainfall.

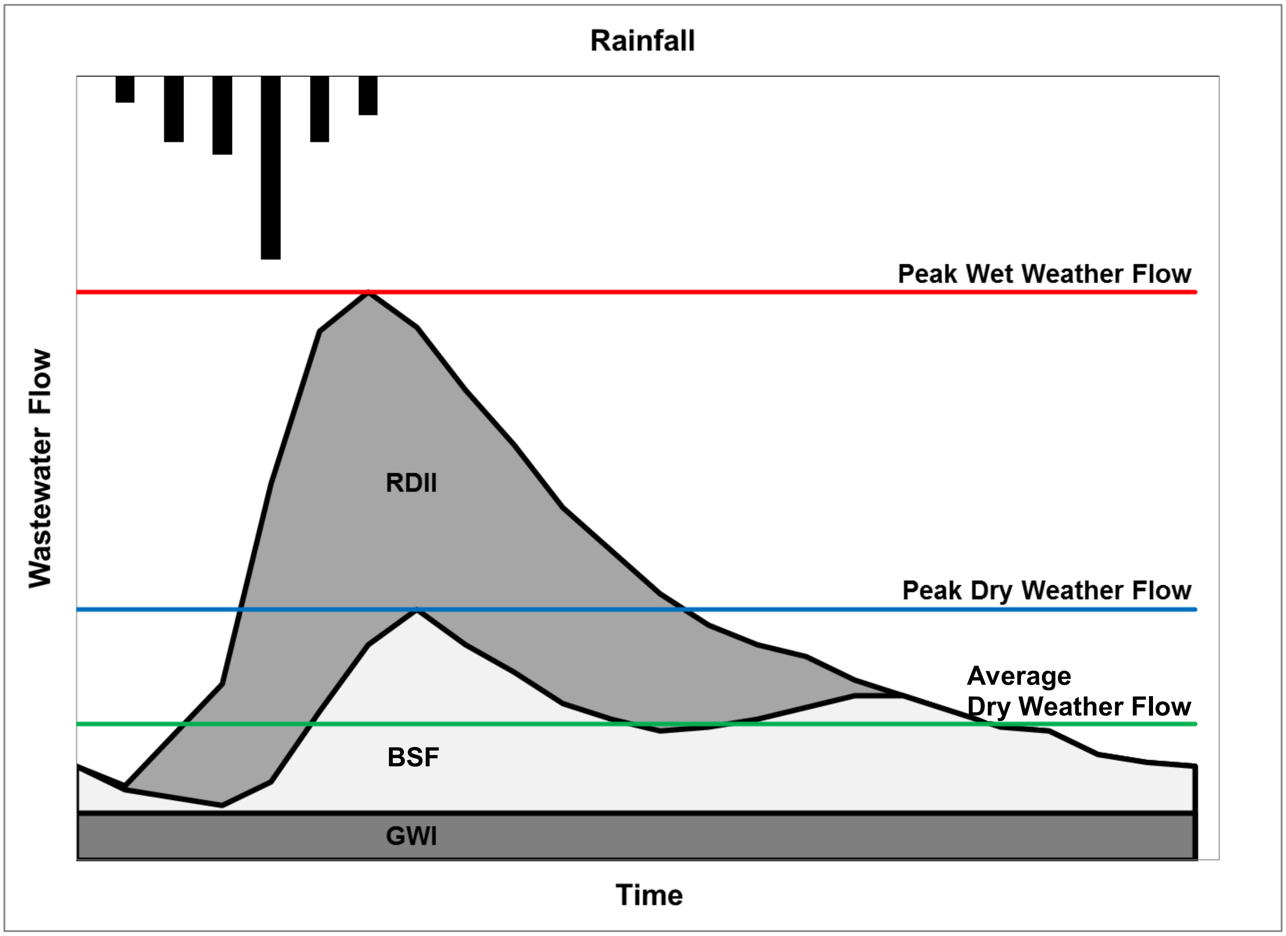
3.1.2 Peak Dry Weather Flow

BSF is typically not discharged into the collection system at a constant rate during the day. BSF varies throughout the day, but typically follows predictable diurnal patterns depending on the type of land use. For example, residential dischargers tend to have high discharge in the morning hours as users wake up and in the evening hours as users return to the home. Commercial dischargers tend to have fairly steady discharge during business hours, but very low discharge outside of business hours; and industrial dischargers have flow patterns that depend upon their individual processes. PDWF is the peak flow experienced in a collection system during dry conditions, and it is determined by the diurnal discharge patterns of the collection system users as described above. PDWF is typically 1.2 to 3.0 times the ADWF in a collection system, depending on the mixture of discharger types and the layout of the collection system.

3.1.3 Peak Wet Weather Flow

PWWF is composed of PDWF with the addition of Rainfall Dependent Inflow and Infiltration (RDII). RDII is storm water inflow and infiltration that enter the system in direct response to rainfall events, either through direct connections such as holes in manhole covers or illegally connected roof leaders or area drains, or, more commonly, through defects in sewer pipes, manholes, and service laterals. RDII typically results in short-term peak flows that recede relatively quickly after the rainfall ends. The magnitude of RDII flows are related to the intensity and duration of the rainfall, the relative soil moisture at the time of the rainfall event, and the condition of the sewers. The wastewater flow components described in this section are presented on Figure 3-1.

Figure 3-1. Wastewater Components for Typical PWWF Conditions



3.2 DESIGN FLOW DEVELOPMENT

The following sections describe how the ADWF, PDWF, and PWWF components for existing and future conditions were developed to calculate existing and future design flows for the City's Sewer Master Plan.

3.2.1 ADWF Development

ADWF development is described below.

3.2.1.1 Historical ADWF

Between the years 2013 to 2016, California experienced a severe three-year drought. This drought significantly impacted water demand patterns and sanitary sewer generation patterns throughout the state, and has made it difficult to establish a true "baseline" water demand or sewer flow for this time period. This difficulty in establishing a baseline complicates the development of reliable future projections. The City's Water Master Plan invested considerable effort into studying the water demand patterns during the drought to develop an existing baseline. The Water Master Plan established that demands in 2013 (high point of demand during the drought) and 2015 (low point of demand during the drought) were critical to development of the baseline demand. Because water demand that is utilized indoors drives sanitary sewer generation, existing ADWF was developed using 2013 and 2015 data, consistent with the development of demands in the City's Water Master Plan.

As discussed above, ADWF consists of both GWI and BSF. Analysis of flow monitoring data conducted for the 2004 Master Plan indicated that GWI values were small enough to be considered negligible. GWI is assumed to be negligible for this Sewer Master Plan as well. Therefore, ADWF is assumed to be composed completely of BSF generated by collection system users.

ADWF was calculated for the collection system by calculating the average flows during non-precipitation days entering the WRP during 2013 and 2015. The average flows were calculated from 15-minute interval Supervisory Control and Data Acquisition (SCADA) data provided by the City. For the purposes of the calculation, a non-precipitation day was considered to be any day for which no precipitation was recorded during that day, as well as during the previous three days. Precipitation data was taken from publicly available National Weather Service records for the Livermore Airport. The ADWF as measured at the WRP for 2013 and 2015 is shown in Table 3-1. The ADWF decreased from 6.82 mgd to 6.02 mgd from 2013 to 2015. The sewer service area population, and the ADWF on a per capita basis that results from dividing the ADWF by the population, are also shown in Table 3-1. As shown, the per capita ADWF value decreased from 80 gallons per capita per day (gpcd) to 70 gpcd between 2013 to 2015.

Table 3-1. Historical ADWF at WRP

Year	ADWF[a], mgd	Population[b], persons	ADWF Per Capita, gpcd
2013	6.82	85,466	80
2015	6.02	86,877	70

[a] WRP SCADA Data from the City.
[b] Population data from City of Livermore 2015 Urban Water Management Plan and Cal Water 2015 Urban Water Management Plan.

To assess the impact of the drought on ADWF, ADWF versus average day water demands were tabulated. Because the majority of water demand in the sewer service area is served by either the City Municipal System or the Cal Water System, and because these two potable water systems have different demand patterns and projections as defined by their respective Urban Water Management Plans (UWMPs), the water demand for these two agencies is shown separately. The water demand compared to ADWF for 2013 and 2015 can be found in Table 3-2. The water demand for the City Municipal system was provided by the City for the Water Master Plan. The water demand for Cal Water was provided via billing records for 2013 and 2015 by Cal Water. All data in Table 3-2, both from the City Municipal System and Cal Water, is based upon billing records and therefore does not include factors for water loss.

Table 3-2. Water Demand and Wastewater Generation Comparison

	2004	2013	2015	Difference between 2013 and 2015	Percentage of Change
Cal Water Winter Water Demand, mgd		5.18	4.53	-0.66	-13%
City Winter Water Demand, mgd		2.83	2.61	-0.21	-8%
Total Winter Water Demand, mgd		**8.01**	**7.14**	**-0.87**	**-11%**
Cal Water Annual Water Demand, mgd		10.00	6.35	-3.65	-36%
City Annual Water Demand, mgd		5.60	3.64	-1.95	-35%
Total Annual Water Demand[(a)], mgd		**15.59**	**9.99**	**-5.60**	**-36%**
Average Dry Weather Flow (WW)[(a)], mgd	5.95	6.45	5.70	-0.76	-12%
Winter Return-To-Sewer		81%	80%		
Annual Return-To-Sewer		41%	57%		

(a) Excluding Ruby Hill developments, LLNL and SNL area

As shown in Table 3-2, total annual water demand decreased by 35 percent between the two water purveyors, with Cal Water's decrease being slightly higher on a percentage basis. Winter water demand decreased 11 percent overall, with Cal Water's percentage decrease again being higher. Since the winter water demand decrease is smaller than the annual water demand decrease, this indicates that the majority of the demand decrease was the result of less outdoor irrigation usage in the sewer service area. This conclusion is supported by the fact that the percentage decrease in ADWF recorded during the same timeframe is nearly identical to the percentage decrease in winter water demand, meaning that the winter Return-To-Sewer Ratio stayed nearly constant between 2013 and 2015. The annual Return-To-Sewer Ratio increased from 42 percent in 2013 to 57 percent in 2015, indicating that a higher percentage of water is going toward indoor use in 2015, and confirming that the majority of conservation took place in outdoor irrigation uses. Because the Cal Water service area experienced a larger percentage drop in water demand during the time period, this may reflect that the Cal Water service area does not utilize recycled water, and therefore has a higher percentage of water devoted to irrigation uses, or may reflect differences in conservation programs and approaches between the two agencies.

3.2.1.2 Existing Rebounded ADWF

Building upon the demand analysis performed for the Water Master Plan, a baseline ADWF independent of drought impacts was calculated for this Sewer Master Plan. This non-drought baseline for existing flows is identified as the existing rebounded ADWF, analogous to the average dry demand rebounded for the Water Master Plan. The baseline non-drought ADWF was developed using the following steps:

- Water billing data from the City and from Cal Water were processed for individual parcels throughout the Sewer Service Area.
- The water billing data for each parcel was increased to account for rebound from water conservation.
- A Return-to-Sewer ratio was applied to the rebounded water value to convert water demand to sewer flow.

The details of these three steps are presented below.

3.2.1.2.1 Historical Water Billing Data Processing

For the Water Master Plan, two sets of spatially allocated demands, one each for 2013 and 2015, were established for water demands in the City's Municipal service area. Spatially allocated water demands were created for both 2013 and 2015 for the Cal Water service area as part of the Sewer Master Plan. Billing records provided by Cal Water were spatially located according to service address in order to achieve this location. The result of this effort was spatially allocated water demand for both 2013 and 2015, attached to parcels throughout the City's sewer service area. Because this data is all based upon billing records, it contains no factors related to water loss. The water demands allocated to parcels also allowed for a summary of water demands to be created by General Plan land use category for both demand years, which is helpful for the development of unit flow factors per land use category that can be applied to future development to generate flow projections.

3.2.1.2.2 Water Demand Rebound

Demand rebound refers to increases in demands after a prolonged drought. As shown in Table 3-2, water demand in the sewer service area decreased approximately 35 percent between 2013 and 2015. The decreases have likely been due to conservation-oriented behavioral changes, such as irrigating less frequently, as well as more permanent changes, such as installation of low-flow toilets or removal of lawns. While the permanent changes can be expected to remain in place after the drought ends, whether or not the behavioral changes continue is less certain.

There are limited precedents from which to draw conclusions regarding demand rebound. The Gold Coast area of Australia experienced a severe drought between June 2002 and January 2004. Demands decreased significantly during the drought as a result of water restrictions, but after the drought ended, the demands rebounded 90 percent (to within 10 percent of what they were prior to the drought). The same drought affected northern New South Wales, where demands also decreased significantly during the drought, but rebounded 84 percent (to within 16 percent of what they were prior to the drought).

While the level to which demands in the City's water service area will rebound is unknown, the City decided to include an assumption of some level of demand rebound into the planning process. In the Water Master Plan, the 2020 target of 192 gpcd is 90 percent of the 2013 per capita water use of 214 gpcd. This would indicate a rebound in demands up to 90 percent of what demands were prior to the current drought. This compares favorably to the demand rebound values of 84 percent and 90 percent that were observed in the New South Wales and Gold Coast areas of Australia. Similar percentages of rebound were applied to the demands in the Cal Water service area for this Sewer Master Plan to create uniformly rebounded water demands to serve as the basis for existing rebounded ADWF.

3.2.1.2.3 Return-to-Sewer Ratio Shift

ADWF is projected by applying a Return-to-Sewer ratio to annual average day water demands. This Return-to-Sewer ratio varies by usage type, with single family dwelling units typically having relatively low ratios, and commercial and industrial users typically having higher ratios. As shown in Table 3-2, the average Return-to-Sewer ratio across the entire sewer service area increased from 41 percent in 2013 to 57 percent in 2015 as outdoor water use was curtailed more heavily than indoor water use during the drought. The Return-to-Sewer ratio after conservation is expected to return nearly to the pre-drought value as behaviors return to pre-drought levels as described above. However, it is estimated that there will be a small Return-to-Sewer ratio "shift" in much the same way that the water demand rebounds. Using a percentage of shift similar to the percentage of demand rebound, the shifted Return-to-Sewer ratio for existing rebounded ADWF is 44 percent. Appropriate Return-to-Sewer ratios were applied to the various General Plan land uses within the sewer service area. These land use specific Return-to-Sewer ratios were calculated such that a flow weighted average Return-to-Sewer ratio of 44 percent was achieved, and these ratios were applied to the existing rebounded water demands to determine the existing rebounded ADWF values by land use. The existing rebounded ADWF values by land use, along with the values used in the 2004 Master Plan and the calculated 2013 and 2015 values for comparison, can be found in Table 3-3.

3.2.1.2.4 Summary of Existing Rebounded ADWF

The development of demands for the Water Master Plan and flows for the Sewer Master Plan were coordinated to achieve consistency and ease in updating and refining. The existing rebounded water demands, Return-to-Sewer ratios, and resulting existing rebounded ADWF are summarized in Table 3-4.

3.2.1.3 Projected Build-Out ADWF

Buildout ADWF projections were developed using the baseline ADWF projections as a starting point. Parcels with existing development were assumed to remain constant in sewer generation unless identified for a Reasonably Foreseeable Development Project. Reasonably Foreseeable Development Projects were identified by City planning staff and were tracked and summarized by inclusion in either the City Municipal service area or Cal Water service area. The Reasonably Foreseeable Development Projects in the City Municipal service area can be seen on Figure 3-2. The Reasonably Foreseeable Development Projects in the Cal Water service area can be seen on Figure 3-3. The ADWF for Reasonably Foreseeable Development Projects in the City Municipal Service Area are shown in Table 3-5. The ADWF for Reasonably Foreseeable Development Projects in the Cal Water Service Area are shown in Table 3-6.

In addition to the flows added for Reasonably Foreseeable Development Projects, vacant land was assumed to be fully developed under build-out conditions. Development was assumed to occur according to General Plan Land Use categorization, and flows were projected according to the values described above and found in Table 3-4. The flows projected for the vacant areas within the sewer service area are shown in Table 3-7. The vacant areas can be found on Figures 3-2 and 3-3, respectively, for the City Municipal service area and the Cal Water service area. It should be noted that that all projected Water Master Plan demands were adjusted for the Sewer Master Plan so that water loss values incorporated in the Water Master Plan were excluded.

Table 3-3. ADWF Factors History and Projection per Land Use

Land Use Category	Land Use Designation	Land Use Code	2004 Master Plan ADWF Factors		2013 Calculated ADWF Factors		2015 Calculated ADWF Factors		Existing Rebounded ADWF Factors	
			gpd per unit	gpad	gpd per unit	gpad	gpd per unit	gpad	gpd per unit	gpad
Residential	Rural Residential	RR	180	-	190	-	150	-	180	-
	Urban Low Residential – 1	UL-1	180	-	190	-	150	-	180	-
	Urban Low Residential – 2	UL-2	180	-	190	-	150	-	180	-
	Urban Low Medium Residential	ULM	180	-	190	-	150	-	180	-
	Urban Medium Residential	UM	180	-	190	-	150	-	180	-
	Urban Medium High Residential	UMH	180	-	190	-	150	-	180	-
	Urban High Residential – 1	UH-1	137	-	140	-	130	-	140	-
	Urban High Residential – 2	UH-2	137	-	140	-	130	-	140	-
	Urban High Residential – 3	UH-3	137	-	140	-	130	-	140	-
	Urban High Residential – 4	UH-4	102	-	80	-	80	-	80	-
	Residential Development Area	SV-RDA	180	-	190	-	150	-	180	-
Downtown	Downtown	DA	-	600	-	790	-	620	-	790
Commercial	Neighborhood Commercial	NC	-	600	-	500	-	400	-	500
	Service Commercial	SC	-	600	-	200	-	180	-	200
	Highway Commercial	HC	-	600	-	150	-	130	-	150
	Office Commercial	OC	-	600	-	730	-	510	-	730
	Community Serving General Commercial	CSGC	-	600	-	250	-	220	-	250
Mixed Use	Neighborhood Mixed Medium Density	NMM	-	2,650	-	2,650	-	2,650	-	2,650
Industrial	Business and Commercial Park	BCP	-	600	-	510	-	430	-	510
	Low Intensity Industrial	LII	-	500	-	420	-	320	-	420
	High Intensity Industrial	HII	-	500	-	600	-	600	-	600
Community Facility	Elementary School	CF-E	-	500	-	480	-	410	-	500
	Intermediate School	CF-I	-	500	-	700	-	490	-	500
	High School	CF-H	-	500	-	480	-	310	-	500
	School General	CF-S	-	500	-	490	-	490	-	500
	Research and Development	CF-R&D	-	200	-	200	-	200	-	200
	Fire Station/ Government Service	CF	-	500	-	440	-	390	-	440
	Hospital	CF-HOSP	-	500	-	4,170	-	3,750	-	4,170
	Civic Center	CF-CC	-	500	-	790	-	330	-	790
	Airport	CF-AIR	-	100	-	100	-	100	-	100
	Cemetery	CF-CE	-	500	-	30	-	30	-	30
Open Space	Limited Agriculture	LDAG	-	-	-	-	-	-	-	-
	Hillside Conservation	HLCN	-	-	-	-	-	-	-	-
	Large Parcel Agriculture	LPA	-	-	-	-	-	-	-	-
	Agriculture/Viticulture	AGVT	-	-	-	-	-	-	-	-
	Parks, Trailways, Recreation Areas	OSP	-	-	-	-	-	-	-	-
South Livermore Valley	Vineyard Commercial	SV-VC	-	-	-	-	-	-	-	500
	Agricultural Preserve	SV-AP	-	-	-	-	-	-	-	-

gpd = gallons per day
gpad = gallons per acre per day

Table 3-4. Summary of Existing Rebounded ADWF[a]						
Land Use Category	Land Use Designation	Land Use Code	2015 Rebounded Water Use[b], mgd	Return-to-Sewer Ratio[c]		Existing Rebounded ADWF, mgd
				With RW Use[d]	Without RW Use[e]	
Residential	Rural Residential	RR	0.131		0.32	0.041
	Urban Low Residential – 1	UL-1	0.155		0.37	0.057
	Urban Low Residential – 2	UL-2	0.665		0.37	0.245
	Urban Low Medium Residential	ULM	1.751		0.42	0.736
	Urban Medium Residential	UM	3.385		0.53	1.777
	Urban Medium High Residential	UMH	1.471		0.53	0.772
	Urban High Residential – 1	UH-1	0.200		0.63	0.126
	Urban High Residential – 2	UH-2	0.955		0.63	0.601
	Urban High Residential – 3	UH-3	0.318		0.74	0.234
	Urban High Residential – 4	UH-4	0.113	0.75	0.73	0.083
	Residential Development Area	SV-RDA	0.869		0.37	0.319
Downtown	Downtown	DA	0.391		0.42	0.164
Commercial	Neighborhood Commercial	NC	0.100		0.53	0.053
	Service Commercial	SC	0.070		0.53	0.037
	Highway Commercial	HC	0.015		0.53	0.008
	Office Commercial	OC	0.069		0.53	0.036
	Community Serving General Commercial	CSGC	0.082		0.63	0.052
Mixed Use	Neighborhood Mixed Medium Density	NMM	0.001		0.63	0.0003
Industrial	Business and Commercial Park	BCP	0.418	0.85	0.73	0.330
	Low Intensity Industrial	LII	0.194		0.79	0.154
	High Intensity Industrial	HII	0.366		0.74	0.271
Community Facility	Elementary School	CF-E	0.125		0.53	0.066
	Intermediate School	CF-I	0.047		0.63	0.030
	High School	CF-H	0.048		0.63	0.030
	School General/ Community College	CF-S	0.005		0.63	0.003
	Fire Station/ Government Service	CF	0.007		0.63	0.004
	Hospital	CF-HOSP	0.047		0.73	0.034
	Civic Center	CF-CC	0.017		0.63	0.010
	Airport	CF-AIR	0.008		0.53	0.004
	Cemetery	CF-CE	0.006		0.21	0.001
South Livermore Valley	Vineyard Commercial	SV-VC	0.018		0.32	0.006
		Total	**12.044**	**0.52**		**6.286**

[a] Excluding Ruby Hill developments, LLNL and SNL area.
[b] Excluding Open Space land use and excluding water losses from all land uses.
[c] Averaged to 0.44, if included return ratios of open spaces and BART, which are zero.
[d] For areas in Zone 1 Water Service Area where recycled water is used.
[e] For Cal-water Service Area, Zone 2 and 3 Water Service Areas, and areas in Zone 1 Water Service Area where recycled water is not used.

Table 3-5. ADWF Projections for Reasonably Foreseeable Development Projects in City Municipal Area										
Planning Areas[a]	Name	Parcel Area, acres	Planned Dwelling Units, DU	Housing Density, DU/acre	Selected Land Use Code	Total Water Demand, gpd [b]	Increase From Existing Water Demand, gpd [b]	Return-to-Sewer Ratio	Total Sewer Flow, gpd	Increase from Existing Sewer Flow, gpd
1a	Outlets - Phase II	17			N/A	12,813	12,813	0.79	10,120	10,120
1b	Outlets - Phase I	46			N/A	36,284	1,000	0.79	28,660	790
2	The Shoppes	12			BCP	15,946	15,946	0.79	12,600	12,600
3	CrossWinds	25			BCP	34,157	34,157	0.79	26,980	26,980
4	Sywest Driving Range	21			BCP	12,788	12,788	0.85	10,870	10,870
5a	Oaks Business Park: Gillig	38			LII	34,578	34,578	0.79	27,320	27,320
5b	Oaks Business Park: Trammel Crow	69			LII	62,464	62,464	0.79	49,350	49,350
5c	Oaks Business Park: Remaining Area	62			LII	55,635	55,635	0.79	43,950	43,950
6	Airport Master Plan (Hangars/Admin)	23			CF-AIR	14,515	6,942	0.53	7,690	3,680
7a	Livermore Valley Charter School: K-8	10			N/A	5,263	0	0.53	2,790	0
7b	Livermore Valley Charter School: Athletics	12			N/A	0	0	0.00	0	0
7c	Livermore Valley Charter School: High School	6			N/A	8,540	0	0.63	5,380	0
8	Las Positas College	147			CF-JC	40,642	10,601	0.63	25,600	6,680
9	Shea Homes, Sage	35	476	14	UH-3	59,220	59,220	0.75	44,415	44,415
10	Ponderosa	6	26	5	UMH	12,003	10,406	0.52	6,300	5,460
11	KB Home	3	58	17	UH-3	11,775	11,775	0.73	8,650	8,650
12	Central Crossing	5	49	10	UH-2	14,057	12,270	0.63	8,860	7,730
13	Garaventa Hills	32	42	1	UL-1	64,709	64,709	0.37	23,780	23,780
14	Open Space	40			OSP-NA	5,386	5,386	0.00	0	0
15	12 Single-Family Homes	10	12	1	UL-1	19,818	19,818	0.37	7,280	7,280
16	Open Space	66			OSP-NA	8,906	8,906	0.00	0	0
17a	BART Site: 300 SF Homes	56	300	5	UMH	120,013	118,033	0.53	63,010	61,970
17b	Open Space	129			OSP-NA	17,414	17,414	0.00	0	0
18	Intel Site	9			LII	9,224	4,480	0.79	7,290	3,540
19	Arroyo Vista Neighborhood Plan	29	495	17	UH-3	101,742	101,742	0.73	74,780	74,780
20	Bennett Drive	13	436	34	UH-5b	57,808	57,808	0.74	42,490	42,490
21	Mc Grant Rent Corp	112			HII	85,404	70,090	0.74	63,200	51,870
22a	Brisa Neighborhood: 465 units	34	465	14	UH-3	93,673	46,305	0.74	68,850	34,030
22b	Brisa Neighborhood: 46 units	1.4	46	34	UH-5b	6,125	6,125	0.73	4,500	4,500
23	PG&E Training Site	44			HII	33,809	32,314	0.74	25,020	23,910
24	6877 Brisa	7			HII	5,082	5,082	0.74	3,760	3,760
25	7600 Hawthorne	13			HII	9,756	9,756	0.74	7,220	7,220
26	7600 Patterson Pass	10			HII	7,576	7,576	0.74	5,610	5,610
27	Grove III	16	58	4	UM	32,344	21,740	0.52	16,980	11,410
28	Ponderosa Vines	5	49	10	UH-2	13,328	13,328	0.63	8,400	8,400
29	Unnamed Development	10	20	2	SV-RDA	22,712	22,712	0.37	8,350	8,350
30	New Private School	122			CF-E	201,357	201,357	0.53	106,720	106,720
31	32 Single-Family Homes	9	32	4	UM	16,861	15,482	0.52	8,850	8,130
	Total	**1,303**	**2,564**			**1,363,730**	**1,190,758**	**0.63**	**865,625**	**744,690**

[a] Locations of planning areas are based on Figure 3-4 and 3-5 in Water Master Plan.
[b] Water demand is decreased by 10% compare to water master plan to exclude water loss value.

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Table 3-6. ADWF Projections for Reasonably Foreseeable Development Projects in Cal Water Service Area

Planning Areas(a)	Name	Description	Parcel Area, acres	Planned Dwelling Units, DU	Housing Density, DU/acre	Recommended Land Use Code	Flow Factor, gpd per unit/gpad(b)		Total Flow, gpd	Increase from Existing Flow, gpd	Note
1	VinSanto II	18 single family houses	4.90	18	4	UM	180	-	3,240	3,240	
2	740 Holmes Street	Redevelopment of 10-unit apartment building with a 24-bed residential care facility for seniors	0.40	24	60	UH-6	80	-	1,920	1,920	Use UH-4 demand factor, since no demand factor available for UH-6.
3	Pleasant View Road	Connecting 19 single family and development of 7 new ones	10.00	3	15	ULM	140	-	3,640	3,640	
4	Sonoma Ave School, 6 du/dc	Redevelopment of school site with 54 single family detached houses, average density of 6 du/dc	9.00	54	6	UMH	140	-	7,560	7,560	
5	Catalina Crossing	Redevelopment of office building with 31-townhouses	2.45	31	13	UH-2	140	-	4,340	4,340	
6	Barcelona Site	Development of 5 townhouses	0.40	5	13	UH-2	80	-	400	400	Use UH-4 demand factor, since no demand factor available for UH-5a.
7	Ruby Hill Site	Development of 11 Large lot single family, about 4,000 to 8,000 square feet each	215.70	11	0	UL-1	180	-	1,980	1,980	
8	SUB16-004, East of Ruby Hill Site	5 single- family and one winery or 30-room inn and restaurant, each parcel 20 acres	120.00	6	0	UL-1	180	-	1,080	1,080	
9	1591 Lomitas	Development of 10 single family, Average density of 2 du/ac	4.90	10	2	UL-2	180	-	1,860	1,800	
10	Chestnut Square	116 multi-family/senior apartment and 44 townhouses	4.50	160	36	UH-5b	80	-	15,060	12,800	Use UH-4 demand factor, since no demand factor available for UH-5b.
11	732 N K St	Development of 6 single family houses	0.50	6	12	UH-3	140	-	840	840	
12	Brighton	Development of 139 Detached houses under construction at 18 du/ac	7.00	128	18	UH-3	80	-	13,070	11,120	
13	Sunflower Hill Project	Development of 6 apartment building which includes 44 units	2.00	44	22	UH-4	80	-	3,560	3,520	
14a	North of Portola	From residential land inventory	11.90	185	16	UH-3	140	-	25,900	25,900	
14b	North of Portola	From residential land inventory	2.00	40	20	UH-3	140	-	5,880	5,600	
15	Primrose Childcare Facility		3.30	1	0	CSGC	-	250	830	830	
16a	First Street Corridor/ Auburn Grove Project	Development of 101 Townhouses	4.70	101	21	UH-4	80	-	8,080	8,080	
16b	First Street Corridor GP Amendment	Townhouses at 16du/ac	17.80	Unknown	16	UH-3	-	2,870	53,440	51,090	
	Total		**506.40**	**2,622**					**152,680**	**145,740**	

(a) Locations of planning areas are shown in Figure 3-3.

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Table 3-7. ADWF Projections for Vacant Areas

Land Use Category (Total Sewer Service Area)	Land Use Designation	Land Use Code	Planned Dwelling Units, DU	Parcel Area, acres	Flow Factor, gpd per unit/gpad[b]		Total Flow, gpd
Residential	Rural Residential	RR	62	-	180	-	11,160
	Urban Low Residential – 1[a]	UL-1	153	-	180	-	27,500
	Urban Low Residential – 2	UL-2	22	-	180	-	3,960
	Urban Low Medium Residential	ULM	12	-	180	-	2,160
	Urban Medium Residential	UM	132	-	180	-	23,800
	Urban Medium High Residential	UMH	191	-	180	-	34,400
	Urban High Residential – 2	UH-2	225	-	140	-	31,500
	Urban High Residential – 3	UH-3	675	-	140	-	94,500
	Urban High Residential – 4	UH-4	1191	-	80	-	95,300
	Residential Development Area	SV-RDA	99	-	180	-	17,800
Downtown	Downtown	DA	-	2.50	-	790	2,000
Commercial	Neighborhood Commercial	NC	-	3.60	-	500	1,800
	Service Commercial	SC	-	31.80	-	200	6,400
	Highway Commercial	HC	-	4.30	-	150	650
	Community Serving General Commercial	CSGC	-	9.20	-	250	2,300
Industrial	Business and Commercial Park	BCP	-	160.40	-	510	81,800
	Low Intensity Industrial	LII	-	16.20	-	420	6,800
	High Intensity Industrial	HII	-	129.00	-	600	77,400
Community Facility	Elementary School	CF-E	-	5.00	-	500	2,500
	Civic Center	CF-CC	-	0.70	-	790	550
	Airport	CF-AIR	-	35.90	-	100	3,590
	Cemetery	CF-CE	-	1.60	-	30	50
South Livermore Valley	Vineyard Commercial	SV-VC	-	16.90	-	500	8,450
	Total		**2762**	**417.10**	**-**	**-**	**536,370**

[a] Including Ruby Hill Developments

[b] gpd = gallons per day and gpad = gallons per acre per day

ADWF projections were developed for point sources into the collection system from large dischargers, and they were calculated independently of the General Plan land use projections. Point source flows into the collection system are detailed in Table 3-8.

Table 3-8. ADWF Point Sources

Discharger	2013 Calibrated, gpd	2015 Calibrated, gpd	Existing Rebounded, gpd	Buildout Projection, gpd
LLNL and SNL	240,000[a]	225,000[a]	295,600[b]	295,600[b]
Ruby Hill Developments	133,000[c]	105,000[c]	126,000[c]	155,000[d]
Total	**373,000**	**330,000**	**421,600**	**450,600**

(a) Source: Water Billing Records
(b) Value given in 2004 Master Plan. It is assumed that LLNL and SNL do not necessarily behave like other customer classes.
(c) 700 single-family residences assumed to active. Calculated based on ADWF factors per residence of 190, 150, and 180 in 2013, 2015, and Existing Rebounded, respectively.
(d) 850 single-family residences plus Reasonably Foreseeable Development Projects assumed to be active.

ADWF projections for the entire sewer service area, incorporating all of the sources of flow projection data described above, are summarized in Table 3-9.

Table 3-9. ADWF History and Projection Summary

Area Description	Service Area	2013 Calibrated, mgd	2015 Calibrated, mgd	Existing Rebounded Projection, mgd	Buildout Projection, mgd
Existing Developed Areas	City Municipal Area	2.51	2.37	2.38[a]	2.38
	CalWater Service Area	3.94	3.32	3.90[a]	3.90
	Ruby Hill Developments, and National Laboratories[b]	0.37	0.33	0.42	0.42
Reasonably Foreseeable Development Projects	City Municipal Area[c]	-	-	-	0.74
	CalWater Service Area[d]	-	-	-	0.15
	Ruby Hill Developments, and National Laboratories	-	-	-	-
Vacant Areas[e]	City Municipal Area	-	-	-	0.20
	CalWater Service Area	-	-	-	0.31
	Ruby Hill Developments, and National Laboratories	-	-	-	0.03
Total		**6.82**	**6.02**	**6.71**	**8.14**

(a) Refer to Table 3-4
(b) Refer to Table 3-8
(c) Refer to Table 3-5
(d) Refer to Table 3-6
(e) Refer to Table 3-7

3.2.2 PDWF Development

PDWF development within the sewer service area is described below.

3.2.2.1 Historical PDWF

The daily hydrographs for flows entering the WRP during the non-precipitation days of 2013 and 2015 were averaged to create composite hydrographs for 2013 and 2015. These hydrographs are presented on Figure 3-4.

The ADWF, PDWF, and resulting peak factor taken from these composite hydrographs are summarized in Table 3-10. The Dry Weather Peak Factors seen for 2013 and 2015 are typical for collection systems similar to the City's.

Table 3-10. Historical PDWF at WRP

Year	ADWF, mgd	PDWF, mgd	Dry Weather Peak Factor
2013	6.82	9.15	1.34
2015	6.02	8.13	1.35

3.2.2.2 Projected PDWF

The dry weather peaking factor is not expected to vary significantly in the future, and a value of 1.35 at the WRP was retained for projections. The projected PDWF in the collection system is presented in Table 3-11.

Table 3-11. Projected PDWF at WRP

Year	ADWF, mgd	PDWF, mgd	Dry Weather Peak Factor
2013 (Calibrated)	6.82	9.15	1.34
2015 (Calibrated)	6.02	8.13	1.35
Existing Rebounded (Projected)	6.71	9.05	1.35
Buildout (Projected)	8.14	10.99	1.35

From 2020 Flow Monitoring:
Sites 1-4 show PDWF/ADWF= 1.7-1.45 (lower flow - higher flow)
Use 1.45, matches well with 1.35.

3.2.3 PWWF Development

Historical PWWF values and design PWWF development are discussed below.

3.2.3.1 Historical PWWF

The 2013 to 2015 timeframe over which the ADWF and PDWF values were developed contained few historical wet weather values because of the on-going drought. Two similar storms, one in 2013 and one in 2015, consisted of a peak rainfall of 0.46 inches over 24 hours. Both of these storms generated approximately 6,200,000 gpd of RDII as measured at the WRP. Therefore, it appears that 6,200,000 gpd of RDII is approximately a two-year return frequency storm result.

3.2.3.2 Projected PWWF

Because of the lack of wet weather flow monitoring data, it was not in the scope of work for this Sewer Master Plan to do a full assessment of RDII factors and PWWF. This full assessment will be performed in the future when flow monitoring is implemented. Because of this fact and because of the few wet weather events captured in flow data at the WRP, it was most appropriate to retain the RDII factor of 800 gpad established for the 2004 Master Plan. Based on the amount of RDII generated by these factors compared to the limited data generated in 2013 and 2015, it is estimated that this value of RDII corresponds to a 5-year return frequency storm for the City's collection system. The 2004 Master Plan indicated that these factors represent a 5-year to 10-year return frequency storm.

Because of evidence of increased winter flows seen in the billing data for the LLNL and SNL areas, reduced RDII factors were established for these areas, whereas the 2004 Master Plan excluded the RDII calculations entirely. The existing RDII factors and the resulting RDII can be found in Table 3-12. The RDII value of 8,612,000 gpd is higher than any RDII values measured at the WRP in 2013 and 2015, and this RDII value, when applied to the existing rebounded PDWF value, results in a design PWWF that is higher than any flow measured at the WRP in 2013 or 2015.

Table 3-12. Existing RDII Generation

Description	Area, acre	Existing RDII Factor, gpad	RDII, gpd
Existing Non-Laboratory Areas	10,644	800	8,515,000
Existing LLNL and SNL Areas	1,215	80	97,000
Total Existing Areas	**11,859**	**-**	**8,612,000**

Because RDII increases over time as a collection system ages, buildout RDII generation factors were increased to determine projected build-out PWWF for design flows. The increased RDII value was estimated to be on the upper end of RDII rates for aging infrastructure in Northern California. With a focused wet weather flow monitoring plan as described in Chapter 6, the City will be able to more precisely determine RDII factors across the collection system for new and aging infrastructure.

New development being brought into service will be served by new, relatively defect-free infrastructure, and is therefore expected to maintain an 800 gpad RDII generation factor. Buildout RDII generation can be found in Table 3-13.

Table 3-13. Buildout RDII Generation

Description	Area, acre	RDII Factor, gpad	RDII, gpd
Existing Non-Laboratory Areas	10,644	1250	13,305,000
Existing LLNL and SNL Areas	1,215	125	152,000
Future Development	2,053	800	1,642,000
Total Buildout Areas	**13,912**	**-**	**15,099,000**

The projected PWWF design flows that result from the RDII generation described above are shown in Table 3-14. A PWWF value of 17.66 mgd will be used to evaluate the hydraulic capacity of the collection system under existing conditions, and a value of 26.09 mgd will be used to evaluate the collection system under future conditions. Although the ADWF values projected for this Sewer Master Plan are lower than those projected for the 2004 Master Plan, the PWWF are slightly higher owing to the increased projected RDII. A priority recommendation of this Sewer Master Plan will be implementation of a comprehensive flow monitoring program to establish RDII characteristics by basin and sub-basin throughout the City's sewer service area.

Table 3-14. Projected PWWF (Design Flows)

Year	ADWF, mgd	PDWF, mgd	RDII, mgd	PWWF, mgd	Wet Weather Peak Factor
Existing Rebounded	6.71	9.05	8.61	17.66	2.63
Buildout	8.14	10.99	15.10	26.09	3.20

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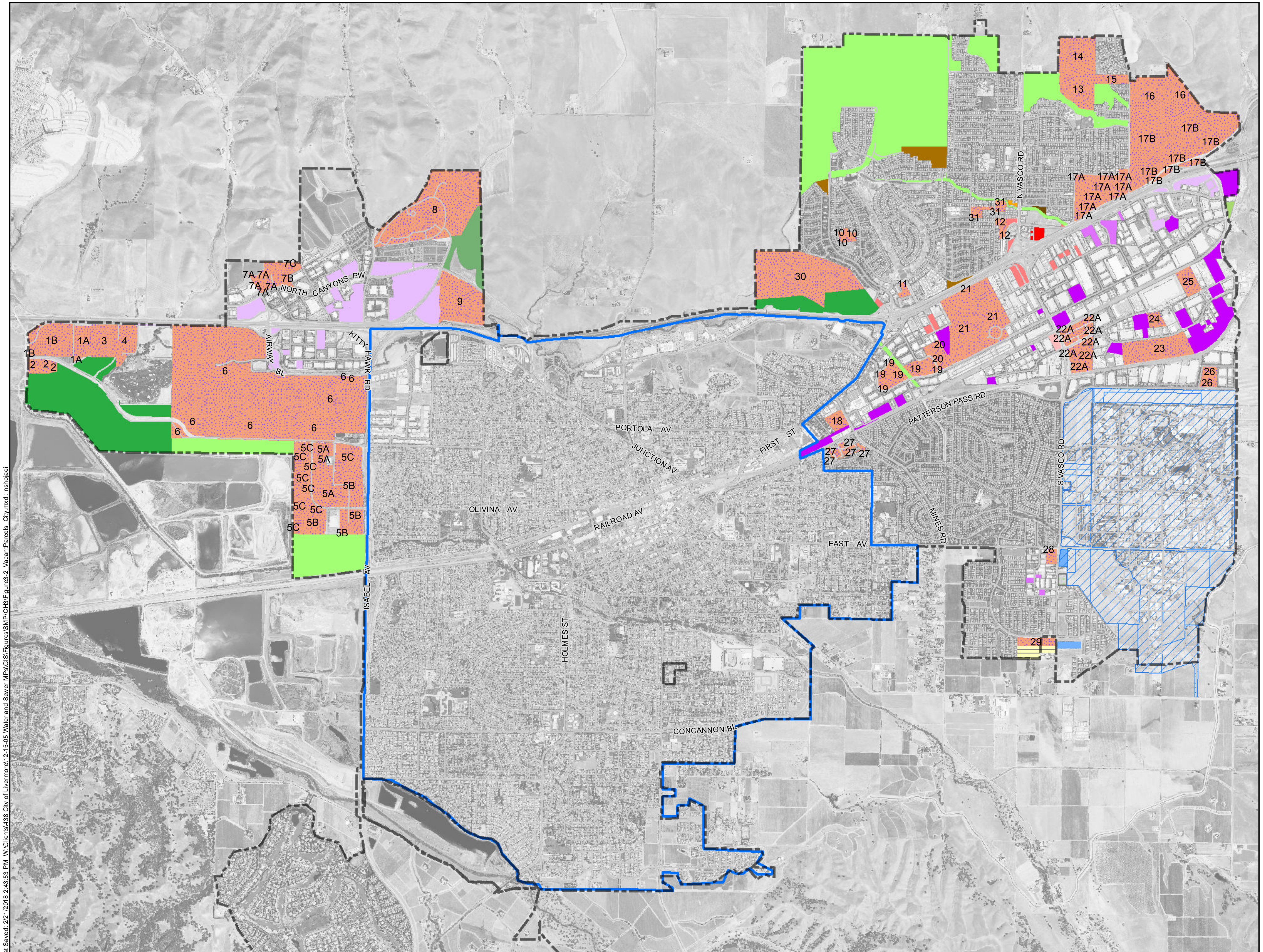

Symbology

- Sewer Service Boundary
- CalWater Boundary
- Developed Parcel
- Reasonably Forseeable Development Projects
- Lawrence Livermore & Sandia National Labs

Vacant Parcels

- Urban Medium Residential (UM)
- Urban Medium High Residential (UMH)
- Urban High Residential (UH-4)
- Neighborhood Commercial (NC)
- Service Commercial (SC)
- Highway Commercial (HC)
- Business and Commercial Park (BCP)
- Low Intensity Industrial (LII)
- High Intensity Industrial (HII)
- Elementary School (CF-E)
- Research and Development (CF-R&D)
- Parks, Trailways, Recreation Areas (OSP)
- Limited Agriculture (LDAG)
- Agriculture/Viticulture (AGVT)
- Hillside Conservation (HLCN)
- Large Parcel Agriculture (LPA)
- Residential Development Area (SV-RDA)

Notes:

1. Refer to Table 3-5 for ADWF projections for Reasonably Foreseeable Development Projects in City Municipal Area.
2. Parcels with current development that have a Reasonably Foreseeable Development Project number reflect further construction and flows beyond existing. See Table 3-5.
3. Refer to Table 3-7 for ADWF projections for vacant areas.

LIVERMORE CALIFORNIA

WEST YOST ASSOCIATES

Figure 3-2

Planning and Vacant Parcels City Municipal Area

City of Livermore
Sewer Master Plan

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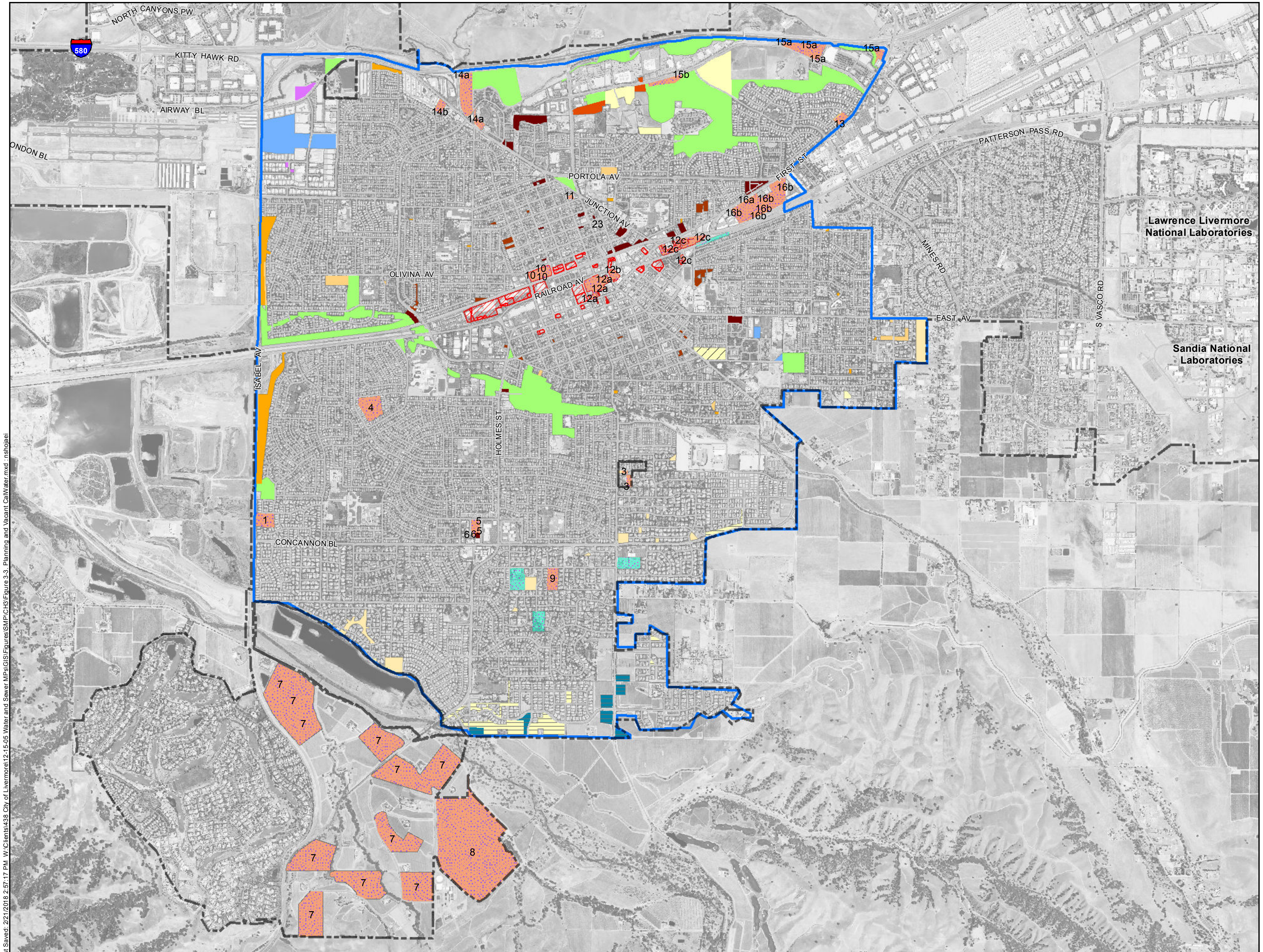

0 1,400 2,800
Scale in Feet

Symbology

- Sewer Service Boundary
- CalWater Boundary
- Developed Parcel
- Under-Developed Parcel
- Reasonably Forseeable Development Projects

Vacant Parcels

- Rural Residential (RR)
- Urban Low Residential #2 - 1.5-2.0 du/acre (UL-2)
- Urban Low Medium Residential (ULM)
- Urban Medium Residential (UM)
- Urban Medium High Residential (UMH)
- Urban High Residential #3 - 14-18 du/acre (UH-3)
- Urban High Residential #2 - 8-14 du/acre (UH-2)
- Neighborhood Commercial
- Service Commercial (SC)
- Highway Commercial (HC)
- Community Serving General Commercial (CSGC)
- Neighborhood Mixed Low Density (NML)
- Low Intensity Industrial (LII)
- Civic Center (CF-CC)
- Cemetry (CF-CE)
- Airport (CF-AIR)
- Downtown Area Specific Plan (DA)
- Parks, Trailways, Recreation Areas (OSP)
- Agriculture/Viticulture (AGVT)
- Vineyard Commercial (VC)
- Residential Development Area (RDA)
- Agricultural Preserve (AP)

Notes:

1. Refer to Table 3-6 for ADWF projections for Reasonably Foreseeable Development Projects in CalWater Area.
2. Parcels with current development that have a Reasonably Foreseeable Development Project number reflect further construction and flows beyond existing. See Table 3-6.
3. Refer to Table 3-7 for ADWF projections for vacant areas.

LIVERMORE CALIFORNIA

WEST YOST ASSOCIATES

Figure 3-3

Planning and Vacant Parcels CalWater Service Area

City of Livermore
Sewer Master Plan

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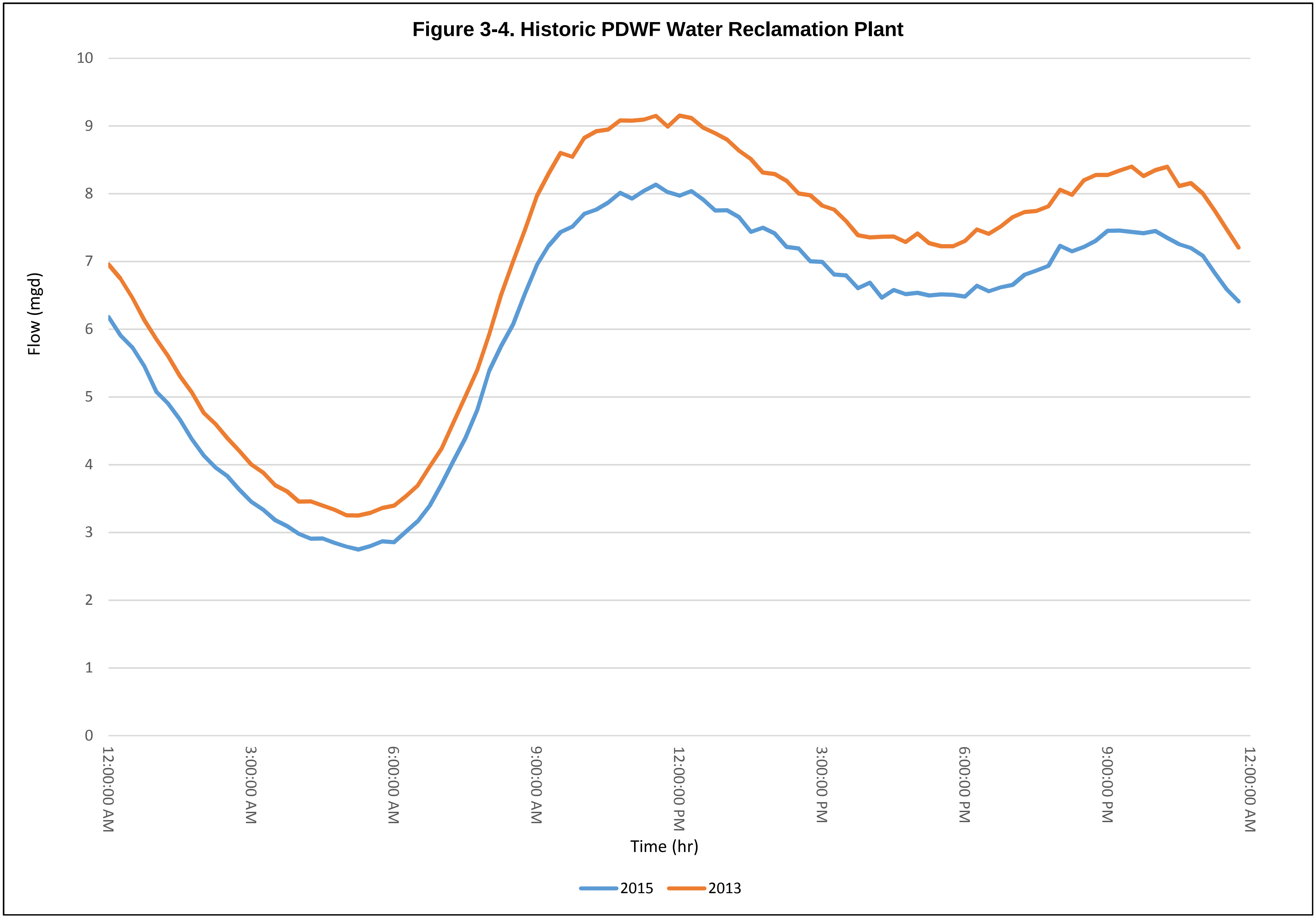
Figure 3-4. Historic PDWF Water Reclamation Plant
10
9
8
7
6
5
4
3
2
1
0
Flow (mgd)
12:00:00 AM
3:00:00 AM
6:00:00 AM
9:00:00 AM
12:00:00 PM
3:00:00 PM
6:00:00 PM
9:00:00 PM
12:00:00 AM
Time (hr)
2015
2013

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The Sewer Master Plan utilizes existing and future design flows to evaluate the capacity requirements of the City's collection system. Chapter 4 summarizes the design flow factors that were developed in detail in Chapter 3. In addition, this chapter summarizes the performance criteria by which the collection system performance is evaluated. The performance criteria address the gravity mains, lift stations, and force mains. Where the performance evaluation identifies recommended improvements, these improvements shall be designed with the goal of being in accordance with the City's current facility planning guidelines, standard specifications and details, and development plan check and proceeding manual.

4.1 DESIGN FLOW FACTORS

ADWF, PDWF, and PWWF design factors are presented below.

4.1.1 ADWF Generation Design Factors

The ADWF Generation Design Factors for the General Plan Land Use contained within the City's Sewer Service Area are presented in Table 4-1. These factors are presented in terms of dwelling units for residential development, and gross area (acreage) for non-residential development. The calculation of these factors is detailed in Chapter 3. As discussed in that chapter, these factors account for both a "rebound" in water demand from drought conditions and a small increase in Return-to-Sewer ratios from those of pre-drought conditions.

4.1.2 PDWF Design Factors

For the Sewer Master Plan, a standard method was utilized for calculating PDWF by applying a diurnal pattern to the ADWF for each collection system user. The diurnal pattern approximates the variation in wastewater discharge over a typical 24-hour period, and varies according to whether the user is primarily residential, commercial or industrial. These design diurnal patterns are independent of location within the collection system, and provide all new development and growth with consistent peak factors typical of their usage patterns. The design residential diurnal pattern can be seen on Figure 4-1. The industrial diurnal pattern can be seen on Figure 4-2. Finally, the commercial diurnal pattern can be seen on Figure 4-3. These patterns were developed based upon previous flow monitoring data in conjunction with industry standards. When the diurnal patterns described here are applied appropriately to individual sewer loads across the sewer service area, flow attenuation and time of travel considerations result in the blended diurnal pattern at the WRP described in Chapter 3.

4.1.3 PWWF Design Factors

As discussed in Chapter 3, PWWF is calculated by adding RDII to the PDWF. For this Sewer Master Plan, the design RDII factor for new development is 800 gpad. Existing development is expected to generate 800 gpad under existing timeframe evaluations, and 1,250 gpad under future timeframe evaluations. The increase in RDII generation is attributed to the physical deterioration of aging infrastructure for existing development and infrastructure. Based upon historical flow data, this rate constitutes approximately a 5-year return frequency storm.

Table 4-1. Design ADWF Generation Factors			
Land Use Category	Land Use Designation	Land Use Code	Design ADWF Factors, gpd per unit
Residential	Rural Residential	RR	180
	Urban Low Residential – 1	UL-1	180
	Urban Low Residential – 2	UL-2	180
	Urban Low Medium Residential	ULM	180
	Urban Medium Residential	UM	180
	Urban Medium High Residential	UMH	180
	Urban High Residential – 1	UH-1	140
	Urban High Residential – 2	UH-2	140
	Urban High Residential – 3	UH-3	140
	Urban High Residential – 4	UH-4	80
	Residential Development Area	SV-RDA	180
Land Use Category	Land Use Designation	Land Use Code	Design ADWF Factors, gpad
Downtown	Downtown	DA	790
Commercial	Neighborhood Commercial	NC	500
	Service Commercial	SC	200
	Highway Commercial	HC	150
	Office Commercial	OC	730
	Community Serving General Commercial	CSGC	250
Mixed Use	Neighborhood Mixed Medium Density	NMM	2,650
Industrial	Business and Commercial Park	BCP	510
	Low Intensity Industrial	LII	420
	High Intensity Industrial	HII	600
Community Facility	Elementary School	CF-E	500
	Intermediate School	CF-I	500
	High School	CF-H	500
	School General	CF-S	500
	Research and Development	CF-R&D	200
	Fire Station/ Government Service	CF	440
	Hospital	CF-HOSP	4,170
	Civic Center	CF-CC	790
	Airport	CF-AIR	100
	Cemetery	CF-CE	30
Open Space	Limited Agriculture	LDAG	-
	Hillside Conservation	HLCN	-
	Large Parcel Agriculture	LPA	-
	Agriculture/Viticulture	AGVT	-
	Parks, Trailways, Recreation Areas	OSP	-
South Livermore Valley	Vineyard Commercial	SV-VC	500
	Agriculture/Viticulture	SV-AGVT	-
	Agricultural Preserve	SV-AP	-

4.2 GRAVITY MAIN PERFORMANCE CRITERIA

The City uses a combination of capacity and surcharge performance criteria to evaluate gravity main performance in the collection system. These criteria are detailed below.

4.2.1 Capacity Calculation

Gravity main flow capacities depend on the roughness of the pipe interior, its geometric configuration (cross-section and length) and slope. The Continuity Equation and the Manning Equation for steady-state flow are used to calculate flow in a gravity main:

Continuity Equation: $Q = V \times A$

where:

Q = peak flow, cubic feet per second (cfs)
V = velocity, feet per second (fps)
A = cross-sectional area of pipe, sq ft

Manning Equation: $V = (1.486 \times R^{2/3} \times S^{1/2})/n$

where:

V = velocity, fps
n = Manning's coefficient of friction
R = hydraulic radius (area divided by wetted perimeter), ft
S = slope of pipe, feet per foot

4.2.2 Manning Coefficient (n)

The Manning Coefficient 'n' is a friction coefficient and varies with respect to pipe material, size of pipe, depth of flow, smoothness of pipe and joints, and extent of root intrusion. For sewer pipes, the Manning coefficient typically ranges between 0.011 and 0.017, with 0.013 being a typical value used for collection system master planning. The default value for the Manning Coefficient used in this Sewer Master Plan is 0.013.

4.2.3 Capacity Performance Criteria

The primary criterion used to evaluate gravity mains is the design (PWWF) flowrate (q) to full pipe flow (Q) ratio (q/Q). When q/Q > 1.0, the design flowrate in the gravity main exceeds the full pipe capacity for that gravity main, and the gravity main is deemed to have insufficient capacity. Gravity mains with insufficient capacity will be categorized into two groups including:

1. Bottleneck minor surcharging and lower priority; and
2. Surcharged conditions exceeding those allowed in Section 4.2.4 and higher priority.

For all parallel, replacement, and new gravity main construction, the gravity main shall be designed such that q/Q does not exceed 0.75. The minimum diameter of such construction shall be 8-inch.

4.2.4 Surcharge Performance Criteria

Surcharging occurs when the hydraulic grade line of the flow is above the crown of a gravity main. Although surcharging is primarily created by gravity mains with insufficient capacities, surcharging can also be created by gravity main alignment, changes in flow direction, and other collection system configurations. In the City's collection system, surcharging greater than 2.0 feet over the crown of a gravity main is not allowed and requires correction when identified. Furthermore, surcharging that results in a hydraulic grade line being closer than 3.0 feet to the ground surface elevation is not allowed, regardless of the depth of the surcharging above the gravity main crown.

4.3 LIFT STATION PERFORMANCE CRITERIA

Lift station holding and pumping capacity criteria are described below.

4.3.1 Lift Station Holding Criteria

The holding volume in a wet well that has an overflow relief mechanism or standby power shall be equivalent to two hours accumulation of the design flow from the fully developed area tributary to the lift station. Wet wells that do not have overflow relief or standby power shall have a holding volume equivalent to four hours accumulation of the design flow from the fully developed area tributary to the lift station.

4.3.2 Lift Station Capacity Criteria

All sewage lift stations shall have sufficient capacity to pump the peak design flow with the largest pump out of service (firm capacity).

4.4 FORCE MAIN PERFORMANCE CRITERIA

Force main hydraulic criteria are typically based on velocity in the force main. Force mains are typically sized such that the velocity in the force main will not exceed 7 fps under peak conditions and will not be less than 2 fps under minimum flow conditions. The maximum velocity prevents excessive wear and tear on the force main, and limits excessive energy expenditures in the lift station due to the high losses that result from higher velocities. The minimum velocity provides self-cleaning and minimize the settlement of solids.

For the Sewer Master Plan, the force main design criteria of a maximum velocity of 7 fps under peak operating conditions and 2 fps under minimum flow conditions are applied.

4.4.1 Head Loss

The Hazen-Williams formula is used to calculate the head loss in force mains due to velocity friction. The formula is:

Head loss Equation: $h_f = \frac{3.022 \times V^{1.85} L}{C^{1.85} \times D^{1.17}}$

where:

V = velocity, fps
C = Hazen-Williams roughness coefficient
D = diameter, ft
L = pipe length, ft

The value of the Hazen-Williams roughness coefficient varies with the type of pipe material and is influenced by the type of construction and age of the pipe. A value of 120 is assumed to be the default value for this Sewer Master Plan.

4.4.2 Minor Losses

In addition to the friction energy lost due to viscous effects, friction losses also result from fittings in the line, changes in direction, and changes in flow area. These losses are known as minor losses and can be calculated with two methods of equivalent lengths and loss coefficients.

With the method of equivalent lengths, each fitting or other flow variation is assumed to produce friction equal to the pipe wall friction from an equivalent length of pipe. The equivalent for all minor losses are added to the pipe length in the Darcy equation. This method is usually limited to the turbulent flow.

Total Length Equation: $L_t = L + \sum L_e$

The generic table of equivalent length is located in the City's Facility Planning Guidelines.

In the method of loss coefficients, each fitting has a loss coefficient, K, associated with it, which, when multiplied by the kinetic energy, gives the loss. Therefore, a loss coefficient is the minor loss expressed in fraction of the velocity head, h_v.

Minor Loss Equation: $h_m = K \times h_v$

The loss coefficient for any minor loss can be calculated if the equivalent length is known.

Loss Coefficient Equation: $K = f \times L_e / D$

where:

f = friction factor
D = diameter, ft
L_e = equivalent length, ft

For this hydraulic analysis, the method of equivalent lengths was used to account for minor losses.

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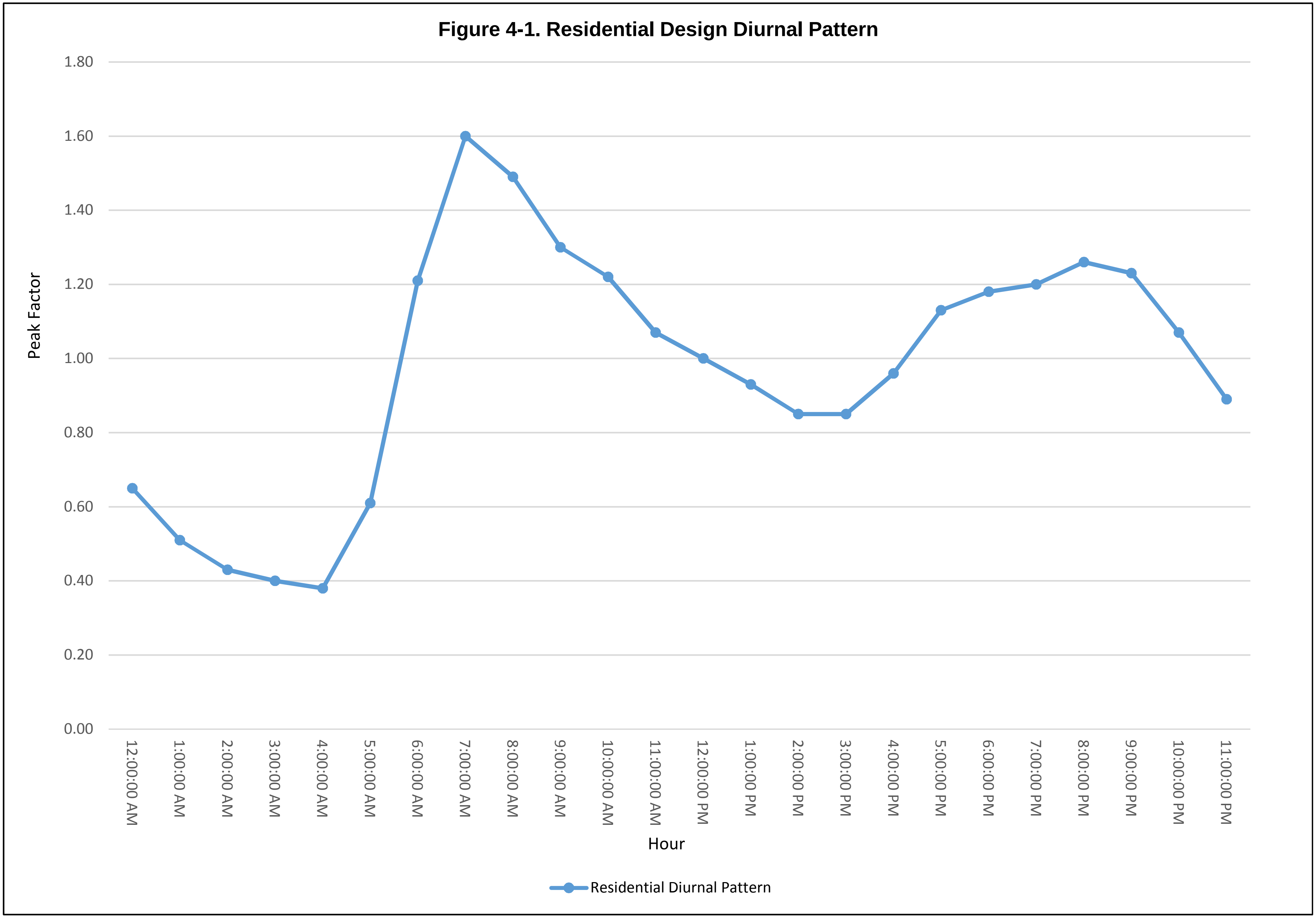

Figure 4-1. Residential Design Diurnal Pattern
Peak Factor
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
12:00:00 AM
1:00:00 AM
2:00:00 AM
3:00:00 AM
4:00:00 AM
5:00:00 AM
6:00:00 AM
7:00:00 AM
8:00:00 AM
9:00:00 AM
10:00:00 AM
11:00:00 AM
12:00:00 PM
1:00:00 PM
2:00:00 PM
3:00:00 PM
4:00:00 PM
5:00:00 PM
6:00:00 PM
7:00:00 PM
8:00:00 PM
9:00:00 PM
10:00:00 PM
11:00:00 PM
Hour
Residential Diurnal Pattern

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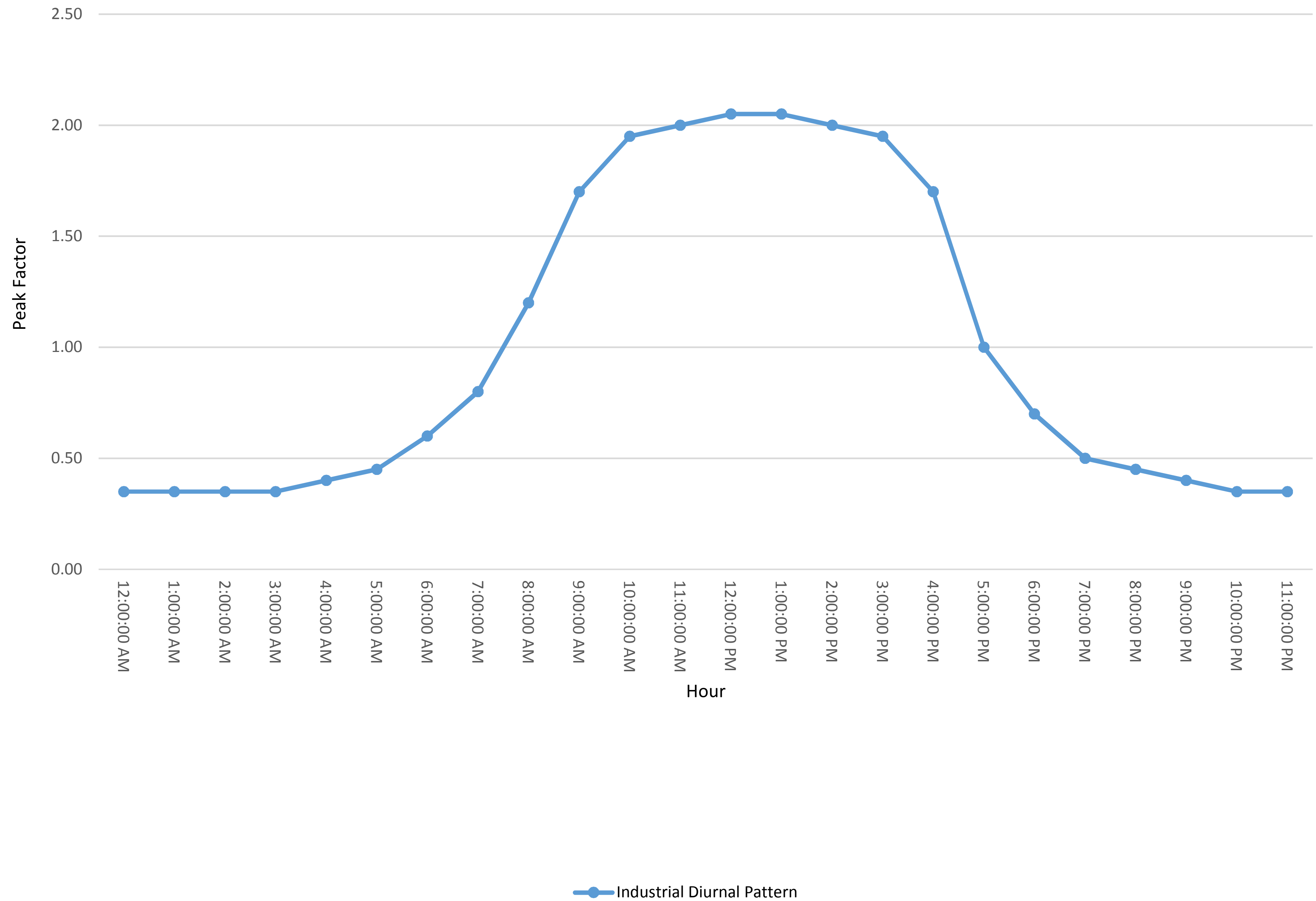
Figure 4-2. Industrial Design Diurnal Pattern



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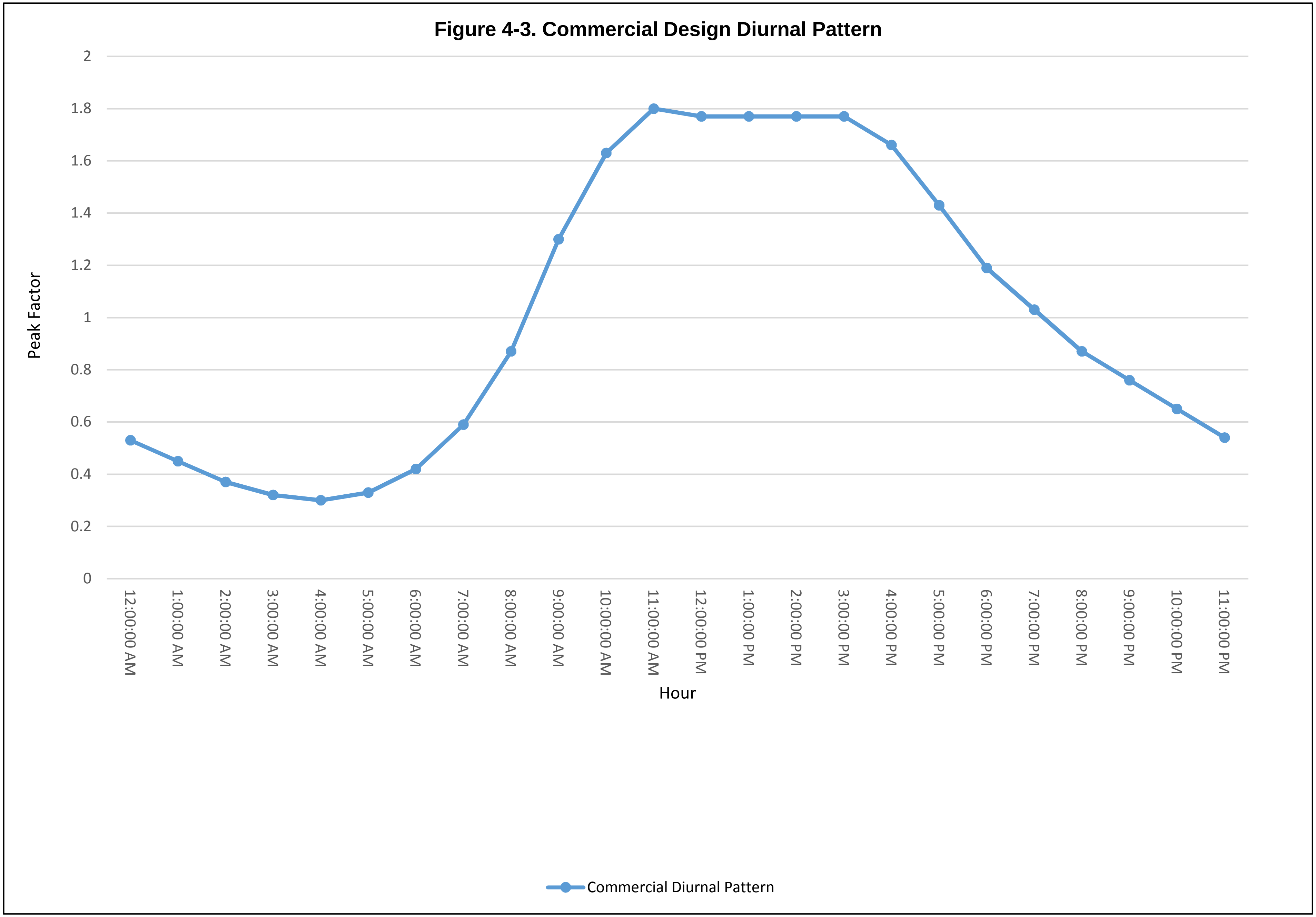

Figure 4-3. Commercial Design Diurnal Pattern
Peak Factor
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
12:00:00 AM
1:00:00 AM
2:00:00 AM
3:00:00 AM
4:00:00 AM
5:00:00 AM
6:00:00 AM
7:00:00 AM
8:00:00 AM
9:00:00 AM
10:00:00 AM
11:00:00 AM
12:00:00 PM
1:00:00 PM
2:00:00 PM
3:00:00 PM
4:00:00 PM
5:00:00 PM
6:00:00 PM
7:00:00 PM
8:00:00 PM
9:00:00 PM
10:00:00 PM
11:00:00 PM
Hour
Commercial Diurnal Pattern

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As part of this Sewer Master Plan, an updated hydraulic model of the City's sanitary sewer system has been developed and utilized for the collection system hydraulic analysis. This chapter contains a summary overview of the model software, the modeled system network, future design flow allocation, and hydraulic capacity evaluation using the design flows described in Chapter 4.

5.1 MODEL DESCRIPTION

As part of the 2004 Master Plan, a hydraulic model of the City's collection system was developed utilizing H2OMap Sewer Pro software (H2OMap Sewer), a product of Innovyze, Inc. H2OMap Sewer was developed specifically for collection system capacity analysis and is widely used in the industry. The H2OMap Sewer hydraulic model, updated as described below, has been used in this Sewer Master Plan to identify hydraulic deficiencies under existing and future conditions, and to evaluate potential relief sewers or other infrastructure improvements to address the possible hydraulic deficiencies.

There are two types of hydraulic simulations used to assess the capacity of collection systems: (1) steady state/static simulations; and (2) extended period/dynamic simulations. Steady state simulations represent a snapshot of the system performance at a given point in time under specific sewage generation conditions (typically a peak flow condition). Extended period/dynamic simulations employ a continuous simulation of the changes in system flow rates over time, and are typically used to analyze the operational performance of the system over a 24-hour or longer period. Extended period/dynamic simulation requires more extensive data input than a steady-state simulation, including appropriate 24-hour diurnal patterns for various land use categories within the collection system, as well as a representation of time-varying collection system response to rainfall. For the purposes of this Sewer Master Plan, as with the 2004 Master Plan, extended period/dynamic simulations have been used to perform hydraulic evaluation of the City's collection system over a 60-hour period.

5.2 HYDRAULIC MODEL UPDATE

This section describes the collection system hydraulic model in detail, describes the updates made to the hydraulic model as part of this Sewer Master Plan, and provides a summary of the existing and future timeframe flow allocations made in the hydraulic model.

5.2.1 Model Network Revisions

The hydraulic model developed for the 2004 Master Plan was a skeletonized model that contained only the trunk gravity mains from the City's collection system. Small diameter gravity mains were excluded from the hydraulic model. For this Sewer Master Plan, the City desired a more comprehensive evaluation of collection system capacity, including the small diameter gravity mains that predominate the collection system. Further, the City desired that a clear link be developed between individual parcel flows and their connection to the collection system. Such a link requires that all gravity mains, regardless of diameter, be included in the hydraulic model. Therefore, as part of this Sewer Master Plan, the hydraulic model has been updated to include a network that contains all collection system gravity mains. Further, the model was updated so that all infrastructure, including gravity mains, lift stations, and force mains, is up to date and represents the collection system as it currently exists in the field.

The City has invested considerable effort in developing and maintaining a GIS database of the collection system, and the collection system GIS is considered the primary data source for the linear assets (gravity mains and force mains) in the collection system. To facilitate the update of the hydraulic model, the 2004 Master Plan hydraulic model was compared against the GIS data (current as of January 2017) to determine data gaps and data discrepancies to be updated in the model. The comparison yielded the following general classes of updates to the hydraulic model:

- Structural improvements or developments that occurred after the 2004 Master Plan were updated into the model.
- Discrepancies in gravity main diameters, gravity main invert elevations, and manhole rim elevations between the hydraulic model and the GIS were identified. Per City staff direction, data in the GIS was considered preeminent and updated into the hydraulic model.
- Infrastructure that appeared in the hydraulic model, but not in the collection system GIS, was identified and investigated on a case-by-case basis to determine which source correctly represented field conditions. The hydraulic model was updated as appropriate.

In addition to the updates described above, the small diameter gravity mains that were not included in the 2004 Master Plan hydraulic model, along with the manholes associated these gravity mains, were imported into the hydraulic model. This data was imported in a manner to preserve a one-to-one relationship with the City's GIS using the following methods:

- Manhole and gravity main unique GIS identifiers (ID) were preserved as unique hydraulic model identifiers where possible. In some cases, multiple manholes or gravity mains had the same identifier in GIS. Because the hydraulic model does not allow non-unique identifiers, the identifier of one of the elements was altered in the hydraulic model as follows:
  - Manholes with the same GIS ID were renamed to their GIS ID concatenated with their unique old facility ID; and
  - Pipes with the same GIS ID were renamed to their GIS ID concatenated with their unique old facility ID.
- The hydraulic model requires an upstream manhole and downstream manhole for each gravity main. In some cases, this geometry was not present in the GIS. In these cases, the geometry was fixed in the hydraulic model as follows:
  - In cases of a missing manhole (i.e., two proximate gravity mains with no manhole between them), the appropriate manhole was created in the model. A unique identifier was created for this new manhole by adding an alphabetical suffix to the identifier of the nearest existing manhole in the model.

  - — In cases of a manhole drawn over a gravity main that was not properly “split” to reflect the presence of the manhole, the gravity main was split and snapped to the manhole to reflect the proper upstream and downstream geometry in the network. Because splitting a gravity main creates a new gravity main in the model, the new gravity main was given a unique identifier consisting of the original identifier with the addition of an alphabetical suffix. Inverts for the split gravity main were determined through interpolation using the length and slope of the original gravity main.

- Because the small diameter gravity mains were being imported into the hydraulic model for the first time, some of the gravity mains did not have the upstream and downstream invert elevation data required for the hydraulic model. As part of its ongoing comprehensive collection system management policies, the City will be collecting and populating this invert elevation data. To facilitate the timely update of the hydraulic model, the following assumptions were made to provide preliminary values for the missing invert elevation:
  - — Where one invert elevation (either upstream or downstream) was known along with the gravity main slope, the second invert elevation was calculated;
  - — Where an invert elevation was unknown on one gravity main, but the corresponding invert elevation was known on the gravity main sharing the manhole, the corresponding invert elevation was assigned (i.e., invert continuity across manholes was assumed); and
  - — Where the data listed above was not available, inverts were calculated assuming minimum slopes of gravity mains from the last known point. The City maintains minimum slope requirements for gravity mains based upon diameter in the City’s current Facility Planning Guidelines document.

All assumed invert values that were developed as described above were documented and prioritized for City investigation going forward. This documentation can be found in Appendix A. In addition to the updates described above, basic data checks were conducted on the updated hydraulic model for missing data and physical inconsistencies (e.g., reverse pipe slopes or diameter changing from larger to smaller rather than vice versa). Figure 5-1 presents the updated model network for the Sewer Master Plan hydraulic evaluation. It is recommended that the City perform field verifications of the high priority infrastructure identified in the gap analysis included in Appendix A and incorporate into the hydraulic model for future updates to improve the accuracy of the model.

5.2.2 Hydraulic Model Flow Updates

Chapter 3 Service Area Sewer Flows detailed the development of existing rebounded and build-out design flows within the City. The following sections describe how these flows were incorporated into the hydraulic model.

5.2.2.1 ADWF Updates

ADWF values were developed on an individual parcel basis. These values were imported into the hydraulic model through the establishment of a parcel-to-manhole link made possible by the inclusion of all gravity mains and all manholes in the model. The parcel-to-manhole link was initiated using GIS proximity analysis to identify the manhole closest to each parcel. Manual review was used to refine areas for which proximity analysis was too imprecise. Such areas included those with parallel gravity mains, or those areas with both trunk and collector gravity mains.

The parcel-to-manhole linkage established a loading manhole for each parcel in the City. ADWF values were summarized by manhole and these summarized flows were imported into the hydraulic model. The parcel-to-manhole linkage is detailed in Appendix A. The H2OMap Sewer modeling software contains 10 loading fields that can be used to organize flows being imported into the model. For the City's hydraulic model, flows were organized into the loading columns as shown in Table 5-1. Existing flows in the hydraulic model consist of loads from Load 1, Load 2, Load 3, and Load 8. Future flows are composed of loads from Load 1, Load 2, Load, 3, Load 4, Load 5, Load 6, Load 7, and Load 9.

Table 5-1. Load Column Description in the Hydraulic Model

Load Column	Load Description
Load 1	ADWF of Existing Developed Areas in City Municipal Water Service Area [(a)]
Load 2	ADWF of Existing Developed Areas in Cal Water Service Area[(a)]
Load 3	Existing Point Sources and Existing ADWF of Reasonably Foreseeable Development Projects[(b)]
Load 4	Future ADWF of Reasonably Foreseeable Development Projects in City Municipal Water Service Area[(c)]
Load 5	Future ADWF of Reasonably Foreseeable Development Projects in Cal Water Service Area[(c)]
Load 6	Future ADWF of Vacant Areas in City Municipal Area and Ruby Hill Development
Load 7	Future ADWF of Vacant Areas in Cal Water Service Area
Load 8	Existing RDII
Load 9	Future RDII
Load 10	Blank for Future Use

(a) Existing developed areas include active parcels that have not been identified for Reasonably Foreseeable Development projects.
(b) Point sources include LLNL and SNL flows.
(c) The total future load for a specific Reasonably Foreseeable Development Project includes an existing load in Load 3 plus a future load in Load 4 or Load 5.

5.2.2.2 PDWF Updates

To generate PDWF from ADWF in the hydraulic model, diurnal curves were applied to ADWF values. As described in Chapter 4, the City's design and performance standards include standard curves for residential, industrial, and commercial discharges. The appropriate diurnal curve was applied in the model based upon land use.

5.2.2.3 PWWF Updates

Chapter 3 describes the method by which RDII was calculated for the City's collection system. RDII generation per acre has been established for existing and future conditions. The acreage tributary to each manhole was summarized and then multiplied by the RDII generation factor. The resulting RDII flow value was then loaded to each individual manhole. As shown in Table 5-1, individual flow load columns were reserved for existing and future RDII values, respectively, in the hydraulic model.

5.3 EXISTING CAPACITY EVALUATION

This section presents the results of the capacity evaluation of the City's collection system under existing flow conditions. Collection system capacity for gravity mains, lift stations, and force mains was assessed with respect to the system's performance under the existing PWWF design flow condition described in Chapter 3, using the design and performance criteria described in Chapter 4.

5.3.1 Existing Gravity Main Hydraulic Evaluation

Gravity mains in the City's collection system exceed the performance criteria under existing rebounded design flows in several locations. Because the City's design and performance criteria for the gravity collection system include both flow criteria in the gravity mains, as well as surcharge depth criteria in the manholes, incidences of performance criteria exceedance have been identified for both gravity mains and manholes.

The gravity mains and manholes that fail to meet performance criteria are displayed on Figure 5-2. The gravity mains that fail to meet performance criteria under existing design flows can be found in Table 5-2. It should be noted that the hydraulic analysis identifies every incidence of the design and performance criteria being exceeded. In the large majority of these incidences, the performance criteria are exceeded in an isolated gravity main that has a low or even flat slope. In most cases, these low and flat slope gravity mains are small diameter gravity mains that were brought into the model for the first time as part of this Sewer Master Plan, and which have poorly verified invert elevation data. It is anticipated that these identified gravity mains do not represent true hydraulic bottlenecks in the collection system. Therefore, these gravity mains have not been included in this Sewer Master Plan as recommended improvements projects. However, it is recommended that in the future the City perform field verification of these isolated mains so their true capacity can be determined and the assumption of no hydraulic bottleneck confirmed.

5.3.2 Existing Lift Station Hydraulic Evaluation

As described in Chapter 4, the City's performance standards require that all collection system lift stations have sufficient capacity to convey design flows with the largest pump out of service, defined as the "firm capacity" of the lift station. Each existing lift station's firm capacity was compared to the existing design flow conveyed to the lift station. If the designed flow was greater than the lift station's firm capacity, then the lift station was considered to have insufficient capacity. The hydraulic model indicates that all of the collection system lift stations currently have sufficient firm capacity to convey existing design flows, as shown in Table 5-3.

The City's performance standards further require that the holding volume in a wet well that has an overflow relief mechanism or standby power shall be equivalent to two hours accumulation of the design flow. Wet wells that do not have overflow relief or standby power shall have a holding volume equivalent to four hours accumulation of the design flow The City's lift stations do not meet the holding volume performance standards.

5.3.3 Existing Force Main Hydraulic Evaluation

Peak force main velocities are provided in Table 5-3. As can be seen, no force mains exceed the maximum peak velocity criteria of 7 fps under existing conditions with the exception of the 8-inch diameter portion of the Airport Lift Station force main which only slightly exceeds the criteria with a value of 7.3 fps. All force mains achieve a minimum velocity of 2.0 fps when operating at firm capacity.

The hydraulic model, particularly the elements concerning lift station and force main capacity analysis, is a planning-level tool and is not intended for operational analysis. An operational analysis of the lift station and force main performance should be performed to confirm that the lift stations and force mains are operating as intended and planned.

Table 5-2. Gravity Mains Not Meeting Performance Criteria Under Existing Rebounded Flow Conditions

Gravity Main ID	Upstream Manhole ID	Downstream Manhole ID	Length, linear feet (LF)	Diameter, in	Description
JLS5C2P0398	JLS5C2F001	JLS5C2037	86	39	Insufficient Slope: Recommended for Inspection
JLS5D4TP2859	JLS5D4T005	JLS5D4T004	228	33	Insufficient Slope: Recommended for Inspection
PPS5F2TP6057	PPS5F2T002	PPS5F2T001A	8	30	Insufficient Slope: Recommended for Inspection
PPS4G3TP1894	PPS4G3T012	PPS4G3T011	293	27	Insufficient Slope: Recommended for Inspection
PPS4G3TP2310	PPS4G3T004	PPS4G3T003	154	27	Insufficient Slope: Recommended for Inspection
DTS6E1TP7077	DTS6E1T027	DTS6E1T026	47	24	Insufficient Slope: Recommended for Inspection
PPS4G3TP1715	PPS4G3T017	PPS4G3T016	120	24	Insufficient Slope: Recommended for Inspection
DTS5E3TP2799	DTS5E3T007	DTS5E3T006	330	18	Insufficient Slope: Recommended for Inspection
DTS6E2TP5942	DTS5E3T034	DTS5E3T033	87	18	Insufficient Slope: Recommended for Inspection
ECS7D3TP5113	ECS7D3T005	ECS7D3T004	180	18	Insufficient Slope: Recommended for Inspection
ECS7D3TP5177	ECS7D3T007	ECS7D3T006	283	18	Insufficient Slope: Recommended for Inspection
PPS4G1TP1604	PPS4G1T019	PPS4G1T018	227	18	Insufficient Slope: Recommended for Inspection
PPS4H3P1777	PPS4H3022	PPS4H3020	74	18	Insufficient Slope: Recommended for Inspection
STS2G4TP0877	STS2G4T007	STS2G4T006	376	18	Insufficient Slope: Recommended for Inspection
ECS8D2P5512	ECS8D2036	ECS8D2035	311	15	Insufficient Slope: Recommended for Inspection
DTS6E2P5965	DTS6E2068A	DTS6E2056	362	12	Insufficient Slope: Recommended for Inspection
ECS7E1P4953	ECS7E1051	ECS7E1050	126	12	Insufficient Slope: Recommended for Inspection
JLS5C2P0113	JLS5C2048	JLS5C2079	263	12	Insufficient Slope: Recommended for Inspection
PPS3H4P1260	PPS3H4036	PPS3H4035	150	12	Insufficient Slope: Recommended for Inspection
PPS3H4P1380	PPS3H4031	PPS3H4030	279	12	Insufficient Slope: Recommended for Inspection
PPS4H4P1644	PPS4H4012	PPS4H4011	299	12	Insufficient Slope: Recommended for Inspection
DTS6E1P2796	DTS6E1027	DTS6E1026	362	10	Insufficient Slope: Recommended for Inspection
DTS6F3P6524	DTS6F3024A	DTS6F3024B	86	10	Insufficient Slope: Recommended for Inspection
EAS6F4P4320	EAS6F4020	EAS6F4019	35	10	Insufficient Slope: Recommended for Inspection
JLS6D2P7585	JLS6D20110	JLS6D20109	151	10	Insufficient Slope: Recommended for Inspection
PPS4G3P1748	PPS4G3016	PPS4G3T015	175	10	Insufficient Slope: Recommended for Inspection
PPS5G4P7563	PPS5G4008	PPS5G4075	72	10	Insufficient Slope: Recommended for Inspection
PPS6G2P7692	PPS6G2001B	PPS6G2001A	90	10	Insufficient Slope: Recommended for Inspection
STS2H4P0820	STS2H2001	STS2H4058	346	10	Insufficient Slope: Recommended for Inspection
STS3G3P1199	STS3G3075	STS3G3072	398	10	Insufficient Slope: Recommended for Inspection
STS3G4P1280	STS3G4005	STS3G4004	46	10	Insufficient Slope: Recommended for Inspection
ACS4C4P1955	ACS4C4019	ACS4C4018	25	8	Insufficient Slope: Recommended for Inspection
DTS5E2P2424	DTS5E2006	DTS5E2005	392	8	Insufficient Slope: Recommended for Inspection
DTS5E2P2545	DTS5E2055	DTS5E2053	279	8	Insufficient Slope: Recommended for Inspection
DTS5E2P2615	DTS5E2066	DTS5E2065	467	8	Insufficient Slope: Recommended for Inspection
DTS5E3P2845	DTS5E3068	DTS5E3067	168	8	Insufficient Slope: Recommended for Inspection
DTS5E3P2846	DTS5E3001	DTS6E1079	27	8	Insufficient Slope: Recommended for Inspection
DTS6E1P3254	DTS6E1064	DTS6E1062	380	8	Insufficient Slope: Recommended for Inspection
DTS6E4P4168	DTS6E4067	DTS6E4060	379	8	Insufficient Slope: Recommended for Inspection
DTS6F3P4205	DTS6F3011	DTS6F3010	212	8	Insufficient Slope: Recommended for Inspection
DTS6F3P4242	DTS6F3018	DTS6F3010	257	8	Insufficient Slope: Recommended for Inspection
DTS6F3P4370	DTS6F3045	DTS6F3044	100	8	Insufficient Slope: Recommended for Inspection
DTS7F1P4681	DTS7F1007	DTS7F1006	126	8	Insufficient Slope: Recommended for Inspection
EAS6F1P3359	EAS6F1012	EAS6F1001A	388	8	Insufficient Slope: Recommended for Inspection
EAS6F1P3955	EAS6F1112	EAS6F1109	255	8	Insufficient Slope: Recommended for Inspection
EAS6F2P3961	EAS6F2033	EAS6F2031	265	8	Insufficient Slope: Recommended for Inspection
EAS6F4P4327	EAS6F4028	EAS6F4026	263	8	Insufficient Slope: Recommended for Inspection
EAS6G4P0493	EAS6G4060A	EAS6G4060	242	8	Insufficient Slope: Recommended for Inspection
EAS7G2P7034	EAS7G2009	EAS7G2008	267	8	Insufficient Slope: Recommended for Inspection
EAS7H1P6214	EAS7H1028	EAS7H1027	199	8	Insufficient Slope: Recommended for Inspection
ECS7D2P4881	ECS7D2062	ECS7D2061	87	8	Insufficient Slope: Recommended for Inspection
ECS7D2P4937	ECS7D2067	ECS7D2066	174	8	Insufficient Slope: Recommended for Inspection
ECS7D2P4940	ECS7D2119	ECS7D2118	68	8	Insufficient Slope: Recommended for Inspection
ECS7D2P4982	ECS7D2059	ECS7D2058	449	8	Insufficient Slope: Recommended for Inspection
ECS7D4P5130	ECS7D4031	ECS7D4029	140	8	Insufficient Slope: Recommended for Inspection
ECS7D4P5368	ECS7D4091	ECS7D4090	311	8	Insufficient Slope: Recommended for Inspection
ECS7E1P4719	ECS7E1011	ECS7E1010	140	8	Undersized: Recommended for Improvement
ECS7E1P4778	ECS7E1087	ECS7E1086	170	8	Insufficient Slope: Recommended for Inspection
ECS7E3P5178	ECS7E3038	ECS7E3037	70	8	Insufficient Slope: Recommended for Inspection
ECS7E3P549	ECS7E3126	ECS7E3125	156	8	Insufficient Slope: Recommended for Inspection
ECS7E4P5170	ECS7E4005	ECS7E4003	26	8	Insufficient Slope: Recommended for Inspection
ECS7E4P5219	ECS7E4015	ECS7E4014	124	8	Insufficient Slope: Recommended for Inspection
ECS8D2P5569	ECS8D2070	ECS8D2069	388	8	Insufficient Slope: Recommended for Inspection
ECS8E1P5617	ECS8E1095	ECS8E1094	122	8	Insufficient Slope: Recommended for Inspection
ECS8E1P5664	ECS8E1089	ECS8E1088	185	8	Insufficient Slope: Recommended for Inspection
ECS8E1P5667	ECS8E1096	ECS8E1091	80	8	Insufficient Slope: Recommended for Inspection
ECS8E1P5730	ECS8E1087	ECS8E1086	210	8	Insufficient Slope: Recommended for Inspection
ECS8E1P5769	ECS8E1082	ECS8E1079	143	8	Insufficient Slope: Recommended for Inspection
ECS8E2P5555	ECS8E2034	ECS8E2033	308	8	Insufficient Slope: Recommended for Inspection
ECS8E3P5899	ECS8E3042	ECS8E3041	187	8	Insufficient Slope: Recommended for Inspection
ECS8E4P7100	ECS8E4072	ECS8E4069	56	8	Insufficient Slope: Recommended for Inspection
JLS4E3P2148	JLS4E3012	JLS4E3011	183	8	Insufficient Slope: Recommended for Inspection
JLS4E3P2177	JLS4E3032	JLS4E3031	140	8	Insufficient Slope: Recommended for Inspection
JLS4E3P2530	JLS4E3024	JLS4E3023	326	8	Insufficient Slope: Recommended for Inspection
JLS5C2P0413	JLS5C2043	JLS5C2040	209	8	Insufficient Slope: Recommended for Inspection
JLS5D2P2232	JLS5D2072	JLS5D2070	173	8	Insufficient Slope: Recommended for Inspection
JLS5D2P7379	JLS5D2035	JLS5D2033	12	8	Insufficient Slope: Recommended for Inspection
JLS5D3P2839	JLS5D3062	JLS5D3055	280	8	Insufficient Slope: Recommended for Inspection
JLS5D3P2969	JLS5D3079	JLS5D3078	133	8	Insufficient Slope: Recommended for Inspection
JLS5D3P2979	JLS5D3077	JLS5D3074	130	8	Insufficient Slope: Recommended for Inspection
JLS5D3P3023	JLS5D3075	JLS5D3074	103	8	Insufficient Slope: Recommended for Inspection
JLS5D3P3055	JLS5D3093	JLS5D3087	262	8	Insufficient Slope: Recommended for Inspection
JLS5D3P3935	JLS5D3034	JLS5D3033	151	8	Insufficient Slope: Recommended for Inspection
JLS6D1P2987	JLS6D1054	JLS6D1051	131	8	Insufficient Slope: Recommended for Inspection
JLS6D1P3027	JLS6D1016	JLS6D1015	154	8	Insufficient Slope: Recommended for Inspection
JLS6D1P3059	JLS6D1051	JLS6D1050	255	8	Insufficient Slope: Recommended for Inspection
JLS6D1P3386	JLS6D1065	JLS6D1064	266	8	Insufficient Slope: Recommended for Inspection
JLS6D1P3680	JLS6D1078	JLS6D1075	130	8	Insufficient Slope: Recommended for Inspection
JLS6D1P3790	JLS6D1089	JLS6D1088	289	8	Insufficient Slope: Recommended for Inspection
JLS6D1P4159	JLS6D1129	JLS6D1125A	178	8	Insufficient Slope: Recommended for Inspection
JLS6D2P3442	JLS6D2057	JLS6D2056	98	8	Insufficient Slope: Recommended for Inspection
JLS6E3P3869	JLS6E3018	JLS6E3017	101	8	Undersized: Recommended for Improvement
JLS6E3P3883	JLS6E3020	JLS6E3019	64	8	Undersized: Recommended for Improvement
JLS6E3P3884	JLS6E3019	JLS6E3018	29	8	Undersized: Recommended for Improvement
JLS6E3P4079	JLS6E3025	JLS6E3024	138	8	Undersized: Recommended for Improvement
JLS6E3P4255	JLS6E3007	JLS6E3005	367	8	Insufficient Slope: Recommended for Inspection
JLS6E3P6179	STUB6043	JLS6E3002	25	8	Insufficient Slope: Recommended for Inspection
PPS4F4P2127	PPS4F4034	PPS4F4033	147	8	Insufficient Slope: Recommended for Inspection
PPS4F4P2128	PPS4F4063	PPS4F4033	118	8	Insufficient Slope: Recommended for Inspection
PPS5F1P2348	PPS5F1041	PPS5F1038	193	8	Insufficient Slope: Recommended for Inspection

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Table 5-2. Gravity Mains Not Meeting Performance Criteria Under Existing Rebounded Flow Conditions

Gravity Main ID	Upstream Manhole ID	Downstream Manhole ID	Length, linear feet (LF)	Diameter, in	Description
PPS5F1P2395	PPS5F1012	PPS5F1011	242	8	Insufficient Slope: Recommended for Inspection
PPS5F1P2410	PPS5F1011	PPS5F1010	23	8	Insufficient Slope: Recommended for Inspection
PPS5F1P2601	PPS5F1022	PPS5F1021	189	8	Insufficient Slope: Recommended for Inspection
PPS5F1P2611	PPS5F1045	PPS5F1044	62	8	Insufficient Slope: Recommended for Inspection
PPS5G1P2355	PPS5G1042	PPS5G1041	413	8	Insufficient Slope: Recommended for Inspection
PPS5G1P2705	PPS5G1006	PPS5G1005	75	8	Insufficient Slope: Recommended for Inspection
PPS5G1P2958	PPS5G1024	PPS5G1021	356	8	Insufficient Slope: Recommended for Inspection
PPS5G2P2640	PPS5G2009	PPS5G2008	399	8	Insufficient Slope: Recommended for Inspection
PPS5G3P2239	PPS5G3007	PPS5G3006	268	8	Insufficient Slope: Recommended for Inspection
PPS5G3P2372	PPS5G3015	PPS5G3002	110	8	Insufficient Slope: Recommended for Inspection
PPS5G3P2896	PPS5G3042	PPS5G3041	182	8	Insufficient Slope: Recommended for Inspection
PPS5G3P3260	PPS5G3073	PPS5G3072	134	8	Insufficient Slope: Recommended for Inspection
PPS5G4P2819	PPS5G4050	PPS5G4049	399	8	Insufficient Slope: Recommended for Inspection
PPS5G4P3173	PPS5G4034	PPS5G4033	302	8	Insufficient Slope: Recommended for Inspection
PPS5H1P2298	PPS5H1027	PPS5H1026	111	8	Insufficient Slope: Recommended for Inspection
PPS5H1P2812	PPS5H1075	PPS5H1047	127	8	Insufficient Slope: Recommended for Inspection
PPS5H1P3347	PPS5H1072	PPS5H1071	96	8	Insufficient Slope: Recommended for Inspection
PPS6G2P3608	PPS6G2017	PPS6G2013	206	8	Undersized: Recommended for Improvement
RHS6D3P4314	RHS6D3035	RHS6D3034	176	8	Insufficient Slope: Recommended for Inspection
RHS6D3P4464	RHS6D3006	RHS6D3005	251	8	Insufficient Slope: Recommended for Inspection
RHS6D3P6241	RHS6D3085	RHS6D3083	142	8	Insufficient Slope: Recommended for Inspection
RHS6D3P6251	RHS6D3068	RHS6D3067	48	8	Insufficient Slope: Recommended for Inspection
RHS7D3P4836	RHS7D3034	RHS7D3033	115	8	Insufficient Slope: Recommended for Inspection
RHS7D3P4867	RHS7D3036	RHS7D3004	253	8	Insufficient Slope: Recommended for Inspection
RHS8C2P0045	RHS8C2001	RHS8D1151	176	8	Insufficient Slope: Recommended for Inspection
RHS8D1P5565	RHS8D1122	RHS8D1121	312	8	Insufficient Slope: Recommended for Inspection
RHS8D3P5733	RHS8D3043	RHS8D3042	104	8	Insufficient Slope: Recommended for Inspection
RHS8D3P5824	RHS8D3036	RHS8D3035	98	8	Undersized: Recommended for Improvement
RHS8D3P5832	RHS8D3034	RHS8D3033	62	8	Undersized: Recommended for Improvement
RHS8D3P5837	RHS8D3030	RHS8D3029	67	8	Undersized: Recommended for Improvement
RHS8D3P5830	RHS8D3035	RHS8D3034	61	8	Undersized: Recommended for Improvement
STS2G4P0936	STS2G4056	STS2G4055	91	8	Insufficient Slope: Recommended for Inspection
STS2G4P0979	STS2G4047	STS2G4T001	198	8	Insufficient Slope: Recommended for Inspection
STS2H4P0919	STS2H4014	STS2H4013	140	8	Insufficient Slope: Recommended for Inspection
STS3F4P1449	STS3F4092	STS3F4091	101	8	Insufficient Slope: Recommended for Inspection
STS3G2P1263	STS3G2053	STS3G2052	257	8	Insufficient Slope: Recommended for Inspection
STS3G3P1392	STS3G3027	STS3G3026	349	8	Insufficient Slope: Recommended for Inspection
STS3G4P1271	STS3G4057	STS3G4004	36	8	Insufficient Slope: Recommended for Inspection
STS3G4P1491	STS3G4026	STS3G4011	110	8	Insufficient Slope: Recommended for Inspection
JLS6E3P3883	JLS6E3020	JLS6E3019	64	8	Undersized: Recommended for Improvement
DTS5E3P3053	DTS5E3028	DTS5E3027	33	6	Insufficient Slope: Recommended for Inspection
JLS6D2P6720	JLS6D2089A	JLS6D2088A	104	6[a]	Undersized: Recommended for Improvement
JLS6E3P4231	JLS6E3032	JLS6E3031	95	6	Undersized: Recommended for Improvement
JLS6E3P4232	JLS6E3031	JLS6E3031A	209	6	Undersized: Recommended for Improvement

[a] City records indicate this gravity main may have already been improved to 10-inch diameter. The diameter should be confirmed before the improvement project is developed.

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Table 5-3. Existing Rebounded Lift Station Capacity Results

Lift Station Name	Lift Station Data				Evaluation Results		
	Pump Number	Pump Capacity, gpm	Firm Capacity, gpm	Force Main Diameter, in	Existing Rebounded Design Flow, gpm	Available Firm Capacity, gpm	Peak Force Main Velocity[a], fps
College Lift Station	1	1,180	1,180	12	630	550	3.35
	2	1,180					
Airport Lift Station	1	1,145	1,145	10/8	680	465	4.68/7.3
	2	1,145					
Rickenbacker Lift Station	1	400	400	8	50	350	2.55
	2	400					
El Charro Lift Station	1	320	320	8	70	250	2.04
	2	320					

(a) Peak force main velocity is calculated at the firm capacity of the lift station.

5.4 BUILDOUT CAPACITY EVALUATION

This section presents the results of the capacity evaluation of the City's collection system under buildout flow conditions. Collection system capacity for gravity mains, lift stations, and force mains was assessed with respect to the system's performance under the buildout PWWF design flow condition described in Chapter 3, using the design and performance criteria described in Chapter 4.

5.4.1 Buildout Gravity Main Hydraulic Evaluation

Because the City's design and performance criteria for the gravity collection system include both flow criteria in the gravity mains, as well as surcharge depth criteria in the manholes, incidences of performance criteria exceedance have been identified for both gravity mains and manholes.

The gravity mains and manholes that fail to meet performance criteria are displayed on Figure 5-3. The gravity mains that fail to meet performance criteria under buildout design flows can be found in Table 5-4. It should be noted that the hydraulic analysis identifies every incidence of the design and performance criteria being exceeded. In the large majority of these incidences, the performance criteria are exceeded in an isolated gravity main that has a low or even flat slope. In most cases, these low and flat slope gravity mains are small diameter gravity mains that were brought into the model for the first time as part of this Sewer Master Plan, and which have poorly verified invert elevation data. It is anticipated that these identified gravity mains do not represent true hydraulic bottlenecks in the collection system. Therefore, these gravity mains have not been included in this Sewer Master Plan as recommended improvement projects. However, it is recommended that in the future the City perform field verification of these isolated mains so their true capacity can be determined and the assumption of no hydraulic bottleneck confirmed.

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Table 5-4. Gravity Mains Not Meeting Performance Criteria Under Buildout Conditions

Gravity Main ID	Upstream Manhole ID	Downstream Manhole ID	Length, LF	Diameter, in	Yes Under Existing Conditions	Description
JLS5C4TP7518	JLS5C4T025	JLS5C4T024	224	60	No	Insufficient Slope: Recommended for Inspection
JLS5C2P0398	JLS5C2F001	JLS5C2037	86	39	Yes	Insufficient Slope: Recommended for Inspection
JLS5D4TP2859	JLS5D4T005	JLS5D4T004	228	33	Yes	Insufficient Slope: Recommended for Inspection
DTS5F3TP7021	PPS5F4001	DTS5F3T011	117	30	No	Insufficient Slope: Recommended for Inspection
PPS5F2TP6057	PPS5F2T002	PPS5F2T001A	8	30	Yes	Insufficient Slope: Recommended for Inspection
PPS4G3TP1894	PPS4G3T012	PPS4G3T011	293	27	Yes	Insufficient Slope: Recommended for Inspection
PPS4G3TP2310	PPS4G3T004	PPS4G3T003	154	27	Yes	Insufficient Slope: Recommended for Inspection
DTS6E1TP6530	DTS6E1T019	DTS6E1T018	52	24	No	Undersized: Recommended for Inspection/Monitoring[a]
DTS6E1TP7077	DTS6E1T027	DTS6E1T026	47	24	Yes	Insufficient Slope: Recommended for Inspection
PPS4G3TP1715	PPS4G3T017	PPS4G3T016	120	24	Yes	Insufficient Slope: Recommended for Inspection
DTS5E3TP2799	DTS5E3T007	DTS5E3T006	330	18	Yes	Insufficient Slope: Recommended for Inspection
DTS6E2TP5942	DTS5E3T034	DTS5E3T033	87	18	Yes	Insufficient Slope: Recommended for Inspection
ECS7D1TP4617	ECS7D1T002	ECS7D1T001	439	18	No	Undersized: Recommended for Improvement
ECS7D3TP5113	ECS7D3T005	ECS7D3T004	180	18	Yes	Insufficient Slope: Recommended for Inspection
ECS7D3TP5177	ECS7D3T007	ECS7D3T006	283	18	Yes	Insufficient Slope: Recommended for Inspection
PPS4G1TP1604	PPS4G1T019	PPS4G1T018	227	18	Yes	Insufficient Slope: Recommended for Inspection
PPS4H3P1777	PPS4H3022	PPS4H3020	74	18	Yes	Insufficient Slope: Recommended for Inspection
STS2G4TP0877	STS2G4T007	STS2G4T006	376	18	Yes	Insufficient Slope: Recommended for Inspection
ECS8D2P5512	ECS8D2036	ECS8D2035	311	15	Yes	Insufficient Slope: Recommended for Inspection
RHS8D3P5817	RHS8D3028	RHS8D3027	245	15	No	Insufficient Slope: Recommended for Inspection
DTS6E2P5965	DTS6E2068A	DTS6E2056	362	12	Yes	Insufficient Slope: Recommended for Inspection
EAS6F1P4053	EAS6F1117	EAS6F1116	116	12	No	Undersized: Recommended for Improvement
ECS7E1P4953	ECS7E1051	ECS7E1050	126	12	Yes	Insufficient Slope: Recommended for Inspection
JLS5C2P0113	JLS5C2048	JLS5C2079	263	12	Yes	Insufficient Slope: Recommended for Inspection
PPS3H4P1260	PPS3H4036	PPS3H4035	150	12	Yes	Insufficient Slope: Recommended for Inspection
PPS3H4P1380	PPS3H4031	PPS3H4030	279	12	Yes	Insufficient Slope: Recommended for Inspection
PPS4H4P1644	PPS4H4012	PPS4H4011	299	12	Yes	Insufficient Slope: Recommended for Inspection
DTS6E1P2796	DTS6E1027	DTS6E1026	362	10	Yes	Insufficient Slope: Recommended for Inspection
DTS6E2P4043	DTS6E2063	DTS6E2062	59	10	No	Undersized: Recommended for Improvement
DTS6F3P6524	DTS6F3024A	DTS6F3024B	86	10	Yes	Insufficient Slope: Recommended for Inspection
EAS6F4P4320	EAS6F4020	EAS6F4019	35	10	Yes	Insufficient Slope: Recommended for Inspection
JLS6D2P3064	JLS6D2070	JLS6D2066	291	10	No	Undersized: Recommended for Improvement
JLS6D2P7605	JLS6D2066	JLS5D2074	268	10	No	Undersized: Recommended for Improvement
JLS5D2P5994	JLS5D2074	JLS5D4T011	73	10	No	Undersized: Recommended for Improvement
JLS6D2P7585	JLS6D20110	JLS6D20109	151	10	Yes	Insufficient Slope: Recommended for Inspection
PPS4G3P1748	PPS4G3016	PPS4G3T015	175	10	Yes	Insufficient Slope: Recommended for Inspection
PPS5G4P7563	PPS5G4008	PPS5G4075	72	10	Yes	Insufficient Slope: Recommended for Inspection
PPS6G2P7692	PPS6G2001B	PPS6G2001A	90	10	Yes	Insufficient Slope: Recommended for Inspection
STS2H4P0820	STS2H2001	STS2H4058	346	10	Yes	Insufficient Slope: Recommended for Inspection
STS3G3P1199	STS3G3075	STS3G3072	398	10	Yes	Insufficient Slope: Recommended for Inspection
STS3G4P1280	STS3G4005	STS3G4004	46	10	Yes	Insufficient Slope: Recommended for Inspection
ACS4C4P1841	ACS4C4005	ACS4C4004	174	8	No	Undersized: Recommended for Improvement
ACS4C4P1847	ACS4C4006	ACS4C4005	285	8	No	Undersized: Recommended for Improvement
ACS4C4P1955	ACS4C4019	ACS4C4018	25	8	Yes	Insufficient Slope: Recommended for Inspection
DTS5E2P2424	DTS5E2006	DTS5E2005	392	8	Yes	Insufficient Slope: Recommended for Inspection
DTS5E2P2545	DTS5E2055	DTS5E2053	279	8	Yes	Insufficient Slope: Recommended for Inspection
DTS5E2P2615	DTS5E2066	DTS5E2065	467	8	Yes	Insufficient Slope: Recommended for Inspection
DTS5E3P2845	DTS5E3068	DTS5E3067	168	8	Yes	Insufficient Slope: Recommended for Inspection
DTS5E3P2846	DTS5E3001	DTS6E1079	27	8	Yes	Insufficient Slope: Recommended for Inspection
DTS6E1P3254	DTS6E1064	DTS6E1062	380	8	Yes	Insufficient Slope: Recommended for Inspection
DTS6E4P4168	DTS6E4067	DTS6E4060	379	8	Yes	Insufficient Slope: Recommended for Inspection
DTS6F3P4205	DTS6F3011	DTS6F3010	212	8	Yes	Insufficient Slope: Recommended for Inspection
DTS6F3P4242	DTS6F3018	DTS6F3010	257	8	Yes	Insufficient Slope: Recommended for Inspection
DTS6F3P4370	DTS6F3045	DTS6F3044	100	8	Yes	Insufficient Slope: Recommended for Inspection
DTS7F1P4681	DTS7F1007	DTS7F1006	126	8	Yes	Insufficient Slope: Recommended for Inspection
EAS6F1P3359	EAS6F1012	EAS6F1001A	388	8	Yes	Insufficient Slope: Recommended for Inspection
EAS6F1P3955	EAS6F1112	EAS6F1109	255	8	Yes	Insufficient Slope: Recommended for Inspection
EAS6F2P3961	EAS6F2033	EAS6F2031	265	8	Yes	Insufficient Slope: Recommended for Inspection
EAS6F4P4327	EAS6F4028	EAS6F4026	263	8	Yes	Insufficient Slope: Recommended for Inspection
EAS6G4P0493	EAS6G4060A	EAS6G4060	242	8	Yes	Insufficient Slope: Recommended for Inspection
EAS7G2P7034	EAS7G2009	EAS7G2008	267	8	Yes	Insufficient Slope: Recommended for Inspection
EAS7H1P6214	EAS7H1028	EAS7H1027	199	8	Yes	Insufficient Slope: Recommended for Inspection
ECS7D2P4881	ECS7D2062	ECS7D2061	87	8	Yes	Insufficient Slope: Recommended for Inspection
ECS7D2P4937	ECS7D2067	ECS7D2066	174	8	Yes	Insufficient Slope: Recommended for Inspection
ECS7D2P4940	ECS7D2119	ECS7D2118	68	8	Yes	Insufficient Slope: Recommended for Inspection
ECS7D2P4982	ECS7D2059	ECS7D2058	449	8	Yes	Insufficient Slope: Recommended for Inspection
ECS7D4P5130	ECS7D4031	ECS7D4029	140	8	Yes	Insufficient Slope: Recommended for Inspection
ECS7D4P5368	ECS7D4091	ECS7D4090	311	8	Yes	Insufficient Slope: Recommended for Inspection
ECS7E1P4719	ECS7E1011	ECS7E1010	140	8	Yes	Undersized: Recommended for Improvement
ECS7E1P4778	ECS7E1087	ECS7E1086	170	8	Yes	Insufficient Slope: Recommended for Inspection
ECS7E1P4950	ECS7E1042	ECS7E1022	149	8	No	Undersized: Recommended for Improvement
ECS7E1P4970	ECS7E1043	ECS7E1042	116	8	No	Undersized: Recommended for Improvement
ECS7E2P4902	ECS7E2003	ECS7E2001	79	8	No	Undersized: Recommended for Improvement
ECS7E2P4905	ECS7E2004	ECS7E2005	120	8	No	Undersized: Recommended for Improvement
ECS7E2P4999	ECS7E2012	ECS7E2009	315	8	No	Undersized: Recommended for Improvement
ECS7E2P7371	ECS7E2009	ECS7E2008	46	8	No	Undersized: Recommended for Improvement
ECS7E3P5178	ECS7E3038	ECS7E3037	70	8	Yes	Insufficient Slope: Recommended for Inspection
ECS7E3P549	ECS7E3126	ECS7E3125	156	8	Yes	Insufficient Slope: Recommended for Inspection
ECS7E4P5170	ECS7E4005	ECS7E4003	26	8	Yes	Insufficient Slope: Recommended for Inspection
ECS7E4P5219	ECS7E4015	ECS7E4014	124	8	Yes	Insufficient Slope: Recommended for Inspection
ECS8D2P5569	ECS8D2070	ECS8D2069	388	8	Yes	Insufficient Slope: Recommended for Inspection
ECS8E1P5617	ECS8E1095	ECS8E1094	122	8	Yes	Insufficient Slope: Recommended for Inspection
ECS8E1P5664	ECS8E1089	ECS8E1088	185	8	Yes	Insufficient Slope: Recommended for Inspection
ECS8E1P5667	ECS8E1096	ECS8E1091	80	8	Yes	Insufficient Slope: Recommended for Inspection
ECS8E1P5703	ECS8E1088	ECS8E1087	227	8	No	Insufficient Slope: Recommended for Inspection
ECS8E1P5730	ECS8E1087	ECS8E1086	210	8	Yes	Insufficient Slope: Recommended for Inspection
ECS8E1P5769	ECS8E1082	ECS8E1079	143	8	Yes	Insufficient Slope: Recommended for Inspection
ECS8E2P5555	ECS8E2034	ECS8E2033	308	8	Yes	Insufficient Slope: Recommended for Inspection
ECS8E3P5899	ECS8E3042	ECS8E3041	187	8	Yes	Insufficient Slope: Recommended for Inspection
ECS8E4P7100	ECS8E4072	ECS8E4069	56	8	Yes	Insufficient Slope: Recommended for Inspection
JLS4E3P2148	JLS4E3012	JLS4E3011	183	8	Yes	Insufficient Slope: Recommended for Inspection
JLS4E3P2177	JLS4E3032	JLS4E3031	140	8	Yes	Insufficient Slope: Recommended for Inspection
JLS4E3P2530	JLS4E3024	JLS4E3023	326	8	Yes	Insufficient Slope: Recommended for Inspection
JLS5C2P0413	JLS5C2043	JLS5C2040	209	8	Yes	Insufficient Slope: Recommended for Inspection
JLS5D2P2232	JLS5D2072	JLS5D2070	173	8	Yes	Insufficient Slope: Recommended for Inspection
JLS5D2P7379	JLS5D2035	JLS5D2033	12	8	Yes	Insufficient Slope: Recommended for Inspection
JLS5D3P2839	JLS5D3062	JLS5D3055	280	8	Yes	Insufficient Slope: Recommended for Inspection
JLS5D3P2969	JLS5D3079	JLS5D3078	133	8	Yes	Insufficient Slope: Recommended for Inspection
JLS5D3P2979	JLS5D3077	JLS5D3074	130	8	Yes	Insufficient Slope: Recommended for Inspection
JLS5D3P3023	JLS5D3075	JLS5D3074	103	8	Yes	Insufficient Slope: Recommended for Inspection
JLS5D3P3055	JLS5D3093	JLS5D3087	262	8	Yes	Insufficient Slope: Recommended for Inspection
JLS5D3P3935	JLS5D3034	JLS5D3033	151	8	Yes	Insufficient Slope: Recommended for Inspection
JLS6D1P2987	JLS6D1054	JLS6D1051	131	8	Yes	Insufficient Slope: Recommended for Inspection
JLS6D1P3027	JLS6D1016	JLS6D1015	154	8	Yes	Insufficient Slope: Recommended for Inspection
JLS6D1P3059	JLS6D1051	JLS6D1050	255	8	Yes	Insufficient Slope: Recommended for Inspection
JLS6D1P3386	JLS6D1065	JLS6D1064	266	8	Yes	Insufficient Slope: Recommended for Inspection
JLS6D1P3680	JLS6D1078	JLS6D1075	130	8	Yes	Insufficient Slope: Recommended for Inspection
JLS6D1P3790	JLS6D1089	JLS6D1088	289	8	Yes	Insufficient Slope: Recommended for Inspection
JLS6D1P4159	JLS6D1129	JLS6D1125A	178	8	Yes	Insufficient Slope: Recommended for Inspection
JLS6D2P3442	JLS6D2057	JLS6D2056	98	8	Yes	Insufficient Slope: Recommended for Inspection
JLS6D2P3834	JLS6E3017	JLS6D2090	95	8	No	Undersized: Recommended for Improvement
JLS6E3P3869	JLS6E3018	JLS6E3017	101	8	Yes	Undersized: Recommended for Improvement
JLS6E3P3883	JLS6E3020	JLS6E3019	64	8	Yes	Undersized: Recommended for Improvement

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Table 5-4. Gravity Mains Not Meeting Performance Criteria Under Buildout Conditions

Gravity Main ID	Upstream Manhole ID	Downstream Manhole ID	Length, LF	Diameter, in	Yes Under Existing Conditions	Description
JLS6E3P3884	JLS6E3019	JLS6E3018	29	8	Yes	Undersized: Recommended for Improvement
JLS6E3P3944	JLS6E3021	JLS6E3020	188	8	No	Undersized: Recommended for Improvement
JLS6E3P3956	JLS6E3022	JLS6E3021	61	8	No	Undersized: Recommended for Improvement
JLS6E3P3980	JLS6E3023	JLS6E3022	116	8	No	Undersized: Recommended for Improvement
JLS6E3P4029	JLS6E3024	JLS6E3023	130	8	No	Undersized: Recommended for Improvement
JLS6E3P4079	JLS6E3025	JLS6E3024	138	8	Yes	Undersized: Recommended for Improvement
JLS6E3P4255	JLS6E3007	JLS6E3005	367	8	Yes	Insufficient Slope: Recommended for Inspection
JLS6E3P6179	STUB6043	JLS6E3002	25	8	Yes	Insufficient Slope: Recommended for Inspection
PPS4F4P2127	PPS4F4034	PPS4F4033	147	8	Yes	Insufficient Slope: Recommended for Inspection
PPS4F4P2128	PPS4F4063	PPS4F4033	118	8	Yes	Insufficient Slope: Recommended for Inspection
PPS5F1P2348	PPS5F1041	PPS5F1038	193	8	Yes	Insufficient Slope: Recommended for Inspection
PPS5F1P2395	PPS5F1012	PPS5F1011	242	8	Yes	Insufficient Slope: Recommended for Inspection
PPS5F1P2410	PPS5F1011	PPS5F1010	23	8	Yes	Insufficient Slope: Recommended for Inspection
PPS5F1P2601	PPS5F1022	PPS5F1021	189	8	Yes	Insufficient Slope: Recommended for Inspection
PPS5F1P2611	PPS5F1045	PPS5F1044	62	8	Yes	Insufficient Slope: Recommended for Inspection
PPS5G1P2355	PPS5G1042	PPS5G1041	413	8	Yes	Insufficient Slope: Recommended for Inspection
PPS5G1P2705	PPS5G1006	PPS5G1005	75	8	Yes	Insufficient Slope: Recommended for Inspection
PPS5G1P2958	PPS5G1024	PPS5G1021	356	8	Yes	Insufficient Slope: Recommended for Inspection
PPS5G2P2640	PPS5G2009	PPS5G2008	399	8	Yes	Insufficient Slope: Recommended for Inspection
PPS5G3P2239	PPS5G3007	PPS5G3006	268	8	Yes	Insufficient Slope: Recommended for Inspection
PPS5G3P2372	PPS5G3015	PPS5G3002	110	8	Yes	Insufficient Slope: Recommended for Inspection
PPS5G3P2896	PPS5G3042	PPS5G3041	182	8	Yes	Insufficient Slope: Recommended for Inspection
PPS5G3P3260	PPS5G3073	PPS5G3072	134	8	Yes	Insufficient Slope: Recommended for Inspection
PPS5G4P2819	PPS5G4050	PPS5G4049	399	8	Yes	Insufficient Slope: Recommended for Inspection
PPS5G4P3173	PPS5G4034	PPS5G4033	302	8	Yes	Insufficient Slope: Recommended for Inspection
PPS5H1P2298	PPS5H1027	PPS5H1026	111	8	Yes	Insufficient Slope: Recommended for Inspection
PPS5H1P2812	PPS5H1075	PPS5H1047	127	8	Yes	Insufficient Slope: Recommended for Inspection
PPS5H1P3347	PPS5H1072	PPS5H1071	96	8	Yes	Insufficient Slope: Recommended for Inspection
PPS6G2P3475	PPS6G2012	PPS6G2011	448	8	No	Undersized: Recommended for Improvement
PPS6G2P3608	PPS6G2017	PPS6G2013	206	8	Yes	Undersized: Recommended for Improvement
RHS6D3P4314	RHS6D3035	RHS6D3034	176	8	Yes	Insufficient Slope: Recommended for Inspection
RHS6D3P4464	RHS6D3006	RHS6D3005	251	8	Yes	Insufficient Slope: Recommended for Inspection
RHS6D3P6241	RHS6D3085	RHS6D3083	142	8	Yes	Insufficient Slope: Recommended for Inspection
RHS6D3P6251	RHS6D3068	RHS6D3067	48	8	Yes	Insufficient Slope: Recommended for Inspection
RHS7D3P4836	RHS7D3034	RHS7D3033	115	8	Yes	Insufficient Slope: Recommended for Inspection
RHS7D3P4867	RHS7D3036	RHS7D3004	253	8	Yes	Insufficient Slope: Recommended for Inspection
RHS8C2P0045	RHS8C2001	RHS8D1151	176	8	Yes	Insufficient Slope: Recommended for Inspection
RHS8D1P5565	RHS8D1122	RHS8D1121	312	8	Yes	Insufficient Slope: Recommended for Inspection
RHS8D3P5733	RHS8D3043	RHS8D3042	104	8	Yes	Insufficient Slope: Recommended for Inspection
RHS8D3P5824	RHS8D3036	RHS8D3035	98	8	Yes	Undersized: Recommended for Improvement
RHS8D3P5830	RHS8D3035	RHS8D3034	61	8	Yes	Undersized: Recommended for Improvement
RHS8D3P5832	RHS8D3034	RHS8D3033	62	8	Yes	Undersized: Recommended for Improvement
RHS8D3P5837	RHS8D3030	RHS8D3029	67	8	Yes	Undersized: Recommended for Improvement
STS2G4P0936	STS2G4056	STS2G4055	91	8	Yes	Insufficient Slope: Recommended for Inspection
STS2G4P0979	STS2G4047	STS2G4T001	198	8	Yes	Insufficient Slope: Recommended for Inspection
STS2H4P0919	STS2H4014	STS2H4013	140	8	Yes	Insufficient Slope: Recommended for Inspection
STS3F4P1449	STS3F4092	STS3F4091	101	8	Yes	Insufficient Slope: Recommended for Inspection
STS3G2P1263	STS3G2053	STS3G2052	257	8	Yes	Insufficient Slope: Recommended for Inspection
STS3G3P1392	STS3G3027	STS3G3026	349	8	Yes	Insufficient Slope: Recommended for Inspection
STS3G4P1271	STS3G4057	STS3G4004	36	8	Yes	Insufficient Slope: Recommended for Inspection
STS3G4P1491	STS3G4026	STS3G4011	110	8	Yes	Insufficient Slope: Recommended for Inspection
DTS5E3P3053	DTS5E3028	DTS5E3027	33	6	Yes	Insufficient Slope: Recommended for Inspection
JLS6E3P4231	JLS6E3032	JLS6E3031	95	6	Yes	Undersized: Recommended for Improvement
JLS6E3P4232	JLS6E3031	JLS6E3031A	209	6	Yes	Undersized: Recommended for Improvement
JLS6D2P6720	JLS6D2089A	JLS6D2088A	104	6	Yes	Undersized: Recommended for Improvement

(a) This gravity main slightly exceeds design criteria (q/Q=1.004) and is an isolated deficiency. It is therefore recommended for monitoring/inspection to confirm deficiency.

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5.4.2 Buildout Lift Station Hydraulic Evaluation

The City's performance standards require that all collection system lift stations have sufficient capacity to convey design flows with the largest pump out of service, defined as the "firm capacity" of the lift station. Each lift station's firm capacity was compared to the buildout design flow conveyed to the lift station. If the designed flow was greater than the lift station's firm capacity, then the lift station was considered to have insufficient capacity. The hydraulic model indicates that all the collection system lift stations, with the exception of the Airport Lift Station, currently have sufficient firm capacity to convey buildout design flows, as shown in Table 5-5. The Airport Lift Station has a deficiency in firm capacity of 335 gpm under buildout conditions. As shown, both the El Charro and College Lift Stations are nearing their firm capacity under buildout flow conditions.

The Airport Lift Station was not identified as deficient under any conditions as part of the 2004 Master Plan. Increased flows are identified as tributary to this lift station because of increased projected development areas. The increased area increases the projected ADWF, but also increases the projected RDII and PWWF. As further discussed in Chapter 7, flow monitoring should be conducted in the basin tributary to the Airport Lift Station to confirm the RDII and PWWF values, which have significant impact on the buildout design flows, and significant impact on the need for an improvement at this lift station.

Table 5-5. Buildout Lift Station Capacity Results

	Lift Station Data				Evaluation Results		
Lift Station Name	Pump Number	Pump Capacity, gpm	Firm Capacity, gpm	Force Main Diameter, in	Buildout Design Flow, gpm	Available Firm Capacity, gpm	Peak Force Main Velocity[a], fps
College Lift Station	1	1,180	1,180	12	990	190	3.35?
	2	1,180					
Airport Lift Station	1	1,145	1,145	10/8	1,480	(335)	6.04/9.44
	2	1,145					
Rickenbacker Lift Station	1	400	400	8	80	320	2.55?
	2	400					
El Charro Lift Station	1	320	320	8	260	60	2.04?
	2	320					

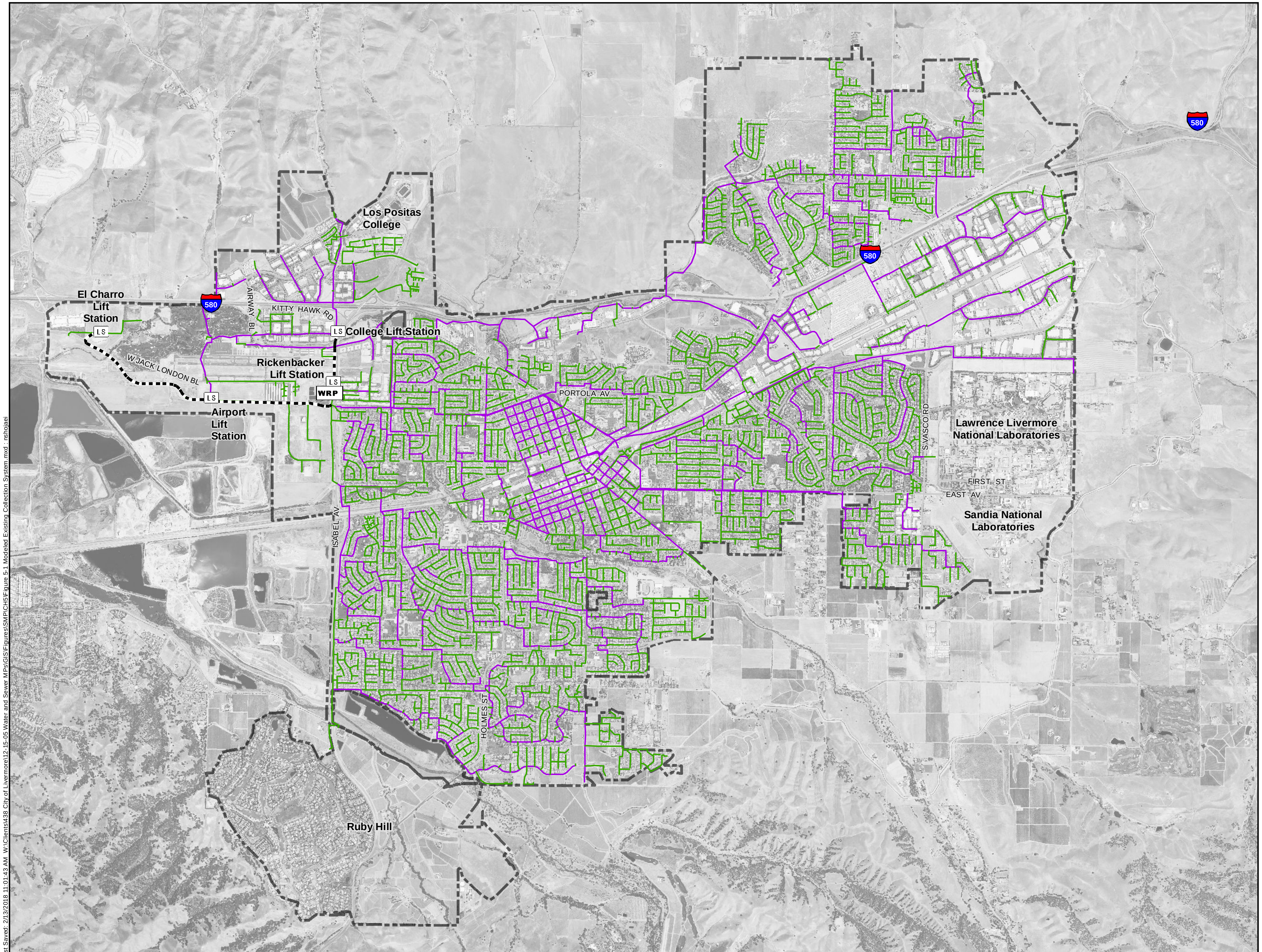
[a] Peak force main velocity is calculated at the firm capacity of the lift station. For the Airport Lift Station, peak force main velocity was calculated using the required buildout firm capacity of 1,480 gpm.

The City's performance standards further require that the holding volume in a wet well that has an overflow relief mechanism or standby power shall be equivalent to two hours accumulation of the design flow. Wet wells that do not have overflow relief or standby power shall have a holding volume equivalent to four hours accumulation of the design flow The City's lift stations do not meet the holding volume performance standards under buildout conditions.

5.4.3 Buildout Force Main Hydraulic Evaluation

Peak force main velocities under buildout conditions are provided in Table 5-6. With an improvement to the Airport Lift Station to expand the capacity to 1,480 gpm such that the Airport Lift Station will meet the buildout capacity requirements, the peak velocity in the 8-inch diameter portion of the Airport Lift Station force main will significantly exceed the criteria of 7 fps. As there are no other lift station improvements required, there are no further changes between existing and buildout force main velocities.

The hydraulic model, particularly the elements concerning lift station and force main capacity analysis, is a planning-level tool and is not intended for operational analysis. An operational analysis of the lift station and force main performance should be performed to confirm that the lift stations and force mains are operating as intended and planned.



LIVERMORE CALIFORNIA

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Figure 5-1

Updated Model Network

City of Livermore
Sewer Master Plan

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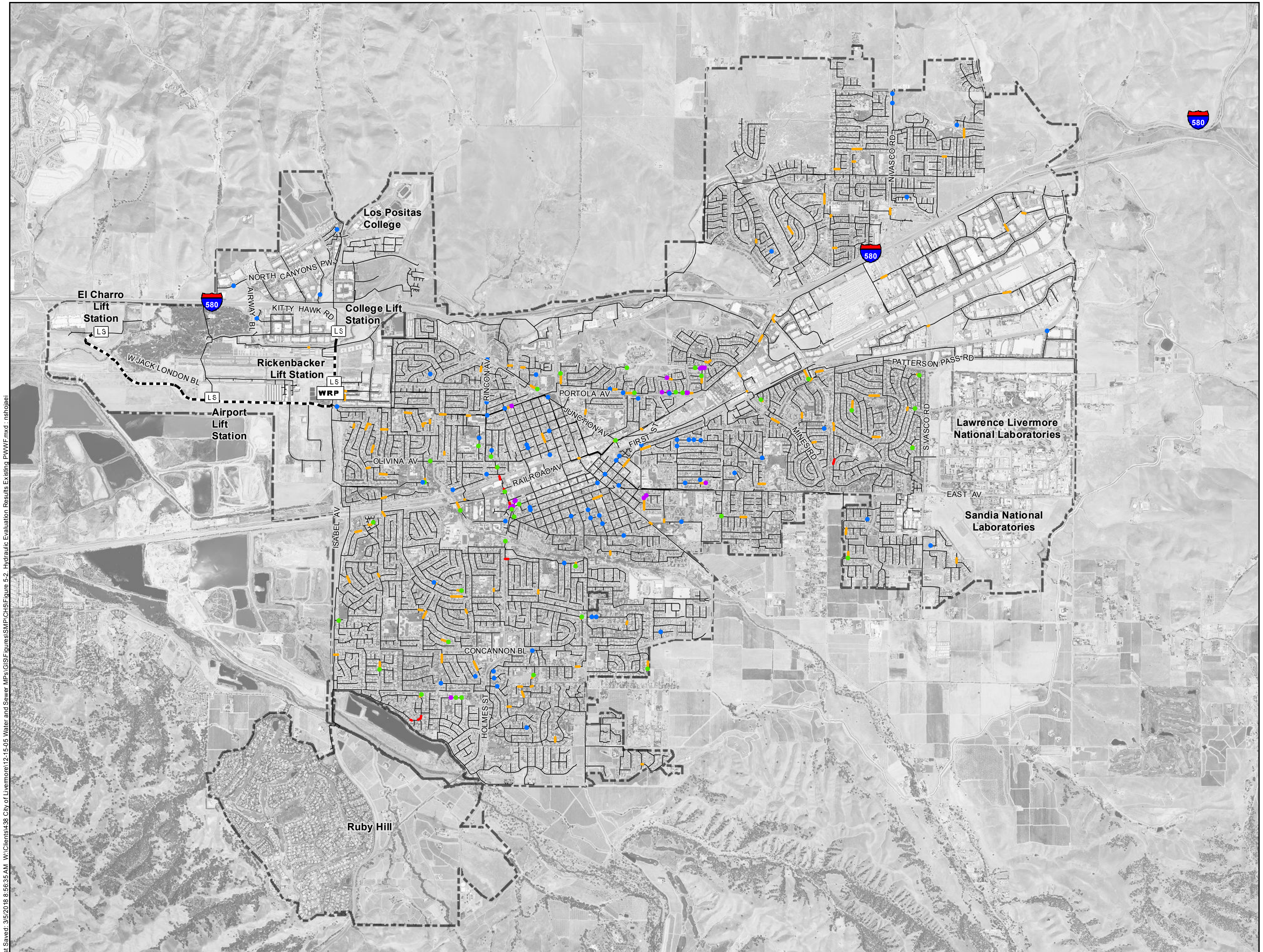

0 2,000 4,000
Scale in Feet

Symbology

WRP Water Reclamation Plant

LS Lift Station

Manhole Capacity Results

- No Capacity issue (not shown)
- Surcharged Depth > 2 ft
- Unfilled Depth ≤ 3 ft
- Surcharged Depth > 2 ft and Unfilled Depth ≤ 3 ft

Gravity Main Capacity Results

- No Deficiency
- Insufficient Slope
- Undersize
- Force Main
- Sewer Service Boundary

LIVERMORE CALIFORNIA

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Figure 5-2

Hydraulic Evaluation Results Existing PWWF

City of Livermore
Sewer Master Plan

Last Saved: 3/5/2018 8:56:35 AM W:\Clients\438 City of Livermore\12-15-05 Water and Sewer MPs\GIS\Figures\SMP\CH5\Figure 5-2_Hydraulic Evaluation Results Existing PWWF.mxd : nshojaei

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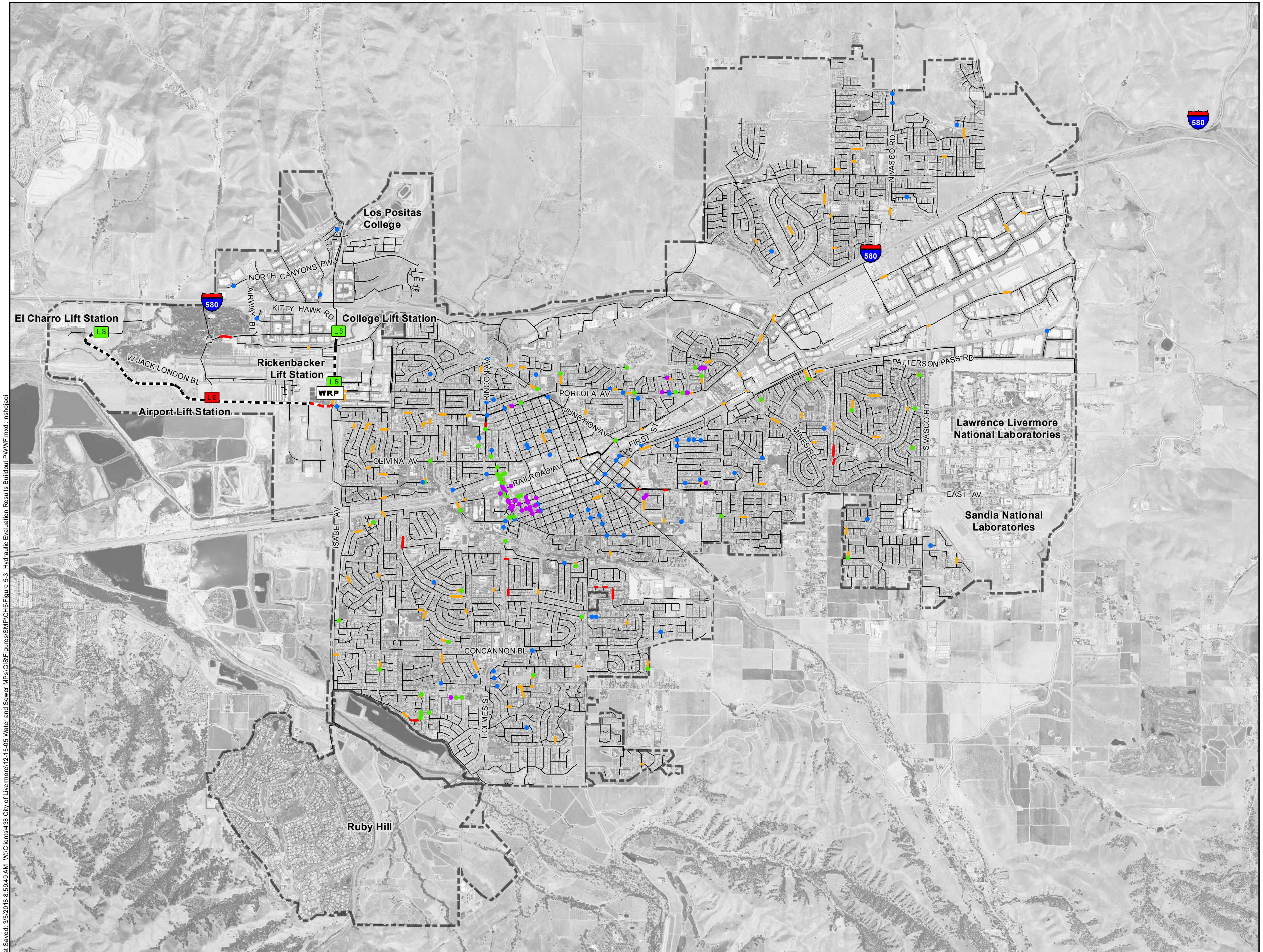

0 2,000 4,000
Scale in Feet

Symbology

WRP Water Reclamation Plant

Lift Station Capacity Results

LS No Capacity Deficiency

LS Capacity Deficiency

Manhole Capacity Results

No Capacity issue (not shown)

Surcharged Depth > 2 ft

Unfilled Depth ≤ 3 ft

Surcharged Depth > 2 ft and Unfilled Depth ≤ 3 ft

Gravity Main Capacity Results

No Deficiency

Insufficient Slope

Undersize

Force Main Capacity Results

No Deficiency

Recommended Upsize

Sewer Service Boundary

LIVERMORE CALIFORNIA

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Figure 5-3

Hydraulic Evaluation Results Buildout PWWF

City of Livermore
Sewer Master Plan

Last Saved: 3/5/2018 8:59:49 AM W:\Clients\438 City of Livermore\12-15-05 Water and Sewer MPs\GIS\Figures\SMP\CH5\Figure 5-3_Hydraulic Evaluation Results Buildout PWWF.mxd : nshojaei

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Whereas previous chapters have focused on the hydraulic capacity of the collection system and the need for future capacity to meet development needs, Chapter 6 summarizes the evaluation of the condition and day-to-day operation of the City's collection system. Maintaining the condition of the collection system and providing effective operation of the collection system are equally important to providing adequate hydraulic capacity in meeting the needs of the City and its customers.

6.1 GRAVITY MAIN OPERATIONAL ANALYSIS

This Sewer Master Plan does not include a business risk assessment of the collection system. The City has previously performed a business risk assessment of the gravity mains as part of its asset management efforts, and may update this assessment using the results of this Sewer Master Plan. Despite the fact that a full business risk assessment was not performed, the development of the capacity analysis for this Sewer Master Plan identified some operational changes that may improve the day-to-day operation of the collection system.

The primary operational improvement that was identified for the collection system, and in particular the gravity mains, was better collection of flow data throughout the collection system. The daily operation of the collection system, as well as the accuracy of the capacity evaluation and planning performed for the collection system, will be improved by greater understanding of the flows, both dry weather and wet weather, throughout the collection system. Systematic flow monitoring will provide that understanding. A recommended flow monitoring plan for the collection system was developed as described below.

6.1.1 Gravity Main Age Isolation

RDII enters collection systems through defects in gravity mains, manholes, and private laterals, and such defects tend to increase in number and severity with age of infrastructure. Therefore, although infrastructure age is not a perfect indicator of RDII risk, it is a strong indicator of risk, particularly if comprehensive condition assessment information is not available. Effective wet weather flow monitoring plans isolate regions within the collection system by age to quantify RDII trends.

In the City's collection system, the oldest infrastructure is found in a central core corresponding to the downtown and Old Town area, with newer infrastructure found proceeding outward and away from this core. Many of the larger diameter trunk gravity mains are older as well. The installation decade of gravity mains throughout the collection system are presented on Figure 6-1.

6.1.2 Potable Water Source Isolation

As described in Chapter 2, and discussed in greater detail in Chapter 3, there are four potable water providers within the City's sewer service area. In a collection system such as the City's, with low amounts of groundwater infiltration and base infiltration, ADWF can be calculated as a fraction (Return-to-Sewer ratio) of the potable water delivered to the service area. Because the four distinct potable water providers in the City's sewer service areas operate with different rate structures, conservation incentives, and recycled water programs, the amount of potable water that ends up in the collection system as ADWF varies for each provider. Therefore, to better quantify the return-to-sewer ratio that is specific to each potable water source, so that existing and future ADWF projections can be refined over time, it is recommended that the City's flow monitoring program isolate the collection system by potable water source where possible. The potable water source delivery areas are displayed on Figure 6-2.

6.1.3 Land Use Isolation

In addition to potable water source isolation, land use isolation allows for effective refinement of Return-to-Sewer ratio values. In addition, non-residential land use flow generation can vary greatly from application to application, and has greater variation from "typical" values. For these reasons, it is recommended that the City's flow monitoring program isolate specific land uses when possible.

6.1.4 Recommended Flow Monitoring Program

In 2016, City staff developed a flow monitoring plan that consisted of purchasing nine flow monitors and placing them around the collection system. City staff identified preliminary locations for these nine monitors. To date, the City has purchased two flow monitors and is testing them at various locations around the collection system.

The nine flow monitoring locations identified by City staff were reviewed and found to be suitable for long-term flow monitoring of the collection system. These locations maximize the amount of data that will be captured across the collection system for both dry weather and wet weather flow quantification. These nine locations identified by City staff can be seen on Figure 6-2.

While the nine locations identified by City staff maximize the amount of data that can be captured by this number of flow monitors, they do not fully isolate areas of the collection system by gravity main age and potable water source as recommended above. Therefore, further flow monitoring locations are recommended to support and complement the permanent flow monitoring being developed by the City:

- A flow monitor should be located immediately downstream of the permanent meter that captures flow from LLNL and SNL as this flow enters the City's collection system. Although such a meter would be redundant to the existing permanent meter for quantifying ADWF, the temporary flow monitor's 15-minute resolution will be far superior to the permanent meter's 24-hour resolution in quantifying RDII flows. Because of the large areas contained within the LLNL and SNL campuses, quantifying RDII rates in these areas is critical for capacity management. The temporary flow monitor will also serve to calibrate the data captured by the permanent meter.
- A flow monitor should be located immediately downstream of the connection from the Ruby Hill development to the City's collection system. Such a meter would isolate the development both for determining RDII values for this significant area, and for determining precise return-to-sewer ratios for ADWF from the area served potable water by the City of Pleasanton.

- A flow monitor should be installed upstream of the Airport Lift Station. As described in Chapter 5, the hydraulic analysis predicts that the Airport Lift Station has insufficient capacity under future conditions. Further quantification of both the dry and wet weather flow into this lift station will be critical for determining the size and timing of the capacity improvement project required. This quantification is of more importance given the potential for redevelopment per the Isabel Neighborhood Plan in the basin tributary to this lift station (see additional discussion in Chapter 7 and Appendix B).
- A flow monitor should be installed upstream of the College Lift Station. As described in Chapter 5, the hydraulic analysis predicts that the College Lift Station will be utilizing nearly its full hydraulic capacity under future conditions. Further quantification of both the dry and wet weather flow into this lift station will allow for more confidence in managing the capacity at this facility. This quantification is of more importance given the potential for redevelopment per the Isabel Neighborhood Plan in the basin tributary to this lift station (see additional discussion in Chapter 7 and Appendix B).
- It is recommended that a flow monitor be installed in the gravity main trunk in East Avenue, just upstream of Mines Road in the eastern portion of the collection system. This flow monitor would serve, in conjunction with the permanent flow monitors already planned by the City, to isolate the portion of the City in the east served potable water by Cal Water from the central portion of the City served by City municipal water sources.
- It is recommended that a flow monitor be installed in the gravity main trunk in Sonoma Avenue, just upstream of where this main connects to the larger main in El Caminito. This flow monitor would serve to isolate an area of particularly old gravity mains in the center of the collection system to quantify RDII rates in these old gravity mains.

With the addition of the six flow monitoring locations recommended above to the nine locations previously identified by the City, the City will have a comprehensive flow monitoring plan that will satisfy the City's requirements for managing the capacity of the collection system. In addition to the flow monitors recommended above, it is recommended that the City install depth-only monitors at two locations that are predicted to surcharge in the hydraulic analysis, as described in Chapter 5. The first of these locations is at Joyce Street, and the second location is in the vicinity of S Street. The depth-only monitors will provide a cost-effective early-warning of potential surcharges in areas that have been identified as having potential capacity problems. The City has already purchased level meters that can be used in these locations.

The cost of the flow monitoring program described above is included as a line item in the recommended Capital Improvement Program (CIP) for the collection system presented in Chapter 7.

6.2 LIFT STATION OPERATIONAL ANALYSIS

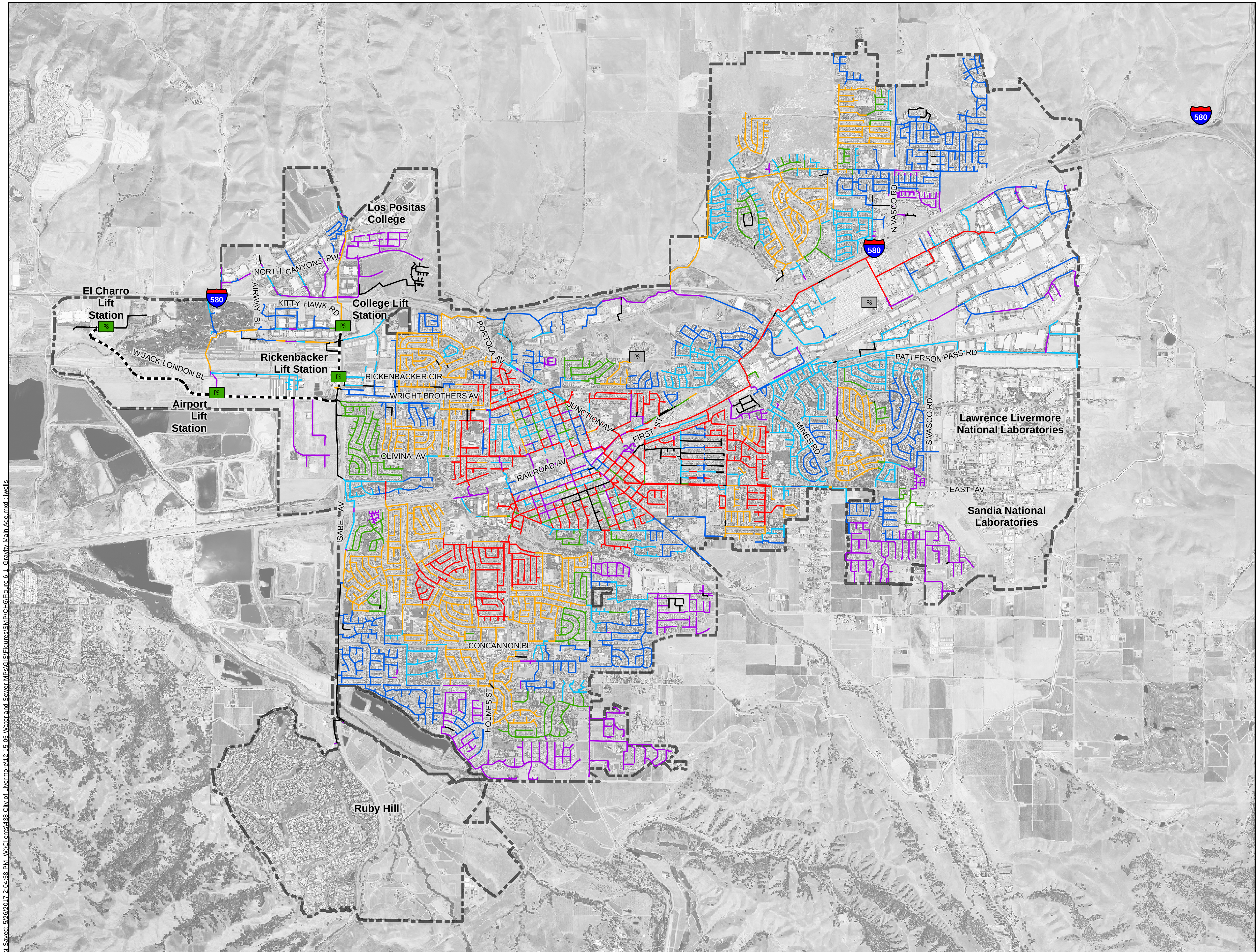
The ability of the four lift stations in the collection system to convey design flows, both under existing and future conditions, was evaluated as described in Chapter 5. However, lift stations can fail even when having sufficient nominal hydraulic capacity. Lift stations have the following principal failure modes: hydraulic capacity failure, maintenance failure, and structural/mechanical failure. These modes are discussed briefly as follows:

- **Capacity Failure**. As part of this Sewer Master Plan, a hydraulic capacity evaluation was conducted on the collection system for current and buildout conditions under peak wet weather flow conditions, as documented in Chapter 5.
- **Maintenance Failure**. Maintenance problems related to pump failure, electrical failure, or grease and odor issues can cause a decrease in the level of service provided by a lift station.
- **Structural/Mechanical Failure**. Older lift stations are more likely to fail than newer ones due to the age of materials and wear from repeated use. Older lift stations are more likely to have cracks, breaks, corrosion, and equipment that is beyond its intended useful life.

Maintenance and mechanical evaluations at the lift stations were not performed as part of this Sewer Master Plan. It is recommended that the City perform these evaluations as part of implementing this Sewer Master Plan. At a minimum, such evaluations should include the following:

- Condition assessment that includes physical inspection of condition and performance at each lift station.
- Performance evaluation of the pumps at each lift station to determine how closely their true capacity is to their stated capacity. The performance evaluation should include the development of system curves to help refine pump selection.
- Operational evaluation to determine the optimal control points such that pump capacity, wet well volume, and existing/future flows are best accounted for.

The cost of the maintenance and mechanical evaluations described above is included as a line item in the recommended CIP for the collection system presented in Chapter 7.



0 2,000 4,000
Scale in Feet

Symbology

- Lift Station
- Private Lift Station

Gravity Main Installation Decade

- 1950s and Earlier
- 1960s
- 1970s
- 1980s
- 1990s
- 2000s
- 2010s
- Force Main
- Sewer Service Boundary

LIVERMORE CALIFORNIA

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Figure 6-1

Gravity Main Installation Decade

City of Livermore
Sewer Master Plan

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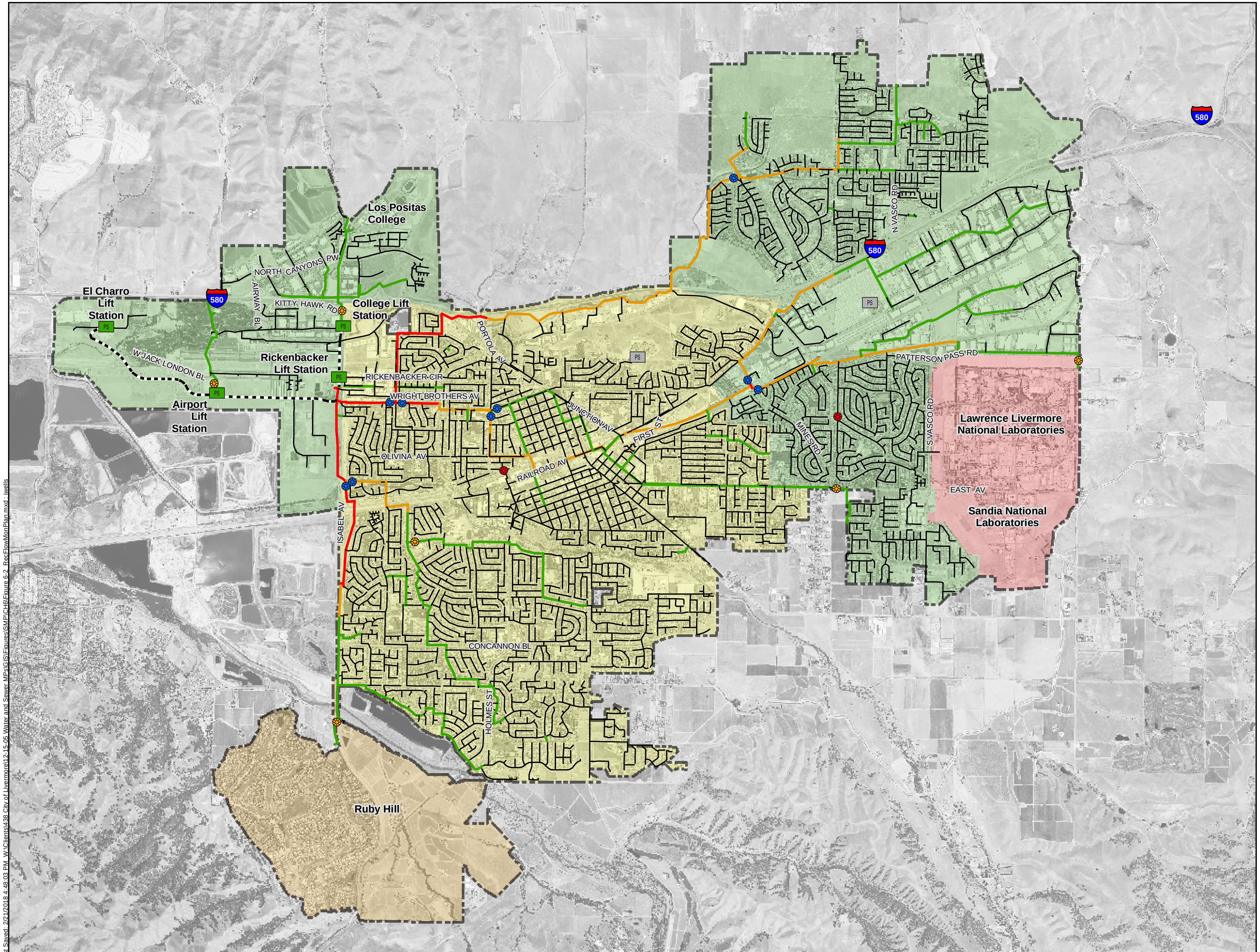

N

0 2,000 4,000

Scale in Feet

Symbology

- Selected Flow Meter Locations
- Additional Recommended Flow Meter Locations
- Recommended Depth Meter Locations
- Lift Station
- Private Lift Station
- Force Main

Gravity Main - Diameter

- 4-inch - 8-inch
- 10-inch - 18-inch
- 21-inch - 33-inch
- 36-inch - 60-inch
- City of Livermore
- Cal Water
- City of Pleasanton
- SFPUC
- Sewer Service Boundary

Notes:
1. SFPUC refers to San Francisco Public Utilities Commission.

LIVERMORE CALIFORNIA

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Figure 6-2

Recommended Flow Monitoring Plan

City of Livermore
Sewer Master Plan

Last Saved: 2/21/2018 4:48:03 PM W:\Clients\438 City of Livermore\12-15-05 Water and Sewer MPs\GIS\Figures\SMP\CH6\Figure 6-2_RecFlowMonPlan.mxd - jwells

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Chapter 7 provides an overview of the recommended improvements for the gravity main, lift stations, and force mains that have been identified in Chapters 5 and 6. These improvements have been prioritized based on the development timeline and risk assessment performed, and includes conceptual costs for the recommended improvement projects.

It is important to note that the focus of this Sewer Master Plan is to recommend capacity related improvement projects for the City's sewer system. It is not the intent for this Sewer Master Plan to be the sole source of all recommended sewer system projects for inclusion in the City's Capital Improvement Plan (CIP). Other sources include the Water Resource Division's asset management program (which focuses on the renewal or replacement of sewer system assets based on and age and condition), regulation and code compliance, operations and maintenance staff input, and coordination with other roadway improvements. The City utilizes and coordinates all sources in the development of the City's overall CIP for the sewer system

This chapter also briefly describes an evaluation of the potential need for additional collection system improvements beyond those identified in Chapters 5 and 6 of this Sewer Master Plan to serve the City's proposed Isabel Neighborhood Plan, which is proposed to develop in conjunction with the proposed future extension of BART to Isabel Avenue. As described in Section 7.1.3 below, it was determined that a small number of collection system improvements beyond those already identified would be required to serve the proposed Isabel Neighborhood Plan. A complete description of the collection system evaluation to serve the proposed Isabel Neighborhood Plan is provided in Appendix B.

7.1 RECOMMENDED SEWER COLLECTION SYSTEM CAPITAL IMPROVEMENT PROGRAM

The recommended collection system capital improvement projects are described below, listed in Table 7-1 and shown in Figure 7-1. It should be noted that the recommended CIP only identifies improvements at a Master Planning level and does not constitute a design of such improvements. Subsequent detailed design will be required to determine the exact sizes and locations of these proposed improvements and to refine the opinion of probable construction cost.

7.1.1 Existing Sewer Collection System Capital Improvement Program

Chapter 5 provided a summary of the evaluation of the City's existing collection system and its ability to meet the recommended design and performance criteria described in Chapter 4. Based on the existing collection system evaluation, improvements were recommended to eliminate existing system deficiencies. These improvements do not include improvements for the gravity mains with low slopes identified in Chapter 5. It is anticipated that these identified gravity mains do not represent true hydraulic bottlenecks in the collection system, and therefore have not been included in this Sewer Master Plan as recommended projects. However, it is recommended that in the future the City perform field verification of these isolated mains so their true capacity can be determined and the assumption of no hydraulic bottleneck confirmed. If a true hydraulic bottleneck is found, the City can develop an improvement project at that time.

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Table 7-1. Summary of Recommended Capital Improvement Projects and Estimated Cost[a]

CIP ID	Improvement Type	Was this a project in the 2004 SMP?	Improvement Description	Estimated Construction Cost[a]	Capital Cost (includes mark-ups)[b]	Existing User Cost Allocation	Future User Cost Allocation
Near-Term Improvements (Near-Term Improvements)							
Gravity Main Improvements							
EX-CIP-P01	Gravity Main Upsize	No	**Existing Design Flow:** Upsize 304 feet of 6-inch to 8-inch gravity main along South Street between First Street and Second Street. Upsize 104 feet of 6-inch gravity main to 10-inch gravity main in Lambaren Avenue at South Street. Upsize 330 feet of 8-inch gravity main to 10-inch gravity main in East Stanley Boulevard between First Street and power station in Railroad Avenue, and gravity main located under railroad at the other side of commercial parking lot. (City records indicate that a portion of this upsize has occurred after performance of the hydraulic evaluation. The status of this project should be confirmed before design is commenced.) **Buildout Design Flow:** Upsize a further 590 feet of 8-inch gravity main to 10-inch gravity main from power station beside Railroad Avenue running into the commercial parking lot up to railroad and between Railroad and Ventura Avenue.	$ 279,000	$ 544,000	$ 290,000	$ 254,000
EX-CIP-P02	Gravity Main Upsize	No	Upsize 289 feet of 8-inch gravity main to 15-inch gravity main in Old Oak Road between Breeze Way and Lakeside Circle.	$ 87,000	$ 170,000	$ 108,800	$ 61,200
EX-CIP-P03	Gravity Main Upsize	Yes, but not constructed	Upsize 140 feet of 8-inch gravity main to 10-inch gravity main in Anza Way between Aberdeen Avenue and Holmes Street and upsize 496 feet of 8-inch gravity main to 10-inch gravity main in Holmes Street between Anza Way and Mocho Street to maintain continuity in diameter	$ 140,000	$ 273,000	$ 273,000	$ -
EX-CIP-P04	Gravity Main Upsize	Yes, but not constructed	**Existing Design Flow:** Upsize 207 feet of 8-inch gravity main to 10-inch gravity main in Lilian Street between Shirley Way and south of Lucille Street. **Buildout Design Flow:** Upsize an additional 605 feet of 8-inch gravity main to 10-inch gravity main in south of Lucille Street.	$ 179,000	$ 349,000	$ 90,000	$ 259,000
EX-CIP-P05	Flow Monitoring Program	No	Conduct flow monitoring program that consists of 15 full flow meter sites and two level-only meter sites. Of the 15 full flow meter sites, two have already been installed. Seven remaining sites identified by the City will be installed, in addition to six additional sites as identified in Chapter 6.[c]	-	$ 300,000	$ 246,000	$ 54,000
				Subtotal	$ 1,636,000	$ 1,007,800	$ 628,200
Collection System Planning Studies							
EX-CIP-P06	Lift Station Assessment	No	Perform operational evaluation to identify the condition and performance characteristics of the City's four lift stations. The study will include a report that prioritizes an improvement plan based upon the inspection results.	-	$ 200,000	$ 200,000	0
EX-CIP-P07	Field Verification of Hydraulic Model	No	Perform field verification of hydraulic model. Field verification will be performed for infrastructure identified in the Gap Analysis as described in Chapter 5, as well as for gravity mains segments that were identified as low slope during the hydraulic modeling. Field verification will include physical inspection and possibly surveying of horizontal and vertical alignment as necessary.[c]	-	$ 75,000	$ 61,500	$ 13,500
				Subtotal	$ 275,000	$ 261,500	$ 13,500
				Existing System Improvement Projects (Near-Term Projects) Total	**$ 1,911,000**	**$ 1,269,300**	**$ 641,700**
Buildout Improvements (2040 Improvements)							
Gravity Main Improvements							
BO-CIP-P01	Gravity Main Upsize	Yes, but not constructed	Upsize 638 feet of 10-inch gravity main to 15-inch gravity main in Rincon Avenue between Elm Street and Pine Street.	$ 191,000	$ 372,000	$ -	$ 372,000
BO-CIP-P02	Gravity Main Upsize	Yes, but not constructed	Upsize 265 feet of 8-inch gravity main to 10-inch gravity main in Aberdeen Avenue between Columbus Avenue and Hudson Way, and upsize 1,288 feet of 8-inch gravity main to 10-inch gravity main in Aberdeen Avenue between Columbus Avenue and Anza Way to maintain continuity in diameter.	$ 341,000	$ 665,000	$ -	$ 665,000
BO-CIP-P03	Gravity Main Upsize	Yes, but not constructed	Upsize 1,215 feet of 8-inch gravity main to 10-inch gravity main in Gamay Road between Quail Court and Cabernet Way, and in Cabernet Way between Gamay Road and Chianti Court. Upsize 1,420 feet of 8-inch gravity main to 10-inch gravity main in Cabernet Way between Chianti Court and Arroyo Road and in Arroyo Road between Cabernet Way and Robertson Park Road to maintain continuity in diameter.	$ 579,000	$ 1,129,000	$ -	$ 1,129,000
BO-CIP-P04	Gravity Main Upsize	No	Upsize 458 feet of 8-inch gravity main to 10-inch gravity main in Clubhouse Drive and upsize 359 feet of 8-inch gravity main to 10-inch gravity main in Clubhouse Drive to maintain continuity in diameter.	$ 180,000	$ 351,000	$ -	$ 351,000
BO-CIP-P05	Gravity Main Upsize	No	Upsize 439 feet of 18-inch gravity main to 21-inch gravity main in El Caminito north of Sonoma Avenue and upsize 801 feet of 18-inch gravity main to 21-inch gravity main in El Caminito north of Sonoma Avenue to Karen Way to maintain continuity in diameter.	$ 521,000	$ 1,016,000	$ -	$ 1,016,000
BO-CIP-P06	Gravity Main Upsize	No	Upsize 59 feet of 10-inch gravity main to 12-inch gravity main in East Avenue at 7th Street. Upsize 116 feet of 12-inch gravity main to 15-inch gravity main in East Avenue east of Dolores Street and upsize 1,072 feet of 12-inch gravity main to 15-inch gravity main in East Avenue between Dolores Street and 7th Street to maintain continuity in diameter.	$ 373,000	$ 727,000	$ -	$ 727,000
				Subtotal	$ 4,260,000	$ -	$ 4,260,000
Lift Station Improvements							
BO-CIP-P07	Capacity Improvement	No	Increase firm capacity of the Airport Lift Station from 1,145 gpm to 1,480 gpm. In addition to capacity increase, rehabilitate lift station electrical, mechanical, and structural elements. Upsize 990 feet of 8-inch force main to 10-inch force main in West Jack London Boulevard to handle increased flows.	$ 966,400	$ 1,884,000	$ 1,458,000	$ 426,000
				Subtotal	$ 1,884,000	$ 1,458,000	$ 426,000
				Buildout Improvement Projects Total	**$ 6,144,000**	**$ 1,458,000**	**$ 4,686,000**
				Total Capital Improvement Plan	**$ 8,055,000**	**$ 2,727,300**	**$ 5,327,700**

[a] Costs shown are based on the March 2017 SF ENR CCI of 11609.

[b] Costs include base construction costs plus 30 percent estimating contingency, and an additional markup equal to 50 percent for professional services.

[c] Costs are allocated 82% to existing users and 18% to future users based upon the ratio of existing rebounded ADWF values to buildout ADWF values.

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The recommended existing collection system improvements are as follows:

- Upsize 304 feet of 6-inch to 8-inch gravity main along South Street between First Street and Second Street. Upsize 104 feet of 6-inch gravity main to 10-inch gravity main in Lambaren Avenue at South Street (City records indicate that a portion of this upsize has occurred after performance of the hydraulic evaluation. The status of this project should be confirmed before design is commenced). Upsize 919 feet of 8-inch gravity main to 10-inch gravity main in East Stanley Boulevard between First Street and Railroad Avenue, and running into the commercial parking lot between Railroad Avenue and Ventura Avenue. (Project No. EX-CIP-P01).
- Upsize 289 feet of 8-inch gravity main to 15-inch gravity main in Old Oak Road between Breeze Way and Lakeside Circle. (Project No. EX-CIP-P02).
- Upsize 140 feet of 8-inch gravity main to 10-inch gravity main in Anza Way between Aberdeen Avenue and Holmes Street. (Project No. EX-CIP-P03).
- Upsize 812 feet of 8-inch gravity main to 10-inch gravity main in Lilian Street between Shirley Way and south of Lucille Street. (Project No. EX-CIP-P04).
- Implement flow monitoring program as described in Chapter 6. The flow monitoring program will consist of fifteen (15) sites with full flow meters, and two (2) sites with level-only meters. (Project No. EX-CIP-P05).

The recommended existing system improvements should be implemented in the near-term. The locations of the recommended existing collection system improvement projects are shown on Figure 7-1.

7.1.2 Future Sewer Collection System Capital Improvement Program

Chapter 5 also provided a summary of the evaluation of the City's future collection system and its ability to meet the recommended design and performance design criteria described in Chapter 4. Based on the future collection system evaluation, improvements were recommended to eliminate future system deficiencies and to meet projected flows at buildout. These improvements do not include improvements for the gravity mains with low slopes identified in Chapter 5. It is anticipated that these identified gravity mains do not represent true hydraulic bottlenecks in the collection system, and therefore have not been included in this Sewer Master Plan as recommended projects. However, it is recommended that in the future the City perform field verification of these isolated mains so their true capacity can be determined and the assumption of no hydraulic bottleneck confirmed.

The recommended buildout collection system improvements are as follows:

- Upsize 638 feet of 10-inch gravity main to 15-inch gravity main in Rincon Avenue between Elm Street and Pine Street. (Project No. BO-CIP-P01).
- Upsize 265 feet of 8-inch gravity main to 10-inch gravity main in Aberdeen Avenue between Columbus Avenue and Hudson Way, and upsize 1,288 feet of 8-inch gravity main to 10-inch gravity main in Aberdeen Avenue between Columbus Avenue and Anza Way to maintain continuity in diameter. (Project No. BO-CIP-P02).

- Upsize 1,215 feet of 8-inch gravity main to 10-inch gravity main in Gamay Road between Quail Court and Cabernet Way, and in Cabernet Way between Gamay Road and Chianti Court. Upsize 1,420 feet of 8-inch gravity main to 10-inch gravity main in Cabernet Way between Chianti Court and Arroyo Road and in Arroyo Road between Cabernet Way and Robertson Park Road to maintain continuity in diameter. (Project No. BO-CIP-P03).
- Upsize 458 feet of 8-inch gravity main to 10-inch gravity main in Clubhouse Drive and upsize 359 feet of 8-inch gravity main to 10-inch gravity main in Clubhouse Drive to maintain continuity in diameter. (Project No. BO-CIP-P04).
- Upsize 439 feet of 18-inch gravity main to 21-inch gravity main in El Caminito north of Sonoma Avenue and upsize 801 feet of 18-inch gravity main to 21-inch gravity main in El Caminito north of Sonoma Avenue to Karen Way to maintain continuity in diameter. (Project No. BO-CIP-P05).
- Upsize 59 feet of 10-inch gravity main to 12-inch gravity main in East Avenue at 7th Street. Upsize 116 feet of 12-inch gravity main to 15-inch gravity main in East Avenue east of Dolores Street and upsize 1,072 feet of 12-inch gravity main to 15-inch gravity main in East Avenue between Dolores Street and 7th Street to maintain continuity in diameter. (Project No. BO-CIP-P06).
- Increase firm capacity of the Airport Lift Station from 1,145 gpm to 1,480 gpm. In addition to capacity increase, rehabilitate lift station electrical, mechanical, and structural elements. Upsize 990 feet of 8-inch force main to 10-inch force main in West Jack London Boulevard to handle increased flows. (Project No. BO-CIP-P07)

The recommended buildout system improvements should be implemented when flows approach buildout levels. The locations of the recommended collection system improvement projects are shown on Figure 7-2.

7.1.3 Additional Improvements to Serve the Isabel Neighborhood Plan

The Isabel Neighborhood Plan (INP) is a proposed development area located in the northwest portion of the City. The INP planning area covers approximately 1,138 acres, and is entirely within the City's urban growth boundary. A portion of the INP planning area lies within the City's water service area (in Pressure Zone 1) and a portion lies within the CalWater Livermore District service area. The INP will guide future development of the area surrounding the proposed BART station in the I-580 median, just east of Isabel Avenue and is contingent upon the extension of BART to this location.

The INP planning area includes both existing developed areas and proposed new development areas. Proposed land uses for the INP are different from those currently included in the City's General Plan. The INP includes new residential areas both north and south of I-580, as well as non-residential, employment generating, uses including ground floor retail, office and commercial. Three new neighborhood parks and open space buffers along the creeks are also proposed to provide recreational opportunities and access to natural areas.

Sewer flows have been projected for the proposed INP land uses to determine if the additional sewer flows associated with the INP trigger required improvements to the City's collection system. The projected ADWF for the INP planning area assuming the INP land uses is 714,000 gpd, which is 195,000 gpd (or about 37 percent) higher than the ADWF for the INP planning area assuming current General Plan land uses.

Existing collection system infrastructure is primarily in place within the INP planning area to serve the existing developed areas. Based on the sewer flow projections for the INP land uses, the following additional collection system improvements would be required to serve future planned development under the proposed INP:

- Additional gravity main improvements (beyond those required for buildout conditions); and
- Additional capacity required at the City's Airport Lift Station (deficiency in firm capacity increases from 335 gpm under buildout conditions to 365 gpm with the INP included).

The required INP CIP projects can be seen on Figure 7-3. It should be noted that extension of services to individual parcels is not included in this analysis and the resulting projects. Extension of services would be provided by developers as necessary. Additional information on the INP proposed land uses, projected sewer flows, and collection system evaluation is provided in Appendix B.

7.1.4 Additional Collection System Studies

As described in Chapter 6, the development of the Sewer Master Plan identified further information that would be valuable for the operation of the collection system. Such data will be used to augment and refine the capacity evaluation that has been performed as part of the Sewer Master Plan, as well as used to evaluate the collection system in a manner that goes beyond capacity evaluation. The following studies are recommended to collect this data:

- Lift Station Assessment. This study will consist of an operational evaluation to identify the condition and performance characteristics of the City's four lift stations. The study will include a report that prioritizes an improvement plan based upon the inspection. The assessment will include an evaluation of the methods that the City may use (alarms, overflow to storage, and other such methods) to mitigate the fact that the lift stations do not have sufficient holding capacity per City criteria in the event of a lift station outage. (Project No. EX-CIP-P06).
- Field Verification of Hydraulic Model. This study will consist field verification of hydraulic model. Field verification will be performed for infrastructure identified in the Gap Analysis as described in Chapter 5, as well as for gravity mains segments that were identified as low slope during the hydraulic modeling. Field verification will include physical inspection and possibly surveying of horizontal and vertical alignment as necessary. Field verification may lead to the development of further hydraulic improvement projects if hydraulic bottlenecks are confirmed. (Project No. EX-CIP-P07).

7.2 CAPITAL IMPROVEMENT PROGRAM COSTS AND IMPLEMENTATION

The Capital Improvement Program costs and implementation assumptions are described below.

7.2.1 Cost Assumptions

The opinion of probable project cost for recommended collection system improvements is presented in March 2017 dollars based on an Engineering News Record (ENR) Construction Cost Index (CCI) of 11609 (San Francisco Average). Base construction costs were developed based on bids on other water facilities design projects and from standard cost estimating guides. The total project cost includes a mark-up equal to 95 percent of the base construction costs, which includes an estimating contingency of 30 percent, and markups of 20 percent for design period services and 30 percent for construction period services. Refer to Table 3 of Appendix C for an example application of project cost markups.

For this Sewer Master Plan, it is assumed that new collection system facilities will be developed in public rights-of-way or on public property; therefore, land acquisition costs have not been included. The opinion of probable construction cost does not include costs for annual operation and maintenance. A complete description of the assumptions used in the development of the opinion of probable construction cost is provided in Appendix C.

7.2.2 Opinion of Probable Project Cost

The opinion of probable project costs for the recommended existing and buildout collection system improvements is presented in Table 7-1.

Table 7-2 summarizes the planning-level opinion of probable project costs by project type to mitigate existing system deficiencies, and to meet future growth in the City's collection system. As described above and detailed in Appendix B, the addition of flows that would result should the INP develop adds several gravity mains (some part of existing projects and some in new locations) to the CIP, and adds to the deficiency predicted for the Airport Lift Station. It should be noted that any in-tract pipelines that may be required as part of new development projects will be fully funded and installed by the project proponents. Therefore, these facilities and corresponding costs are not included.

Table 7-2. Opinion of Probable Project Costs for Recommended Collection System Capital Improvements by Project Type[(a,b)]

Collection System Improvement Type	Existing (Near-Term)	Buildout	Total
Gravity Main Improvements	$1,636,000	$4,260,000	$5,896,000
Lift Station Improvements	-	$1,884,000	$1,844,000
Collection System Planning Studies	$275,000	-	$275,000
Opinion of Probable Project Costs	$1,911,000	$6,144,000	$8,055,000

(a) Costs shown are based on the March 2017 SF ENR CCI of 11609.

(b) Total Project Costs include the Estimated Construction Costs which include an estimating contingency of 30 percent of the Base Construction Cost, and Design and Construction Period Services equal to 50 percent of the Estimated Construction Costs.

As shown, the total opinion of probable project costs for collection system improvements to support the City's existing and buildout sewer flows is $8,055,000. Of this amount, approximately $1,911,000 is required to address existing system deficiencies, and approximately $6,144,000 is required to support future planned growth.

Existing collection system improvements to address existing system deficiencies should be completed as funding permits. The construction of capital improvements for buildout conditions should be coordinated with the proposed schedules of new development to ensure that require infrastructure will be in place to serve future customers. The potential INP flows would add further improvements as described above, and would add approximately $540,000 in probable construction costs to the total for future flows. The additional improvements required for potential INP flows are displayed on Figure 7-3. Details for these improvements can be found in Appendix B.

Table 7-1 also shows the proposed cost allocation of the recommended improvements to existing and future collection system customers. Total capital costs allocated to existing users are approximately $2.7 million, and total capital costs allocated to future users are approximately $5.3 million. As shown, most of the recommended capital improvements specific provide benefits to either existing or future customers. Several gravity main improvement projects provide benefits to both existing and future customers. Costs for these projects were allocated based upon the extent of improvements required to serve existing customers versus the extent required to serve future customers. The improvement to the Airport Lift Station similarly provides benefits to both existing and future customers. Costs were allocated based upon the design flow to the lift station required by existing customers (1,145 gpm) versus design flow required by future customers (1,480 gpm).

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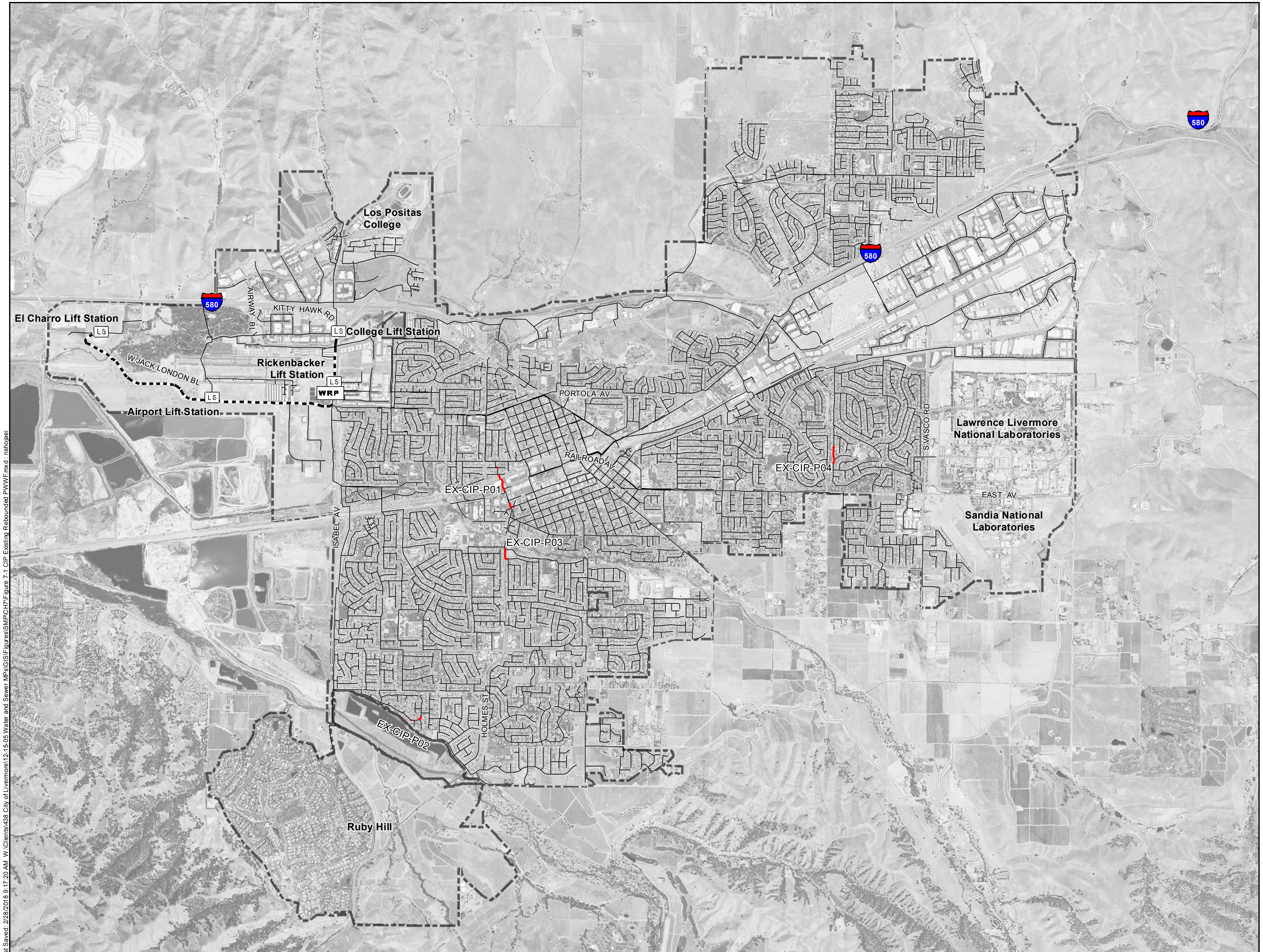

Last Saved: 2/28/2018 9:17:20 AM W:\Clients\438 City of Livermore\12-15-05 Water and Sewer MPs\GIS\Figures\SMP\CH7\Figure 7-1 CIP Existing Rebounded PWWF.mxd : nshojaei

N

0 2,000 4,000

Scale in Feet

Symbology

- WRP Water Reclamation Plant
- LS Lift Station
- Replace Existing Gravity Main
- Gravity Main
- Force Main
- Sewer Service Boundary

LIVERMORE CALIFORNIA

WEST YOST ASSOCIATES

Figure 7-1

Recommended Capital Improvement Program Existing Rebounded PWWF

City of Livermore
Sewer Master Plan

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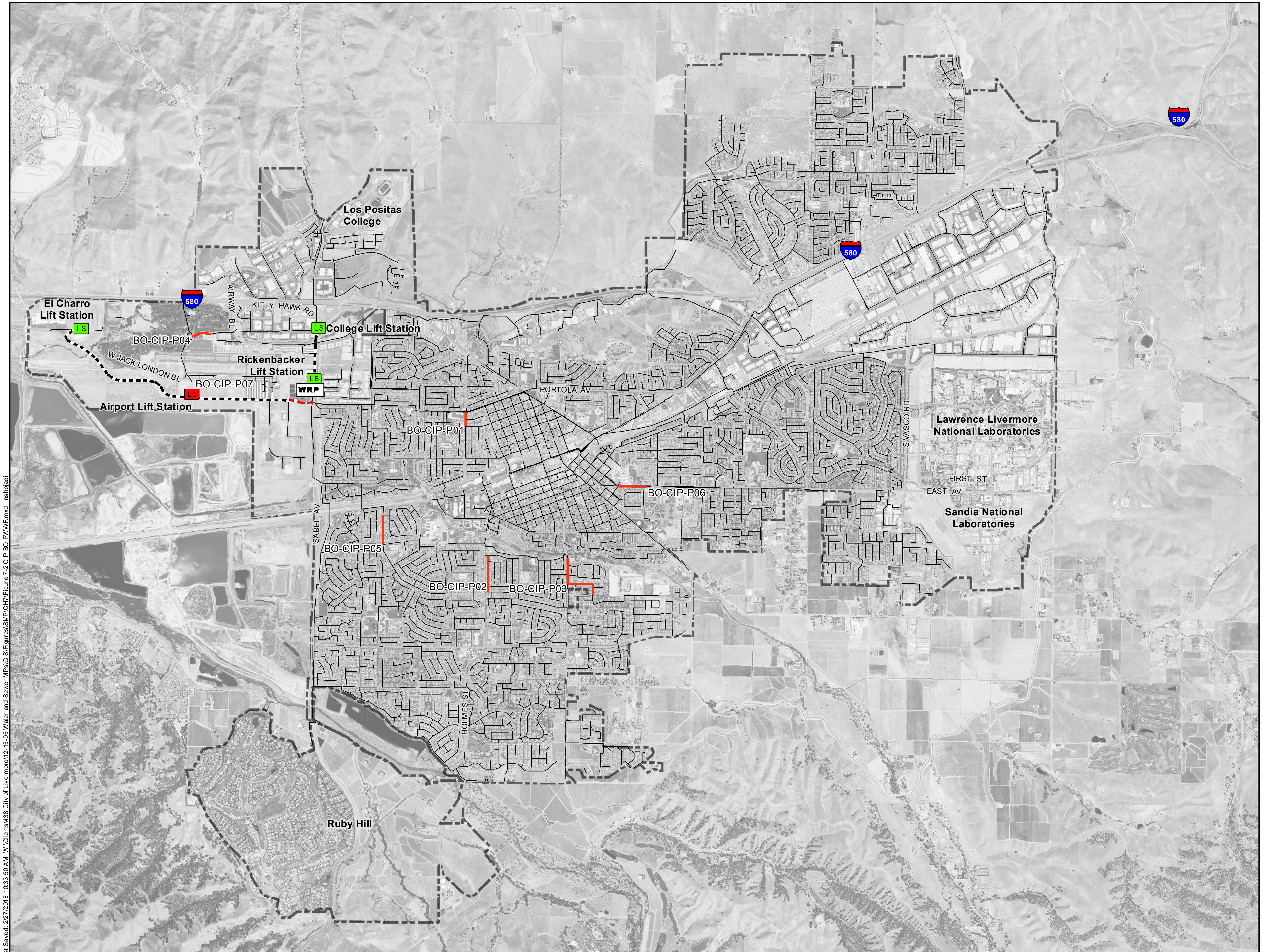

0 2,000 4,000
Scale in Feet

Symbology

- WRP Water Reclamation Plant
- LS Replace Existing Lift Station
- LS Lift Station
- Replace Existing Force Main
- Force Main
- Replace Existing Gravity Main
- Gravity Main
- Sewer Service Boundary

LIVERMORE CALIFORNIA

WEST YOST ASSOCIATES

Figure 7-2

Recommended Capital Improvement Program Buildout PWWF

City of Livermore
Sewer Master Plan

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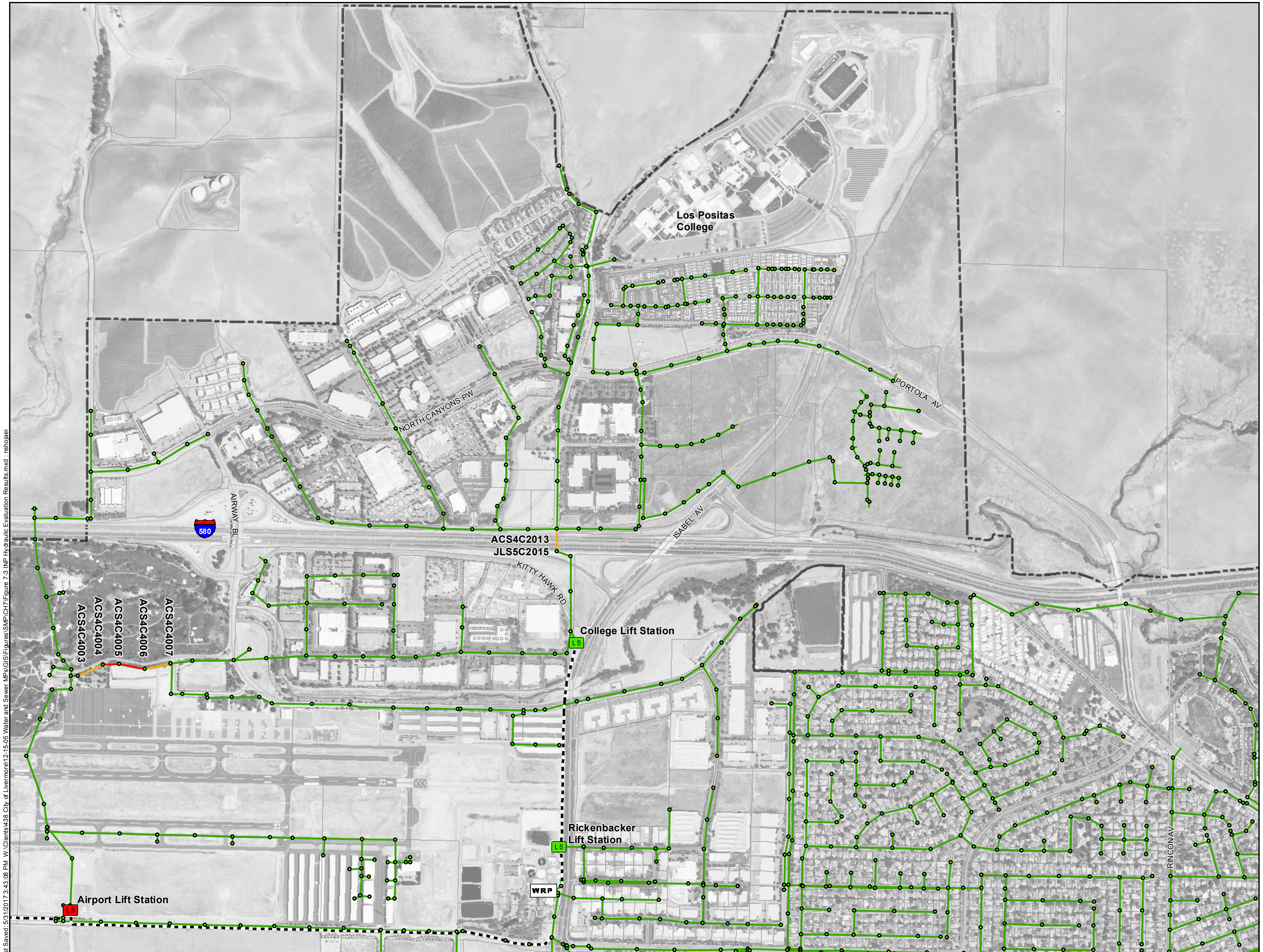

0 500 1,000
Scale in Feet

Symbology

WRP Water Reclamation Plant

Lift Station Capacity Results

LS No Capacity Deficiency

LS Capacity Deficiency Under Both General Plan Build-Out and INP Scenarios

Manhole

Gravity Main Capacity Results

No Deficiency

Deficiency Under INP Scenario Only

Deficiency Under Both General Plan Build-out and INP Scenarios

Force Main

Sewer Service Boundary

Note:
1. Labels shown are upstream and downstream manholes' ID of gravity main capacity deficiencies.

LIVERMORE CALIFORNIA

WEST YOST ASSOCIATES

Figure 7-3

INP Hydraulic Evaluation Results

City of Livermore
Sewer Master PLan

Last Saved: 5/31/2017 3:43:08 PM W:\Clients\438 City of Livermore\12-15-05 Water and Sewer MPs\GIS\Figures\SMP\CH7\Figure 7-3 INP Hydraulic Evaluation Results.mxd : nshojaei

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APPENDIX A

Collection System Hydraulic Model Modeler's Notebook

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INTRODUCTION

The purpose of this Collection System Hydraulic Model Modeler's Notebook (Modeler's Notebook) is to document the facilities that are included in the City of Livermore's (City's) sewer collection system and the manner in which these facilities are simulated in the City's sewer collection system hydraulic model. This Modeler's Notebook and associated database are compiled from the information available at the time of the model development. West Yost Associates (West Yost) developed this Modeler's Notebook to provide the City with a means to evaluate and review the information that West Yost has incorporated into the hydraulic model, and also to provide the City with a "living" reference for use by the City's modeling staff and outside parties that will be using the hydraulic model. The facility information provided is current as of January 2017.

This Modeler's Notebook is organized as follows:

- Model Development Notes
- Model Scenarios
- Calibration Simulations and Results

MODEL DEVELOPMENT NOTES

Information on the City hydraulic model development is included below.

Hydraulic Model Background

As part of the 2004 Master Plan, a hydraulic model of the City's collection system was developed utilizing H2OMap Sewer Pro software (H2OMap Sewer), a product of Innovyze, Inc. H2OMap Sewer was developed specifically for collection system capacity analysis and is widely used in the industry. The hydraulic model developed for the 2004 Master Plan was a skeletonized model that contained only the trunk gravity mains from the City's collection system. Small diameter gravity mains were excluded from the hydraulic model.

For this Sewer Master Plan, the City desired a more comprehensive evaluation of collection system capacity, including the small diameter gravity mains that predominate the collection system. Further, the City desired that a clear link be developed between individual parcel flows and their connection to the collection system. Such a link requires that all gravity mains, regardless of diameter, be included in the hydraulic model. Therefore, as part of this Sewer Master Plan, the hydraulic model has been updated to include a network that contains all collection system gravity mains. As shown in Figure 1, the model was updated so that all infrastructure, including gravity mains, lift stations, and force mains, is up to date and represents the collection system as it currently exists in the field.

Model Naming Scheme

A specific naming scheme for network elements is used in the hydraulic model and is presented in Table 1. The gravity main and force main naming schemes are based on the "PipeID(New)" field in GIS. Further identification for wet wells, manholes, chambers, and outlets will be based on unique identification for each facility. Naming schemes for lift stations also include a reference to the associated wet well identification.

Manhole and gravity main unique GIS identifiers were preserved as unique hydraulic model identifiers, where possible. In some cases, multiple manholes or gravity mains had the same identifier in GIS. Because the hydraulic model does not allow non-unique identifiers, the identifier of one of the elements was altered in the hydraulic model as follows:

- Manholes with the same GIS ID were renamed to their GIS ID concatenated with their unique old facility ID; and
- Pipes with the same GIS ID were renamed to their GIS ID concatenated with their unique old facility ID.

The hydraulic model requires an upstream manhole and downstream manhole for each gravity main. In some cases, this geometry was not present in the GIS. In these cases, the geometry was fixed in the hydraulic model as follows:

- In cases of a missing manhole (i.e., two proximate gravity mains with no manhole between them), the appropriate manhole was created in the hydraulic model. A unique identifier was created for this new manhole by adding an alphabetical suffix to the identifier of the nearest existing manhole in the model.
- In cases of a manhole drawn over a gravity main that was not properly "split" to reflect the presence of the manhole, the gravity main was split and snapped to the manhole to reflect the proper upstream and downstream geometry in the network. Because splitting a gravity main creates a new gravity main in the hydraulic model, the new gravity main was given a unique identifier consisting of the original identifier with the addition of an alphabetical suffix. Inverts for the split gravity main were determined through interpolation using the length and slope of the original gravity main.

Table 1. Naming Scheme for Network Elements

Model Component	Naming Scheme
Gravity Pipelines	PipeID(New)
Force Main	PipeID(New)
Normal Manholes	MHID(New)
Chamber Manholes	CH-Lift Station Name "CH" = Chamber
Outlet Manholes	MHID(New)
Wet Wells	WW-Lift Station Name "WW" = Wet Well
Wet Well Lift Station	LS-Lift Station Name "LS" = Lift Station

Model Element Information

The information associated with each element in the hydraulic model includes several data fields that have been added or filled by West Yost to include additional information for future reference and/or use. These additional data fields are listed below along with a brief description.

Manhole

- OLD_ID –This field contains the manhole old identification number
- WY_OWNER – Owner of the manhole
- WY_SOURCE – This field indicates if the manhole was exported from GIS to the hydraulic model or if it was existing in the hydraulic model
- ZONE – This field shows the type of updates based on the geodatabase data received by January 2017
- 2016WY_COM – Comments by West Yost about the GIS data

Pipe

- OLD_ID –This field contains the pipeline old identification number
- WY_OWNER – Owner of the pipeline
- WY_SOURCE – This field indicates if the pipeline was exported from GIS to the hydraulic model or if it was existing in the hydraulic model
- ZONE – This field shows the type of updates based on the geodatabase data received by January 2017
- 2016WY_COM – Comments by West Yost about the GIS data
- INVERT_ADJ – Summarizes the type of adjustment on pipeline invert elevation
- DOWN_STRU – Old ID of downstream manhole
- UP_STRU – Old ID of upstream manhole
- CIP – Summarizes the CIP project ID
- Material – Material of the pipelines

GIS Gap Analysis

West Yost's GIS data gap analysis identified required additional data and discrepant data that would be determined to model and evaluate City's collection system. This information was discussed with City staff, and was requested where available. Attachment 1 includes the discussed information and proposed results that was confirmed by City's staff.

GIS Mapping Import

The January 2017 Geodatabase update was used to import properties and data into the modeling facilities. The unique ID developed for each facility was used to import data into the hydraulic model based on the mapping scheme for gravity mains as shown in Table 2 and manholes as shown in Table 3.

Wet wells, lift stations and force mains were included in the hydraulic model based on as-built drawings provided by City staff.

Table 2. Gravity Main Pipeline Mapping

GIS Data Field	Description	Model Data Field
MATERIAL	Pipeline material	PIPEHYD->MATERIAL
MhUpID (New)	Upstream Manhole ID	LINK->FROM[(a)]
MhDownID (New)	Downstream Manhole ID	LINK->TO[(a)]
DIAMETER	Pipeline diameter in inches	PIPEHYD->DIAMETER
LENGTH	Pipe length in feet	PIPEHYD->LENGTH
INVERT_IN	Upstream Invert Elevation in feet	PIPEHYD->FROM_INV
INVERT_OUT	Downstream Invert Elevation in feet	PIPEHYD->FROM_INV
OWNER	Pipeline owner	WY_OWNER

(a) To and from link manhole identifications were revised to include the appropriate notation as described in Table 1. Naming Scheme for Network Elements.

Table 3. Manhole Mapping

GIS Data Field	Description	Model Data Field
Rim	Upstream Rim Elevation in feet	MHHYD->RIM_ELEV
OWNER	Name of Improvement Plan Reference	WY_OWNER

Flow Development

As discussed in Chapter 3 of Sewer Master Plan, ADWF is projected by applying a Return-to-Sewer ratio to average day water demands. This Return-to-Sewer ratio varies by usage type, with single family dwelling units typically having relatively low ratios, and commercial and industrial users typically have higher ratios.

Buildout ADWF projections were developed using the baseline 2020 ADWF projections as a starting point. Projected flows from reasonably foreseeable development projects, as identified by City planning staff, were added to the 2020 ADWF projections. Projected flows from other vacant areas were added as well. The projected flows from both the development projects and the vacant land were tracked and summarized by inclusion in either the City Municipal service area or CalWater service area.

Model Load Fields

ADWF values were developed on an individual parcel basis. These values were imported into the hydraulic model through the establishment of a parcel-to-manhole link made possible by the inclusion of all gravity mains and all manholes in the hydraulic model. The parcel-to-manhole link was initiated using GIS proximity analysis to identify the manhole closest to each parcel. The parcel-to-manhole linkage established a loading manhole for each parcel in the City. ADWF values were summarized by manhole and these summarized flows were imported into the hydraulic model. The H2OMap Sewer modeling software contains 10 loading fields that can be used to organize flows being imported into the model. For the City's hydraulic model, flows were organized into the loading columns as shown in Table 4.

Table 4. Load Column Description in the Hydraulic Model

Load Column	Load Description
Load 1	ADWF of Existing Developed Areas in City Municipal Water Service Area
Load 2	ADWF of Existing Developed Areas in Cal Water Service Area
Load 3	Existing Point Sources and Existing ADWF of Reasonably Foreseeable Development Projects
Load 4	Future ADWF of Reasonably Foreseeable Development Projects in City Municipal Water Service Area
Load 5	Future ADWF of Reasonably Foreseeable Development Projects in Cal Water Service Area
Load 6	Future ADWF of Vacant Areas in City Municipal Area and Ruby Hill Development
Load 7	Future ADWF of Vacant Areas in Cal Water Service Area
Load 8	Existing RDII
Load 9	Future RDII
Load 10	Blank for Future Use

MODEL SCENARIOS

H2OMap Sewer software allows the user to create unique scenarios to differentiate between different conditions for analysis within the same hydraulic model. In addition to the base scenarios, 10 additional scenarios were created in the model. These scenarios were created to evaluate various hydraulic conditions which include the following:

- Wet Weather Flow – Five scenarios were created in the hydraulic model
- Average Dry Weather Flow – Three scenarios were created in the hydraulic model
- Peak Dry Weather Flow – Two scenarios were created in the hydraulic model

The scenario names and associated descriptions are presented in Table 5.

Table 5. Model Scenario Descriptions

Scenario Name	Scenario Description
BASE	Base Network
EX_ADWF_2016	2016 Existing System and Existing Average Dry Weather Flow
EX_PDWF_2016	2016 Existing System Peak Dry Weather Flow
EX_PWWF_2016	2016 Existing System Peak Wet Weather Flow
EX_DESIGN_2016	2016 Existing System Peak Wet Weather Flow with Existing CIP
BO_ADWF	2016 Existing System and Future Average Dry Weather Flow
BO_PDWF	2016 Existing System and Future Peak Dry Weather Flow
BO_PWWF	2016 Existing System and Future Peak Wet Weather Flow
BO_DESIGN	Future Peak Wet Weather Flow with Future CIP
ISABEL_AVE_PROJECT_PWWF	Future Peak Wet Weather Flow Considering Isabel Neighborhood Development
ISABEL_ADWF	Future Average Dry Weather Flow Considering Isabel Neighborhood Development

In addition, Table 19 (included at the end of this Modeler's Notebook) summarizes and defines the organization of each scenario in the hydraulic model based on the following items discussed below.

Model Data Sets

Within each scenario, data sets are used to describe specific system facilities and system conditions. Data sets can be common to multiple scenarios or they can be unique to a specific scenario. A brief description of each type of data set is provided below.

Manhole Sets

Manhole sets store the loads assigned to each individual manhole under a specified condition. Developed ADWF data is used to develop the associated patterns for each manhole. For the scenarios listed in Table 5, a unique manhole set is used to represent the various load conditions associated with each scenario, as shown in Table 6.

Table 6. Manhole Sets

Manhole Set	Definition
BASE	Default
EX_ADWF_2016	Existing Average Dry Weather Flow
EX_PDWF_2016	Diurnal Patterns with Peakable Existing Average Dry Weather Flow
EX_PWWF_2016	RDII and Diurnal Patterns with Peakable Existing Average Dry Weather Flow
BUILDOUT_ADWF	Future Average Dry Weather Flow
BUILDOUT_PDWF	Diurnal Patterns with Peakable Future Average Dry Weather Flow
BUILDOUT_PWWF	RDII and Diurnal Patterns with Peakable Future Average Dry Weather Flow
ISABEL_PWWF	RDII and Diurnal Patterns with Peakable Future Average Dry Weather Flow Considering Isabel Neighborhood Development
ISABEL_ADWF	Future Average Dry Weather Flow Considering Isabel Neighborhood Development

Wet Well Sets

Wet Well sets store the hydraulic modeling information (e.g., diameter, bottom elevation, minimum level, maximum level, and initial level) assigned to each individual wet well under a specified condition. Table 7 lists the wet well sets used in the hydraulic model.

Table 7. Wet Well Sets

Wet Well Set	Description	Definition
BASE	Base Wet Well Set	Default (no data)
2016-EXSYS	2016 Existing Wet Wells	Wet Well data for 2016 scenarios

Pipe Sets

Pipe sets store the hydraulic modeling information (e.g., diameter, length, slope, roughness coefficient, and presence of parallel pipes of the same characteristics) assigned to each individual pipe or open channel under a specified condition. Pipes can be either gravity or force mains. Unique pipe sets were created and are shown in Table 8.

Table 8. Pipe Sets

Pipe Set	Description	Definition
BASE	Base Pipe Set	Default
2016PIPESET	2016 Existing Pipe System	Piping system for use in dry weather 2016 scenarios
ADJUST_INVERT	Adjusted Invert elevation	Piping system considering adjustment of nonrealistic invert elevation
EX_CIP	CIP to Serve Existing Design Flow	Improved piping system to serve the existing design flow
BO_CIP	CIP to Serve Future Design Flow	Improved piping system to serve the future design flow

Pump Sets

Pump sets store hydraulic modeling information (e.g., type of pump, diameter, elevation, design flow, design head, pump curve) assigned to each individual pump under a specified condition. Table 9 lists the pump sets used in the hydraulic model.

Table 9. Pump Sets

Pump Set	Description	Definition
BASE	Base Pump Set	Default
2016-EXSYS	2016 Existing Pump System	Pump data for 2016 scenarios

Pump Control Sets

Pump Control sets store hydraulic modeling information (e.g., type of control method and on/off settings) assigned to each pump under a specified condition. Table 10 lists the pump control sets used in the hydraulic model.

Table 10. Pump Control Sets

Pump Set	Description	Definition
BASE	Base Pump Set	Default
2016-EXSYS	2016 Existing Pump Controls	Pump operational control for 2016 scenarios

Extra Loading Sets

Extra Loading sets store additional loading hydraulic modeling information (e.g., unpeakable flow, peakable flow, and load patterns) assigned to each manhole under a specified condition. Table 11 lists the extra loading sets used in the hydraulic model.

Table 11. Extra Loading Sets

Extra Loading Sets	Description	Definition
BASE	Base Extra Loading Set	Default
2016-EXSYS	2016 Existing System Extra Loading Set	Default

Flow Split Sets

Flow Split sets store the flow split method information (e.g., fixed percentage, variable flow, inflow-outflow or automatic split methods) assigned to each pipeline. Table 12 lists the flow split sets used in the hydraulic model.

Table 12. Flow Split Sets

Flow Split Set	Description	Definition
BASE	Base Flow Split Set	Flow Split at each manhole
2016-EXSYS	2016 Existing System Flow Split Set	Flow Split at each manhole

Pipe Design Sets

Pipe Design sets store depth-to-diameter design curves, depth-to-diameter analysis curves, replacement and parallel cost curves and user specified criteria for pipeline design. Table 13 lists the pipe design sets used in the hydraulic model.

Table 13. Pipe Design Sets

Pipe Design Set	Definition
BASE	Default
2016-EXSYS	Default

Pipe Infiltration Sets

Pipe Infiltration sets store the infiltration type information (e.g., none, pipe length, pipe diameter-length, pipe surface area, count based or pattern based methods) assigned to each pipeline. Table 14 lists the pipe infiltration sets used in the hydraulic model.

Table 14. Pipe Infiltration Sets

Pipe Infiltration Set	Definition
BASE	Default
2016-EXSYS	Default

Operation Sets

Operation sets store the pattern and curve information (e.g., pump curve data) assigned to each facility. Table 15 lists the operation sets used in the hydraulic model.

Table 15. Operation Sets

Operation Set	Definition
BASE	Default
2016-EXSYS	Default

Facility Manager

The Facility Manager defines the active facilities for each specified scenario by using query sets. Table 16 lists the query sets that are used in the Facility Manager under each specified condition. In the event a facility is abandoned with a new facility as replacement, a new facility will be added in the hydraulic model with a unique identification and the abandoned facility will also remain within the hydraulic model as inactive to keep historical mapping facilities (i.e. if a gravity main is replaced and abandoned due to a new gravity main, a parallel gravity main will be drawn in the hydraulic model and the "replaced" facility will be retired as opposed to changing the facility information of the "replaced" gravity main).

Table 16. Query Sets in Facility Manager

Query Set	Description	Condition
EX_SYSTEM_2016	2016 Existing System Facilities	Use with 2016 existing system scenarios

Simulation Options

Simulation Options contains the hydraulic simulation criteria necessary for the hydraulic engine to run. The Simulation Option can be altered to associate with a given condition. Table 17 lists the Simulation Options used in the hydraulic model.

Table 17. Simulation Options

Simulation Option	Description
BASE	Base Simulation Option
2016	2016 Simulation Option for ADWF scenarios
PEAKING	2016 Simulation Option for PDWF and PWWF scenarios

Simulation Time

Simulation Time contains the hydraulic simulation time-step information. The Simulation Time can be altered to associate with a given condition. Table 18 lists the Simulation Time used in the hydraulic model.

Table 18. Simulation Time

Simulation Time	Description
BASE	Base Simulation Time (Steady State)
PEAKING[(a)]	60-hour Extended Period Simulation

(a) Five Day simulation time required one-minute report time step, six-minute pump hydraulic time step, and one-hour flow pattern time step.

Model Scenario Organization

As discussed previously, each scenario in the hydraulic model is developed using various data sets, query sets, simulation options, and simulation time settings. Table 19 summarizes the data sets, query set, simulation option, and simulation time assigned to each scenario.

Average Dry Weather Flow

A 48-hour EPS was modeled using the ADWF values allocated into the hydraulic model with no peaking or diurnal patterns. The EPS ADWF scenarios are intended only as reference scenarios for how flows are peaked during the peak dry weather flow analysis.

Peak Dry Weather Flow

A 60-hour EPS was modeled using the ADWF values allocated into the hydraulic model and applying a diurnal peaking factor to simulate the PDWF. Diurnal patterns were developed for residential, commercial, and industrial type land uses and applied within the hydraulic model. These design diurnal patterns are independent of location within the collection system, and provide all new development and growth with consistent peak factors typical of their usage patterns. The design residential diurnal pattern can be seen on Figure 2. The industrial diurnal pattern can be seen on Figure 3. Finally, the commercial diurnal pattern can be seen on Figure 4. Figure 5 shows the modeled existing and buildout flow information for PDWF scenario at Water Reclamation Plant.

Peak Wet Weather Flow

As discussed in Chapter 3 of the Sewer Master Plan, PWWF is calculated by adding RDII to the PDWF. For this Sewer Master Plan, the design RDII factor for new development is 800 gpad. Existing development is expected to generate 800 gpad under existing timeframe evaluations, and 1,250 gpad under future timeframe evaluations. The increase in RDII generation is attributed to the physical deterioration of aging infrastructure for existing development and infrastructure.

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Table 19. Organization of Model Scenarios

Scenario Name	Specific Report Option	Simulation Option	Simulation Time	Facility Query Set	Manhole Set	Wet Well Set	Pipe Set	Pump Set	Pump Control Set	Extra Loading Set	Flow Split Set	Pipe Design Set	Pipe Infiltration Set	Operation Set
BASE	BASE	BASE	BASE	ENTIRE NETWORK	BASE	BASE	BASE	BASE	BASE	BASE	BASE	BASE	BASE	BASE
EX_ADWF_2016	2016	2016	2016	EX_SYSTEM_2016	EX_ADWF_2016	2016-EXSYS	2016PIPESET	2016-EXSYS	2016-EXSYS	2016-EXSYS	2016-EXSYS	2016-EXSYS	2016-EXSYS	2016-EXSYS
EX_PDWF_2016	2016	PEAKING	PEAKING	EX_SYSTEM_2016	EX_PDWF_2016	2016-EXSYS	2016PIPESET	2016-EXSYS	2016-EXSYS	2016-EXSYS	2016-EXSYS	2016-EXSYS	2016-EXSYS	2016-EXSYS
EX_PWWF_2016	2016	PEAKING	PEAKING	EX_SYSTEM_2016	EX_PWWF_2016	2016-EXSYS	ADJUST_INVERT	2016-EXSYS	2016-EXSYS	2016-EXSYS	2016-EXSYS	2016-EXSYS	2016-EXSYS	2016-EXSYS
EX_DESIGN_2016	2016	PEAKING	PEAKING	EX_SYSTEM_2016	EX_PWWF_2016	2016-EXSYS	EX_CIP	2016-EXSYS	2016-EXSYS	2016-EXSYS	2016-EXSYS	2016-EXSYS	2016-EXSYS	2016-EXSYS
BO_ADWF	2016	2016	2016	EX_SYSTEM_2016	BUILDOUT_ADWF	2016-EXSYS	2016PIPESET	2016-EXSYS	2016-EXSYS	2016-EXSYS	2016-EXSYS	2016-EXSYS	2016-EXSYS	2016-EXSYS
BO_PDWF	2016	PEAKING	PEAKING	EX_SYSTEM_2016	BUILDOUT_PDWF	2016-EXSYS	2016PIPESET	2016-EXSYS	2016-EXSYS	2016-EXSYS	2016-EXSYS	2016-EXSYS	2016-EXSYS	2016-EXSYS
BO_PWWF	2016	PEAKING	PEAKING	EX_SYSTEM_2016	BUILDOUT_PWWF	2016-EXSYS	ADJUST_INVERT	2016-EXSYS	2016-EXSYS	2016-EXSYS	2016-EXSYS	2016-EXSYS	2016-EXSYS	2016-EXSYS
BO_DESIGN	2016	PEAKING	PEAKING	EX_SYSTEM_2016	BUILDOUT_PWWF	2016-EXSYS	BO_CIP	2016-EXSYS	2016-EXSYS	2016-EXSYS	2016-EXSYS	2016-EXSYS	2016-EXSYS	2016-EXSYS
ISABEL_AVE_PROJECT_PWWF	2016	PEAKING	PEAKING	EX_SYSTEM_2016	ISABEL_PWWF	2016-EXSYS	ADJUST_INVERT	2016-EXSYS	2016-EXSYS	2016-EXSYS	2016-EXSYS	2016-EXSYS	2016-EXSYS	2016-EXSYS
ISABEL_ADWF	2016	2016	2016	EX_SYSTEM_2016	ISABEL_ADWF	2016-EXSYS	2016PIPESET	2016-EXSYS	2016-EXSYS	2016-EXSYS	2016-EXSYS	2016-EXSYS	2016-EXSYS	2016-EXSYS

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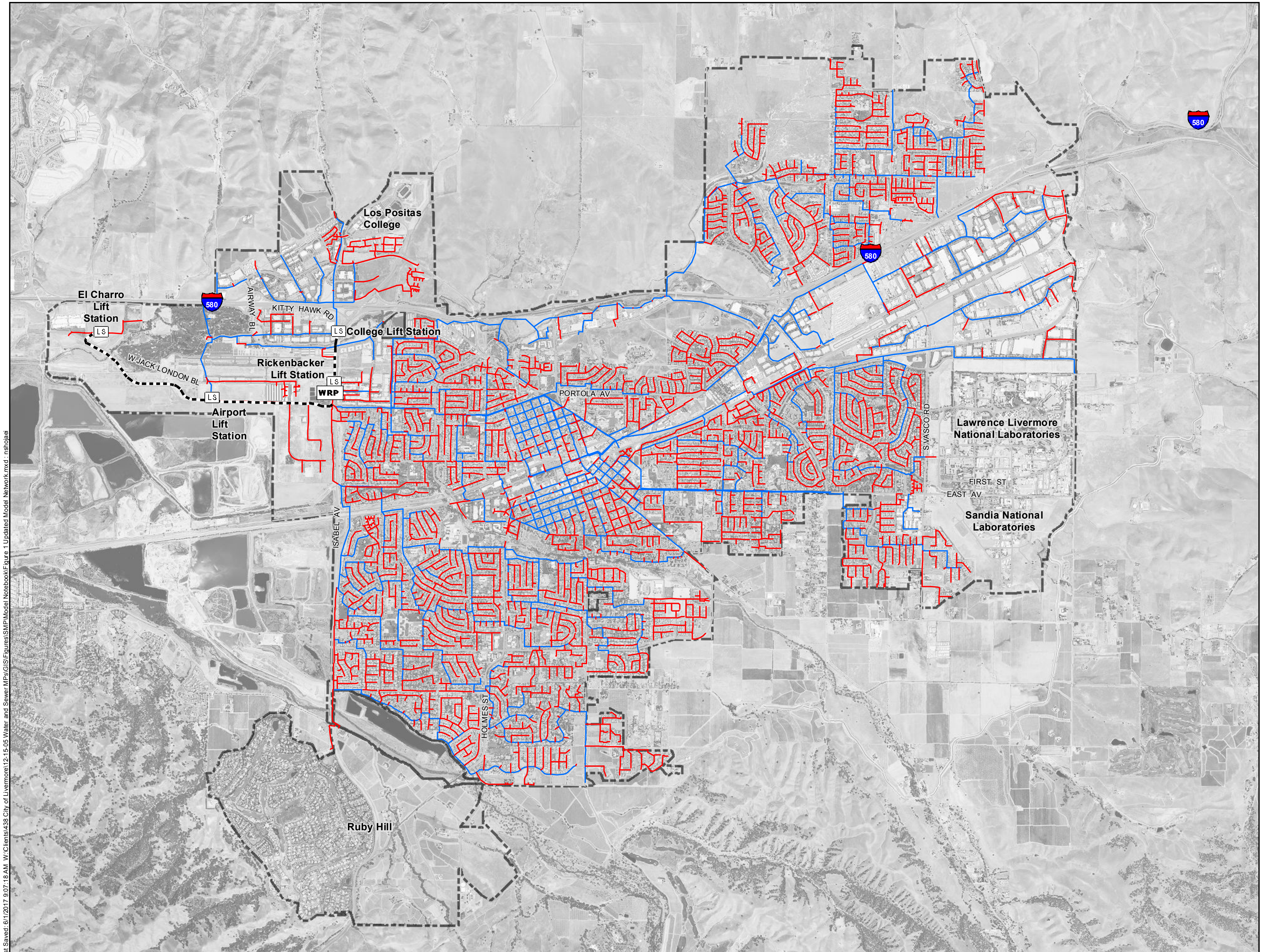

0 2,000 4,000
Scale in Feet

Symbology

- WRP Water Reclamation Plant
- LS Lift Station
- Gravity Main in 2004 Model
- Gravity Main in 2016 Model
- Force Main
- Sewer Service Boundary

LIVERMORE CALIFORNIA

WEST YOST ASSOCIATES

Figure 1

Updated Model Network

City of Livermore
Sewer Master Plan

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Figure 2. Residential Design Diurnal Pattern

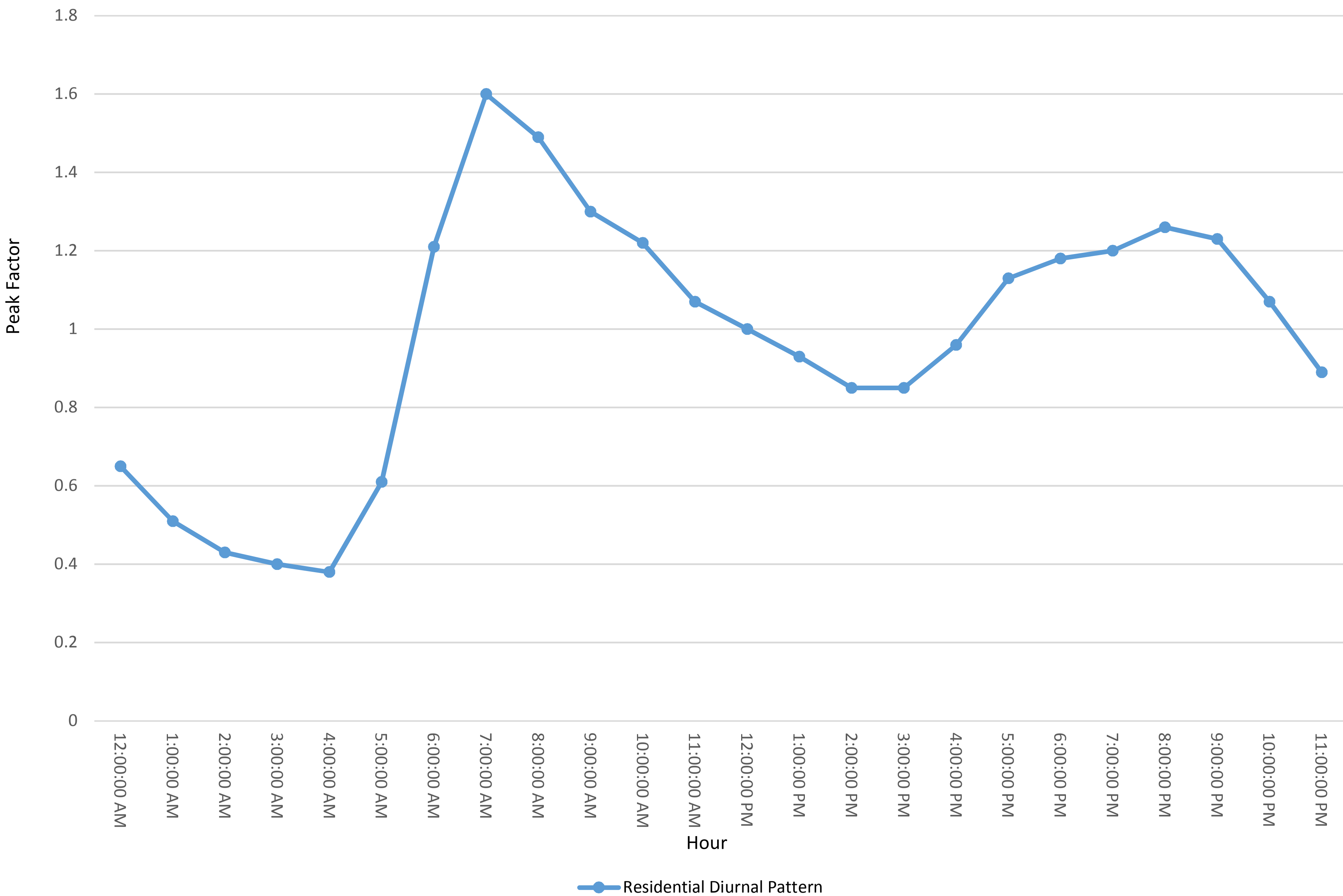

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Figure 3. Industrial Design Diurnal Pattern

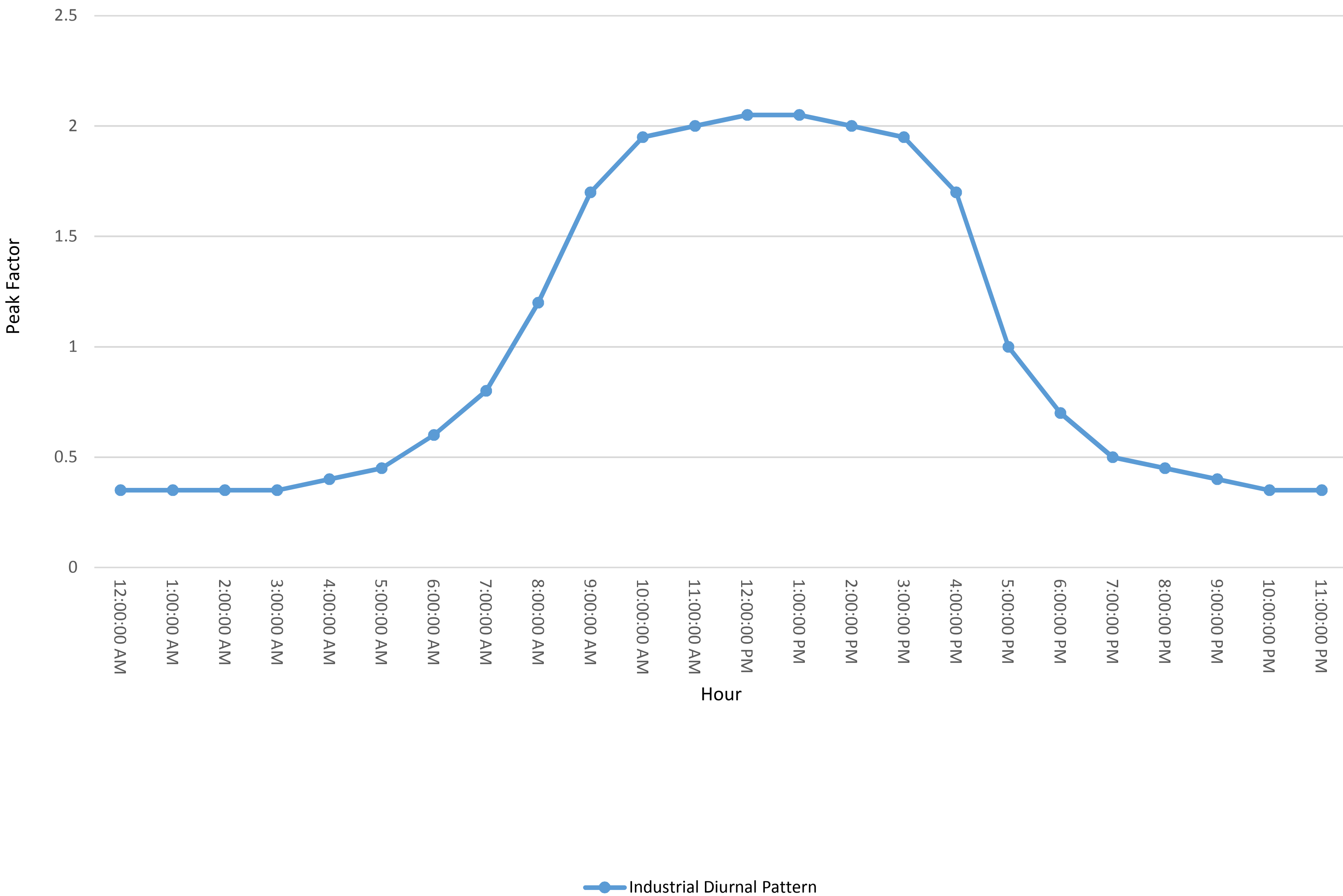

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Figure 4. Commercial Design Diurnal Pattern

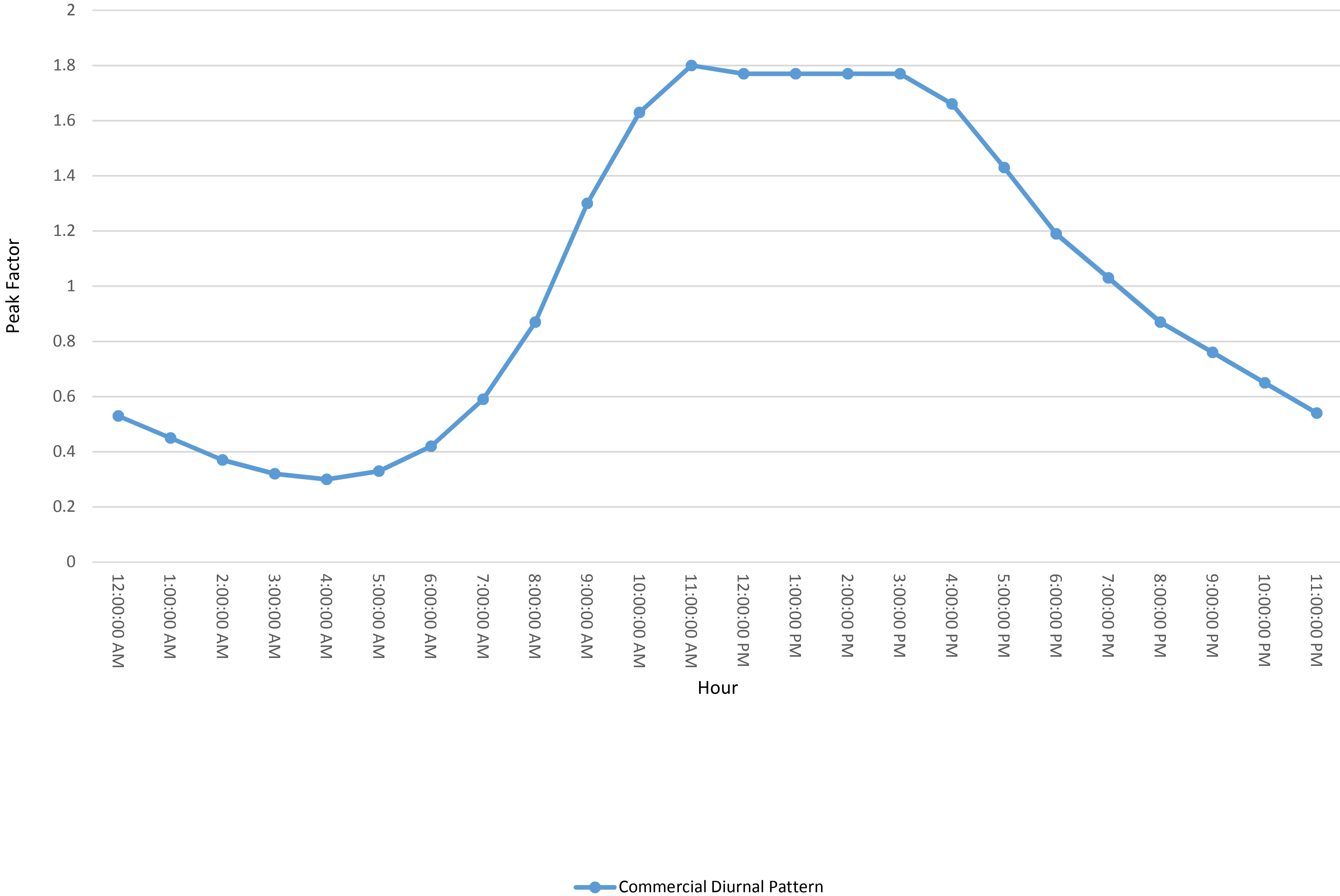

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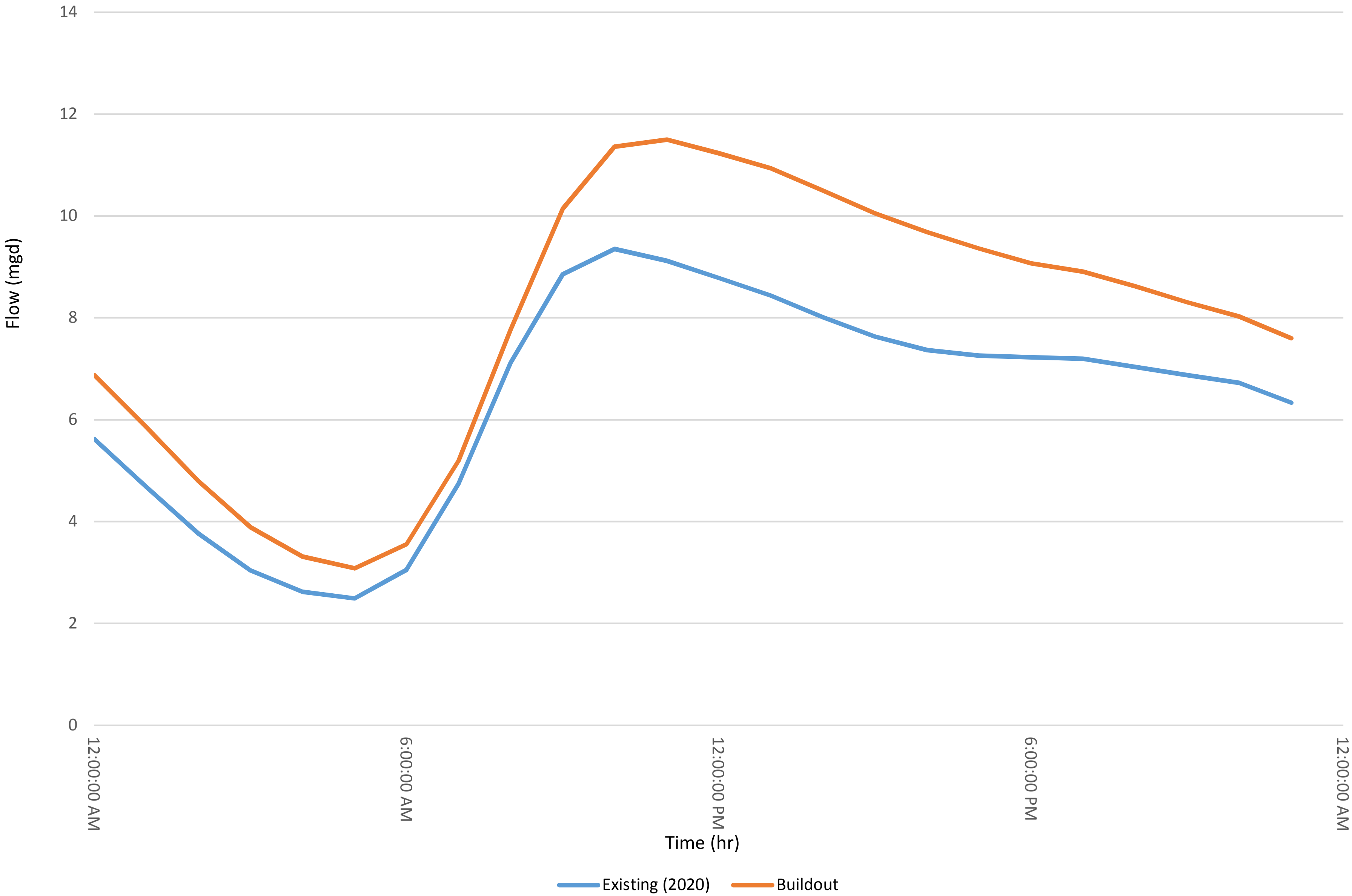
Figure 5. Modeled Existing and Buildout PDWF at Water Reclamation Plant



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ATTACHMENT 1

GIS Gap Analysis

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Table 1. List of Gravity Mains with Unknown Invert Elevation by Priority

GIS Information						Proposed Invert Elevation		Source		Status		Proposed	
ID	PipeID	MhUpstream ID	Upstream Invert Elevation, ft	Mh Downstream ID	Downstream Invert Elevation, ft	Upstream Invert Elevation, ft	Downstream Invert Elevation, ft	Upstream Invert	Downstream Invert	Upstream Invert	Downstream Invert	Upstream Invert Elevation, ft	Downstream Invert Elevation, ft
2138	PPS5F2TP2138	PPS5F2T011B	0.00	PPS5F2T011A	0.00	0.00	0.00	-	-	Unknown	Unknown	522.789	522.765
741	STS3F2TP0741	STS3F2T014	0.00	STS3F2T013	0.00	0.00	0.00	-	-	Unknown	Unknown	487.744	487.552
722	STS3F2TP0722	TICK221	0.00	STS3F2T014	0.00	0.00	0.00	-	-	Unknown	Unknown	487.770	487.744
721	STS3F2TP0721	TICK218	0.00	STS3F2T014	0.00	0.00	0.00	-	-	Unknown	Unknown	487.770	487.744
7072	DTS6E2TP7072	DTS5E3T023A	0.00	DTS5E3T022B	0.00	0.00	0.00	-	-	Unknown	Unknown	477.928	477.782
7071	DTS6E2TP7071	DTS5E3T023B	0.00	DTS5E3T023A	0.00	0.00	0.00	-	-	Unknown	Unknown	477.938	477.928
7066	DTS6E2TP7066	DTS5E3T022B	0.00	DTS5E3T022A	0.00	0.00	0.00	-	-	Unknown	Unknown	477.782	477.670
7644	STS3G2P7644	STS3G2069	0.00	STS3G2068	0.00	0.00	0.00	-	-	Unknown	Unknown	516.659	516.392
7645	STS3G2P7645	STS3G2068	0.00	STS3G2067	0.00	0.00	0.00	-	-	Unknown	Unknown	516.392	516.287
7646	STS3G2P7646	STS3G2067	0.00	STS3G2066	0.00	0.00	0.00	-	-	Unknown	Unknown	516.287	516.017
7641	STS3G2P7641	STS3G2072	0.00	STS3G2077	0.00	0.00	0.00	-	-	Unknown	Unknown	517.222	517.047
7643	STS3G2P7643	STS3G2070	0.00	STS3G2069	0.00	0.00	0.00	-	-	Unknown	Unknown	517.002	516.659
7647	STS3G2P7647	STS3G2066	0.00	STS3G2065	0.00	0.00	0.00	-	-	Unknown	Unknown	516.017	515.749
7648	STS3G2P7648	STS3G2065	0.00	STS3G2064	0.00	0.00	0.00	-	-	Unknown	Unknown	515.749	515.369
3627	EAS6F2P3627	EAS6F2014	0.00	EAS6F2098	0.00	0.00	0.00	-	-	Unknown	Unknown	528.081	527.500
7642	STS3G2P7642	STS3G2077	0.00	STS3G2070	0.00	0.00	0.00	-	-	Unknown	Unknown	517.047	517.002
4015	DTS6E2P4015	DTS6E2042B	0.00	DTS6E2042A	0.00	0.00	0.00	-		Unknown	Unknown	495.322	494.974
4449	DTS6E4P4449	DTS6E4107	0.00	DTS6E4106	0.00	0.00	0.00	-	-	Unknown	Unknown	507.370	506.374
4101	DTS6E4P4101	DTS6E4090	0.00	TICK3564	0.00	0.00	0.00	-	-	Unknown	Unknown	494.752	494.351
2642	ACS5C1P2642	ACS5C1013	0.00	ACS5C1012	0.00	0.00	0.00	-	-	Unknown	Unknown	391.946	391.255
2644	ACS5C1P2644	PRIVATE2131	0.00	ACS5C1013	0.00	0.00	0.00	-	-	Unknown	Unknown	392.271	391.946
4040	DTS6E2P4040	DTS6E2047	0.00	DTS6E2046	0.00	0.00	0.00	-	-	Unknown	Unknown	499.728	499.479
3399	DTS6E1P3399	PRIVATE2878	0.00	DTS6E1078	0.00	0.00	0.00	-	-	Unknown	Unknown	477.789	476.871
6640	DTS6E2P6640	DTS6E2089	0.00	DTS6E2088	0.00	0.00	0.00	-	-	Unknown	Unknown	489.306	489.059
6630	DTS6E2P6630	DTS6E2082	0.00	DTS6E2081	0.00	0.00	0.00	-	-	Unknown	Unknown	488.522	488.040
6629	DTS6E2P6629	DTS6E2091	0.00	DTS6E2090	0.00	0.00	0.00	-	-	Unknown	Unknown	489.714	489.523
6625	DTS6E2P6625	DTS6E2090	0.00	DTS6E2088	0.00	0.00	0.00	-	-	Unknown	Unknown	489.523	489.059
6628	DTS6E2P6628	DTS6E2085	0.00	DTS6E2084	0.00	0.00	0.00	-	-	Unknown	Unknown	488.916	488.715
6648	DTS6E2P6648	DTS6E2084	0.00	DTS6E2081	0.00	0.00	0.00	-	-	Unknown	Unknown	488.715	488.040
4372	DTS6E4P4372	DTS6E4103	0.00	DTS6E4102	0.00	0.00	0.00	-	-	Unknown	Unknown	506.833	506.023
2444	ACS5C1P2444	STUB1943	0.00	ACS5C1001	0.00	0.00	0.00	-	-	Unknown	Unknown	361.704	361.401
4443	DTS6E4P4443	DTS6E4094	0.00	DTS6E4072	0.00	0.00	0.00	-	-	Unknown	Unknown	505.370	504.110
2646	ACS5C1P2646	ACS5C1018	0.00	ACS5C1017	0.00	0.00	0.00	-	-	Unknown	Unknown	393.496	392.866
2649	ACS5C1P2649	PRIVATE2136	0.00	ACS5C1013	0.00	0.00	0.00	-	-	Unknown	Unknown	392.168	391.946
4306	DTS6E4P4306	DTS6E4100	0.00	DTS6E4099	0.00	0.00	0.00	-	-	Unknown	Unknown	504.805	504.050
6639	DTS6E2P6639	DTS6E2088	0.00	DTS6E2087	0.00	0.00	0.00	-	-	Unknown	Unknown	489.059	488.667
4388	DTS6E4P4388	DTS6E4102	0.00	DTS6E4101	0.00	0.00	0.00	-	-	Unknown	Unknown	506.023	505.340
4389	DTS6E4P4389	DTS6E4101	0.00	DTS6E4099	0.00	0.00	0.00	-	-	Unknown	Unknown	505.340	504.050
4328	JLS6E3P4328	JLS6E3065	0.00	JLS6E3064	0.00	0.00	0.00	-	-	Unknown	Unknown	470.894	469.737
3159	DTS6E1P3159	DTS6E1075	0.00	TICK2683	0.00	0.00	0.00	-	-	Unknown	Unknown	475.222	474.596
4472	DTS6E4P4472	DTS6E4108	0.00	DTS6E4107	0.00	0.00	0.00	-	-	Unknown	Unknown	507.679	507.370
4020	DTS6E2P4020	DTS6E2046A	0.00	DTS6E2046	0.00	0.00	0.00	-	-	Unknown	Unknown	499.863	499.479
6649	DTS6E2P6649	DTS6E2087	0.00	DTS6E2086	0.00	0.00	0.00	-	-	Unknown	Unknown	488.667	488.475
6637	DTS6E2P6637	DTS6E2086	0.00	DTS6E2081	0.00	0.00	0.00	-	-	Unknown	Unknown	488.475	488.040
6636	DTS6E2P6636	DTS6E2081	0.00	DTS6E2080	0.00	0.00	0.00	-	-	Unknown	Unknown	488.040	487.735
6635	DTS6E2P6635	DTS6E2080	0.00	DTS6E2079	0.00	0.00	0.00	-	-	Unknown	Unknown	487.735	487.310
6634	DTS6E2P6634	DTS6E2079	0.00	DTS6E2078	0.00	0.00	0.00	-	-	Unknown	Unknown	487.310	486.526
6631	DTS6E2P6631	DTS6E2083	0.00	DTS6E2082	0.00	0.00	0.00	-	-	Unknown	Unknown	488.968	488.522
4410	DTS6E4P4410	DTS6E4106	0.00	DTS6E4094	0.00	0.00	0.00	-	-	Unknown	Unknown	506.374	505.370
4411	DTS6E4P4411	DTS6E4094	0.00	DTS6E4093	0.00	0.00	0.00	-	-	Unknown	Unknown	505.371	504.078
2522	ACS5C1P2522	ACS5C1023	0.00	ACS5C1011	0.00	0.00	0.00	-	-	Unknown	Unknown	390.984	390.660
2387	ACS5C1P2387	ACS5C1014	0.00	ACS5C1010	0.00	0.00	0.00	-	-	Unknown	Unknown	391.240	389.840
2500	ACS5C1P2500	PRIVATE1977	0.00	PRIVATE1999	0.00	0.00	0.00	-	-	Unknown	Unknown	392.909	392.590
2501	ACS5C1P2501	PRIVATE1999	0.00	ACS5C1015	0.00	0.00	0.00	-	-	Unknown	Unknown	392.590	392.216
4334	DTS6E4P4334	DTS6E4099	0.00	DTS6E4093	0.00	0.00	0.00	-	-	Unknown	Unknown	505.325	504.078
2389	ACS5C1P2389	ACS5C1003	0.00	ACS5C1002	0.00	0.00	0.00	-	-	Unknown	Unknown	372.070	370.470
2390	ACS5C1P2390	ACS5C1002	0.00	ACS5C1001	0.00	0.00	0.00	-	-	Unknown	Unknown	370.470	368.470
2391	ACS5C1P2391	ACS5C1010	0.00	ACS5C1009	0.00	0.00	0.00	-	-	Unknown	Unknown	389.740	388.140
2392	ACS5C1P2392	ACS5C1009	0.00	ACS5C1008	0.00	0.00	0.00	-	-	Unknown	Unknown	388.040	383.370
2393	ACS5C1P2393	ACS5C1008	0.00	ACS5C1007	0.00	0.00	0.00	-	-	Unknown	Unknown	383.270	380.770
2536	ACS5C1P2536	PRIVATE2033	0.00	ACS5C1023	0.00	0.00	0.00	-	-	Unknown	Unknown	391.414	390.984
4110	DTS6E2P4110	DTS6E2074	0.00	DTS6E2073	0.00	0.00	0.00	-	-	Unknown	Unknown	486.018	485.373
3554	JLS6D2P3554	JLS6D2083	0.00	JLS6D2082	0.00	0.00	0.00	-	-	Unknown	Unknown	458.400	457.793
3555	JLS6D2P3555	JLS6D2084	0.00	JLS6D2082	0.00	0.00	0.00	-	-	Unknown	Unknown	458.704	457.793
4181	DTS6E4P4181	DTS6E4091	0.00	DTS6E4090	0.00	0.00	0.00	-	-	Unknown	Unknown	499.415	494.752
2566	ACS5C1P2566	ACS5C1012	0.00	ACS5C1023	0.00	0.00	0.00	-	-	Unknown	Unknown	391.255	390.984
2567	ACS5C1P2567	PRIVATE2059	0.00	ACS5C1012	0.00	0.00	0.00	-	-	Unknown	Unknown	391.538	391.255
2569	ACS5C1P2569	ACS5C1017	0.00	ACS5C1015	0.00	0.00	0.00	-	-	Unknown	Unknown	392.866	392.216
2570	ACS5C1P2570	PRIVATE2061	0.00	ACS5C1017	0.00	0.00	0.00	-	-	Unknown	Unknown	393.140	392.866
2475	ACS5C1P2475	PRIVATE1973	0.00	ACS5C1009	0.00	0.00	0.00	-	-	Unknown	Unknown	390.183	389.600
2382	ACS5C1P2382	ACS5C1005	0.00	ACS5C1004	0.00	0.00	0.00	-	-	Unknown	Unknown	376.970	373.770
2383	ACS5C1P2383	ACS5C1006	0.00	ACS5C1005	0.00	0.00	0.00	-	-	Unknown	Unknown	379.070	377.070
2385	ACS5C1P2385	ACS5C1007	0.00	ACS5C1006	0.00	0.00	0.00	-	-	Unknown	Unknown	380.667	379.070
2386	ACS5C1P2386	ACS5C1004	0.00	ACS5C1003	0.00	0.00	0.00	-	-	Unknown	Unknown	373.670	372.070
3570	DTS6E1P3570	DTS6E1081	0.00	DTS6E1080	0.00	0.00	0.00	-	-	Unknown	Unknown	479.813	478.685
3456	JLS6D2P3456	JLS6D2085	0.00	JLS6D2084	0.00	0.00	0.00	-	-	Unknown	Unknown	459.128	458.704
2493	ACS5C1P2493	PRIVATE1989	0.00	ACS5C1011	0.00	0.00	0.00	-	-	Unknown	Unknown	391.122	390.660
2494	ACS5C1P2494	ACS5C1011	0.00	ACS5C1010	0.00	0.00	0.00	-	-	Unknown	Unknown	390.660	389.940
2499	ACS5C1P2499	ACS5C1015	0.00	ACS5C1014	0.00	0.00	0.00	-	-	Unknown	Unknown	392.216	391.440
2502	ACS5C1P2502	PRIVATE2000	0.00	PRIVATE1999	0.00	0.00	0.00	-	-	Unknown	Unknown	392.757	392.590
2504	ACS5C1P2504	PRIVATE2002	0.00	ACS5C1015	0.00	0.00	0.00	-	-	Unknown	Unknown	392.468	392.216
4023	DTS6E2P4023	DTS6E2060	0.00	DTS6E2046	0.00	0.00	0.00	-	-	Unknown	Unknown	501.151	499.479
4307	DTS6E4P4307	DTS6E4099	0.00	DTS6E4098	0.00	0.00	0.00	-	-	Unknown	Unknown	504.050	502.797
4248	DTS6E4P4248	DTS6E4092	0.00	DTS6E4091	0.00	0.00	0.00	-	-	Unknown	Unknown	501.551	499.415
4247	DTS6E4P4247	DTS6E4098	0.00	DTS6E4092	0.00	0.00	0.00	-	-	Unknown	Unknown	502.797	501.551
4335	DTS6E4P4335	DTS6E4093	0.00	DTS6E4092	0.00	0.00	0.00	-	-	Unknown	Unknown	504.078	501.551
4178	DTS6F3P4178	DTS6F3006	0.00	DTS6F3005	0.00	0.00	0.00	-	-	Unknown	Unknown	503.807	503.008
4146	DTS6F3P4146	DTS6F3005	0.00	DTS6F3003	0.00	0.00	0.00	-	-	Unknown	Unknown	503.008	501.708
4017	DTS6E2P4017	DTS6E2042A	0.00	DTS6E2042	0.00	0.00	0.00	-	-	Unknown	Unknown	494.974	494.686
3282	DTS6E1P3282	DTS6E1076	0.00	TICK2703	0.00	0.00	0.00	-	-	Unknown	Unknown	475.730	474.609
3400	DTS6E1P3400	DTS6E1078	0.00	DTS6E1076	0.00	0.00	0.00	-	-	Unknown	Unknown	476.871	475.730
3281	DTS6E1P3281	DTS6E1077	0.00	DTS6E1076	0.00	0.00	0.00	-	-	Unknown	Unknown	476.364	475.730
4634	DTS7F1P4634	DTS7F1032	0.00	DTS7F1031	0.00	0.00	0.00	-	-	Unknown	Unknown	521.872	521.573
4639	DTS7F1P4639	DTS7F1034	0.00	DTS7F1033	0.00	0.00	0.00	-	-	Unknown	Unknown	523.910	522.729
4635	DTS7F1P4635	DTS7F1033	0.00	DTS7F1031	0.00	0.00	0.00	-	-	Unknown	Unknown	522.729	521.573
4509	DTS6E4P4509	DTS6E4076	0.00	DTS6E4075	0.00	0.00	0.00	-	-	Unknown	Unknown	514.957	514.546
4505	DTS6E4P4505	DTS6E4073	0.00	DTS6E4072	0.00	0.00	0.00	-	-	Unknown	Unknown	505.069	504.110
4507	DTS6E4P4507	DTS6E4074	0.00	DTS6E4073	0.00	0.00	0.00	-	-	Unknown	Unknown	513.486	512.424
4508	DTS6E4P4508	DTS6E4075	0.00	DTS6E4074	0.00	0.00	0.00	-	-	Unknown	Unknown	514.546	513.486
3344	DTS6E1P3344	DTS6E1011	0.00	TICK2860	0.00	0.00	0.00	-	-	Unknown	Unknown	463.878	463.173
6040	DTS6E2P6040	DTS6E2064	0.00	DTS6E2052	0.00	0.00	0.00	-	-	Unknown	Unknown	493.335	492.429
1827	STS4E4P1827	STS4E3060	0.00	STS4E3059	0.00	0.00	0.00	-	-	Unknown	Unknown	440.910	440.296
6170	PPS4G3P6170	PPS4G3058	0.00	PPS4G3057	0.00	0.00	0.00	-	-	Unknown	Unknown	519.708	518.655
6748	JLS6E3P6748	JLS6E3030B	0.00	JLS6E3030A	0.00	0.00	0.00	-	-	Unknown	Unknown	459.341	458.890
4308	JLS6E3P4308	JLS6E3041A	0.00	JLS6E3041	0.00	0.00	0.00	-	-	Unknown	Unknown	462.153	462.083
1860	STS4E4P1860	STS4E3060A	0.00	STS4E3060	0.00	0.00	0.00	-	-	Unknown	Unknown	441.458	440.910
1774	STS4E4P1774	STS4E3057	0.00	STS4E3056	0.00	0.00	0.00	-	-	Unknown	Unknown	439.519	438.978
686	STS2G2P0686	STS2G2020	0.00	STS2G2019	0.00	0.00	0.00	-	-	Unknown	Unknown	514.643	514.196
2341	JLS5D2P2341	JLS5D2101	0.00	JLS5D2100	0.00	0.00	0.00	-	-	Unknown	Unknown	447.182	446.655
6050	PPS5G1P6050	PPS5G1044	0.00	PPS5G1043	0.00	0.00	0.00	-	-	Unknown	Unknown	517.794	517.075
684	STS2G2P0684	STS2G2021	0.00	STS2G2019	0.00	0.00	0.00	-	-	Unknown	Unknown	515.255	514.196
2471	JLS4E3P2471	JLS4E3022	0.00	JLS4E3021	0.00	0.00	0.00	-	-	Unknown	Unknown	450.885	450.427
446	PPS5G1P0446	PPS5G117C	0.00	PPS5G1017B	0.00	0.00	0.00	-	-	Unknown	Unknown	523.475	523.201
644	JLS5D1P0644	JLS5D1029	0.00	JLS5D1028	0.00	0.00	0.00	-	-	Unknown	Unknown	420.032	419.522
1493	PPS4H1P1493	PPS4H1028	0.00	PPS4H1027	0.00	0.00	0.00	-	-	Unknown	Unknown	532.535	531.512
4475	DTS6E4P4475	DTS6E4021	0.00	DTS6E4020	0.00	0.00	0.00	-	-	Unknown	Unknown	482.410	481.872
5250	ECS7E4P5250	ECS7E4023	0.00	ECS7E4022	0.00	0.00	0.00	-	-	Unknown	Unknown	524.347	523.504
394	JLS5D1P0394	JLS5D1028	0.00	JLS5D1026	0.00	0.00	0.00	-	-	Unknown	Unknown	419.522	418.681
5018	ECS7E2P5018	ECS7E2034	0.00	ECS7E2033	0.00	0.00	0.00	-	-	Unknown	Unknown	540.906	540.286
4975	ECS7E2P4975	ECS7E2037	0.00	ECS7E2035	0.00	0.00	0.00	-	-	Unknown	Unknown	540.473	539.721
1448	PPS4H1P1448	PPS4H1029	0.00	PPS4H1028	0.00	0.00	0.00	-	-	Unknown	Unknown	533.393	532.535
642	JLS5D1P0642	JLS5D1027	0.00	JLS5D1026	0.00	0.00	0.00	-	-	Unknown	Unknown	419.193	418.681
2451	JLS5D2P2451	JLS5D2099	0.00	JLS5D2098	0.00	0.00	0.00	-	-	Unknown	Unknown	447.059	445.957
2452	JLS5D2P2452	JLS5D2100	0.00	JLS5D2098	0.00	0.00	0.00	-	-	Unknown	Unknown	446.655	445.957
395	JLS5D1P0395	JLS5D1030	0.00	JLS5D1028	0.00	0.00	0.00	-	-	Unknown	Unknown	420.026	419.522
388	JLS5D1P0388	JLS5D1022	0.00	JLS5D1020	0.00	0.00	0.00	-	-	Unknown	Unknown	416.943	416.086
6633	DTS6E2P6633	DTS6E2078	0.00	DTS6E2077	0.00	0.00	0.00	-	-	Unknown	Unknown	486.526	486.437
2694	DTS6E1P2694	STUB2189	0.00	DTS6E1035A	0.00	0.00	0.00	-	-	Unknown	Unknown	466.281	465.996
636	JLS5D1P0636	JLS5D1021	0.00	JLS5D1020	0.00	0.00	0.00	-	-	Unknown	Unknown	416.594	416.086
637	JLS5D1P0637	JLS5D1023	0.00	JLS5D1022	0.00	0.00	0.00	-	-	Unknown	Unknown	417.452	416.943
2573	PPS5G2P2573	PPS5G2006	0.00	PPS5G2005	0.00	0.00	0.00	-	-	Unknown	Unknown	542.358	537.236
5004	ECS7E2P5004	ECS7E2035	0.00	ECS7E2030	0.00	0.00	0.00	-	-	Unknown	Unknown	539.721	539.332
5006	ECS7E2P5006	ECS7E2032	0.00	ECS7E2031	0.00	0.00	0.00	-	-	Unknown	Unknown	540.523	540.050
5007	ECS7E2P5007	ECS7E2031	0.00	ECS7E2030	0.00	0.00	0.00	-	-	Unknown	Unknown	540.050	539.332
5014	ECS7E2P5014	ECS7E2033	0.00	ECS7E2031	0.00	0.00	0.00	-	-	Unknown	Unknown	540.286	540.050
4976	ECS7E2P4976	ECS7E2036	0.00	ECS7E2035	0.00	0.00	0.00	-	-	Unknown	Unknown	540.284	539.721
1802	STS4E4P1802	STS4E3059	0.00	STS4E3058	0.00	0.00	0.00	-	-	Unknown	Unknown	440.296	440.090
444	JLS5D3P0444	JLS5D3069	0.00	JLS5D3068	0.00	0.00	0.00	-	-	Unknown	Unknown	418.158	417.251
549	ECS7E3P549	ECS7E3126	0.00	ECS7E3125	0.00	0.00	0.00	-	-	Unknown	Unknown	527.955	528.030
3802	JLS6D2P3802	JLS6D2094	0.00	JLS6D2093	0.00	0.00	0.00	-	-	Unknown	Unknown	452.961	452.689
2374	JLS5D2P2374	JLS5D2096	0.00	JLS5D2094	0.00	0.00	0.00	-	-	Unknown	Unknown	445.044	444.841
2384	JLS5D2P2384	JLS5D2095	0.00	JLS5D2094	0.00	0.00	0.00	-	-	Unknown	Unknown	445.308	444.841
3973	PPS6G2P3973	PPS6G2060A	0.00	PPS6G2060	0.00	0.00	0.00	-	-	Unknown	Unknown	569.084	568.978
2325	JLS5D2P2325	JLS5D2102	0.00	JLS5D2101	0.00	0.00	0.00	-	-	Unknown	Unknown	447.591	447.182
385	JLS5C2P0385	JLS5C2075	0.00	JLS5C2074	0.00	0.00	0.00	-	-	Unknown	Unknown	402.436	401.678
387	JLS5D1P0387	JLS5D1020	0.00	JLS5D1019	0.00	0.00	0.00	-	-	Unknown	Unknown	416.086	404.443
7377	JLS6E3P7377	JLS6E3033A	0.00	JLS6E3033	0.00	0.00	0.00	-	-	Unknown	Unknown	462.195	462.097
2508	JLS4E3P2508	JLS4E3021	0.00	JLS4E3020	0.00	0.00	0.00	-	-	Unknown	Unknown	450.427	449.862
5479	ECS7E3P5479	ECS7E3074	0.00	ECS7E3073	0.00	0.00	0.00	-	-	Unknown	Unknown	523.787	502.373
1799	STS4E4P1799	STS4E3058	0.00	STS4E3057	0.00	0.00	0.00	-	-	Unknown	Unknown	440.090	439.519
3947	PPS6G2P3947	PPS6G2064	0.00	PPS6G2063	0.00	0.00	0.00	-	-	Unknown	Unknown	571.660	570.521
550	ECS7E3P0550	ECS7E3127	0.00	ECS7E3126	0.00	0.00	0.00	-	-	Unknown	Unknown	528.524	527.955
2845	DTS5E3P2845	DTS5E3068	0.00	DTS5E3067	0.00	0.00	0.00	-	-	Unknown	Unknown	474.307	474.401
7512	ECS7E2P7512	ECS7E2039	0.00	ECS7E2038	0.00	0.00	0.00	-	-	Unknown	Unknown	540.234	539.637
7514	ECS7E2P7514	ECS7E2040	0.00	ECS7E2039	0.00	0.00	0.00	-	-	Unknown	Unknown	540.281	540.234
7515	ECS7E2P7515	ECS7E2042	0.00	ECS7E2041	0.00	0.00	0.00	-	-	Unknown	Unknown	540.391	540.299

Table 1. List of Gravity Mains with Unknown Invert Elevation by Priority

GIS Information						Proposed Invert Elevation		Source		Status		Proposed	
ID	PipeID	MhUpstream ID	Upstream Invert Elevation, ft	Mh Downstream ID	Downstream Invert Elevation, ft	Upstream Invert Elevation, ft	Downstream Invert Elevation, ft	Upstream Invert	Downstream Invert	Upstream Invert	Downstream Invert	Upstream Invert Elevation, ft	Downstream Invert Elevation, ft
7452	STS2H3P7452	STS2H3034B	0.00	STS2H3034A	0.00	0.00	0.00	-	-	Unknown	Unknown	521.856	521.434
742	STS3F2TP0742	STS3F2T022	0.00	STS3F2T013	0.00	0.00	0.00	-	-	Unknown	Unknown	487.982	487.552
7511	ECS7E2P7511	ECS7E2038	0.00	ECS7E2030	0.00	0.00	0.00	-	-	Unknown	Unknown	539.637	539.332
7513	ECS7E2P7513	ECS7E2041	0.00	ECS7E2040	0.00	0.00	0.00	-	-	Unknown	Unknown	540.299	540.281
7561	RHS8D4P7561	RHS8D4101	0.00	RHS8D4005A	0.00	0.00	0.00	-	-	Unknown	Unknown	439.317	438.779
7562	RHS8D4P7562	RHS8D4102	0.00	RHS8D4101	0.00	0.00	0.00	-	-	Unknown	Unknown	440.132	439.317
445	JLS5D3P0445	JLS5D3083A	0.00	JLS5D3083	0.00	0.00	0.00	-	-	Unknown	Unknown	410.297	409.739
7635	ACS2C4P7635	ACS4C4010A	0.00	ACS4C4008A	0.00	0.00	0.00	-	-	Unknown	Unknown	374.098	372.786
1504	STS3F4P1504	STS3F4102	0.00	STS3F4099	0.00	0.00	0.00	-	-	Unknown	Unknown	501.884	501.027
7610	JLS5D2P7610	JLS5D2100A	0.00	JLS5D2100	0.00	0.00	0.00	-	-	Unknown	Unknown	446.790	446.655
7612	JLS5D2P7612	JLS5D2082A	0.00	JLS5D2082	0.00	0.00	0.00	-	-	Unknown	Unknown	454.090	453.920
7625	STS2H3P7625	STS2H3057C	0.00	STS2H3057B	0.00	0.00	0.00	-	-	Unknown	Unknown	529.639	529.330
6065	DTS5E3P6065	DTS5E3054	0.00	DTS5E3050	0.00	0.00	0.00	-	-	Unknown	Unknown	504.145	504.057
7385	DTS5E3P7385	DTS5E3050	0.00	DTS5E3049	0.00	0.00	0.00	-	-	Unknown	Unknown	504.057	499.405
2866	DTS5E3P2866	STUB2368	0.00	DTS5E3052	0.00	0.00	0.00	-	-	Unknown	Unknown	506.867	506.830
3848	EAS6F1P3848	EAS6F1099	0.00	EAS6F1098	0.00	0.00	0.00	-	-	Unknown	Unknown	522.880	516.366
4910	ECS7D2P4910	ECS7D2063A	0.00	ECS7D2063	0.00	0.00	0.00	-	-	Unknown	Unknown	443.763	443.390
4929	ECS7D2P4929	ECS7D2065	0.00	ECS7D2063A	0.00	0.00	0.00	-	-	Unknown	Unknown	445.810	444.851
4638	DTS7F1P4638	DTS7F1035	0.00	DTS7F1034	0.00	0.00	0.00	-	-	Unknown	Unknown	524.355	523.910
7609	ECS7D2P7609	ECS7D2098	0.00	ECS7D2098A	0.00	0.00	0.00	-	-	Unknown	Unknown	470.986	470.319
7828	ACS4D1P7828	STUB7598	0.00	ACS4D1128	0.00	0.00	0.00	-	-	Unknown	Unknown	428.583	428.410
7818	ACS4D1P7818	STUB7596	0.00	ACS4D1149	0.00	0.00	0.00	-	-	Unknown	Unknown	436.666	436.539
7804	ACS4D1P7804	STUB7597	0.00	ACS4D1150	0.00	0.00	0.00	-	-	Unknown	Unknown	436.962	436.852
7805	ACS4D1P7805	STUB7587	0.00	ACS4D1171	0.00	0.00	0.00	-	-	Unknown	Unknown	438.826	438.492
7811	ACS4D1P7811	ACS4D1171	0.00	ACS4D1170	0.00	0.00	0.00	-	-	Unknown	Unknown	438.492	438.200
7813	ACS4D1P7813	ACS4D1151	0.00	ACS4D1150	0.00	0.00	0.00	-	-	Unknown	Unknown	437.465	436.852
7679	STS2G3P7679	STS2G3034	0.00	STS2G3033	0.00	0.00	0.00	-	-	Unknown	Unknown	508.186	507.970
7678	STS2G3P7678	STS2G3032	0.00	STS2G3026	0.00	0.00	0.00	-	-	Unknown	Unknown	507.551	507.000
7680	STS2G3P7680	STS2G3033	0.00	STS2G3032	0.00	0.00	0.00	-	-	Unknown	Unknown	507.970	507.551
7681	ACS4C2P7681	ACS4C2026B	0.00	ACS4C2026A	0.00	0.00	0.00	-	-	Unknown	Unknown	455.524	454.927
548	ECS7E3P548	ECS7E3125	0.00	ECS7E3124	0.00	0.00	0.00	-	-	Unknown	Unknown	527.930	527.490
547	ECS7E3P547	ECS7E3124	0.00	ECS7E3123	0.00	0.00	0.00	-	-	Unknown	Unknown	527.390	526.597
551	ECS7E3P0551	TICK5829	0.00	ECS7E3124	0.00	0.00	0.00	-	-	Unknown	Unknown	527.550	527.490
7827	ACS4D1P7827	STUB7599	0.00	ACS4D1128	0.00	0.00	0.00	-	-	Unknown	Unknown	428.476	428.410
7831	ACS4D1P7831	ACS4D1128	0.00	ACS4D1127	0.00	0.00	0.00	-	-	Unknown	Unknown	428.410	428.314
7816	ACS4D1P7816	ACS4D1150	0.00	ACS4D1149	0.00	0.00	0.00	-	-	Unknown	Unknown	436.852	436.539
7806	ACS4D1P7806	ACS4D1149	0.00	ACS4D1148	0.00	0.00	0.00	-	-	Unknown	Unknown	436.539	436.154
6108	STS4E4TP6108	TICK5955	0.00	STS4E4T008	448.88	0.00	448.88	-	GIS	Unknown	-	448.899	448.880
5151	ECS7E3P5151	ECS7E3014	0.00	ECS7E3013	497.90	0.00	497.90	-	GIS	Unknown	-	498.381	497.900
5152	ECS7E3P5152	ECS7E3022	0.00	ECS7E3021	496.15	0.00	496.15	-	GIS	Unknown	-	496.739	496.150
2178	PPS5F2TP2178	PPS5F2T011A	0.00	PPS5F2T011	0.00	0.00	522.58	-	Model	Unknown	-	522.765	522.580
745	STS2F4P0745	STUB243	0.00	STS2F4021	479.32	0.00	479.32	-	GIS	Unknown	-	479.419	479.320
1295	STS3F4P1295	STS3F4064A	0.00	STS3F4064	494.58	0.00	494.58	-	GIS	Unknown	-	494.746	494.580
281	ACS4C2P0281	STUB5560	0.00	ACS4C2051	405.36	0.00	405.36	-	GIS	Unknown	-	405.448	405.360
1066	PPS3H4P1066	TICK567	0.00	PPS3H4048	568.79	0.00	568.79	-	GIS	Unknown	-	568.894	568.790
6746	JLS6E3P6746	JLS6E3036A	0.00	JLS6E3036B	0.00	460.75	0.00	Interpolate	-	Need Confirmation	Unknown	460.750	459.790
6745	JLS6E3P6745	JLS6E3036B	0.00	JLS6E3026A	0.00	0.00	457.02	-	Model	Unknown	-	457.625	457.022
860	STS2G4P0860	STS2G4039	0.00	STS2G4037	517.00	0.00	517.00	-	GIS	Unknown	-	517.753	517.000
2803	DTS5E3P2803	DTS5E3020	0.00	DTS5E3019	508.00	0.00	508.00	-	GIS	Unknown	-	509.010	508.000
5206	ECS7E4P5206	ECS7E4022	0.00	ECS7E4021	522.44	0.00	522.44	-	GIS	Unknown	-	523.504	522.440
272	ACS4C2P0272	ACS4C2010	0.00	ACS4C2009	414.38	0.00	414.38	-	GIS	Unknown	-	414.710	414.380
3726	JLS6D2P3726	JLS6D2086	0.00	JLS6D2081	456.60	0.00	456.60	-	GIS	Unknown	-	458.012	456.600
2595	JLS5D2P2595	JLS5D2106	0.00	JLS5D2103	450.73	0.00	450.73	-	GIS	Unknown	-	451.154	450.730
5126	ECS7D4P5126	ECS7D4043	0.00	ECS7D4042	469.21	0.00	469.21	-	GIS	Unknown	-	469.654	469.210
2525	PPS5G2P2525	PPS5G2039	0.00	PPS5G2038	546.00	0.00	546.00	-	GIS	Unknown	-	546.434	546.000
1924	PPS4F4P1924	PPS4F4002	0.00	PPS4F4001	515.99	0.00	515.99	-	GIS	Unknown	-	516.478	515.990
5255	ECS7E3P5255	ECS7E3064	0.00	ECS7E3063	502.08	0.00	502.08	-	GIS	Unknown	-	502.712	502.080
3421	JLS5D3P3421	JLS5D3022	0.00	JLS5D3021	426.31	0.00	426.31	-	GIS	Unknown	-	426.905	426.310
1006	STS2G3P1006	STS2G3018	0.00	STS2G3013	499.30	0.00	499.30	-	GIS	Unknown	-	500.058	499.300
6225	PPS3H4P6225	STUB6090	0.00	PPS3H4047	581.08	0.00	581.08	-	GIS	Unknown	-	581.337	581.080
5934	DTS5E3P5934	DTS5E3082	0.00	DTS5E3006	475.90	0.00	475.90	-	GIS	Unknown	-	477.396	475.900
1908	PPS4F4P1908	PPS4F4003	521.20	PPS4F4002	0.00	521.20	0.00	GIS	-	-	Unknown	521.200	521.038
1909	PPS4F4P1909	PPS4F4006	525.21	PPS4F4002	0.00	525.21	0.00	GIS	-	-	Unknown	525.210	525.040
2248	JLS5C2P2248	TICK1742	0.00	JLS5C2033	403.33	0.00	403.33	-	GIS	Unknown	-	403.431	403.330
4296	JLS6E3P4296	PRIVATE3807	0.00	JLS6E3039	462.42	0.00	462.42	-	GIS	Unknown	-	462.775	462.420
4304	JLS6E3P4304	JLS6E3041	0.00	JLS6E3037	461.61	0.00	461.61	-	GIS	Unknown	-	462.083	461.610
4365	DTS6E4P4365	DTS6E4043	0.00	DTS6E4042	492.04	0.00	492.04	-	GIS	Unknown	-	492.484	492.040
4250	JLS6E3P4250	JLS6E3036	0.00	JLS6E3036A	460.75	0.00	460.75	-	GIS	Unknown	-	461.365	460.750
638	JLS5D1P0638	JLS5D1025	0.00	JLS5D1024	417.80	0.00	417.80	-	GIS	Unknown	-	418.757	417.800
2710	JLS5D2P2710	JLS5D2031	0.00	JLS5D2030	438.17	0.00	438.17	-	GIS	Unknown	-	438.750	438.170
2712	JLS5D2P2712	JLS5D2081	0.00	JLS5D2079	452.42	0.00	452.42	-	GIS	Unknown	-	452.897	452.420
1487	STS3F4P1487	STS3F4098	500.37	STS3F4097	0.00	500.37	0.00	GIS	-	-	Unknown	500.370	500.083
3667	JLS6D2P3667	JLS6D2042	0.00	JLS6D2041	449.50	0.00	449.50	-	GIS	Unknown	-	449.657	449.500
3451	JLS6D1P3451	JLS6D1062	0.00	JLS6D1061	415.54	0.00	415.54	-	GIS	Unknown	-	416.046	415.540
5288	ECS7E3P5288	ECS7E3052	0.00	ECS7E3051	522.81	0.00	522.81	-	GIS	Unknown	-	523.230	522.810
5289	ECS7E3P5289	ECS7E3047	0.00	ECS7E3046	525.93	0.00	525.93	-	GIS	Unknown	-	526.375	525.930
2152	DTS5E2P2152	STUB1619	0.00	DTS5E2007	476.70	0.00	476.70	-	GIS	Unknown	-	477.131	476.700
137	ACS4C4P0137	STUB5916	0.00	ACS4C4055	389.33	0.00	389.33	-	GIS	Unknown	-	389.587	389.330
3138	JLS5D3P3138	JLS5D3110	0.00	JLS5D3109	420.00	0.00	420.00	-	GIS	Unknown	-	420.234	420.000
690	STS2G2P0690	STS2G2029	0.00	STS2G2028	509.25	0.00	509.25	-	GIS	Unknown	-	509.573	509.250
691	STS2G2P0691	TICK190	0.00	STS2G2028	509.25	0.00	509.25	-	GIS	Unknown	-	509.762	509.250
5822	ECS8E1P5822	ECS8E1054	0.00	ECS8E1053	476.99	0.00	476.99	-	GIS	Unknown	-	477.497	476.990
4474	DTS6E4P4474	DTS6E4026	0.00	DTS6E4025	485.20	0.00	485.20	-	GIS	Unknown	-	485.928	485.200
2489	PPS5G3P2489	PPS5G3013	0.00	PPS5G3011	527.80	0.00	527.80	-	GIS	Unknown	-	528.641	527.800
1059	STS3G2P1059	STS3G2058	0.00	STS3G2009	510.85	0.00	510.85	-	GIS	Unknown	-	511.253	510.850
5132	RHS7D3P5132	ECS7D3T004A	0.00	ECS7D3T004	436.79	0.00	436.79	-	GIS	Unknown	-	437.274	436.790
3404	EAS6F1P3404	EAS6F1061	0.00	EAS6F1060	517.90	0.00	517.90	-	GIS	Unknown	-	518.179	517.900
3415	PPS6G2P3415	PPS6G2004	0.00	PPS6G2003	551.04	0.00	551.04	-	GIS	Unknown	-	551.884	551.040
4416	DTS6E4P4416	DTS6E4055	0.00	DTS6E4054	498.52	0.00	498.52	-	GIS	Unknown	-	499.161	498.520
4419	EAS6F4P4419	EAS6F4027	0.00	EAS6F4026	0.00	0.00	537.20	-	Model	Unknown	-	538.618	537.200
4421	JLS6E3P4421	JLS6E3053	0.00	JLS6E3052	471.40	0.00	471.40	-	GIS	Unknown	-	472.243	471.400
4429	JLS6E3P4429	JLS6E3058	468.50	JLS6E3044	0.00	468.50	0.00	GIS	-	-	Unknown	468.500	467.123
1428	STS3G3P1428	STS3G3037	0.00	STS3G3036	506.53	0.00	506.53	-	GIS	Unknown	-	507.111	506.530
3951	DTS6E2P3951	DTS6E2026	0.00	DTS6E2025	488.04	0.00	488.04	-	GIS	Unknown	-	488.532	488.040
3953	EAS6F1P3953	EAS6F1110	0.00	EAS6F1109	525.20	0.00	525.20	-	GIS	Unknown	-	525.702	525.200
5316	ECS7E3P5316	ECS7E3096	0.00	ECS7E3095	521.55	0.00	521.55	-	GIS	Unknown	-	522.005	521.550
5319	ECS7E3P5319	ECS7E3069	0.00	ECS7E3068	500.99	0.00	500.99	-	GIS	Unknown	-	501.679	500.990
6198	EAS6G4P6198	EAS6D4085	0.00	EAS6G4084	580.30	0.00	580.30	-	GIS	Unknown	-	581.467	580.300
4358	EAS6F4P4358	EAS6F4065	0.00	EAS6F4063	542.65	0.00	542.65	-	GIS	Unknown	-	543.117	542.650
3458	JLS5D3P3458	JLS5D3092	0.00	JLS5D3091	419.38	0.00	419.38	-	GIS	Unknown	-	419.703	419.380
283	ACS4C2P0283	TICK5565	0.00	ACS4C2028	413.59	0.00	413.59	-	GIS	Unknown	-	413.629	413.590
285	ACS4C2P0285	STUB5564	0.00	ACS4C2028	413.59	0.00	413.59	-	GIS	Unknown	-	413.846	413.590
4385	EAS6F4P4385	EAS6F4072P	0.00	EAS6F4072	553.02	0.00	553.02	-	GIS	Unknown	-	553.508	553.020
4013	PPS6G2P4013	PPS6G2068	0.00	PPS6G2067	572.22	0.00	572.22	-	GIS	Unknown	-	573.069	572.220
4911	ECS7E1P4911	ECS7E1035	0.00	ECS7E1034	491.02	0.00	491.02	-	GIS	Unknown	-	491.588	491.020
3169	DTS6E1P3169	DTS6E1057	0.00	DTS6E1056	463.60	0.00	463.60	-	GIS	Unknown	-	464.392	463.600
5848	ECS8E1P5848	ECS8E1077	0.00	ECS8E1076	492.70	0.00	492.70	-	GIS	Unknown	-	493.202	492.700
305	PPS4H4P0305	PPS4H4053	580.00	PPS4H4052	0.00	580.00	0.00	GIS	-	-	Unknown	580.000	579.416
5579	ECS8E2P5579	ECS8E2022	0.00	ECS8E2021	543.45	0.00	543.45	-	GIS	Unknown	-	543.599	543.450
2623	PPS5G2P2623	PPS5G2007	543.17	PPS5G2006	0.00	543.17	0.00	GIS	-	-	Unknown	543.170	542.358
6121	PPS4G3P6121	PPS4G3063	0.00	PPS4G3062	514.10	0.00	514.10	-	GIS	Unknown	-	514.199	514.100
3396	PPS6G2P3396	PPS6G2010	0.00	PPS6G2008	553.10	0.00	553.10	-	GIS	Unknown	-	553.526	553.100
685	STS2G2P0685	STS2G2019	0.00	STS2G2017	0.00	0.00	513.42	-	Model	Unknown	-	514.196	513.320
4154	JLS6E3P4154	PRIVATE3628	0.00	JLS6E3010	449.45	0.00	449.45	-	GIS	Unknown	-	450.190	449.450
4344	JLS6E3P4344	JLS6E3044	0.00	JLS6E3043	0.00	0.00	464.73	-	Model	Unknown	-	464.913	464.730
4350	JLS6E3P4350	JLS6E3064	0.00	JLS6E3046	0.00	0.00	468.61	-	Model	Unknown	-	469.737	468.610
817	STS2F4P0817	STS2F4008	0.00	STS2F4007	492.39	0.00	492.39	-	GIS	Unknown	-	493.098	492.390
2240	JLS5D1P2240	JLS5D1015	0.00	JLS5D1014	421.13	0.00	421.13	-	GIS	Unknown	-	421.637	421.130
1640	PPS4H4P1640	PPS4H4051	0.00	PPS4H4050	585.10	0.00	585.10	-	GIS	Unknown	-	585.597	585.100
2129	JLS5D1P2129	JLS5D1086	0.00	JLS5D1085	425.80	0.00	425.80	-	GIS	Unknown	-	426.527	425.800
3894	PPS6G2P3894	PPS6G2052A	0.00	PPS6G2052	562.62	0.00	562.62	-	GIS	Unknown	-	562.827	562.620
3581	DTS6E2P3581	DTS6E2049	0.00	DTS6E2038	488.05	0.00	488.05	-	GIS	Unknown	-	488.993	488.050
2811	DTS5E3P2811	DTS5E3069	474.42	DTS5E3068	0.00	474.42	0.00	GIS	-	-	Unknown	474.420	474.307
4969	RHS7D3P4969	RHS7D3047	0.00	RHS7D3046	417.24	0.00	417.24	-	GIS	Unknown	-	417.892	417.240
2695	DTS6E1P2695	DTS6E1036	470.65	DTS6E1035A	0.00	470.65	0.00	GIS	-	-	Unknown	470.650	470.169
3269	PPS5G4P3269	PPS5G4016	0.00	PPS5G4015	566.68	0.00	566.68	-	GIS	Unknown	-	567.566	566.680
1891	JLS4E3P1891	JLS4E3003	0.00	JLS4E3002	434.52	0.00	434.52	-	GIS	Unknown	-	435.090	434.520
4830	ECS7D2P4830	ECS7D2022	0.00	ECS7D2021	454.83	0.00	454.83	-	GIS	Unknown	-	455.226	454.830
2144	JLS5D1P2144	JLS5D1018	0.00	JLS5D1017	423.73	0.00	423.73	-	GIS	Unknown	-	424.109	423.730
4274	JLS6E3P4274	PRIVATE3756	0.00	JLS6E3039	462.42	0.00	462.42	-	GIS	Unknown	-	462.790	462.420
4709	DTS6F3P4709	PRIVATE4203	0.00	DTS6F3034	530.37	0.00	530.37	-	GIS	Unknown	-	530.500	530.370
4710	DTS6F3P4710	PRIVATE4204	0.00	DTS6F3035	530.83	0.00	530.83	-	GIS	Unknown	-	531.020	530.830
4957	ECS7D2P4957	ECS7D2071	0.00	ECS7D1T010	434.69	0.00	434.69	-	GIS	Unknown	-	435.283	434.690
4959	ECS7E1P4959	STUB4452	0.00	ECS7E1098	507.17	0.00	507.17	-	GIS	Unknown	-	507.257	507.170
4960	ECS7D2P4960	ECS7D2024	0.00	ECS7D2023	456.64	0.00	456.64	-	GIS	Unknown	-	457.437	456.640
1700	ACS4C4P1700	ACS4C4056	0.00	ACS4C4037	396.80	0.00	396.80	-	GIS	Unknown	-	396.930	396.800
422	JLS5C2P0422	JLS5C2065	0.00	JLS5C2056	0.00	0.00	405.40	-	Model	Unknown	-	406.565	405.400
2842	PPS5G2P2842	PPS5G2048	0.00	PPS5G2047	558.91	0.00	558.91	-	GIS	Unknown	-	559.148	558.910
5312	ECS7E3P5312	ECS7E3041	0.00	ECS7E3040	525.71	0.00	525.71	-	GIS	Unknown	-	526.558	525.710
4447	EAS6F4P4447	EAS6F4025	0.00	EAS6F4024	539.62	0.00	539.62	-	GIS	Unknown	-	540.191	539.620
2671	DTS5E3P2671	DTS5E3096	0.00	DTS5E3094	512.00	0.00	512.00	-	GIS	Unknown	-	512.372	512.000
2672	DTS5E3P2672	DTS5E3095	0.00	DTS5E3094	512.00	0.00	512.00	-	GIS	Unknown	-	512.305	512.000
2674	JLS5D2P2674	JLS5D2082	0.00	JLS5D2079	452.42	0.00	452.42	-	GIS	Unknown	-	453.920	452.420
2675	JLS5D2P2675	JLS5D2080	0.00	JLS5D2079	452.42	0.00	452.42	-	GIS	Unknown	-	452.976	452.420
2396	PPS5G3P2396	PPS5G3012	0.00	PPS5G3011	527.80	0.00	527.80	-	GIS	Unknown	-	528.398	527.800
2397	PPS5G3P2397	PPS5G3011	527.80	PPS5G3010	0.00	527.80	0.00	GIS	-	-	Unknown	527.800	527.319
3920	PPS6G2P3920	PPS6G2069	573.27	PPS6G2068	0.00	573.27	0.00	GIS	-	-	Unknown	573.270	572.423
2007	JLS5D1P2007	JLS5D1103	0.00	JLS5D1102	425.28	0.00	425.28	-	GIS	Unknown	-	425.853	425.280
5497	ECS7E3P5497	ECS7E3075	524.44	ECS7E3074	0.00	524.44	0.00	GIS	-	-	Unknown	524.440	523.787
6710	DTS6E1P6710	DTS6E1080	0.00	DTS6E1T025	478.64	0.00	478.64	-	GIS	Unknown	-	478.685	478.640
4229	JLS6E3P4229	JLS6E3033	0.00	JLS6E3032	0.00	0.00	461.26	-	Model	Unknown	-	462.097	461.260
1580	STS3G3P1580	STS3G3054A	0.00	STS3G3054	508.56	0.00	508.56	-	GIS	Unknown	-	508.762	508.560
1277	STS3F4P1277	STS3F4020	496.70	STS3F4019	0.00	496.70	0.00	GIS	-	-	Unknown	496.700	496.075
1278	STS3F4P1278	STS3F4019	0.00	STS3F4018	491.73	0.00	491.73	-	GIS	Unknown	-	492.198	491.730
5960	DTS5E3P5960	DTS5E3004	0.00	DTS5E3002	472.90	0.00	472.90	-	GIS	Unknown	-	473.417	472.900
397	JLS5C2P0397	JLS5C2066	0.00	JLS5C2066A	0.00	0.00	403.30	-	Model	Unknown	-	403.475	403.300

Table 1. List of Gravity Mains with Unknown Invert Elevation by Priority

GIS Information						Proposed Invert Elevation		Source		Status		Proposed	
ID	PipeID	MhUpstream ID	Upstream Invert Elevation, ft	Mh Downstream ID	Downstream Invert Elevation, ft	Upstream Invert Elevation, ft	Downstream Invert Elevation, ft	Upstream Invert	Downstream Invert	Upstream Invert	Downstream Invert	Upstream Invert Elevation, ft	Downstream Invert Elevation, ft
3212	DTS5E3P3212	DTS5E3007	0.00	DTS5E3006	475.90	0.00	475.90	-	GIS	Unknown	-	476.512	475.900
5005	ECS7E2P5005	ECS7E2030	0.00	ECS7E2029	538.00	0.00	538.00	-	GIS	Unknown	-	539.332	538.000
5009	ECS7D2P5009	ECS7D2076	0.00	ECS7D2075	438.88	0.00	438.88	-	GIS	Unknown	-	439.572	438.880
1500	PPS4H1P1500	PPS4H1027	0.00	PPS4H1026	531.10	0.00	531.10	-	GIS	Unknown	-	531.512	531.100
3556	JLS6D2P3556	JLS6D2082	0.00	JLS6D2081	456.60	0.00	456.60	-	GIS	Unknown	-	457.793	456.600
4318	DTS6E4P4318	DTS6E4029	0.00	DTS6E4028	488.13	0.00	488.13	-	GIS	Unknown	-	488.858	488.130
4323	JLS6E3P4323	JLS6E3042A	0.00	JLS6E3042	0.00	0.00	461.28	-	Model	Unknown	-	462.403	461.280
5874	ECS8E1P5874	ECS8E1065	0.00	ECS8E1064	475.62	0.00	475.62	-	GIS	Unknown	-	475.891	475.620
7380	PPS4F4P7380	PPS4F4058A	0.00	PPS4F4058	533.98	0.00	533.98	-	GIS	Unknown	-	534.382	533.980
5384	ECS7E4P5384	ECS7E4063	0.00	ECS7E4062	527.92	0.00	527.92	-	GIS	Unknown	-	528.449	527.920
5386	ECS7E4P5386	ECS7E4064	530.70	ECS7E4063	0.00	530.70	0.00	GIS	-	-	Unknown	530.700	529.403
4496	JLS6E3P4496	JLS6E3062	0.00	JLS6E3061	0.00	471.44	0.00	Interpolate	-	Need Confirmation	Unknown	471.440	470.478
4135	JLS6E3P4135	JLS6E3094A	0.00	JLS6E3094	466.44	0.00	466.44	-	GIS	Unknown	-	466.519	466.440
5104	ECS7E3P5104	ECS7E3005	0.00	ECS7E3004	482.88	0.00	482.88	-	GIS	Unknown	-	483.615	482.880
896	STS2F4P0896	STS2F4024	0.00	STS2F4023	486.06	0.00	486.06	-	GIS	Unknown	-	486.411	486.060
864	STS2F4P0864	STS2F4026	0.00	STS2F4025	488.65	0.00	488.65	-	GIS	Unknown	-	489.267	488.650
7084	DTS6E2P7084	DTS6E2003A	0.00	DTS6E2003	0.00	0.00	463.32	-	Model	Unknown	-	463.742	463.600
4184	JLS6E3P4184	JLS6E3030A	0.00	JLS6E3030	457.41	0.00	457.41	-	GIS	Unknown	-	458.890	457.410
6284	EAS6G4P6284	EAS6G4019	569.00	EAS6G4018	0.00	569.00	0.00	GIS	-	-	Unknown	569.000	568.725
6285	EAS6G4P6285	EAS6G4018	0.00	EAS6G4017	566.40	0.00	566.40	-	GIS	Unknown	-	566.537	566.400
2563	PPS5G3P2563	PPS5G3020	0.00	PPS5G3019	528.70	0.00	528.70	-	GIS	Unknown	-	528.905	528.700
1786	PPS5I1P1786	TICK1270	589.98	PPS5I1019	0.00	589.98	0.00	GIS	-	-	Unknown	589.980	589.892
2998	PPS5G4P2998	PPS5G4046	0.00	PPS5G4045	548.50	0.00	548.50	-	GIS	Unknown	-	549.269	548.500
2313	JLS5D2P2313	JLS5D2113	0.00	JLS5D2112	443.47	0.00	443.47	-	GIS	Unknown	-	443.847	443.470
5222	ECS7E3P5222	ECS7E3025	0.00	ECS7E3024	510.89	0.00	510.89	-	GIS	Unknown	-	511.926	510.890
1394	STS3G4P1394	STS3G4091	520.84	STS3G4090	0.00	520.84	0.00	GIS	-	-	Unknown	520.840	520.190
3798	JLS6D1P3798	TICK3318	0.00	JLS6D1093	430.36	0.00	430.36	-	GIS	Unknown	-	430.548	430.360
3801	JLS6D2P3801	JLS6D2092	0.00	JLS6D2090A	456.05	0.00	456.05	-	GIS	Unknown	-	457.601	456.050
3803	JLS6D2P3803	JLS6D2093	0.00	JLS6D2090	452.10	0.00	452.10	-	GIS	Unknown	-	452.689	452.100
2380	ACS5C1P2380	ACS5C1001	0.00	ACS4C3T001	360.80	0.00	360.80	-	GIS	Unknown	-	365.000	360.800
3972	PPS6G2P3972	PPS6G2060	0.00	PPS6G2059	568.77	0.00	568.77	-	GIS	Unknown	-	568.978	568.770
3482	DTS6E1P3482	DTS6E1082	478.65	DTS6E1082A	0.00	478.65	0.00	GIS	-	-	Unknown	478.650	475.900
5406	RHS7D3P5406	RHS7D3088	0.00	RHS7D3087	439.20	0.00	439.20	-	GIS	Unknown	-	439.509	439.200
3814	PPS6G2P3814	PPS6G2057	0.00	PPS6G2056	566.12	0.00	566.12	-	GIS	Unknown	-	567.062	566.120
4466	DTS6E4P4466	DTS6E4072	0.00	DTS6E4065	503.84	0.00	503.84	-	GIS	Unknown	-	505.087	503.840
2205	DTS5E2P2205	DTS5E2024	0.00	DTS5E2023	533.24	0.00	533.24	-	GIS	Unknown	-	533.869	533.240
5356	ECS7E3P5356	STUB4848	0.00	ECS7E3088	517.50	0.00	517.50	-	GIS	Unknown	-	517.617	517.500
4543	JLS6E3P4543	JLS6E3063	0.00	JLS6E3062	471.44	0.00	471.44	-	GIS	Unknown	-	472.004	471.440
3938	JLS6D2P3938	JLS6D2027	0.00	JLS6D2026	441.20	0.00	441.20	-	GIS	Unknown	-	441.537	441.200
3521	JLS5D3P3521	JLS5D3113	0.00	JLS5D3112	421.70	0.00	421.70	-	GIS	Unknown	-	422.439	421.700
3539	JLS5D3P3539	JLS5D3019	0.00	JLS5D3018	423.91	0.00	423.91	-	GIS	Unknown	-	424.375	423.910
2542	JLS5D2P2542	JLS5D2094	0.00	JLS5D2093	443.53	0.00	443.53	-	GIS	Unknown	-	444.841	443.530
6096	STS4F3TP6096	TICK5963	0.00	STS4F3T004	456.55	0.00	456.55	-	GIS	Unknown	-	456.618	456.550
3145	EAS6F2P3145	EAS6F2045	521.27	EAS6F2044	0.00	521.27	0.00	GIS	-	-	Unknown	521.270	520.635
2322	JLS5D2P2322	JLS5D2111	0.00	JLS5D2109	442.35	0.00	442.35	-	GIS	Unknown	-	442.818	442.350
2330	JLS4E3P2330	JLS4E3018A	0.00	JLS4E3018	447.75	0.00	447.75	-	GIS	Unknown	-	448.732	447.750
4430	JLS6E3P4430	JLS6E3060	0.00	JLS6E3058	468.50	0.00	468.50	-	GIS	Unknown	-	469.002	468.500
4432	JLS6E3P4432	JLS6E3061	0.00	JLS6E3047	0.00	0.00	471.44	-	Model	Unknown	-	472.402	471.440
916	STS2H3P0916	STS2H3044	0.00	STS2H3044A	532.04	0.00	532.04	-	GIS	Unknown	-	532.090	532.040
5106	ECS7D2P5106	ECS7D2117	0.00	ECS7D2115	475.93	0.00	475.93	-	GIS	Unknown	-	476.572	475.930
5109	ECS7E1P5109	ECS7E1063	0.00	ECS7E1059	506.60	0.00	506.60	-	GIS	Unknown	-	507.259	506.600
3314	JLS5D3P3314	JLS5D3040	0.00	JLS5D3039	428.33	0.00	428.33	-	GIS	Unknown	-	428.789	428.330
1162	PPS3H4P1162	STUB658	0.00	PPS3H4077	552.62	0.00	552.62	-	GIS	Unknown	-	552.898	552.620
384	JLS5C2P0384	JLS5C2074	0.00	JLS5C2060	0.00	0.00	401.73	-	Model	Unknown	-	401.678	401.230
386	JLS5D1P0386	JLS5D1019	0.00	JLS5D1001	0.00	0.00	404.40	-	Model	Unknown	-	404.443	404.400
5033	ECS7E1P5033	ECS7E1106	0.00	ECS7E1105	505.74	0.00	505.74	-	GIS	Unknown	-	505.964	505.740
4376	DTS6F3P4376	DTS6F3049	0.00	DTS6F3048	521.60	0.00	521.60	-	GIS	Unknown	-	521.925	521.600
4377	DTS6F3P4377	DTS6F3050	522.78	DTS6F3049	0.00	522.78	0.00	GIS	-	-	Unknown	522.780	522.310
3674	JLS6D1P3674	JLS6D1087	0.00	JLS6D1086	423.40	0.00	423.40	-	GIS	Unknown	-	423.850	423.400
4872	ECS7D2P4872	ECS7D2046	0.00	ECS7D2045	445.29	0.00	445.29	-	GIS	Unknown	-	445.669	445.290
4879	ECS7E1P4879	STUB4371	0.00	ECS7E1034	491.02	0.00	491.02	-	GIS	Unknown	-	491.454	491.020
941	STS2G4P0941	STS2G4072	0.00	STS2G4071	516.83	0.00	516.83	-	GIS	Unknown	-	516.995	516.830
1429	STS3G3P1429	STS3G3033	0.00	STS3G3032	506.12	0.00	506.12	-	GIS	Unknown	-	506.436	506.120
1214	PPS3H4P1214	STUB706	0.00	PPS3H4078	554.12	0.00	554.12	-	GIS	Unknown	-	554.399	554.120
1220	STS3G3P1220	STS3G3022	0.00	STS3G3021	0.00	0.00	498.91	-	Model	Unknown	-	499.053	498.910
7419	JLS4E3P7419	JLS4E3006	441.69	JLS4E3005	0.00	441.69	0.00	GIS	-	-	Unknown	441.690	440.880
7420	JLS4E3P7420	JLS4E3004	440.88	JLS4E3002A	0.00	440.88	0.00	GIS	-	-	Unknown	440.880	440.080
4210	DTS6E4P4210	DTS6E4069	0.00	DTS6E4068	497.79	0.00	497.79	-	GIS	Unknown	-	498.471	497.790
992	STS2G3P0992	STS2G3007	0.00	STS2G3006	0.00	0.00	492.33	-	Interpolate	Unknown	Need Confirmation	493.455	492.330
1996	JLS5D1P1996	JLS5D1075	0.00	JLS5D1074	422.60	0.00	422.60	-	GIS	Unknown	-	423.921	422.600
1167	STS3F4P1167	STS3F4036A	0.00	STS3F4036	492.96	0.00	492.96	-	GIS	Unknown	-	493.569	492.960
4172	JLS6D1P4172	JLS6D1126	0.00	JLS6D1125	0.00	0.00	417.66	-	Model	Unknown	-	418.492	417.490
3779	PPS6G2P3779	PPS6G2041	0.00	PPS6G2040	560.78	0.00	560.78	-	GIS	Unknown	-	561.299	560.780
5755	ECS8E1P5755	ECS8E1081	0.00	ECS8E1080	482.89	0.00	482.89	-	GIS	Unknown	-	483.291	482.890
850	STS2G4P0850	STS2G4004	0.00	STS2G4003	508.95	0.00	508.95	-	GIS	Unknown	-	509.754	508.950
851	STS2F4P0851	STS2F4006	0.00	STS2F4005	491.47	0.00	491.47	-	GIS	Unknown	-	492.135	491.470
2496	PPS5G3P2496	PPS5G3014	535.80	PPS5G3013	0.00	535.80	0.00	GIS	-	-	Unknown	535.800	535.502
1533	STS3G4P1533	STS3G4037	0.00	STS3G4035	516.32	0.00	516.32	-	GIS	Unknown	-	516.586	516.320
6581	RHS9E1P6581	PRIVATE6423	0.00	RHS9E1066	473.27	0.00	473.27	-	GIS	Unknown	-	473.473	473.270
1563	STS3G3P1563	STS3G3059	0.00	STS3G3058	507.19	0.00	507.19	-	GIS	Unknown	-	507.925	507.190
2507	JLS4E3P2507	JLS4E3020	0.00	JLS4E3019	449.21	0.00	449.21	-	GIS	Unknown	-	449.862	449.210
1460	STS3F4P1460	STS3F4134A	0.00	STS3F4134	498.68	0.00	498.68	-	GIS	Unknown	-	498.763	498.680
1465	STS3F4P1465	STS3F4079	0.00	STS3F4078	0.00	0.00	500.08	-	Model	Unknown	-	500.884	500.080
1467	STS3F4P1467	STS3F4136	0.00	STS3F4135	491.42	0.00	491.42	-	GIS	Unknown	-	491.504	491.420
5778	ECS8E1P5778	ECS8E1058	0.00	ECS8E1057	473.78	0.00	473.78	-	GIS	Unknown	-	474.518	473.780
2327	PPS5F1P2327	TICK1828	0.00	PPS5F1002	519.28	0.00	519.28	-	GIS	Unknown	-	519.376	519.280
4678	DTS7F1P4678	DTS7F1016	0.00	DTS7F1015	512.76	0.00	512.76	-	GIS	Unknown	-	512.936	512.760
3650	PPS6G2P3650	PPS6G2043A	0.00	PPS6G2043	565.67	0.00	565.67	-	GIS	Unknown	-	565.931	565.670
1793	PPS4F4P1793	PPS4F4101	0.00	PPS4F4102	511.56	0.00	511.56	-	GIS	Unknown	-	511.925	511.560
840	STS2G4P0840	STS2G4009	0.00	STS2G4008	506.69	0.00	506.69	-	GIS	Unknown	-	507.197	506.690
844	STS2H1P0844	STS2H1063	0.00	STS2H1062	0.00	0.00	527.22	-	Model	Unknown	-	528.357	527.220
7456	WLS4B3P7456	WY7241	0.00	WLS4B3012	344.30	0.00	344.30	-	GIS	Unknown	-	344.333	344.300
3657	PPS6G2P3657	PPS6G2044A	0.00	PPS6G2044	568.80	0.00	568.80	-	GIS	Unknown	-	569.253	568.800
2519	PPS5G2P2519	PPS5G2005	0.00	PPS5G2004	536.38	0.00	536.38	-	GIS	Unknown	-	537.236	536.380
5068	ECS7E1P5068	ECS7E1054A	0.00	ECS7E1054	495.00	0.00	495.00	-	GIS	Unknown	-	495.484	495.000
5078	RHS7D3P5078	RHS7D3061	0.00	RHS7D3060	424.64	0.00	424.64	-	GIS	Unknown	-	424.866	424.640
786	STS2G4P0786	STS2G4013	0.00	STS2G4012	508.32	0.00	508.32	-	GIS	Unknown	-	508.934	508.320
1970	JLS5D1P1970	JLS5D1081	0.00	JLS5D1080	423.29	0.00	423.29	-	GIS	Unknown	-	423.861	423.290
5983	DTS6E2P5983	DTS6E2060	0.00	DTS6E2059	503.92	0.00	503.92	-	GIS	Unknown	-	504.270	503.920
4021	DTS6E2P4021	DTS6E2059	503.92	DTS6E2058	0.00	503.92	0.00	GIS	-	-	Unknown	503.920	502.950
7057	ACS4C2P7057	ACS4C2101	0.00	ACS4C2100	0.00	0.00	443.39	-	Model	Unknown	-	444.265	443.388
4682	DTS7F1P4682	DTS7F1014	0.00	DTS7F1013	511.17	0.00	511.17	-	GIS	Unknown	-	511.578	511.170
867	STS2G4P0867	STS2G4038	0.00	STS2G4037	517.00	0.00	517.00	-	GIS	Unknown	-	517.278	517.000
868	STS2H1P0868	TICK369	0.00	STS2H1064	527.71	0.00	527.71	-	GIS	Unknown	-	527.816	527.710
6584	RHS9E1P6584	PRIVATE6426	0.00	RHS9E1014	453.67	0.00	453.67	-	GIS	Unknown	-	453.873	453.670
6583	RHS9E1P6583	PRIVATE6427	0.00	RHS9E1013	453.35	0.00	453.35	-	GIS	Unknown	-	453.553	453.350
6582	RHS9E1P6582	PRIVATE6424	0.00	RHS9E1065	472.17	0.00	472.17	-	GIS	Unknown	-	472.373	472.170
4619	DTS6E4P4619	DTS6E4047	0.00	DTS6E4046	498.72	0.00	498.72	-	GIS	Unknown	-	499.045	498.720
4625	RHS6D3P4625	RHS6D3018	0.00	RHS6D3017	418.31	0.00	418.31	-	GIS	Unknown	-	419.066	418.310
4704	DTS6F3P4704	PRIVATE4197	0.00	DTS6F3033	529.93	0.00	529.93	-	GIS	Unknown	-	530.103	529.930
3995	PPS6G2P3995	PPS6G2063	0.00	PPS6G2062	570.01	0.00	570.01	-	GIS	Unknown	-	570.521	570.010
893	STS2H4P0893	STS2H4031A	0.00	STS2H4031	545.33	0.00	545.33	-	GIS	Unknown	-	545.429	545.330
4361	RHS6D3P4361	RHS6D3042	0.00	RHS6D3041	426.30	0.00	426.30	-	GIS	Unknown	-	426.671	426.300
2547	JLS5D2P2547	JLS5D2098	0.00	JLS5D2097	445.10	0.00	445.10	-	GIS	Unknown	-	445.957	445.100
2553	JLS5D2P2553	JLS5D2016	0.00	JLS5D2015	438.21	0.00	438.21	-	GIS	Unknown	-	438.543	438.210
2557	PPS4G3TP2557	PPS4G3T002	509.66	PPS4G3T001	0.00	509.66	0.00	GIS	-	-	Unknown	509.660	509.585
2561	PPS5G3P2561	PPS5G3032A	0.00	PPS5G3032	526.52	0.00	526.52	-	GIS	Unknown	-	526.635	526.520
2816	PPS5G1P2816	TICK2310	0.00	PPS5G1016	521.52	0.00	521.52	-	GIS	Unknown	-	521.616	521.520
4591	DTS7F1P4591	DTS7F1042	0.00	DTS7F1041	509.48	0.00	509.48	-	GIS	Unknown	-	510.086	509.480
7050	EAS6F1P7050	EAS6F1036A	0.00	EAS6F1036R	496.40	0.00	496.40	-	GIS	Unknown	-	497.600	496.400
7052	DTS6E2TP7052	DTS5E3T022A	0.00	DTS5E3T022	0.00	0.00	476.10	-	Model	Unknown	-	477.670	477.660
4139	DTS6E4P4139	DTS6E4090	0.00	DTS6E4067	494.88	0.00	494.88	-	GIS	Unknown	-	496.134	494.880
1108	PPS3H4P1108	STUB598	0.00	PPS3H4081	561.07	0.00	561.07	-	GIS	Unknown	-	561.349	561.070
5278	ECS7E4P5278	ECS7E4024	524.74	ECS7E4023	0.00	524.74	0.00	GIS	-	-	Unknown	524.740	524.347
4669	ECS7D2P4669	ECS7D2010	0.00	ECS7D2009	444.03	0.00	444.03	-	GIS	Unknown	-	444.537	444.030
2278	DTS5E2P2278	DTS5E2042	0.00	DTS5E2041	535.80	0.00	535.80	-	GIS	Unknown	-	536.639	535.800
6585	RHS9E1P6585	PRIVATE6425	0.00	RHS9E1015	464.17	0.00	464.17	-	GIS	Unknown	-	464.373	464.170
3729	DTS6E2P3729	DTS6E2007	0.00	DTS6E1T021	466.50	0.00	466.50	-	GIS	Unknown	-	467.478	466.503
7085	DTS6E2P7085	DTS6E2004	0.00	DTS6E2003A	0.00	464.08	0.00	Model	-	-	Unknown	463.980	463.652
3058	EAS6F2P3058	EAS6F2092	525.93	EAS6F2091	0.00	525.93	0.00	GIS	-	-	Unknown	525.930	525.463
3057	EAS6F2P3057	EAS6F2091	0.00	EAS6F2090	522.78	0.00	522.78	-	GIS	Unknown	-	524.130	522.780
3236	EAS6F2P3236	EAS6F2044	0.00	EAS6F2043	519.60	0.00	519.60	-	GIS	Unknown	-	520.379	519.600
3259	EAS6F1P3259	EAS6F1035	0.00	EAS6F1033	516.35	0.00	516.35	-	GIS	Unknown	-	516.702	516.350
3221	EAS6F1P3221	EAS6F1034	0.00	EAS6F1033	516.35	0.00	516.35	-	GIS	Unknown	-	516.648	516.350
230	ACS4C2P0230	ACS4C2078	0.00	ACS4C2077	434.50	0.00	434.50	-	GIS	Unknown	-	434.853	434.500
798	STS2F4P0798	STS2F4015	0.00	STS2F4014	491.72	0.00	491.72	-	GIS	Unknown	-	492.511	491.720
2887	PPS5G1P2887	TICK2366	0.00	PPS5G1020	523.08	0.00	523.08	-	GIS	Unknown	-	523.570	523.080
3957	JLS6D1P3957	JLS6D1085	0.00	JLS6D1084	431.88	0.00	431.88	-	GIS	Unknown	-	432.329	431.880
1756	STS4E4P1756	STS4E3056	0.00	STS4E4T001	0.00	0.00	438.41	-	Model	Unknown	-	438.978	438.410
5706	ECS8D2P5706	TICK5198	0.00	ECS8D2060	468.60	0.00	468.60	-	GIS	Unknown	-	468.755	468.600
1539	PPS4G1TP1539	TICK1033	0.00	PPS4H1001	522.49	0.00	522.49	-	GIS	Unknown	-	522.561	522.490
7449	STS2H3P7449	STS2H3057B	0.00	STS2H3057	529.00	0.00	529.00	-	GIS	Unknown	-	529.330	529.000
942	STS2H3P0942	STS2H3057A	0.00	STS2H3052	522.65	0.00	522.65	-	GIS	Unknown	-	523.171	522.650
7448	STS2H3P7448	STS2H3056	523.08	STS2H3057A	0.00	523.08	0.00	GIS	-	-	Unknown	523.080	522.753
7450	STS2H3P7450	STS2H3045A	0.00	STS2H3045	530.97	0.00	530.97	-	GIS	Unknown	-	531.515	530.970
7451	STS2H3P7451	STS2H3048A	0.00	STS2H3048	529.64	0.00	529.64	-	GIS	Unknown	-	530.191	529.640
7453	STS2H3P7453	STS2H3034A	0.00	STS2H3034	521.37	0.00	521.37	-	GIS	Unknown	-	521.434	521.370
1554	STS3G3P1554	STS3G3050	0.00	STS3G3048	0.00	513.47	0.00	Interpolate	-	Need Confirmation	Unknown	513.470	510.757
1531	STS3G3P1531	STS3G3048	0.00	STS3G3060	508.08	0.00	508.08	-	GIS	Unknown	-	509.162	508.080
3115	EAS6F1P3115	EAS6F1022	518.00	EAS6F1021	0.00	518.00	0.00	GIS	-	-	Unknown	518.000	516.760
3162	EAS6F1P3162	EAS6F1021	0.00	EAS6F1020	510.88	0.00	510.88	-	GIS	Unknown	-	511.836	510.880
7638	JLS6D1P7638	JLS6D1001C	0.00	JLS6D1001B	401.48	0.00	401.48	-	GIS	Unknown	-	401.595	401.480
6044	JLS6D1P6044	JLS6D1001	402.15	JLS6D1001C	0.00	402.15	0.00	GIS	-	-	Unknown	402.150	401.641
5937	DTS6E2TP5937	DTS5E3T023	478.00	DTS5E3T023B	0.00	478.00	0.00	GIS	-	-	Unknown	478.000	478.000
1004	STS3G1TP1004	TICK501	0.00	STS3G1T005	494.56	0.00	494.56	-	GIS	Unknown	-	494.649	494.560
7640	STS3G2P7640	STS3G2064	0.00	STS3G2037	0.00	0.00	515.34	-	Model	Unknown	-	515.369	515.142

Table 1. List of Gravity Mains with Unknown Invert Elevation by Priority

GIS Information						Proposed Invert Elevation		Source		Status		Proposed	
ID	PipeID	MhUpstream ID	Upstream Invert Elevation, ft	Mh Downstream ID	Downstream Invert Elevation, ft	Upstream Invert Elevation, ft	Downstream Invert Elevation, ft	Upstream Invert	Downstream Invert	Upstream Invert	Downstream Invert	Upstream Invert Elevation, ft	Downstream Invert Elevation, ft
7639	STS3G2P7639	STS3G2050	0.00	STS3G2072	0.00	517.59	0.00	Model	-	-	Unknown	517.590	517.222
1222	STS3G2P1222	STS3G2054	0.00	STS3G2053	519.57	0.00	519.57	-	GIS	Unknown	-	519.830	519.570
3565	JLS6D2P3565	JLS6D2064	0.00	JLS6D2063	436.36	0.00	436.36	-	GIS	Unknown	-	436.835	436.360
3568	JLS6D2P3568	JLS6D2065	0.00	JLS6D2063	436.36	0.00	436.36	-	GIS	Unknown	-	436.624	436.360
3618	EAS6F2P3618	EAS6F2025	0.00	EAS6F2023	0.00	0.00	532.20	-	Model	Unknown	-	532.200	532.200
3615	EAS6F2P3615	EAS6F2024	0.00	EAS6F2023	532.20	0.00	532.20	-	GIS	Unknown	-	532.733	532.200
7412	EAS6F2P7412	EAS6F2066A	0.00	EAS6F2066	535.02	0.00	535.02	-	GIS	Unknown	-	535.451	535.020
3397	EAS6F2P3397	EAS6F2068	536.34	EAS6F2066A	0.00	536.34	0.00	GIS	-	-	Unknown	536.340	535.310
803	STS3F2TP0803	STS3F2T013	0.00	STS3F2T012	0.00	0.00	487.13	-	Model	Unknown	-	487.552	487.130
7497	WLS4B3P7497	WY7274	0.00	WLS4B3009	344.00	0.00	344.00	-	GIS	Unknown	-	344.033	344.000
7495	WLS4B3P7495	WY7281	339.10	ECLS	0.00	339.10	0.00	GIS	-	-	Unknown	339.100	339.000
7530	JLS5C2P7530	JLS5C2080	0.00	JLS5C2078	0.00	0.00	397.50	-	Model	Unknown	-	394.396	394.319
7529	JLS5C2P7529	JLS5C2081	0.00	JLS5C2077	392.77	0.00	392.77	-	GIS	Unknown	-	393.645	392.774
7582	JLS5C2P7582	JLS5C2078	394.32	JLS5C2081	0.00	394.32	0.00	GIS	-	-	Unknown	394.319	394.308
400	JLS5C4TP0400	JLS5C4T019	396.90	JLS5C4T018	0.00	396.90	0.00	GIS	-	-	Unknown	396.900	396.800
2143	JLS5D1P2143	JLS5D1055	0.00	JLS5D1054	428.23	0.00	428.23	-	GIS	Unknown	-	428.543	428.230
7555	JLS5D1P7555	JLS5D1061A	0.00	JLS5D1061	429.86	0.00	429.86	-	GIS	Unknown	-	430.520	429.860
7556	JLS5D1P7556	JLS5D1064A	0.00	JLS5D1064	432.50	0.00	432.50	-	GIS	Unknown	-	432.764	432.500
2941	DTS5E3P2941	DTS5E3100	506.00	DTS5E3104	0.00	506.00	0.00	GIS	-	-	Unknown	506.000	504.820
7557	DTS5E3P7557	DTS5E3104	0.00	DTS5E3097	0.00	0.00	491.22	-	Model	Unknown	-	491.844	491.220
2095	JLS5D1P2095	JLS5D1110	0.00	JLS5D1109	431.82	0.00	431.82	-	GIS	Unknown	-	432.603	431.820
602	RHS8D4P0602	RHS8D4005A	0.00	RHS8D4005	438.56	0.00	438.56	-	GIS	Unknown	-	438.779	438.560
7565	STS3G2P7565	STS3G2038A	0.00	STS3G2038	517.80	0.00	517.80	-	GIS	Unknown	-	518.628	517.800
5437	ECS7D4P5437	ECS7D4071	0.00	ECS7D4070	483.90	0.00	483.90	-	GIS	Unknown	-	484.437	483.900
433	JLS5D3P0433	JLS5D3083	0.00	JLS5D3082	0.00	0.00	409.33	-	Model	Unknown	-	409.739	409.330
3580	JLS5D3P3580	JLS5D3026	0.00	JLS5D3025	427.66	0.00	427.66	-	GIS	Unknown	-	428.457	427.660
7629	JLS5D3P7629	JLS5D3025	0.00	JLS5D3024	427.66	0.00	427.66	-	GIS	Unknown	-	428.156	427.660
3587	JLS5D3P3587	JLS5D3029A	0.00	JLS5D3029	435.70	0.00	435.70	-	GIS	Unknown	-	436.271	435.700
3585	JLS5D3P3585	JLS5D3028A	0.00	JLS5D3028	433.47	0.00	433.47	-	GIS	Unknown	-	434.200	433.470
7631	JLS5D3P7631	JLS5D3029	435.70	JLS5D3028A	0.00	435.70	0.00	GIS	-	-	Unknown	435.700	435.437
3041	JLS5D3P3041	JLS5D3060	0.00	JLS5D3057	0.00	0.00	417.26	-	Model	Unknown	-	418.134	417.360
7632	JLS5D3P7632	JLS5D3059	0.00	JLS5D3060	0.00	420.43	0.00	Model	-	-	Unknown	420.430	420.196
3583	JLS5D3P3583	JLS5D3024A	0.00	JLS5D3024B	427.66	0.00	427.66	-	GIS	Unknown	-	428.255	427.660
7614	JLS5D2P7614	JLS5D2108	439.65	JLS5D2092A	0.00	439.65	0.00	GIS	-	-	Unknown	439.650	438.280
7615	DTS6F3P7615	DTS6F3025A	0.00	DTS6F3024	514.90	0.00	514.90	-	GIS	Unknown	-	515.860	514.900
7383	DTS6E2P7383	DTS6E2058	0.00	DTS6E2055	496.00	0.00	496.00	-	GIS	Unknown	-	497.270	496.000
3868	DTS6E2P3868	DTS6E2057	0.00	DTS6E2055	496.00	0.00	496.00	-	GIS	Unknown	-	497.229	496.000
3739	DTS6E2P3739	DTS6E2057	0.00	DTS6E2056	0.00	0.00	492.86	-	Model	Unknown	-	494.115	492.860
3637	DTS6E2P3637	DTS6E2056	0.00	DTS6E2051A	0.00	492.86	0.00	Model	-	-	Unknown	497.860	495.027
6026	DTS6E2P6026	DTS6E2052	0.00	DTS6E2051	0.00	0.00	495.03	-	Model	Unknown	-	495.731	495.027
4418	ECS6D4P4418	ECS6D4092	0.00	ECS6D4091	442.20	0.00	442.20	-	GIS	Unknown	-	442.473	442.200
4461	ECS6D4P4461	ECS6D4088	0.00	ECS6D4086	441.62	0.00	441.62	-	GIS	Unknown	-	442.162	441.620
2175	JLS5D2P2175	JLS5D2073	0.00	JLS5D2070	438.67	0.00	438.67	-	GIS	Unknown	-	439.410	438.670
2233	JLS5D2P2233	JLS5D2068	0.00	JLS5D2067	437.59	0.00	437.59	-	GIS	Unknown	-	438.194	437.590
2228	JLS5D2P2228	JLS5D2066	0.00	JLS5D2065	436.56	0.00	436.56	-	GIS	Unknown	-	436.802	436.560
4898	RHS7D3P4898	RHS7D3059	0.00	RHS7D3058	424.56	0.00	424.56	-	GIS	Unknown	-	424.838	424.560
7661	EAS7H1P7661	TICK7431	0.00	TICK7430	615.83	0.00	615.83	-	GIS	Unknown	-	615.900	615.830
3129	DTS5E3P3129	DTS5E3082	0.00	DTS5E3081	0.00	0.00	476.95	-	Model	Unknown	-	478.023	476.950
2734	DTS6E1P2734	DTS6E1035A	0.00	DTS6E1035	465.50	0.00	465.50	-	GIS	Unknown	-	465.996	465.500
5964	DTS5E3P5964	DTS5E3067	0.00	DTS5E3066	473.41	0.00	473.41	-	GIS	Unknown	-	474.401	473.410
2990	DTS5E3P2990	DTS5E3051A	504.93	DTS5E3050	0.00	504.93	0.00	GIS	-	-	Unknown	504.930	504.057
3038	DTS5E3P3038	DTS5E3049	0.00	DTS5E3049A	498.56	0.00	498.56	-	GIS	Unknown	-	499.405	498.560
2934	DTS5E3P2934	DTS5E3052	0.00	DTS5E3051	0.00	0.00	505.10	-	Model	Unknown	-	506.830	505.263
2510	PPS5F1P2510	PPS5F1047	0.00	PPS5F1046	563.50	0.00	563.50	-	GIS	Unknown	-	564.409	563.500
233	ACS4C2P0233	ACS4C2109	0.00	ACS4C2066	425.54	0.00	425.54	-	GIS	Unknown	-	426.008	425.540
224	ACS4C2P0224	ACS4C2095	0.00	ACS4C2068	426.43	0.00	426.43	-	GIS	Unknown	-	426.489	426.430
226	ACS4C2P0226	ACS4C2094	0.00	ACS4C2068	426.43	0.00	426.43	-	GIS	Unknown	-	426.454	426.430
7669	STS3G2P7669	TICK7440	0.00	STS3G2057A	522.02	0.00	522.02	-	GIS	Unknown	-	522.208	522.020
7670	STS3G2P7670	TICK7439	0.00	STS3G2057A	522.02	0.00	522.02	-	GIS	Unknown	-	522.128	522.020
7671	STS3G2P7671	TICK7441	0.00	STS3G2057B	523.12	0.00	523.12	-	GIS	Unknown	-	523.306	523.120
7672	STS3G2P7672	TICK7442	0.00	STS3G2057C	523.52	0.00	523.52	-	GIS	Unknown	-	523.631	523.520
3787	EAS6F1P3787	EAS6F1090	0.00	EAS6F1089	519.68	0.00	519.68	-	GIS	Unknown	-	520.224	519.680
3846	EAS6F1P3846	EAS6F1098	0.00	EAS6F1097	515.21	0.00	515.21	-	GIS	Unknown	-	516.366	515.210
3604	DTS6E2P3604	DTS6E2027A	0.00	DTS6E2027	481.29	0.00	481.29	-	GIS	Unknown	-	481.577	481.290
4498	DTS6E4P4498	DTS6E4036	0.00	DTS6E4035	496.74	0.00	496.74	-	GIS	Unknown	-	497.266	496.740
4493	DTS6E4P4493	DTS6E4035	496.74	DTS6E4030	0.00	496.74	0.00	GIS	-	-	Unknown	496.740	495.425
3720	EAS6F2P3720	EAS6F2027	534.98	EAS6F2025	0.00	534.98	0.00	GIS	-	-	Unknown	534.980	534.080
3620	EAS6F2P3620	EAS6F2026	0.00	EAS6F2025	532.20	0.00	532.20	-	GIS	Unknown	-	532.649	532.200
3621	EAS6F1P3621	EAS6F1081	0.00	EAS6F1080R	516.78	0.00	516.78	-	GIS	Unknown	-	517.106	516.780
7440	EAS6F1P7440	EAS6F4001	525.26	EAS6F1130	0.00	525.26	0.00	GIS	-	-	Unknown	525.260	523.090
4260	EAS6F4P4260	EAS6F4016	0.00	EAS6F4015	528.80	0.00	528.80	-	GIS	Unknown	-	530.109	528.800
4295	EAS6F4P4295	EAS6F4018	0.00	EAS6F4017	531.29	0.00	531.29	-	GIS	Unknown	-	532.135	531.290
3484	PPS6G2P3484	PPS6G2016	0.00	PPS6G2015	554.30	0.00	554.30	-	GIS	Unknown	-	555.132	554.300
3567	PPS6G2P3567	PPS6G2028	557.51	PPS6G2027	0.00	557.51	0.00	GIS	-	-	Unknown	557.510	557.051
3589	PPS6G2P3589	PPS6G2027	0.00	PPS6G2025	555.42	0.00	555.42	-	GIS	Unknown	-	556.403	555.420
4019	DTS6E2P4019	DTS6E2046	0.00	DTS6E2045	498.82	0.00	498.82	-	GIS	Unknown	-	499.479	498.820
4151	DTS6F3P4151	DTS6F3003	0.00	DTS6F3002	500.50	0.00	500.50	-	GIS	Unknown	-	501.708	500.500
4018	DTS6E2P4018	DTS6E2042	0.00	DTS6E2041	494.10	0.00	494.10	-	GIS	Unknown	-	494.686	494.100
4052	DTS6E2P4052	TICK3564	0.00	DTS6E2041	494.10	0.00	494.10	-	GIS	Unknown	-	494.351	494.100
3928	DTS6E2P3928	DTS6E2036	0.00	DTS6E2035	487.72	0.00	487.72	-	GIS	Unknown	-	488.464	487.720
3390	EAS6F2P3390	EAS6F2086	0.00	EAS6F2083	533.60	0.00	533.60	-	GIS	Unknown	-	534.101	533.600
7418	EAS6F2P7418	EAS6F2084A	0.00	EAS6F2084	534.36	0.00	534.36	-	GIS	Unknown	-	535.018	534.360
3307	EAS6F2P3307	EAS6F2085	551.20	EAS6F2084A	0.00	551.20	0.00	GIS	-	-	Unknown	551.200	550.236
3085	EAS6F2P3085	EAS6F2078	0.00	EAS6F2077	555.14	0.00	555.14	-	GIS	Unknown	-	555.327	555.140
3352	PPS6G1P3352	PPS6G1054B	0.00	PPS6G1054	533.77	0.00	533.77	-	GIS	Unknown	-	533.853	533.770
3348	PPS6G1P3348	PPS6G1054A	0.00	PPS6G1054	533.77	0.00	533.77	-	GIS	Unknown	-	533.857	533.770
4448	EAS6F4P4448	NO	0.00	EAS6F4078	546.16	0.00	546.16	-	GIS	Unknown	-	546.621	546.160
4470	EAS6F4P4470	EAS6F4079	548.30	NO	0.00	548.30	0.00	GIS	-	-	Unknown	548.300	548.004
4563	EAS6F4P4563	EAS6F4036	0.00	EAS6F4035	539.04	0.00	539.04	-	GIS	Unknown	-	539.509	539.040
4453	EAS6F4P4453	EAS6F4090P	0.00	EAS6F4090	557.79	0.00	557.79	-	GIS	Unknown	-	557.872	557.790
4567	EAS6F4P4567	EAS6F4091P	0.00	EAS6F4091	558.68	0.00	558.68	-	GIS	Unknown	-	558.758	558.680
4895	ECS7D2P4895	ECS7D2063	0.00	ECS7D2061	0.00	0.00	442.03	-	Model	Unknown	-	442.815	442.030
4894	ECS7D2P4894	ECS7D2064	0.00	ECS7D2063	443.39	0.00	443.39	-	GIS	Unknown	-	443.785	443.390
4884	ECS7D2P4884	ECS7D2047	448.55	ECS7D2046	0.00	448.55	0.00	GIS	-	-	Unknown	448.550	447.833
4809	ECS7D2P4809	ECS7D2053	0.00	ECS7D2052	450.58	0.00	450.58	-	GIS	Unknown	-	450.910	450.580
4848	ECS7D2P4848	ECS7D2052A	0.00	ECS7D2052	450.58	0.00	450.58	-	GIS	Unknown	-	451.354	450.580
4850	ECS7D2P4850	ECS7D2051	0.00	ECS7D2050	447.85	0.00	447.85	-	GIS	Unknown	-	448.347	447.850
4983	ECS7D2P4983	ECS7D2060	0.00	ECS7D2059	450.06	0.00	450.06	-	GIS	Unknown	-	450.884	450.060
5315	ECS7D3TP5315	TICK4806	0.00	ECS7D3T010	438.24	0.00	438.24	-	GIS	Unknown	-	438.362	438.240
5435	ECS7D3TP5435	TICK4921	0.00	ECS7D3T012	439.14	0.00	439.14	-	GIS	Unknown	-	439.225	439.140
5648	ECS8D2P5648	ECS8D2046	0.00	ECS8D2045	458.48	0.00	458.48	-	GIS	Unknown	-	458.804	458.480
5609	ECS8D2P5609	ECS8D2040	0.00	ECS8D2039	464.39	0.00	464.39	-	GIS	Unknown	-	464.819	464.390
5598	ECS8D2P5598	ECS8D2072	0.00	ECS8D2070	467.67	0.00	467.67	-	GIS	Unknown	-	468.532	467.670
4899	ECS7D2P4899	ECS7D2106	0.00	ECS7D2105	470.40	0.00	470.40	-	GIS	Unknown	-	470.741	470.400
4841	ECS7D2P4841	ECS7D2098A	0.00	ECS7D2097	469.00	0.00	469.00	-	GIS	Unknown	-	470.319	469.000
4689	DTS7F1P4689	DTS7F1031	0.00	DTS7F1030	0.00	0.00	520.69	-	Model	Unknown	-	521.573	520.690
7485	ACS5C4P7485	ACS5C4003	366.18	ACS5C4044	0.00	366.18	0.00	GIS	-	-	Unknown	366.180	366.130
7484	WLS4B3FP7484	WLS4B3F001	372.95	ACS5C4044	0.00	372.95	0.00	GIS	-	-	Unknown	372.950	372.703
6785	ACS5C4P6785	ACS5C4044	0.00	ACS5C4002	363.78	0.00	363.78	-	GIS	Unknown	-	363.996	363.780
7807	ACS4D1P7807	ACS4D1148	0.00	ACS4D1141	0.00	0.00	435.76	-	Model	Unknown	-	436.154	435.760
7810	ACS4D1P7810	ACS4D1141	0.00	ACS4D1140	0.00	435.76	0.00	Model	-	-	Unknown	435.760	435.621
7815	ACS4D1P7815	ACS4D1140	0.00	ACS4D1130	0.00	0.00	434.89	-	Model	Unknown	-	435.072	434.890
7817	ACS4D1P7817	ACS4D1170	0.00	ACS4D1152	0.00	0.00	440.38	-	Model	Unknown	-	438.200	437.802
7812	ACS4D1P7812	ACS4D1152	0.00	ACS4D1151	0.00	440.38	0.00	Model	-	-	Unknown	437.802	437.465
7826	ACS4D1P7826	ACS4D1129	0.00	ACS4D1126	0.00	0.00	427.64	-	Model	Unknown	-	427.803	427.640
7830	ACS4D1P7830	ACS4D1130	0.00	ACS4D1129	0.00	434.89	0.00	Model	-	-	Unknown	434.890	434.748
4406	RHS6D3P4406	RHS6D3026B	0.00	RHS6D3026	417.90	0.00	417.90	-	GIS	Unknown	-	418.101	417.900
4412	RHS6D3P4412	RHS6D3026A	0.00	RHS6D3026	417.90	0.00	417.90	-	GIS	Unknown	-	418.080	417.900
5055	RHS8D1P5055	RHS8D1055	0.00	RHS8D1054	416.83	0.00	416.83	-	GIS	Unknown	-	417.620	416.830
5428	RHS7D3P5428	TICK4914	0.00	RHS7D3093	424.74	0.00	424.74	-	GIS	Unknown	-	424.825	424.740
4996	RHS8D1P4996	RHS8D1035	0.00	RHS8D1034	412.54	0.00	412.54	-	GIS	Unknown	-	413.084	412.540
4943	RHS7D3P4943	RHS7D3040	0.00	RHS7D3039	410.73	0.00	410.73	-	GIS	Unknown	-	411.279	410.730
2921	PPS5G4P2921	PPS5G4068	0.00	PPS5G4067	552.53	0.00	552.53	-	GIS	Unknown	-	553.565	552.530
5971	STS2G3P5971	STS2G3026	507.00	STS2G3026A	0.00	507.00	0.00	GIS	-	-	Unknown	507.000	506.357
7628	STS2G3P7628	STS2G3026A	0.00	STS3G1T005	506.36	0.00	506.36	-	GIS	Unknown	-	506.465	506.360
4886	RHS7D3P4886	RHS7D3018	0.00	RHS7D3017	416.72	0.00	416.72	-	GIS	Unknown	-	416.825	416.720
1749	JLS5C2P1749	JLS5C2023A	0.00	JLS5C2023	407.51	0.00	407.51	-	GIS	Unknown	-	407.583	407.510
1245	STS3G3P1245	STS3G3089	0.00	STS3G3084	0.00	0.00	503.80	-	Model	Unknown	-	504.185	503.800
1243	STS3G3P1243	STS3G3090	0.00	STS3G3023	500.18	0.00	500.18	-	GIS	Unknown	-	500.427	500.180
1409	STS3G3P1409	STS3G3017	0.00	STS3G3016	504.43	0.00	504.43	-	GIS	Unknown	-	504.658	504.430
7378	STS3F4P7378	STS3F4127A	0.00	STS3F4127	507.62	0.00	507.62	-	GIS	Unknown	-	508.468	507.620
7375	STS3F4P7375	STS3F4124	506.30	STS374124A	0.00	506.30	0.00	GIS	-	-	Unknown	506.300	505.350
3199	EAS6F2P3199	EAS6F2058	0.00	EAS6F2056	527.44	0.00	527.44	-	GIS	Unknown	-	528.096	527.440
5663	ECS8E1P5663	ECS8E1097	0.00	ECS8E1096	545.69	0.00	545.69	-	GIS	Unknown	-	546.038	534.230
5744	ECS8E1P5744	TICK5235	0.00	ECS8E1100	529.79	0.00	529.79	-	GIS	Unknown	-	529.866	529.790
7682	ACS4C2P7682	ACS4C2026A	0.00	ACS4C2026	0.00	0.00	454.40	-	Model	Unknown	-	454.927	454.400
133	ACS4C2P0133	ACS4C2024A	0.00	ACS4C2023	423.11	0.00	423.11	-	GIS	Unknown	-	424.049	423.110
7683	ACS4C2P7683	ACS4C2024	435.43	ACS4C2024A	0.00	435.43	0.00	GIS	-	-	Unknown	435.430	435.100
3529	PPS5G4P3529	PPS5G4020	0.00	PPS5G4019	569.20	0.00	569.20	-	GIS	Unknown	-	569.595	569.200
2983	PPS5G4P2983	PPS5G4009	0.00	PPS5G4008	542.52	0.00	542.52	-	GIS	Unknown	-	542.682	542.520
3490	PPS6H1P3490	PPS6H1016A	0.00	PPS6H1016	585.78	0.00	585.78	-	GIS	Unknown	-	585.854	585.780
3000	JLS6D2P3000	JLS6D2059	0.00	JLS6D2058	431.75	0.00	431.75	-	GIS	Unknown	-	431.954	431.750
3005	JLS6D2P3005	JLS6D2015	0.00	JLS6D2014	436.09	0.00	436.09	-	GIS	Unknown	-	436.389	436.090
1315	STS3F4P1315	STS3F4014	495.73	STS3F4013	0.00	495.73	0.00	GIS	-	-	Unknown	495.730	495.142
1314	STS3F4P1314	STS3F4013	0.00	STS3F4012	491.07	0.00	491.07	-	GIS	Unknown	-	491.327	491.070
5523	ECS7E3P5523	ECS7E3123	0.00	ECS7E3121	526.05	0.00	526.05	-	GIS	Unknown	-	526.360	526.050
4511	DTS6E4P4511	DTS6E4077	515.71	DTS6E4076	0.00	515.71	0.00	GIS	-	-	Unknown	515.710	514.957
4506	DTS6E4P4506	DTS6E4073	0.00	DTS6E4066	0.00	0.00	505.10	-	Model	Unknown	-	506.444	505.100
4517	DTS6E4P4517	DTS6E4087	0.00	DTS6E4085	0.00	521.25	0.00	Model	-	-	Unknown	521.250	520.387
4516	DTS6E4P4516	DTS6E4085	0.00	DTS6E4084	518.93	0.00	518.93	-	GIS	Unknown	-	519.063	518.930
6051	PPS5G1P6051	PPS5G1043	0.00	PPS5F2T004	516.80	0.00	516.80	-	GIS	Unknown	-	517.075	516.800
2537	DTS5E2P2537	DTS5E2054	0.00	DTS5E2053	511.80	0.00	511.80	-	GIS	Unknown	-	512.182	511.800
2187	DTS5E2P2187	DTS5E2052	0.00	DTS5E2051	568.00	0.00	568.00	-	GIS	Unknown	-	568.882	568.000
5276	ECS7E3P5276	ECS7E3044	0.00	ECS7E3043	513.47	0.00	513.47	-	GIS	Unknown	-	514.305	513.470
7677	PPS5G4P7677	STUB7447	0.00	PPS5G4065	547.92	0.00	547.92	-	GIS	Unknown	-	547.941	547.920
2995	JLS5D3P2995	JLS5D3051	0.00	JLS5D3050	431.85	0.00	431.85	-	GIS	Unknown	-	432.048	431.850

Table 1. List of Gravity Mains with Unknown Invert Elevation by Priority

GIS Information						Proposed Invert Elevation		Source		Status		Proposed	
ID	PipeID	MhUpstream ID	Upstream Invert Elevation, ft	Mh Downstream ID	Downstream Invert Elevation, ft	Upstream Invert Elevation, ft	Downstream Invert Elevation, ft	Upstream Invert	Downstream Invert	Upstream Invert	Downstream Invert	Upstream Invert Elevation, ft	Downstream Invert Elevation, ft
3033	PPS5G4P3033	PPS5G4070	0.00	PPS5G4069	554.21	0.00	554.21	-	GIS	Unknown	-	558.540	554.210
5812	ECS8E3P5812	ECS8E3039	0.00	ECS8E3038	510.04	0.00	510.04	-	GIS	Unknown	-	510.519	510.040
2897	PPS5G4P2897	PPS5G4052	0.00	PPS5G4051	547.97	0.00	547.97	-	GIS	Unknown	-	548.816	547.970
3346	DTS6E1P3346	TICK2860	0.00	DTS6E1010	463.08	0.00	463.08	-	GIS	Unknown	-	463.173	463.080
3526	DTS6E2P3526	DTS6E2065R	0.00	DTS6E2064	0.00	489.53	0.00	Model	-	-	Unknown	493.888	493.335
7745	EAS6F1P7745	TICK7514	0.00	EAS6F1065R	508.71	0.00	508.71	-	GIS	Unknown	-	509.128	508.710
7744	EAS6F1P7744	EAS6F1148R	509.72	TICK7514	0.00	509.72	0.00	GIS	-	-	Unknown	509.720	509.700
3546	EAS6F1P3546	EAS6F1070	0.00	EAS6F1069	518.90	0.00	518.90	-	GIS	Unknown	-	519.100	518.900
7761	EAS6F1P7761	EAS6F1074	0.00	EAS6F1072R	522.14	0.00	522.14	-	GIS	Unknown	-	522.419	522.140
3315	EAS6F1P3315	TICK2797	0.00	EAS6F1049R	513.75	0.00	513.75	-	GIS	Unknown	-	514.009	513.750
3275	EAS6F1P3275	TICK2797	0.00	EAS6F1030	512.90	0.00	512.90	-	GIS	Unknown	-	513.505	512.900
7067	EAS6F2P7067	EAS6F2098	0.00	EAS6F2013	527.46	0.00	527.46	-	GIS	Unknown	-	527.500	527.460
1888	PPS5I1P1888	TICK1375	0.00	PPS5I1017	604.03	0.00	604.03	-	GIS	Unknown	-	604.111	604.030
1804	PPS5I1P1804	PPS5I1019	0.00	PPS5I1018	588.09	0.00	588.09	-	GIS	Unknown	-	589.334	588.090
7829	ACS4D1P7829	ACS4D1127	0.00	ACS4D1126	427.74	0.00	427.74	-	GIS	Unknown	-	428.314	427.740
6037	RHS8D3P6037	RHS8D3012A	0.00	RHS8D3012R	418.20	0.00	418.20	-	GIS	Unknown	-	418.447	418.200
25	RHS8D3P0025	RHS8D3011A	0.00	RHS8D3103	419.49	0.00	419.49	-	GIS	Unknown	-	419.661	419.490
7051	PPS4G3TP7051	PPS4G3T001	0.00	PPS5F2T002	508.73	0.00	508.73	-	GIS	Unknown	-	508.859	508.730
2825	DTS6E1P2825	STUB2326	0.00	DTS6E1012	451.49	0.00	451.49	-	GIS	Unknown	-	451.721	451.490
1231	STS3G3P1231	STS3G3065	0.00	STS3G3064	0.00	0.00	499.31	-	Model	Unknown	-	500.132	499.310
807	STS2G4P0807	STS2G4028	0.00	STS2G4027	516.20	0.00	516.20	-	GIS	Unknown	-	516.701	516.200
3196	DTS5E3P3196	DTS5E3006	475.90	DTS5E3005	0.00	475.90	0.00	GIS	-	-	Unknown	475.900	474.637
6171	PPS4G3P6171	PPS4G3057	0.00	PPS4G3056	517.50	0.00	517.50	-	GIS	Unknown	-	518.655	517.500
7372	ECS7E2P7372	ECS7E2010	0.00	ECS7E2009	0.00	0.00	510.80	-	Model	Unknown	-	512.201	510.798
4032	DTS6E2P4032	DTS6E2012	0.00	DTS6E2011	472.37	0.00	472.37	-	GIS	Unknown	-	472.913	472.370
5146	ECS7E3P5146	ECS7E3015	0.00	ECS7E3013	497.90	0.00	497.90	-	GIS	Unknown	-	498.424	497.900
3881	PPS6G2P3881	PPS6G2065	572.28	PPS6G2064	0.00	572.28	0.00	GIS	-	-	Unknown	572.280	571.660
3838	PPS6G2P3838	PPS6G2053A	0.00	PPS6G2053	563.44	0.00	563.44	-	GIS	Unknown	-	563.566	563.440
2216	JLS5D1P2216	JLS5D1063	0.00	JLS5D1062	0.00	0.00	430.89	-	Model	Unknown	-	431.443	430.890
5203	ECS7E3P5203	ECS7E3057	0.00	ECS7E3056	493.22	0.00	493.22	-	GIS	Unknown	-	494.147	493.220
5204	ECS7E4P5204	ECS7E4065	0.00	ECS7E4031	526.36	0.00	526.36	-	GIS	Unknown	-	526.825	526.360
6100	STS4F3TP6100	TICK5968	0.00	STS4F3T007	460.79	0.00	460.79	-	GIS	Unknown	-	460.854	460.790
6101	STS4F3TP6101	TICK5964	0.00	STS4F3T005	458.39	0.00	458.39	-	GIS	Unknown	-	458.456	458.390
1471	STS3G3P1471	STS3G3046A	0.00	STS3G3046	509.60	0.00	509.60	-	GIS	Unknown	-	509.794	509.600
955	STS2H4P0955	STS2H4016	0.00	STS2H4015	534.58	0.00	534.58	-	GIS	Unknown	-	535.795	534.580
4584	DTS7F1P4584	DTS7F1039	0.00	DTS7F1038	507.44	0.00	507.44	-	GIS	Unknown	-	508.098	507.440
7069	EAS6F4P7069	EAS6F4116	0.00	EAS6F2022	538.30	0.00	538.30	-	GIS	Unknown	-	538.637	538.300
765	STS2G4P0765	STS2G4019	0.00	STS2G4018	508.75	0.00	508.75	-	GIS	Unknown	-	509.002	508.750
4034	DTS6E2P4034	PRIVATE3492	0.00	DTS6E2062	0.00	0.00	498.76	-	Model	Unknown	-	499.347	498.760
647	STS2G2P0647	STS2G2061A	0.00	STS2G2061	517.86	0.00	517.86	-	GIS	Unknown	-	518.081	517.860
2090	JLS5D2P2090	PRIVATE1548	0.00	JLS5D2115	440.80	0.00	440.80	-	GIS	Unknown	-	441.220	440.800
669	STS2G2P0669	STS2G2043	0.00	STS2G2034	509.30	0.00	509.30	-	GIS	Unknown	-	509.637	509.300
671	STS2G2P0671	STS2G2044	0.00	STS2G2035	510.50	0.00	510.50	-	GIS	Unknown	-	510.840	510.500
675	STS2G2P0675	STS2G2041	0.00	STS2G2040	516.66	0.00	516.66	-	GIS	Unknown	-	517.238	516.660
678	STS2G2P0678	STS2G2042	0.00	STS2G2040	516.66	0.00	516.66	-	GIS	Unknown	-	516.833	516.660
2426	DTS5E2P2426	DTS5E2038	0.00	DTS5E2037	491.61	0.00	491.61	-	GIS	Unknown	-	491.810	491.610
4404	DTS6E4P4404	DTS6E4030	0.00	DTS6E4028	488.13	0.00	488.13	-	GIS	Unknown	-	489.573	488.130
3923	JLS6D1P3923	JLS6D1077	0.00	JLS6D1076	420.80	0.00	420.80	-	GIS	Unknown	-	421.638	420.800
4082	PPS6G2P4082	PPS6G2061	570.72	PPS6G2060	0.00	570.72	0.00	GIS	-	-	Unknown	570.720	569.833
5273	ECS7E4P5273	ECS7E4033	0.00	ECS7E4032	527.80	0.00	527.80	-	GIS	Unknown	-	528.087	527.800
4441	DTS6E4P4441	DTS6E4104	0.00	DTS6E4102	0.00	513.91	0.00	Model	-	-	Unknown	513.910	512.783
1192	STS3F4P1192	STS3F4026	0.00	STS3F4025	489.69	0.00	489.69	-	GIS	Unknown	-	490.103	489.690
1194	STS3F4P1194	STS3F4031	490.94	STS3F4026	0.00	490.94	0.00	GIS	-	-	Unknown	490.940	490.392
4392	DTS6E4P4392	DTS6E4064	0.00	DTS6E4063	501.20	0.00	501.20	-	GIS	Unknown	-	501.788	501.200
2800	PPS5H1P2800	PPS5H1049	557.64	PPS5H1048	0.00	557.64	0.00	GIS	-	-	Unknown	557.640	557.176
4039	DTS6E2P4039	DTS6E2075	489.43	DTS6E2073	0.00	489.43	0.00	GIS	-	-	Unknown	489.430	488.160
5121	ECS7E1P5121	ECS7E1057	0.00	ECS7E1056	500.70	0.00	500.70	-	GIS	Unknown	-	501.183	500.700
2731	DTS5E3P2731	DTS5E3071	0.00	DTS5E3070	474.87	0.00	474.87	-	GIS	Unknown	-	475.587	474.870
4733	DTS7F1P4733	DTS7F1022	0.00	DTS7F1021	513.90	0.00	513.90	-	GIS	Unknown	-	514.441	513.900
143	ACS4C4P0143	ACS4C4052	0.00	ACS4C4031	380.93	0.00	380.93	-	GIS	Unknown	-	382.271	380.930
293	ACS4C2P0293	STUB5576	0.00	ACS4C3T016	384.00	0.00	384.00	-	GIS	Unknown	-	384.043	384.000
294	ACS4C3TP0294	STUB5574	0.00	ACS4C3T016	383.01	0.00	383.01	-	GIS	Unknown	-	383.031	383.010
295	ACS4C2P0295	STUB5578	0.00	ACS4C3T016	384.00	0.00	384.00	-	GIS	Unknown	-	384.045	384.000
296	PPS4H4P0296	PPS4H4052	0.00	PPS4H4042A	578.06	0.00	578.06	-	GIS	Unknown	-	578.195	578.060
2168	DTS5E2P2168	DTS5E2018	0.00	DTS5E2017	510.34	0.00	510.34	-	GIS	Unknown	-	510.870	510.340
5355	ECS7E3P5355	ECS7E3089	0.00	ECS7E3088	517.50	0.00	517.50	-	GIS	Unknown	-	518.150	517.500
2252	PPS5F1P2252	PPS5F1035A	0.00	PPS5F1035	600.78	0.00	600.78	-	GIS	Unknown	-	600.863	600.780
2767	JLS5D2P2767	JLS5D2078	0.00	JLS5D2077	448.17	0.00	448.17	-	GIS	Unknown	-	448.664	448.170
3309	DTS6E1P3309	DTS6E1059	0.00	DTS6E1058	466.06	0.00	466.06	-	GIS	Unknown	-	467.024	466.060
5771	ECS8E3P5771	ECS8E3056	0.00	ECS8E3055	512.00	0.00	512.00	-	GIS	Unknown	-	512.539	512.000
5640	RHS8D1P5640	RHS8D1126A	0.00	RHS8D1125	425.48	0.00	425.48	-	GIS	Unknown	-	426.166	425.480
2971	DTS5E3P2971	DTS5E3003	0.00	DTS5E3002	472.90	0.00	472.90	-	GIS	Unknown	-	473.697	472.900
447	PPS5G1P0447	PPS5G1017B	0.00	PPS5G1017A	0.00	0.00	522.92	-	Model	Unknown	-	523.201	522.588
450	JLS5D3P0450	JLS5D3070	0.00	JLS5D3069	0.00	418.93	0.00	Model	-	-	Unknown	418.930	418.158
6107	STS4FITP6107	STS4F1T003A	465.97	TICK5975	0.00	465.97	0.00	GIS	-	-	Unknown	465.970	465.955
4292	DTS6E4P4292	DTS6E4041	0.00	DTS6E4040	489.75	0.00	489.75	-	GIS	Unknown	-	490.368	489.750
6709	DTS6E2P6709	STUB6504	0.00	DTS6E2021	475.21	0.00	475.21	-	GIS	Unknown	-	475.285	475.210
3440	EAS6F1P3440	EAS6F1062	0.00	EAS6F1060	518.08	0.00	518.08	-	GIS	Unknown	-	518.324	518.080
2412	PPS5G2P2412	PPS5G2037	0.00	PPS5G2036	544.84	0.00	544.84	-	GIS	Unknown	-	545.310	544.840
1359	STS3F4P1359	STS3F4008	496.15	STS3F4007	0.00	496.15	0.00	GIS	-	-	Unknown	496.150	495.534
1360	STS3F4P1360	STS3F4007	0.00	STS3F4006	490.87	0.00	490.87	-	GIS	Unknown	-	491.027	490.870
1482	STS3F4P1482	STS3F4097	0.00	STS3F4093	500.45	0.00	500.45	-	GIS	Unknown	-	500.739	500.450
6042	ACS4C4P6042	ACS4C4053	387.88	ACS4C4052	0.00	387.88	0.00	GIS	-	-	Unknown	387.880	387.154
4741	DTS7F1P4741	DTS7F1024	0.00	DTS7F1023	518.40	0.00	518.40	-	GIS	Unknown	-	518.607	518.400
327	PPS4H1P0327	PPS4H1004A	0.00	PPS4H1004	0.00	0.00	535.10	-	Model	Unknown	-	535.897	535.100
329	ACS4C4P0329	STUB5607	0.00	ACS4C4048	394.61	0.00	394.61	-	GIS	Unknown	-	394.761	394.610
330	ACS4C4P0330	STUB5606	0.00	ACS4C4048	394.61	0.00	394.61	-	GIS	Unknown	-	394.696	394.610
4572	ECS7D2P4572	ECS7D2008	0.00	ECS7D2007	442.39	0.00	442.39	-	GIS	Unknown	-	443.273	442.390
4579	DTS7F1P4579	DTS7F1043	510.93	DTS7F1042	0.00	510.93	0.00	GIS	-	-	Unknown	510.930	510.678
4371	JLS6E3P4371	JLS6E3093	0.00	JLS6E3092	454.04	0.00	454.04	-	GIS	Unknown	-	454.542	454.040
4003	EAS6F1P4003	EAS6F1111	0.00	EAS6F1109	525.20	0.00	525.20	-	GIS	Unknown	-	525.690	525.200
2473	JLS4E3P2473	JLS4E3023A	0.00	JLS4E3023	449.75	0.00	449.75	-	GIS	Unknown	-	449.861	449.750
2820	JLS5D2P2820	JLS5D2014	0.00	JLS5D2013	441.72	0.00	441.72	-	GIS	Unknown	-	442.132	441.720
4992	RHS7D3P4992	RHS7D3056A	0.00	RHS7D3056	0.00	0.00	422.06	-	Model	Unknown	-	422.175	422.060
4994	ECS7D2P4994	ECS7D2073	0.00	ECS7D2072	437.00	0.00	437.00	-	GIS	Unknown	-	437.528	437.000
5442	ECS7E3P5442	ECS7E3073	0.00	ECS7E3072	501.99	0.00	501.99	-	GIS	Unknown	-	502.373	501.990
4442	DTS6E4P4442	DTS6E4020	0.00	DTS6E4019	480.80	0.00	480.80	-	GIS	Unknown	-	481.872	480.800
1926	JLS5D1P1926	JLS5D1070	0.00	JLS5D1069	416.90	0.00	416.90	-	GIS	Unknown	-	417.397	416.900
2344	PPS5G3P2344	PPS5G3010	0.00	PPS5G3009	526.70	0.00	526.70	-	GIS	Unknown	-	527.084	526.700
5052	ECS7E1P5052	ECS7E1114	0.00	ECS7E1113	507.49	0.00	507.49	-	GIS	Unknown	-	507.790	507.490
1557	STS3G3P1557	TICK1053	0.00	STS3G3050	513.47	0.00	513.47	-	GIS	Unknown	-	513.705	513.470
1561	STS3F4P1561	STS374124A	0.00	STS3F4123	504.19	0.00	504.19	-	GIS	Unknown	-	505.350	504.190
5294	ECS7E3P5294	ECS7E3033	0.00	ECS7E3032	520.10	0.00	520.10	-	GIS	Unknown	-	520.826	520.100
2334	DTS5E2P2334	DTS5E2061	0.00	DTS5E2060	545.10	0.00	545.10	-	GIS	Unknown	-	545.570	545.100
2215	JLS5D1P2215	JLS5D1065	433.58	JLS5D1063	0.00	433.58	0.00	GIS	-	-	Unknown	433.580	432.259
6103	STS4F3TP6103	TICK5971	0.00	STS4F3T009	463.99	0.00	463.99	-	GIS	Unknown	-	464.056	463.990
5986	JLS5D2P5986	JLS5D2012	0.00	JLS5D2011	440.75	0.00	440.75	-	GIS	Unknown	-	441.429	440.750
6322	ECS7D4P6322	ECS7D4068A	0.00	ECS7D4068	480.40	0.00	480.40	-	GIS	Unknown	-	480.700	480.400
5020	ECS7E1P5020	ECS7E1068A	0.00	ECS7E1068	506.73	0.00	506.73	-	GIS	Unknown	-	507.231	506.730
5462	ECS7E3P5462	STUB4953	0.00	ECS7E3104	523.44	0.00	523.44	-	GIS	Unknown	-	523.524	523.440
3563	JLS6D2P3563	JLS6D2023	0.00	JLS6D2022	438.55	0.00	438.55	-	GIS	Unknown	-	438.934	438.550
5087	ECS7E3P5087	ECS7E3012	0.00	ECS7E3011	486.86	0.00	486.86	-	GIS	Unknown	-	487.410	486.860
2785	PPS5H1P2785	PPS5H1048	0.00	PPS5H1047	560.90	0.00	560.90	-	GIS	Unknown	-	561.564	560.900
1095	STS3G2P1095	STS3G2027	0.00	STS3G2022	509.95	0.00	509.95	-	GIS	Unknown	-	510.254	509.950
3929	JLS6D2P3929	JLS6D2028	0.00	JLS6D2026	441.20	0.00	441.20	-	GIS	Unknown	-	441.543	441.200
3073	DTS5E3P3073	DTS5E3005	0.00	DTS5E3002	472.90	0.00	472.90	-	GIS	Unknown	-	474.148	472.900
1366	STS3G4P1366	STS3G4090	0.00	STS3G4089	519.33	0.00	519.33	-	GIS	Unknown	-	519.874	519.330
4095	DTS6E2P4095	DTS6E2073	0.00	DTS6E2072	484.11	0.00	484.11	-	GIS	Unknown	-	485.373	484.110
2234	JLS5D1P2234	JLS5D1064	432.50	JLS5D1063	0.00	432.50	0.00	GIS	-	-	Unknown	432.500	432.317
1422	STS3F4P1422	TICK914	0.00	STS3F4077	499.23	0.00	499.23	-	GIS	Unknown	-	499.418	499.230
2774	DTS5E3P2774	DTS5E3058	0.00	DTS5E3057	520.50	0.00	520.50	-	GIS	Unknown	-	521.278	520.500
2099	JLS5D1P2099	JLS5D1012	0.00	JLS5D1011	419.55	0.00	419.55	-	GIS	Unknown	-	419.848	419.550
2210	DTS5E2P2210	DTS5E2032	0.00	DTS5E2031	537.20	0.00	537.20	-	GIS	Unknown	-	537.788	537.200
4396	DTS6F3P4396	DTS6F3046A	0.00	DTS6F3046	519.82	0.00	519.82	-	GIS	Unknown	-	520.123	519.820
978	STS2H4P0978	STS2H4036A	0.00	STS2H4036	545.91	0.00	545.91	-	GIS	Unknown	-	546.011	545.910
1963	PPS4F4P1963	PPS4F4015	536.90	PPS4F4014	0.00	536.90	0.00	GIS	-	-	Unknown	536.900	536.351
5642	RHS8D1P5642	RHS8D1126B	427.75	RHS8D1126A	0.00	427.75	0.00	GIS	-	-	Unknown	427.750	427.176
5776	ECS8E3P5776	ECS8E3030A	0.00	ECS8E3030	527.17	0.00	527.17	-	GIS	Unknown	-	527.546	527.170
389	JLS5D1P0389	JLS5D1024	0.00	JLS5D1022	0.00	417.80	0.00	Interpolate	-	Need Confirmation	Unknown	417.800	416.943
390	JLS5D1P0390	JLS5D1135	0.00	JLS5D1134	0.00	0.00	421.84	-	Model	Unknown	-	422.729	421.840
391	JLS5D1P0391	JLS5D1026	0.00	JLS5D1024	0.00	0.00	417.80	-	Interpolate	Unknown	-	418.681	417.800
2747	JLS5D1P2747	JLS5D1038	0.00	JLS5D1037	424.95	0.00	424.95	-	GIS	Unknown	-	425.745	424.950
1815	ACS4C4P1815	TICK1304	0.00	ACS4C4026	373.68	0.00	373.68	-	GIS	Unknown	-	373.763	373.680
1816	ACS4C4P1816	TICK1301	0.00	ACS4C4026	373.68	0.00	373.68	-	GIS	Unknown	-	373.763	373.680
715	STS2G2P0715	STS2G2013	0.00	STS2G2009	515.67	0.00	515.67	-	GIS	Unknown	-	516.186	515.670
1724	JLS5D1P1724	JLS5D1118A	0.00	JLS5D1118	415.98	0.00	415.98	-	GIS	Unknown	-	416.112	415.980
6632	DTS6E2P6632	DTS6E2077	0.00	DTS5E3T029A	0.00	0.00	485.08	-	Model	Unknown	-	486.437	485.085
1962	PPS4F4P1962	PPS4F4014	0.00	PPS4F4002	526.20	0.00	526.20	-	GIS	Unknown	-	527.168	526.200
3304	DTS5E3P3304	DTS5E3008	0.00	DTS5E3006	475.90	0.00	475.90	-	GIS	Unknown	-	477.008	475.900
5859	ECS8E3P5859	ECS8E3009	0.00	ECS8E3008	485.83	0.00	485.83	-	GIS	Unknown	-	486.139	485.830
443	JLS5D3P0443	JLS5D3068	0.00	JLS5D3054	0.00	0.00	415.23	-	Model	Unknown	-	416.039	415.130
476	EAS6G4P0476	EAS6G4014	0.00	EAS6G4013	0.00	0.00	568.60	-	Model	Unknown	-	568.963	568.500
1593	STS3G3P1593	STS3G3057A	0.00	STS3G3057	509.89	0.00	509.89	-	GIS	Unknown	-	510.286	509.890
2655	DTS6E1P2655	STUB2146	0.00	DTS6E1036	470.65	0.00	470.65	-	GIS	Unknown	-	470.774	470.650
6560	ACS4C2P6560	ACS4C2076	0.00	ACS4C2075	460.65	0.00	460.65	-	GIS	Unknown	-	431.371	430.550
4656	DTS7F1P4656	DTS7F1004	0.00	DTS7F1003	504.76	0.00	504.76	-	GIS	Unknown	-	505.128	504.760
4662	DTS7F1P4662	DTS7F1015	512.76	DTS7F1014	0.00	512.76	0.00	GIS	-	-	Unknown	512.760	511.738
2964	PPS5G4P2964	PPS5G4073	0.00	PPS5G4072	555.92	0.00	555.92	-	GIS	Unknown	-	556.323	555.920
5326	ECS7E3P5326	ECS7E3107	0.00	ECS7E3106	521.64	0.00	521.64	-	GIS	Unknown	-	522.313	521.640
2158	DTS5E2P2158	TICK1634	0.00	DTS5E2009	501.11	0.00	501.11	-	GIS	Unknown	-	501.277	501.110
1227	STS3F4P1227	STS3F4027	491.20	STS3F4026	0.00	491.20	0.00	GIS	-	-	Unknown	491.200	490.305
3148	EAS6F2P3148	EAS6F2042	0.00	EAS6F2041	521.00	0.00	521.00	-	GIS	Unknown	-	521.490	521.000
3820	DTS6E2P3820	DTS6E2010B	0.00	DTS6E2010A	0.00	0.00	478.69	-	Model	Unknown	-	481.017	478.690
4279	JLS6E3P4279	JLS6E3037	461.61	JLS6E3036	0.00	461.61	0.00	GIS	-	-	Unknown	461.610	461.284
5196	ECS7E3P5196	ECS7E3019	0.00	ECS7E3018	497.50	0.00	497.50	-	GIS	Unknown	-	498.293	497.500
3341	JLS5D3P3341	JLS5D3016	0.00	JLS5D3015	428.00	0.00	428.00	-	GIS	Unknown	-	428.488	428.000

Table 1. List of Gravity Mains with Unknown Invert Elevation by Priority

GIS Information						Proposed Invert Elevation		Source		Status		Proposed	
ID	PipeID	MhUpstream ID	Upstream Invert Elevation, ft	Mh Downstream ID	Downstream Invert Elevation, ft	Upstream Invert Elevation, ft	Downstream Invert Elevation, ft	Upstream Invert	Downstream Invert	Upstream Invert	Downstream Invert	Upstream Invert Elevation, ft	Downstream Invert Elevation, ft
5212	ECS7E3P5212	ECS7E3059	0.00	ECS7E3058	496.26	0.00	496.26	-	GIS	Unknown	-	496.728	496.260
779	STS2F4P0779	STS2F4011	0.00	STS2F4009	493.28	0.00	493.28	-	GIS	Unknown	-	493.648	493.280
780	STS2F4P0780	STS2F4010	0.00	STS2F4009	493.28	0.00	493.28	-	GIS	Unknown	-	493.874	493.280
1778	PPS4H3P1778	PPS4H3021	0.00	PPS4H3020	542.44	0.00	542.44	-	GIS	Unknown	-	542.489	542.440
2676	DTS5E3P2676	DTS5E3025	0.00	DTS5E3024	533.00	0.00	533.00	-	GIS	Unknown	-	533.251	533.000
2679	DTS5E3P2679	DTS5E3103	0.00	DTS5E3101	515.58	0.00	515.58	-	GIS	Unknown	-	515.910	515.580
2039	PPS4H3P2039	TICK1528	0.00	PPS4H3001R	531.79	0.00	531.79	-	GIS	Unknown	-	531.899	531.790
7633	JLS5D3P7633	JLS5D3028	433.47	JLS5D3024A	0.00	433.47	0.00	GIS	-	-	Unknown	433.470	433.103
7634	ACS2C4P7634	ACS4C4010	374.22	ACS4C4010A	0.00	374.22	0.00	GIS	-	-	Unknown	374.220	374.098
7636	ACS2C4P7636	ACS4C4008A	0.00	ACS4C4008	372.40	0.00	372.40	-	GIS	Unknown	-	372.786	372.400
4285	DTS6E4P4285	DTS6E4092	0.00	DTS6E4070	0.00	0.00	500.30	-	Model	Unknown	-	501.551	500.300
4208	DTS6F3P4208	DTS6F3005	0.00	DTS6F3004	504.50	0.00	504.50	-	GIS	Unknown	-	505.754	504.500
2928	JLS5D3P2928	JLS5D3080	0.00	JLS5D3079	425.10	0.00	425.10	-	GIS	Unknown	-	425.470	425.100
1505	STS3F4P1505	STS3F4099	0.00	STS3F4098	0.00	0.00	500.37	-	Interpolate	Unknown	Need Confirmation	501.027	500.370
1525	STS3F4P1525	STS3F4100	0.00	STS3F4099	0.00	502.31	0.00	Model	-	-	Unknown	502.310	501.453
7374	STS3F4P7374	STS3F4144	0.00	STS3F4100	0.00	0.00	502.31	-	Model	Unknown	-	503.224	502.310
5953	DTS6E1P5953	DTS6E1034	464.80	DTS6E1033	0.00	464.80	0.00	GIS	-	-	Unknown	464.800	464.448
5954	DTS6E1P5954	DTS6E1033	0.00	DTS5E3T014	462.20	0.00	462.20	-	GIS	Unknown	-	463.406	462.200
7605	JLS6D2P7605	JLS6D2066	440.99	JLS6D2066A	0.00	440.99	0.00	GIS	-	-	Unknown	440.990	439.980
3416	JLS6D2P3416	JLS6D2008	0.00	JLS6D2007	442.40	0.00	442.40	-	GIS	Unknown	-	443.469	442.400
7588	JLS6D2P7588	JLS6D2009	450.19	JLS6D2008	0.00	450.19	0.00	GIS	-	-	Unknown	450.190	449.141
3417	JLS6D2P3417	JLS6D2011	0.00	JLS6D2009	450.19	0.00	450.19	-	GIS	Unknown	-	450.669	450.190
3537	JLS6D2P3537	JLS6D2010	0.00	JLS6D2009	450.19	0.00	450.19	-	GIS	Unknown	-	451.013	450.190
3677	JLS6D2P3677	JLS6D2088	0.00	JLS6D2088A	452.30	0.00	452.30	-	GIS	Unknown	-	453.465	452.300
3676	JLS6D2P3676	JLS6D2089	0.00	JLS6D2089A	457.75	0.00	457.75	-	GIS	Unknown	-	458.902	457.750
7607	DTS6E4P7606	DTS6E4053A	0.00	DTS6E4053	0.00	0.00	495.60	-	Model	Unknown	-	496.057	495.380
7611	JLS5D2P7611	JLS5D2090	442.40	JLS5D2084A	0.00	442.40	0.00	GIS	-	-	Unknown	442.400	437.090
6077	JLS5D2P6077	JLS5D2123A	0.00	JLS5D2122	445.10	0.00	445.10	-	GIS	Unknown	-	445.697	445.100
5595	ECS8D2P5595	ECS8D2079	0.00	ECS8D2078	462.40	0.00	462.40	-	GIS	Unknown	-	463.142	462.400
5611	ECS8D2P5611	ECS8D2077	0.00	ECS8D2076	475.00	0.00	475.00	-	GIS	Unknown	-	475.354	475.000
5635	ECS8D2P5635	ECS8D2056	0.00	ECS8D2055	467.83	0.00	467.83	-	GIS	Unknown	-	468.704	467.830
4588	DTS6E4P4588	DTS6E4086	520.93	DTS6E4085	0.00	520.93	0.00	GIS	-	-	Unknown	520.930	519.621
5912	ECS8E3P5912	ECS8E3020A	0.00	ECS8E3020	480.91	0.00	480.91	-	GIS	Unknown	-	481.402	480.910
3543	JLS5D3P3543	JLS5D3049	0.00	JLS5D3048	433.34	0.00	433.34	-	GIS	Unknown	-	434.068	433.340
4431	RHS6D3P4431	RHS6D3050	0.00	RHS6D3049	428.58	0.00	428.58	-	GIS	Unknown	-	429.059	428.580
4626	RHS6D3P4626	RHS6D3047	0.00	RHS6D3046	425.68	0.00	425.68	-	GIS	Unknown	-	425.957	425.680
4605	RHS6D3P4605	RHS6D3044	0.00	RHS6D3043	421.12	0.00	421.12	-	GIS	Unknown	-	421.388	421.120
3179	DTS6E1P3179	TICK2703	0.00	DTS6E1074	474.50	0.00	474.50	-	GIS	Unknown	-	474.609	474.500
3163	DTS6E1P3163	TICK2683	0.00	DTS6E1074	474.50	0.00	474.50	-	GIS	Unknown	-	474.596	474.500
3849	EAS6F1P3849	EAS6F1100R	524.16	EAS6F1099	0.00	524.16	0.00	GIS	-	-	Unknown	524.160	522.880
2698	JLS5D2P2698	JLS5D2088	0.00	JLS5D2086	437.20	0.00	437.20	-	GIS	Unknown	-	437.574	437.200
2658	JLS5D2P2658	JLS5D2087	0.00	JLS5D2086	437.20	0.00	437.20	-	GIS	Unknown	-	437.727	437.200
7382	DTS6E4P7382	DTS6F3002	0.00	DTS6E4091	0.00	500.50	0.00	Model	-	-	Unknown	500.500	499.415
2858	JLS5D2P2858	JLS5D2042	0.00	JLS5D2040	435.19	0.00	435.19	-	GIS	Unknown	-	435.481	435.190
5999	DTS6E1P5999	STUB2324	0.00	DTS5E3T005	448.89	0.00	448.89	-	GIS	Unknown	-	449.036	448.890
4444	DTS6E4P4444	DTS6E4072	0.00	DTS6E4071	0.00	0.00	502.82	-	Model	Unknown	-	504.110	502.820
4359	DTS6E4P4359	DTS6E4093	0.00	DTS6E4071	0.00	0.00	502.82	-	Model	Unknown	-	504.078	502.820
4666	ECS7D2P4666	ECS7D2089	0.00	ECS7D2084	456.16	0.00	456.16	-	GIS	Unknown	-	457.027	456.160
4672	ECS7D2P4672	ECS7D2091	462.36	ECS7D2089	0.00	462.36	0.00	GIS	-	-	Unknown	462.360	461.423
4758	ECS7D2P4758	ECS7D2090	462.95	ECS7D2089	0.00	462.95	0.00	GIS	-	-	Unknown	462.950	461.561
4674	ECS7D2P4674	ECS7D2096	0.00	ECS7D2095	467.30	0.00	467.30	-	GIS	Unknown	-	467.907	467.300
4369	JLS6E3P4369	JLS6E3092	0.00	JLS6E3013	0.00	454.04	452.86	Interpolate	Model	Need Confirmation	-	454.040	452.860
3257	JLS5D3P3257	JLS5D3039	0.00	JLS5D3038	0.00	428.33	426.03	Interpolate	Model	Need Confirmation	-	428.330	426.030
217	STS3G4P0217	STS3G4088	0.00	STS3G4086	0.00	519.33	517.31	Interpolate	Model	Need Confirmation	-	519.330	517.310
4822	RHS7D3P4822	RHS7D3066	0.00	RHS7D3063	429.00	429.00	429.00	AMBIGUOUS MH	GIS	Need Confirmation	-	429.459	429.000
4424	DTS6E4P4424	DTS6E4025	0.00	DTS6E4024	0.00	485.20	485.20	Interpolate	Model	Need Confirmation	-	485.200	485.200
5761	ECS8E3P5761	ECS8E3067	0.00	ECS8E3066	0.00	517.51	516.71	AMBIGUOUS MH	Model	Need Confirmation	-	516.817	516.710
7022	EAS7G2P7022	EAS7G2005	0.00	EAS7G2004	0.00	577.78	576.78	Ambiguous MH	Model	Need Confirmation	-	577.265	576.780
997	STS2G3P0997	STS2G3006	0.00	STS2G3003	0.00	492.33	491.23	Interpolate	Model	Need Confirmation	-	492.330	491.230
5399	ECS7E3P5399	ECS7E3112	0.00	ECS7E3110	0.00	518.20	517.20	Ambiguous MH	Model	Need Confirmation	-	518.150	517.200
7447	PPS4G1TP7447	PPS4G1T009	515.19	PPS4G1T008A	0.00	515.19	515.19	GIS	Interpolate	-	Need Confirmation	515.190	514.670
7554	JLS5C2P7554	JLS5C2F001	0.00	CB	0.00	397.20	402.66	Model	Interpolate	-	Need Confirmation	397.270	397.217
7608	JLS5D2P7608	JLS5D2079	0.00	JLS5D2077A	448.17	452.42	448.17	Interpolate	GIS	Need Confirmation	-	449.172	448.170

Table 2. GIS and Model Discrepancy by Diameter

Pipe ID	Manhole Upstream ID	Manhole Downstream ID	GIS Diameter, inch	Model Diameter, inch	Proposed Diameter, inch
JLS5D1P0643	JLS5D1134	JLS5D1044	12	33	12
JLS5D1TP0382	JLS5D1001	JLS5D1T002	12	30	12
JLS5D1P0639	JLS5D1043	JLS5D1042	12	30	12
JLS5D1P0640	JLS5D1042	JLS5D1001	12	30	12
JLS5D1P0641	JLS5D1044	JLS5D1043	12	30	12
DTS5E3TP2879	DTS5E3T003	DTS5E3T002	21	24	21
RHS8D1P0054	RHS8D1002	RHS8D1001	36	18	36
DTS6E2P3874	DTS6E2054	DTS5E3T030	18	15	18
DTS6E2P3965	DTS6E2061	DTS6E2054	18	15	18
JLS6E3P4088	JLS6E3075	JLS6E3074	12	10	12
DTS6E2P3757	DTS6E2033	DTS6E2030	6	10	6
JLS6D2P6019	JLS6D2019	JLS6D2018	8	10	8
JLS6D2P6020	JLS6D2020	JLS6D2019	8	10	8
JLS5D2P2535	JLS5D2004	JLS5D2003	8	10	8
JLS5D2P2539	JLS5D2005	JLS5D2004	8	10	8
JLS6E3P3979	JLS6E3074	JLS6E3073	12	10	12
DTS6E2P3909	DTS6E2025	DTS6E2019	8	10	8
DTS6E2P3949	DTS6E2024	DTS6E2017	8	10	8
ACS5C1P2748	ACS5C1021	ACS5C1020	8	10	8
JLS6E3P4107	JLS6E3076	JLS6E3075	12	10	12
JLS6D2P3507	JLS6D2021	JLS6D2019	8	10	8
JLS6E3P4166	JLS6E3078	JLS6E3076	12	10	12
JLS6E3P4262	JLS6E3081	JLS6E3079	12	10	12
JLS6E3P4224	JLS6E3079	JLS6E3078	12	10	12
DTS6E4P4226	DTS6E4039	DTS6E4038	10	10	10
JLS5C2FP7533	JLS5C2F002	JLS5C2F001	12	10	12
ECS8D2P5701	ECS8D2061	ECS8D2060	15	8	15
ECS8D2P5699	ECS8D2060	ECS8D2057	15	8	15
JLS5D2P5994	JLS5D2074	JLS5D4T011	10	8	10
JLS6D2P6869	JLS6D2090	JLS6D2090A	10	8	10
JLS6D2P6731	JLS6D2088A	DTS6E1T009	10	8	10
JLS6D2P6734	JLS6D2090A	JLS6D2089A	10	8	10
EAS6F1P3283	EAS6F1018	EAS6F1013	8	6	8
EAS6F1P3319	EAS6F1013	EAS6F1012	8	6	8
EAS6F1P3359	EAS6F1012	EAS6F1001A	8	6	8
EAS6F1P7049	EAS6F1001A	EAS6F1001	8	6	8

Table 3. List of Larger Gravity Mains Upstream of Smaller Gravity Main

Pipe ID	Manhole Upstream ID	Manhole Downstream ID	GIS Diameter, inch	Comments
RHS6C2TP0076	RHS6C2T003	RHS6C2T002	36	36-inch between 39-inch
DTS5F3TP2744	DTS5F3T012	PPS5F4001	30	30-inch to 27-inch
DTS5F3TP2810	DTS5F3T011	DTS5F3T010	30	30-inch to 27-inch
DTS5F3TP2881	DTS5F3T010	DTS5F3T009	30	30-inch to 27-inch
DTS5F3TP2925	DTS5F3T009	DTS5F3T008	30	30-inch to 27-inch
DTS5F3TP2988	DTS5F3T008	DTS5F3T007	30	30-inch to 27-inch
DTS5F3TP3035	DTS5F3T007	DTS5F3T006	30	30-inch to 27-inch
DTS5F3TP3084	DTS5F3T006	DTS5F3T005	30	30-inch to 27-inch
DTS5F3TP7021	PPS5F4001	DTS5F3T011	30	30-inch to 27-inch
PPS5F2TP2625	PPS5F2T001A	PPS5F2T001	30	30-inch to 27-inch
PPS5F2TP2684	PPS5F2T001	DTS5F3T012	30	30-inch to 27-inch
DTS5F3TP3111	DTS5F3T005	DTS5F3T004	27	27-inch to 24
DTS5F3TP3120	DTS5F3T004	DTS5F3T002	27	27-inch to 24
DTS5F3TP5945	DTS5F3T002	DTS5F3T001A	24	24-inch between 27-inch
DTS5F3TP7411	DTS5F3T002	DTS5F3T001A	24	24-inch between 27-inch
DTS6E1TP6530	DTS6E1T019	DTS6E1T018	24	24-inch between 27-inch
DTS6E1TP6532	DTS6E1T020	DTS6E1T019	24	24-inch between 27-inch
DTS6E1TP6696	DTS6E1T036	DTS6E1T035	24	24-inch between 27-inch
DTS6E1TP6698	DTS6E1T033	DTS6E1T031	24	24-inch between 27-inch
DTS6E1TP6699	DTS6E1T031	DTS6E1T030	24	24-inch between 27-inch
DTS6E1TP6701	DTS6E1T034	DTS6E1T033	24	24-inch between 27-inch
DTS6E1TP6702	DTS6E1T035	DTS6E1T034	24	24-inch between 27-inch
DTS6E1TP6730	DTS6E1T015	DTS6E1T014	24	24-inch between 27-inch
DTS6E1TP6733	DTS6E1T018	DTS6E1T017	24	24-inch between 27-inch
DTS6E1TP6735	DTS6E1T016	DTS6E1T015	24	24-inch between 27-inch
DTS6E1TP6736	DTS6E1T014	DTS6E1T013	24	24-inch between 27-inch
DTS6E1TP6737	DTS6E1T013	DTS6E1T012	24	24-inch between 27-inch
DTS6E1TP6738	DTS6E1T012	DTS6E1T011	24	24-inch between 27-inch
DTS6E1TP6739	DTS6E1T011	DTS6E1T010	24	24-inch between 27-inch
DTS6E1TP6740	DTS6E1T017	DTS6E1T016	24	24-inch between 27-inch
DTS6E1TP6866	DTS5F3T001	DTS6E1T036	24	24-inch between 27-inch
DTS6E1TP7073	DTS6E1T030	DTS6E1T029	24	24-inch between 27-inch
DTS6E1TP7074	DTS6E1T029	DTS6E1T028	24	24-inch between 27-inch
DTS6E1TP7075	DTS6E1T028	DTS6E1T027	24	24-inch between 27-inch
DTS6E1TP7077	DTS6E1T027	DTS6E1T026	24	24-inch between 27-inch
DTS6E1TP7078	DTS6E1T026	EAS6G4093	24	24-inch between 27-inch
DTS6E1TP7079	DTS6E1T025	DTS6E1T024	24	24-inch between 27-inch
DTS6E1TP7080	DTS6E1T024	DTS6E1T023	24	24-inch between 27-inch
DTS6E1TP7081	DTS6E1T023	DTS6E1T022	24	24-inch between 27-inch
DTS6E1TP7082	DTS6E1T022	DTS6E1T021	24	24-inch between 27-inch
DTS6E1TP7083	DTS6E1T021	DTS6E1T020	24	24-inch between 27-inch
DTS6E1TP7386	DTS5F3T001A	DTS5F3T001	24	24-inch between 27-inch
PPS4H3P1777	PPS4H3022	PPS4H3020	18	18-inch to 10-inch
PPS4H4P1691	PPS4H4005	PPS4H4004	18	18-inch to 10-inch
PPS4H4P1707	PPS4H4004	PPS4H4003	18	18-inch to 10-inch
PPS4H4P1730	PPS4H4003	PPS4H4002	18	18-inch to 10-inch
PPS4H4P1760	PPS4H4002	PPS4H4001	18	18-inch to 10-inch
PPS4H4P1775	PPS4H4001	PPS4H3022	18	18-inch to 10-inch
RHS8D3P5732	RHS8D3018	RHS8D3017	18	18-inch between 15-inch
RHS8D3P5750	RHS8D3019	RHS8D3018	18	18-inch between 15-inch
RHS8D3P5758	RHS8D3020	RHS8D3019	18	18-inch between 15-inch
RHS8D3P5762	RHS8D3021	RHS8D3020	18	18-inch between 15-inch
JLS5D1P2036	JLS5D1099	JLS5D1098	15	15-inch to 8-inch
ACS4C2P0283	TICK5565	ACS4C2028	12	12-inch to 8-inch
DTS6F3P4690	DTS6F3033	DTS6F3032	12	12-inch conveys to 8-inch
DTS6F3P4705	DTS6F3034	DTS6F3033	12	12-inch conveys to 8-inch
DTS6F3P4706	DTS6F3035	DTS6F3034	12	12-inch conveys to 8-inch
EAS6F1P3220	EAS6F2039	EAS6F1033	12	12-inch to 8-inch
EAS6F2P3231	EAS6F2040	EAS6F2039	12	12-inch to 8-inch
EAS6F2P3237	EAS6F2043	EAS6F2040	12	12-inch to 8-inch
EAS6F2P3240	EAS6F2046	EAS6F2043	12	12-inch to 8-inch
EAS6F2P3288	EAS6F2050	EAS6F2046	12	12-inch to 8-inch
EAS6F2P3296	EAS6F2055	EAS6F2050	12	12-inch to 8-inch
EAS6F2P3308	EAS6F2059	EAS6F2055	12	12-inch to 8-inch
EAS6F2P3336	EAS6F2060	EAS6F2059	12	12-inch to 8-inch
EAS6F2P3402	EAS6F2061	EAS6F2060	12	12-inch to 8-inch
EAS6F2P3502	EAS6F2063	EAS6F2061	12	12-inch to 8-inch
EAS6F2P3511	EAS6F2064	EAS6F2063	12	12-inch to 8-inch
EAS6F2P3514	EAS6F2065	EAS6F2064	12	12-inch to 8-inch
ECS8E3P5911	ECS8E3025	ECS8E3024	12	12-inch conveys to 8 and 10-inch
RHS7D3P4861	RHS7D3054	RHS7D3053	12	12-inch conveys to 8-inch
RHS7D3P4864	RHS7D3062	RHS7D3054	12	12-inch conveys to 8-inch
RHS7D3P4873	RHS7D3053	RHS7D3049	12	12-inch conveys to 8-inch
RHS7D3P4946	RHS7D3068	RHS7D3062	12	12-inch conveys to 8-inch
RHS7D3P4995	RHS7D3069	RHS7D3068	12	12-inch conveys to 8-inch
RHS7D3P5046	RHS7D3070	RHS7D3069	12	12-inch conveys to 8-inch
RHS7D3P5099	RHS7D3071	RHS7D3070	12	12-inch conveys to 8-inch
RHS7D3P5100	RHS7D3077	RHS7D3071	12	12-inch conveys to 8-inch
STS2H1P0789	STS2H1057	STS2H1056	12	12-inch to 8-inch
STS2H1P0808	STS2H1056	STS2H1054	12	12-inch to 8-inch
STS2H1P0863	STS2H1055	STS2H1054	12	12-inch to 8-inch
STS3G2P7667	STS3G2057B	STS3G2057A	12	12-inch to 8-inch
STS3G2P7668	STS3G2057C	STS3G2057B	12	12-inch to 8-inch
STS3G3P1254	STS3G4001	STS3G3077	12	10-inch between 8-inch
STS3G4P1268	STS3G4002	STS3G4001	12	10-inch between 8-inch
STS3G4P1272	STS3G4004	STS3G4002	12	10-inch between 8-inch
JLS5C2P0421	JLS5C2056	JLS5C2064	10	10-inch between 8-inch
JLS5C2P6066	JLS5C2064	JLS5C2062	10	10-inch between 8-inch
JLS5D2P2583	JLS5D2001A	JLS5D2004	10	10-inch betweeen 8-inch
JLS6D2P3064	JLS6D2070	JLS6D2066	10	10-inch between 8-inch
JLS6D2P7605	JLS6D2066	JLS6D2066A	10	10-inch between 8-inch
JLS6E3P4091	JLS6E3026	JLS6E3025	10	10-inch between 8-inch
JLS6E3P4145	JLS6E3001A	JLS6E3001	10	10-inch between 8-inch
JLS6E3P4180	JLS6E3003	JLS6E3002	10	10-inch between 8-inch
JLS6E3P4185	JLS6E3030	JLS6E3026A	10	10-inch between 8-inch
JLS6E3P6178	JLS6E3002	JLS6E3001A	10	10-inch between 8-inch
JLS6E3P6744	JLS6E3026A	JLS6E3026	10	10-inch between 8-inch
PPS4F4P1667	PPS4F4113	PPS4F4114	10	10-inch between 8-inch
PPS4F4P6067	PPS4F4111	PPS4F4112	10	10-inch between 8-inch
PPS4F4P6068	PPS4F4112	PPS4F4113	10	10-inch between 8-inch
PPS5G4P2304	PPS5G4002	PPS5G4001	10	10-inch to 8-inch
PPS5G4P2492	PPS5G4003	PPS5G4002	10	10-inch to 8-inch
PPS5G4P2587	PPS5G4004	PPS5G4003	10	10-inch to 8-inch

Table 3. List of Larger Gravity Mains Upstream of Smaller Gravity Main

Pipe ID	Manhole Upstream ID	Manhole Downstream ID	GIS Diameter, inch	Comments
PPS5G4P3018	PPS6G2001A	PPS5G4008	10	10-inch to 8-inch
PPS5G4P6320	PPS5G4001	PPS5G4001A	10	10-inch to 8-inch
PPS6H1P3488	PPS6H1012	PPS6H1011	10	10-inch to 8-inch
PPS6H1P3491	PPS6H1013	PPS6H1012	10	10-inch to 8-inch
PPS6H1P3492	PPS6H1013A	PPS6H1013	10	10-inch to 8-inch
PPS6H1P3494	PPS6H1014	PPS6H1013A	10	10-inch to 8-inch
PPS6H1P3497	PPS6H1011	PPS6H1011A	10	10-inch to 8-inch
PPS6H1P3549	PPS6H1011A	PPS6H1010	10	10-inch to 8-inch
PPS6H1P3685	PPS6H1010	PPS6H1009	10	10-inch to 8-inch
PPS6H1P3732	PPS6H1009	PPS6H1008	10	10-inch to 8-inch
PPS6H1P3753	PPS6H1008	PPS6H1007	10	10-inch to 8-inch
PPS6H1P3754	PPS6H1007	PPS6H1006	10	10-inch to 8-inch
STS3G2P1262	STS3G2051	STS3G2050	10	10-inch between 8-inch
STS3G2P6023	STS3G2052	STS3G2051	10	10-inch between 8-inch
STS3G2P7639	STS3G2050	STS3G2072	10	10-inch between 8-inch
STS3G2P7640	STS3G2064	STS3G2037	10	10-inch between 8-inch
STS3G2P7641	STS3G2072	STS3G2077	10	10-inch between 8-inch
STS3G2P7642	STS3G2077	STS3G2070	10	10-inch between 8-inch
STS3G2P7643	STS3G2070	STS3G2069	10	10-inch between 8-inch
STS3G2P7644	STS3G2069	STS3G2068	10	10-inch between 8-inch
STS3G2P7645	STS3G2068	STS3G2067	10	10-inch between 8-inch
STS3G2P7646	STS3G2067	STS3G2066	10	10-inch between 8-inch
STS3G2P7647	STS3G2066	STS3G2065	10	10-inch between 8-inch
STS3G2P7648	STS3G2065	STS3G2064	10	10-inch between 8-inch
STS3G3P1119	STS3G3071	STS3G3070	10	10-inch between 8-inch
STS3G3P1124	STS3G3072	STS3G3071	10	10-inch between 8-inch
STS3G3P1199	STS3G3075	STS3G3072	10	10-inch between 8-inch
STS3G3P1244	STS3G3076	STS3G3075	10	10-inch between 8-inch
STS3G3P1255	STS3G3077	STS3G3076	10	10-inch between 8-inch
STS3G3P1292	STS3G3078	STS3G3077	10	10-inch between 8-inch
STS3G4P1280	STS3G4005	STS3G4004	10	10-inch between 8-inch
STS3G4P1343	STS3G4006	STS3G4005	10	10-inch between 8-inch
ACS4C2P0298	ACS4C2028	ACS4C2027	8	8-inch between 12-inch
JLS6D2P2961	JLS6D2066A	JLS5D2074	8	8-inch between 10-inch
RHS8D3P5824	RHS8D3036	RHS8D3035	8	8-inch between 15-inch
RHS8D3P5830	RHS8D3035	RHS8D3034	8	8-inch between 15-inch
RHS8D3P5832	RHS8D3034	RHS8D3033	8	8-inch between 15-inch
RHS8D3P5837	RHS8D3030	RHS8D3029	8	8-inch between 15-inch
JLS6D2P6720	JLS6D2089A	JLS6D2088A	6	6-inch between 8-inch

Table 4.a GIS Gravity Mains and Manholes Discrepancy by Owner - List of Gravity Mains					
Pipe ID	Manhole Upstream ID	Manhole Downstream ID	Type	Owner By GIS	Proposed Owner
JLS6E3P3883	JLS6E3020	JLS6E3019	PIPE	PRIVATE	PUBLIC
PPS4H1P6082	Private5950	PrivPump5949	PIPE	PUBLIC	PRIVATE
PPS4H1P6083	Private5951	Private5950	PIPE	PUBLIC	PRIVATE
PPS4H1P6084	Private5952	Private5951	PIPE	PUBLIC	PRIVATE
ECS7F3P7406	ECS7F3036	ECS7F3035	PIPE	PRIVATE	PUBLIC
PPS4H1P6081	PrivPump5949	ForceMain	FORCED	PUBLIC	PRIVATE
PPS4H1P6085	Private5948	PrivPump5949	PIPE	PUBLIC	PRIVATE
PPS4H1P6086	Private5947	Private5948	PIPE	PUBLIC	PRIVATE
PPS4H1P6087	Private5953	PrivPump5949	PIPE	PUBLIC	PRIVATE
ECS7F3P7410	ECS7F3051	ECS7F3050	PIPE	PRIVATE	PUBLIC
PPS5I2TP7444	PPS5I2T012	PRIVATE7228	PIPE	PUBLIC	PRIVATE
	Confirmed by Mike Wells				

Table 4.b GIS Gravity Mains and Manholes Discrepancy by Owner - List of Manholes

Manhole ID	Type	Basin ID	Owner By GIS	Proposed Owner
DTS5E2092	MH	DTS5E2	PUBLIC	PRIVATE
JLS6E3019	MH	JLS6E3	PUBLIC	PUBLIC
ECS7E2023	MH	ECS7E2	PUBLIC	PRIVATE
PRIVATE5947	TICK	PPS4H1	PUBLIC	PRIVATE
PRIVATE5948	MH	PPS4H1	PUBLIC	PRIVATE
PrivPump5949	PUMP	PPS4H1	PRIVATE	PRIVATE
PRIVATE5950	MH	PPS4H1	PUBLIC	PRIVATE
PRIVATE5951	SSCO	PPS4H1	PUBLIC	PRIVATE
PRIVATE5952	TICK	PPS4H1	PUBLIC	PRIVATE
PRIVATE5953	PLUG	PPS4H1	PUBLIC	PRIVATE
PRIVATE6496	MH	EAS6F2	PUBLIC	PRIVATE
PRIVATE6497	MH	EAS6F2	PUBLIC	PRIVATE
PRIVATE6498	MH	EAS6F2	PUBLIC	PRIVATE
PRIVATE6499	MH	EAS6F2	PUBLIC	PRIVATE
ECS7F3051	MH	ECS7F3	PUBLIC	PUBLIC
ECS7F3036	MH	ECS7F3	PUBLIC	PUBLIC
PRIVATE7228	NODE	PPS5I2T	PRIVATE	PRIVATE
EAS6F1101R	MH	EAS6F1	PUBLIC	PRIVATE
EAS6F1105R	MH	EAS6F1	PUBLIC	PRIVATE

Confirmed by Mike Wells

Table 5. GIS and Model Discrepancy by Invert Elevation

Pipe ID	Manhole Upstream ID	GIS Upstream Invert Elevation, ft	Model Upstream Invert Elevation, ft	Upstream Invert Elevation Difference, ft	Manhole Downstream ID	GIS Downstream Invert Elevation, ft	Model Downstream Invert Elevation, ft	Downstream Invert Elevation Difference, ft	Proposed Upstream Invert Elevation, ft	Proposed Downstream Invert Elevation, ft	Status
DTS6E1TP6702	DTS6E1T035	485.146	485.15	-0.004	DTS6E1T034	483.206	483.21	-0.004	485.146	483.206	Different_Invert_In & Out
DTS6E1TP6701	DTS6E1T034	483.206	483.21	-0.004	DTS6E1T033	481.526	481.53	-0.004	483.206	481.526	Different_Invert_In & Out
DTS5E3P6700	DTS5E3014	487.771	487.77	0.001	DTS6E1T032	486.056	486.06	-0.004	487.771	486.056	Different_Invert_In & Out
DTS6E1TP6698	DTS6E1T033	481.526	481.53	-0.004	DTS6E1T031	479.166	479.17	-0.004	481.526	479.166	Different_Invert_In & Out
DTS5E3P6697	DTS6E1T032	486.056	486.06	-0.004	DTS6E1T031	479.916	479.92	-0.004	486.056	479.916	Different_Invert_In & Out
PPS4H4P0278	PPS4H4044	578.26	578.4	-0.14	PPS4H4043A	578.06	578.16	-0.1	578.26	578.06	Different_Invert_In & Out
EAS6G4P6202	EAS6G4094	582.4	583.1	-0.7	EAS6G4089	580.9	580.8	0.1	582.4	580.9	Different_Invert_In & Out
EAS6G4P6194	EAS6G4089	580.9	580.8	0.1	EAS6G4090	580.8	580.5	0.3	580.9	580.8	Different_Invert_In & Out
EAS6G4P6196	EAS6G4090	580.7	580.5	0.2	EAS6G4086	578.9	578.8	0.1	580.7	578.9	Different_Invert_In & Out
RHS6C2TP0061	RHS7C2T002	403.1	403.14	-0.04	RHS6C2T020	402.94	402.89	0.05	403.1	402.94	Different_Invert_In & Out
ACS4C2P0271	ACS4C2011	425.8	422.53	3.27	ACS4C2009	414.28	416.37	-2.09	425.8	414.28	Different_Invert_In & Out
ACS4C2P0274	ACS4C2009	414.28	416.37	-2.09	ACS4C2008	405.54	410.62	-5.08	414.28	405.54	Different_Invert_In & Out
JLS6E3P4088	JLS6E3075	464.93	466	-1.07	JLS6E3074	463.94	465.2	-1.26	464.93	463.94	Different_Invert_In & Out
RHS9E1P6893	RHS9E1032	458.17	457.24	0.93	RHS9E1031	457.92	456.48	1.44	458.17	457.92	Different_Invert_In & Out
RHS9E1P6895	RHS9E1035	459.76	459.77	-0.01	RHS9E1033	459.48	459.38	0.1	459.76	459.48	Different_Invert_In & Out
RHS9E1P6896	RHS9E1036	460.11	460.12	-0.01	RHS9E1035	459.76	459.77	-0.01	460.11	459.76	Different_Invert_In & Out
RHS9E1P6897	RHS9E1037	460.46	460.47	-0.01	RHS9E1036	460.11	460.12	-0.01	460.46	460.11	Different_Invert_In & Out
JLS5C2P0368	JLS5C2050	399.64	399.38	0.26	JLS5C2049	399.33	398.79	0.54	399.64	399.33	Different_Invert_In & Out
EAS6G4P6258	EAS6G4075	574.5	561.17	13.33	EAS6G4074	572.9	532.53	40.37	574.5	572.9	Different_Invert_In & Out
EAS6G4P6259	EAS6G4074	572.8	532.53	40.27	EAS6G4073	572.5	527.4	45.1	572.8	572.5	Different_Invert_In & Out
PPS4G3TP2310	PPS4G3T004	510.01	510.02	-0.01	PPS4G3T003	511.32	509.88	1.44	510.01	511.32	Different_Invert_In & Out
DTS6E4P4094	DTS6E4059	492.97	493.02	-0.05	DTS6E4058	490.43	490.49	-0.06	492.97	490.43	Different_Invert_In & Out
JLS5D1P0639	JLS5D1043	414.55	414.48	0.07	JLS5D1042	408.8	408.89	-0.09	414.55	408.8	Different_Invert_In & Out
JLS5D1P0640	JLS5D1042	408.8	408.89	-0.09	JLS5D1001	404.61	404.4	0.21	408.8	404.61	Different_Invert_In & Out
JLS5D1P0641	JLS5D1044	420.22	420.07	0.15	JLS5D1043	414.55	414.48	0.07	420.22	414.55	Different_Invert_In & Out
EAS6G4P0489	EAS6G4064	568.9	566.18	2.72	EAS6G4060	564.5	563.46	1.04	568.9	564.5	Different_Invert_In & Out
EAS6G4P0490	EAS6G4066	569.2	568.9	0.3	EAS6G4064	568.9	566.18	2.72	569.2	568.9	Different_Invert_In & Out
PPS5G3P2896	PPS5G3042	531	531.1	-0.1	PPS5G3041	531.1	531	0.1	531	531.1	Different_Invert_In & Out
EAS6G4P6183	EAS6G4134	587.1	589.2	-2.1	EAS6G4100	585.3	587.3	-2	587.1	585.3	Different_Invert_In & Out
RHS9E1P6900	RHS9E1072	478.77	475.72	3.05	RHS9E1071	476.4	473.88	2.52	478.77	476.4	Different_Invert_In & Out
RHS9E1P6902	RHS9E1073	479.4	476.56	2.84	RHS9E1072	478.87	475.72	3.15	479.4	478.87	Different_Invert_In & Out
RHS9E1P6903	RHS9E1082	482.1	479.91	2.19	RHS9E1073	479.4	476.56	2.84	482.1	479.4	Different_Invert_In & Out
RHS9E1P6904	RHS9E1083	483.4	481.92	1.48	RHS9E1082	482.2	479.91	2.29	483.4	482.2	Different_Invert_In & Out
RHS9E1P6906	RHS9E1103	493.9	493.65	0.25	RHS9E1102	490	489.17	0.83	493.9	490	Different_Invert_In & Out
RHS9E1P6907	RHS9E1104	495.5	495.38	0.12	RHS9E1103	494	493.65	0.35	495.5	494	Different_Invert_In & Out
RHS9E1P6908	RHS9E1107	514.3	510.48	3.82	RHS9E1106	502.2	502.1	0.1	514.3	502.2	Different_Invert_In & Out
STS2H4P0820	STS2H2001	535.94	536.8	-0.86	STS2H4058	536.8	535.94	0.86	535.94	536.8	Different_Invert_In & Out
JLS6E3P6178	JLS6E3002	445.13	444.7	0.43	JLS6E3001A	444.54	443.7	0.84	445.13	444.54	Different_Invert_In & Out
DTS6E1TP6866	DTS5F3T001	485.9	491.597	-5.697	DTS6E1T036	485.2	490.52	-5.32	485.9	485.2	Different_Invert_In & Out
JLS6E3P6117	JLS6E3045A	468.16	468.61	-0.45	JLS6E3045	464.9	468.061	-3.161	468.16	464.9	Different_Invert_In & Out
DTS6E4P4235	DTS6E4022	479.013	479.01	0.003	DTS6E4017	474.603	474.6	0.003	479.013	474.603	Different_Invert_In & Out
PPS3H4P1260	PPS3H4036	556.15	556.45	-0.3	PPS3H4035	556.45	556.15	0.3	556.15	556.45	Different_Invert_In & Out
STS3G3P1067	STS3G3001	496.3	491.96	4.34	STS3G1T001	497	490.85	6.15	496.3	497	Different_Invert_In & Out
EAS7H1P6188	EAS7H1001	591.8	604.9	-13.1	EAS6G4136	591.5	591.4	0.1	591.8	591.5	Different_Invert_In & Out
EAS7H1P6956	EAS7H1023	609.5	609.8	-0.3	EAS7H1022	606.3	606.2	0.1	609.5	606.3	Different_Invert_In & Out
EAS7H1P6958	EAS7H1021	602.7	601.99	0.71	EAS7H1020	597.7	597.6	0.1	602.7	597.7	Different_Invert_In & Out
DTS6E1TP6532	DTS6E1T020	464.388	464.39	-0.002	DTS6E1T019	462.267	463.33	-1.063	464.388	462.267	Different_Invert_In & Out
RHS7C2TP0057	RHS8D1001	403.66	403.62	0.04	RHS7C2T002	403.1	403.14	-0.04	403.66	403.1	Different_Invert_In & Out
JLS5C4TP0087	RHS6C2T001	406.57	398.78	7.79	JLS5C4T009	404.96	398.53	6.43	406.57	404.96	Different_Invert_In & Out
STS3G4P1491	STS3G4026	512.58	513.03	-0.45	STS3G4011	513.03	512.58	0.45	512.58	513.03	Different_Invert_In & Out
EAS6G4P6257	EAS6G4076	574.8	563.22	11.58	EAS6G4075	574.6	561.17	13.43	574.8	574.6	Different_Invert_In & Out
RHS9E1P6506	RHS9E1018	444.3	445.43	-1.13	RHS9E1017	443.7	444.62	-0.92	444.3	443.7	Different_Invert_In & Out
JLS6E3P6118	JLS6E3046	468.53	468.061	0.469	JLS6E3045A	468.16	464.9	3.26	468.53	468.16	Different_Invert_In & Out
RHS6D3P4473	RHS6D3037	419.3	419.64	-0.34	RHS6D3036	419.64	419.3	0.34	419.3	419.64	Different_Invert_In & Out
JLS5C2P0367	JLS5C2049	399.53	398.79	0.74	JLS5C2048	398.87	398.2	0.67	399.53	398.87	Different_Invert_In & Out
DTS6E1TP6531	DTS6E2004	463.977	464.08	-0.103	DTS6E1T019	463.327	463.33	-0.003	463.977	463.327	Different_Invert_In & Out
JLS5D2P2634	JLS5D2092	440.28	438.28	2	JLS5D2090	442.4	437.77	4.63	440.28	442.4	Different_Invert_In & Out
JLS6D1P2987	JLS6D1054	409.76	410.26	-0.5	JLS6D1051	410.26	409.76	0.5	409.76	410.26	Different_Invert_In & Out
PPS4G3TP1894	PPS4G3T012	511.57	511.6	-0.03	PPS4G3T011	511.59	511.38	0.21	511.57	511.59	Different_Invert_In & Out
JLS6E3P4145	JLS6E3001A	444.44	444.7	-0.26	JLS6E3001	444.04	443.7	0.34	444.44	444.04	Different_Invert_In & Out
STS2H1P0740	STS2H1009	516.9	520.33	-3.43	STS2H1008	520.43	515.19	5.24	516.9	520.43	Different_Invert_In & Out
EAS6G4P6187	EAS6G4097	583.2	585.3	-2.1	EAS6G4094	582.5	583.1	-0.6	583.2	582.5	Different_Invert_In & Out
JLS6D1P3680	JLS6D1078	419.42	420.62	-1.2	JLS6D1075	420.62	419.42	1.2	419.42	420.62	Different_Invert_In & Out
DTS6E1TP6722	DTS6E1T002	442.406	442.41	-0.004	DTS6E1T001	441.181	441.18	0.001	442.406	441.181	Different_Invert_In & Out
DTS6E1TP6721	DTS6E1T001	441.131	441.13	0.001	JLS5D4T014	440.876	440.88	-0.004	441.131	440.876	Different_Invert_In & Out
EAS7H1P6217	EAS7H1038	622.6	662.6	-40	EAS7H1037	620.9	621.3	-0.4	622.6	620.9	Different_Invert_In & Out
JLS6D1P3027	JLS6D1016	406.51	406.36	0.15	JLS6D1015	406.51	405.79	0.72	406.51	406.51	Different_Invert_In & Out
DTS6E1TP6737	DTS6E1T013	453.516	453.52	-0.004	DTS6E1T012	452.736	452.74	-0.004	453.516	452.736	Different_Invert_In & Out
DTS6E1TP6738	DTS6E1T012	452.736	452.74	-0.004	DTS6E1T011	451.056	451.06	-0.004	452.736	451.056	Different_Invert_In & Out
DTS6E1TP6739	DTS6E1T011	451.056	451.06	-0.004	DTS6E1T010	449.786	449.79	-0.004	451.056	449.786	Different_Invert_In & Out
DTS6E1TP6732	DTS6E1T010	449.786	449.79	-0.004	DTS6E1T009	448.481	448.48	0.001	449.786	448.481	Different_Invert_In & Out
DTS6E1TP6729	DTS6E1T009	448.481	448.48	0.001	DTS6E1T008	447.201	447.2	0.001	448.481	447.201	Different_Invert_In & Out
DTS6E1TP6728	DTS6E1T008	447.201	447.2	0.001	DTS6E1T007	446.951	446.87	0.081	447.201	446.951	Different_Invert_In & Out
DTS6E1TP6727	DTS6E1T007	446.87	446.95	-0.08	DTS6E1T006	446.556	446.56	-0.004	446.87	446.556	Different_Invert_In & Out
DTS6E1TP6726	DTS6E1T006	446.556	446.56	-0.004	DTS6E1T005	445.376	445.38	-0.004	446.556	445.376	Different_Invert_In & Out
JLS5D3P3055	JLS5D3093	412.61	413.66	-1.05	JLS5D3087	412.61	412.66	-0.05	412.61	412.61	Different_Invert_In & Out
RHS8D3P5832	RHS8D3034	429.3	429.4	-0.1	RHS8D3033	429.92	429.26	0.66	429.3	429.92	Different_Invert_In & Out
JLS6E3P4298	JLS6E3066	470.69	471.314	-0.624	JLS6E3071A	469.5	469.782	-0.282	470.69	469.5	Different_Invert_In & Out
RHS9E1P6890	RHS9E1029	457.46	454.19	3.27	RHS9E1028	457.26	452.2	5.06	457.46	457.26	Different_Invert_In & Out
RHS9E1P6891	RHS9E1030	457.67	455.33	2.34	RHS9E1029	457.56	454.19	3.37	457.67	457.56	Different_Invert_In & Out
RHS9E1P6500	RHS9E1002	441.46	441.49	-0.03	RHS9E1001	441.25	441.11	0.14	441.46	441.25	Different_Invert_In & Out
EAS6G4P6184	EAS6G4100	585.2	587.3	-2.1	EAS6G4098	584.2	585.8	-1.6	585.2	584.2	Different_Invert_In & Out
DTS5F3TP3035	DTS5F3T007	501.3	501.25	0.05	DTS5F3T006	499.76	499.8	-0.04	501.3	499.76	Different_Invert_In & Out
JLS6E3P3979	JLS6E3074	463.94	465.2	-1.26	JLS6E3073	463.56	464	-0.44	463.94	463.56	Different_Invert_In & Out
PPS6H1P3813	PPS6H1005	579.85	579.68	0.17	PPS6H1004	579.46	579.29	0.17	579.85	579.46	Different_Invert_In & Out
ECS7E4P5170	ECS7E4005	512.18	514.16	-1.98	ECS7E4003	514.08	513.97	0.11	512.18	514.08	Different_Invert_In & Out
RHS9E1P6552	RHS9E1056	467.6	468.78	-1.18	RHS9E1055	467.22	467.6	-0.38	467.6	467.22	Different_Invert_In & Out
STS3G4P1280	STS3G4005	507.49	507.77	-0.28	STS3G4004	507.77	507.49	0.28	507.49	507.77	Different_Invert_In & Out
DTS5F3TP3120	DTS5F3T004	496.02	495.86	0.16	DTS5F3T002	494.26	494.41	-0.15	496.02	494.26	Different_Invert_In & Out
DTS6E1TP7386	DTS5F3T001A	488.39	494.41	-6.02	DTS5F3T001	485.9	491.595	-5.695	488.39	485.9	Different_Invert_In & Out
RHS7D3P4874	RHS7D3034	417.62	418.65	-1.03	RHS7D3049	418.65	417.62	1.03	417.62	418.65	Different_Invert_In & Out
JLS6E3P4107	JLS6E3076	468.39	468.97	-0.58	JLS6E3075	464.93	465.3	-0.37	468.39	464.93	Different_Invert_In & Out
DTS6E1TP3223	DTS6E1T036	490.516	490.52	-0.004	DTS5E3T034	484.2	487.977	-3.777	490.516	484.2	Different_Invert_In & Out
DTS6E1TP7082	DTS6E1T022	466.963	466.96	0.003	DTS6E1T021	465.503	465.5	0.003	466.963	465.503	Different_Invert_In & Out
DTS6E1TP7083	DTS6E1T021	465.503	465.5	0.003	DTS6E1T020	464.388	464.39	-0.002	465.503	464.388	Different_Invert_In & Out
DTS5F3TP3084	DTS5F3T006	499.76	499.8	-0.04	DTS5F3T005	498.49	498.35	0.14	499.76	498.49	Different_Invert_In & Out
JLS6E3P6529	JLS6E3072A	466.3	467.453	-1.153	JLS6E3072	465.8	466.83	-1.03	466.3	465.8	Different_Invert_In & Out
DTS6E4P4261	DTS6E4017	474.603	474.6	0.003	JLS6E3081	471.81	472.09	-0.28	474.603	471.81	Different_Invert_In & Out
JLS6E3P4262	JLS6E3081	471.81	472.3	-0.49	JLS6E3079	470.8	470.86	-0.06	471.81	470.8	Different_Invert_In & Out
JLS6E3P4273	JLS6E3081	471.81	472.09	-0.28	JLS6E3080	471.583	471.58	0.003	471.81	471.583	Different_Invert_In & Out
RHS8D3P5817	RHS8D3028	426.58	426.68	-0.1	RHS8D3027	427.52	426.58	0.94	426.58	427.52	Different_Invert_In & Out
DTS6E4P4133	DTS6E4058	490.43	490.49	-0.06	DTS6E4050	487.99	488.04	-0.05	490.43	487.99	Different_Invert_In & Out
DTS5F3TP2810	DTS5F3T011	506.4	506.21	0.19	DTS5F3T010	505.16	505.11	0.05	506.4	505.16	Different_Invert_In & Out
EAS7H1P6604	EAS7H1018	593.8	593.7	0.1	EAS7H1001	591.9	591.8	0.1	593.8	591.9	Different_Invert_In & Out
DTS6F3P4702	DTS6F3035	530.73	531.01	-0.28	DTS6F3036	531.01	530.73	0.28	530.73	531.01	Different_Invert_In & Out
ECS7D3TP5177	ECS7D3T007	437.05	437.07	-0.02	ECS7D3T006	437.12	436.67	0.45	437.05	437.12	Different_Invert_In & Out
RHS9E1P6501	RHS9E1003	441.73	441.78	-0.05	RHS9E1002	441.58	441.49	0.09	441.73	441.58	Different_Invert_In & Out
RHS9E1P6502	RHS9E1004	442.02	442.14	-0.12	RHS9E1003	441.83	441.78	0.05	442.02	441.83	Different_Invert_In & Out
RHS9E1P6503	RHS9E1005	442.41	442.69	-0.28	RHS9E1004	442.12	442.14	-0.02	442.41	442.12	Different_Invert_In & Out
DTS5F3TP5945	DTS5F3T002	494.26	494.41	-0.15	DTS5F3T001A	490.1	491.595	-1.495	494.26	490.1	Different_Invert_In & Out
DTS5F3TP3111	DTS5F3T005	498.49	498.35	0.14	DTS5F3T004	496.02	496	0.02	498.49	496.02	Different_Invert_In & Out
ECS8E1P5730	ECS8E1087	520.92	522.3	-1.38	ECS8E1086	522.3	520.92	1.38	520.92	522.3	Different_Invert_In & Out
RHS9E1P6892	RHS9E1031	457.92	456.48	1.44	RHS9E1030	457.67	455.33	2.34	457.92	457.67	Different_Invert_In & Out
DTS6E4P4192	DTS6E4038	485.25	485.5	-0.25	DTS6E4037	482.7	482.23	0.47	485.25	482.7	Different_Invert_In & Out
DTS6E4P4164	DTS6E4050	487.96	488.04	-0.08	DTS6E4038	485.25	485.5	-0.25	487.96	485.25	Different_Invert_In & Out
JLS6E3P4166	JLS6E3078	469.67	470.5	-0.83	JLS6E3076	468.39	465.3	3.09	469.67	468.39	Different_Invert_In & Out
JLS6E3P4180	JLS6E3003	445.75	445.3	0.45	JLS6E3002	445.23	444.7	0.53	445.75	445.23	Different_Invert_In & Out
RHS9E1P6509	RHS9E1025	453.4	448.46	4.94	RHS9E1024	449.1	447.7	1.4	453.4	449.1	Different_Invert_In & Out
RHS9E1P6510	RHS9E1026	454.72	449.84	4.88	RHS9E1025	453.4	448.46	4.94	454.72	453.4	Different_Invert_In & Out
RHS9E1P6511	RHS9E1027	456.82	450.91	5.91	RHS9E1026	545.72	449.84	95.88	456.82	545.72	Different_Invert_In & Out
RHS9E1P6512	RHS9E1028	457.26	452.2	5.06	RHS9E1027	456.82	450.91	5.91	457.26	456.82	Different_Invert_In & Out
PPS6H1P3805	PPS6H1003	578.89	578.83	0.06	PPS6H1002	579.26	578.51	0.75	578.89	579.26	Different_Invert_In & Out
EAS7H1P6221	EAS7H1025	615.7	615.8	-0.1	EAS7H1024	613.6	613.5	0.1	615.7	613.6	Different_Invert_In & Out
RHS9E1P6563	RHS9E1055	467.22	467.6	-0.38	RHS9E1054	464.9	465.37	-0.47	467.22	464.9	Different_Invert_In & Out
RHS9E1P6561	RHS9E1043	462.66	462.55	0.11	RHS9E1042	462.36	462.15	0.21	462.66	462.36	Different_Invert_In & Out
RHS9E1P6577	RHS9E1042	462.36	462.15	0.21	RHS9E1041	462.03	461.71	0.32	462.36	462.03	Different_Invert_In & Out
DTS5F3TP7411	DTS5F3T002	490.1	494.41	-4.31	DTS5F3T001A	488.39	491.595	-3.205	490.1	488.39	Different_Invert_In & Out
DTS6E1TP6696	DTS6E1T036	490.516	490.52	-0.004	DTS6E1T035	488.05	485.15	2.9	490.516	488.05	Different_Invert_In & Out
DTS6E1TP6733	DTS6E1T018	461.436	462.58	-1.144	DTS6E1T017	460.39	460.31	0.08	461.436	460.39	Different_Invert_In & Out
DTS6E1TP6740	DTS6E1T017	460.309	460.31	-0.001	DTS6E1T016	459.519	459.52	-0.001	460.309	459.519	Different_Invert_In & Out
DTS6E1TP6735	DTS6E1T016	459.519	459.52	-0.001	DTS6E1T015	454.326	454.33	-0.004	459.519	454.326	Different_Invert_In & Out
DTS6E1TP6730	DTS6E1T015	454.326	454.33	-0.004	DTS6E1T014	454.216	454.22	-0.004	454.326	454.216	Different_Invert_In & Out
DTS6E4P4220	DTS6E4037	482.64	482.23	0.41	DTS6E4022	479.29	479.01	0.28	482.64	479.29	Different_Invert_In & Out
JLS6E3P4224	JLS6E3079	470.8	470.86	-0.06	JLS6E3078	469.67	470.5	-0.83	470.8	469.67	Different_Invert_In & Out
STS2H2P0688	STS2H2024	541.66	541.56	0.1	STS2H2022	541.56	541.24	0.32	541.66	541.56	Different_Invert_In & Out
DTS6E2P6708	DTS6E2021	475.21	471.176	4.034	DTS6E2020	472.65	472.68	-0.03	475.21	472.65	Different_Invert_In & Out
DTS6E2P6695	DTS6E2020	472.65	472.68	-0.03	JLS6E3078	469.67	470.5	-0.83	472.65	469.67	Different_Invert_In & Out
DTS6E1TP6530	DTS6E1T019	462.267	462.27	-0.003	DTS6E1T018	462.2	461.44	0.76	462.267	462.2	Different_Invert_In & Out
STS2G4TP0877	STS2G4T007	502.28	502.99	-0.71	STS2G4T006	502.99	502.28	0.71	502.28	502.99	Different_Invert_In & Out
DTS6E1TP6736	DTS6E1T014	454.216	454.22	-0.004	DTS6E1T013	543.516	453.52	89.996	454.216	543.516	Different_Invert_In & Out
PPS4H4P1612	PPS4H4020	562.14	566.45	-4.31	PPS4H4019	566.6	562.34	4.26	562.14	566.6	Different_Invert_In & Out
RHS6D3P4314	RHS6D3035	418.04	418.08	-0.04	RHS6D3034	418.08	418.04	0.04	418.04	418.08	Different_Invert_In & Out
JLS6E3P4326	JLS6E3083	475.02	475.08	-0.06	JLS6E3081	471.81	471.99	-0.18	475.02	471.81	Different_Invert_In & Out
EAS6G4P6186	EAS6G4098	584.1	585.8	-1.7	EAS6G4097	583.8	585.3	-1.5	584.1	583.8	Different_Invert_In & Out
EAS6F1P7049	EAS6F1001A	496.42	495.93	0.49	EAS6F1001R	496.4	495.9	0.5	496.42	496.4	Different_Invert_In & Out
DTS5E2P2610	DTS5E2065	535.1	522.61	12.49	DTS5E2064	519.9	521.5	-1.6	535.1	519.9	Different_Invert_In & Out
DTS5E2P2615	DTS5E2066	519	533.85	-14.85	DTS5E2065	519.65	522.61	-2.96	519	519.65	Different_Invert_In & Out
RHS9E1P6490	RHS9E1001	441.15	441.11	0.04	RHS8D4075	440.93	440.9	0.03	441.15	440.93	Different_Invert_In & Out
ACS4D1P6128	ACS4D1019	418.51	419.33	-0.82	ACS4D1018	418.03	418.13	-0.1	418.51	418.03	Different_Invert_In & Out
PPS4G3TP7442	PPS4G3T015	513	501	12	PPS4G3T014	512.5	511.95	0.55	513	512.5	Different_Invert_In & Out
PPS4G3TP7443	PPS4G3T015	513	501	12	PPS4G3T014	512.5	512.15	0.35	513	512.5	Different_Invert_In & Out
EAS6F1P3359	EAS6F1012	495.9	497	-1.1	EAS6F1001A	496.42	495.93	0.49	495.9	496.42	Different_Invert_In & Out
DTS6E1TP6699	DTS6E1T031	479.116	479.12	-0.004	DTS6E1T030	477.833	477.83	0.003	479.116	477.833	Different_Invert_In & Out
ACS4C3TP7626	ACS4C3T009A	366.05	362.946	3.104	ACS4C3T009	363.67	363.57	0.1	366.05	363.67	Different_Invert_In & Out
PPS5F2TP2684	PPS5F2T001	508.15	508.16	-0.01	DTS5F3T012	507.26	507.16	0.1	508.15	507.26	Different_Invert_In & Out
DTS5F3TP2881	DTS5F3T010	505.16	505.11	0.05	DTS5F3T009	504.21	503.98	0.23	505.16	504.21	Different_Invert_In & Out
DTS5F3TP2988	DTS5F3T008	502.66	502.72	-0.06	DTS5F3T007	501.3	501.25	0.05	502.66	501.3	Different_Invert_In & Out
DTS5F3TP2925	DTS5F3T009	504.21	503.98	0.23	DTS5F3T008	502.66	502.72	-0.06	504.21	502.66	Different_Invert_In & Out
JLS5C4TP0102	JLS5C4T013	397.63	397.76	-0.13	JLS5C4T012	397.76	397.63	0.13	397.63	397.76	Different_Invert_In & Out
JLS5C2FP7533	JLS5C2F002	386.3601312	392.462	-6.1018688	JLS5C2F001	398.3088048	394.223	4.0858048	386.3601312	398.3088048	Different_Invert_In & Out
JLS5C2P7540	JLS5C2012	399.3750648	399.376	-0.0009352	ACJCLS	396.501084	396.5	0.001084	399.3750648	396.501084	Different_Invert_In & Out
ACS4C4P1955	ACS4C4019	387.83	388.03	-0.2	ACS4C4018	388.03	384.27	3.76	387.83	388.03	Different_Invert_In & Out
JLS5C2P7541	JLS5C2009A	394.6933632	394.8	-0.1066368	ACS4C4023	390.8810736	390.81	0.0710736	394.6933632	390.8810736	Different_Invert_In & Out
JLS5C2FP7539	ACJCLS	398.518776	382.222	16.296776	TICK7315	380.1528576	384.685	-4.5321424	398.518776	380.1528576	Different_Invert_In & Out
RHS6C2TP0080	RHS6C2T009	402.58	405.13	-2.55	RHS6C2T008	399.87	402.58	-2.71	402.58	399.87	Different_Invert_In & Out
DTS6E1P3506	DTS6E1T027	478.782	478.65	0.132	DTS6E1082	478.65	472.63	6.02	478.782	478.65	Different_Invert_In & Out
DTS6E1TP7075	DTS6E1T028	473.722	473.72	0.002	DTS6E1T027	472.632	472.63	0.002	473.722	472.632	Different_Invert_In & Out
DTS6E1TP7077	DTS6E1T027	472.632	472.63	0.002	DTS6E1T026	472.613	472.61	0.003	472.632	472.613	Different_Invert_In & Out
DTS6E1P2758	DTS6E1020	468.48	468.8	-0.32	DTS6E1019	468.14	468.11	0.03	468.48	468.14	Different_Invert_In & Out

Table 5. GIS and Model Discrepancy by Invert Elevation

Pipe ID	Manhole Upstream ID	GIS Upstream Invert Elevation, ft	Model Upstream Invert Elevation, ft	Upstream Invert Elevation Difference, ft	Manhole Downstream ID	GIS Downstream Invert Elevation, ft	Model Downstream Invert Elevation, ft	Downstream Invert Elevation Difference, ft	Proposed Upstream Invert Elevation, ft	Proposed Downstream Invert Elevation, ft	Status
DTS6E1TP6718	DTS6E1T003	442.931	442.93	0.001	DTS6E1T002	442.406	442.41	-0.004	442.931	442.406	Different_Invert_In & Out
JLS5D3P7618	JLS5D3114	410.13	410.085	0.045	JLS5D3084	409.46	409.4	0.06	410.13	409.46	Different_Invert_In & Out
ACS4C3TP7627	ACS4C3T009B	366.05	364.902	1.148	ACS4C3T009A	363.67	363.92	-0.25	366.05	363.67	Different_Invert_In & Out
DTS5E3P2846	DTS5E3001	471.14	471.5	-0.36	DTS6E1079	471.5	471.14	0.36	471.14	471.5	Different_Invert_In & Out
DTS5E3P3127	DTS5E3017	497.45	497.14	0.31	DTS5E3016	497.14	494.36	2.78	497.45	497.14	Different_Invert_In & Out
DTS5E3P3067	DTS5E3027	498.41	498.14	0.27	DTS5E3017	497.45	497.14	0.31	498.41	497.45	Different_Invert_In & Out
DTS5E3P2902	DTS5E3032	515.23	514.97	0.26	DTS5E3031	510.99	512	-1.01	515.23	510.99	Different_Invert_In & Out
DTS5E3P2861	DTS5E3033	516.88	516.68	0.2	DTS5E3032	515.23	514.97	0.26	516.88	515.23	Different_Invert_In & Out
DTS5E3P2944	DTS5E3031	510.89	510.55	0.34	DTS5E3030	505.93	507.55	-1.62	510.89	505.93	Different_Invert_In & Out
JLS6E3P4436	JLS6E3086	487.5	482.82	4.68	JLS6E3085	482.82	479.9	2.92	487.5	482.82	Different_Invert_In & Out
JLS6E3P4468	JLS6E3087	482.82	484.5	-1.68	JLS6E3086	479.9	482.82	-2.92	482.82	479.9	Different_Invert_In & Out
PPS5F2TP2625	PPS5F2T001A	509.01	509.05	-0.04	PPS5F2T001	508.15	508.16	-0.01	509.01	508.15	Different_Invert_In & Out
PPS5F2TP6057	PPS5F2T002	508.72	509.05	-0.33	PPS5F2T001A	509.01	508.16	0.85	508.72	509.01	Different_Invert_In & Out
DTS6E2P5956	DTS6E2043	492.18	495.027	-2.847	DTS6E2050	488.5	492.18	-3.68	492.18	488.5	Different_Invert_In & Out
JLS5D4TP6705	JLS5D4T013	440.476	440.48	-0.004	JLS5E3T001	440.226	440.23	-0.004	440.476	440.226	Different_Invert_In & Out
JLS5D4TP6723	JLS5D4T014	440.806	440.81	-0.004	JLS5D4T013	440.636	440.64	-0.004	440.806	440.636	Different_Invert_In & Out
JLS5D2P7381	JLS5D2126	446.88	446.85	0.03	DTS5E3T003	446.26	446.8	-0.54	446.88	446.26	Different_Invert_In & Out
DTS6E2P5947	DTS6E2039	488.05	488.87	-0.82	DTS6E2038	488.87	488.05	0.82	488.05	488.87	Different_Invert_In & Out
PPS5G4P2982	PPS5G4074	542.04	542.33	-0.29	PPS5G4007	541.7	541.4	0.3	542.04	541.7	Different_Invert_In & Out
PPS5G4P6320	PPS5G4001	530.43	530.54	-0.11	PPS5G4001A	529.9	527.52	2.38	530.43	529.9	Different_Invert_In & Out
PPS5G4P2304	PPS5G4002	531.89	531.77	0.12	PPS5G4001	530.43	530.54	-0.11	531.89	530.43	Different_Invert_In & Out
PPS5G4P2492	PPS5G4003	535.21	535.01	0.2	PPS5G4002	531.89	531.77	0.12	535.21	531.89	Different_Invert_In & Out
PPS5G4P7684	PPS5G4007	541.7	541.4	0.3	PPS5G4006A	540.76	539.83	0.93	541.7	540.76	Different_Invert_In & Out
STS3G2P1308	STS3G2057	521.56	521.48	0.08	STS3G2056	520.64	520.74	-0.1	521.56	520.64	Different_Invert_In & Out
STS3G2P1304	STS3G2056	520.74	520.64	0.1	STS3G2055	519.44	519.54	-0.1	520.74	519.44	Different_Invert_In & Out
PPS5G4P7563	PPS5G4008	542.44	542.38	0.06	PPS5G4075	542.38	542.44	-0.06	542.44	542.38	Different_Invert_In & Out
DTS5E2P2545	DTS5E2055	510.5	511.8	-1.3	DTS5E2053	511.8	510.5	1.3	510.5	511.8	Different_Invert_In & Out
PPS4G1TP1604	PPS4G1T019	525.89	525.99	-0.1	PPS4G1T018	525.99	525.89	0.1	525.89	525.99	Different_Invert_In & Out
RHS8D1P0054	RHS8D1139	406.5	403.91	2.59	RHS8D1001	403.83	403.62	0.21	406.5	403.83	Different_Invert_In & Out
JLS5C4TP0089	JLS5C4T009	404.96	398.53	6.43	JLS5C4T008	403.37	398.26	5.11	404.96	403.37	Different_Invert_In & Out
JLS5C4TP0091	JLS5C4T008	403.37	398.26	5.11	JLS6D1012	397.92	398.04	-0.12	403.37	397.92	Different_Invert_In & Out
EAS6G4P6206	EAS6G4084	578.2	578.2	0	EAS6G4082	577.2	577.1	0.1	578.2	577.2	Different invert Out
EAS6G4P0463	EAS6G4002	555.57	555.57	0	EAS6G4001	553.45	553.62	-0.17	555.57	553.45	Different invert Out
EAS6G4P0467	EAS6G4007A	561.6	561.6	0	EAS6G4007	561.1	561.2	-0.1	561.6	561.1	Different invert Out
EAS6G4P0468	EAS6G4007	561.1	561.1	0	EAS6G4006	558	558.1	-0.1	561.1	558	Different invert Out
STS2H2P0159	STS2H2039	545.59	545.59	0	STS2H2037	544.95	545.05	-0.1	545.59	544.95	Different invert Out
STS2H2P0163	STS2H2034	544.43	544.43	0	STS2H2029	544.05	544.15	-0.1	544.43	544.05	Different invert Out
JLS6E3P4403	JLS6E3085	479.9	479.9	0	JLS6E3083	475.02	475.08	-0.06	479.9	475.02	Different invert Out
ACS4D1P6134	ACS4D1007	408.5	408.5	0	ACS4D1005	407.89	407.76	0.13	408.5	407.89	Different invert Out
RHS8D3P5803	RHS8D3027	426.58	426.58	0	RHS8D3026	436.38	426.38	10	426.58	436.38	Different invert Out
STS2H1P0767	STS2H1023	525.41	525.41	0	STS2H1022	524.11	524.44	-0.33	525.41	524.11	Different invert Out
JLS6E3P4353	JLS6E3082	473.7	473.7	0	JLS6E3066	470.69	471.314	-0.624	473.7	470.69	Different invert Out
ACS4D1P6133	ACS4D1015	411.21	411.21	0	ACS4D1008	409.83	408.5	1.33	411.21	409.83	Different invert Out
ACS4C2P0267	ACS4C2012	426.64	426.64	0	ACS4C2011	425.8	422.53	3.27	426.64	425.8	Different invert Out
RHS9E1P6894	RHS9E1033	459.38	459.38	0	RHS9E1032	458.17	457.24	0.93	459.38	458.17	Different invert Out
RHS9E1P6898	RHS9E1038	460.73	460.73	0	RHS9E1037	460.46	460.47	-0.01	460.73	460.46	Different invert Out
JLS5C2P0370	JLS5C2051	399.94	399.94	0	JLS5C2050	399.64	399.38	0.26	399.94	399.64	Different invert Out
RHS9E1P6911	RHS9E1084	484.68	484.68	0	RHS9E1083	483.5	481.92	1.58	484.68	483.5	Different invert Out
STS2G4P0175	STS2G4052	499.89	499.89	0	STS2G4051	498.19	498.29	-0.1	499.89	498.19	Different invert Out
STS3G4P1488	STS3G4027	513.91	513.91	0	STS3G4026	521.58	513.03	8.55	513.91	521.58	Different invert Out
JLS5D3TP0100	JLS5D3T002	398.68	398.68	0	JLS5D3T001	398.46	398.13	0.33	398.68	398.46	Different invert Out
EAS7H1P6957	EAS7H1022	606.2	606.2	0	EAS7H1021	602.8	601.99	0.81	606.2	602.8	Different invert Out
STS2H2P0152	STS2H2048	547.36	547.36	0	STS2H2046	546.76	546.86	-0.1	547.36	546.76	Different invert Out
EAS6G4P6181	EAS6G4136	591.4	591.4	0	EAS6G4134	587.2	589.2	-2	591.4	587.2	Different invert Out
PPS4H4P0292	PPS4H4043	576.56	576.56	0	PPS4H4042A	576.06	576.09	-0.03	576.56	576.06	Different invert Out
RHS9E1P6909	RHS9E1108	520.73	520.73	0	RHS9E1107	514.4	510.48	3.92	520.73	514.4	Different invert Out
JLS5D3P3130	JLS5D3095	414.55	414.55	0	JLS5D3093	412.61	413.66	-1.05	414.55	412.61	Different invert Out
DTS6E4P4239	DTS6E4039	487.39	487.39	0	DTS6E4027	484.51	484.78	-0.27	487.39	484.51	Different invert Out
DTS7F1P4747	DTS7F1026	519.69	519.69	0	DTS7F1025	518.98	519.16	-0.18	519.69	518.98	Different invert Out
DTS6E2P3839	DTS6E2005	465.33	465.33	0	DTS6E2004	464.077	463.98	0.097	465.33	464.077	Different invert Out
STS2G4P0181	STS2G4062	507.02	507.02	0	STS2G4061	505.96	506.58	-0.62	507.02	505.96	Different invert Out
RHS8D3P5835	RHS8D3032	429.04	429.04	0	RHS8D3031	429.09	428.76	0.33	429.04	429.09	Different invert Out
JLS5D1TP0377	JLS5D1T003	403.71	403.71	0	JLS5D1T002	402.82	403.3	-0.48	403.71	402.82	Different invert Out
EAS7H1P6959	EAS7H1020	597.6	597.6	0	EAS7H1019	594	593.8	0.2	597.6	594	Different invert Out
RHS8D1P0056	RHS8D1015	404.08	404.08	0	RHS8D1001	403.83	403.62	0.21	404.08	403.83	Different invert Out
RHS9E1P6914	RHS9E1105	497.1	497.1	0	RHS9E1104	495.5	495.38	0.12	497.1	495.5	Different invert Out
RHS9E1P6915	RHS9E1106	502.1	502.1	0	RHS9E1105	497.2	497.1	0.1	502.1	497.2	Different invert Out
JLS5D1P0643	JLS5D1134	421.84	421.84	0	JLS5D1044	420.22	420.07	0.15	421.84	420.22	Different invert Out
EAS6G4P6255	EAS6G4078	576	576	0	EAS6G4077	575.6	575.5	0.1	576	575.6	Different invert Out
EAS6G4P6256	EAS6G4077	575.5	575.5	0	EAS6G4076	574.9	574.71	0.19	575.5	574.9	Different invert Out
RHS9E1P6507	RHS9E1019	447.7	447.7	0	RHS9E1018	444.3	445.43	-1.13	447.7	444.3	Different invert Out
DTS5F3TP7021	PPS5F4001	506.51	506.51	0	DTS5F3T011	506.4	506.21	0.19	506.51	506.4	Different invert Out
EAS6F1P3919	EAS6F1138	0	501.96	0	EAS6F1137	499.51	499.28	0.23	0	499.51	Different invert Out
JLS6E3P4234	JLS6E3071	468.99	468.99	0	JLS6E3072A	466.3	467.453	-1.153	468.99	466.3	Different invert Out
DTS6E2P6533	DTS6E2003	462.2	462.2	0	DTS6E1T018	461.436	461.44	-0.004	462.2	461.436	Different invert Out
EAS6G4P0471	EAS6G4011	563.2	563.2	0	EAS6G4009	562.8	562.9	-0.1	563.2	562.8	Different invert Out
EAS6G4P0472	EAS6G4012	565.2	565.2	0	EAS6G4011	563.2	563.3	-0.1	565.2	563.2	Different invert Out
EAS6G4P0473	EAS6G4017	566.3	566.3	0	EAS6G4012	565.2	565.3	-0.1	566.3	565.2	Different invert Out
STS2G4P0188	STS3G2001	500.4	500.4	0	STS2G4051	500.18	498.29	1.89	500.4	500.18	Different invert Out
STS3G1TP1041	STS3G1T002	489.94	489.94	0	STS3G1T001	497	487.6	9.4	489.94	497	Different invert Out
EAS6G4P0481	EAS6G4056	561.2	561.2	0	EAS6G4053	599.92	559.59	40.33	561.2	599.92	Different invert Out
EAS7H1P6215	EAS7H1037	620.8	620.8	0	EAS7H1026	617.7	618.1	-0.4	620.8	617.7	Different invert Out
JLS5C2P0325	JLS5C2015	403.02	403.02	0	JLS5C2014	401.65	401.53	0.12	403.02	401.65	Different invert Out
JLS6E3P4297	JLS6E3080	471.42	471.42	0	JLS6E3066	470.69	471.314	-0.624	471.42	470.69	Different invert Out
ACS4C3TP2353	STUB1857	0	356	0	ACS4C3T001	357.28	355.145	2.135	0	357.28	Different invert Out
RHS8D4P0603	RHS8D4023	456.5	456.5	0	RHS8DA016	448.56	448.66	-0.1	456.5	448.56	Different invert Out
RHS8D4P0607	RHS8D4007	436.49	436.49	0	RHS8D4006	433.83	435.93	-2.1	436.49	433.83	Different invert Out
RHS8D4P0610	RHS8DA016	448.56	448.56	0	RHS8D4013	447.5	447.6	-0.1	448.56	447.5	Different invert Out
PPS4H3P1777	PPS4H3022	542.61	542.61	0	PPS4H3020	542.77	542.34	0.43	542.61	542.77	Different invert Out
DTS6E1P6000	DTS6E1021	471.09	471.09	0	DTS6E1020	468.8	468.48	0.32	471.09	468.8	Different invert Out
EAS6F2P6871	EAS6F2001	531.3	531.3	0	EAS6F2001A	530.94	530.05	0.89	531.3	530.94	Different invert Out
DTS6E1TP7074	DTS6E1T029	474.49	474.49	0	DTS6E1T028	473.722	473.72	0.002	474.49	473.722	Different invert Out
DTS6E2P7131	DTS6E2009	475.8	475.8	0	DTS6E1T024	475.08	469.35	5.73	475.8	475.08	Different invert Out
DTS6E1TP7081	DTS6E1T023	469	469	0	DTS6E1T022	466.963	466.96	0.003	469	466.963	Different invert Out
ECS7E1P4953	ECS7E1051	489.3	489.3	0	ECS7E1050	490.1	489.08	1.02	489.3	490.1	Different invert Out
DTS5E3P5943	DTS5E3015	0	492.76	0	DTS5E3014	487.841	489.88	-2.039	0	487.841	Different invert Out
DTS6E4P4264	DTS6E4023	482.24	482.24	0	DTS6E4022	482.34	480.31	2.03	482.24	482.34	Different invert Out
EAS6G4P0461	AEC5729	560	560	0	EAS6G4001	553.62	553.45	0.17	560	553.62	Different invert Out
RHS7D3P4836	RHS7D3034	417.62	417.62	0	RHS7D3033	419.26	417.26	2	417.62	419.26	Different invert Out
JLS6D1P3059	JLS6D1051	409.76	409.76	0	JLS6D1050	411.73	408.75	2.98	409.76	411.73	Different invert Out
PPS5H1P2812	PPS5H1075	559.01	559.01	0	PPS5H1047	560.9	558.98	1.92	559.01	560.9	Different invert Out
RHS9E1P6504	RHS9E1006	443	443	0	RHS9E1005	442.74	442.69	0.05	443	442.74	Different invert Out
DTS6E4P4165	DTS6E4038	485.5	485.5	0	DTS6E2072	484.11	484.21	-0.1	485.5	484.11	Different invert Out
JLS5D1TP0429	JLS5D1T001	402.7	402.7	0	JLS5D3T008	402.02	402.16	-0.14	402.7	402.02	Different invert Out
RHS9E1P6571	RHS9E1067	472.2	472.2	0	RHS9E1056	467.6	468.78	-1.18	472.2	467.6	Different invert Out
JLS4D4TP1870	JLS4D4T004	410.69	410.69	0	JLS4D4T003	423.68	410.54	13.14	410.69	423.68	Different invert Out
ECS7D3TP5113	ECS7D3T005	436.32	436.32	0	ECS7D3T004	436.79	435.99	0.8	436.32	436.79	Different invert Out
RHS8D3P5824	RHS8D3036	430.16	430.16	0	RHS8D3035	449.87	429.87	20	430.16	449.87	Different invert Out
EAS7H1P6220	EAS7H1026	616.9	616.9	0	EAS7H1025	518.7	615.8	-97.1	616.9	518.7	Different invert Out
EAS7H1P6222	EAS7H1024	613.5	613.5	0	EAS7H1023	609.6	609.8	-0.2	613.5	609.6	Different invert Out
EAS6F1P5982	EAS6F1140	0	506.59	0	EAS6F1139	503.92	504.08	-0.16	0	503.92	Different invert Out
DTS6E2P4223	DTS6E2069	0	474.994	0	JLS6E3079	470.8	470.86	-0.06	0	470.8	Different invert Out
DTS6E4P4226	DTS6E4039	487.39	487.39	0	DTS6E4038	485.25	485.5	-0.25	487.39	485.25	Different invert Out
STS2H4P0995	STS2H4012	529.16	529.16	0	STS2H4010	531.14	528.04	3.1	529.16	531.14	Different invert Out
STS3G3P1099	STS3G3002	493.08	493.08	0	STS3G3001	496.3	491.96	4.34	493.08	496.3	Different invert Out
STS2H1P0888	STS2H1004	514.6	514.6	0	STS2G4T011	514.6	513.6	1	514.6	514.6	Different invert Out
PPS5G3P2372	PPS5G3015	523.82	523.82	0	PPS5G3002	523.89	522.9	0.99	523.82	523.89	Different invert Out
PPS4F4P1752	PPS4F4104	509.7	509.7	0	PPS4F4105	507.91	507.97	-0.06	509.7	507.91	Different invert Out
DTS6E4P4325	DTS6E4018	479.67	479.67	0	JLS6E3083	475.02	475.08	-0.06	479.67	475.02	Different invert Out
RHS8D4P0587	RHS8D4003	434.86	434.86	0	RHS8D4002	434.26	434.25	0.01	434.86	434.26	Different invert Out
STS3G3P1199	STS3G3075	505.3	505.3	0	STS3G3072	506.55	503.88	2.67	505.3	506.55	Different invert Out
ECS8E4P6415	ECS8E4001	519.98	519.98	0	ECS8E3065	517.52	519.06	-1.54	519.98	517.52	Different invert Out
PPS4G3P1748	PPS4G3016	512.78	512.78	0	PPS4G3T015	513	512.5	0.5	512.78	513	Different invert Out
PPS4G3TP1715	PPS4G3T017	0	513.08	0	PPS4G3T016	513.08	513	0.08	0	513.08	Different invert Out
ACS4C3TP1848	ACS4C3T009	363.57	363.57	0	ACS4C3T008	365.92	363.04	2.88	363.57	365.92	Different invert Out
EAS6F2P2915	EAS6F2087	510.46	510.46	0	DTS5F3T009	507.21	503.98	3.23	510.46	507.21	Different invert Out
STS2G4TP1011	STS2G4T001	495.4	495.4	0	STS3G1T006	505.33	494	11.33	495.4	505.33	Different invert Out
JLS5C2P0113	JLS5C2048	398.87	398.87	0	JLS5C2079	399.60144	397.87	1.73144	398.87	399.60144	Different invert Out
ACS4C4P0337	JLS5C2012	399.56	399.56	0	ACS4C4051A	397.61	396.8	0.81	399.56	397.61	Different invert Out
ECS8E4P6414	ECS8E4099	0	520.96	0	ECS8E4001	520.08	519.98	0.1	0	520.08	Different invert Out
DTS6E1TP6724	DTS6E1T004	444.24	444.24	0	DTS6E1T003	441.95	443.65	-1.7	444.24	441.95	Different invert Out
DTS6F3P6524	DTS6F3024A	0	512.78	0	DTS6F3024B	512.78	512.068	0.712	0	512.78	Different invert Out
JLS5D3P2967	JLS5D3086	0	411.71	0	JLS5D3084A	411.17	410.81	0.36	0	411.17	Different invert Out
RHS6D3P4281	RHS6D3034	418.08	418.08	0	RHS6D3T010	422.42	417	5.42	418.08	422.42	Different invert Out
DTS6E2P3648	DTS6E2051	0	495.027	0	DTS6E2050	488.5	495.027	-6.527	0	488.5	Different invert Out
PPS4H4P7623	PPS4H4014	556.48	556.48	0	PPS4H4013A	556.1	555.35	0.75	556.48	556.1	Different invert Out
ACS4C3TP6016	ACS4C3T010	366.05	366.05	0	ACS4C3T009B	363.67	364.907	-1.237	366.05	363.67	Different invert Out
DTS5E3P7558	DTS5E3083A	0	486.41	0	DTS5E3083	481.77	480.52	1.25	0	481.77	Different invert Out
DTS5E3P2889	DTS6E1079	471.5	471.5	0	DTS6E1021	469.88	469.98	-0.1	471.5	469.88	Different invert Out
DTS5E3P6001	DTS5E3085	0	471.39	0	DTS6E1032	468.58	467.28	1.3	0	468.58	Different invert Out
DTS5E3P3052	DTS5E3029	501.55	501.55	0	DTS5E3028	497.14	498.48	-1.34	501.55	497.14	Different invert Out
ACS4C2P0223	ACS4C2096	0	428	0	ACS4C2068	426.43	426.5	-0.07	0	426.43	Different invert Out
JLS6E3P4483	JLS6E3088	484.57	484.57	0	JLS6E3087	487.5	484.5	3	484.57	487.5	Different invert Out
AEC4059	AEC3574	0	531.43	0	AEC3571	527.65	527.75	-0.1	0	527.65	Different invert Out
DTS6E2TP5957	DTS5E3T030	0	488.56	0	DTS5E3T029A	484.64	485.084	-0.444	0	484.64	Different invert Out
PPS6G1P3297	PPS6G1045	530.43	530.43	0	PPS6G1044	540.95	529.78	11.17	530.43	540.95	Different invert Out
RHS9E1P6569	RHS9E1045	462.99	462.99	0	RHS9E1043	462.66	462.55	0.11	462.99	462.66	Different invert Out
PPS5I2TP2071	PPS5I2T010	572.94	572.94	0	PPS5I2T009	579.2	571	8.2	572.94	579.2	Different invert Out
DTS6E1P2754	DTS6E1028	0	456.01	0	DTS6E1027	450.92	453.63	-2.71	0	450.92	Different invert Out
JLS5D2P2583	JLS5D2001A	426.52	426.52	0	JLS5D2004	425.95	426.05	-0.1	426.52	425.95	Different invert Out
JLS5D4TP5989	JLS5D4T009	432.6	432.6	0	JLS5D4T008	432.7	431.03	1.67	432.6	432.7	Different invert Out
JLS5D2P2876	JLS5D2117	446.6	446.6	0	DTS5E3T002	446.07	446.55	-0.48	446.6	446.07	Different invert Out
JLS5D2P2883	DTS6E1012	451.49	451.49	0	JLS5D2126	446.88	447.61	-0.73	451.49	446.88	Different invert Out
DTS5E3TP2799	DTS5E3T007	451.08	451.08	0	DTS5E3T006	453.09	449.11	3.98	451.08	453.09	Different invert Out
ACS5C4P6300	ACS5C1022	358.11	358.11	0	ACS5C4001	356.68	357.03	-0.35	358.11	356.68	Different invert Out
RHS7D3P4967	RHS7D3042	0	411.96	0	RHS7D3041	410.73	411.45	-0.72	0	410.73	Different invert Out
PPS5G4P2587	PPS5G4004	536.83	536.83	0	PPS5G4003	535.21	535.01	0.2	536.83	535.21	Different invert Out
PPS5G4P2652	PPS5G4005	538.25	538.25	0	PPS5G4004	536.9	536.83	0.07	538.25	536.9	Different invert Out
PPS5G4P7685	PPS5G4006	539.83	539.83	0	PPS5G4005A	539.03	538.25	0.78	539.83	539.03	Different invert Out
PPS5F2TP2588	PPS5F2T003	516.47	516.47	0	PPS5F2T003A	515.65	516.09	-0.44	516.47	515.65	Different invert Out
PPS5H2TP2113	PPS5H2T022	533.5	533.5	0	PPS5H2T007R	530.42	530.53	-0.11	533.5	530.42	Different invert Out
DTS6E2P5967	EAS6F1136	498.89	498.89	0	DTS6E2068A	493.25	492.86	0.39	498.89	493.25	Different invert Out
RHS6C2TP0085	RHS6C2T002	399.05	399.05	0	RHS6C2T001	406.57	398.78	7.79	399.05	406.57	Different invert Out
EAS6F1P3730	EAS6F1137	499.51	499.28	0.23	EAS6F1136	0	498.92	0	499.51	0	Different Invert In
RHS8D3P5791	RHS8D3026	436.38	426.38	10	RHS8D3025	426.15	426.15	0	436.38	426.15	Different Invert In
RHS9E1P6505	RHS9E1017	443.7	444.62	-0.92	RHS9E1016	443.4	443.4	0	443.7	443.4	Different Invert In
JLS6E3P4352	JLS6E3083	475.02	475.08	-0.06	JLS6E3082	0	473.7	0	475.02	0	Different Invert In
JLS5D3P3051	JLS5D3087	412.61	412.66	-0.05	JLS5D3086	0	411.71	0	412.61	0	Different Invert In
RHS6C2TP0060	RHS6C2T020	402.94	402.89	0.05	RHS6C2T019	402.49	402.49	0	402.94	402.49	Different Invert In

Table 5. GIS and Model Discrepancy by Invert Elevation

Pipe ID	Manhole Upstream ID	GIS Upstream Invert Elevation, ft	Model Upstream Invert Elevation, ft	Upstream Invert Elevation Difference, ft	Manhole Downstream ID	GIS Downstream Invert Elevation, ft	Model Downstream Invert Elevation, ft	Downstream Invert Elevation Difference, ft	Proposed Upstream Invert Elevation, ft	Proposed Downstream Invert Elevation, ft	Status
ACS4C2P0276	ACS4C2008	405.51	410.62	-5.11	ACS4C2005	403.76	403.76	0	405.51	403.76	Different Invert In
RHS9E1P6899	RHS9E1071	476.3	473.88	2.42	RHS9E1067	472.2	472.2	0	476.3	472.2	Different Invert In
STS2H2P0171	STS2H2025A	542.42	542.49	-0.07	STS2H2025	542.32	542.32	0	542.42	542.32	Different Invert In
DTS6E2P4096	DTS6E2072	484.11	484.69	-0.58	DTS6E2023	482.5	482.5	0	484.11	482.5	Different Invert In
EAS6G4P0488	EAS6G4060	564.5	563.46	1.04	EAS6G4059	562.7	562.7	0	564.5	562.7	Different Invert In
RHS9E1P6905	RHS9E1102	490	489.17	0.83	RHS9E1084	484.68	484.68	0	490	484.68	Different Invert In
PPS4F4P6067	PPS4F4111	497.06	496.96	0.1	PPS4F4112	495.9	495.9	0	497.06	495.9	Different Invert In
RHS9E1P6508	RHS9E1024	449.1	448.46	0.64	RHS9E1019	447.7	447.7	0	449.1	447.7	Different Invert In
JLS5C2P0328	JLS5C2014	401.55	401.53	0.02	JLS5C2013	400.64	400.64	0	401.55	400.64	Different Invert In
STS3G4P1492	STS3G4011	512.58	512.59	-0.01	STS3G4010	511.7	511.7	0	512.58	511.7	Different Invert In
ACS4C2P0300	ACS4C2001	387.11	386.56	0.55	ACS4C3T015	0	383.42	0	387.11	0	Different Invert In
DTS5F3TP2744	DTS5F3T012	507.26	507.16	0.1	PPS5F4001	506.51	506.51	0	507.26	506.51	Different Invert In
JLS5D1TP0360	JLS5D1T004	404.04	404.18	-0.14	JLS5D1T003	403.81	403.81	0	404.04	403.81	Different Invert In
JLS6D1P2981	JLS6D1015	406.51	405.79	0.72	JLS6D1014	405.33	405.33	0	406.51	405.33	Different Invert In
DTS6E1P3285	DTS6E1025	475.88	475.9	-0.02	DTS6E1024	475.4	475.4	0	475.88	475.4	Different Invert In
JLS5D1P0392	JLS5D1138	423.11	422.17	0.94	JLS5D1134	421.84	421.84	0	423.11	421.84	Different Invert In
DTS6E1TP6725	DTS6E1T005	445.376	445.38	-0.004	DTS6E1T004	444.24	444.24	0	445.376	444.24	Different Invert In
DTS5E3P3053	DTS5E3028	497.14	498.48	-1.34	DTS5E3027	0	498.14	0	497.14	0	Different Invert In
RHS9E1P6568	RHS9E1041	462.03	461.71	0.32	RHS9E1039	461.22	461.22	0	462.03	461.22	Different Invert In
RHS8D4P0614	RHS8D4011	437.63	437.39	0.24	RHS8D4010	437.11	437.11	0	437.63	437.11	Different Invert In
JLS6E3P4251	JLS6E3071A	469.5	469.782	-0.282	JLS6E3071	468.99	468.99	0	469.5	468.99	Different Invert In
PPS5G4P2250	PPS5G4001A	529.9	530.54	-0.64	PPS5H2T005	527.52	527.52	0	529.9	527.52	Different Invert In
PPS4H4P0312	PPS4H4042A	578.06	576.09	1.97	PPS4H4042	575.01	575.01	0	578.06	575.01	Different Invert In
DTS5E2P6003	DTS5E2033	474.46	474.45	0.01	DTS5E2011	467.36	467.36	0	474.46	467.36	Different Invert In
DTS6E1TP7073	DTS6E1T030	477.833	477.83	0.003	DTS6E1T029	474.49	474.49	0	477.833	474.49	Different Invert In
DTS6E1TP7078	DTS6E1T026	472.613	472.61	0.003	EAS6G4093	470.75	470.75	0	472.613	470.75	Different Invert In
DTS6E2TP5942	DTS5E3T034	484.1	486.9	-2.8	DTS5E3T033	0	486.12	0	484.1	0	Different Invert In
DTS6E2P4130	DTS6E2071	482.5	485.1	-2.6	DTS6E2022	479.94	479.94	0	482.5	479.94	Different Invert In
DTS6F3P6526	DTS6F3024B	512.78	512.068	0.712	DTS6F3023	510.18	510.18	0	512.78	510.18	Different Invert In
DTS6E1P3540	DTS6E1008	462.15	462.31	-0.16	DTS6E1006	0	462.15	0	462.15	0	Different Invert In
EAS7H1P6603	EAS7H1019	594	597.6	-3.6	EAS7H1018	593.8	593.8	0	594	593.8	Different Invert In
STS3G4P1271	STS3G4057	507.07	508.03	-0.96	STS3G4004	507.49	507.49	0	507.07	507.49	Different Invert In
EAS6F1P4027	EAS6F1139	503.92	504.08	-0.16	EAS6F1138	0	501.96	0	503.92	0	Different Invert In
DTS6E2P3655	DTS6E2050	488.5	495.027	-6.527	DTS5E3T029	484.64	484.64	0	488.5	484.64	Different Invert In
JLS6E3P6706	JLS6E3078	469.67	470.5	-0.83	JLS6E3072	466.83	466.83	0	469.67	466.83	Different Invert In
ACS4D1P7370	ACS4D1008	409.83	411.21	-1.38	ACS4D1007	408.5	408.5	0	409.83	408.5	Different Invert In
JLS5C4TP7522	JLS5C4T002	397.09	397.23	-0.14	JLS5C4T022	396.99	396.99	0	397.09	396.99	Different Invert In
ACS4D1P6138	ACS4D1113	407.97	407.92	0.05	ACS4D1005	407.76	407.76	0	407.97	407.76	Different Invert In
ACS4C4P0338	ACS4C4051A	399	398.1	0.9	ACS4C4051	387.64	387.64	0	399	387.64	Different Invert In
DTS6E1P2757	DTS6E1032	468.58	467.27	1.31	DTS6E1031	0	465.06	0	468.58	0	Different Invert In
DTS6E1P2703	DTS6E1019	468.11	468.14	-0.03	DTS6E1018	463.95	463.95	0	468.11	463.95	Different Invert In
JLS5D2P7614	JLS5D2108	439.65	439.64	0.01	JLS5D2092A	0	438.28	0	439.65	0	Different Invert In
JLS5D3P0451	JLS5D3084A	411.71	410.81	0.9	JLS5D3114	410.13	410.13	0	411.71	410.13	Different Invert In
JLS5D1P2163	JLS5D1090	428.8	431.55	-2.75	JLS5D1062	430.89	430.89	0	428.8	430.89	Different Invert In
DTS5E3P7762	DTS5E3081A	478.72	480.52	-1.8	DTS5E3081	0	476.95	0	478.72	0	Different Invert In
EAS6F4P5975	EAS6F2001A	530.94	531.3	-0.36	EAS6F4005	530.05	530.05	0	530.94	530.05	Different Invert In
EAS6F4P4320	EAS6F4020	523.4	532.4	-9	EAS6F4019	532.3	532.3	0	523.4	532.3	Different Invert In
STS2G4P0176	STS2G4059	500.25	503.08	-2.83	STS2G4052	499.89	499.89	0	500.25	499.89	Different Invert In
DTS6E4P4041	DTS6E2040	494.7	493.2	1.5	DTS6E4059	492.99	492.99	0	494.7	492.99	Different Invert In
PPS6G1P3226	PPS6G1044	540.95	529.77	11.18	PPS6G1043	528.79	528.79	0	540.95	528.79	Different Invert In
DTS6E1P2955	DTS6E1052	465.5	465.73	-0.23	DTS6E1047	462.63	462.63	0	465.5	462.63	Different Invert In
RHS9E1P6570	RHS9E1054	464.9	465.37	-0.47	RHS9E1045	462.99	462.99	0	464.9	462.99	Different Invert In
JLS5D2P2780	JLS5D2084	427.09	437.09	-10	JLS5D2083	0	436.69	0	427.09	0	Different Invert In
DTS6E2P3890	DTS6E2044	495.88	491.68	4.2	DTS5E3T030	0	495.88	0	495.88	0	Different Invert In
DTS5E3TP2804	DTS5E3T006	453.09	449.11	3.98	DTS5E3T005	448.89	448.89	0	453.09	448.89	Different Invert In
DTS6E1P2796	DTS6E1027	450.92	453.63	-2.71	DTS6E1026	0	451.02	0	450.92	0	Different Invert In
DTS6E1P3254	DTS6E1064	465.67	465.85	-0.18	DTS6E1062	465.76	465.76	0	465.67	465.76	Different Invert In
DTS6E1P3338	DTS6E1070	470.46	470.7	-0.24	DTS6E1069	0	468.7	0	470.46	0	Different Invert In
ACS5C4P6301	ACS5C4001	356.68	357.03	-0.35	ALS	356.55	356.55	0	356.68	356.55	Different Invert In
ACS4C3TP6299	ACS4C3T001	359.4	359.3	0.1	ACS5C1022	358.11	358.11	0	359.4	358.11	Different Invert In
RHS8D3P7675	RHS8D3037A	431.03	432.32	-1.29	RHS8D3037	430.74	430.74	0	431.03	430.74	Different Invert In
RHS7D3P4956	RHS7D3041	411.96	411.45	0.51	RHS7D3039	0	410.73	0	411.96	0	Different Invert In
PPS5G4P2903	PPS5G4006A	540.76	541.4	-0.64	PPS5G4006	539.83	539.83	0	540.76	539.83	Different Invert In
PPS5G4P2778	PPS5G4005A	539.03	539.83	-0.8	PPS5G4005	538.25	538.25	0	539.03	538.25	Different Invert In
DTS6E2P3629	DTS6E1T024	475.08	469.35	5.73	DTS6E1072A	0	468.96	0	475.08	0	Different Invert In
DTS6E2P5965	DTS6E2068A	489.44	493.888	-4.448	DTS6E2056	0	492.86	0	489.44	0	Different Invert In
PPS5H2TP2136	PPS5H2T007R	530.47	530.53	-0.06	PPS5H2T006	528.5	528.5	0	530.47	528.5	Different Invert In
JLS6D1P7637	JLS6D1012A	402	404.58	-2.58	JLS6D1012	397.92	397.92	0	402	397.92	Different Invert In
JLS5D3TP0097	JLS5D3T001	398.36	398.13	0.23	JLS5C4T004A	398.03	398.03	0	398.36	398.03	Different Invert In

Table 6. Miscellanious GIS Questions/Updates						
Pipe ID	Manhole Upstream ID	Manhole Downstream ID	Diameter, inch	Upstream Invert Elevation, ft	Downstream Invert Elevation, ft	WY Update
STS3F2P6751	STS3F2005	STS3F2004	8.00	495.71	495.09	MH_DNID changed from ACS5C4007 to STS3F2004
JLS6E3P4257	JLS6E3069	JLS6E3069A	8.00	465.70	463.60	MH_DNID changed from JLS6E3068 to JLS6E3069A
PPS5F2TP6047	PPS5F2T003A	PPS5F2T003B	24.00	515.65	513.55	MH_DNID change from PPS5F2T002 to PPS5F2T003B
ACS4D1P7338	ACS4D1110	ACS4D1109	8.00	462.74	458.74	MH_DNID changed from PPS3H4070 to ACS4D1109
RHS9E1P6519	PRIVATE6337	RHS9E1021	6.00	463.44	463.27	MH_DNID changed from RHS9E1007 to RHS9E1021
JLS6E3P6529	JLS6E3072A	JLS6E3072	8.00	466.30	465.80	MH_DNID changed form ABN to JLS6E3072
JLS6E3P4190	JLS6E3096	JLS6E3072	8.00	467.92	465.80	MH_DNID changed form ABN to JLS6E3072
RHS9E1P6557	RHS9E1052	RHS9E1051	8.00	472.00	470.71	MH_DNID changed from RHS9E1107 to RHS9E1051
RHS8D4P6942	RHS8D4004A	RHS8D4004	8.00	454.05	450.75	MH_DNID cahnged from RHS8D4091 to RHS8D4004
DTS6E2P7085	DTS6E2004	DTS6E2003A	8.00	0.00	0.00	MH_UPID changed from STS2G4034 to DTS6E2004
STS2H3P7453	STS2H3034A	STS2H3034	8.00	0.00	521.37	MH_DNID changed from STS2H3034B to STS2H3034
WY7486	WY7276	WY7279	8.00	346.62	345.06	Down_Struc_ID (OLD ID) changed from 7276 to 7279
WY7499	WY7285	WY7276	8.00	350.95	346.62	DOWN_STRUC ID (OLD ID) changed from 7279 to 7276
ACS4C2P7664	ACS4C2056B	ACS4C2056A	6.00	426.57	426.00	MH_UPID changed from 2059A to 2056B and MH_DNID changed from 2059B to 2056A
ACS4C2P7665	ACS4C2056A	ACS4C2056	6.00	425.90	424.90	MH_UPID was changed from ACS4C2059B to ACS4C2056A
STS2G3P7678	STS2G3032	STS2G3026	0.00	0.00	0.00	Unknown Diameter modeled as 8inch
STS2G3P7679	STS2G3034	STS2G3033	0.00	0.00	0.00	Unknown Diameter modeled as 8inch
STS2G3P7680	STS2G3033	STS2G3032	0.00	0.00	0.00	Unknown Diameter modeled as 8inch

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APPENDIX B

Isabel Neighborhood Plan Sewer System Evaluation Project

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REPORT | MAY 2017

Isabel Neighborhood Plan Sewer System Evaluation

Prepared for

City of Livermore

Project No. 438-12-15-05

REGISTERED PROFESSIONAL ENGINEER
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Table of Contents

List of Tables

List of Figures

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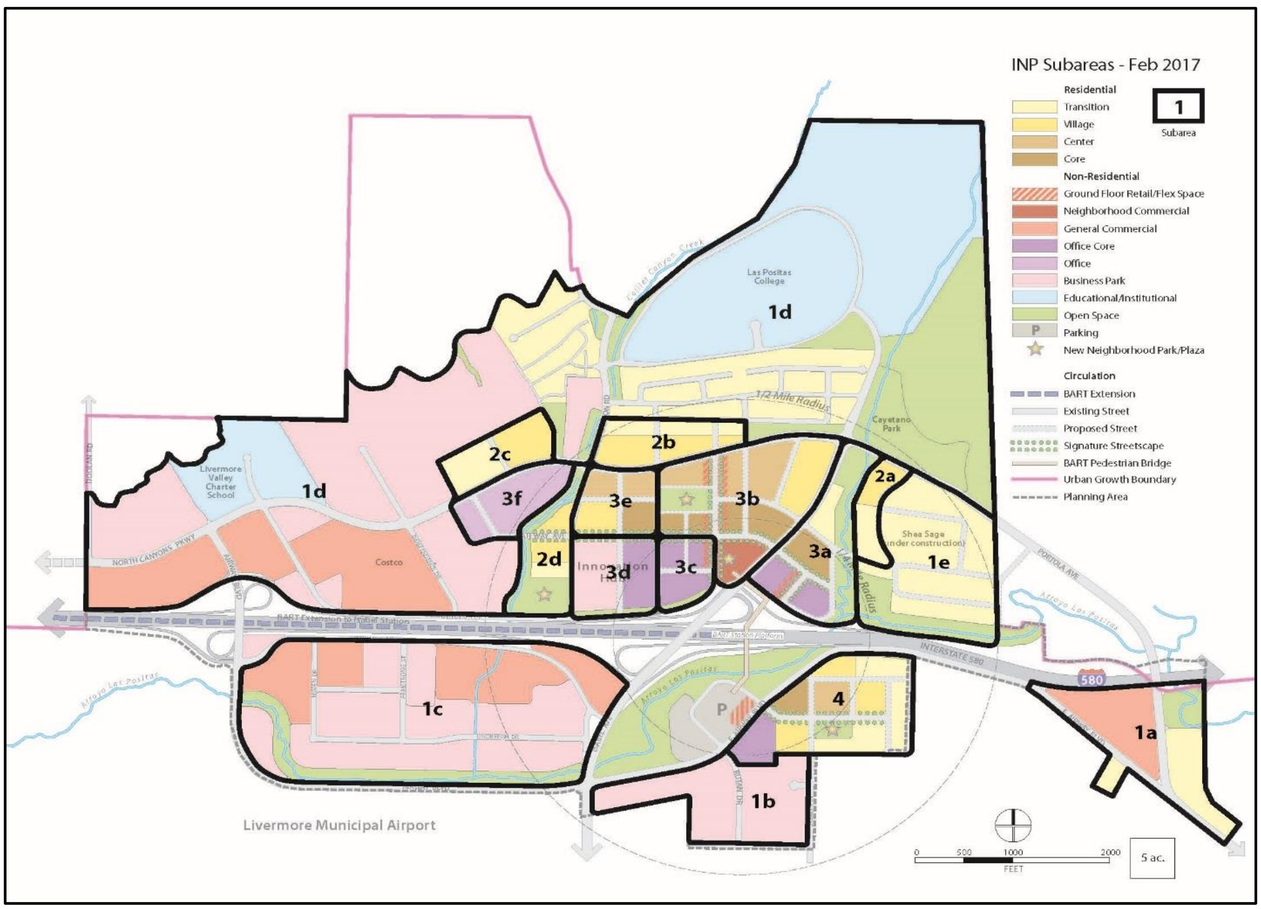
OVERVIEW

The Isabel Neighborhood Plan (INP) is a proposed development area located in the northwest portion of the City. The planning area for the INP covers approximately 1,138 acres, and is entirely within the City's urban growth boundary. The INP will guide future development of the area surrounding the proposed BART station in the Interstate 580 median, just east of Isabel Avenue and is contingent upon the extension of BART to this location.

Proposed land uses for the INP planning area are different from those currently included in the City's current adopted General Plan. The INP includes new residential areas both north and south of Interstate 580, as well as non-residential, employment generating, uses including ground floor retail, office and commercial. Three new neighborhood parks and open space buffers along the creeks are also proposed to provide recreational opportunities and access to natural areas.

Figure 1. Proposed Land Uses



The INP planning area includes both existing developed areas and proposed new development areas. Existing collection system infrastructure is in place to serve the existing developed areas within the INP planning area. However, as described in Chapter 5 of the 2017 Sewer Master Plan, improvements will be needed to serve future buildout of the INP planning area, even under current General Plan land uses, without development of the proposed INP land uses. And, as described below, some of those improvements would need to be modified to accommodate the development of the proposed INP.

The following describes the INP proposed land uses, projected collection system flows, and required collection system improvements to serve the proposed INP.

LAND USE ASSUMPTIONS

- Proposed INP land uses are based on information provided by the City of Livermore Planning Division.
  - Residential and Non-Residential acres by subarea and land use designation (INP Draft Plan Buildout 02/21/17).
  - Residential dwelling units by subarea (Preferred Plan Buildout – Residential Units, INP Draft Plan Buildout by Subarea 02/16/17).
  - INP Subarea Map (February 2017).
- Proposed INP land uses are provided for both Change Areas (i.e., proposed new development) and Non-Change Areas (i.e., existing development).
- The entire proposed INP planning area lies within the City of Livermore sewer service area.
- The proposed INP land uses by subarea are summarized in Table 1.

EVALUATION ASSUMPTIONS

- The INP sewer system evaluations to be performed by West Yost Associates (West Yost) will consider the projected sewer flows for both the Change Areas and the Non-Change Areas to evaluate overall City sewer infrastructure needs at buildout of the portions of the proposed INP which lie within the City's sewer service area.
- For the collection system modeling for the INP, existing sewer flows within the INP area will be removed and will be replaced with estimated total sewer flows for the INP project. This approach has been used to accurately reflect the existing and proposed new development, and, in particular, the proposed redevelopment of existing developed parcels. This approach is different from that used in the 2017 Sewer Master Plan where existing sewer flows for developed parcels are added to projected flows for planned developments and vacant parcels to determine the total flows.

Table 1. Proposed Land Uses by Subarea

		Residential, acres						Non-Residential, acres										
Subarea	Existing vs. New[(a)]	Transition	Village	Center	Core	Total Residential Acres	Residential Dwelling Units (du)	Ground Floor Retail/ Flex Space	Neighborhood Commercial	General Commercial	Office Core	Office	Business Park	Public/ Institutional	Total Non-Residential Acres	Total Acres	Subarea Total Acres	Notes
1a	New	11.2				11.2	224								-	**11.2**	**25.2**	INP Subarea 1a is in CalWater water service area
	Existing					-				14.0					14.0	**14.0**		
1b	New					-							10.2		10.2	**10.2**	**31.2**	INP Subarea 1b is in CalWater water service area
	Existing					-							21.0		21.0	**21.0**		
1c	New					-				7.0			4.8		11.8	**11.8**	**102.2**	
	Existing					-				30.9			59.5		90.4	**90.4**		
1d	New					-				12.4			7.4		19.8	**19.8**	**294.0**	
	Existing	53.8				53.8	907			59.3			80.9	80.2	220.4	**274.2**		
1e	New					-									-	**-**	**31.1**	Area is currently being developed; this is the Shea Sage development which is already approved and currently under construction; not yet "existing"
	Existing	31.1				31.1	476								-	**31.1**		
2a	New	3.5	3.2			6.7	182								-	**6.7**	**6.7**	
	Existing					-									-	**-**		
2b	New	4.6	7.7			12.3	361								-	**12.3**	**13.1**	
	Existing	0.8				0.8									-	**0.8**		
2c	New	5.5	6.2			11.7	328								-	**11.7**	**11.7**	
	Existing					-									-	**-**		
2d	New	1.7	4.0			5.7	174								-	**5.7**	**5.7**	
	Existing					-									-	**-**		
3a	New	2.8			3.8	6.6	507	0.9			6.4				7.3	**13.9**	**13.9**	
	Existing					-									-	**-**		
3b	New		6.4	10.8	7.9	25.1	1,278	2.5	4.1						6.6	**31.7**	**31.7**	
	Existing					-									-	**-**		
3c	New					-		0.5			6.9				7.4	**7.4**	**7.4**	
	Existing					-									-	**-**		
3d	New					-					5.9		8.0		13.9	**13.9**	**13.9**	Area is currently developed; does not reflect existing office buildings proposed to be replaced under INP project
	Existing					-									-	**-**		
3e	New		3.3	4.0	2.7	10.0	488								-	**10.0**	**10.0**	Area is currently developed; does not reflect existing office buildings proposed to be replaced under INP project
	Existing					-									-	**-**		
3f	New					-						6.2			6.2	**6.2**	**12.2**	Area is currently developed; does not reflect replacement of existing office building
	Existing					-						6.0			6.0	**6.0**		
4	New	10.3	7.5	3.1	2.6	23.5	795				5.2				5.2	**28.7**	**28.7**	INP Subarea 4 is in CalWater water service area
	Existing					-									-	**-**		
Outside of Subarea	New					-		0.9							0.9	**0.9**		
	Existing					-									-	**-**	**0.9**	
Totals	**New**	**39.6**	**38.3**	**17.9**	**17.0**	**112.8**	**4,337**	**4.8**	**4.1**	**19.4**	**24.4**	**6.2**	**30.4**	**-**	**89.3**	**202.1**		
	Existing	**85.7**	**-**	**-**	**-**	**85.7**	**1,383**	**-**	**-**	**104.2**	**-**	**6.0**	**161.4**	**80.2**	**351.8**	**437.5**		
	Total	**125.3**	**38.3**	**17.9**	**17.0**	**198.5**	**5,720**	**4.8**	**4.1**	**123.6**	**24.4**	**12.2**	**191.8**	**80.2**	**441.1**	**639.6**	**639.6**	**Does not include Parks and Open Space**

Source: INP Draft Plan Buildout 02/21/2017 (residential and non-residential acreages by subarea) and INP Draft Plan Buildout 02/16/2017 (residential dwelling units by subarea)

[(a)] "New" corresponds with "Change Areas" in the INP Land Use Plan; "Existing" corresponds with "Non-Change Areas" in the INP Land Use Plan.

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SEWER FLOW ASSUMPTIONS

Sewer Service Area

- All INP subareas are located in the City of Livermore sewer service area.

Sewer Flow Factors

- The average dry weather flow (ADWF) factor for all proposed INP residential land uses is assumed to be 80 gallons per day (gpd) per dwelling unit (du), (consistent with the ADWF factor for UH-4 residential land uses in the 2017 Sewer Master Plan). This ADWF factor is considered appropriate for the UH-4 density, as well as higher density development, as the individual dwelling unit square footages and occupancy of the higher density development would be, similar to UH-4 development, only with higher Floor Area Ratios (FAR) (e.g., additional stories) to provide for more dwelling units per acre.
- The ADWF for non-residential land uses is based on the ADWF factor for Business/Commercial Park (BCP) of 510 gallons per acre per day (gpad) (based on the ADWF factors established for the 2017 Sewer Master Plan).
  - The proposed non-residential land uses within the proposed INP include Ground Floor Retail/Flex Space, Neighborhood Commercial, General Commercial, Business Park and Public/Institutional, which will have sewer flow consistent with the BCP land use category.
  - Proposed Office Core and Office land uses are proposed to have multi-story office buildings (4 to 6 stories for Office Core and 3 to 4 stories for Office). The proposed Floor Area Ratios (FAR) for Office Core and Office land uses are consistent with the proposed multi-story construction. To account for ADWF in Office Core and Office land uses, the BCP ADWF factor is scaled up for Office Core (3 times the BCP ADWF factor, or 1,530 gpad) and for Office (2 times the BCP ADWF factor, or 1,020 gpad).

Projected Sewer Flow

- The projected ADWF sewer flow for the INP by subarea is provided in Table 2.
- A summary of the projected ADWF for the INP is provided in Table 3.

Incremental Additional ADWF for the INP

Sewer flows for the INP planning area with and without the proposed INP land uses are summarized in the table below (Table 4). As shown, the projected ADWF with the INP is approximately 37 percent higher than the projected ADWF based on the City's 2017 Sewer Master Plan assumptions, which are based on developed parcels and projected sewer flows for planned new development and vacant parcels based on General Plan land uses. The ADWF projected for the INP grew by a higher percentage than the average daily water demands for the INP. The higher percentage of ADWF growth is a result of existing and planned non-residential General Plan land uses in the CalWater water service area, which have a relatively low return-to-sewer ratio because of irrigation uses, being replaced with higher return-to-sewer ratio land uses proposed in the INP.

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Table 2. Projected Sewer Flow (ADWF)

Subarea	Existing vs. New [(a)]	Residential Sewer Flow, gpd	Residential Sewer Flow, af/yr	Office Core Sewer Flow, gpd	Office Core Sewer Flow, af/yr	Office Sewer Flow, gpd	Office Sewer Flow, af/yr	Other Non-Residential Sewer Flow, gpd	Other Non-Residential Sewer Flow, af/yr	Total ADWF, gpd	Total ADWF, af/yr	Notes
	ADWF Factor	80		1530		1020		510				
	Unit	gpd/du		gpad		gpad		gpad				
1a	New	17,920	20	-	-	-	-	-	-	**17,920**	**20**	
	Existing	-	-	-	-	-	-	7,140	8	**7,140**	**8**	
1b	New	-	-	-	-	-	-	5,202	6	**5,202**	**6**	
	Existing	-	-	-	-	-	-	10,710	12	**10,710**	**12**	
1c	New	-	-	-	-	-	-	6,018	7	**6,018**	**7**	
	Existing	-	-	-	-	-	-	46,104	52	**46,104**	**52**	
1d	New	-	-	-	-	-	-	10,098	11	**10,098**	**11**	
	Existing	72,560	81	-	-	-	-	112,404	126	**184,964**	**207**	
1e	New	-	-	-	-	-	-	-	-	**-**	**-**	
	Existing	38,080	43	-	-	-	-	-	-	**38,080**	**43**	
2a	New	14,560	16	-	-	-	-	-	-	**14,560**	**16**	
	Existing	-	-	-	-	-	-	-	-	**-**	**-**	
2b	New	28,880	32	-	-	-	-	-	-	**28,880**	**32**	
	Existing	-	-	-	-	-	-	-	-	**-**	**-**	
2c	New	26,240	29	-	-	-	-	-	-	**26,240**	**29**	
	Existing	-	-	-	-	-	-	-	-	**-**	**-**	
2d	New	13,920	16	-	-	-	-	-	-	**13,920**	**16**	
	Existing	-	-	-	-	-	-	-	-	**-**	**-**	
3a	New	40,560	45	9,792	11	-	-	459	1	**50,811**	**57**	
	Existing	-	-	-	-	-	-	-	-	**-**	**-**	
3b	New	102,240	115	-	-	-	-	3,366	4	**105,606**	**118**	
	Existing	-	-	-	-	-	-	-	-	**-**	**-**	
3c	New	-	-	10,557	12	-	-	255	0	**10,812**	**12**	
	Existing	-	-	-	-	-	-	-	-	**-**	**-**	
3d	New	-	-	9,027	10	-	-	4,080	5	**13,107**	**15**	
	Existing	-	-	-	-	-	-	-	-	**-**	**-**	
3e	New	39,040	44	-	-	-	-	-	-	**39,040**	**44**	
	Existing	-	-	-	-	-	-	-	-	**-**	**-**	
3f	New	-	-	-	-	6,324	7	-	-	**6,324**	**7**	
	Existing	-	-	-	-	6,120	7	-	-	**6,120**	**7**	
4	New	63,600	71	7,956	9	-	-	-	-	**71,556**	**80**	
	Existing	-	-	-	-	-	-	-	-	**-**	**-**	
Outside of Subarea	New	-	-	-	-	-	-	459	1	**459**	**1**	
	Existing	-	-	-	-	-	-	-	-	**-**	**-**	
Totals for INP	**New**	**346,960**	**389**	**37,332**	**42**	**6,324**	**7**	**29,937**	**34**	**420,553**	**471**	All INP Subareas
	Existing	**110,640**	**124**	**-**	**-**	**6,120**	**7**	**176,358**	**198**	**293,118**	**328**	
	Total	**457,600**	**513**	**37,332**	**42**	**12,444**	**14**	**206,295**	**231**	**713,671**	**799**	

[(a)] "New" corresponds with "Change Areas" in the INP Land Use Plan; "Existing" corresponds with "Non-Change Areas" in the INP Land Use Plan.

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Table 3. Projected ADWF

Service Area	Land Use	Average Dry Weather Flow (ADWF)	
		gpd	af/yr
Overall INP	Residential	457,600	513
	Non-Residential	256,071	287
	Total INP	**713,671**	**799**

Table 4. Planning Area Sewer Flows without Proposed INP Land Uses

	ADWF for INP Area, gpd
ADWF without INP[a]	519,000
ADWF with INP[b]	714,000
Difference in ADWF with INP	**195,000**

(a) As included in the City's 2017 Sewer Master Plan, based on developed parcels and projected sewer flows for planned new development and vacant parcels within the INP planning area based on General Plan land uses.
(b) Based on proposed INP land uses, which include both developed parcels and planned new development based on the INP.

Assumed ADWF Loading Locations for the INP

Because the development of the INP may result in the abandonment of existing collection system infrastructure and in the development of new gravity mains to serve the new development, it cannot be assumed that parcels within the INP will load to the same point in the future as they do currently. The future loading points will depend on the individual development projects, on the laterals that are designed to connect these projects to the collection system, and on the layout of the gravity mains designed to serve the projects.

Assumed ADWF loading locations for INP subareas were provided to West Yost based upon the current best estimates of future development patterns. Some subareas did not have assumed flow loading points provided, so for these subareas, West Yost assumed a ADWF loading point based upon the existing collection system. Gravity mains in the collection system that are upstream of the assumed ADWF loading points, either currently existing or proposed, are not evaluated for capacity in this study, and should be evaluated for capacity as part of the development design. The assumed ADWF loading locations are shown on Figure 2.

Peak Dry Weather Flow and Peak Wet Weather Flow for the INP

Consistent with the 2017 Sewer Master Plan, Peak Dry Weather Flow (PDWF) was calculated by applying appropriate, calibrated diurnal patterns to the ADWF from each land use in the INP. Peak Wet Weather Flow (PWWF), which is the design flow used for hydraulic evaluation of the collection system, was calculated by applying acreage-based Rainfall Dependent Inflow and Infiltration (RDII) factors to the INP subareas, consistent with the methodology of the 2017 Sewer Master Plan.

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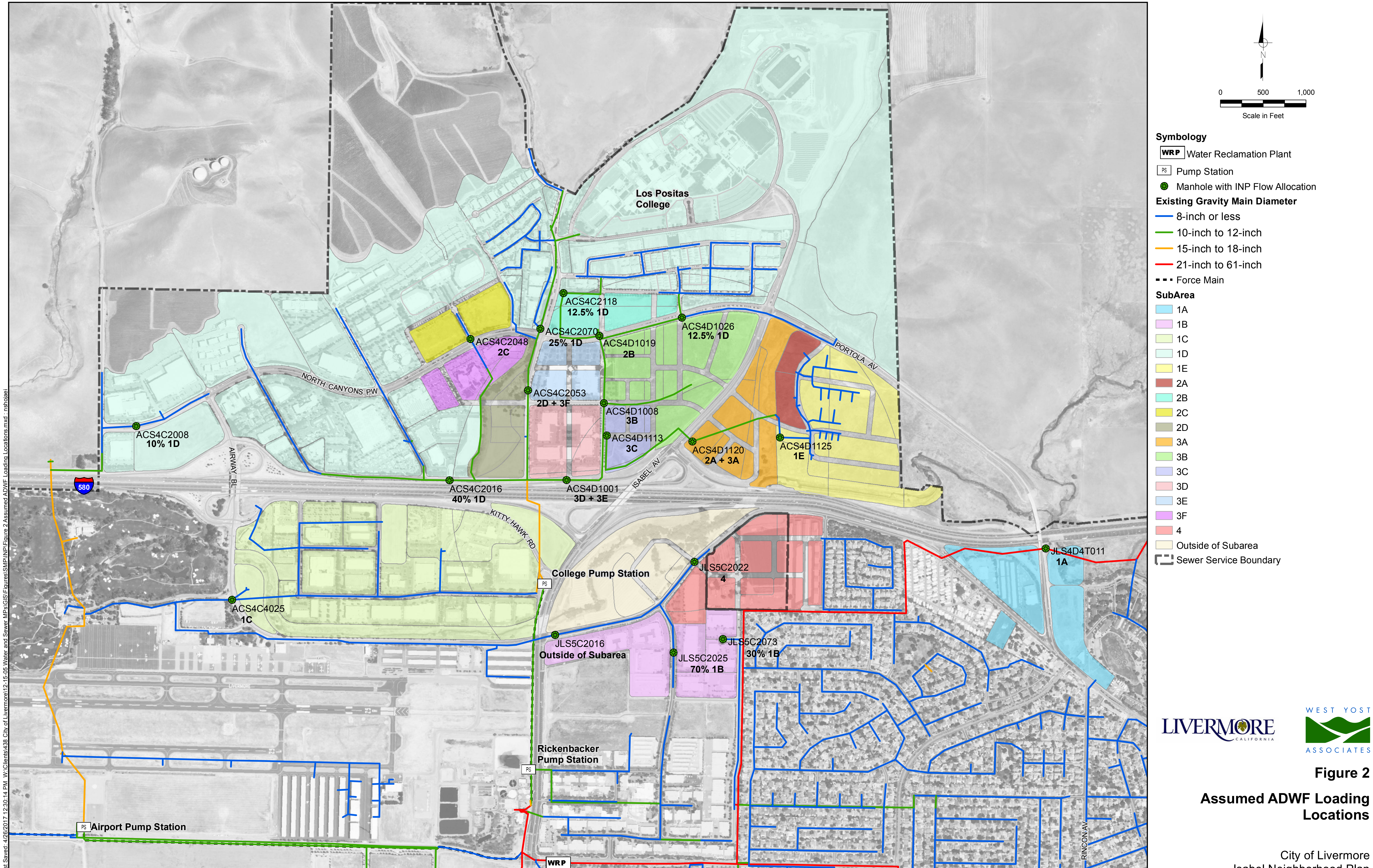

LIVERMORE CALIFORNIA

WEST YOST ASSOCIATES

Figure 2

Assumed ADWF Loading Locations

City of Livermore
Isabel Neighborhood Plan

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REQUIRED COLLECTION SYSTEM INFRASTRUCTURE TO SERVE THE PROPOSED INP

The collection system to which the INP is tributary was evaluated using the design and performance criteria developed for the 2017 Sewer Master Plan. The tributary collection system, which includes a multitude of gravity mains, the College Pump Station, the Airport Pump Station, and the force mains associated with these two pump stations, has no hydraulic deficiencies identified in the hydraulic model under existing PWWF design conditions. However, under existing PWWF design conditions, the existing tributary collection system has very little surplus capacity, and increased future flows trigger hydraulic improvements, both when the Isabel INP is considered and when it is not.

The following collection system infrastructure improvements are required to serve the proposed INP. These improvements are in addition to required collection system improvements for Build-Out design flows described in the 2017 Sewer Master Plan. The improvements required for Build-Out design flows without considering the INP are presented in conjunction with the INP improvements to facilitate comparisons between the two future conditions. The gravity main improvements required to serve the proposed INP can be found in Table 5. As can be seen in the table, two out of the five required gravity main improvements are required to serve Build-out conditions without the INP being considered as well. Three out of the five improvements are required only for the INP.

The results of the hydraulic evaluation for collection system pump stations that serve the INP area are shown in Table 6. As shown in the table, the College Pump Station has enough hydraulic capacity to serve both the Build-out and INP design flows. The INP design flow utilizes nearly the full capacity of the College Pump Station and would leave little capacity in reserve. The Airport Pump Station is hydraulically deficient under Build-out conditions both when the INP is considered, and when it is not. The results of the INP hydraulic evaluation can be seen on Figure 3.

The force main for each pump station was hydraulically sufficient under all conditions.

Estimated costs for the additional collection system improvements to serve the proposed INP are shown in Table 7 below. The estimated costs are developed using unit costs for construction to which a 30 percent planning contingency and a 30 percent factor for engineering, administration, and management are then applied. Unit cost and contingency assumptions from the 2017 Sewer Master Plan were used to develop the estimated capital costs shown in the table.

It should be noted that downstream of MH ACS4C4003, which is the downstream boundary of the gravity main improvements in Clubhouse Drive required to serve the INP, there remains a single 8-inch diameter gravity main that dumps into the 18-inch diameter gravity main that flows south toward the Airport Pump Station. If the gravity mains in Table 7 are upgraded to 10-inch diameter as recommended, this single 8-inch diameter gravity main will remain between a 10-inch diameter gravity mains upstream and a 15-inch diameter gravity main downstream. Although this 8-inch diameter gravity main is not technically deficient by performance criteria standards and thus has not been recommended for improvement in this analysis, the City should consider increasing the diameter of this gravity main to 10-inch diameter as part of the Clubhouse Drive project to maintain continuity of diameters for operations and maintenance purposes.

Table 5. Gravity Main Improvements Required to Serve INP

Upstream Manhole ID	Downstream Manhole ID	Length, LF	Current Dia., in	INP Proposed Dia., in	Maximum q/Q with Current Diameter[a]			Maximum q/Q after Improvement		
					Existing Design	Build-out Design	INP Design	Existing Design	Build-out Design	INP Design
ACS4C2013	JLS5C2015	236	15	18	0.624	0.984	**1.067**	0.384	0.607	0.658
ACS4C4007	ACS4C4006	276	8	10	0.673	0.986	**1.024**	0.371	0.547	0.565
ACS4C4006	ACS4C4005	285	8	10	0.684	**1.007**	**1.041**	0.377	0.556	0.574
ACS4C4005	ACS4C4004	189	8	10	0.686	**1.009**	**1.043**	0.378	0.557	0.575
ACS4C4004	ACS4C4003	287	8	10	0.671	0.982	**1.022**	0.370	0.545	0.564

[a] A gravity main is judged to be deficient when the maximum q/Q value exceeds 1.0 under the design condition for that gravity main.

Table 6. Pump Station Improvements Required to Serve INP

Pump Station Name	Pump Station Data		Existing Design		Build-out Design		INP Design	
	Firm Capacity, gpm	Existing Force Main Diameter, in	Design Flow, gpm	Available Firm Capacity, gpm	Design Flow, gpm	Available Firm Capacity, gpm	Design Flow, gpm	Available Firm Capacity, gpm
College Pump Station	~~1,180~~ 1,400	12	~~630~~ 430	~~550~~ 970	990	190	~~1,070~~ 1,029	~~110~~ 371
Airport Pump Station	1,145	10	680	465	1,480	**(335)**[a]	1,510	**(365)**[a]

[a] Negative values show deficient capacity.

Table 7. Estimated Costs for Improvements Required to Serve INP[(a)]

Improvement Type	Improvement Description	Estimated Cost[(b)], Build-out Requirements	Estimated Cost[(b)], INP Requirements
Gravity Main Upsize	Replace 236 lf of 15-inch diameter gravity main with 18-inch diameter between MH ACS4C2013 and MH JLS5C2015 under I-580. Jack and Bore installation assumed because of location.	-	$313,000
Gravity Main Upsize	Replace 276 lf of 8-inch diameter gravity main with 10-inch diameter between MH ACS4C4007 and MH ACS4C4006 in Clubhouse Drive. Open cut replacement is assumed.	-	$103,000
Gravity Main Upsize	Replace 285 lf of 8-inch diameter gravity main with 10-inch diameter between MH ACS4C4006 and MH ACS4C4005 in Clubhouse Drive. Open cut replacement is assumed.	$106,000	$106,000
Gravity Main Upsize	Replace 189 lf of 8-inch diameter gravity main with 10-inch diameter between MH ACS4C4005 and MH ACS4C4004 in Clubhouse Drive. Open cut replacement is assumed.	$71,000	$71,000
Gravity Main Upsize	Replace 287 lf of 8-inch diameter gravity main with 10-inch diameter between MH ACS4C4004 and MH ACS4C4003 in Clubhouse Drive. Open cut replacement is assumed.	-	$106,000
Pump Station Capacity Increase	Provide required capacity for design flow at the Airport Pump Station. This improvement is assumed to be an upgrade using existing facilities where possible, and not a full replacement.	$1,254,000	$1,273,000
	Total	**$1,431,000**	**$1,972,000**

(a) Based on March 2017 ENR CCI of 11609.44 (San Francisco Average).
(b) Estimated costs include a 30% planning contingency and a 30% factor for engineering, administration, and management.

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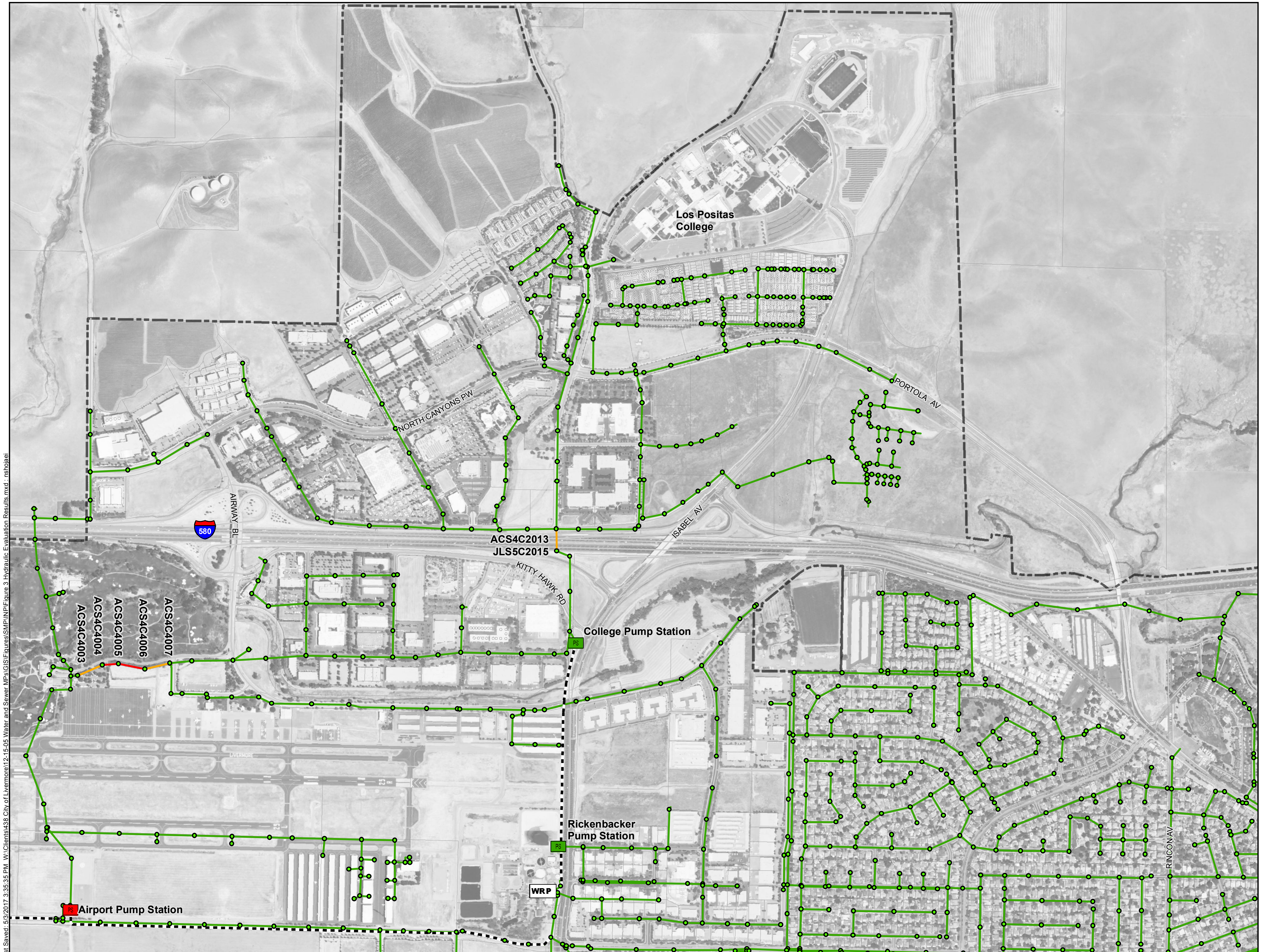

N

0 500 1,000

Scale in Feet

Symbology

WRP Water Reclamation Plant

Pump Station Capacity Results

No Capacity Deficiency

Capacity Deficiency Under Both General Plan Build-Out and INP Scenarios

Manhole

Gravity Main Capacity Results

No Deficiency

Deficiency Under INP Scenario Only

Deficiency Under Both General Plan Build-out and INP Scenarios

Force Main

Sewer Service Boundary

Note:
1. Labels shown are upstream and downstream manholes' ID of gravity main capacity deficiencies.

LIVERMORE CALIFORNIA

WEST YOST ASSOCIATES

Figure 3

Hydraulic Evaluation Results

City of Livermore
Isabel Neighborhood Plan

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APPENDIX C

Cost Estimating Assumptions

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1.1 OVERVIEW

This appendix provides the assumptions used by West Yost to develop an opinion of the probable construction cost for the planning and design of recommended sewer system facilities for the City's sewer system. The opinion of probable construction cost was developed based on a combination of data supplied by manufacturers, published industry standard cost data and curves, construction costs for similar facilities built by other public agencies, and construction costs previously estimated by West Yost for similar facilities with similar construction cost indexes.

Additionally, the costs presented in this appendix are for construction only and do not include uncertainties in estimation or unexpected construction costs (e.g., variations in final quantities) or cost estimates for land acquisition, engineering, legal costs, environmental review, soils investigation, surveying, construction management, and inspections and/or contract administration. Some of these additional cost items are referred to as contingency costs or mark-ups, and are further described in the last section of this appendix.

The opinion of probable construction cost has been adjusted to reflect March 2017 costs at an Engineering News Record (ENR) Construction Cost Index (CCI) of 11609 (San Francisco Average). These construction costs are to be used for conceptual cost estimates only, and should be updated regularly. Construction costs presented in this appendix are not intended to represent the lowest prices in the industry for each type of construction; rather they are representative of average or typical construction costs. These planning-level construction costs have been prepared for guidance in evaluating various facility improvement options, and are intended for budgetary purposes only, within the context of this master planning effort.

The following sections of this appendix describe the assumptions used to develop the opinion of probable construction cost for the planning and design of recommended sewer system facilities for the City's sewer system. The cost estimates prepared for this Sewer Master Plan are in accordance with the guidelines of the Association for the Advancement of Cost Engineering (AACE) International for a Class 5 Estimate, suitable for long-range capital planning, with an accuracy range of -50 percent to +100 percent.

1.2 PIPELINE REHABILITATION, REPAIR, AND REPLACEMENT METHODS AND BASE COSTS

The following base costs include sales tax, overhead and profit, and general conditions. They do not include estimating contingency, which is discussed separately in Section 1.3 below.

1.2.1 Rehabilitation, Repair and Replacement Methods

The following rehabilitation, repair, and replacement methods are potential options for the City's gravity main and force main projects: open cut construction, pipe bursting, pipe reaming, and tunneling. For projects that require the installation of a new relief sewer to address wet weather flows, in-situ methods for the existing pipe, such as the use of cured-in-place pipe, may be considered in conjunction with construction of the new relief sewer pipeline. Specific to the City's projects, factors that determine the most cost-effective rehabilitation method include geological and physical setting, existing pipeline material and condition, and available construction access.

1.2.1.1 Open Cut Construction

Description: Open cut or open trench construction, also known as cut and cover, has historically been the most widely used approach for sewer pipe replacements. A trench is excavated that is approximately 18 inches to 2 feet wider than the replacement pipe, and 6 to 12 inches deeper than the bottom of pipe. A new pipe is installed, backfill material placed and compacted, and pavement and surface facilities restored. Often, the new pipe is installed in a different location than the original pipe, and the original pipe abandoned in place. In this case, sewer flow continues through the original pipe, and a planned shutdown is scheduled during the "tie-in," when the new pipe is connected to the existing pipe. Alternatively, the existing pipe is removed to allow replacement of the new pipe in the same location. The existing flow is bypassed through a temporary pumped system during construction operations.

Advantages and Limitations: Historically, open cut construction has been more cost effective than trenchless technologies, and consequently, more widely used for pipe replacement. Open cut construction is appropriate in most soil conditions, and could be beneficial in locations where significant utility crossings are present, depending on the depths of existing utilities. An open trench can be adjusted in the field to avoid existing underground obstructions, or to otherwise relocate the new pipe. This method enables installation of a larger diameter pipeline where capacity issues are present, or improved materials when available or needed.

One limitation to open cut construction is in shoring and dewatering. Shoring of the trench walls is required for personnel safety and an engineered shoring system is required when a trench is greater than 5 feet in depth, in accordance with California Labor Code Section 6705. Excavation below the groundwater table, or in soils that permit infiltration of groundwater into the open trench, necessitate aggressive dewatering methods. The added cost of these requirements can decrease the economic viability of open cut construction in specific situations. For pipeline installations in new alignments, a geotechnical investigation is recommended during the design phase to determine shoring requirements and whether groundwater is anticipated during construction.

Open cut construction is also difficult where construction access is limited, or on steep hillsides. Open cut construction also impacts surface features and traffic, may introduce safety concerns in highly used or highly traveled locations, and creates temporary noise and dust impacts. Historically, Caltrans has required trenchless construction methods to be used for the installation of new pipelines within their rights of way.

1.2.1.2 Pipe Bursting

Description: Pipe bursting is a trenchless construction method by which existing pipe is replaced with the same size or typically one size larger pipe in the same location. Pipe bursting is most effective in replacing pipes that are less than 24 inches in diameter and are at least 4 feet deep. This method is the most cost effective when there are few lateral connections, when the old pipe is structurally deteriorated or is easily fractured (e.g., vitrified clay pipe), and when additional capacity is needed and trenchless methods are desired or required.

A conical pipe bursting head is conveyed through the pipe, exerting outward forces that fracture the existing pipe and displace fragments outward into the soil. The head is driven by pneumatic pressure, hydraulic expansion, or static pull; the head is connected to and pulls in the new pipe.

The pipe bursting head is inserted and also retrieved through new access pits that are located at approximately 400- to 500-foot intervals.

The optimal pull length is dependent upon the size of the host pipe, the degree of upsize required, and the type of soil in the surrounding subsurface. Additional pits, typically 2 feet wide by 2 feet long, are required at each service lateral connection and at crossing utilities. Pipes suitable for pipe bursting are those made of brittle materials, such as vitrified clay. Special bursting heads with cutting elements are required for more ductile pipe materials such as steel, polyvinyl chloride (PVC) and ductile iron. Typically, the replacement pipe material will be high-density polyethylene (HDPE) or fused PVC. Construction using PVC requires longer pit lengths than with HDPE because PVC requires a longer bending radius.

Advantages and Limitations: Pipe bursting is quickly gaining popularity as a replacement methodology for small diameter sewers. If HDPE pipe is used, a relatively small pit (as compared to open trench) is required for entry of the pipe bursting head, which can be extracted through an existing manhole. Pipe bursting replaces the existing pipe by up to two diameter sizes without significant open trenching, and therefore reduces surface impacts. The unit cost of pipe bursting is decreasing, and often comparable to open cut methods.

Existing conditions must be considered carefully when specifying pipe bursting. Flowing soils such as sand, highly incompressible soils such as rock, installations below the groundwater table, sensitive utilities located within two to three pipe diameters of the pipe to be burst, historical point repairs that are not conducive to bursting such as steel couplings, or significant sags or pipe collapses will limit the success of pipe bursting operations. Pipe bursting may also create ground vibrations and outward ground displacements adjacent to the pipe alignment; these displacements are exacerbated in shallow installations or when the pipe is significantly upsized. When the existing pipe is shallow, this ground displacement may be controlled by saw cutting pavement over the pipe in advance of the bursting operation. This approach localizes surface heave and provides for more simplified trench patch repair.

Pipe bursting is performed between pits spaced 400 to 500 feet apart. A manhole can be used in lieu of the receiving pit. During the pipe bursting process, the rehabilitated pipe segment must be taken out of service by rerouting or bypassing sewer flows. Laterals are reconnected through external pits after the pipe bursting activities are completed.

1.2.1.3 Cured in Place Pipe (CIPP)

Description: CIPP is a trenchless repair method that installs a resin-saturated felt liner into the host pipe through existing manholes. The liner is made of interwoven polyester and may be fiber-reinforced for additional strength. Commonly manufactured resins include unsaturated polyester, vinyl ester, and epoxy, each having distinct chemical resistance to domestic wastewater. The CIPP liner is installed by inversion using water or pressurized air; after the liner is in place, the resin-impregnated tube is cured using hot water, steam, or high-intensity ultraviolet light, creating a seamless pipe that fits tightly against the host pipe wall. Laterals are then connected to the mainline pipe using a remote-controlled cutting device.

Advantages and Limitations: CIPP is a viable rehabilitation technology in 6-inch or larger gravity sewers where the existing pipe has sufficient capacity. Because laterals are connected from inside the lined pipe, little or no trenching is required. Therefore, CIPP may be a preferred alternative in pipelines where trenching would be cost prohibitive. The CIPP method can be used to address structural problems such as cracks and structurally deficient segments, as well as root intrusions because the liner forms itself generally to the shape of the host pipe, and can span gaps caused by roots up to 1 inch in diameter. Larger gaps and alignment deficiencies such as offset joints and sags would require a point repair prior to lining.

The flexibility of the resin tube allows installation through existing bends, further minimizing the need for excavation. The liner is resistant to chemical attack, eliminates groundwater from entering the sewer, and retards further corrosion and erosion of the pipeline.

The thickness of CIPP liner typically ranges from ½ inch to 1 inch and therefore, the final inside diameter is approximately 1 to 2 inches less than the inside diameter of the existing pipe. The liner typically has less flow friction compared to the host pipe, so the reduction in diameter does not result in a reduction in hydraulic capacity, particularly for pipe above 8 inches in diameter.

CIPP installation requires bypass pumping and groundwater dewatering, if in a high groundwater area. Installation length is generally limited to approximately 800 feet due to curing limitations. Therefore, if manholes are located further apart than 800 feet, intermediate trenched access locations are required. Another challenge associated with using CIPP is the procurement, treatment, and/or disposal of water used during the curing process; during the curing process of any resin system, volatile organic compounds are released and must be closely monitored.

CIPP is a viable alternative to pipeline replacement when pipeline replacement options are cost-prohibitive, and when existing pipe diameter can be reduced without compromising system performance. CIPP is not recommended when pipeline slopes or other constraints limit the use of hydroflushing as a cleaning method.

1.2.1.4 Pipe Reaming

Description: Pipe reaming is very similar to pipe bursting in that an existing pipe is drilled out and a new pipe of equal or greater diameter inserted in its place. Because pipe reaming does not displace the broken pieces of the old pipe into the soil, this method is better suited to pipe rehabilitation where nearby pipes or utilities might be impacted by the displaced soil.

Pipe reaming employs a directional drill which pulverizes and grinds up the existing pipe while a new pipe is inserted behind it. The old pipe is accessed by an insertion trench, and the drill head is pulled through the pipe by a drill line which runs from an insertion trench where the pipe is accessed to the next manhole. The broken pipe is carried away through the old pipe by drill fluid and collected at the downstream manhole.

Pipe reaming can be used to remove brittle pipes such as those composed of vitrified clay, PVC, asbestos concrete, or ductile iron. Fused PVC or HDPE are typically used for the replacement pipe. Pipe reaming has been effective at replacing sections of sewer over 1,000 feet in length or more with little soil disruption.

Advantages and Limitations: Like other trenchless technologies, pipe reaming is advantageous when trying to minimize the impact of construction on traffic and business. When using pipe reaming as a rehabilitation technology, adequate space must be available for the insertion pit and the heavy machinery necessary for directional drilling and handling of the solids generated by the drilling process. Pipe reaming can become very expensive if there are a large number of laterals that must be reconnected to the replaced pipe.

1.2.1.5 Tunneling

Description: Where open cut construction is not feasible, practical, or cost effective, trenchless methods can be used to install the sewer pipe. Commonly used trenchless methods include jack-and-bore above the water table, micro tunneling below the water table, and horizontal direction drilling. These methods involve pre-drilling the pipeline alignment and then installing new pipe through the opening. When installed below Caltrans or railroad right of ways, an additional casing may be required by the governing jurisdiction.

Advantages and Limitations: Tunneling presents similar advantages to pipe bursting and pipe reaming related to minimized surface impacts when compared to open cut construction. Pipe size increase is not limited with tunneling methods and longer lengths of pipe can be replaced through a single bore.

Tunneling requires precise location of existing utilities and is not always appropriate where the new pipeline must maintain a precise slope or avoid numerous underground facilities. Additionally, tunneling requires an understanding of the materials to be tunneled through. Tunneling requires experienced equipment operators that are skilled with the location and guidance of the necessary equipment. Tunneling is assumed to be required along and across Caltrans and railroad rights-of-way.

1.2.2 Pipeline Cost Estimates

For the Sewer Master Plan, it was assumed that pipelines would be installed using open cut methods under normal conditions. The descriptions for pipe bursting and pipe reaming are included for reference, in the event that preliminary design indicates that these methods are more feasible for a particular project. Tunneling methods are assumed to be used when normal conditions are not present, such as when construction must take place under a freeway, railroad track, or similar obstacle. The pipeline unit construction costs used in the Sewer Master Plan are shown in Table 1. The tunneling costs are shown in Table 2.

Table 1. Unit Construction Costs for Pipelines[a,b]	
Pipeline Diameter, inches	Unit Construction Cost, $/linear foot
8	176
10	220
12	264
15	300
18	360
21	420
24	480
27	540
30	600
33	660
36	720

(a) Costs based on San Francisco Peninsula pipeline cost estimates, scaled up to March 2017 ENR CCI of 11609 (San Francisco Average).
(b) Costs based on polyvinyl chloride pipe.

Table 2. Unit Construction Costs for Tunneling (Bore and Jack)[a,b]	
Pipeline Size	Unit Construction Cost, $/linear foot
8-inch diameter (16-inch diameter casing)	530
12-inch diameter (21-inch diameter casing)	605
15-inch diameter (24-inch diameter casing)	700
21-inch diameter (30-inch diameter casing)	865

(a) Costs based on San Francisco Peninsula pipeline cost estimates, scaled up to March 2017 ENR CCI of 11609 (San Francisco Average).
(b) Conductor pipe is not included in cost.

1.3 LIFT STATION CONSTRUCTION AND CAPACITY UPGRADE CONCEPTUAL COSTS

The hydraulic capacity analysis presented in Chapter 5 identified existing lift stations with insufficient capacity. Lift station new construction and capacity upgrade construction cost estimates are based upon pre-established West Yost costs curves for wastewater lift stations, which combine the cost curves presented in Shank's "Pumping Station Design" with cost data from actual projects completed in the last 10 years.

The lift station firm capacity (the capacity of the station with the largest pump in reserve) is the key value to input to the curves. From the capacity value, a line is drawn to where capacity intersects the cost curve lines. Two lines are provided to reflect difficult construction conditions and comparatively easy construction conditions.

1.4 CONTINGENCY COSTS AND MARK-UPS

Contingency costs or mark-ups must be reviewed on a case-by-case basis because they will vary considerably with each construction project. However, to assist City staff with budgeting for recommended water system facility improvements, the following percentages were developed.

- Estimating Contingencies (30 percent): The construction costs presented above are representative of the construction of wastewater collection system facilities under normal construction conditions and schedules; consequently, it is appropriate to allow for estimating and construction uncertainties unavoidably associated with the conceptual planning of projects. Factors such as unexpected construction conditions, the need for unforeseen mechanical items, and variations in design and final quantities are only a few of the items that can increase project costs.
- Design and Construction Period Services (50 percent): Professional services have been divided into two categories as shown below.

Design Period Services:	20 percent
Construction Period Services:	30 percent
Total:	50 percent

Design period services associated with new facilities include preliminary investigations and reports, right-of-way acquisition, foundation explorations, preparation of drawings and specifications for construction, surveying and staking, sampling of testing material, and start-up services. Design period services also include permitting and regulatory compliance, as well as City administration, legal, and associated activities. Construction period services cover items such as contract management and inspection during construction.

The total markup, including contingencies and professional services, is compounded, and amounts to 95 percent of the estimated construction cost. However, it must be noted that for smaller or more complicated projects, the design cost may increase by 10 to 20 percent of the estimated construction cost.

An example application of these standard mark-ups to a project with an assumed base construction cost of $1.0 million is shown in Table 3. As shown, the total cost of all project markups is 95 percent of the base construction cost for each construction project.

Table 3. Example Application of Project Cost Mark-ups		
Cost Component	Percent	Cost
Base Construction Cost[(a)]		$1,000,000
Estimating Contingency	30%	$300,000
Total Construction Cost		$1,300,000
Design Period Services (Consultant/City to perform design, bid, permitting, CEQA, regulatory, legal, outreach, administration)	20%	$260,000
Construction Period Services (Consultant/City to perform construction management, inspection, testing, programming, engineering support, change order contingency)	30%	$390,000
Total Project Cost		**$1,950,000**

(a) Assumed cost of an example project.

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WEST YOST ASSOCIATES