City of San Mateo, Town of Hillsborough, and Crystal Springs County Sanitation District

Sewer System Flow Monitoring and Hydraulic Modeling

Final Report

May 2010

RMC

Water and Environment

Table of Contents

List of Tables

List of Figures

Appendices

Executive Summary

This report presents the results of wet weather flow monitoring and modeling studies conducted for the City of San Mateo, Town of Hillsborough, and Crystal Springs County Sanitation District (CSCSD) to evaluate sewer system flows and capacity requirements in each respective system and the combined flows in jointly used facilities. The focus of this study was on CSCSD's Polhemus Trunk Sewer, Hillsborough's Crystal Springs/El Cerrito Trunk Sewer, and San Mateo's trunk system downstream of the Hillsborough/San Mateo city limits, which conveys the combined flows from the three agencies to San Mateo's Dale Avenue Pump Station. From there, the flows are pumped to the San Mateo Wastewater Treatment Plant. The San Mateo County administrative center and juvenile facilities on Tower Road also contribute flow to the jointly used facilities.

Flows in the system are currently measured by two permanent flow meters that are owned and maintained, respectively, by CSCSD at the downstream end of the Polhemus Trunk Sewer, and by San Mateo on El Cerrito Avenue at Gramercy Drive at the border with Hillsborough. The allocation of metered flows to the contributing agencies is complicated by the fact that there are some small areas of one agency that discharge into the trunk sewer owned by another agency.

The objectives of the study were to determine the flow contribution from each agency to jointly used facilities in order to verify the capacity requirements for sewer improvements needed to alleviate sewer system overflows and comply with the requirements of the Cease and Desist Order issued to the three agencies in 2009 by the San Francisco Bay Regional Water Quality Control Board. The study included an extensive wet weather flow monitoring program conducted during the winter 2008/09, and development and calibration of hydraulic models of each agency's trunk sewer system. The flow monitoring data and models were used to quantify design flows and identify potential capacity deficiencies in the systems.

Table ES-1 summarizes the design flows for each portion of the system. It should be noted, however, that the small size of some of the metered areas and challenging site conditions (e.g., steep slopes, backwater from surcharged downstream trunk sewers, debris and other obstructions, etc.), reduces the accuracy of some of the data, particular for sites in CSCSD and Hillsborough. Therefore, the distribution of flows shown in the table for areas upstream of the CSCSD and El Cerrito Meters, particularly for the small County and San Mateo areas, may need further confirmation.

The modeling identified capacity deficiencies in various areas of the trunk sewer systems, including the portion of Hillsborough's Crystal Springs/El Cerrito Trunk Sewer that has not yet been improved, and many areas within the San Mateo's system that had previously been identified as capacity deficient in the City's 2005 City-Wide Sewer System Study. The modeling conducted for this study confirmed the need for the Phase II Crystal Spring/El Cerrito Avenue Relief sewer project, and indicated that the proposed sewer, as designed, would be adequate to convey the predicted design flows.

This study has also indicated the need for improved flow monitoring data to verify and track the flows from the various portions of the system. Improvements to existing permanent flow monitoring, including potential new meters and/or improved maintenance and calibration procedures for existing meters, have been implemented or are being considered by the three agencies. The agencies should also consider conducting another system-wide flow monitoring program in the future once some of the major capacity improvement projects are completed.

Table ES-1: Design Flows

Agency	Incremental Flow				Total Flow			
	ADWF (MGD)	PWWF (MGD)	% ADWF	% PWWF	ADWF (MGD)	PWWF (MGD)	% ADWF	% PWWF
To CSCSD Meter (Polhemus Road upstream of Crystal Springs Road)								
County	*0.023*	*0.61*	*5%*	*13%*	*0.023*	*0.61*	*5%*	*13%*
CSCSD	0.33	3.53	75%	75%	0.33	3.53	75%	75%
San Mateo	*0.088*	*0.55*	*20%*	*12%*	*0.088*	*0.55*	*20%*	*12%*
Total	**0.44**	**4.7**			**0.44**	**4.7**		
To El Cerrito Avenue Meter (El Cerrito Avenue at Gramercy Drive)								
County	*0*	*0*	*0%*	*0%*	*0.023*	*0.60*	*2%*	*6%*
CSCSD	0.005	*0.23*	*1%*	*4%*	0.33	3.72	32%	37%
Hillsborough	0.59	5.13	97%	94%	0.59	5.13	56%	51%
San Mateo	*0.012*	*0.11*	*2%*	*2%*	*0.100*	*0.65*	*10%*	*6%*
Total	**0.60**	**5.5**			**1.04**	**10.1**		
To Dale Avenue Pump Station								
County	*0*	*0*	*0%*	*0%*	*0.02*	*0.60*	*0.2%*	*0.7%*
CSCSD	0	0	0%	0%	0.33	3.72	4%	4%
Hillsborough	*0.066*	*0.88*	*1%*	*1%*	0.65	6.01	7%	7%
San Mateo	8.37	76.0	99%	99%	8.47	76.7	89%	88%
Total	**8.44**	**76.9**			**9.48**	**87.0**		

Notes:
ADWF = average dry weather flow, including estimated flow from future development.
PWWF = peak wet weather flow based on a 5-year design storm in an unrestricted system.

1 Introduction

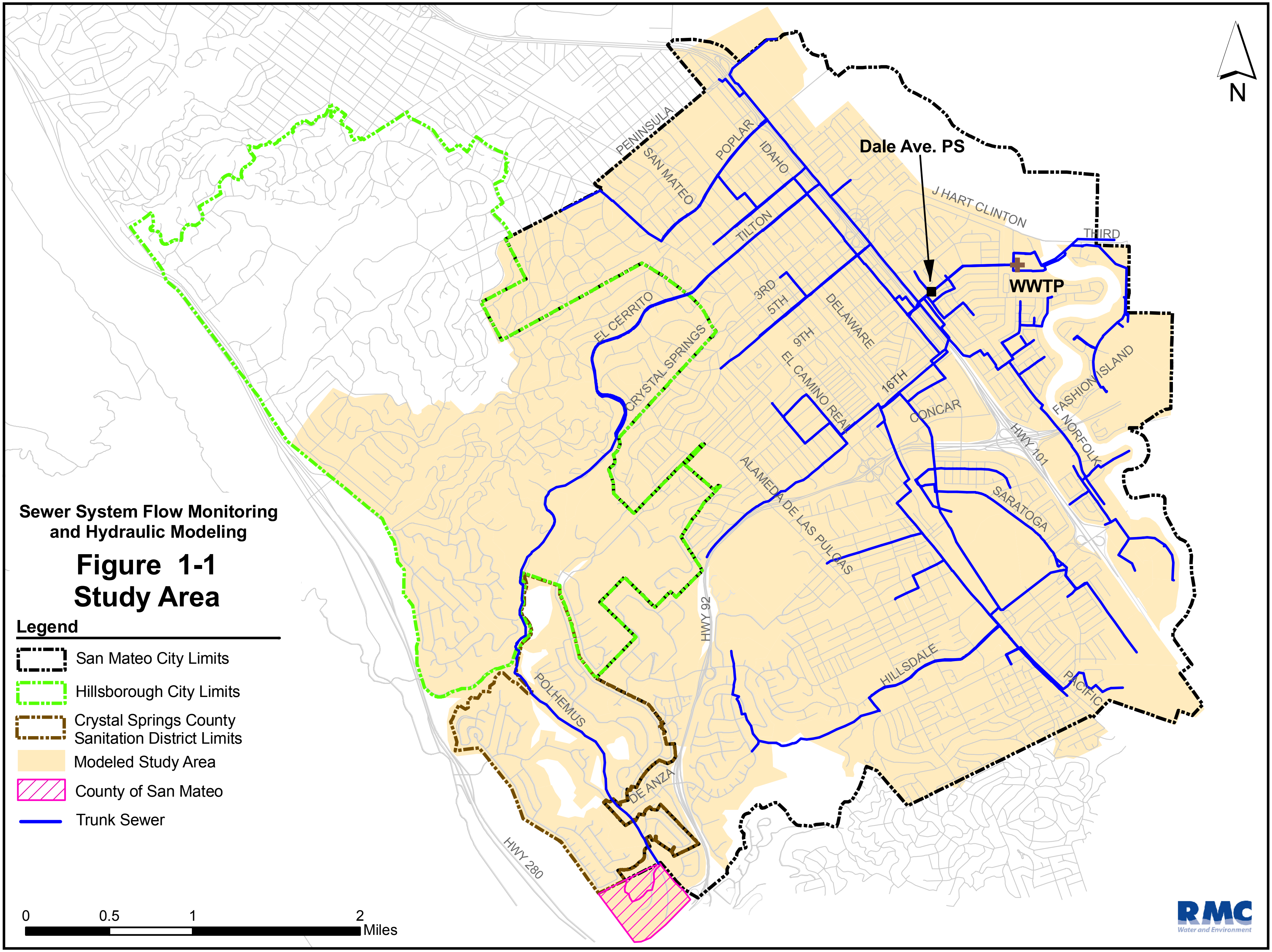
This report presents the results of wet weather flow monitoring and modeling studies conducted for the City of San Mateo (San Mateo or City), Town of Hillsborough (Hillsborough or Town), and Crystal Springs County Sanitation District (CSCSD) to evaluate sewer system flows and capacity requirements in each respective system and the combined flows in jointly used facilities. (Note: for Hillsborough, the report only addresses the portion of the system tributary to the San Mateo Wastewater Treatment Plant; the remainder of Hillsborough's flow is conveyed to the City of Burlingame.) San Mateo, Hillsborough, and CSCSD are collectively referred to as "the agencies" in this report. This report was prepared by RMC Water and Environment under separate agreements with each agency.

1.1 Background and Purpose of Study

The agencies each own and operate sewer collection systems that ultimately convey wastewater flows to San Mateo's Wastewater Treatment Plant (WWTP), which also receives flow from Foster City. The main conveyance pipelines that are the primary focus of this study consist of the Polhemus Trunk Sewer, which is owned by CSCSD and runs along Polhemus Road from Tower Road to Crystal Springs Road; the Crystal Springs/El Cerrito Trunk Sewer, owned by Hillsborough, extending along Crystal Springs Road and El Cerrito Avenue from the downstream end of the Polhemus Trunk to the border with San Mateo at Gramercy Drive; and the Tilton/Idaho Trunk Sewer, owned by San Mateo, which conveys the combined flows from the agencies to San Mateo's Dale Avenue Pump Station via trunk sewers in El Cerrito Avenue, Tilton Avenue and Idaho Street to Sunnybrae Avenue and across Highway 101. Flows from most of the remainder of San Mateo are also conveyed to the Dale Avenue Pump Station, from where they are pumped to the WWTP. These facilities and the overall service area for this study are shown in **Figure 1-1**.

The original agreement regarding ownership and responsibility for jointly used facilities was executed in 1989 between San Mateo, Hillsborough, CSCSD, and the County of San Mateo (the County contributes flow from its Tower Road complex to the CSCSD system). That agreement specified the way in which the flow contribution from each agency for jointly used facilities would be measured and calculated. Over the years, however, issues have arisen as to the accuracy of the two permanent flow meters used to quantify these flows (the CSCSD meter located at the downstream end of the Polhemus trunk at the border of CSCSD and Hillsborough, and the El Cerrito meter located at the downstream end of the Crystal Spring/El Cerrito trunk at the border of Hillsborough and San Mateo). Furthermore, sanitary sewer overflows have occurred along the Crystal Springs/El Cerrito trunk sewer due to high wet weather flows. These overflows, among others, have resulted in the recent issuance of a Cease and Desist Order (CDO) from the San Francisco Bay Regional Water Quality Control Board (RWQCB) to the three agencies.

Although Hillsborough has previously completed Phase I of an improvement project to upgrade the Crystal Springs/El Cerrito trunk sewer, the Phase II (downstream) portion of the project has not yet been constructed, pending confirmation of the design flows and appropriate design flow allocations for the upstream contributing agencies. This allocation is complicated by the issues with the permanent flow meters, as well as the fact that small portions of San Mateo's sewer system discharge into both the CSCSD and Hillsborough systems along the Polhemus and Crystal Springs/El Cerrito trunks. Therefore, one of the primary objectives of this study is to provide sufficient information to quantify the flows from each agency and confirm the sizing of the Phase II Crystal Springs/El Cerrito trunk sewer improvements and additional improvements within San Mateo that would be needed to convey the flows downstream to the Dale Avenue Pump Station.



Sewer System Flow Monitoring and Hydraulic Modeling

Figure 1-1
Study Area

The agencies are also evaluating and implementing changes to the existing permanent flow meters to improve the accuracy and reliability of the collected flow data. In October 2009, San Mateo replaced the flume and meter at the El Cerrito Avenue location with a permanent, open-channel depth-velocity meter. CSCSD has conducted previous studies to assess the accuracy of its magnetic flow meter on the Polhemus trunk sewer, and RMC has prepared an assessment of the existing meter operation as part of the current work for CSCSD. Alternatives for other types of permanent metering at the CSCSD/Hillsborough boundary have also been developed and will be provided in separate documents to those agencies.

Each of the agencies has previously conducted various studies relating to their respective sewer systems. The following paragraphs briefly summarize those previous studies.

1.1.1 San Mateo

San Mateo completed the Los Prados-South Shoreview Sewer Study in 2000 and City-Wide Sewer System Study in 2005. Those studies included development of hydraulic models of the trunk sewer system calibrated to flow monitoring data collected under various programs between 1997 and 2002. The studies identified capacity deficiencies in the existing trunk sewer system and a number of relief projects that would be needed to alleviate the capacity deficiencies. The City has constructed some of the smaller projects and is in the process of designing several of the major ones, including the Los Prados (Norfolk Street) and South Trunk relief sewers. The City is also preparing a wet weather master plan to identify the most cost-effective approach overall for dealing with wet weather issues at its treatment plant and within its collection system.

1.1.2 Hillsborough

Hillsborough completed a number of studies during the 1990s focused on quantifying infiltration/inflow (I/I) flows and identifying needed sewer rehabilitation and sewer improvement projects to deal with wet weather issues. A specific study was focused on the Lakeview and Crystal Springs subbasins, which comprise most of the portion of the system tributary to San Mateo. The study included a model of the Crystal Springs/El Cerrito trunk sewer to assess the capacity of the sewer and determine required capacity improvements. The studies also identified sewer rehabilitation needs for the trunk sewer as well as upstream portions of the collection system. As noted above, Hillsborough subsequently designed and constructed the Phase I Crystal Spring/El Cerrito sewer improvement project and has substantially completed design of the Phase II project.

1.1.3 Crystal Springs County Sanitation District

As part of an overall Master Plan for all of its sanitation and sewer maintenance districts, the County of San Mateo completed a Sewer Master Plan for CSCSD in 1999. That study included flow monitoring and modeling of the Polhemus trunk sewer and identified the need for capacity improvements for the lower portion of the trunk sewer. Those improvements were completed in 2003. The remaining identified improvements were needed to address structural and maintenance problems in the system.

1.2 Scope of Work

The scope of work for the current studies consists of the following major tasks:

- Conduct wet weather flow and rainfall monitoring during the winter 2008/09 in all three systems in order to quantify existing flows and flow response to rainfall events.
- Develop an updated hydraulic model of the trunk sewer systems of all three agencies, calibrated to the flow monitoring data collected as part of the study.
- Develop design peak wet weather flows and contributions from each agency.

- Using the hydraulic model, identify capacity deficiencies in the trunk sewer systems under existing and future projected design storm peak wet weather flow conditions.
- Confirm the adequacy of the Phase II Crystal Springs/El Cerrito sewer improvement project to convey the projected peak wet weather flows.

Other tasks, specific to each agency and not included in this report, include assessment of permanent metering options (as discussed above), evaluation of subbasin flows and potential effectiveness of previous sewer rehabilitation efforts, and development of alternatives to address capacity deficiencies identified in this study. The results of these tasks, if included in the scope of work, will be provided in separate technical memoranda to the respective agencies.

1.3 Report Organization

This report is divided into the following major sections:

- Section 1, Introduction, describes the background and purpose of the study, scope of work, and report organization, and provides a list of abbreviations and definitions of key terms used in the report.
- Section 2, Hydraulic Models, describes the modeled trunk sewer system for each agency and how the models were developed.
- Section 3, Flow Monitoring, describes the flow monitoring program, including meter and rain gauge locations, potential limitations of the monitoring data, and a summary of the storm events and monitored flows.
- Section 4, Design Flows, describes the basis for developing each component of design wastewater flows and the estimated design flows for each agency's system.
- Section 5, Capacity Assessment, presents the results of the hydraulic modeling and predicted capacity deficiencies in the trunk sewer systems. This section also reviews the proposed improvements for the Crystal Springs/El Cerrito trunk sewer.

1.4 Abbreviations and Definitions

The following abbreviations and definitions are used throughout this report:

ADWF	Average flow during dry weather periods, typically consisting of average base wastewater flow plus dry season groundwater infiltration.
BWF	Base wastewater flow: sanitary and process flow contributions from residential, commercial, institutional, and industrial users of the system.
CDO	Cease and Desist Order
City	City of San Mateo
County	County of San Mateo
CSCSD	Crystal Springs County Sanitation District
Design Storm	Rainfall event that defines the peak wet weather flows for which required sewer system capacity is determined. For San Mateo and its tributary agencies, the design storm is a 6-hour, 5-year frequency rainfall event defined based on rainfall intensity-duration-frequency statistics.

Diurnal Profile	Change in base wastewater flow over a typical 24-hour period.
DU	Dwelling unit
DWF	Dry weather flow: the flow during non-rainfall periods, composed of base wastewater flow plus any dry season groundwater infiltration.
fps	Feet per second
GIS	Geographic Information System: a computerized system in which geographical features (e.g., sewer facilities, parcels, land use) are linked to an attribute database to facilitate analysis and presentation of information.
gpd	Gallons per day
GWI	Groundwater infiltration: extraneous water that infiltrates into a sewer system from the ground through defective pipes and manholes. Groundwater infiltration is considered to be a relatively constant daily flow that varies seasonally and depends on location of sewers with respect to the groundwater table.
Hillsborough	Town of Hillsborough
I/I	Infiltration/inflow: extraneous groundwater and/or storm water that enter a sanitary sewer system.
MGD	Million gallons per day
PDWF	Peak dry weather flow: the peak flow during a non-rainfall period.
PS	Pump Station
PWWF	Peak wet weather flow: the peak flow during a given storm event from dry weather flow plus infiltration and inflow.
RDI/I	Rainfall-dependent infiltration/inflow: the infiltration and inflow into a sewer system directly related to a rainfall event. RDI/I may cause rapid, short-term peak flows in the sewer system that recede after the rainfall has ended.
RMC	RMC Water and Environment
RWQCB	San Francisco Bay Regional Water Quality Control Board
San Mateo	City of San Mateo
Subcatchment	An area tributary to a modeled manhole, used for estimating a flow load to the model.
Surcharge	The hydraulic condition in a sewer pipeline in which the elevation of the hydraulic gradeline (water level) is above the crown (top) of the pipe. Under such a condition, the water in the pipe rises into the manholes and could overflow onto the ground if the hydraulic gradeline exceeds the elevation of the manhole rims.
Town	Town of Hillsborough
WWF	Wet weather flow: the flow during rainfall periods, composed of base wastewater flow, wet season groundwater infiltration, and rainfall-dependent I/I.
WWTP	Wastewater Treatment Plant

2 Hydraulic Models

Hydraulic models of the trunk sewer systems of the three agencies were developed using InfoWorks CS™, a fully dynamic hydraulic modeling software that has been used for previous modeling of San Mateo's sewer system. The models comprise the trunk sewer systems of each agency, primarily the 10-inch and larger diameter pipes plus additional smaller pipes that transport wastewater flows generated and collected in each agency's system to the San Mateo WWTP. Flow inputs to the modeled trunk sewer system are defined by sewer subbasins (called "subcatchments" in InfoWorks), each of which represents the flow generated in a specific area of the collection system that discharges to the modeled trunk system at a single location or several locations in close proximity. In the models, each subcatchment is associated with a specific "load manhole" in the modeled network and data that define its flow contribution (e.g., contributing area, population, and flow parameters).

The subsections below describe the modeled sewer systems of each agency and how the models were developed. The development of model loads is described in Section 4, Design Flows. Although the individual agency models were developed separately, the model networks were later joined to form a fully connected network to be used for the capacity assessment presented in this report.

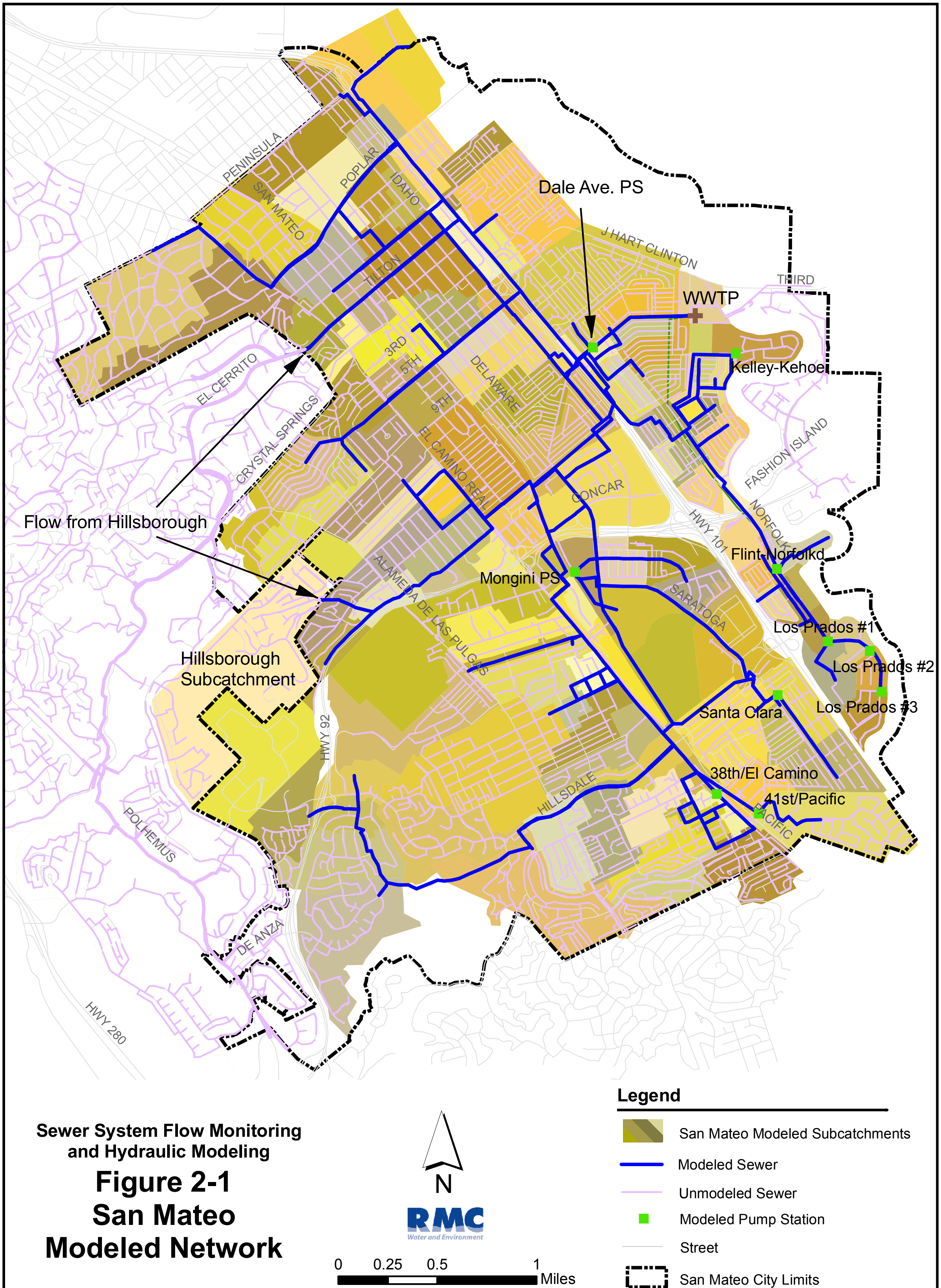
2.1 City of San Mateo

Models of the San Mateo trunk sewer system were developed in the two sewer system studies mentioned previously: the Los Prados South Shoreview Sewer Study and the City-Wide Sewer System Study. For this study, the previous models were updated based on new information obtained from the City's current sewer GIS files, and the models were combined into a single network. Specifically, the latest model includes as-built information for the trunk sewers that have been constructed since the initial development of the previous models, including the El Camino/Palm, Concar Drive, Saratoga Drive, and Patricia Avenue sewer projects. In addition, the subcatchment delineation in the model was reviewed and refined in some areas to better reflect the configuration of the system and loading to the modeled trunk network. Where data were available, pump station configuration and operational data in the model were also updated.

In addition to the above updates, the latest model also includes the Dale Avenue Pump Station and force mains to the WWTP (in the previous models, the Dale Avenue Pump Station was not explicitly modeled, but was considered a model "outfall"). However, the Mariners Island sewer system is not included in the model because there is not sufficient data available on sewer invert elevations and pump station configurations and operational parameters to develop the model of that portion of the system. The Mariners Island system discharges directly to the WWTP; therefore flows do not impact any of the San Mateo/Hillsborough/CSCSD jointly used facilities. (Note: flows from Foster City also discharge to the San Mateo WWTP but do not impact City of San Mateo conveyance facilities.)

Note that in addition to flows entering the system from Hillsborough at El Cerrito Avenue, additional flows from Hillsborough enter San Mateo's system from an area located immediately north of the College of San Mateo. These flows discharge to San Mateo's system at the end of Yew Street. The subcatchment representing this portion of Hillsborough is included in San Mateo's model.

Figure 2-1 shows the modeled San Mateo trunk sewer network and subcatchments.



Sewer System Flow Monitoring and Hydraulic Modeling

Figure 2-1
San Mateo Modeled Network

RMC Water and Environment

2.2 Town of Hillsborough

Hillsborough provided current GIS files of sewers and subbasins for use in developing the model of the Crystal Springs/El Cerrito trunk sewer. Since the GIS does not include information on manhole rim and sewer invert elevations, this information was developed from data obtained from a manhole survey that was conducted in 1995 as part of the modeling and planning for the Crystal Springs/El Cerrito sewer improvement project, and from information shown on the design drawings for the Phase I and Phase II projects. The GIS sewer subbasins were also refined and subdivided to delineate subcatchments for the model. In some areas, the model includes small segments of branch sewers that connect to the trunk sewer for purposes of facilitating model calibration. The rim and invert data for these branch sewers were estimated, and these segments were not included as part of the capacity assessment.

It should be noted that in 1997 Hillsborough constructed the Cherry Creek Pump Station on Hayne Road to divert flow from a portion of the Town's sewer system that was previously tributary to the City of Burlingame into the San Mateo system. The flows from the area tributary to the Cherry Creek Pump Station have been included in the model. Those flows discharge to a sewer in Roblar Avenue, which connects to the El Cerrito trunk sewer about 700 feet upstream of the Hillsborough/San Mateo border.

A small portion of San Mateo in the area of Parrott Drive and Oak Valley Court discharges to the Crystal Springs trunk sewer in Hillsborough. This area has been included as a separate subcatchment in the Hillsborough model. Similarly, a small area of CSCSD along Parrot Drive north of Bel Aire Road discharges to the Crystal Springs trunk sewer just downstream of the connection of the Polhemus Road trunk sewer at Crystal Springs Road. This area has also been included as a separate subcatchment in the Hillsborough model.

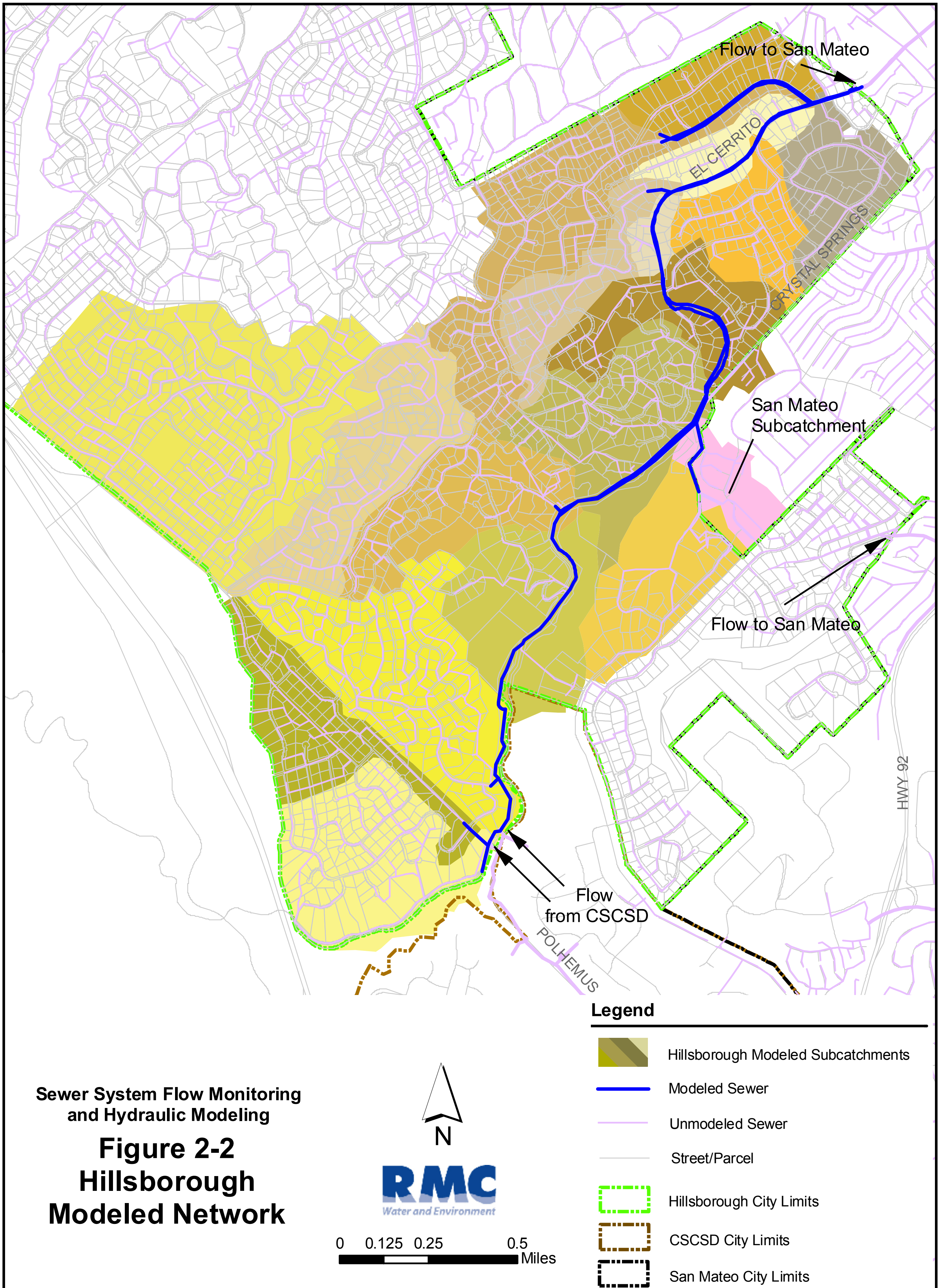
Figure 2-2 shows the modeled Hillsborough trunk sewer network and subcatchments.

2.3 Crystal Springs County Sanitation District

CSCSD provided current sewer GIS files for use in developing the model of the Polhemus trunk sewer. Rim and invert data for the modeled trunk sewer were derived from sewer as-built drawings provided by CSCSD. Subbasins had been previously delineated in GIS files developed by San Mateo several years ago. The GIS sewer subbasins were refined and subdivided to delineate subcatchments for the model. As in the Hillsborough model, the CSCSD model includes small segments of branch sewers that connect to the trunk sewer for purposes of facilitating model calibration. The rim and invert data for these branch sewers were estimated, and these segments were not included as part of the capacity assessment.

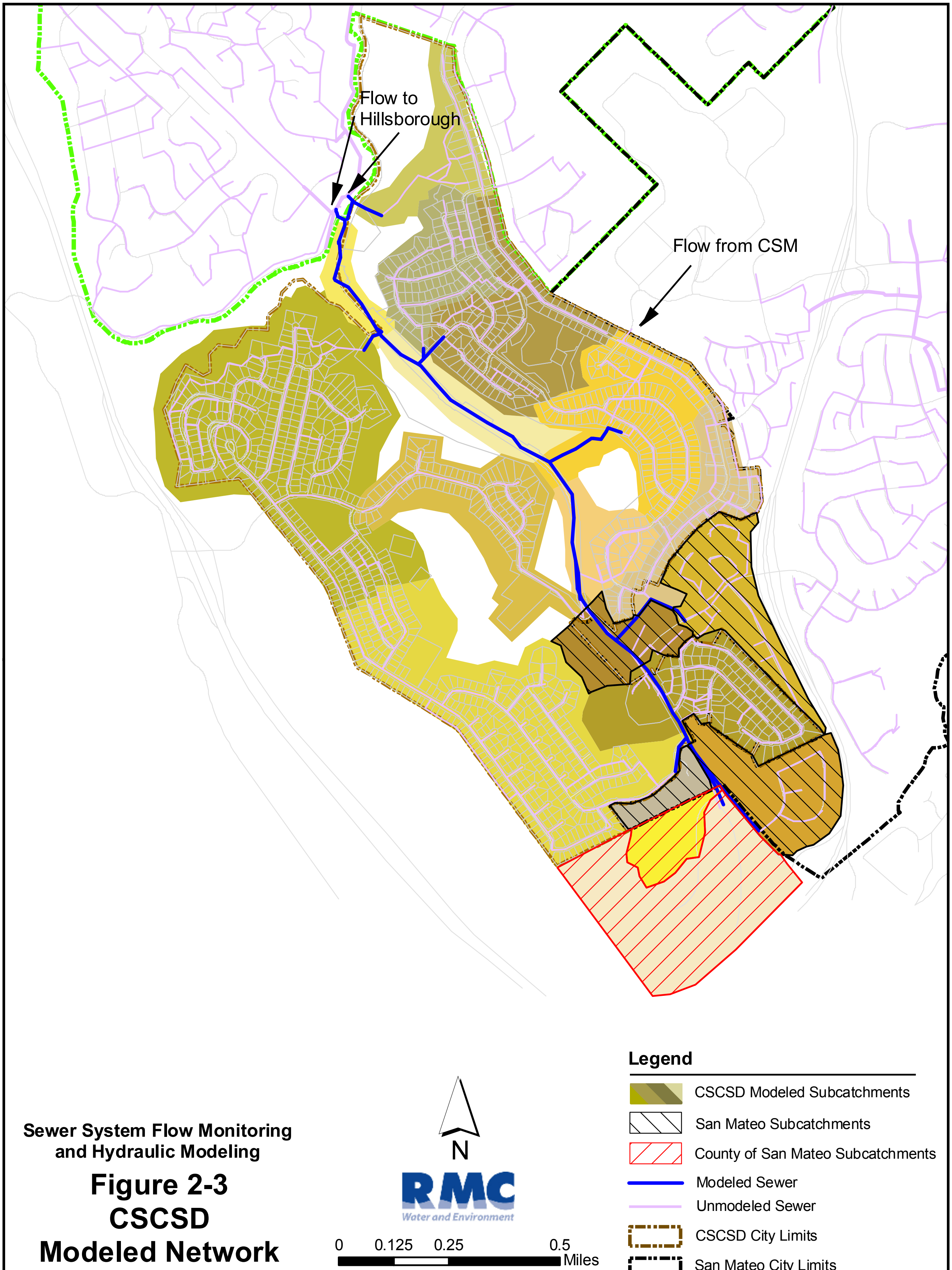
CSCSD receives flow from portions of San Mateo (including the administration building on the College of San Mateo campus), as well as from the County of San Mateo administrative offices and juvenile facilities on Tower Road. The San Mateo areas discharging to CSCSD include the Lakewood Circle neighborhood, the Ticonderoga Townhomes, and an area located north and south of De Anza Boulevard and west of Highway 92. These three areas of San Mateo, as well as the County's facilities, have been included as separate subcatchments in the CSCSD model.

Figure 2-3 shows the modeled CSCSD trunk sewer network and subcatchments.



Sewer System Flow Monitoring and Hydraulic Modeling

Figure 2-2 Hillsborough Modeled Network



Sewer System Flow Monitoring and Hydraulic Modeling

Figure 2-3
CSCSD
Modeled Network

RMC
Water and Environment

3 Flow Monitoring

A wet weather flow monitoring program was conducted for all three agencies during early 2009. The program included meters placed to confirm flows in the major trunk sewers and to isolate and quantify flows from individual subbasins within each agency's system, as well as meters placed at agency boundaries to quantify flows discharging from one agency into another.

3.1 Monitoring Program

A total of 74 flow meters were installed in the systems for a period of approximately two months. The meters were installed between January 9 and January 27 and removed between March 30 and April 12. **Figure 3-1, Figure 3-2,** and **Figure 3-3** show the locations of the meters in the San Mateo, Hillsborough, and CSCSD systems, respectively. **Table 3-1** lists the meter locations and other pertinent information. All of the meters (except two located at pump stations in San Mateo) were open-channel, area-velocity meters that record both flow depth and velocity and calculate flow rate based on the Continuity equation. The meters are capable of operation under surcharge conditions. The two pump stations in San Mateo (Los Prados #1 and 41st & Pacific) were metered by pump runtime recorders, which log the time that the pumps are running or turn on and off. Flow rates are calculated based on pump discharge rates determined through drawdown testing or by computed wet well volumes and on/off level set points.

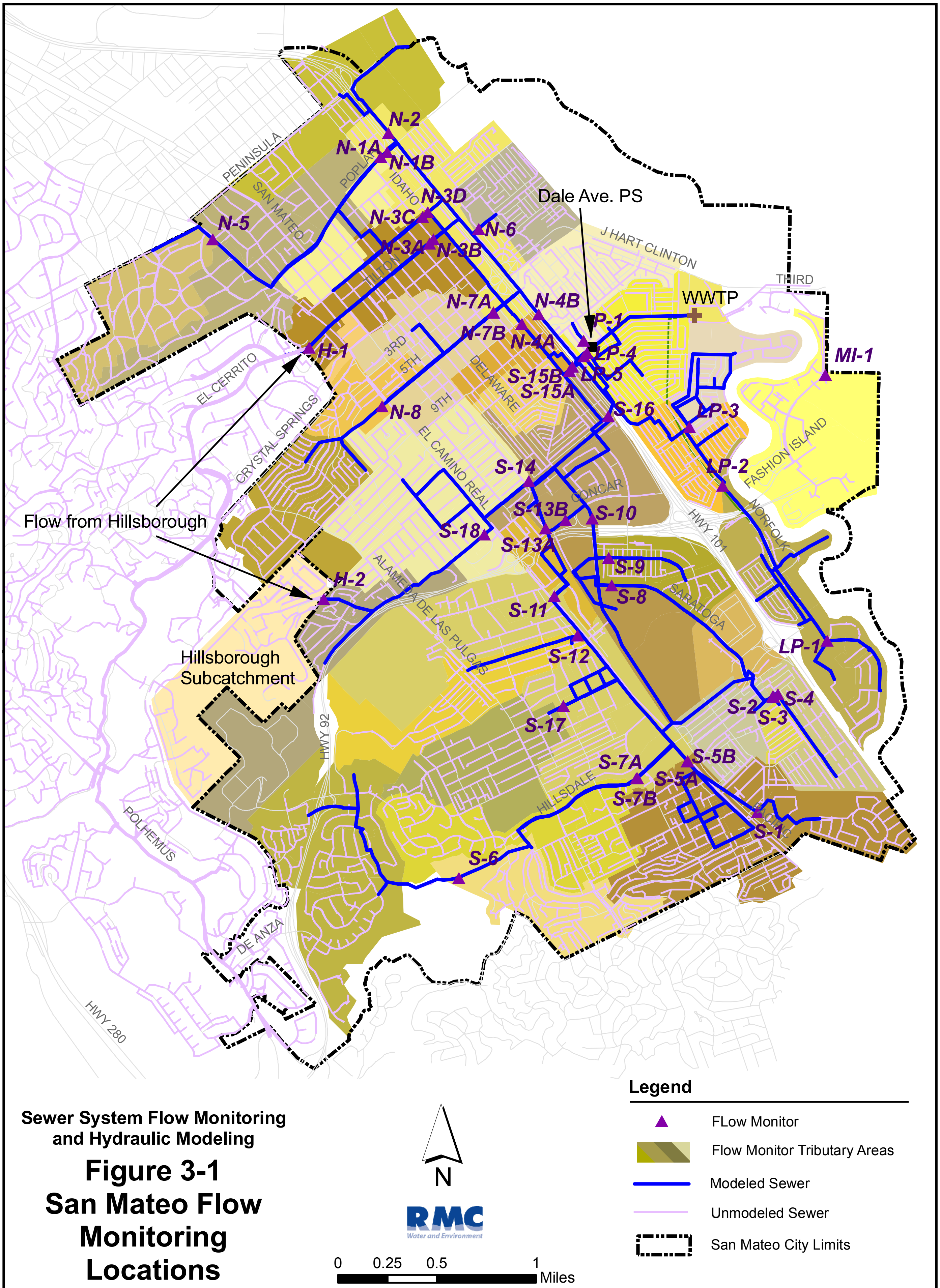
In addition to the flow meters, eight rain gauges were installed at locations throughout the agencies' service areas. The locations of the rain gauges are listed in **Table 3-2** and shown in **Figure 3-4**.

3.2 Flow Monitoring Limitations

Flow monitoring provides invaluable information about the quantities and characteristics of flows in the system, and is critical to model calibration, assessing system capacity, and sizing required improvements. However, the limitations of flow monitoring data and the factors that impact data accuracy need to be recognized and considered when using the information. Flow meters are typically specified with a laboratory accuracy of ±2 percent or better. When placed in sewers with "good" hydraulic conditions, they can be expected to yield data accurate to within ±5 percent. "Good" conditions typically mean straight-through manholes without side connections or bends; smooth, laminar flow; flow depths of greater than 2 inches (but not surcharged) and velocities in the range of greater than 1 to 5 feet per second (fps); and flows not impacted significantly by backwater, turbulence, sediment or debris. When some or all of these latter conditions occur, then accuracy is further reduced.

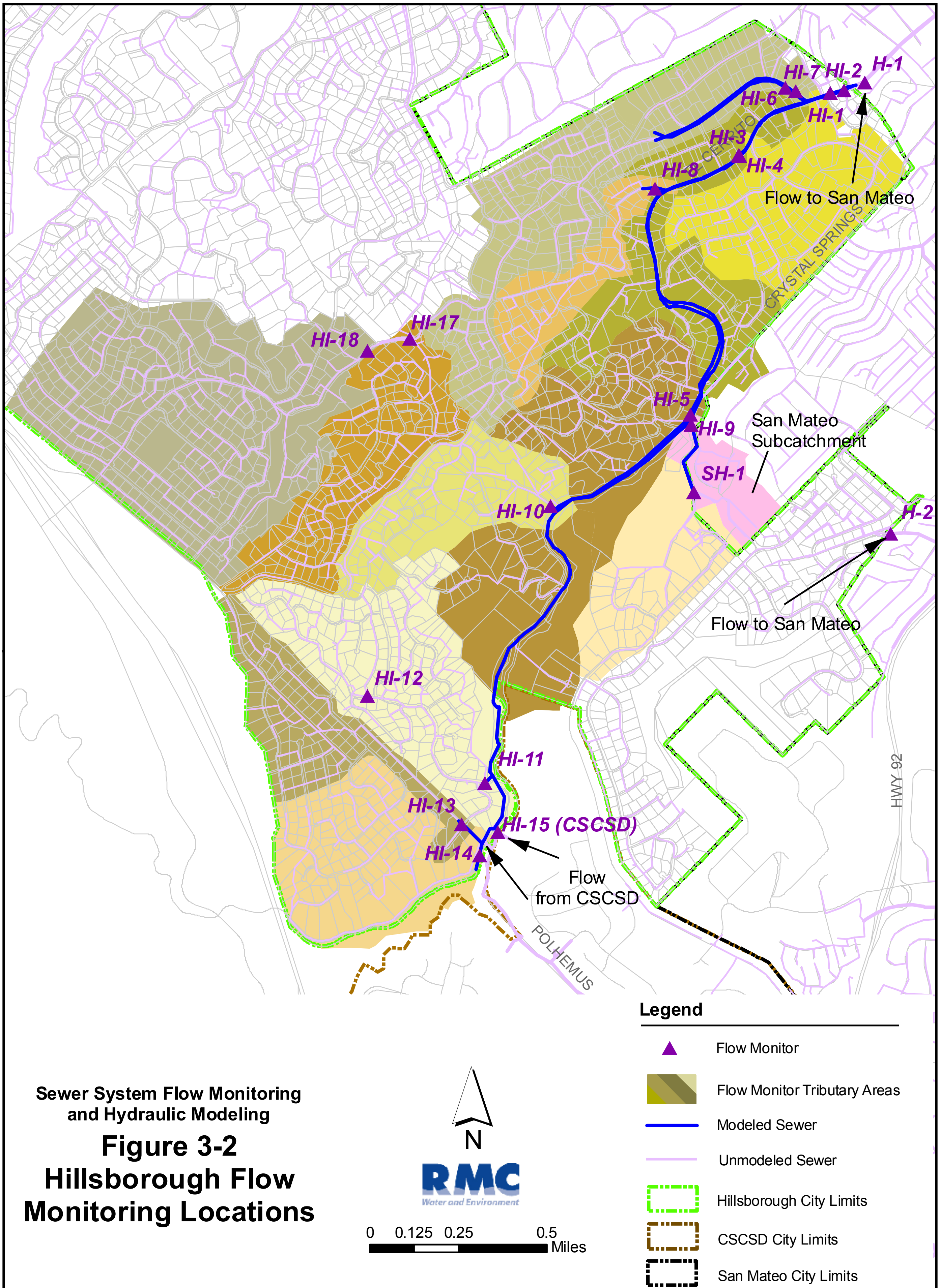
Some of factors that may have impacted flow monitoring accuracy for this study include:

- **Size of tributary areas.** Small areas generate lower flows, which are often difficult to meter because flow depths may be very low and flows may exhibit large variability. Many of the meters installed in the Hillsborough and CSCSD systems were situated to isolate very small areas, particularly in cases where it was desired to separately meter flows from individual agencies. As a result, the accuracy of the data for some of these meters can be expected to be lower than meters with larger tributary areas. Overall, the meters placed in the San Mateo system were installed on larger diameter sewers and captured flows from larger areas than those installed in Hillsborough and CSCSD. When evaluating meter data, greater reliance is placed on the meters with larger flows, such as those located along the major trunk sewers, so as to ensure a reasonable overall flow balance in the system. If the smaller meters do not "jive" with the overall system flows, then the data may need to be adjusted to achieve an overall balance while still retaining the characteristic flow response of the smaller metered areas.



Sewer System Flow Monitoring and Hydraulic Modeling

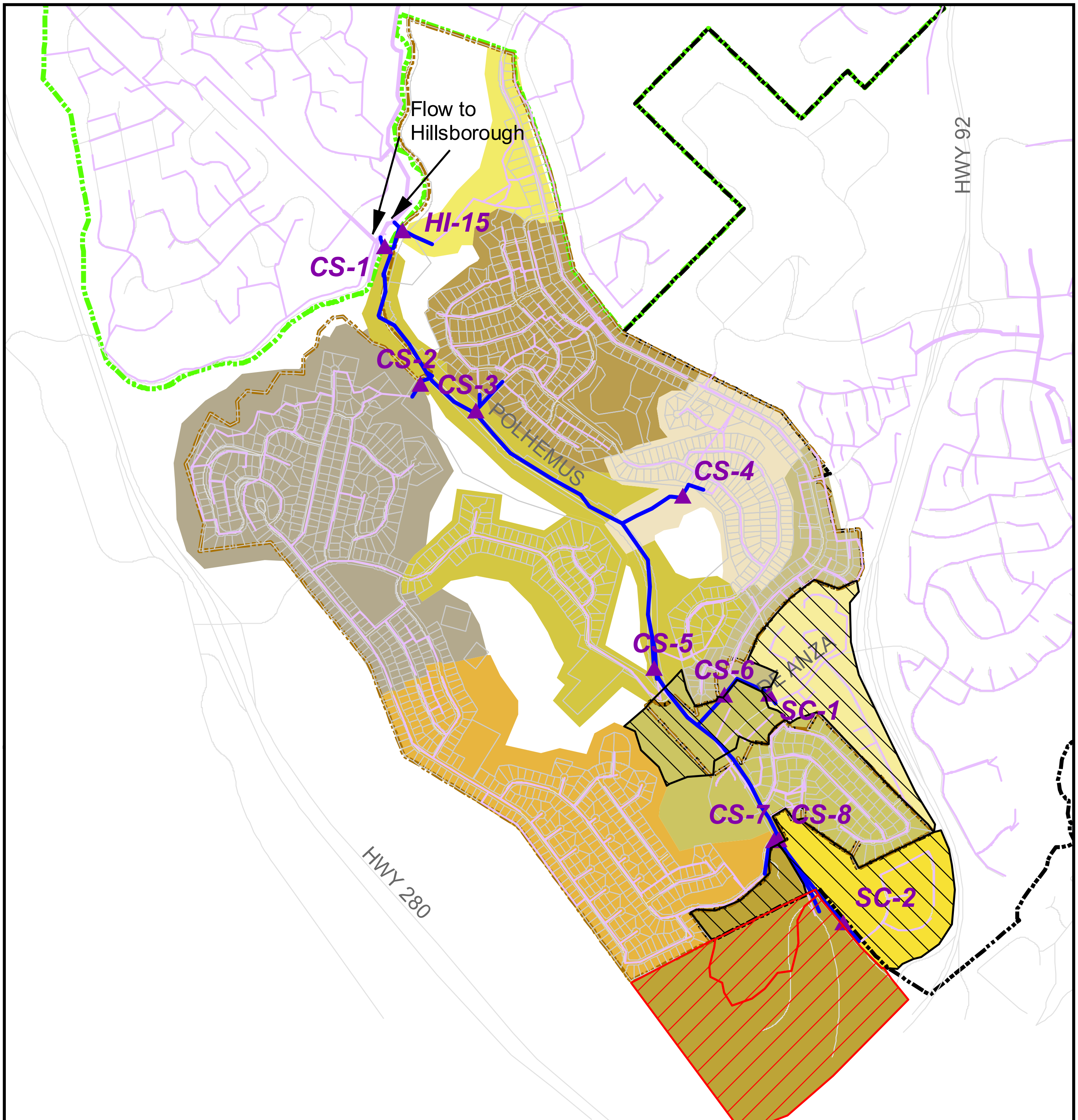
Figure 3-1
San Mateo Flow Monitoring Locations



Sewer System Flow Monitoring and Hydraulic Modeling

Figure 3-2 Hillsborough Flow Monitoring Locations

RMC Water and Environment



Sewer System Flow Monitoring and Hydraulic Modeling

Figure 3-3
CSCSD Flow Monitoring Locations

RMC Water and Environment

Legend

- Flow Monitor
- Flow Monitor Tributary Areas
- San Mateo Subcatchments
- County of San Mateo Subcatchments
- Modeled Sewer
- Unmodeled Sewer
- CSCSD City Limits
- San Mateo City Limits
- Hillsborough City Limits

Table 3-1: Flow Meter Locations

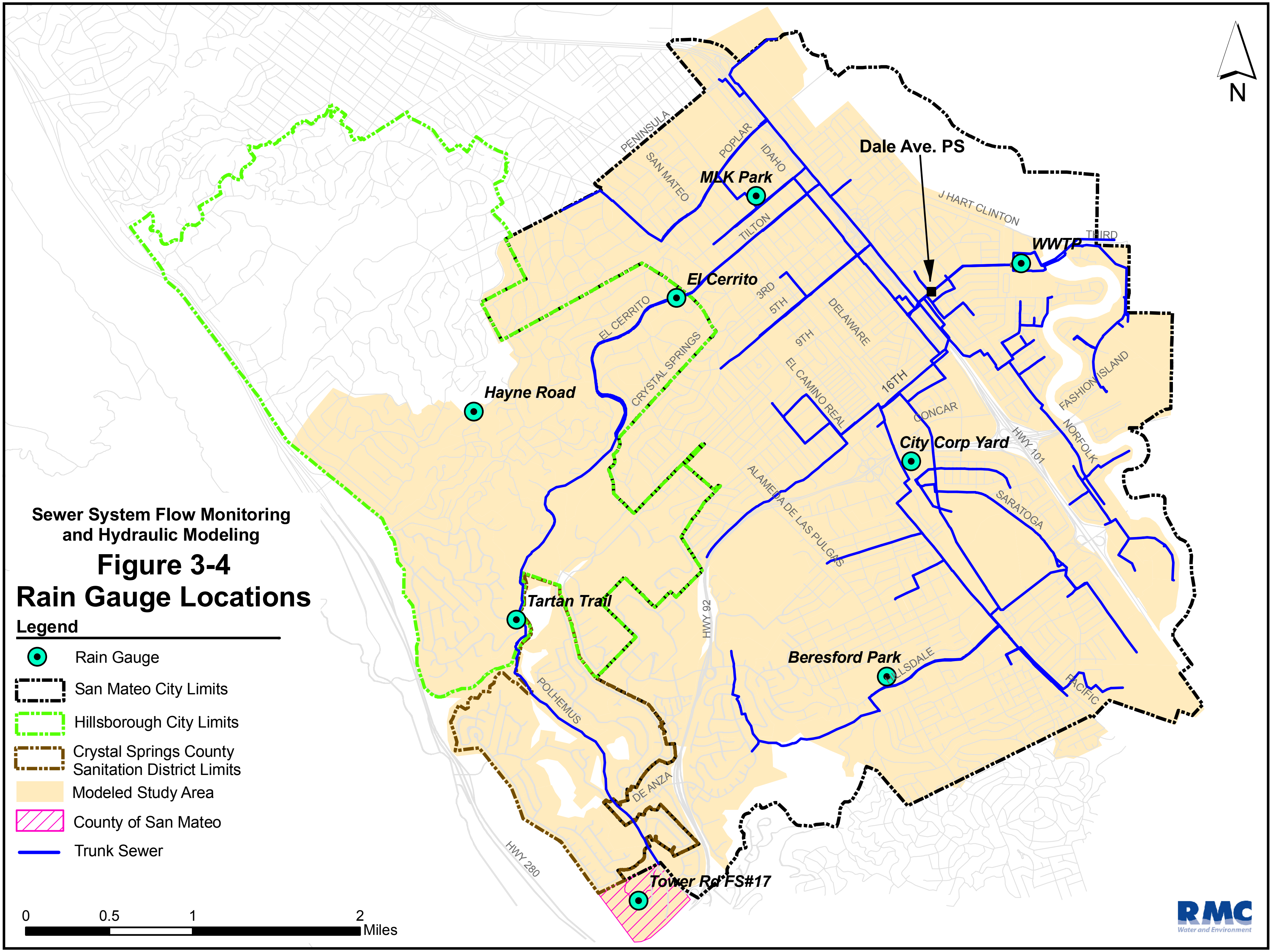
Flow Meter ID	Manhole ID	Pipe Dia. (in.)	Location
N-1A	08G-11X	15	Poplar at Amphlett
N-1B	08G-08X	18	Poplar at Idaho
N-2	07G-09X	21	Bayshore n/o Poplar
N-3A	10H-11X	15	Tilton at Humboldt
N-3B	10H-09X	18	Tilton w/o Humboldt
N-3C	09H-02X	15	Monte Diablo w/o Idaho
N-3D	09H-19X	12	Monte Diablo at Idaho
N-4A	12I-40X	27	Idaho s/o 7th Ave
N-4B	12J-11X	36	Bayshore s/o Dakota
N-5	10D-14X	12	El Camino Real at State
N-6	10I-03X	10	Cypress at Kingston
N-7A	12I-07X	18	Fifth Ave. at Humboldt
N-7B	12I-08X	12	Fifth Ave. at Humboldt
N-8	15G-04X	12	Fifth Ave. w/o El Camino
S-1	25N-WW1	PS	41st & Pacific Pump Station
S-2	22N-13X	10	Santa Clara w/o Saratoga
S-3	22N-13X	6	Pasadena at Almaden
S-4	22N-05X	12	Santa Clara w/o Pasadena
S-5A	24L-23X	12 (w)	El Camino Real n/o 36th Ave
S-5B	24L-23X	12 (e)	El Camino Real n/o 36th Ave
S-6	27H-07X	15	Laurelwood Dr.
S-7A	24L-07X	18	Hillsdale w/o Edison
S-7B	24L-22X	10	Hillsdale w/o Edison
S-8	19K-35X	18	Saratoga e/o Delaware
S-9	19K-11X	15	Esmt s/o Bermuda at Texas
S-10	18K-01X	33	Delaware s/o Concar
S-11	20J-05X	21	21st Ave. e/o El Camino
S-12	21J-32X	8	24th Ave. w/o El Camino
S-13A	18J-10X	21	Railroad at Leslie
S-13B	18J-17X	30	Concar w/o Pacific
S-14	17J-05X	18	16th Ave. e/o South Blvd.
S-15A	14J-34X	10	Sunnybrae w/o S. Amphlett
S-15B	13J-28X	10	S. Amphlett n/o Sunnybrae
S-16	15K-30A	39	16th Ave. at Carlisle
S-17	22J-05X	10	28th Ave. at Hacienda
S-18	18I-05X	15	Borel at Jasmine
P-1	13K-12X	18	Patricia at Dale esmt
LP-1	21O-WW1	PS	Los Prados PS #1
LP-2	17M-10X	18	Norfolk at Susan Ct.
LP-3	15L-35X	15	Eisenhower at Wellesley
LP-4	13K-07X	12	Dale esmt w/o Patricia
LP-5	13K-05X	24	Norton at Dale esmt
MI-1	14O-08X	21	Mariners Island Blvd. n/o Trader Ln.

Table 3-1: Flow Meter Locations (cont'd.)

Flow Meter ID	Manhole ID	Pipe Dia. (in.)	Location
H-1	13F-10X	18	El Cerrito e/o Gramercy
H-2	20F-10X	8	Yew w/o Vernon
SH-1	19D-05X	6	Hillsdale w/o Edison
SC-1	29E-01X	8	Parrott w/o De Anza
SC-2	31E-11X	8	Ralston betw. Polhemus & Lakewood Cir
HI-1	13J42	15	El Cerrito at De Sabla Rd
HI-2	Betw 13J6&13J41	15	El Cerrito at De Sabla Rd
HI-3	13I33	12	El Cerrito betw Stonehedge & Poett
HI-4	13I34	15	El Cerrito betw Stonehedge & Poett
HI-5	15G2	15	Crystal Springs betw El Cerrito & Ridgeway
HI-6	12I13	14	Roblar betw El Cerrito & Ericson
HI-7	12J31	10	Roblar betw El Cerrito & Ericson
HI-8	12H16	8	Hayne w/o El Cerrito
HI-9	15G31 (City 18D-16X)	8	Crystal Springs esmt from Oak Valley Ct
HI-10	15E15	8	Crystal Springs Terr at Crystal Springs
HI-11	18C4	6	Tartan Trail at Crystal Springs
HI-12	16C1 outlet	6	Tartan Trail w/o Braemar
HI-13	18C17	6	Lakeview Dr (easement)
HI-14	18C30	8	Crystal Springs at Polhemus
HI-15	CSCSD MH 284 outlet	15	Polhemus at Crystal Springs
HI-17	MH CH#5 (or #4?)	8	Hayne Rd e/o Cherry Creek PS
HI-18	12E18	8	Hayne Rd at Cherry Creek diversion
CS-1	6023	14	Polhemus at Crystal Springs
CS-2	475	8	Esmt off of Polhemus n/o Ascension
CS-3	6013	6	Ascension Dr. at Polhemus
CS-4	520	6	Behind 1610 Ascension
CS-5	601	12	Polhemus n/o Bunker Hill
CS-6	673	8	Esmt off of Polhmus n/o De Anza
CS-7	796	8	Ticonderoga at Polhemus
CS-8	796	8 in/10 out	Polhemus at Ticonderoga

Table 3-2: Rain Gauge Locations

Rain Gauge	Location
1	Martin Luther King Jr. Park
2	City of San Mateo Corporation Yard
3	San Mateo WWTP
4	Beresford Park
5	Fire Station #17 (Tower Rd.)
6	Tartan Trail Rd. at Crystal Springs Rd.
7	Hayne Road (Cherry Creek Pump Station)
8	El Cerrito Ave. at De Salba Rd.



Sewer System Flow Monitoring
and Hydraulic Modeling
Figure 3-4
Rain Gauge Locations
Legend
Rain Gauge
San Mateo City Limits
Hillsborough City Limits
Crystal Springs County
Sanitation District Limits
Modeled Study Area
County of San Mateo
Trunk Sewer
0
0.5
1
2
Miles
N
Dale Ave. PS
MLK Park
WWTP
El Cerrito
Hayne Road
City Corp Yard
Tartan Trail
Beresford Park
Tower Rd FS#17
PENINSULA
SAN MATEO
POPLAR
IDAHO
TILTON
J HART CLINTON
THIRD
3RD
5TH
9TH
DELAWARE
EL CERRITO
CRYSTAL SPRINGS
EL CAMINO REAL
16TH
CONCAR
FASHION ISLAND
HWY 101
NORFOLK
SARATOGA
ALAMEDA DE LAS PULGAS
HWY 92
HILLSDALE
PACIFIC
POLHEMUS
DE ANZA
HWY 280
RMC
Water and Environment

- **Site hydraulics.** Hydraulic conditions at the meter sites, such as bends, pipe junctions, steep slopes, and surcharge or backwater caused by downstream conditions, can negatively impact flow monitoring data quality. Many of the meters in the Hillsborough and CSCSD systems were installed on branch sewers to the Polhemus/Crystal Springs/El Cerrito trunk in order to be able to isolate the flows discharging to the trunk sewer from individual sewer subbasins. Because of the topography of the service area, many of these sewers were small diameter pipes with steep slopes, creating conditions with low flow depths and high velocities. Furthermore, during storm events, several sites were subject to severe backwater conditions due to surcharging in the downstream Crystal Springs/El Cerrito trunk sewer.
- **Debris and other obstructions.** Several of the sites were subject to obstructions from roots or debris. At one critical site, meter CS-1 located at the boundary of the CSCSD and Hillsborough systems, a debris blockage downstream of the meter appeared to have been "caught" on the meter for several weeks and resulted in loss of good data for the key mid-February storm period.

The project team carefully reviewed all of the flow meter data for consistency and reasonableness, and used best engineering judgment in utilizing the data. Highest confidence was placed in the meter data for larger areas with reasonable flow depths and velocities, stable site hydraulics, and minimal impact from debris or downstream surcharge. **Table 3-3** provides comments about meter site issues and data quality for the meter sites in the Hillsborough and CSCSD area tributary to the Polhemus/Crystal Springs/El Cerrito trunk sewers. Further discussion on the use of the flow monitoring data for model calibration is presented in Section 4 of this report.

Table 3-3: Flow Meter Comments

Flow Meter ID	Comments
H-1	Good site, consistent data.
HI-1	Significant surcharge for most of mid-February and early March; surcharge caused sensor to turn and lost depth data. Upstream cross connections and likely flow diversions between HI-1 and HI-2.
HI-2	Similar issues as HI-2. Flow sensor slipped out during mid-February through early March period.
HI-3	Velocity dropped out occasionally. Upstream cross connections and likely flow diversions between HI-3 and HI-4.
HI-4	Depth and velocity dropped out Feb. 18-22; otherwise fairly consistent data.
HI-5	Small bend in manhole, but data generally good; surcharge during large storms.
HI-6	Some debris issues, surcharging during large storms.
HI-7	Significant debris problems, significant surcharging and backup from El Cerrito Ave.
HI-8	Roots in manhole for most of period (removed Mar 19)
HI-9	Shallow manhole, flat line, very slow moving flow, debris accumulation; poor site.
HI-10	A lot of depth dropouts.
HI-11	Shallow, fast flow; meter in an inside drop into manhole. Poor site, but no alternative.
HI-12	Generally okay.
HI-13	Shallow, very fast flow but generally okay.
HI-14	Generally okay.
HI-15	Very small flow (trickle), depth too low to measure accurately.
HI-17	Some gravel in pipe, generally okay.
HI-18	Generally good; negative velocity during Feb. 15 storm.

Table 3-3: Flow Meter Comments (cont'd.)

Flow Meter ID	Comments
SH-1	Low flow; contractor busted manhole wall to connect a pipe midway through study, suspected source of infiltration
CS-1	Fast flow with bend in manhole. Debris blockage occurred in late Jan. downstream of manhole but not initially evident, backup got worse after mid-Feb. storms, eventually was cleared by flow monitoring crew.
CS-2	Slow moving flow with some debris, generally okay.
CS-3	Very fast, shallow flow; some visible pulsing.
CS-4	90 degree bend in manhole; shallow flow.
CS-5	Good site, consistent data.
CS-6	Depth dropouts at low flow.
CS-7	Sensor moved 2 feet up pipe around Feb. 17 by persons unknown; data generally poor.
CS-8	Sensor moved from inlet to outlet pipe around Feb. 17 by persons unknown.
SC-1	Very fast, shallow flow. Meter failed, lost data last part of Feb.
SC-2	Shallow flow, very bouncy.

3.3 Summary of Storm Events and Monitored Flows

A total of about 8 to 11 inches of rainfall (depending on location) fell during the monitoring period, mostly during the period mid-February through the first week of March. **Table 3-4** summarizes the rainfall for the storm events recorded during the monitoring period at each of the rain gauges. The largest storm events occurred during the period February 15-17, with other good-sized storms occurring on February 22-23 and March 1-5. **Figure 3-5** shows a plot of the hourly rainfall for one of the rain gauges. Plots of the rainfall for all gauges are included in **Appendix A**.

Table 3-4: Rainfall (in inches) for Monitoring Period Storm Events

Start Date	Start Time	Duration (hours)	MLK Park	Corp Yard	WWTP	Beres-ford Park	FS #17	Tartan Trail	Hayne Road	El Cerrito Ave.	Avg.
1/23/09	4:00	22	0.17	0.20	0.19	0.22	0.12	0.22	--	0.25	0.20
2/5/09	2:00	12	0.14	0.13	0.11	0.13	0.14	0.15	0.20	0.20	0.17
2/5/09	23:00	24	0.18	0.30	0.30	0.26	0.17	0.17	0.20	0.17	0.18
2/8/09	18:00	10	0.22	0.16	0.20	0.21	0.30	0.33	0.35	0.29	0.32
2/10/09	22:00	33	0.53	0.35	0.57	0.28	0.39	0.46	0.62	0.51	0.50
2/13/09	1:00	32	0.75	0.81	0.64	0.91	0.87	0.46	0.62	0.51	0.62
2/15/09	3:00	66	3.50	3.22	3.59	2.61	2.69	3.17	3.61	3.45	3.23
2/22/09	1:00	33	0.80	0.74	0.72	0.90	0.81	1.15	1.23	1.05	1.06
2/23/09	20:00	6	0.15	0.08	0.07	0.10	0.11	0.26	0.30	0.25	0.23
3/1/09	4:00	42	0.57	0.52	0.46	0.77	0.68	1.15	1.11	0.92	0.97
3/3/09	8:00	28	0.63	0.81	0.68	0.94	0.90	0.93	0.96	0.77	0.89
3/5/09	1:00	7	0.29	0.20	0.19	0.22	0.13	0.26	0.25	0.25	0.22
3/21/09	23:00	8	0.24	0.19	0.15	0.23	0.26	0.37	0.37	--	0.33
		Storm Totals	**8.17**	**7.71**	**7.87**	**7.78**	**7.57**	**9.08**	**9.82**	**8.62**	**8.77**
		Period Totals	**8.45**	**7.94**	**8.07**	**8.07**	**8.21**	**10.73**	**11.12**	**9.26**	**9.83**

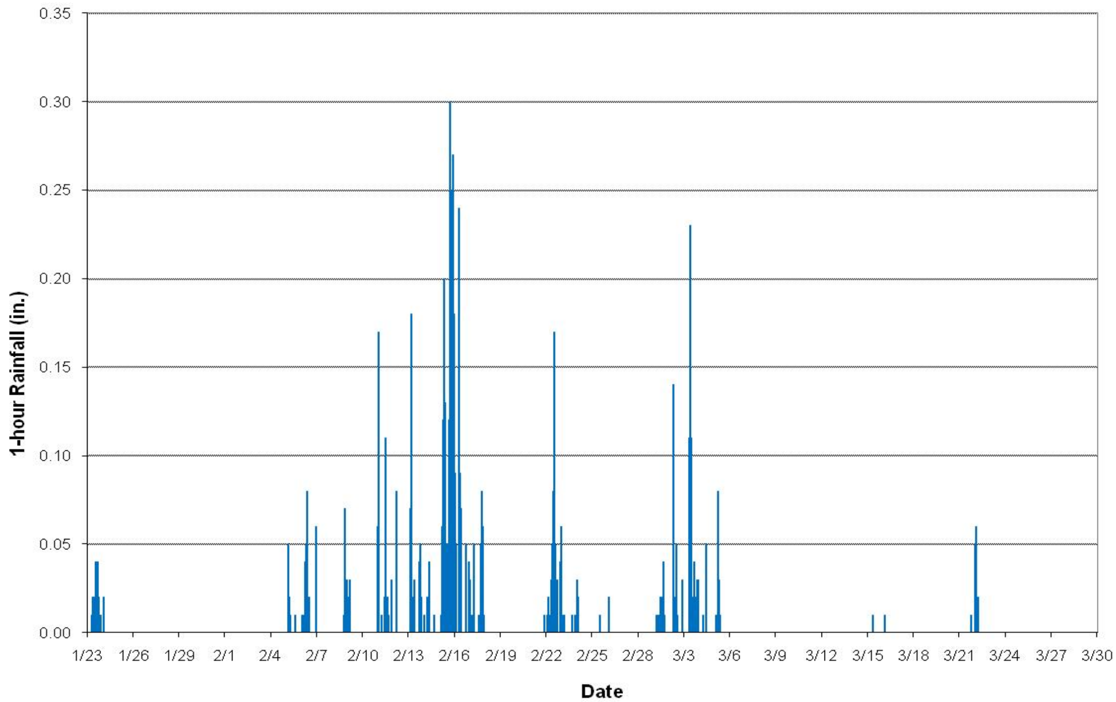


Figure 3-5: Typical Rainfall During the Flow Monitoring Period

Figures 3-6, 3-7, 3-8, and 3-9 show plots of the recorded flows at four locations in the system: on the 12-inch Polhemus Road trunk sewer at Bunker Hill Drive in CSCSD (meter CS-5), on the 15-inch Crystal Springs Road trunk sewer at El Cerrito Avenue in Hillsborough (meter HI-5), on the 18-inch El Cerrito Avenue trunk sewer near Gramercy Drive at the Hillsborough/San Mateo border (meter H-1), and on the 27-inch trunk sewer in Idaho Street at 7th Avenue in San Mateo (meter N-4A). Plots of the flow data for all meters are included in **Appendices B, C, and D** for San Mateo, Hillsborough, and CSCSD, respectively. Plots for meters at agency boundaries are included in the appendices for both respective agencies.

The storm events in February 2009 caused considerable surcharging at the meter sites. In fact, half of the gravity meter sites (36 of 72 sites) surcharged during the February 15-17 events. Much of the surcharging occurred along the main trunk sewers in the Hillsborough and San Mateo systems, and some overflows were also reported in both systems. Peak storm flow measured in the El Cerrito Avenue trunk sewer at the Hillsborough/San Mateo border was measured at about 4.5 MGD. Peak flow at the Dale Avenue Pump Station was about 50 MGD (compared to a normal daily peak hour flow of about 16 MGD); however, true peak flows would have been attenuated due to the significant surcharging in the upstream system. Based on rainfall depth-duration-frequency statistics for the San Mateo area, the February 15-17 storms were estimated to be approximately 1-year or less frequency events based on short (1- to 6-hour) durations and almost a 2-year frequency event based on 24-hour duration.

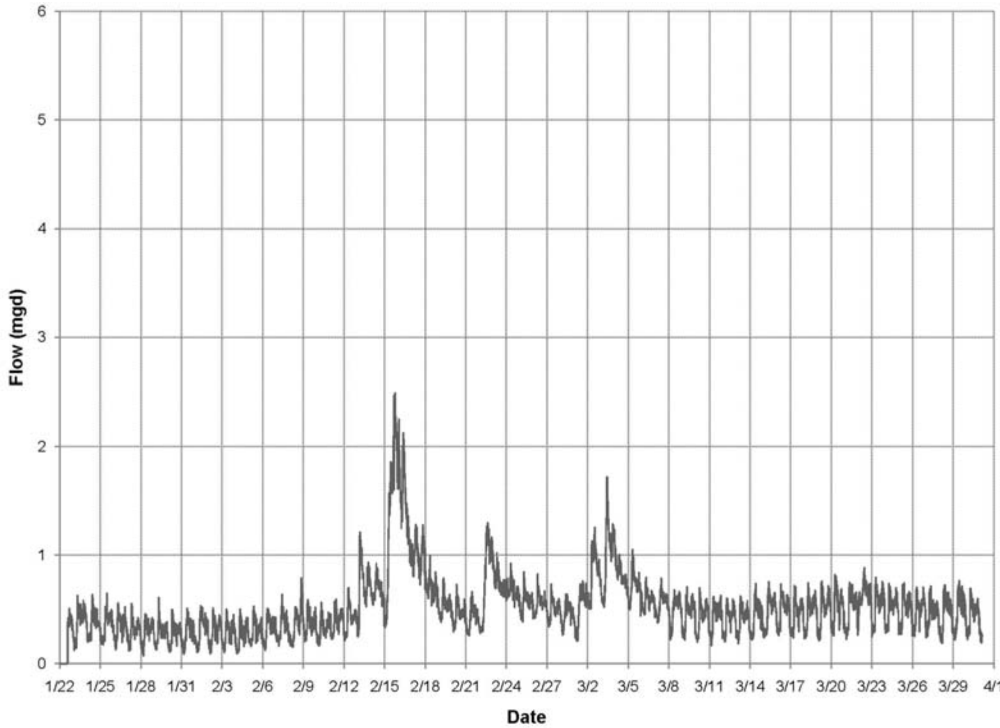


Figure 3-6: Meter CS-5 Recorded Flows

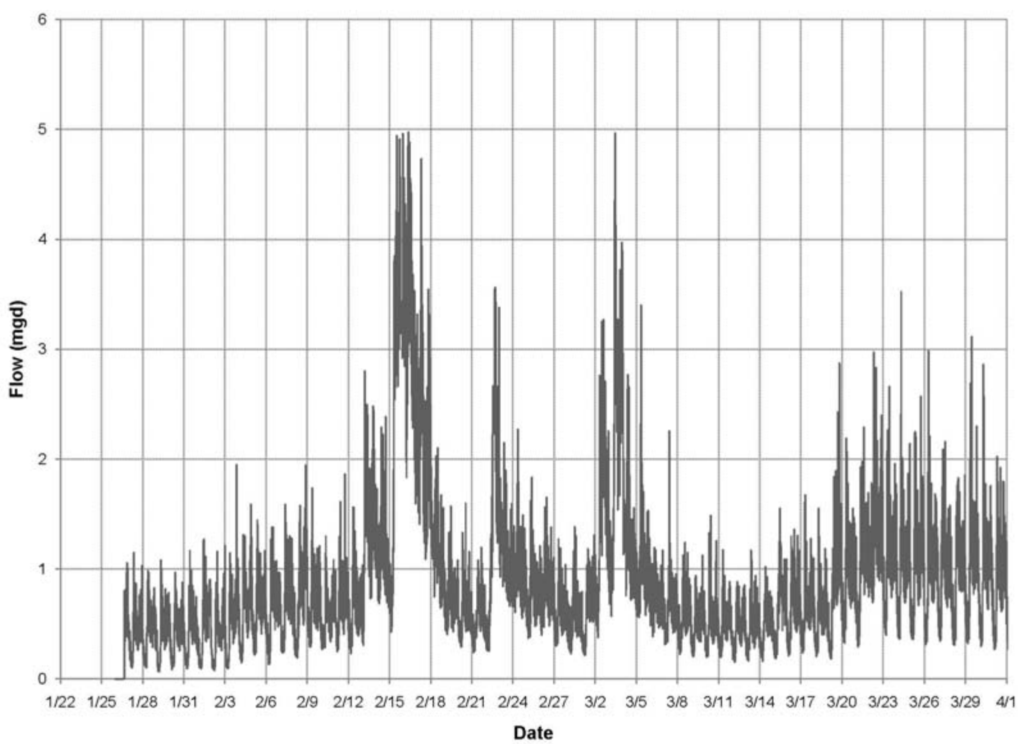


Figure 3-7: Meter HI-5 Recorded Flows

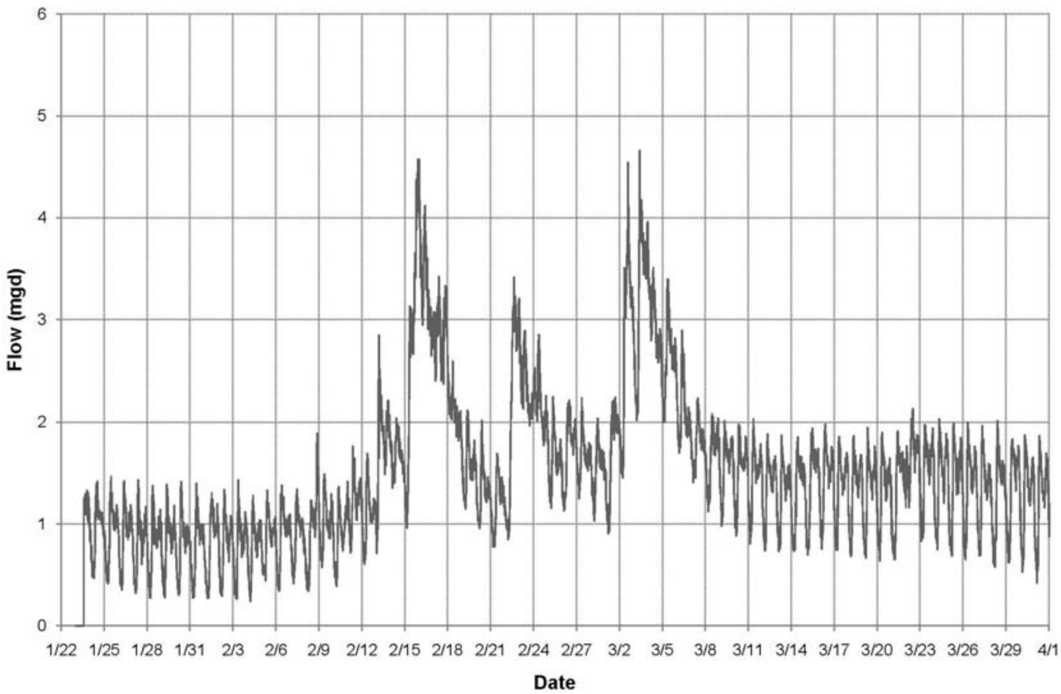


Figure 3-8: Meter H-1 Recorded Flows

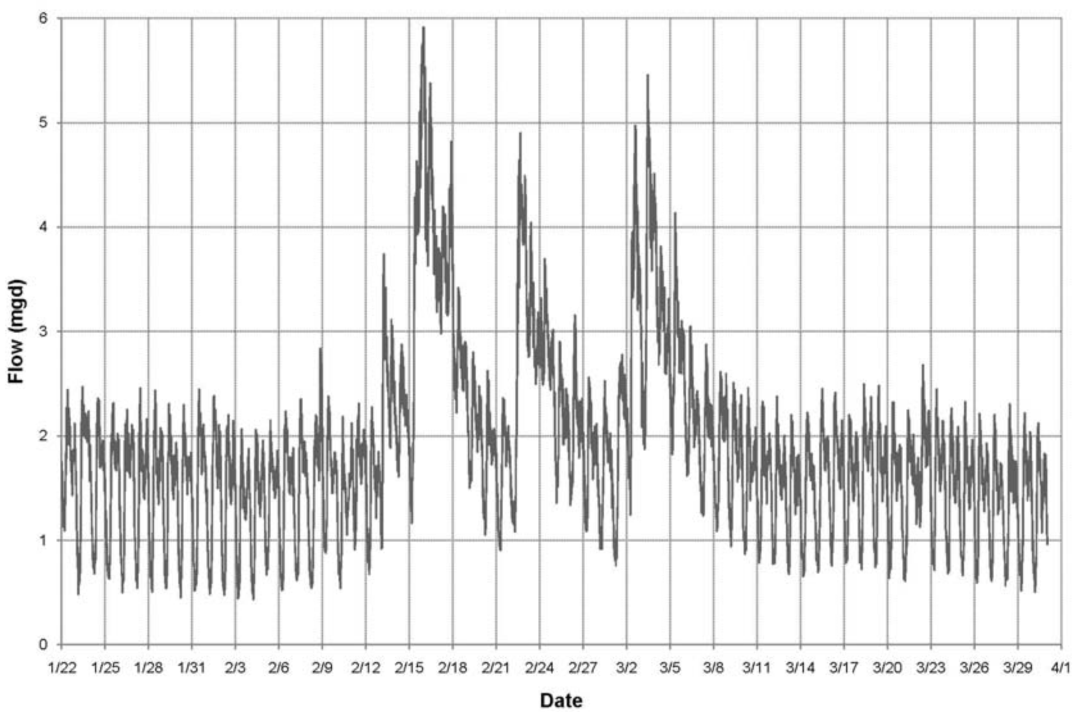


Figure 3-9: Meter N-4A Recorded Flows

4 Design Flows

This section describes the components of wastewater flows and the development of design wastewater flow estimates for the San Mateo, Hillsborough, and CSCSD systems. Water use data provided the primary basis for estimating average base wastewater flows. Flow monitoring and rainfall data were then used to calibrate the sewer model for both dry and wet weather flow conditions.

4.1 Wastewater Flow Components

Wastewater flows typically include three components: base wastewater flow (BWF), groundwater infiltration (GWI), and rainfall-dependent infiltration/inflow (RDI/I). BWF represents the sanitary and process flow contributions from residential, commercial, institutional, and industrial users of the system. GWI is groundwater that infiltrates into the sewer through defects in pipes and manholes. GWI is typically seasonal in nature and remains relatively constant during specific periods of the year, although may not vary much on a seasonal basis in some low-lying areas near the bay. RDI/I is storm water inflow and infiltration that enter the system in direct response to rainfall events. RDI/I can occur through direct connections such as holes in manhole covers or illegally connected roof leaders or area drains, or through defects in sewer pipes, manholes, and service laterals. RDI/I typically results in short term peak flows that recede quickly after the rainfall ends. Dry weather flow (DWF) consists of BWF plus GWI, while wet weather flow (WWF) adds the RDI/I component.

These three flow components are illustrated conceptually in **Figure 4-1**.

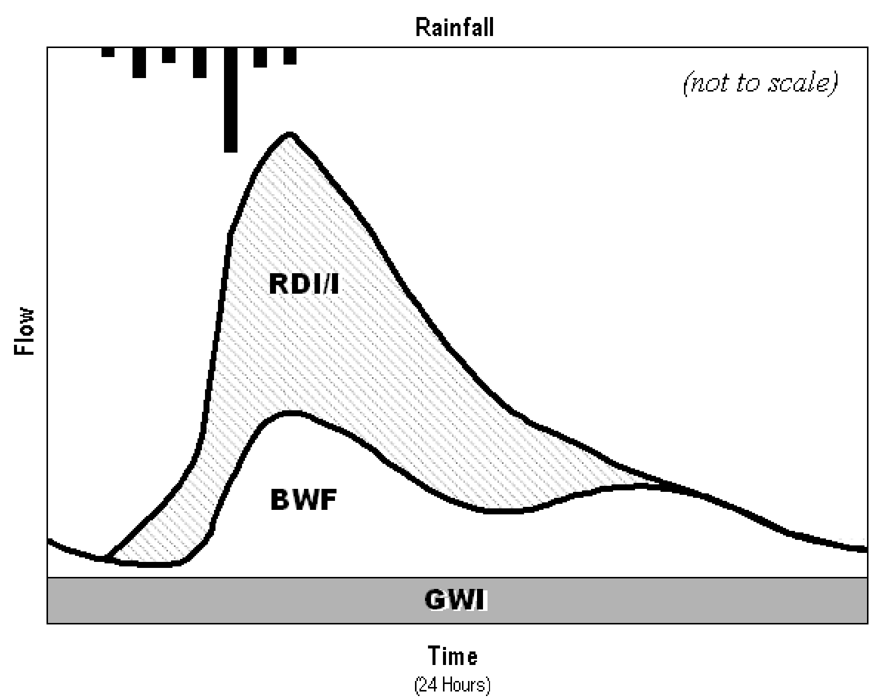


Figure 4-1: Wastewater Flow Components

4.2 Development of Design Flows

As discussed previously, subcatchments represent areas of the collection system tributary to modeled manholes. All model loads, including BWF, GWI, and RDI/I are estimated at the subcatchment level for input into the model. Flow monitoring data are then compared to model flows at the flow monitoring locations to refine the magnitude and timing of model loads. The following sub-sections describe the development and assumptions for each load component, and the process of calibrating the model to determine design wastewater flows.

4.2.1 Base Wastewater Flow

Base wastewater flows were estimated based on winter water use data for the period November 2007 through March 2008) available from the water purveyors that serve the study area: the Town of Hillsborough and the California Water Service Company. Winter water use is typically a reasonable basis for estimating wastewater flows because outdoor water use for irrigation is minimal, and most water used in the winter is ultimately discharged to the sewer system. In some affluent communities such as Hillsborough, however, wintertime irrigation can be significant. Therefore, for Hillsborough, winter water use was adjusted (as discussed below under Model Calibration) where it appeared that irrigation could be a significant factor.

Base wastewater flows, estimated based on winter water use, were assigned to individual parcels throughout the study area based on the water use records. Where water records could not be associated with specific parcels (as may be the case where the customer billing address is different than the parcel address), winter water use was estimated based on the number of dwelling units (DUs) for residential parcels or square footage of building floor space for non-residential parcels, obtained from assessor parcel information, using unit flow factors developed based on the parcels for which water records were available. The parcel flows were then summed by sewer subcatchment to develop the preliminary subcatchment BWF loads to the model.

Diurnal BWF Variations

Base wastewater flows vary on an hourly basis throughout the day according to typical diurnal patterns. Diurnal patterns may also vary on weekdays versus weekends. For this study, a single set of typical residential and non-residential patterns (with distinct patterns for weekdays and weekends) were used to represent BWF. While different areas of the system and land use types may exhibit slightly different patterns of use, peak flows in the San Mateo area systems are dominated by wet weather events, so small differences in diurnal BWF are generally not significant.

Future Flows

For sewer capacity assessment, design flows must also account for potential increases in BWF due to new development or redevelopment. For CSCSD and Hillsborough, very little future growth is expected. CSCSD identified two planned projects totaling 36 new dwelling units. Hillsborough consists primarily of single-family residential development, and it was assumed that there would be no significant additional development in the area.

For San Mateo, information on additional future flows was derived from the City's Inventory of Sites Available for New Housing Development (Appendix A of the Housing Element of the City's General Plan) and information on specific development projects currently under construction, approved, or under review by the City's Planning Division, as posted on the City's website. Estimates of future dwelling units and/or square footage of non-residential building floor space were available by parcel from these sources. Future BWF was estimated by applying the following unit flow factors to the development data:

- Single family residential 220 gpd/DU

- Multi-family residential 160 gpd/DU
- Non-residential 0.1 gpd/sq. ft.

The future parcel flows were then aggregated by subcatchment and added to the model loads (if a parcel was to be completely redeveloped, then the existing flow was replaced).

4.2.2 Infiltration/Inflow

Infiltration/inflow (I/I) includes GWI and RDI/I. Estimates of GWI and RDI/I are based on flow monitoring data and developed as part of the model calibration process.

Groundwater Infiltration

Depending on location, GWI may vary from a very minor component of flows in the sewer system to a significant percentage of the flow during non-rainfall periods. In the context of this modeling study, GWI represents the incremental amount of infiltration (above the nominal amount assumed to be included in dry weather BWF) that would be expected following periods of rainfall after storms have saturated the ground.

The magnitude of GWI is determined based on flow monitoring data. GWI is quantified by comparing flow monitoring data for non-rainfall periods at each monitor site to modeled dry weather flows calculated based on the BWF estimates described above. If monitored flows are higher than modeled BWF, the difference is assumed to be due to GWI.

Rainfall-Dependent Infiltration/Inflow

The magnitude of RDI/I is related to the intensity and duration of the rainfall, the relative soil moisture at the time of the rainfall event (typically a function of the amount of antecedent rainfall prior to the event), the condition of the sewers, and other factors such as soil type and topography. RDI/I flows are typically quantified based on the volume of runoff entering the sewer system, usually expressed as a percentage of the rainfall volume and the shape of the resulting RDI/I hydrograph. The shape of the hydrograph is defined by separating the total RDI/I hydrograph into three components, representing fast, medium, and slow flow response to rainfall, as shown in **Figure 4-2.** The three components are defined based on their respective percentages of the total RDI/I volume and other parameters that define the time duration from rainfall to peak flow response and the time of flow recession after the rainfall. In some cases, there may also be a fourth very slow component representing a prolonged elevated flow response after the rainfall.

As with GWI, RDI/I is quantified based on flow monitoring data as part of the model calibration process, as described below.

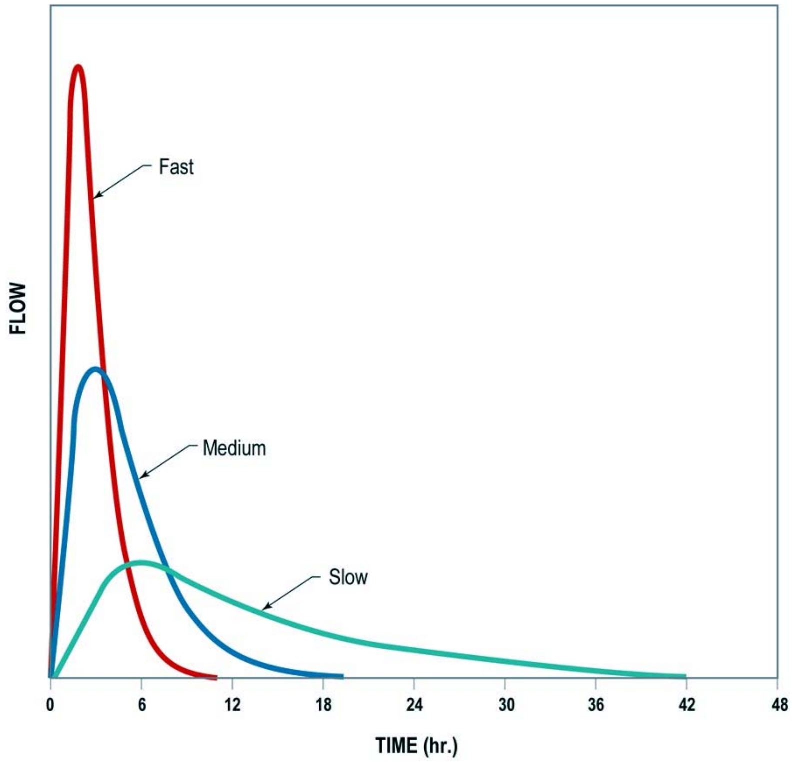


Figure 4-2: RDI/I Hydrograph Components

4.3 Model Calibration

Model calibration is the process of comparing model-simulated flows in the system to observed flows from flow monitoring data in order to develop and refine model flow parameters. Model calibration is conducted first for dry weather conditions to confirm or refine BWF and GWI estimates, and then for monitored wet weather events to develop model RDI/I parameters. In wet weather calibration, the focus is on achieving an accurate overall flow volume balance in the system, and in matching the magnitude of peak flows and shape of the RDI/I hydrographs at the meter locations to the greatest extent possible.

The initial dry weather calibration indicated that the BWF estimates based on winter water use data in Hillsborough were resulting in model flows that were higher than monitored flows overall, possibly due to irrigation use during the winter months. Therefore, the water use values were reduced to account for this discrepancy. Specifically, a flow "ceiling" of 500 gpd/DU was set for any individual parcel. This reduction resulted in a reasonable match of total BWF in the system to total monitored flows, although there may still have been some differences between modeled and metered dry weather flows for some upstream subbasin meter locations.

In calibrating the models, particularly for Hillsborough and CSCSD, it was not always possible to get a good "match" between modeled and monitored flows at all meter locations. In general, matching the peak wet weather flows at upstream subbasin meters resulted in overestimating the flow volume and peak flows at downstream meters along the trunk. Accordingly, greater emphasis was placed on the meters considered to have the most reliable data (larger areas and trunk meters, as discussed above) in order to maintain a reasonable flow balance in the system. Adjustments were made to upstream subcatchment RDI/I parameters to achieve a reasonable downstream match while still retaining the relative differences and hydrograph shape characteristics of the individual subcatchments.

4.4 Estimated Design Flows

Design flows represent the highest flow rates that the sewer system should be designed to convey. Typically this is a peak flow under a large wet weather event, called a “design event”.

4.4.1 Design Event

The “design event” establishes the maximum recurrence frequency under which a design performance criterion can be exceeded. The performance criterion may be “no overflows”, or more conservatively, “no surcharge.” Thus, if the performance criterion is “no overflows” and the recurrence frequency is 5 years, then the system must be designed such that overflows due to capacity limitations would occur no more frequently than once every 5 years.

In practice, the design event is often equated to a specified recurrence frequency *rainfall* event. Thus, the “design flow” is equated to the flow that would occur for a X-year frequency rainfall event, and the system would be sized such that the design performance criterion is not exceeded for the X-year rainfall event flows. It is important to note that this is not necessarily the same as saying that the flows in the system would violate the performance criterion only once in every X years, because the magnitude of RDI/I flows are governed by other factors in addition to the intensity and duration of the rainfall. However, using rainfall recurrence frequency as a design *flow* criterion is generally considered to be a reasonable approach to establishing design flows.

There is currently no official regulatory policy with respect to design storms for sanitary sewer systems in California. Where design storms have been mandated by regulatory agencies, this has typically been the result of a negotiated agreement, often established in legal consent decrees or compliance orders, in response to documented wet weather overflow problems. Agencies in the Bay Area typically use design storms of 5 to 10 years. The previous sewer studies for the San Mateo system utilized a 6-hour duration, 5-year frequency design storm, which was “synthesized” based on the City’s rainfall intensity-duration-frequency curves used for storm drainage design. A 6-hour duration represents a reasonable maximum flow travel time in a medium size wastewater collection system, so it is appropriate for use in analyzing the impact of rainfall on a sewer system. The San Mateo 5-year design storm rainfall consists of 1-hour rainfall increments, with each nested duration representing a 5-year frequency rainfall intensity for that duration.

Because rainfall amounts vary throughout the study area, a single design rainfall event is not appropriate for the entire area. To refine the previous San Mateo 5-year design storm, a rainfall depth-duration-frequency worksheet used by San Mateo County for drainage design was utilized. The worksheet is based on the NOAA Atlas 2 methodology and utilizes values downloaded from the NOAA Atlas 2 website. A copy of the worksheet is included in **Appendix E**. The worksheet was used to determine the 5-year frequency rainfall amounts for durations ranging from 1 to 6 hours for the flow monitoring program rain gauges locations. To simplify the design storm modeling, one of the rain gauge locations (City Corporation Yard site) was used to represent the lower study area elevations (most of San Mateo), and another (Tartan Trail site) to represent the higher elevations (most of Hillsborough and CSCSD). Based on the values calculated by the worksheet, a 6-hour design storm was constructed for each rain gauge. The design storm rainfall for these two locations is shown in **Figure 4-3**.

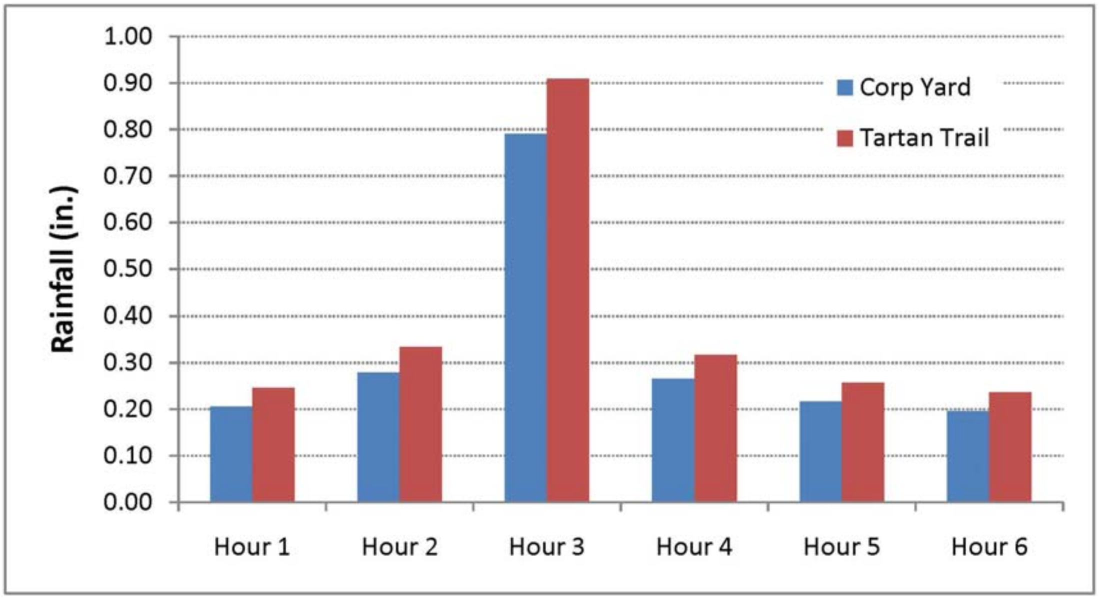


Figure 4-3: Design Storm Rainfall

4.4.2 System Design Flows

Design peak wet weather flows are determined by running the hydraulic model using the calibrated model parameters applied to the design rainfall event. To be conservative, the design event was timed so that the peak RDI/I in most areas approximately coincides with the peak weekday diurnal flow. The design flow model runs also include future BWF from new development and redevelopment, as described previously.

As indicated by the surcharging in the system documented by the flow monitoring and the model results presented in the subsequent section of this report, significant portions of the existing trunk sewer systems do not have sufficient capacity to convey design peak wet weather flows. Therefore, to accurately determine peak design flows, it is necessary to remove the hydraulic restrictions that limit the peak flows that can be conveyed downstream. For this purpose, an "upsized system model" was created by arbitrarily increasing the size of every modeled pipe by a factor of two, and increasing the capacity of modeled pump stations. This model therefore allows the predicted design storm peak wet weather flows to be conveyed downstream without restrictions. The upsized system model was used to develop preliminary estimates of the design flows throughout the system and preliminary allocations of the design flows in major trunk sewer segments to the upstream contributing agencies. The design flows are summarized in **Table 4-1**.

It is important to note that the allocation of peak wet weather flows to small areas along the Polhemus/Crystal Springs/El Cerrito trunk sewer reflects the limitations of the flow monitoring data and model calibration, as discussed previously. For these reasons, the allocation of peak flows upstream of the CSCSD and El Cerrito Avenue meters, particularly to the County area and to the portions of San Mateo tributary to these trunk sewers, may not be accurate due to flow monitoring data limitations.

Table 4-1: Design Flows

Agency	Incremental Flow				Total Flow			
	ADWF (MGD)	PWWF (MGD)	% ADWF	% PWWF	ADWF (MGD)	PWWF (MGD)	% ADWF	% PWWF
To CSCSD Meter								
County	*0.023*	*0.61*	*5%*	*13%*	*0.023*	*0.61*	*5%*	*13%*
CSCSD	0.33	3.53	75%	75%	0.33	3.53	75%	75%
San Mateo	*0.088*	*0.55*	*20%*	*12%*	*0.088*	*0.55*	*20%*	*12%*
Total	**0.44**	**4.7**			**0.44**	**4.7**		
To El Cerrito Avenue Meter								
County	*0*	*0*	*0%*	*0%*	*0.023*	*0.60*	*2%*	*6%*
CSCSD	0.005	*0.23*	*1%*	*4%*	0.33	3.72	32%	37%
Hillsborough	0.59	5.13	97%	94%	0.59	5.13	56%	51%
San Mateo	*0.012*	*0.11*	*2%*	*2%*	*0.100*	*0.65*	*10%*	*6%*
Total	**0.60**	**5.5**			**1.04**	**10.1**		
To Dale Avenue Pump Station								
County	*0*	*0*	*0%*	*0%*	*0.02*	*0.60*	*0.2%*	*0.7%*
CSCSD	0	0	0%	0%	0.33	3.72	4%	4%
Hillsborough	*0.066*	*0.88*	*1%*	*1%*	0.65	6.01	7%	7%
San Mateo	8.37	76.0	99%	99%	8.47	76.7	89%	88%
Total	**8.44**	**76.9**			**9.48**	**87.0**		

ADWF = average dry weather flow

PWWF = peak wet weather flow

Notes:

1. Includes estimated flows from new development for CSCSD and San Mateo (estimated at 0.2 MGD ADWF to the Dale Avenue Pump Station). See discussion of methodology used to estimate future flows in Section 4.2.1.
2. PWWF based on design storm peak flow in unrestricted system.
3. Assumes Flint-Norfolk Pump Station discharge and Bay Meadows flows (estimated at 0.7 MGD ADWF and 3.4 MGD PWWF total) are routed directly to WWTP (not included in total to Dale Avenue Pump Station)
4. Allocation of PWWF to areas upstream of CSCSD and El Cerrito Meters, particularly County and San Mateo, may not be accurate due to flow monitoring data limitations. Improved flow measurement would enhance the reliability of these estimates.

5 Capacity Assessment

Using the design flow model parameters described in the previous section, the existing system model was run to identify predicted capacity deficiencies in the existing trunk sewer systems, specifically where flows would exceed pipe capacity and result in surcharging, backwater, or potential overflows. The predicted capacity deficiencies are described below and depicted on maps of each system. The lines shown in red on the maps are those that are predicted to surcharge due to capacity deficiency ("throttle surcharge"), the lines shown in orange are surcharged due to backwater from downstream throttle conditions, and the blue circles represent predicted locations of potential overflows. The maps do not depict the *level* of surcharging (i.e., the height of the water level above the pipe crowns), only where surcharging occurs. Some surcharging may be very minor and not a cause for concern. Therefore, it is important to examine the model hydraulic profiles to identify the severity of surcharge. Selected profiles are included in **Appendix F**.

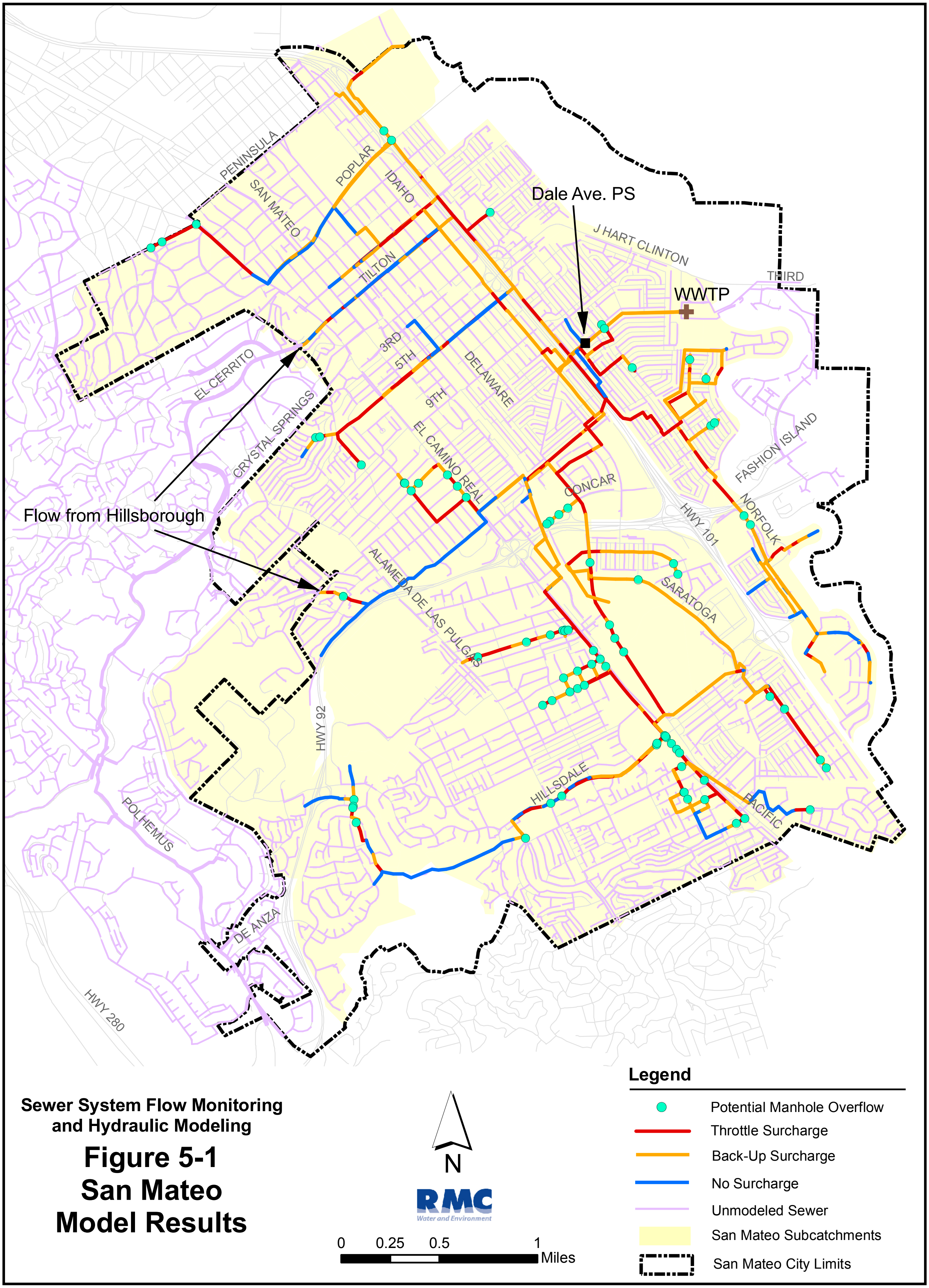
Note that the locations of predicted overflows are not necessarily the areas with the most critical capacity deficiencies, but rather the locations where backwater from downstream deficiencies reaches a high enough level to exceed the elevations of the manhole rims. Note also that because the model does not include the smaller diameter pipelines, and therefore does not account for the potential "storage" capacity available in those pipes, the actual magnitude and location of overflows may not match actual overflow sites. The model results were compared to the dates and locations of overflows reported by the three agencies in the State of California Integrated Water Quality System, and also reviewed with San Mateo, Hillsborough, and CSCSD staff, who confirmed that many of the locations indicated in the model as being potential overflow points have, in fact, experienced overflows or surcharge during wet weather.

As discussed in the previous section on System Design Flows, when the system is severely capacity limited, as in many areas of the trunk networks, the peak flows in the downstream portions of the system will be significantly dampened. If upstream constrictions are relieved, peak flows downstream would be higher, and additional capacity problems could be induced. For this reason, the results for the existing system model may not necessarily reflect the true extent of capacity limitations in the system.

5.1 Predicted Capacity Deficiencies in Existing Trunk Sewer Systems

5.1.1 San Mateo

Figure 5-1 shows the model results for the San Mateo trunk sewer system. The results are very similar to those predicted based on the modeling conducted for the City-Wide Sewer System Study, with extensive surcharging and potential overflows in many areas of the system. Because of the capacity limitations of the Dale Avenue Pump Station and WWTP, the peak flow that can be pumped is limited to about 50 MGD. As a result, flows back up into the trunk sewer systems on the west side of Highway 101. The profile plots in Appendix F include those for the El Cerrito/Tilton, Idaho, North (Bayshore), South (Dale/Delaware), and El Camino Real trunk sewers. The backup of the system from the Dale Avenue Pump Station is very evident in the plots of the North and South trunk systems.



Sewer System Flow Monitoring and Hydraulic Modeling

Figure 5-1
San Mateo
Model Results

5.1.2 Hillsborough

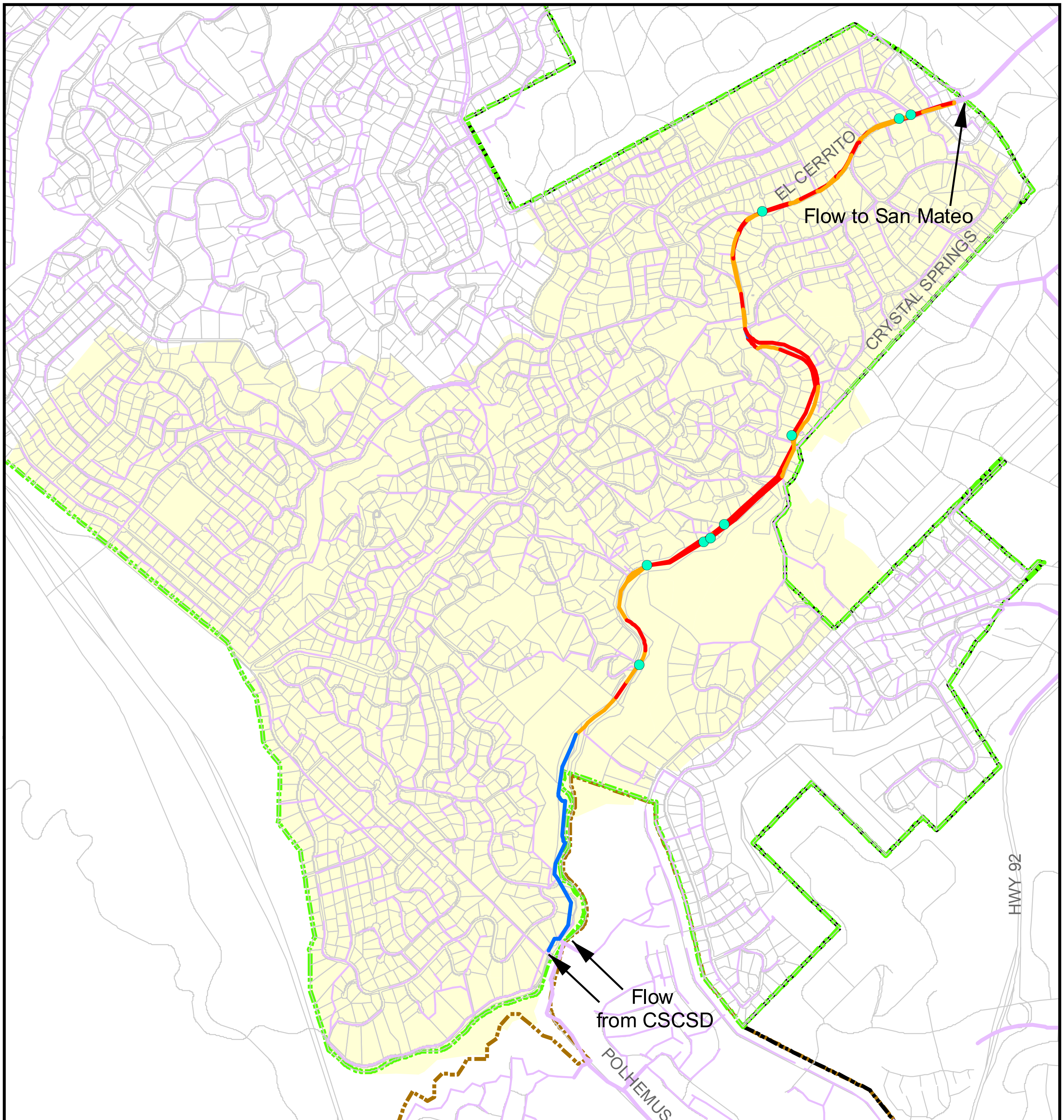
Figure 5-2 shows the model results for the Crystal Springs/El Cerrito trunk sewer. As expected, the lower portions of the trunk (which will be replaced as part of the proposed Crystal Springs/El Cerrito Phase II sewer improvement project) show significant surcharge and overflows under the design storm model runs. The upper portion (this is the Phase I project already constructed) has adequate capacity, but is backed up for about 1,000 feet due to the capacity issues in the lower trunk. Profile plots of the existing Crystal Springs/El Cerrito trunk sewer through Hillsborough are included in Appendix F.

5.1.3 Crystal Springs County Sanitation District

Figure 5-3 shows the model results for the Polhemus trunk sewer. As indicated in the figure and in the profile plots of the sewer included in Appendix F, there are several areas of concern with respect to trunk sewer capacity. In the upper portion of the Polhemus trunk sewer from north of Bunker Hill Drive, the existing 12-inch sewer is very flat (slope of about 0.5 percent), and the model predicts surcharging and backwater up to about De Anza Boulevard, with a potential overflow. In the middle portion of the trunk sewer (from south of Ascension Drive to north of Bunker Hill Drive), the existing 12-inch HDPE pipe is also predicted to be surcharged (note: the pipe diameter in the model reflects the inside diameter of the pipe). Under existing conditions, some backup surcharge is also evident in the lower portion of the Polhemus trunk, primarily due to model-predicted headlosses at pipe bends. However, if the capacity limitations in the upper and middle portions of the trunk sewer were to be relieved, higher peak flows could be conveyed downstream and result in additional surcharging in the lower trunk (see last profile in Appendix F).

5.2 Required Improvements for Crystal Springs/El Cerrito Trunk Sewer

To confirm the current design of the Phase II Crystal Springs/El Cerrito sewer improvement project, the model network was updated to include the proposed pipe improvements, and the model was run for the design flow conditions. The model results indicate that the Phase II project would provide adequate capacity to convey the peak design storm flows except for the portion north of Woodridge Road, where the sewer is very deep under a hill and it is proposed to keep the existing 18-inch pipe in place. The peak flow in the 18-inch line would exceed pipe capacity, causing a potential backup upstream during a design storm event. The model shows that the backup would extend upstream into the flatter, shallower portions of the Phase I trunk with the hydraulic gradeline potentially above the ground surface in some locations. The Town has recognized this potential issue, and has incorporated pressurized manholes (with vents to release potential air pressure buildup) into the design to prevent overflows. **Appendix G** contains profiles of the proposed Phase II sewer and the existing Phase I sewer showing the predicted backup from the constricted 18-inch pipe.



Legend

- Potential Manhole Overflow
- Throttle Surcharge
- Back-Up Surcharge
- No Surcharge
- Unmodeled Sewer
- Hillsborough Subcatchments
- Hillsborough City Limits
- CSCSD City Limits
- San Mateo City Limits

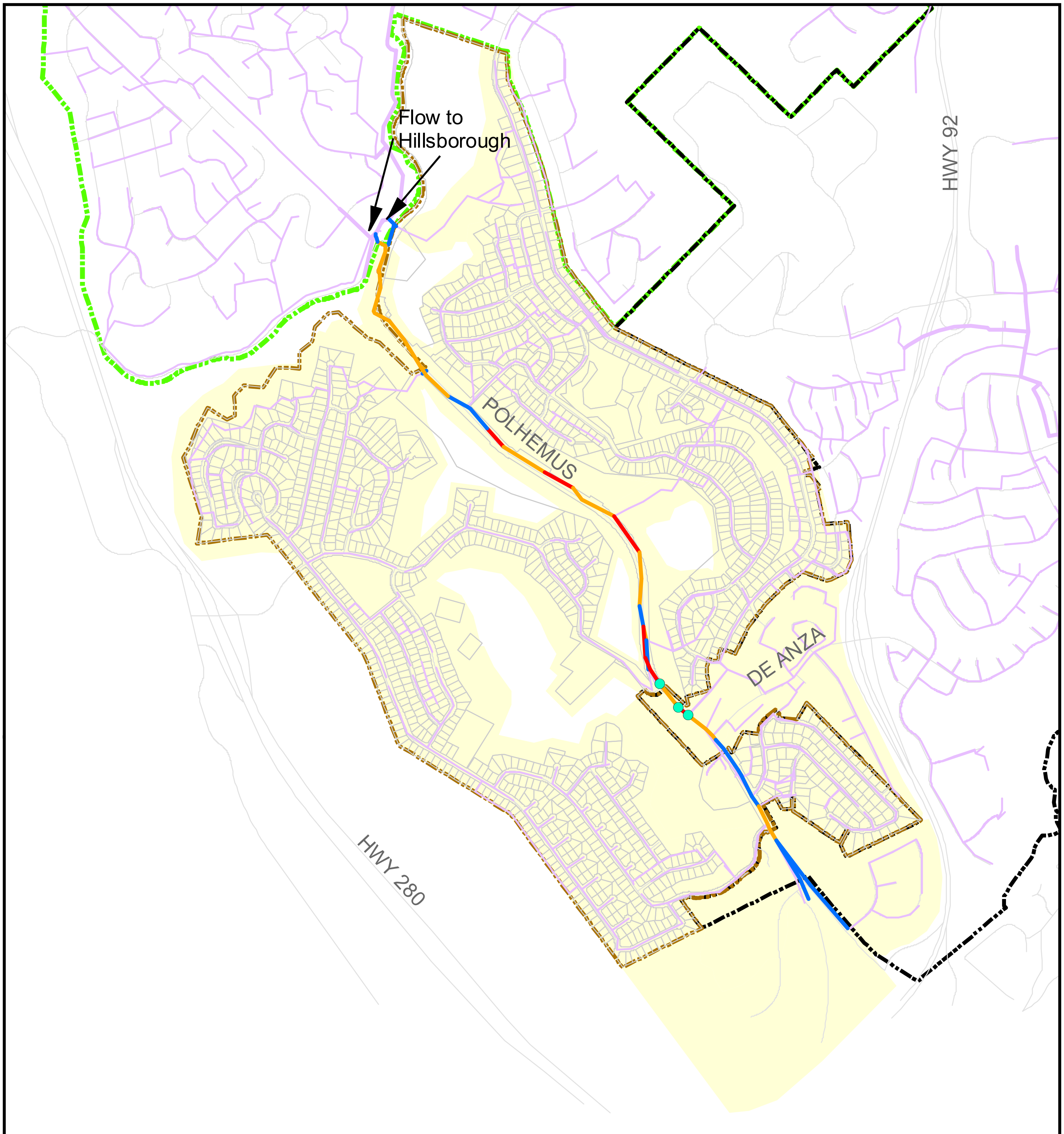
Sewer System Flow Monitoring and Hydraulic Modeling

Figure 5-2
Hillsborough Model Results

N

RMC
Water and Environment

0 0.125 0.25 0.5 Miles



Sewer System Flow Monitoring and Hydraulic Modeling

Figure 5-3
CSCSD
Model Results

N

RMC
Water and Environment

0 0.125 0.25 0.5 Miles

Legend

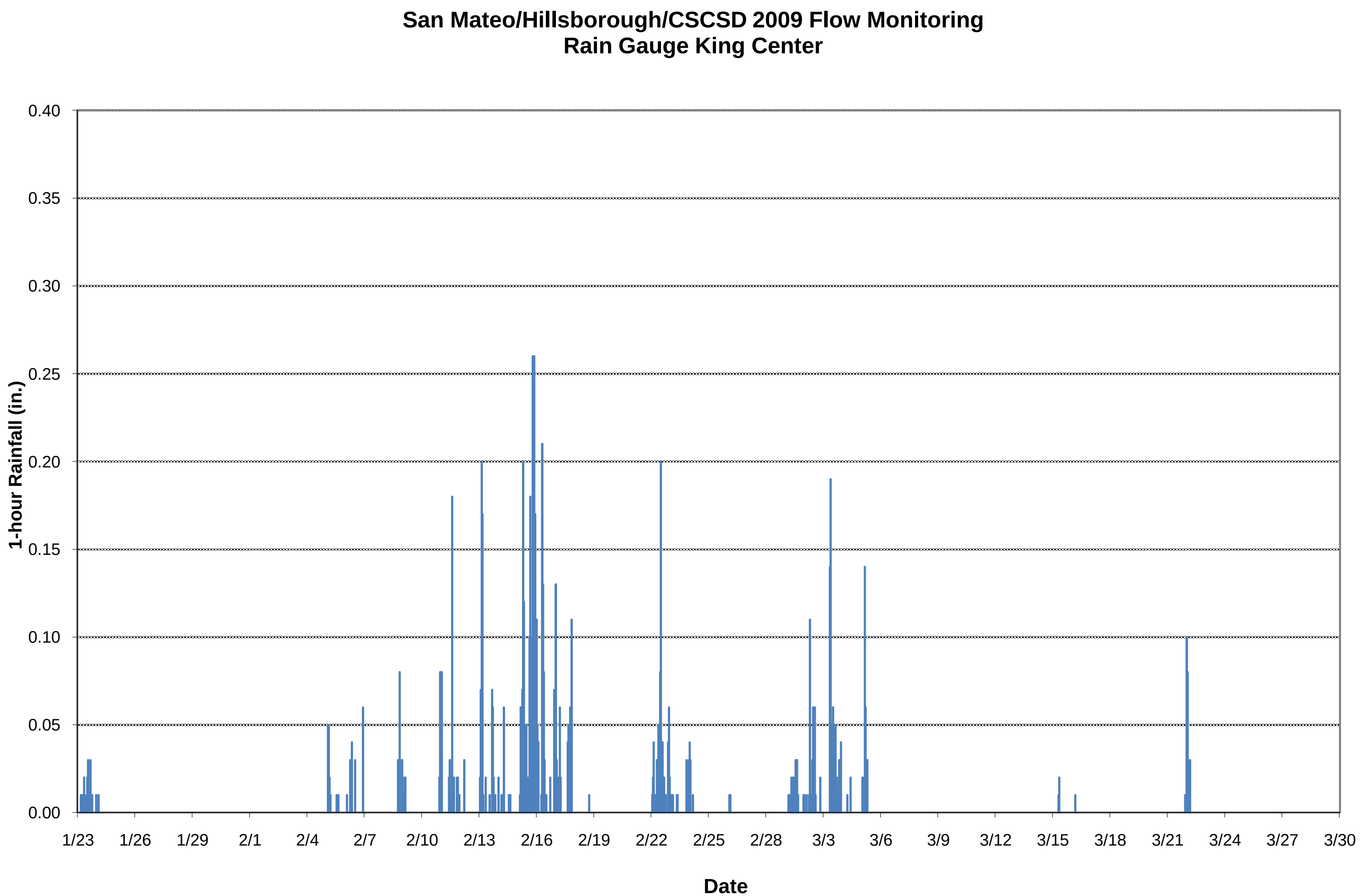
- Potential Manhole Overflow
- Throttle Surcharge
- Back-Up Surcharge
- No Surcharge
- Unmodeled Sewer
- CSCSD Subcatchments
- CSCSD City Limits
- San Mateo City Limits
- Hillsborough City Limits

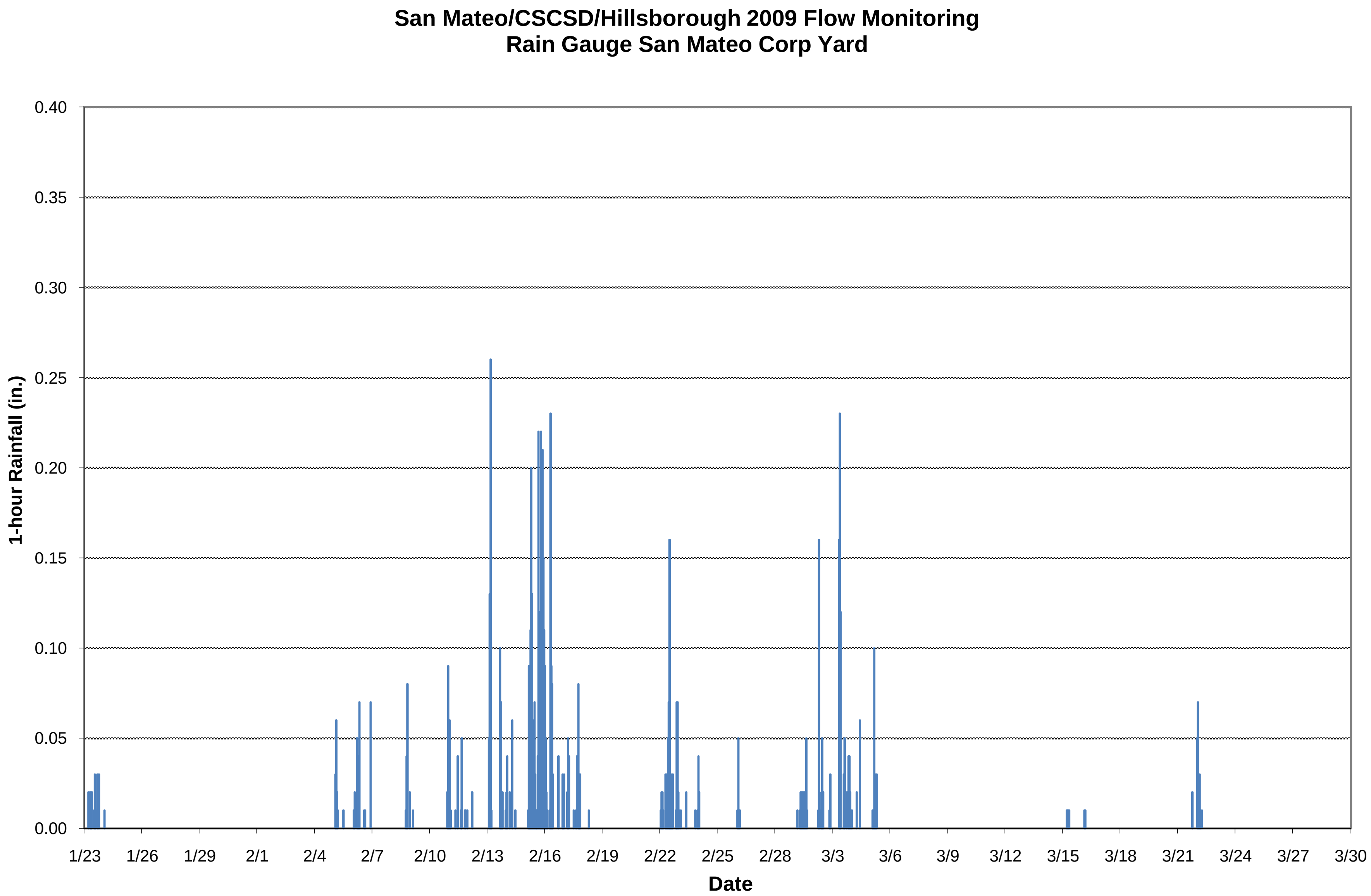
5.3 Next Steps

The calibrated hydraulic models can now be used to develop and test proposed solutions to identified capacity deficiencies in order to provide information for the design of wet weather capacity improvements. The model could be used to evaluate potential refinements to the proposed Phase II Crystal Springs/El Cerrito project to minimize the potential backup due to the undersized 18-inch sewer segment; and possible improvements needed in portions of the CSCSD Polhemus trunk sewer. For San Mateo, the improvements proposed as part of the City-Wide Sewer System Study and updated through more recent sewer predesign studies and wet weather planning initiatives, as well as potential new alternatives, should be incorporated into the model and the model used to refine pipeline sizes and alignments.

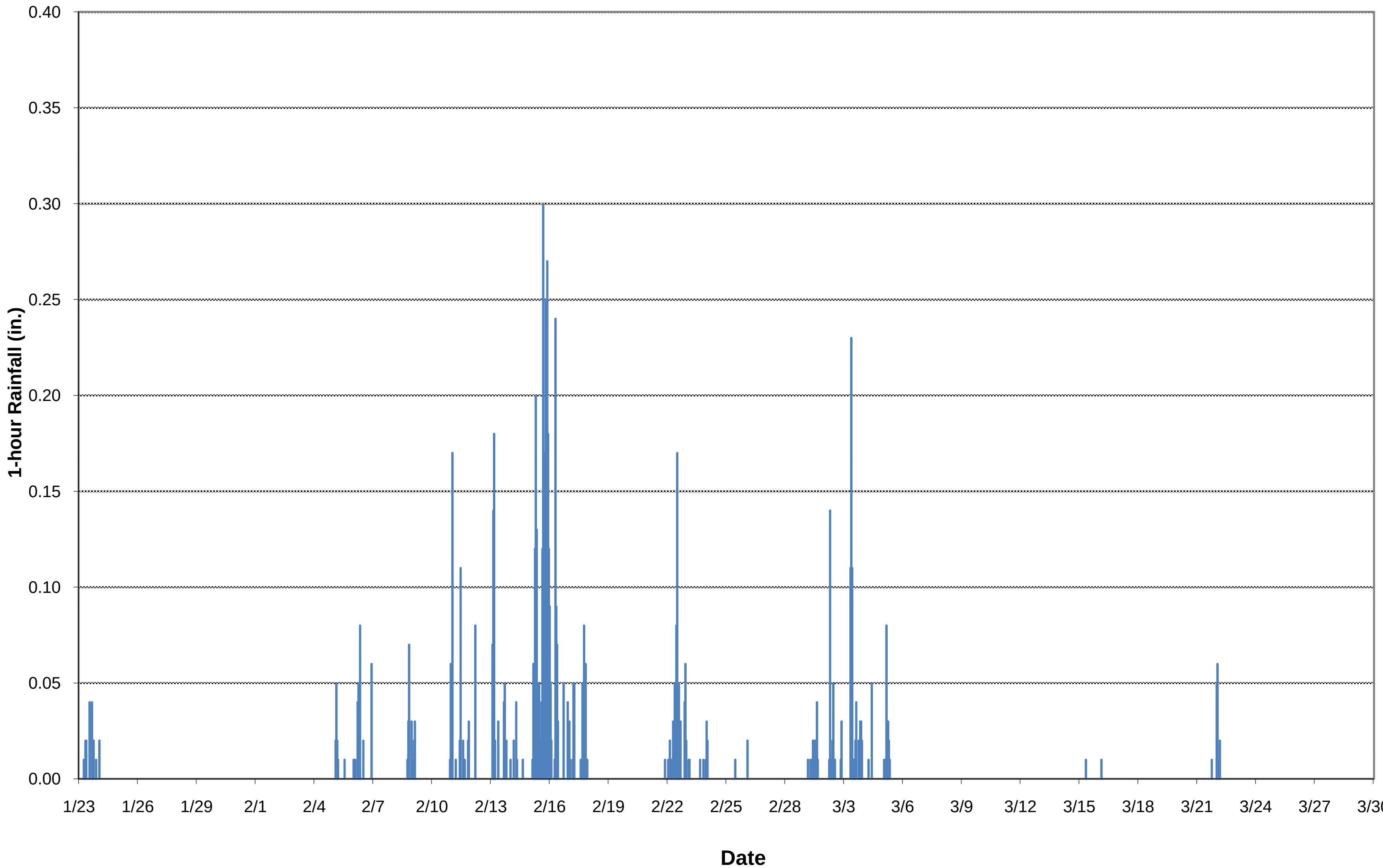
This study has also indicated the need for improved flow monitoring data to verify and track the flows from the various portions of the system. Improvements to existing permanent flow monitoring, including potential new meters and/or improved maintenance and calibration procedures for existing meters, have been implemented or are being considered by the three agencies. The agencies should also consider conducting another system-wide flow monitoring program in the future once some of the major capacity improvement projects, including the Crystal Springs/El Cerrito relief project and other downstream projects in San Mateo, are completed. Prior to implementing such a program, the agencies should ensure that the sewer pipes upstream and downstream of proposed meter locations are cleaned and free of debris or other conditions that could adversely impact the quality of the flow monitoring data.

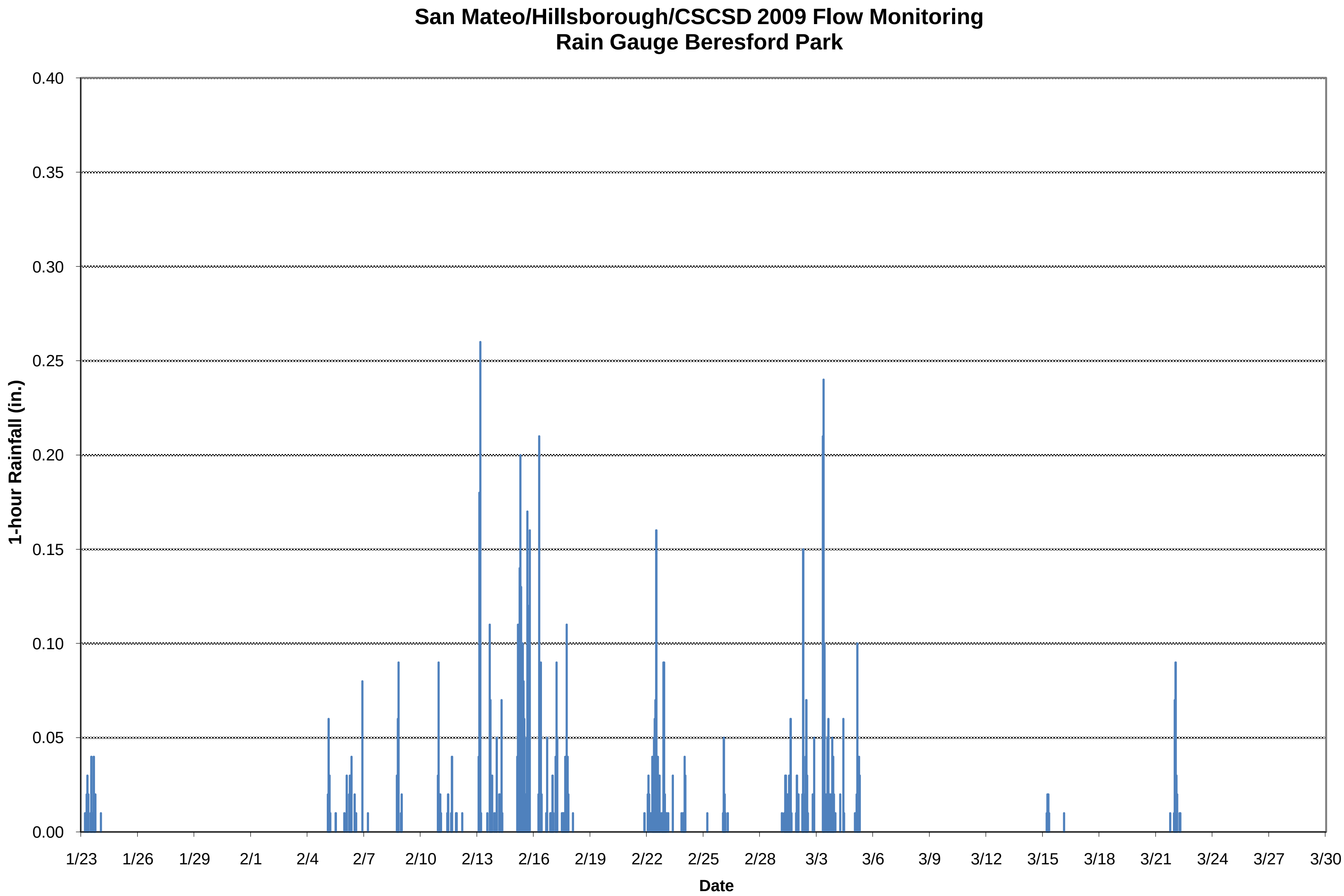
Appendix A - Rainfall Plots


San Mateo/Hillsborough/CSCSD 2009 Flow Monitoring
Rain Gauge King Center
1-hour Rainfall (in.)
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
1/23
1/26
1/29
2/1
2/4
2/7
2/10
2/13
2/16
2/19
2/22
2/25
2/28
3/3
3/6
3/9
3/12
3/15
3/18
3/21
3/24
3/27
3/30
Date

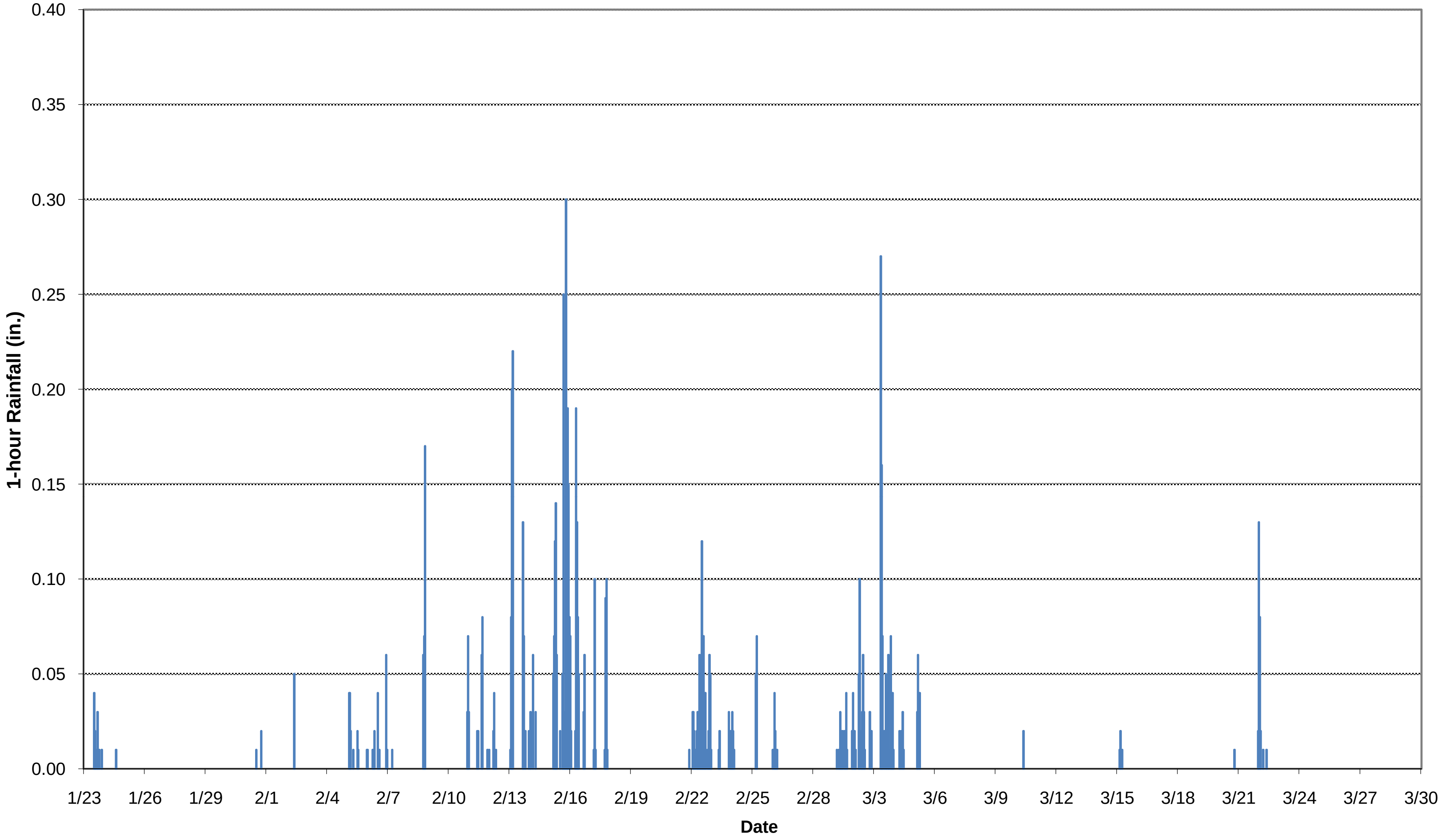

San Mateo/CSCSD/Hillsborough 2009 Flow Monitoring
Rain Gauge San Mateo Corp Yard
1-hour Rainfall (in.)
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
1/23
1/26
1/29
2/1
2/4
2/7
2/10
2/13
2/16
2/19
2/22
2/25
2/28
3/3
3/6
3/9
3/12
3/15
3/18
3/21
3/24
3/27
3/30
Date

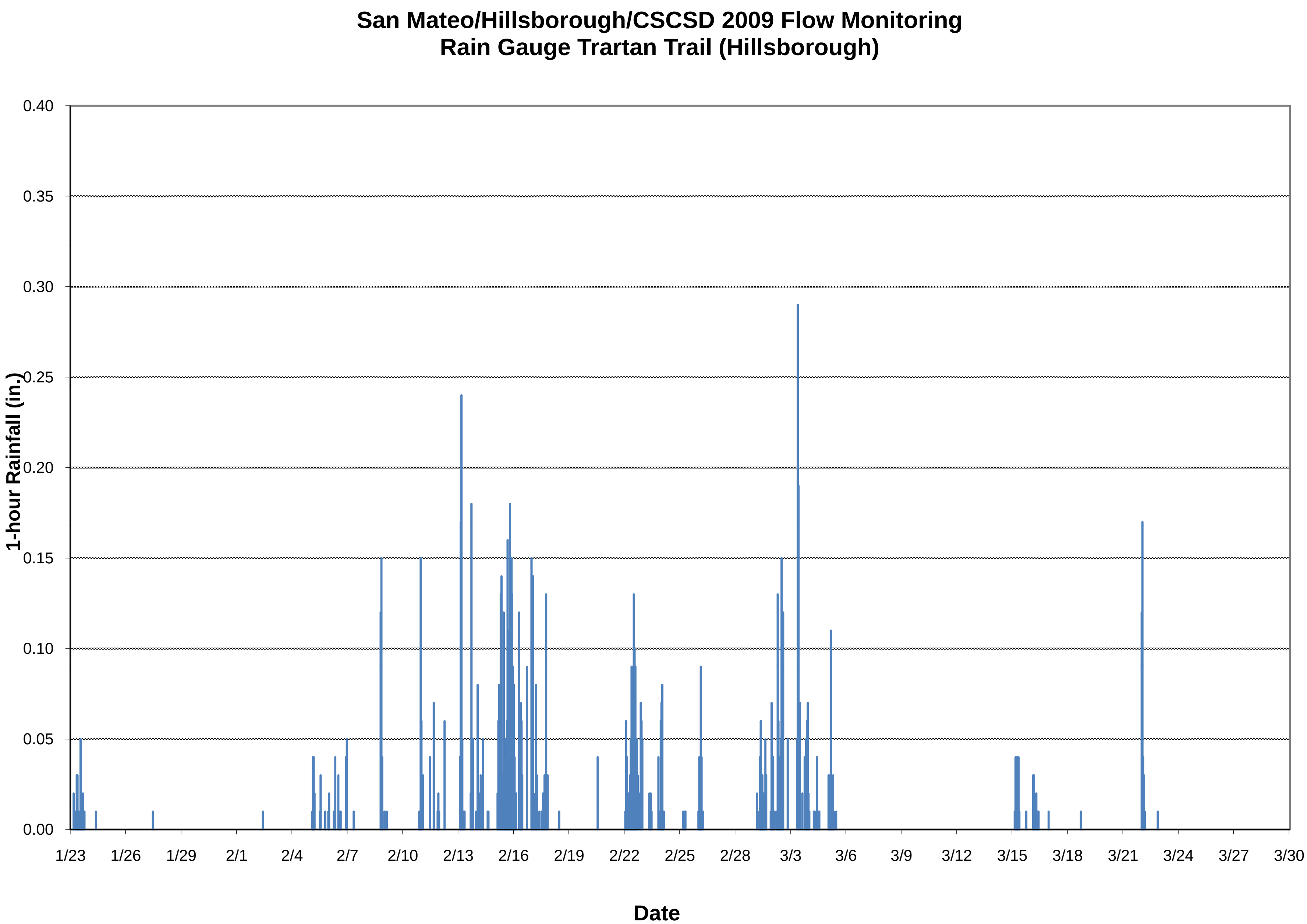
San Mateo/CSCSD/Hillsborough 2009 Flow Monitoring
Rain Gauge San Mateo WWTP



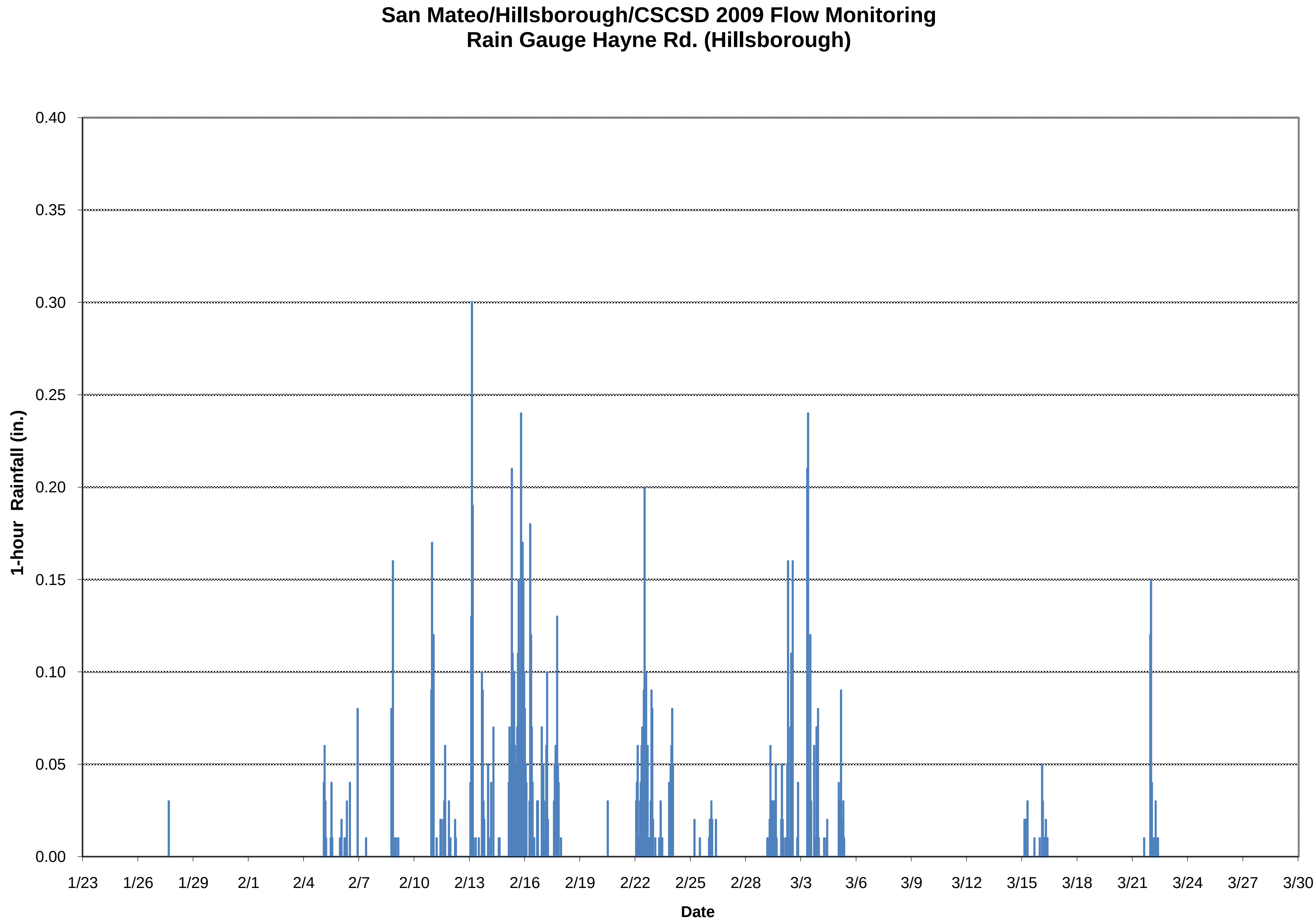

San Mateo/Hillsborough/CSCSD 2009 Flow Monitoring
Rain Gauge Beresford Park
1-hour Rainfall (in.)
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
1/23
1/26
1/29
2/1
2/4
2/7
2/10
2/13
2/16
2/19
2/22
2/25
2/28
3/3
3/6
3/9
3/12
3/15
3/18
3/21
3/24
3/27
3/30
Date

San Mateo/Hillsborough/CSCSD 2009 Flow Monitoring
Rain Gauge Fire Station #17 (Tower Road)

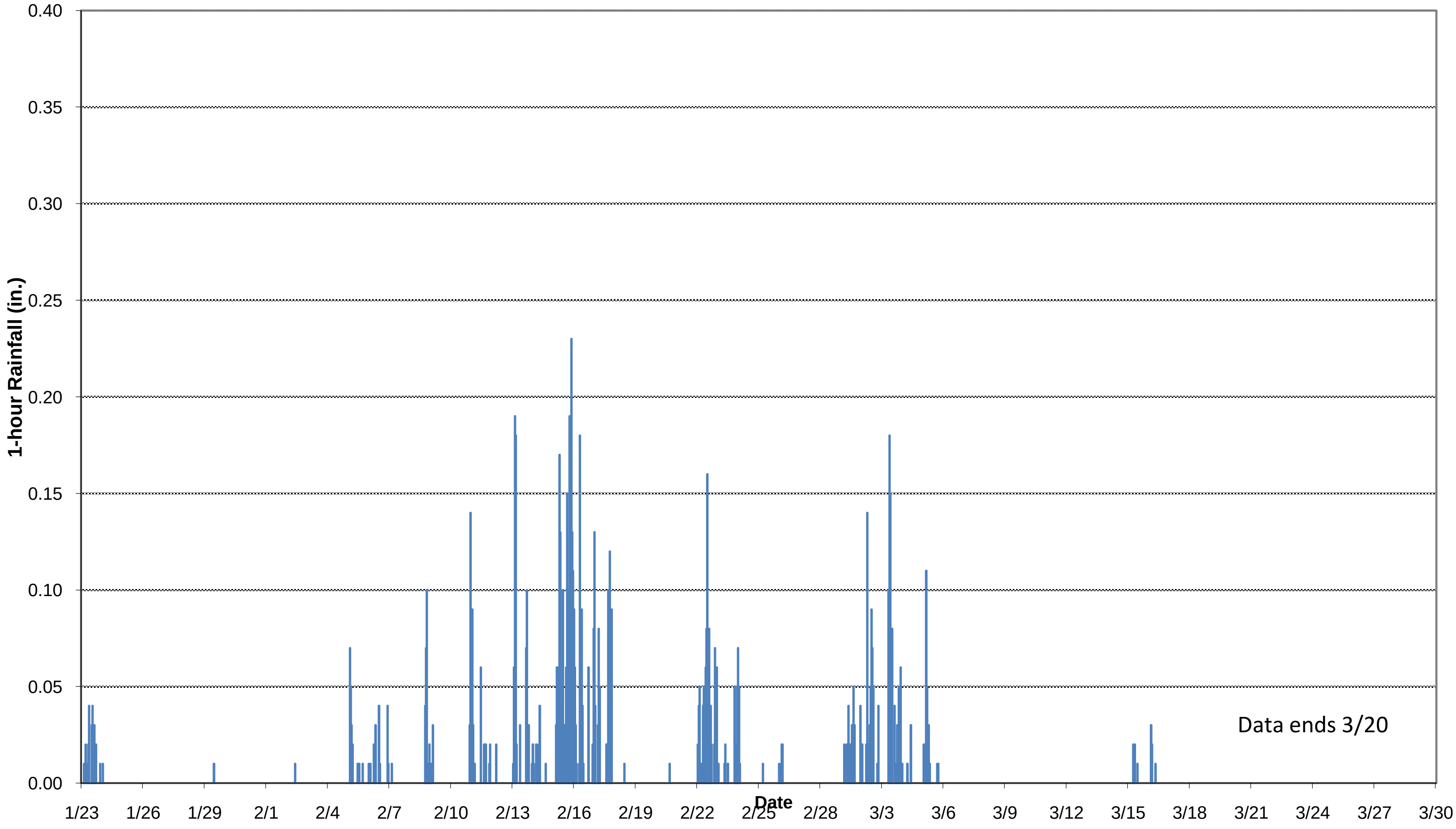




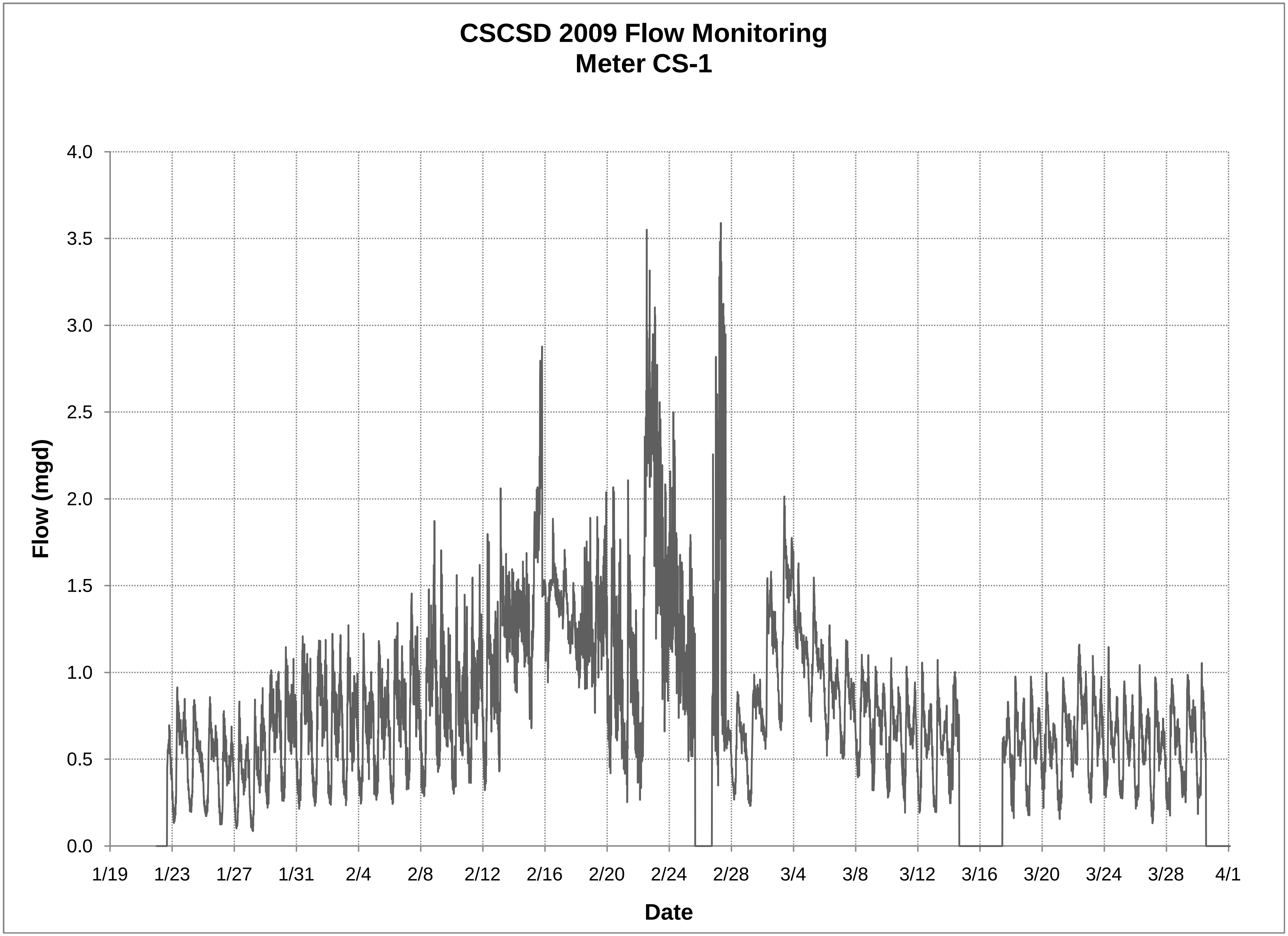
San Mateo/Hillsborough/CSCSD 2009 Flow Monitoring
Rain Gauge Trartan Trail (Hillsborough)
1-hour Rainfall (in.)
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
1/23
1/26
1/29
2/1
2/4
2/7
2/10
2/13
2/16
2/19
2/22
2/25
2/28
3/3
3/6
3/9
3/12
3/15
3/18
3/21
3/24
3/27
3/30
Date


San Mateo/Hillsborough/CSCSD 2009 Flow Monitoring
Rain Gauge Hayne Rd. (Hillsborough)
1-hour Rainfall (in.)
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
1/23
1/26
1/29
2/1
2/4
2/7
2/10
2/13
2/16
2/19
2/22
2/25
2/28
3/3
3/6
3/9
3/12
3/15
3/18
3/21
3/24
3/27
3/30
Date

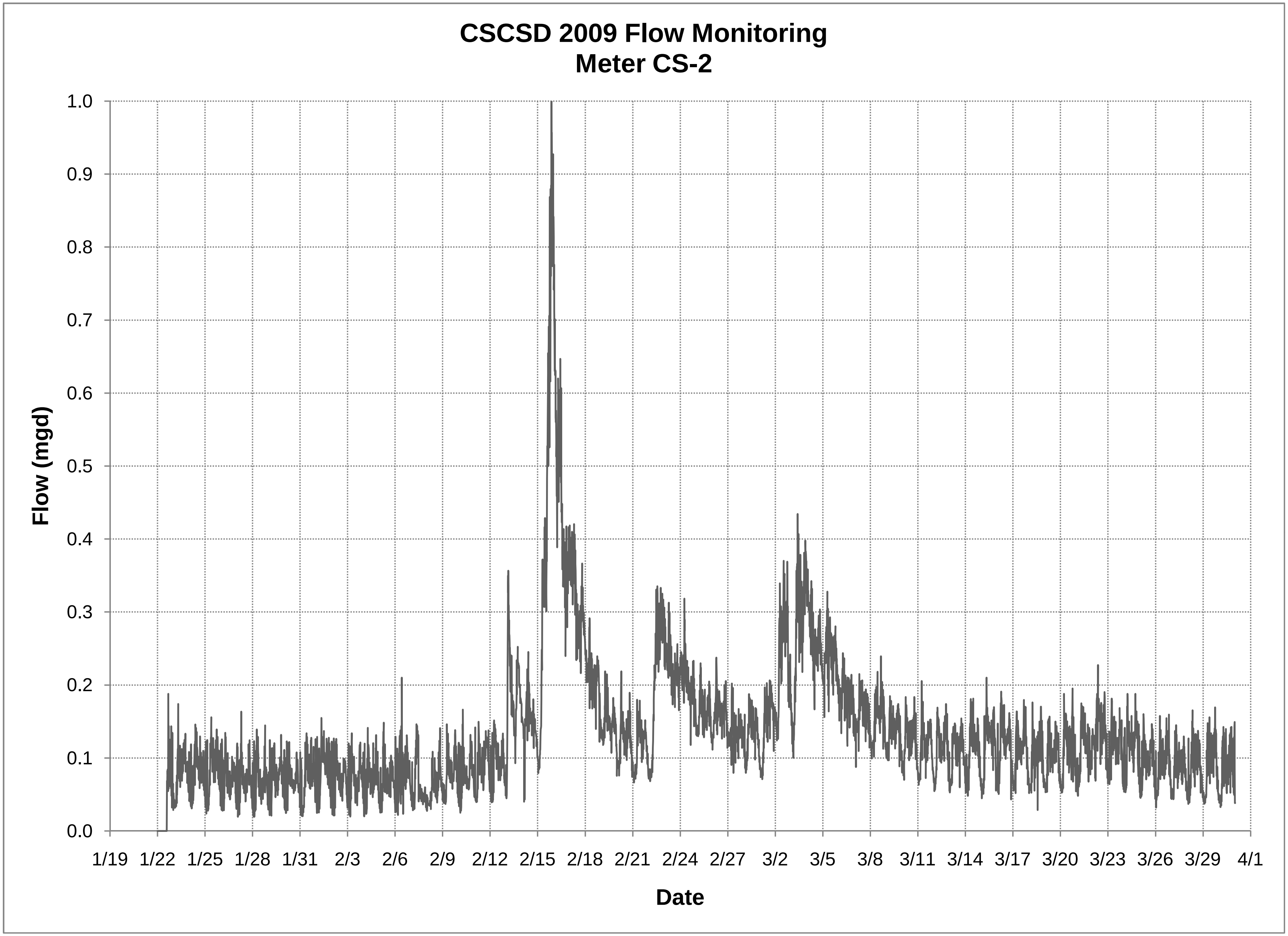
San Mateo/Hillsborough/CSCSD 2009 Flow Monitoring
Rain Gauge El Cerrito Ave. (Hillsborough)

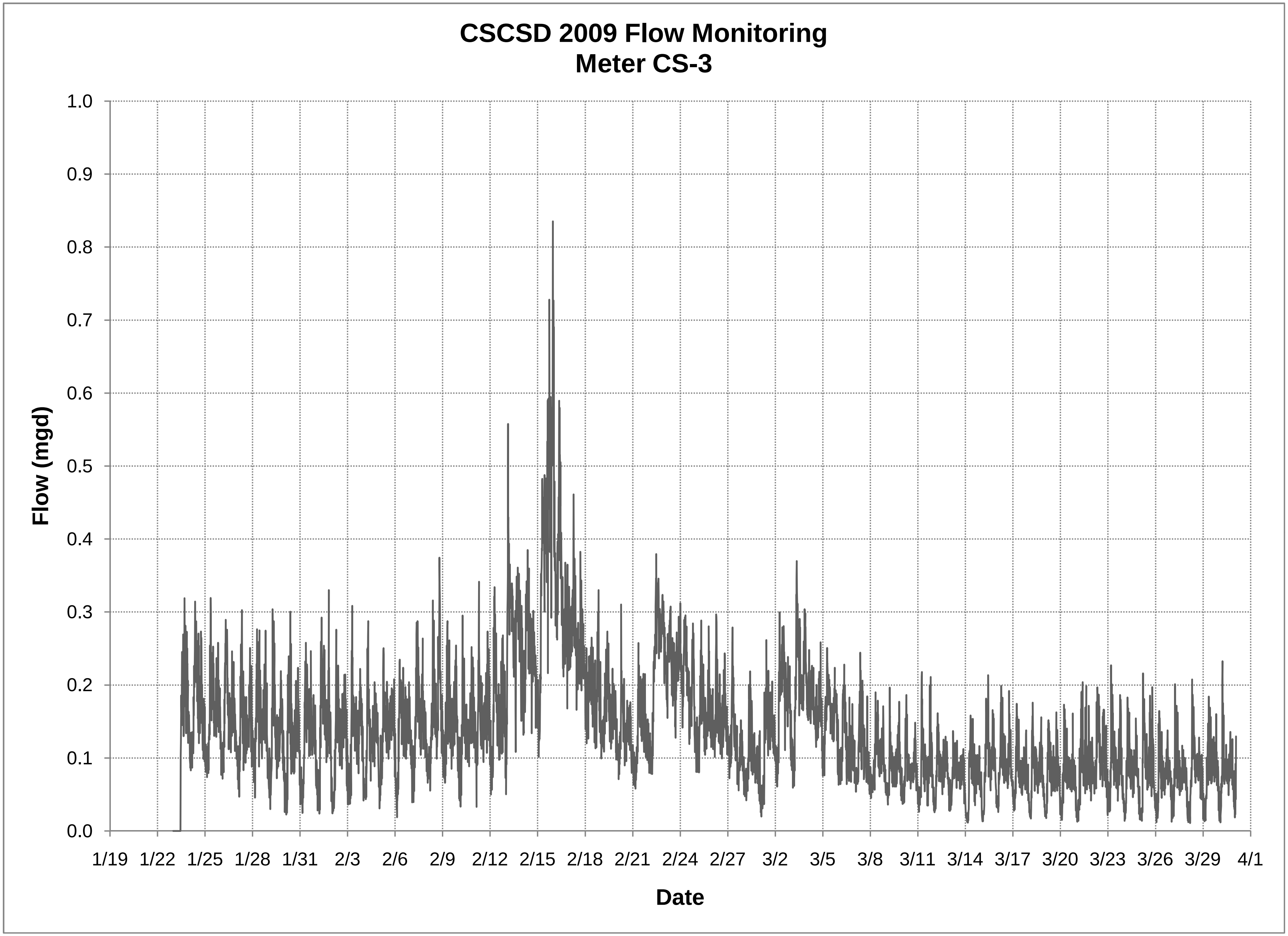


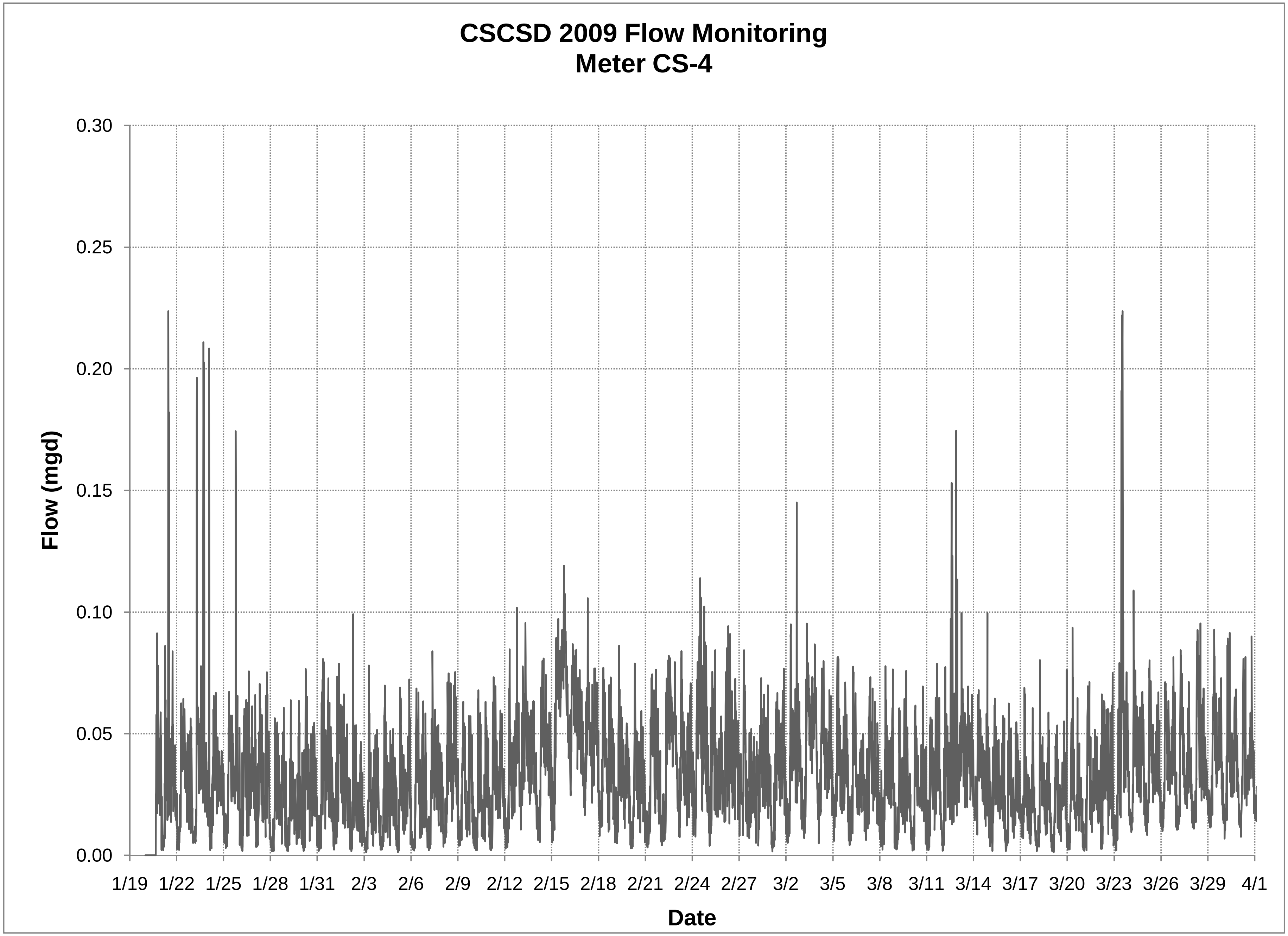
Appendix D - CSCSD Flow Monitoring Plots

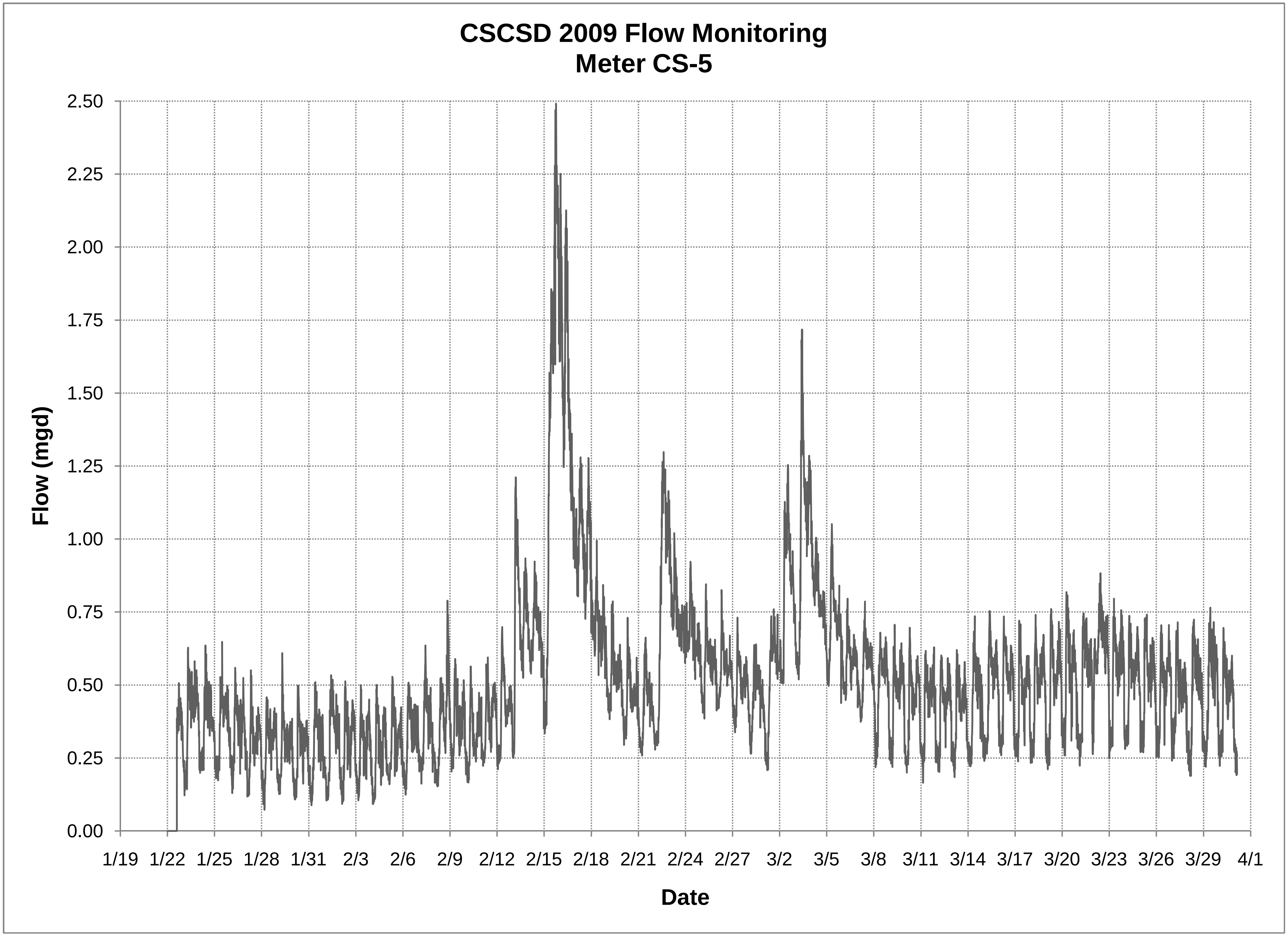


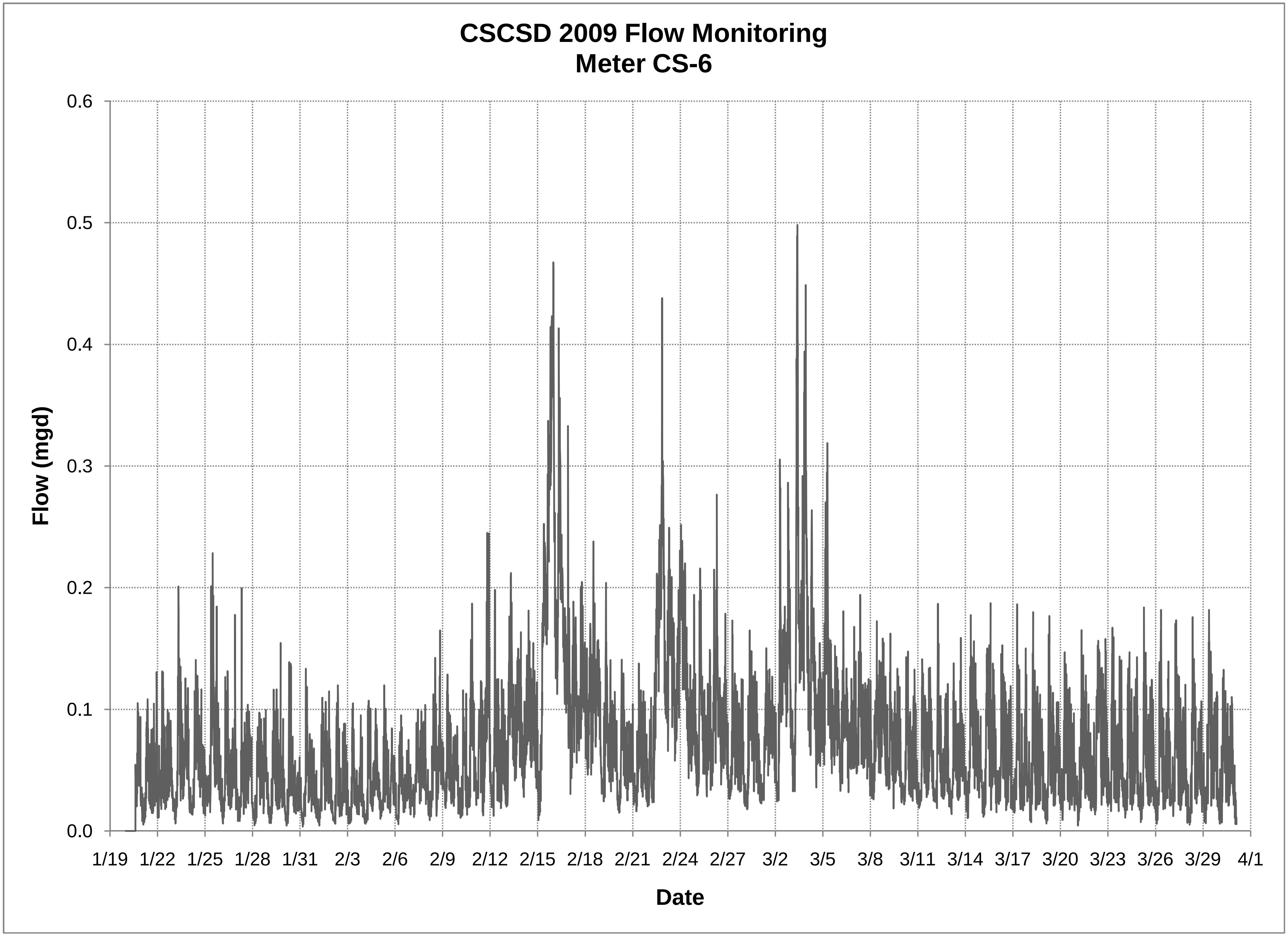
CSCSD 2009 Flow Monitoring
Meter CS-1
Flow (mgd)
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
1/19
1/23
1/27
1/31
2/4
2/8
2/12
2/16
2/20
2/24
2/28
3/4
3/8
3/12
3/16
3/20
3/24
3/28
4/1
Date

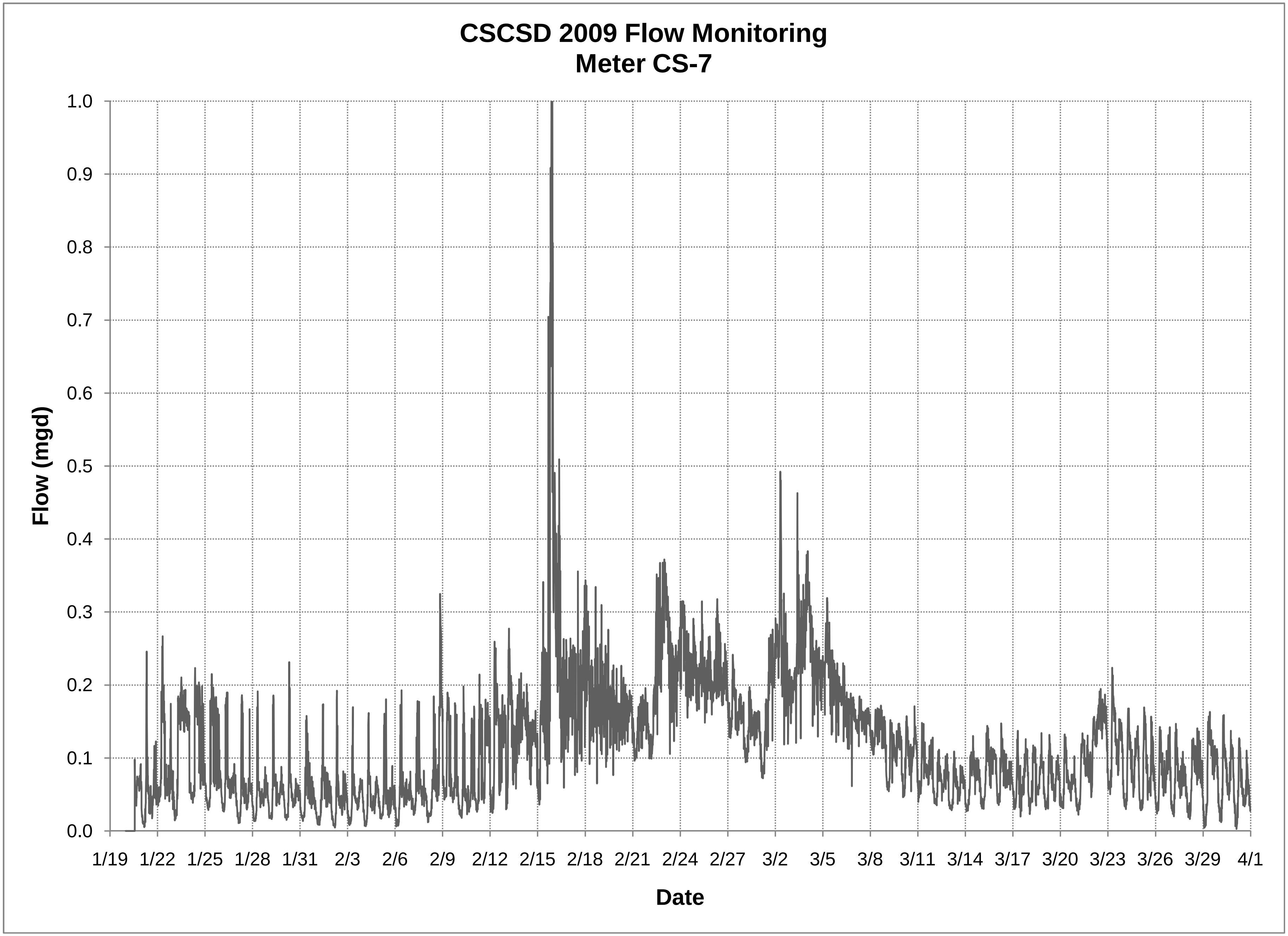

CSCSD 2009 Flow Monitoring
Meter CS-2
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
Flow (mgd)
1/19
1/22
1/25
1/28
1/31
2/3
2/6
2/9
2/12
2/15
2/18
2/21
2/24
2/27
3/2
3/5
3/8
3/11
3/14
3/17
3/20
3/23
3/26
3/29
4/1
Date

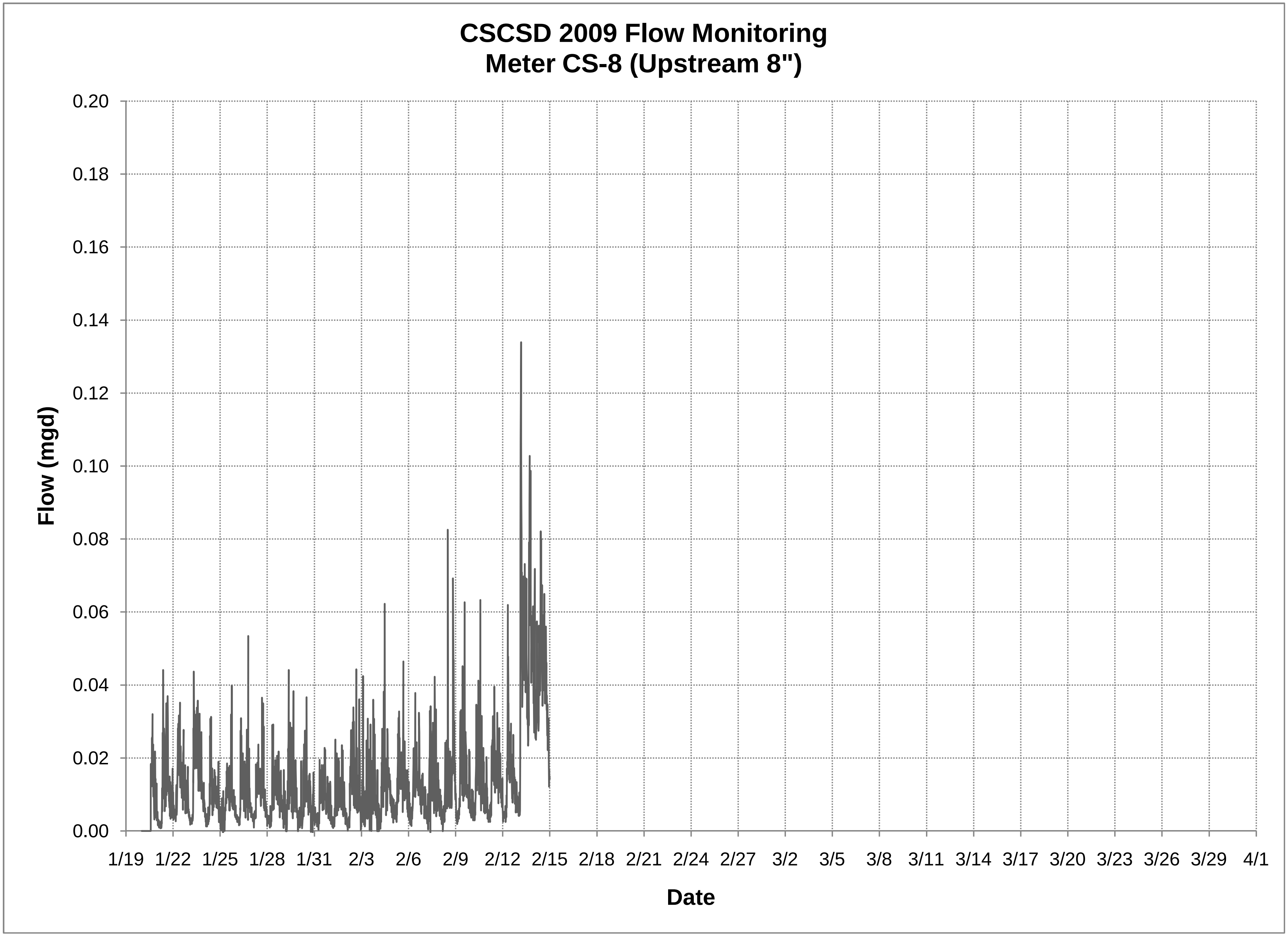

CSCSD 2009 Flow Monitoring
Meter CS-3
Flow (mgd)
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
1/19
1/22
1/25
1/28
1/31
2/3
2/6
2/9
2/12
2/15
2/18
2/21
2/24
2/27
3/2
3/5
3/8
3/11
3/14
3/17
3/20
3/23
3/26
3/29
4/1
Date

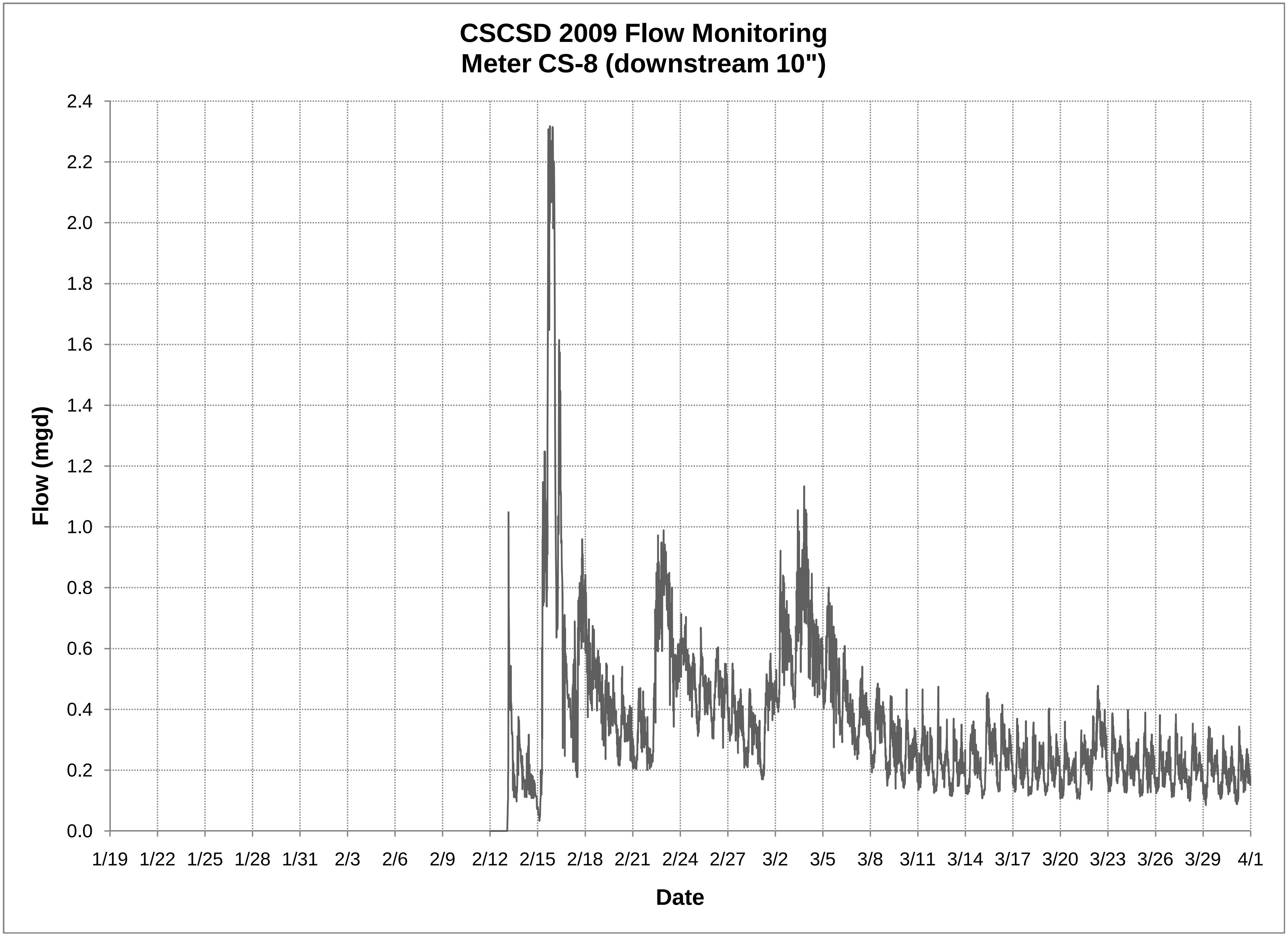

CSCSD 2009 Flow Monitoring
Meter CS-4
Flow (mgd)
0.30
0.25
0.20
0.15
0.10
0.05
0.00
1/19
1/22
1/25
1/28
1/31
2/3
2/6
2/9
2/12
2/15
2/18
2/21
2/24
2/27
3/2
3/5
3/8
3/11
3/14
3/17
3/20
3/23
3/26
3/29
4/1
Date

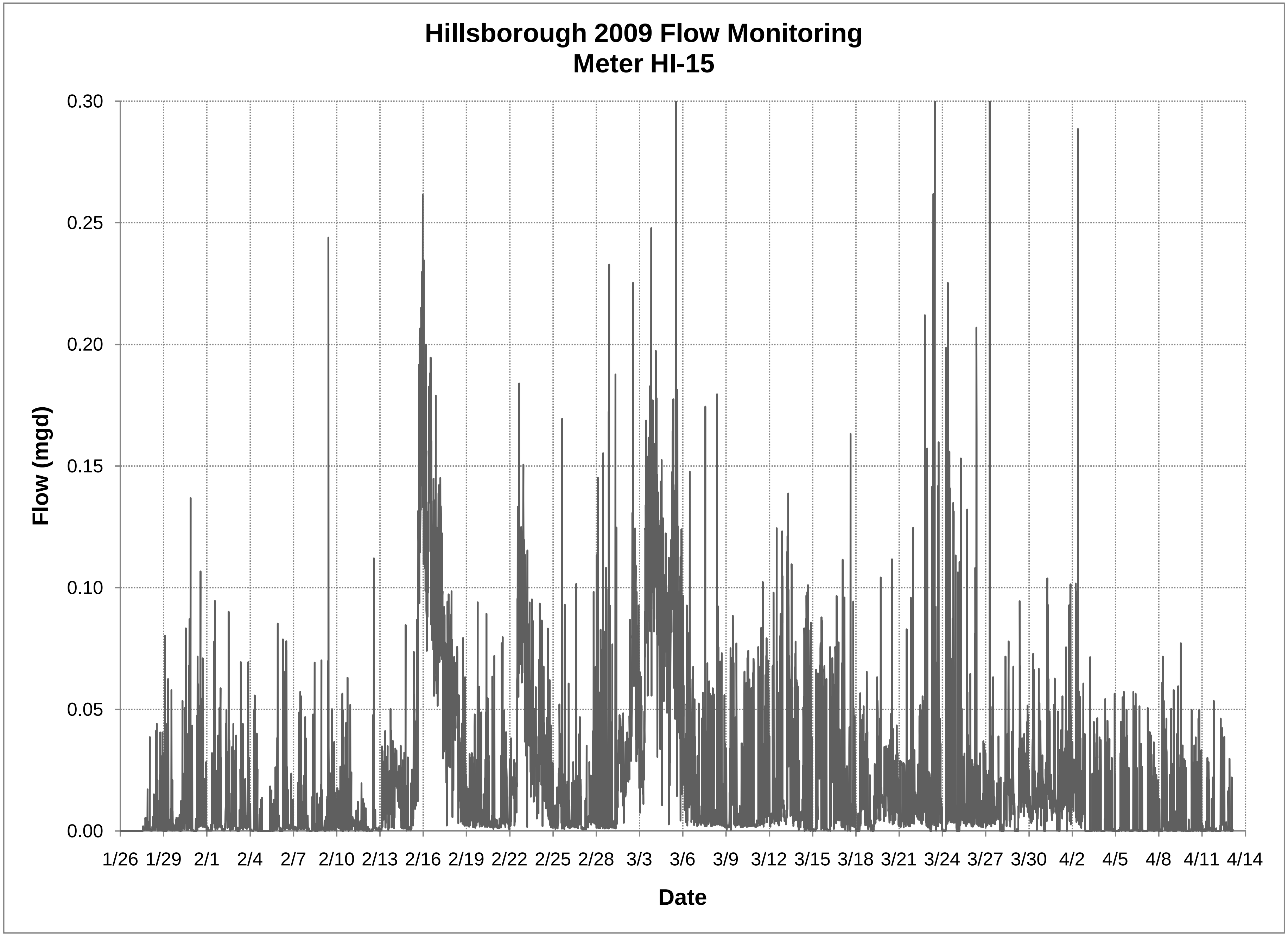

CSCSD 2009 Flow Monitoring
Meter CS-5
Flow (mgd)
2.50
2.25
2.00
1.75
1.50
1.25
1.00
0.75
0.50
0.25
0.00
1/19
1/22
1/25
1/28
1/31
2/3
2/6
2/9
2/12
2/15
2/18
2/21
2/24
2/27
3/2
3/5
3/8
3/11
3/14
3/17
3/20
3/23
3/26
3/29
4/1
Date


CSCSD 2009 Flow Monitoring
Meter CS-6
Flow (mgd)
0.6
0.5
0.4
0.3
0.2
0.1
0.0
1/19
1/22
1/25
1/28
1/31
2/3
2/6
2/9
2/12
2/15
2/18
2/21
2/24
2/27
3/2
3/5
3/8
3/11
3/14
3/17
3/20
3/23
3/26
3/29
4/1
Date

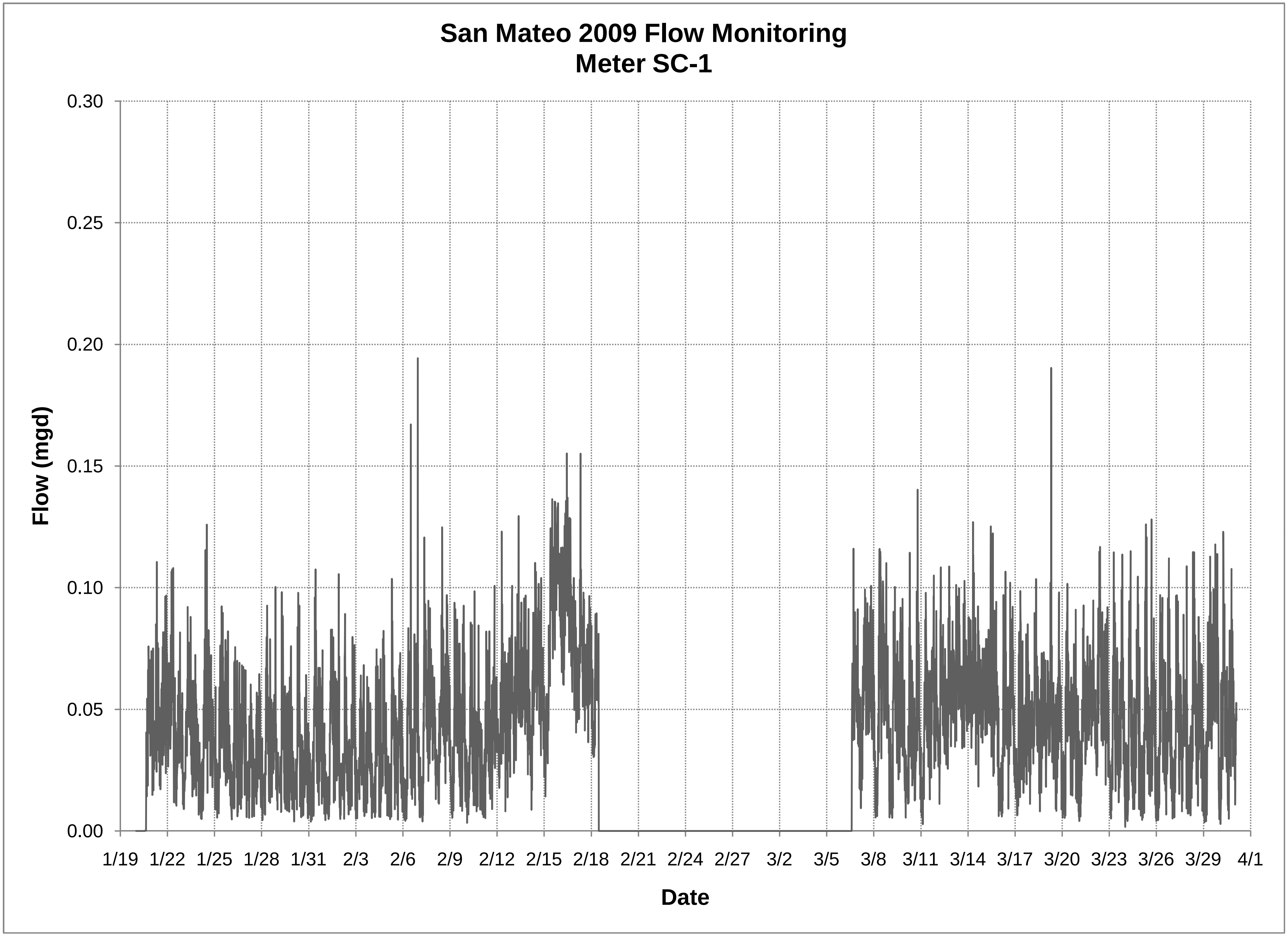

CSCSD 2009 Flow Monitoring
Meter CS-7
Flow (mgd)
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
1/19
1/22
1/25
1/28
1/31
2/3
2/6
2/9
2/12
2/15
2/18
2/21
2/24
2/27
3/2
3/5
3/8
3/11
3/14
3/17
3/20
3/23
3/26
3/29
4/1
Date

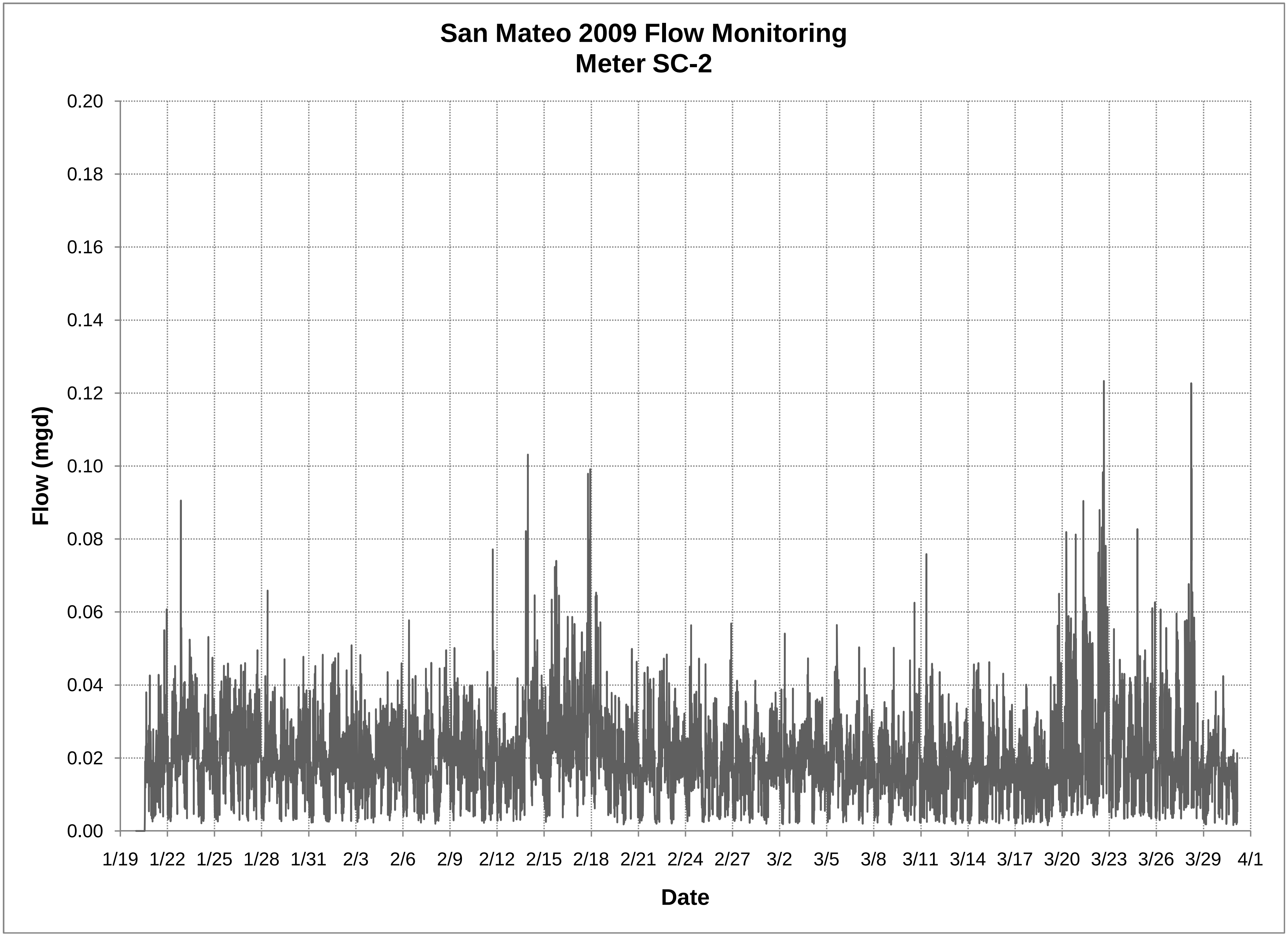

CSCSD 2009 Flow Monitoring
Meter CS-8 (Upstream 8")
Flow (mgd)
0.20
0.18
0.16
0.14
0.12
0.10
0.08
0.06
0.04
0.02
0.00
1/19
1/22
1/25
1/28
1/31
2/3
2/6
2/9
2/12
2/15
2/18
2/21
2/24
2/27
3/2
3/5
3/8
3/11
3/14
3/17
3/20
3/23
3/26
3/29
4/1
Date


CSCSD 2009 Flow Monitoring
Meter CS-8 (downstream 10")
Flow (mgd)
2.4
2.2
2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
1/19
1/22
1/25
1/28
1/31
2/3
2/6
2/9
2/12
2/15
2/18
2/21
2/24
2/27
3/2
3/5
3/8
3/11
3/14
3/17
3/20
3/23
3/26
3/29
4/1
Date



Hillsborough 2009 Flow Monitoring
Meter HI-15
Flow (mgd)
0.30
0.25
0.20
0.15
0.10
0.05
0.00
1/26 1/29 2/1 2/4 2/7 2/10 2/13 2/16 2/19 2/22 2/25 2/28 3/3 3/6 3/9 3/12 3/15 3/18 3/21 3/24 3/27 3/30 4/2 4/5 4/8 4/11 4/14
Date


San Mateo 2009 Flow Monitoring
Meter SC-1
Flow (mgd)
0.30
0.25
0.20
0.15
0.10
0.05
0.00
1/19
1/22
1/25
1/28
1/31
2/3
2/6
2/9
2/12
2/15
2/18
2/21
2/24
2/27
3/2
3/5
3/8
3/11
3/14
3/17
3/20
3/23
3/26
3/29
4/1
Date



San Mateo 2009 Flow Monitoring
Meter SC-2
Flow (mgd)
0.20
0.18
0.16
0.14
0.12
0.10
0.08
0.06
0.04
0.02
0.00
1/19
1/22
1/25
1/28
1/31
2/3
2/6
2/9
2/12
2/15
2/18
2/21
2/24
2/27
3/2
3/5
3/8
3/11
3/14
3/17
3/20
3/23
3/26
3/29
4/1
Date

Appendix E - Design Rainfall Calculation Worksheet

A worksheet to build a Depth-Duration-Frequency and IDF Curves from NOAA Atlas 2 for San Mateo County, California

All yellow highlighted cells are data entry areas

Location name: 2215 Ralmer

1. Fill in geographical coordinates (DDD.MM) and region.

Lat (Deg.min):	37.28	e.g. 37.17 is 37 degrees and 17 minutes
Long (Deg.min):	-122.09	
Region :	4	Enter Region. (Roughly, region 3 is above 1000 ft elevation, rest of county is region 4)

2. Geographical coordinates converted from minute/second format to decimal degrees:

Latitude:	**37.47**
Longitude	**-122.15**

3. Enter decimal lat/long values (green) into NOAA Atlas 2 website: http://www.weather.gov/oh/hdsc/noaaatlas2.htm

4. Enter the 4 values (inches) obtained from the website:

All other values and graphs will be automatically computed

Duration (hrs)	Frequency (years) 2	100	
6	1.4	2.6	inches
24	2.31	4.43	inches

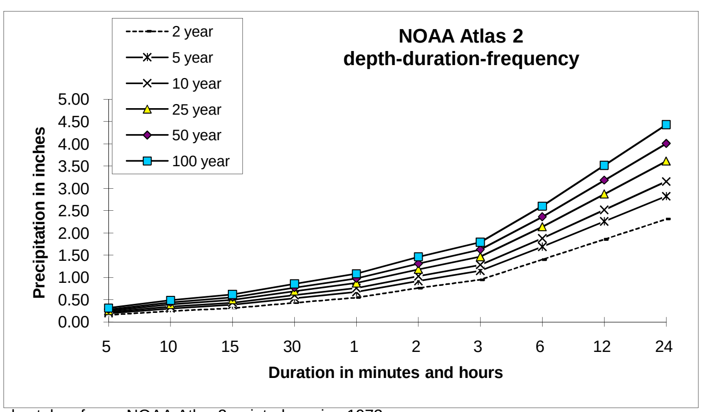
		Region 3	4	
A=x1*(x1/x2)	0.8485			37
B=x3/x1	1.8571			-122
x5=lat-32	5.2800			
C=x3*(x1/x2)	1.5758			
P(1,2) =		0.57	0.55	
P(1,100) =		1.16	1.08	

5. Click on intensity-duration-frequency tab to get rainfall intensity

Depth-Duration-Frequncy Table (not the same as intensity)

Duration	Frequency (years) 2	5	10	25	50	100
(Minutes)						
5	0.16	0.20	0.22	0.25	0.28	0.31
10	0.25	0.30	0.34	0.39	0.44	0.49
15	0.31	0.39	0.43	0.50	0.56	0.62
30	0.43	0.54	0.60	0.69	0.77	0.86
(Hours)						
1	0.55	0.68	0.76	0.88	0.98	1.08
2	0.76	0.92	1.03	1.18	1.31	1.46
3	0.95	1.15	1.28	1.47	1.62	1.79
6	1.40	1.69	1.88	2.14	2.36	2.60
12	1.86	2.26	2.52	2.87	3.18	3.52
24	2.31	2.82	3.15	3.61	4.00	4.43

Depth is in inches



All formulas taken from : NOAA Atlas 2, printed version 1973

Notes from NOAA Atlas 2, paper version (1973):
"Equations to provide estimates for the 1-hr duration and for 2- and 100-yr return periods are shown on Table 11. The variable [(x1)(x1/x2)] can be regarded as the 6-hr value times the slope of a line connecting the 6-hr and 24-hr values for the appropriate return period. The variable y2 appears in the right side of the 100-yr 1-hr equations for Regions 1, 3, 4, and 5. If the 2-hr 1-hr value is not required, the equation for y2 can be substituted, and the second equation for y100 shown in Table 11 can be used."

y2 = 2-yr 1-hr estimated value
y100 = 100-yr 1-hr estimated value
x1 = 2-yr 6-hr value
x2 = 2-yr24-hr value
x3 = 100-yr6-hr value
x4 = 100-yr 24-hr value
x5 = latitude (in decimals) minus 32 degrees

Table 11

Region 3
y2 = 0.111 + 0.545 [(x1)(x1/x2)]
y100 = 0.221 + 0.885 [(y2)(x3/x1)]
or
y100 = 0.221+ 0.098(x3/x1) + 0.482[(x3)(x1/x2)]

Region 4
y2 = 0.107 + 0.315(x1)
y100 = -0.391 + 1.224[(y2)(x3/x1)] + 0.043(x5)
or
y100 = -0.391 + 0.131(x3/x1) + 0.386(x3) + 0.043(x5)

Note on regions:
The printed version of NOAA Atlas 2 contains a schematic showing region boundaries, however the drawing is very crude and its derivation is not explained in the text.

Table 12: Adjustment factors to obtain n-minute estimates from 1-hr values

Minutes	5	10	15	30
Ratio to 1-hr	0.29	0.45	0.57	0.79

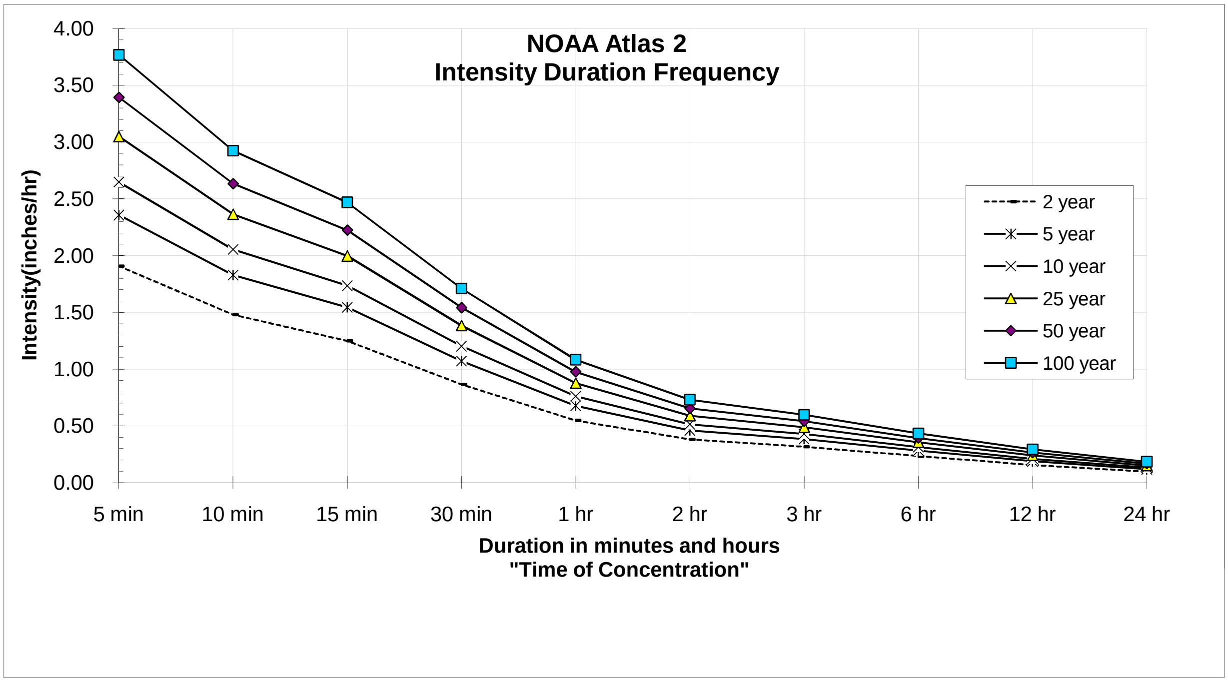
Estimates for 2- and 3-hr precipitation frequency values
Region 3 and 4
2-hr = 0.240 (6-hr) + 0.760 (1-hr)
3-hr = 0.468 (6-hr) + 0.532 (1-hr)

Intensity-Duration-Frequency

Intensity (inches per hour)

Duration	2	5	10	25	50	100 <<Return Period (years)
5 min	1.91	2.36	2.65	3.05	3.39	3.77
10 min	1.48	1.83	2.05	2.36	2.63	2.92
15 min	1.25	1.54	1.73	2.00	2.22	2.47
30 min	0.87	1.07	1.20	1.38	1.54	1.71
1 hr	0.55	0.68	0.76	0.88	0.98	1.08
2 hr	0.38	0.46	0.51	0.59	0.65	0.73
3 hr	0.32	0.38	0.43	0.49	0.54	0.60
6 hr	0.23	0.28	0.31	0.36	0.39	0.43
12 hr	0.15	0.19	0.21	0.24	0.27	0.29
24 hr	0.10	0.12	0.13	0.15	0.17	0.18

Location name:



NOAA Atlas 2

"Note: Effective August 6, 2003, NOAA Atlas 2 has been superceded by NOAA Atlas 14 for Arizona, Nevada, New Mexico, Utah and southeastern California. Visit the Precipitation Frequency Data Server for more information."

Welcome to the Hydrometeorological Design Studies Center web page for **NOAA Atlas 2**, the Precipitaiton-Frequency Atlas of the Western United States, 1973. This web page provides access to high-resolution (15-sec) NOAA Atlas 2 GIS rasters (grids) for 7 states in the western U.S..

To view scanned versions of NOAA Atlas 2, please visit the current PF publications page.

- The GIS rasters can either be retrieved via HTTP (web browser) or anonymous FTP.
- Please read the **metadata** and disclaimer before making any use of these datasets.
- To obtain the precipitation frequency estimates for 2-yr 6-hr, 2-yr 24-hr, 100-yr 6-hr, and 100-yr 24-hr at a given point, enter the longitude **(as a negative number)** and latitude in **decimal degrees** here: (enter 45° 30' 00" as 45.500)

Latitude: **Longitude:** Submit Reset

- To view a scanned version of NOAA Atlas 2 for a specific state, please visit our precipitation frequency information page.
- To view a complete set of scanned images of maps from NOAA Atlas 2, visit the *Western Regional Climate Center.
- These spatial data sets are provided in an ArcInfo ASCII grid format. This format is importable by ArcInfo (with asciigrid command), ArcView 3.x Spatial Analyst extension or ArcGIS 8.x (ArcToolbox function "ASCII to Grid"). If you don't have ArcInfo or ArcView Spatial Analyst, you can visit the *Geocommunity web page for list of free, fully functional raster-based GIS mapping and viewing software. ***NOTE:*** *The links on this page are provided on this web page as a convenience to users and does not imply endorsement by or represent opinions of the U.S. Government.*
- For technical questions please contact Tye Parzybok at tye.parzybok@noaa.gov.

SEE METADATA	**Metadata -- "data about data."** A metadata file is available and may contain important information about this spatial data set. We **strongly recommend** that you read the **metadata file** before making any use of these datasets. (For information about metadata in general, click here) .

HTTP Retrieval Information

Please remember that spatial data files typically are very big! A 28.8K modem, for example, takes about 10 minutes to download a 1 MByte file, even longer if there's network traffic. Plan accordingly. Downloading these files, which have a .gz suffix and a ftp:// prefix, will cause your browser to either spawn a SaveAs window or uncompress the file and display them. However, it is best to save the file rather than view it on your screen. See your browser's instructions on how to do this. You may use anonymous ftp to retrieve files that are too large to conveniently retrieve with a broswer, or to retrieve several or all files at once.

Western U.S. Download 2-yr 6-hr

Western U.S. Download 2-yr 24-hr

Western U.S. Download 100-yr 6-hr

Western U.S. Download 100-yr 24-hr

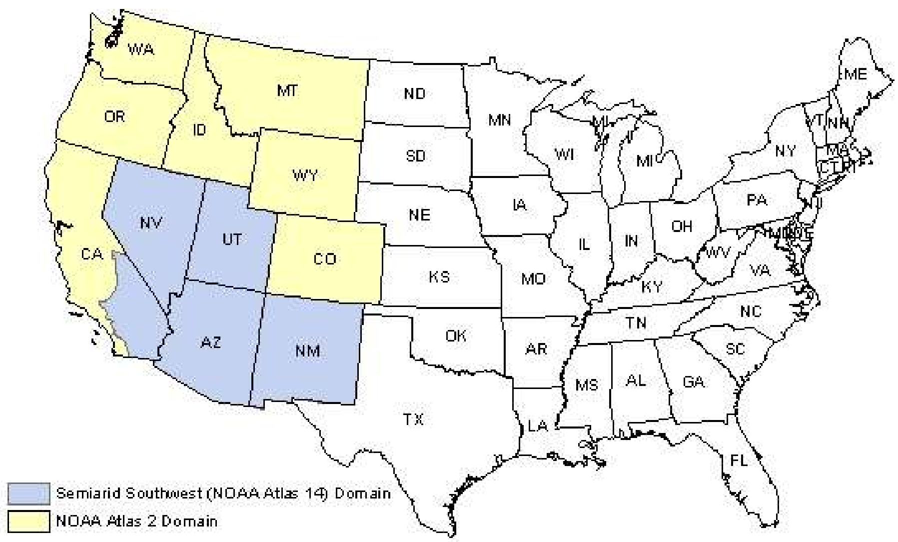
FTP Retrieval Information

Please remember that spatial data files typically are very big! A 28.8K modem, for example, takes about 10 minutes to download a 1 MByte file, even longer if there's network traffic. Plan accordingly. Clicking on files with a .gz suffix or ftp:// prefix will cause your browser to make an "ftp" retrieval. You will want to save this retrieval in a file rather than view it on your screen. See your browser's instructions on how to do this. You may use anonymous ftp to retrieve files that are too large to conveniently retrieve with a broswer, or if you to retrieve several or all files. Give the login name as *anonymous* and your email-address as the password. When transferring compressed files, remember to use the *binary* transfer method.

For example, to get *na2_westus_100yr24hr.asc.gz* and save it on your computer, you would need to do the following from a prompt. If using an FTP tool, you will use the same logic.

Action	Type this
Open ftp to the server.	*ftp hdsc.nws.noaa.gov*
Login as anonymous user.	*anonymous*
Give the password, your email id.	*myemail@company.com*
Switch to binary mode.	*bin*
Change directory.	*cd pub/hdsc/data/westus/*
Get the file.	*get na2_westus_100yr24hr.asc.gz*
Optionally, get other files.	*(whatever)*
Quit ftp.	*quit*

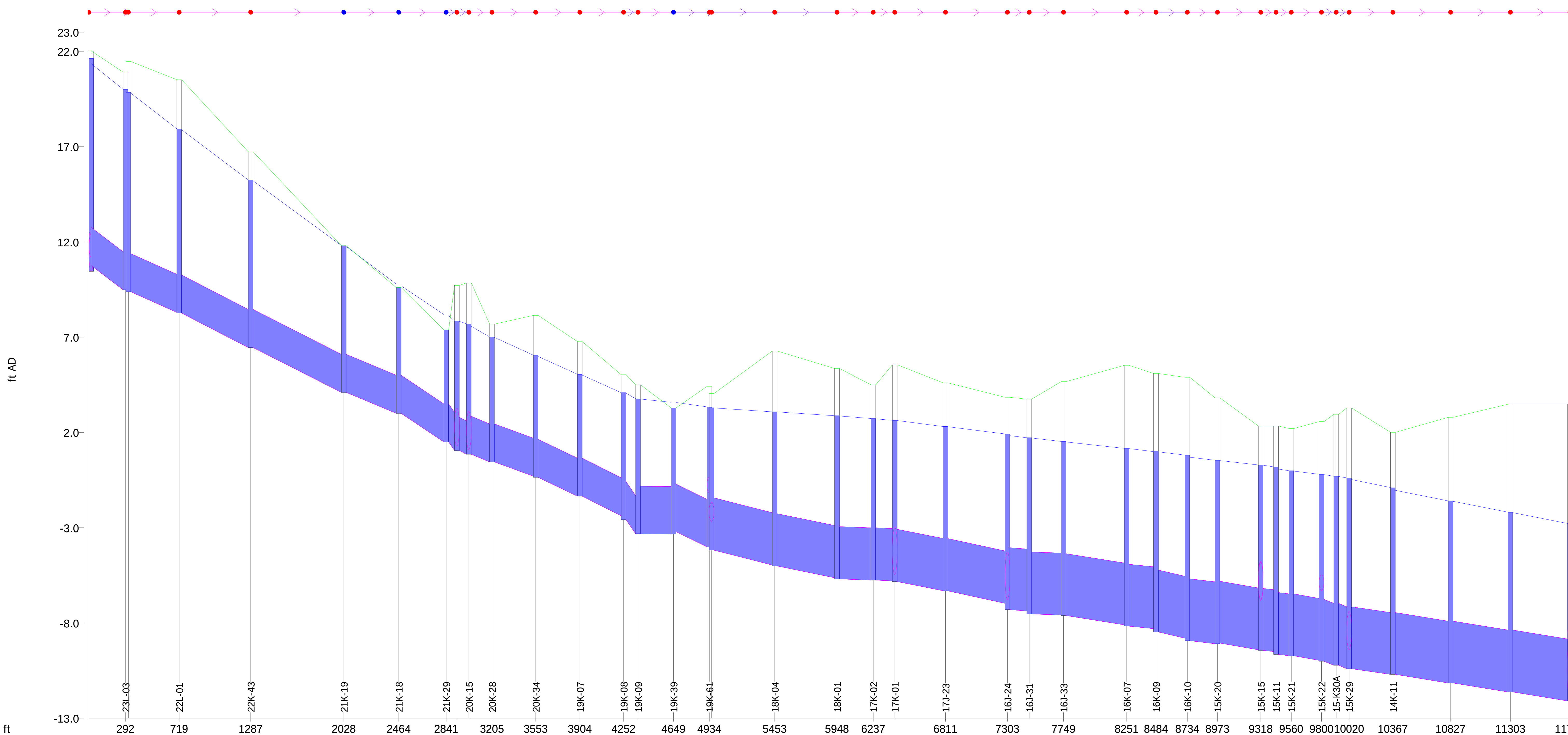
NOAA Atlas 2 Domain



Main Link Categories:
Home | OHD

Appendix F - Selected Model Hydraulic Profile Plots

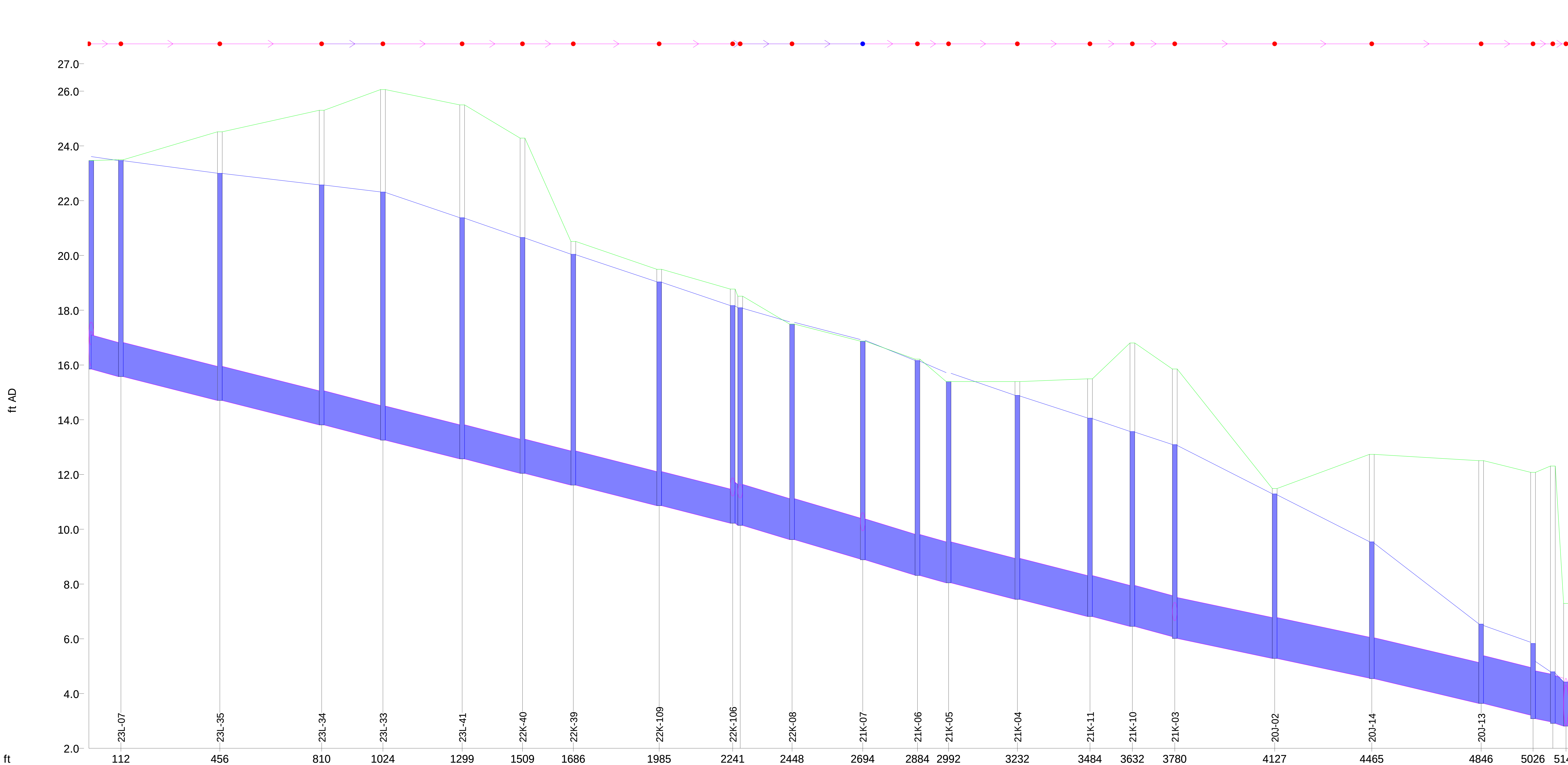
Long Section for Network - Existing Network	Print Date - 5/13/2010 12:21:24 PM
Selection - Existing South Trunk	San Mateo South (Dale/Delaware) trunk sewer



Link	-	23L-02.1	22L-01.1	22K-43.1	21K-19.1	21K-18.1	-	-	-	20K-34.1	-	-	-	-	19K-04.1	18K-04.1	-	-	17K-01.1	17J-23.1	-	-	16J-33.1	-	-	-	-	-	-	-	-	-	-	14K-11.1	14K-10.1	14K-02.1
leng	292.0	403.5	568.9	740.1	436.4	377.3	-	-	347.8	351.0	347.8	-	282.2	284.8	502.0	495.4	288.7	-	403.5	492.1	-	272.3	502.0	232.9	249.3	239.5	344.5	-	-	239.5	-	-	347.8	459.3	475.7	472.4
widt	24.0	24.0	24.0	24.0	24.0	24.0	-	24.0	24.0	24.0	24.0	-	30.0	30.0	33.0	33.0	33.0	33.0	33.0	33.0	39.0	39.0	39.0	39.0	39.0	39.0	39.0	-	-	39.0	-	-	39.0	39.0	39.0	39.0
us ir	10.761	9.380	8.261	6.453	4.100	3.000	-	-	0.449	-0.361	-1.348	-	-3.320	-3.209	-4.180	-5.010	-5.689	-	-5.830	-6.319	-	-7.530	-7.612	-	-	-	-9.058	-	-	-	-	-	-10.400	-10.699	-11.152	-11.621
ds ir	9.482	8.301	6.453	4.100	3.000	1.500	-	-	-0.299	-1.348	-2.379	-	-3.340	-4.011	-4.961	-5.630	-5.751	-	-6.309	-6.969	-	-7.579	-8.100	-	-	-	-9.409	-	-	-	-	-	-10.699	-11.152	-11.621	-12.090
grad	0.438	0.267	0.318	0.318	0.252	0.398	-	-	0.215	0.281	0.296	-	0.007	0.282	0.156	0.125	0.022	-	0.119	0.132	-	0.018	0.097	0.056	0.132	0.067	0.102	-	-	0.100	-	-	0.086	0.099	0.099	0.099
pfc (	9.70	7.58	8.26	8.26	7.35	9.24	-	6.84	6.79	7.77	7.97	-	2.23	14.07	13.47	12.09	5.02	5.19	11.77	12.41	-	7.18	16.67	12.68	19.38	13.84	17.06	-	-	16.90	-	-	15.65	16.77	16.78	16.84
DS F	-	10.07914	9.99078	10.01724	10.06098	10.19600	-	-	9.70776	9.67542	9.64805	-	-	-	10.64565	10.64789	-	-	15.80355	15.78428	-	-	17.47055	-	-	-	-	-	-	-	-	-	-	22.41446	22.27279	21.95462
surc	2.00	2.00	2.00	2.00	2.00	2.00	-	2.00	2.00	2.00	2.00	-	2.00	1.00	1.00	1.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	1.00	2.00	2.00	-	-	2.00	-	-	2.00	2.00	2.00	2.00

Nod	-	-	-	22L-01	22K-43	21K-19	21K-18	-	-	-	20K-34	19K-07	-	-	-	-	-	18K-04	18K-01	-	-	17J-23	16J-24	-	16J-33	16K-07	-	-	-	-	-	-	-	14K-11	14K-10	14K-02	-
Asse	-	-		22L-01X	22K-22X	21K-08X	21K-18X	-	-	-	-	-	-	-	-	-	-	18K-04X	18K-01X	-	-	17J-23X	-	-	16J-33X	16K-07X	-	-	-	-	-	-	-	14K-11X	14K-10X	14K-02X	-
grou	-	-	-	20.512	16.725	11.800	9.600	-	-	7.684	8.143	6.765	-	-	3.287	-	4.042	6.273	5.354	-	5.551	4.600	3.845	-	4.665	5.518	-	-	3.812	-	-	-	-	2.008	2.795	3.484	-
floo	-	-	-	-2.580	-1.481	0.000	-0.000	-	-	-	-2.092	-1.716	-	-	-	-	-	-3.190	-2.479	-	-	-2.290	-1.930	-	-3.139	-4.352	-	-	-3.273	-	-	-	-	-2.912	-4.387	-5.671	-

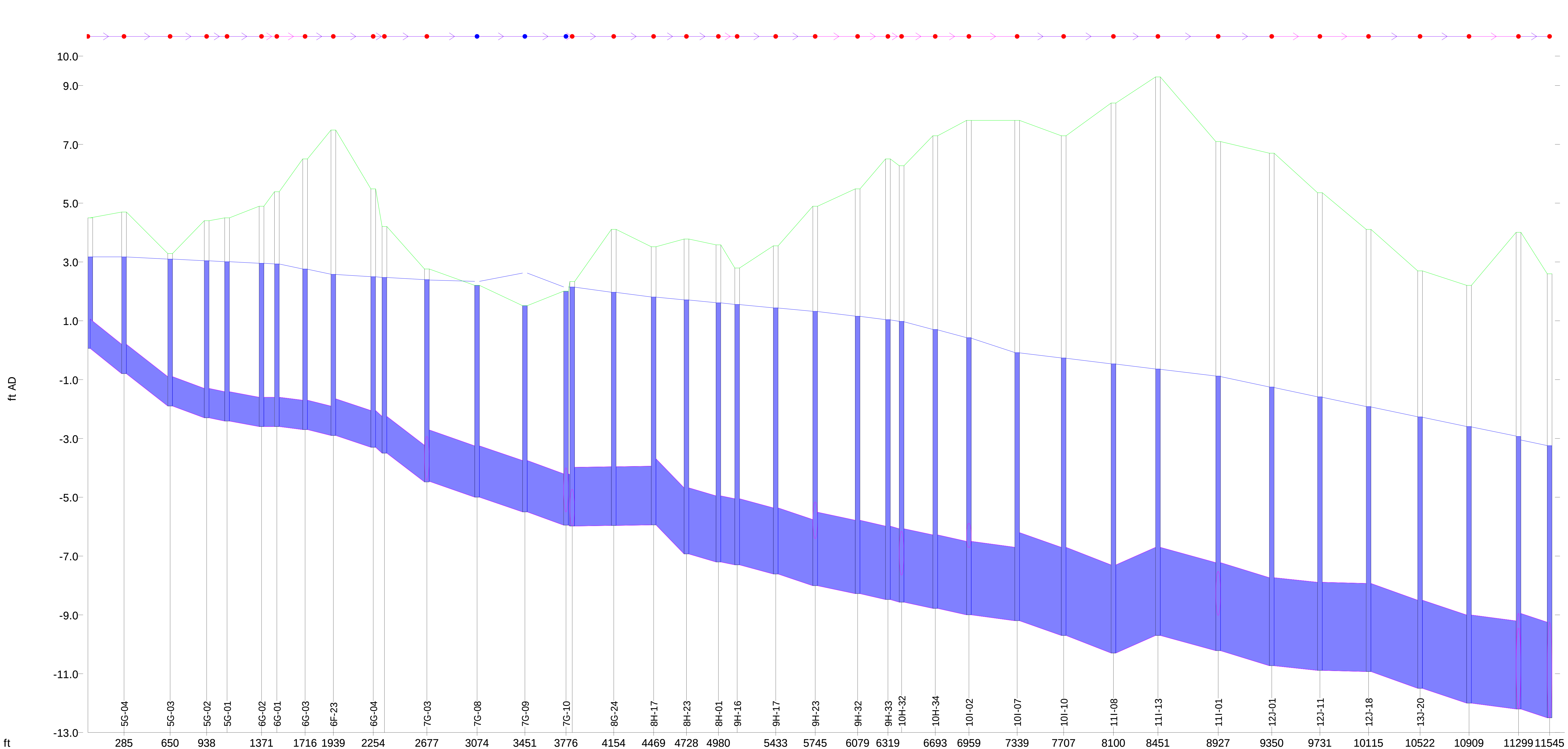
Long Section for Network - Existing Network	Print Date - 5/13/2010 12:22:07 PM
Selection - El Camino	San Mateo El Camino Real (n/o Hillsdale) trunk sewer



Link	-	23L-07.1	23L-35.1	23L-34.1	23L-33.1	23L-41.1	22K-40.1	22K-39.1	22K-109.1	22K-107.1	22K-08.1	21K-07.1	-	21K-05.1	21K-04.1	-	-	21K-03.1	20J-02.1	20J-14.1	20J-13.1	-	-
leng	111.5	344.5	354.3	213.3	275.6	210.0	177.2	298.6	255.9	180.4	246.1	190.3	108.3	239.5	252.6	147.6	147.6	347.8	337.9	380.6	180.4	-	-
widt	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	21.0	-	-
us ir	-	15.571	14.701	13.809	13.251	12.569	12.041	11.611	10.860	10.141	9.619	8.881	8.310	8.041	7.441	6.811	6.450	6.010	5.279	4.541	3.638	-	-
ds ir	-	14.701	13.809	13.271	12.569	12.041	11.611	10.860	10.220	9.619	8.911	8.320	8.041	7.441	6.811	6.450	6.079	5.279	4.560	3.638	3.209	-	-
grac	0.250	0.252	0.252	0.252	0.248	0.252	0.243	0.252	0.250	0.289	0.288	0.295	0.248	0.251	0.249	0.244	0.251	0.210	0.213	0.237	0.238	-	-
pfc (	2.09	2.10	2.10	2.10	2.08	2.09	2.06	2.09	2.09	3.65	3.64	3.68	3.38	3.40	3.39	3.35	3.40	3.11	3.13	3.30	4.99	-	-
DS F	-	2.25024	1.92787	1.75787	2.41506	2.40793	2.40065	2.39645	2.39480	3.56783	3.48687	4.41560	-	4.17763	4.17980	4.18269	4.18570	5.15511	5.15648	6.01636	6.01524	-	-
surc	2.00	2.00	2.00	1.00	2.00	2.00	2.00	2.00	2.00	1.00	1.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	-	-

Nod	-	23L-07	23L-35	23L-34	23L-33	23L-41	22K-40	22K-39	22K-109	-	-	22K-08	21K-07	21K-06	21K-05	21K-04	21K-11	21K-10	21K-03	20J-02	20J-14	20J-13	-	-
Asse	-	23L-07X	23L-15X	23L-16X	23L-18X	23L-01X	22K-17X	22K-18X	22K-19X	-	-	22K-08X	21K-07X	-	21K-05X	21K-04X	21K-11X	-	21K-03X	20J-02X	20J-14X	20J-13X	-	-
grou	-	23.497	24.514	25.302	26.056	25.499	24.285	20.512	19.495	18.773	-	17.493	16.870	16.214	15.394	15.394	15.492	16.804	15.853	11.490	12.736	12.507	-	-
flooc	-	-0.032	-1.513	-2.725	-3.738	-4.121	-3.630	-0.467	-0.459	-0.604	-	-0.000	0.000	-0.050	-0.000	-0.503	-1.431	-3.234	-2.760	-0.198	-3.194	-5.969	-	-

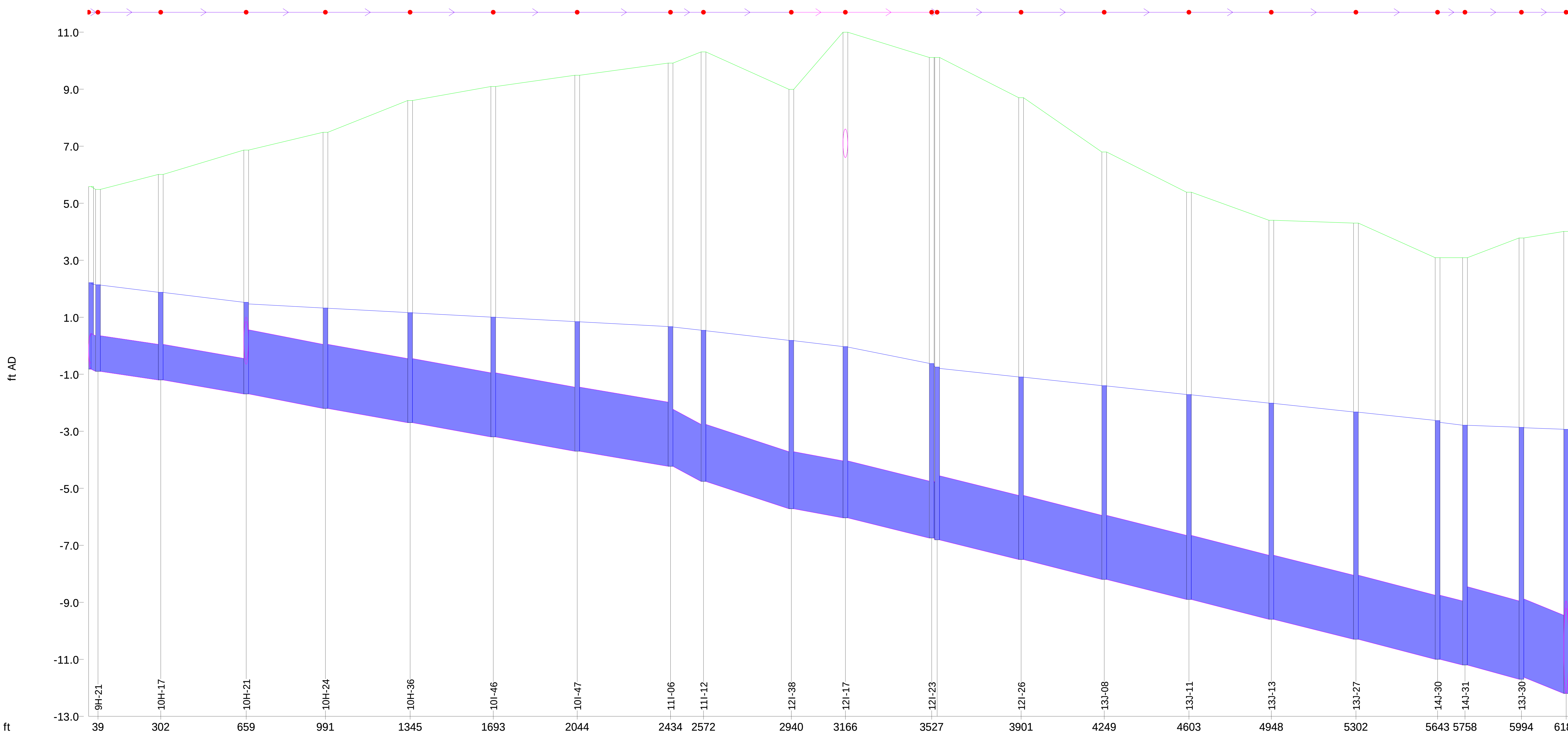
Long Section for Network - Existing Network	Print Date - 5/13/2010 12:20:26 PM
Selection - Existing North Trunk	San Mateo North (Bayshore) trunk sewre



Link	-	5G-04.1	-	-	-	-	-	-	6F-23.1	-	6G-05.1	7G-03.1	7G-08.1	7G-09.1	8G-15.1	8G-24.1	-	-	-	9H-16.1	9H-17.1	9H-23.1	-	-	-	-	10I-02.1	10I-07.1	10I-10.1	11I-08.1	11I-13.2	11I-01.1	12J-01.1	12J-11.1	12J-18.1	13J-20.1	13J-21.1	-
leng	285.4	364.2	288.7	-	272.3	-	223.1	223.1	315.0	-	334.6	397.0	377.3	324.8	328.1	315.0	259.2	252.6	-	305.1	311.7	334.6	239.5	-	265.7	265.7	380.6	367.5	393.7	351.0	475.7	423.2	380.6	383.9	406.8	387.1	390.4	246.1
widt	12.0	12.0	12.0	-	12.0	-	12.0	12.0	15.0	-	15.0	21.0	21.0	21.0	24.0	24.0	27.0	27.0	-	27.0	27.0	30.0	30.0	-	30.0	30.0	30.0	36.0	36.0	36.0	36.0	36.0	36.0	36.0	36.0	36.0	36.0	39.0
us ir	0.059	-0.801	-1.900	-	-2.411	-	-	-	-2.900	-	-3.501	-4.459	-5.000	-5.499	-5.981	-5.961	-5.942	-6.929	-	-7.300	-7.612	-8.009	-	-	-8.570	-8.780	-8.999	-9.199	-9.701	-10.299	-9.701	-10.220	-10.732	-10.889	-10.928	-11.499	-12.001	-
ds ir	-0.801	-1.900	-2.300	-	-2.598	-	-	-	-3.301	-	-4.482	-5.000	-5.499	-5.951	-5.961	-5.942	-6.929	-7.201	-	-7.612	-8.009	-8.281	-	-	-8.780	-8.999	-9.199	-9.701	-10.299	-9.701	-10.220	-10.732	-10.889	-10.928	-11.499	-12.001	-12.201	-
grad	0.301	0.302	0.139	-	0.069	-	0.046	0.090	0.127	-	0.293	0.136	0.132	0.139	-0.006	-0.006	0.381	0.108	-	0.102	0.127	0.081	0.084	-	0.079	0.083	0.053	0.137	0.152	-0.170	0.109	0.121	0.041	0.010	0.140	0.130	0.051	0.121
pfc (	1.27	1.27	0.86	-	0.60	-	0.49	0.69	1.49	-	2.26	3.77	3.72	3.82	-1.13	-1.16	12.37	6.58	-	6.40	7.15	7.56	7.66	-	7.45	7.63	6.08	15.92	16.77	-17.76	14.21	14.97	8.76	4.36	16.13	15.51	9.75	18.61
DS F	-	0.33364	-	-	-	-	-	-	0.70155	-	0.74102	2.02962	2.21678	1.56888	5.19643	5.18087	-	-	-	-	5.79886	8.10487	-	-	-	-	10.66894	10.49735	10.55665	-	10.20156	12.44832	12.43527	12.42459	12.41163	12.39928	12.38468	-
surc	1.00	1.00	1.00	-	1.00	-	2.00	1.00	1.00	-	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	-	1.00	1.00	2.00	2.00	-	2.00	2.00	2.00	1.00	1.00	1.00	1.00	1.00	2.00	2.00	1.00	1.00	2.00	1.00

Nod	-	5G-04	5G-03	-	-	-	-	-	6F-23	-	-	7G-03	7G-08	7G-09	-	-	8G-24	8H-17	-	-	-	9H-17	9H-23	9H-32	-	-	-	10I-02	10I-07	10I-10	11I-08	11I-13	11I-01	12J-01	12J-11	12J-18	13J-20	13J-21	13J-31
Asse	-	-	-	-	-	-	-	-	-	-	-	07G-03X	07G-08X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10I-07X	10I-10X	11I-08X	11I-13X	11I-01X	12J-01X	12J-11X	12J-18X	13J-22X	13J-21X	-
grou	-	4.698	3.287	-	-	-	-	-	7.487	-	-	2.762	2.205	1.516	-	-	4.108	3.517	3.780	-	-	3.550	4.895	5.486	-	-	7.290	7.815	7.815	7.290	8.406	9.291	7.093	6.699	5.354	4.108	2.697	2.205	4.009
flooc	-	-1.526	-0.189	-	-	-	-	-	-	-	-	-0.362	-0.000	0.000	-	-	-2.137	-1.707	-	-	-	-2.111	-3.573	-4.328	-	-	-	-7.389	-7.896	-7.555	-8.870	-9.931	-7.972	-7.951	-6.940	-6.024	-4.962	-4.800	-6.941

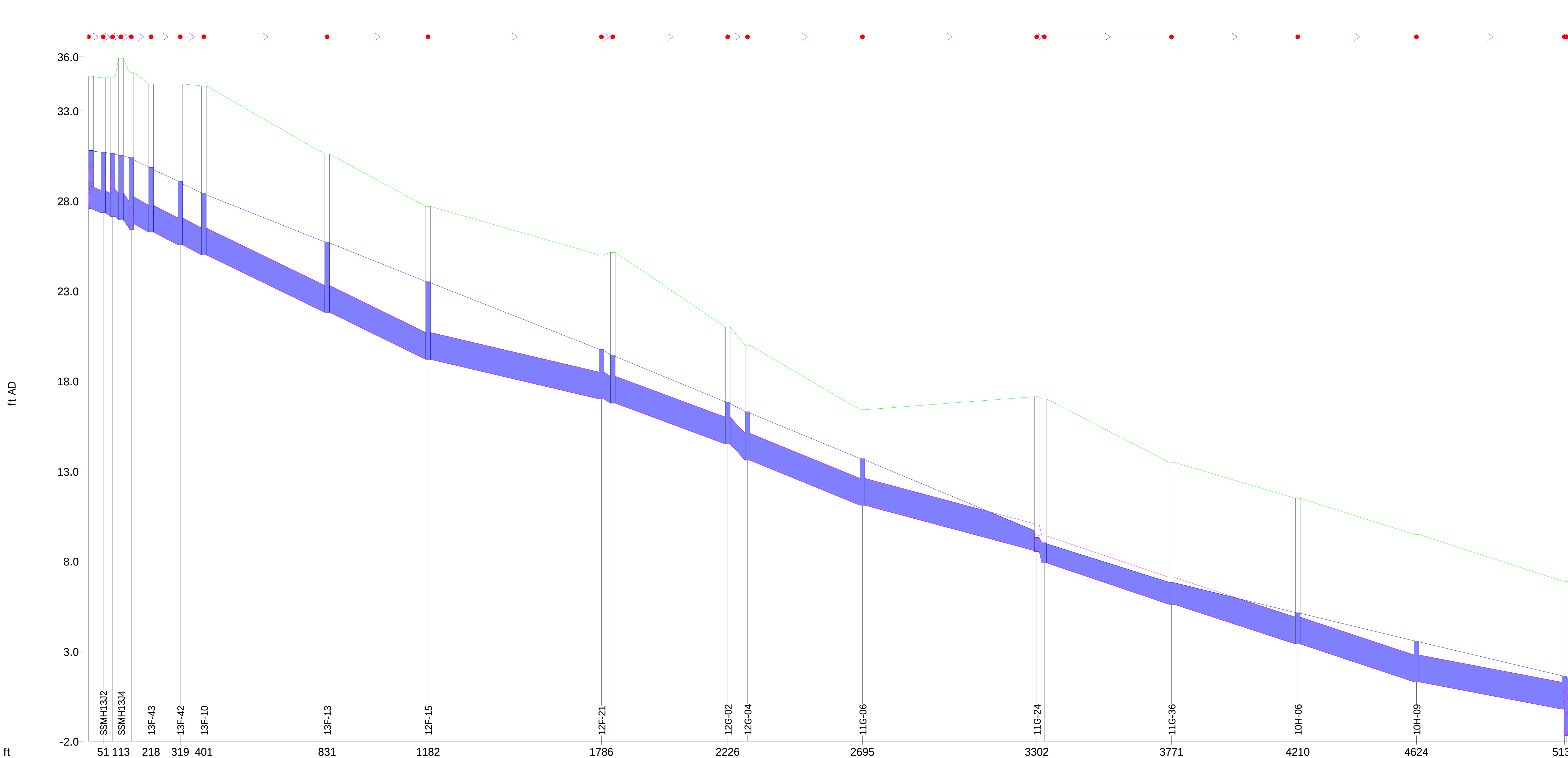
Long Section for Network - Existing Network	Print Date - 5/13/2010 12:25:57 PM
Selection - Idaho	San Mateo Idaho trunk sewer



Link	9H-21.1	10H-17.1	10H-21.1	10H-24.1	10H-36.1	10I-46.1	10I-47.1	-	11I-12.1	12I-38.1	12I-17.2	12I-24.1	12I-26.1	13J-08.1	13J-11.1	13J-13.1	13J-27.1	-	14J-31.1	13J-30.1
leng	262.5	357.6	331.4	354.3	347.8	351.0	390.4	137.8	367.5	226.4	360.9	351.0	347.8	354.3	344.5	354.3	341.2	-	236.2	187.0
widt	15.0	15.0	27.0	27.0	27.0	27.0	27.0	24.0	24.0	24.0	24.0	27.0	27.0	27.0	27.0	27.0	27.0	27.0	33.0	33.0
us ir	-0.899	-1.201	-1.690	-2.201	-2.700	-3.199	-3.701	-4.229	-4.760	-5.719	-6.040	-6.811	-7.500	-8.199	-8.901	-9.600	-10.299	-	-11.201	-11.631
ds ir	-1.201	-1.693	-2.201	-2.700	-3.199	-3.701	-4.229	-4.760	-5.719	-6.040	-6.749	-7.500	-8.199	-8.901	-9.600	-10.299	-11.001	-	-11.699	-12.201
grac	0.115	0.138	0.154	0.141	0.143	0.143	0.135	0.386	0.261	0.142	0.196	0.196	0.201	0.198	0.203	0.197	0.206	-	0.211	0.305
pfc (	1.42	1.55	7.87	7.52	7.59	7.58	7.37	9.10	7.48	5.52	6.49	8.88	8.98	8.92	9.02	8.90	9.09	8.36	15.70	18.88
DS F	1.30181	1.30139	5.58457	5.56616	5.54426	5.51129	5.48078	-	5.76062	5.76699	7.00583	6.98120	7.01893	7.04090	7.04957	7.05609	7.06237	-	7.07322	7.07866
surc	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	2.00	2.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

Nod	Asse	grou	flooc
9H-21	-	5.486	-
10H-17	10H-17X	6.010	-4.135
10H-21	10H-21X	6.864	-5.340
10H-24	10H-24X	7.487	-6.163
10H-36	10H-36X	8.602	-7.440
10I-46	11I-19X	9.094	-8.089
10I-47	11I-21X	9.488	-8.642
11I-06	11I-06X	9.915	-9.243
11I-12	11I-12X	10.308	-9.765
12I-38	12I-38X	8.996	-8.808
12I-17	12I-17X	10.997	-11.027
12I-23	12I-23X	10.112	-10.736
12I-24	12I-24X	10.112	-10.858
12I-26	12I-40X	8.701	-9.795
13J-08	13J-08X	6.798	-8.198
13J-11	13J-11X	5.387	-7.097
13J-13	13J-13X	4.403	-6.415
13J-27	13J-27X	4.304	-6.627
14J-30	14J-30X	3.091	-5.716
14J-31	-	3.091	-5.877
13J-30	13J-30X	3.780	-6.641
-	-	-	-

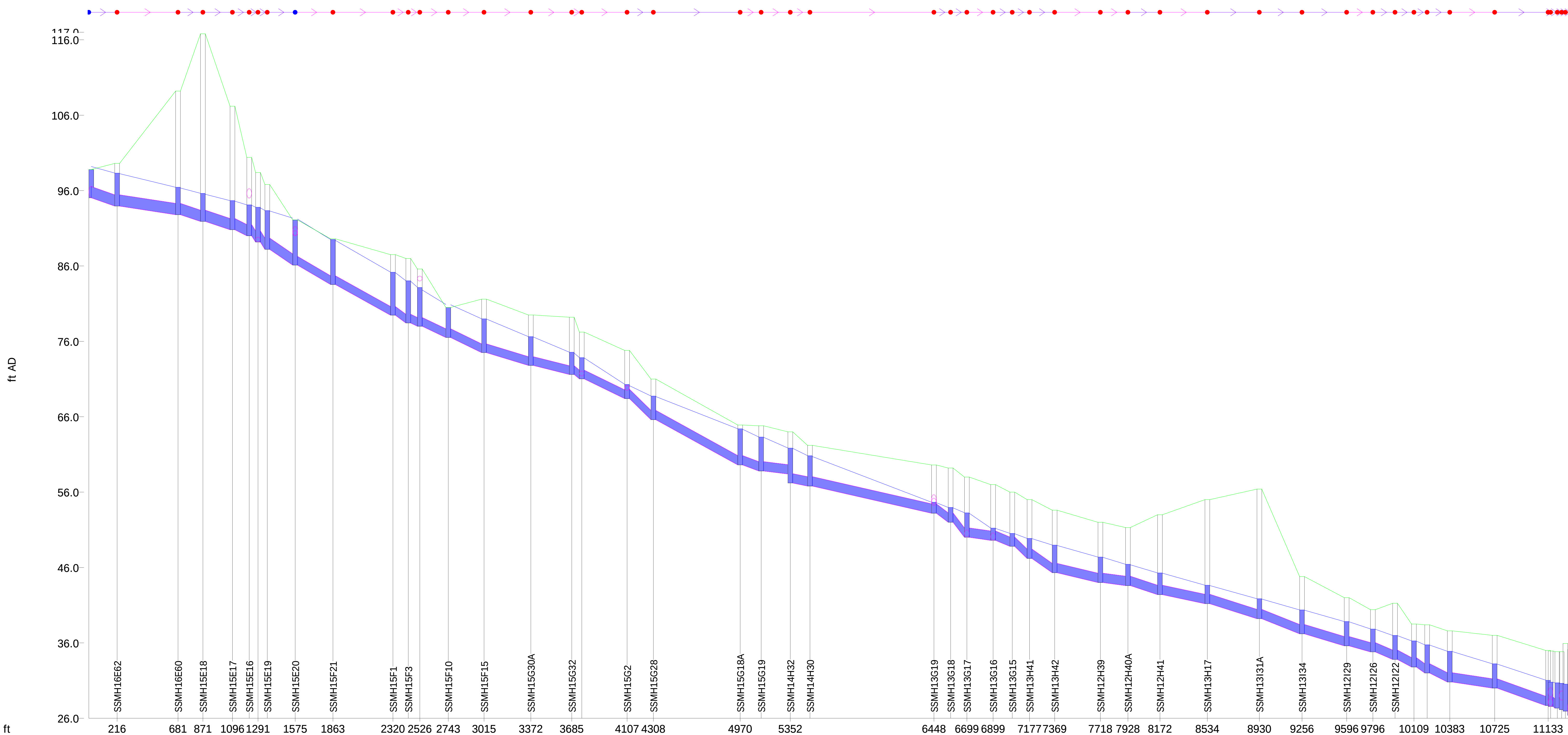
Long Section for Network - Existing Network	Print Date - 5/13/2010 12:26:47 PM
Selection - El Cerrito/Tilton trunk	San Mateo El Cerrito/Tilton trunk sewer



Link	-	-	-	-	13F-10.1	13F-13.1	12F-15.1	-	12F-24.1	-	12G-04.1	11G-06.1	11G-25.1	11G-36.1	10H-06.1	10H-09.1
leng	-	-	101.7	82.0	429.3	351.5	603.7	-	400.3	-	400.3	607.0	442.9	439.6	413.4	515.1
widt	-	-	18.0	18.0	18.0	18.0	18.0	-	18.0	-	18.0	18.0	18.0	18.0	18.0	18.0
us ir	-	-	-	-	25.000	21.811	19.199	-	16.768	-	13.599	11.099	7.900	5.600	3.399	1.299
ds ir	-	-	-	-	21.811	19.199	17.001	-	14.501	-	11.099	8.579	5.600	3.399	1.299	-0.220
grac	-	-	0.687	-	0.743	0.743	0.364	-	0.566	-	0.625	0.415	0.519	0.501	0.508	0.295
pfc (	-	-	5.62	5.61	5.85	5.85	4.09	-	5.10	-	5.36	4.37	4.89	4.80	4.83	3.68
DS F	-	-	-	-	5.27543	5.27519	5.27507	-	5.36111	-	5.36106	5.36104	4.12633	4.13832	4.13992	4.14368
surc	-	-	1.00	1.00	1.00	1.00	2.00	-	2.00	-	2.00	2.00	0.82	1.00	1.00	2.00

Nod	-	-	13F-10	13F-13	12F-15	12F-21	12F-24	12G-02	12G-04	11G-06	11G-24	11G-25	11G-36	10H-06	10H-09	10H-22
Asse	-	-	13F-10X	13F-13X	12F-15X	12F-21X	12F-24X	12G-02X	12G-04X	11G-06X	11G-24X	11G-25X	11G-36X	10H-06X	10H-09X	10H-22X
grou	-	-	34.390	30.600	27.697	25.007	25.138	21.004	19.987	16.411	17.133	17.001	13.491	11.490	9.488	6.896
floo	-	-	-5.960	-4.887	-4.180	-5.248	-5.695	-4.166	-3.694	-2.719	-7.814	-7.975	-6.664	-6.347	-5.915	-5.264

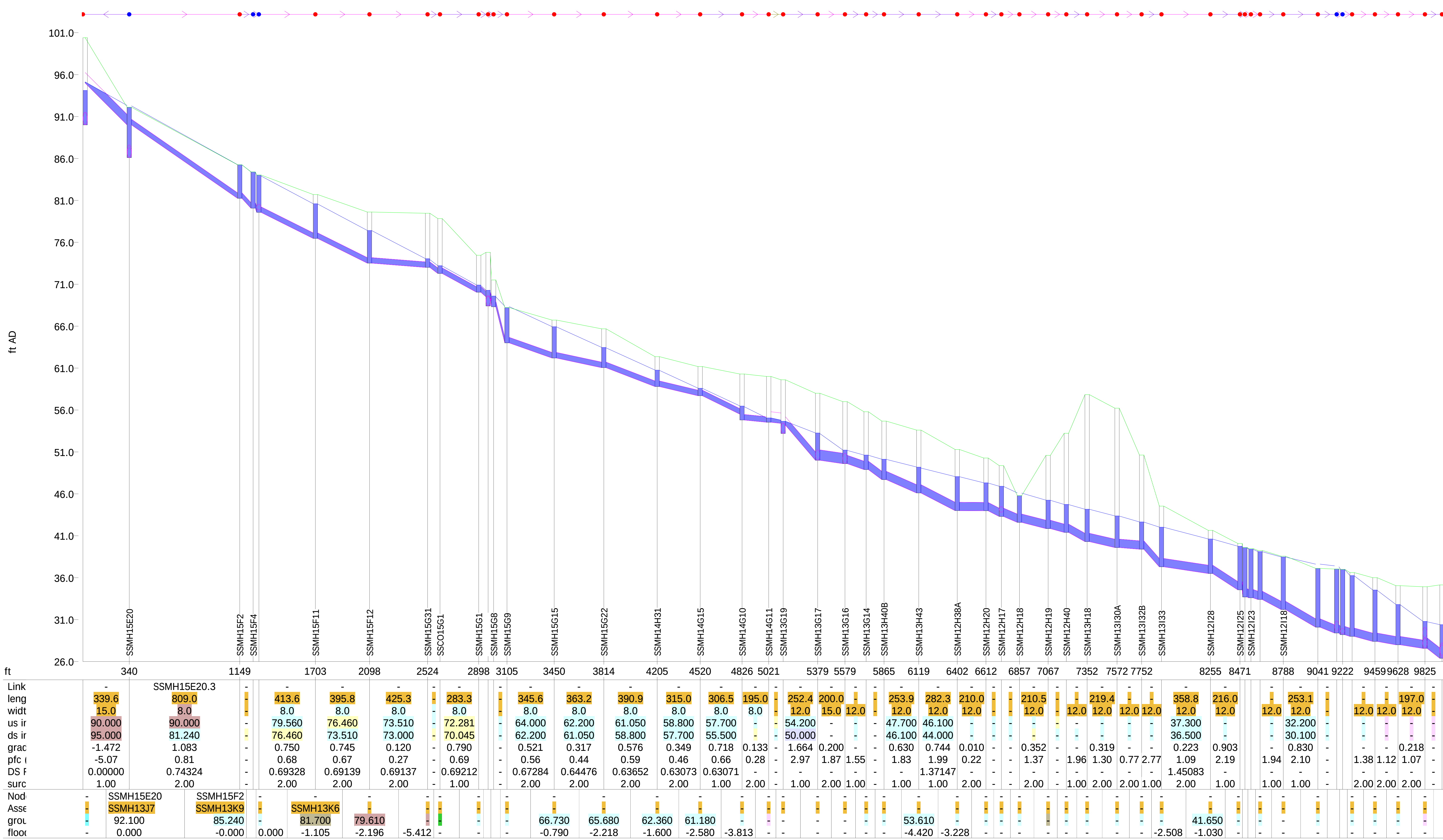
Long Section for Network - Existing Network	Print Date - 5/13/2010 12:29:43 PM
Selection - Hillsborough Lower 14"	Hillsborough Lower (14"/15") trunk sewer



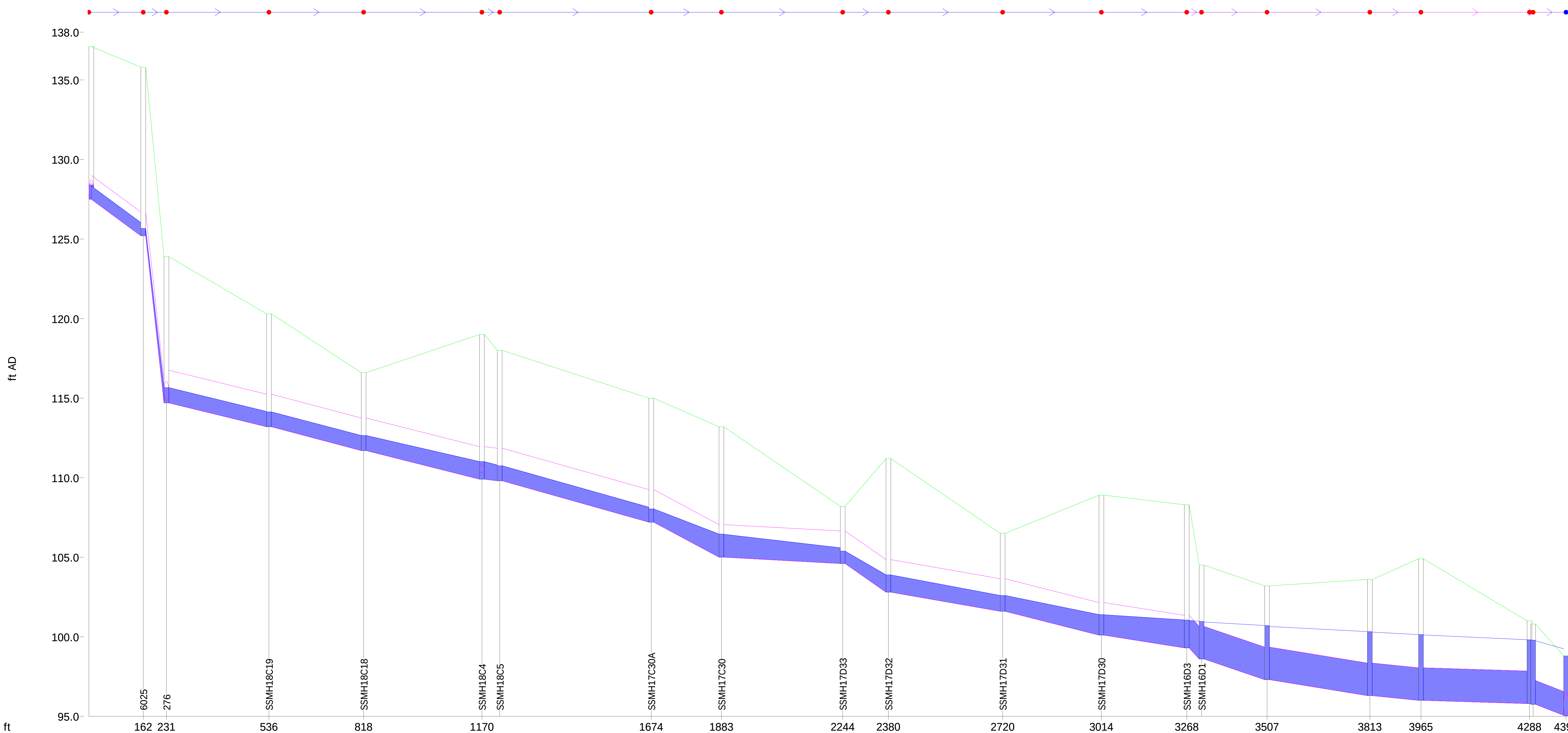
Link	leng	widt	us ir	ds ir	grac	pfc (	DS F	surc
-	216.0	18.0	-	-	0.509	4.85	-	1.00
-	465.0	18.0	93.940	92.800	0.245	3.36	4.19388	2.00
-	-	18.0	-	-	-	4.67	-	1.00
-	225.0	18.0	-	-	0.489	4.75	-	1.00
-	-	-	-	-	-	-	-	-
-	212.7	18.0	-	-	0.987	6.75	-	1.00
-	288.1	14.0	86.100	83.540	0.889	3.28	-	2.00
-	457.6	14.0	83.540	79.470	0.889	3.28	3.32704	2.00
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	217.2	14.0	-	-	0.690	2.89	-	2.00
-	272.2	14.0	76.500	74.500	0.735	2.98	-	2.00
-	357.0	14.0	74.500	72.800	0.476	2.40	3.02997	2.00
-	312.5	14.0	72.800	71.600	0.384	2.15	3.03108	2.00
-	345.8	14.0	71.022	68.400	0.758	3.03	3.49409	2.00
-	-	15.0	-	-	-	4.93	-	1.00
SSMH15G28.1	662.3	15.0	65.600	59.600	0.906	3.97	3.34614	1.00
-	-	-	-	-	-	-	-	-
-	222.2	15.0	-	-	0.180	1.77	-	2.00
-	-	-	-	-	-	-	-	-
SSMH14H30.1	946.0	15.0	56.800	53.200	0.381	2.58	3.33915	2.00
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	15.0	-	-	-	1.87	-	2.00
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	15.0	-	-	-	4.15	-	1.00
-	348.7	15.0	45.300	44.000	0.373	2.55	2.86606	2.00
-	210.0	15.0	-	-	0.190	1.82	-	2.00
-	244.3	15.0	-	-	0.491	2.93	-	1.00
-	361.7	15.0	42.400	41.200	0.332	2.41	2.85877	2.00
-	396.6	15.0	41.200	39.200	0.504	2.97	2.84700	1.00
-	325.5	15.0	39.200	37.200	0.614	3.27	2.81288	1.00
-	340.7	15.0	37.200	35.600	0.470	2.86	2.78218	1.00
-	-	15.0	-	-	-	2.64	-	2.00
-	-	15.0	-	-	-	3.21	-	1.00
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	15.0	-	-	-	3.48	-	1.00
-	341.9	15.0	30.800	30.000	0.234	2.02	2.87295	2.00
-	408.2	15.0	30.000	27.677	0.569	3.15	3.00875	1.00

Nod	Asse	grou	flooc
-	-	99.600	-1.286
-	-	-	-12.764
-	-	-	-
-	-	-	-
-	-	-	-
-	-	-	0.000
-	-	89.600	-0.098
-	-	-	-2.331
-	-	-	-
-	-	-	-
-	-	81.600	-2.610
-	-	79.500	-2.877
-	-	-	-
-		-	-
-	-	-	-
-	-	71.000	-2.257
-	-	64.900	-0.497
-	-	-	-
-	-	-	-
SSMH14H30	SSMH10L7	62.200	-1.370
SSMH13G19	SSMH10K18	59.600	-4.941
-	-	-	-
-	-	-	-
-	-	-	-
-	-	-	-
-	-	-	-
-	-	-	-
-	-	-	-4.617
-	-	-	-
-	-	53.000	-7.718
-	-	55.000	-11.349
-	-	56.400	-14.543
-	-	44.800	-4.430
-	-	-	-
-	-	-	-
-	-	-	-
-	-	-	-
-	-	-	-
-	-	-	-
-	-	37.000	-3.775
-	-	-	-

Long Section for Network - Existing Network	Print Date - 5/13/2010 12:32:09 PM
Selection - Hillsborough Lower 12"	Hillsborough Lower (8"/12") trunk sewer



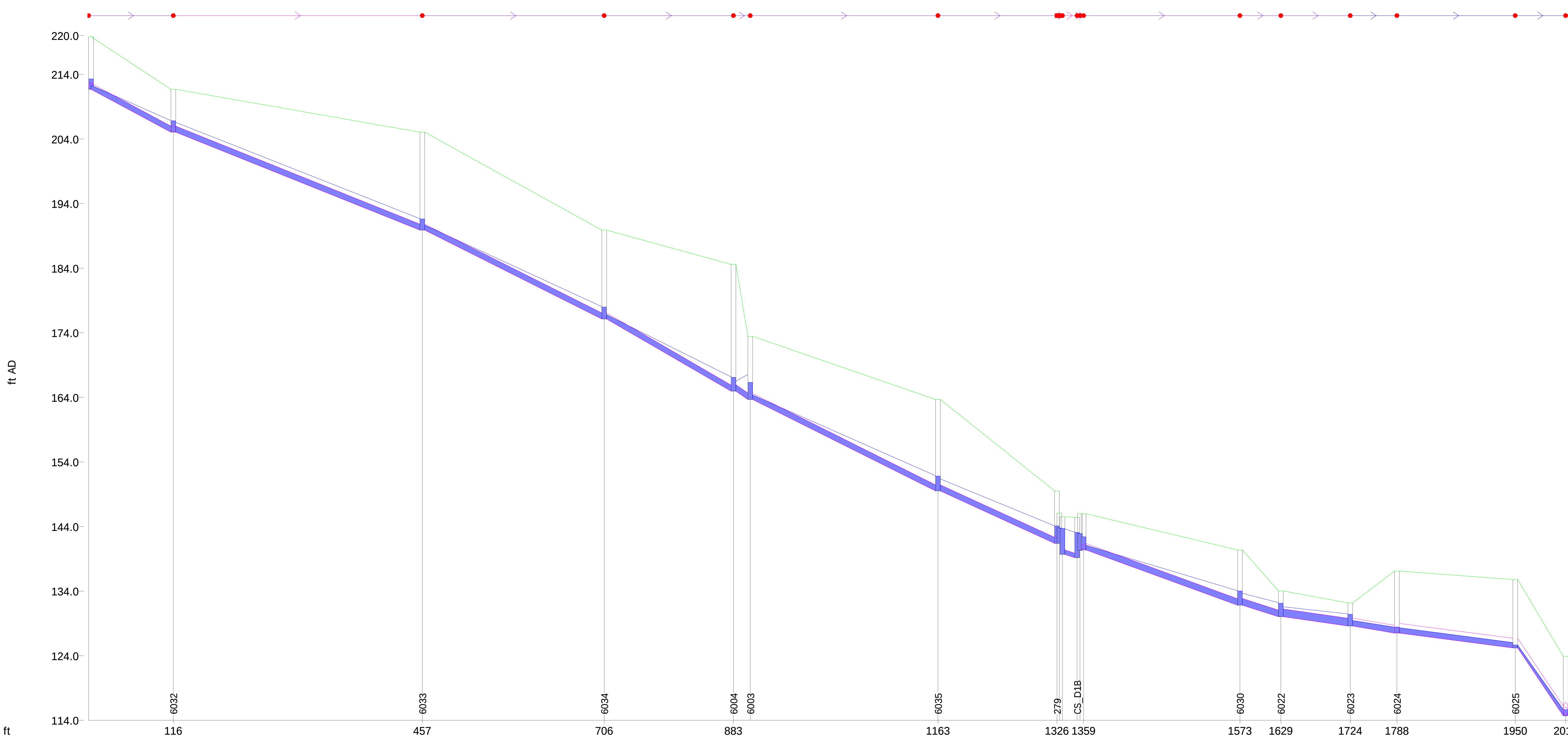
Long Section for Network - Existing Network	Print Date - 5/13/2010 12:34:52 PM
Selection - Hillsborough CS Phase 1	Hillsborough Crystal Springs Phase I trunk sewer



Link	leng	widt	us ir	ds ir	grac	pfc (	DS F	surc
6024.1	162.0	18.0	127.500	125.200	1.420	8.09	4.55300	0.55
-	69.0	18.0	-	-	-	-	-	0.65
276.1	305.0	24.6	114.700	113.200	0.492	10.95	4.82132	0.47
SSMH18C19.1	282.0	24.6	113.200	111.700	0.532	11.39	4.82094	0.46
SSMH18C18.1	352.0	24.6	111.700	109.900	0.511	11.17	4.82123	0.54
-	-	-	-	-	-	-	-	-
SSMH18C5.2	451.0	24.6	109.800	107.200	0.576	11.86	5.11917	0.46
-	209.0	24.6	107.200	105.000	1.053	16.02	5.11898	0.71
SSMH17C30.1	361.0	24.6	105.000	104.600	0.111	5.20	5.11865	0.70
-	136.0	24.6	104.600	102.800	1.324	17.97	5.11856	0.53
SSMH17D32.2	340.0	24.6	102.800	101.600	0.353	9.28	5.11833	0.53
SSMH17D31.2	294.0	24.6	101.600	100.100	0.510	11.16	5.11798	0.63
SSMH17D30.1	254.0	24.6	100.100	99.300	0.315	8.77	5.14456	0.86
-	-	-	-	-	-	-	-	-
SSMH16D1.1	195.0	24.6	98.600	97.300	0.667	12.75	5.24979	1.00
SSMH16D2.1	306.0	24.6	97.300	96.300	0.327	8.93	5.25428	1.00
-	152.0	24.6	96.300	96.000	0.197	6.94	5.25540	1.00
SSMH16D5.1	323.0	24.6	96.000	95.800	0.062	3.89	5.26237	2.00
-	98.0	18.0	-	-	0.704	5.70	-	1.00

Nod	Asse	grou	floo
-		-	-
6025		-	-
276		123.890	-8.226
SSMH18C19	SSMH18I8	120.300	-6.164
SSMH18C18	SSMH18I9	116.600	-3.948
SSMH18C4	SSMH17I21	119.000	-7.987
SSMH18C5	SSMH17I24	118.000	-7.250
SSMH17C30A	SSMH17I2	115.000	-6.960
SSMH17C30	SSMH17I1	113.200	-6.745
SSMH17D33	SSMH16I9	108.200	-2.814
SSMH17D32	SSMH16I16	111.200	-7.309
SSMH17D31	SSMH16I17	106.500	-3.903
SSMH17D30	SSMH16I18	108.900	-7.505
-	-	108.300	-7.246
-	-	-	-3.535
SSMH16D2	SSMH15J7	103.200	-2.498
SSMH16D4	SSMH15J6	103.600	-3.276
SSMH16D5	SSMH15J5	104.900	-4.766
-	SSMH15J4	101.000	-1.189
-	-	-	-
-	-	-	-

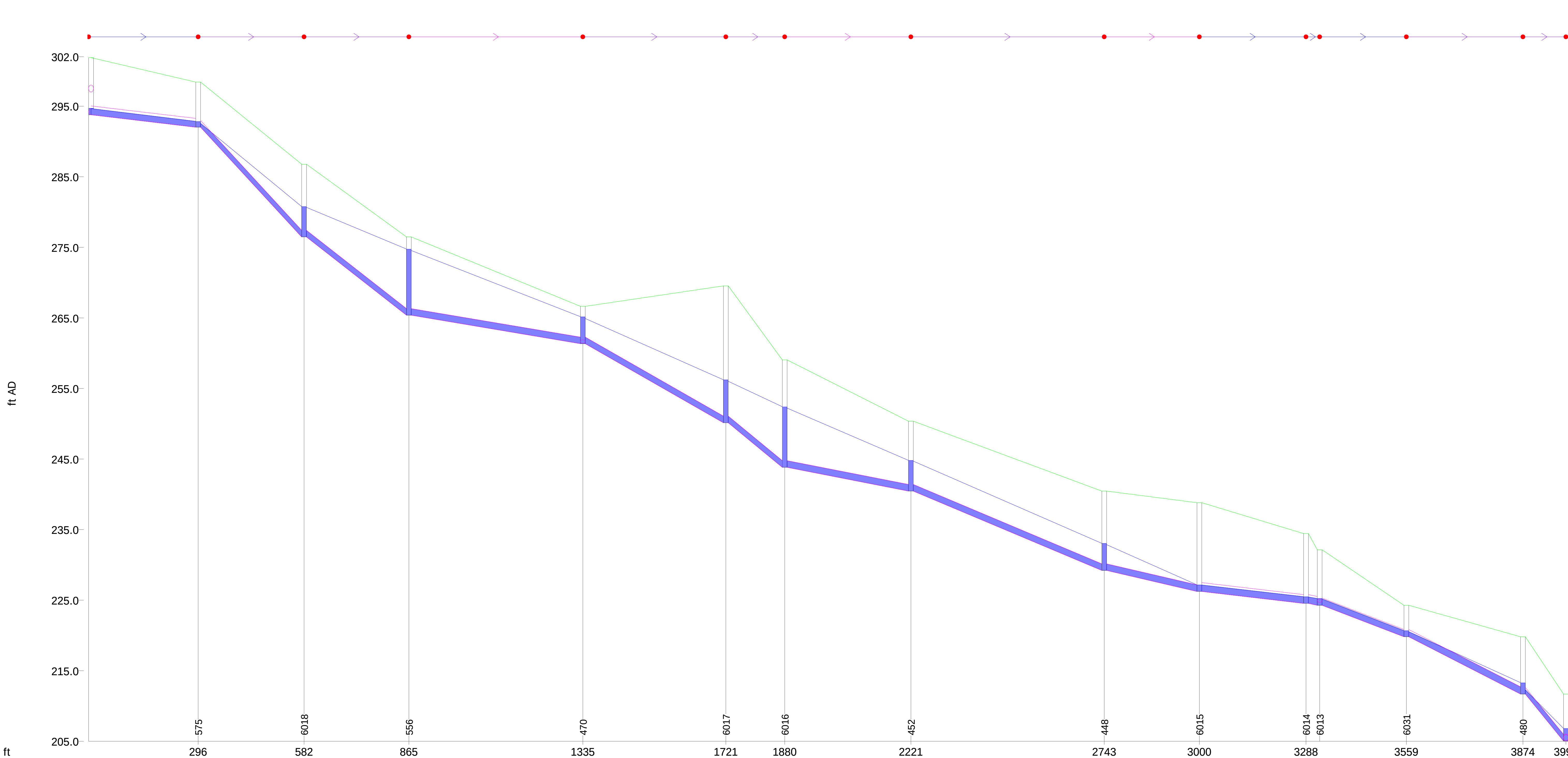
Long Section for Network - Existing Network	Print Date - 5/13/2010 5:00:01 PM
Selection - CSCSD Lower	CSCSD Lower Polhemus trunk sewer



Link	480.1	6032.1	6033.1	6034.1	-	6003.1	6035.1	-	6037.1	6030.1	6022.1	6023.1	6024.1	6025.1
leng	116.0	341.0	249.0	177.0	-	257.0	163.0	-	214.0	56.0	95.0	64.0	162.0	69.0
widt	11.2	11.2	11.2	11.2	-	11.2	11.2	-	12.0	12.4	14.4	14.4	18.0	18.0
us ir	211.690	205.040	189.880	176.130	-	163.660	149.500	-	140.370	131.820	130.030	128.600	127.500	125.200
ds ir	205.040	189.880	176.130	164.960	-	149.500	141.400	-	131.820	130.030	128.600	127.500	125.200	114.700
grad	5.733	4.446	5.522	6.311	-	5.510	4.969	-	3.995	3.196	1.505	1.719	1.420	15.217
pfc (	4.59	4.04	4.50	4.81	-	4.50	4.27	-	4.60	4.49	4.63	4.95	8.09	26.49
DS F	3.25221	4.34430	3.95285	3.95549	-	3.95495	3.95479	-	3.95453	4.09035	3.95449	3.95453	4.55300	4.55301
surc	1.00	2.00	1.00	1.00	-	1.00	1.00	-	1.00	1.00	1.00	0.76	0.55	0.65

Node	480	6032	6033	6034	6004	6003	6035	279	6037	6030	6022	6023	6024	6025	276
Asse															
grou	-	211.690	205.040	189.880	184.570	173.440	163.660	149.500	145.970	140.370	134.030	132.170	137.100	135.800	-
flood	-6.528	-4.876	-13.428	-11.909	-17.472	-7.122	-11.844	-5.410	-3.561	-6.341	-1.898	-1.745	-8.698	-10.134	-

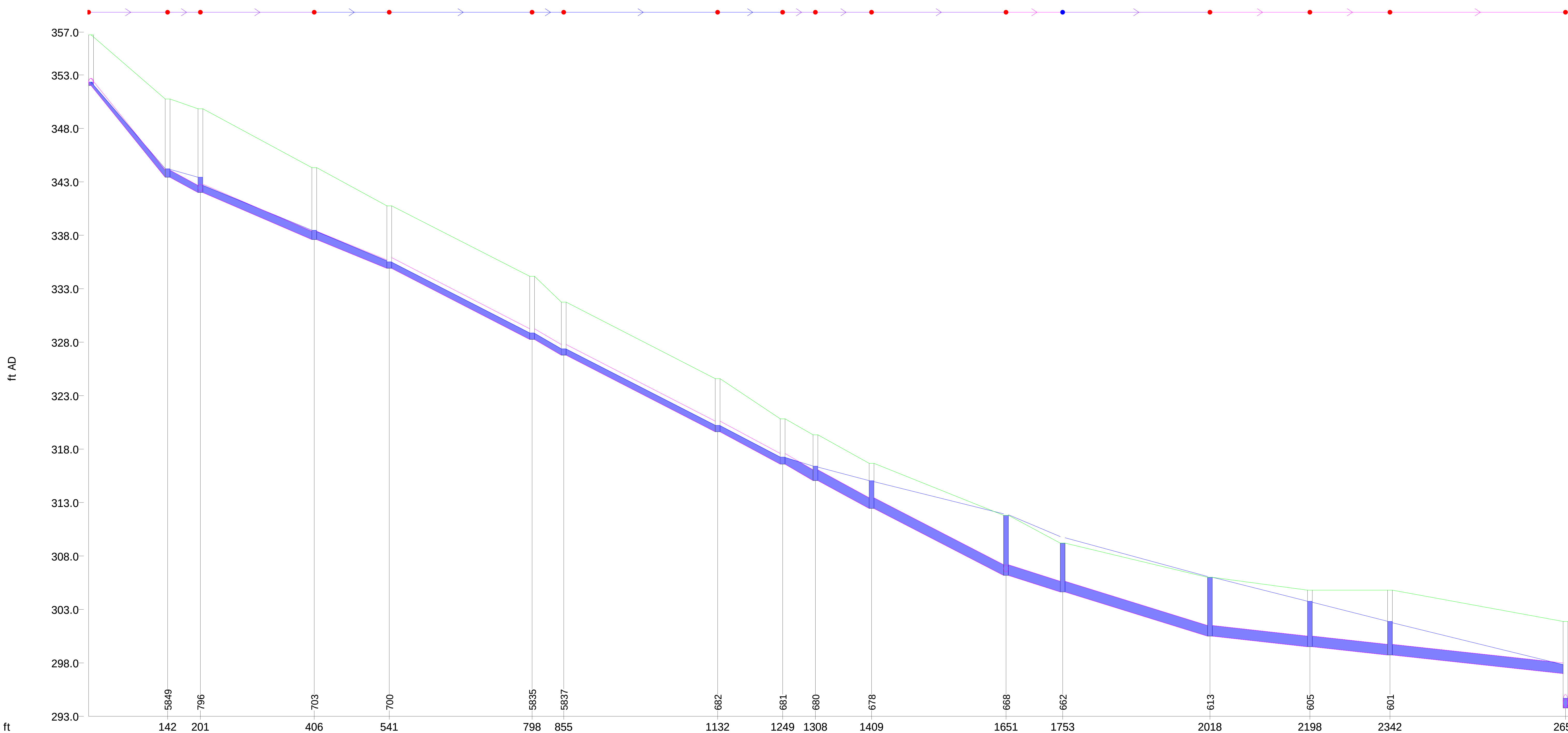
Long Section for Network - Existing Network	Print Date - 5/13/2010 5:02:55 PM
Selection - CSCSD Middle	CSCSD Middle Polhemus trunk sewer



Link	593.1	575.1	6018.1	556.1	470.1	6017.1	6016.1	452.1	448.1	6015.1	-	6013.1	6031.1	480.1
leng	296.0	286.0	283.0	470.0	386.0	159.0	341.0	522.0	257.0	288.0	-	234.0	315.0	116.0
widt	15.0	11.2	11.2	11.2	11.2	11.2	11.2	11.2	11.2	15.0	-	12.3	12.3	11.2
us ir	293.780	292.020	276.470	265.380	261.340	250.140	243.830	240.460	229.210	226.240	-	224.270	219.810	211.690
ds ir	292.020	276.470	265.380	261.340	250.140	243.830	240.460	229.210	226.240	224.540	-	219.810	211.690	205.040
grac	0.595	5.437	3.919	0.860	2.902	3.969	0.988	2.155	1.156	0.590	-	1.906	2.578	5.733
pfc (	3.22	4.47	3.79	1.78	3.26	3.82	1.90	2.81	2.06	3.21	-	3.40	3.95	4.59
DS F	2.69274	2.69253	2.69285	2.75782	2.80648	2.80594	2.80553	2.80545	2.81084	2.81194	-	3.25058	3.25052	3.25221
surc	0.71	1.00	1.00	2.00	1.00	1.00	2.00	1.00	2.00	0.76	-	0.88	1.00	1.00

Nod	593	575	6018	556	470	6017	6016	452	448	6015	6014	6013	6031	480	-
Asse															
grou	301.880	298.420	286.770	276.470	266.640	269.540	259.040	250.360	240.460	238.810	234.440	232.140	224.270	219.810	-
floo	-7.190	-5.604	-6.004	-1.736	-1.495	-13.329	-6.644	-5.557	-7.423	-11.648	-8.954	-6.907	-3.593	-6.528	-

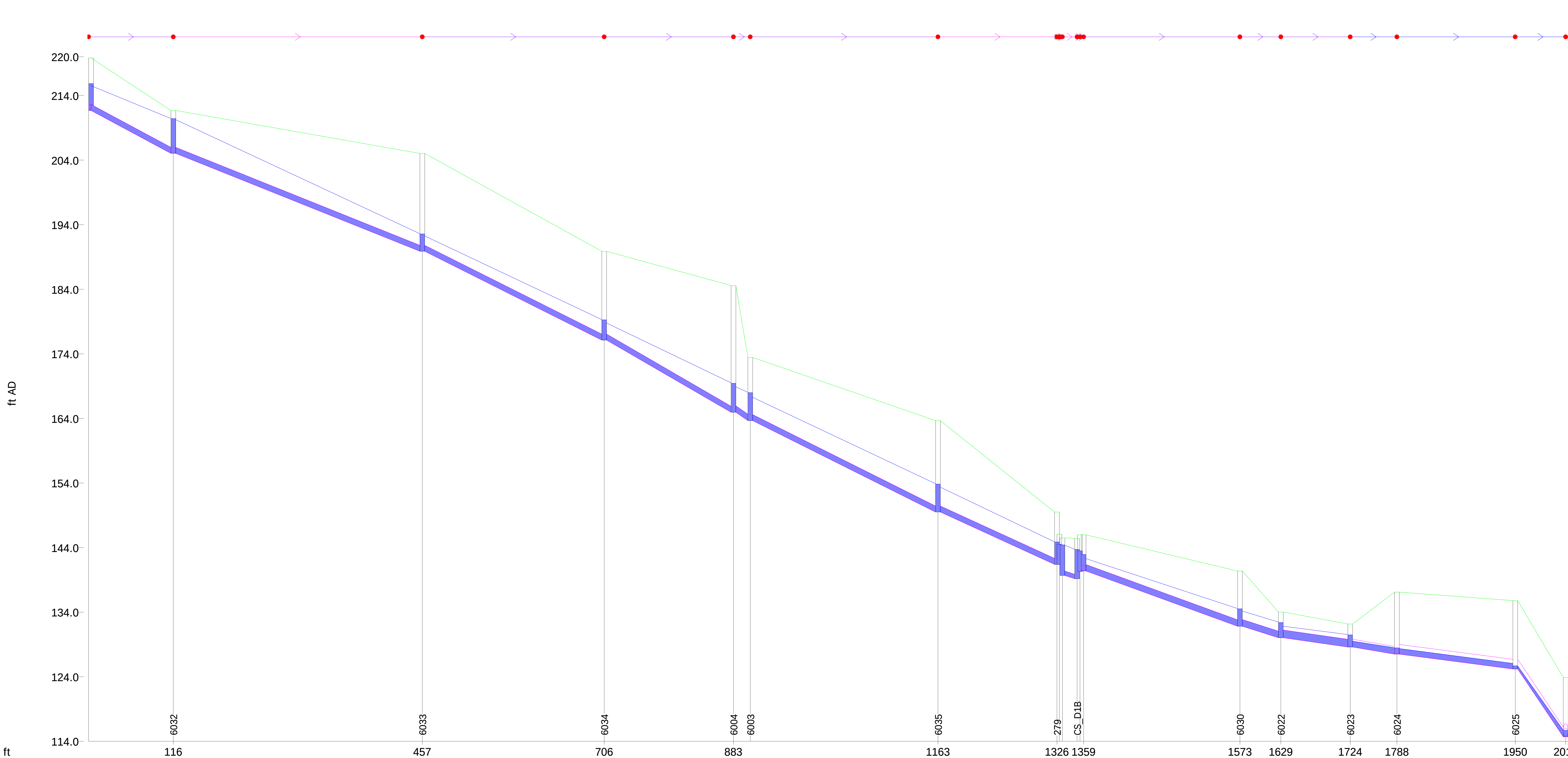
Long Section for Network - Existing Network	Print Date - 5/13/2010 5:04:13 PM
Selection - CSCSD upper	CSCSD Upper Polhemus trunk sewer



Link	31E-04X.1	-	796.1	703.1	700.1	-	5837.1	682.1	681.1	680.1	678.1	668.1	662.1	613.1	605.1	601.1
leng	142.2	59.0	205.0	135.0	257.0	57.0	277.0	117.0	59.0	101.0	242.0	102.0	265.0	180.0	144.0	316.0
widt	8.0	8.0	9.4	9.4	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0
us ir	352.011	-	342.000	337.600	334.910	-	326.783	319.613	-	315.058	312.444	306.180	304.630	300.500	299.510	298.730
ds ir	343.420	-	337.600	334.910	328.258	-	319.613	316.585	-	312.444	306.180	304.630	300.500	299.510	298.730	297.000
grad	6.042	2.407	2.146	1.993	2.588	2.588	2.588	2.588	2.588	2.588	2.588	1.520	1.558	0.550	0.542	0.547
pfc (	1.92	1.21	1.76	1.70	3.71	3.71	3.71	3.71	3.71	3.71	3.71	2.84	2.88	1.71	1.70	1.70
DS F	0.85635	-	1.65851	1.65820	2.30485	-	2.30485	2.30576	-	2.53147	2.54765	3.45051	2.62876	2.55746	2.54577	2.54206
surc	1.00	1.00	1.00	0.96	0.61	0.60	0.61	0.67	1.00	1.00	1.00	2.00	1.00	2.00	2.00	2.00

Nod	-	5849	796	703	700	5835	5837	682	681	680	678	668	662	613	605	601	593
Asse																	
grou	-	350.750	349.833	344.333	340.750	334.167	331.750	324.583	320.833	319.333	316.667	311.800	309.200	306.000	304.800	304.800	301.880
floo	-4.415	-6.527	-6.406	-5.866	-5.228	-5.299	-4.370	-4.361	-3.582	-2.929	-1.630	-0.000	0.000	-0.000	-1.040	-2.921	-7.190

Long Section for Network - Existing Network_upsize CS u/s of MH 6015 at 01 09:00:00	Print Date - 5/13/2010 5:14:36 PM
Selection - CSCSD Lower	CSCSD Lower Polhemus trunk sewer w/upstream capacity limitations relieved

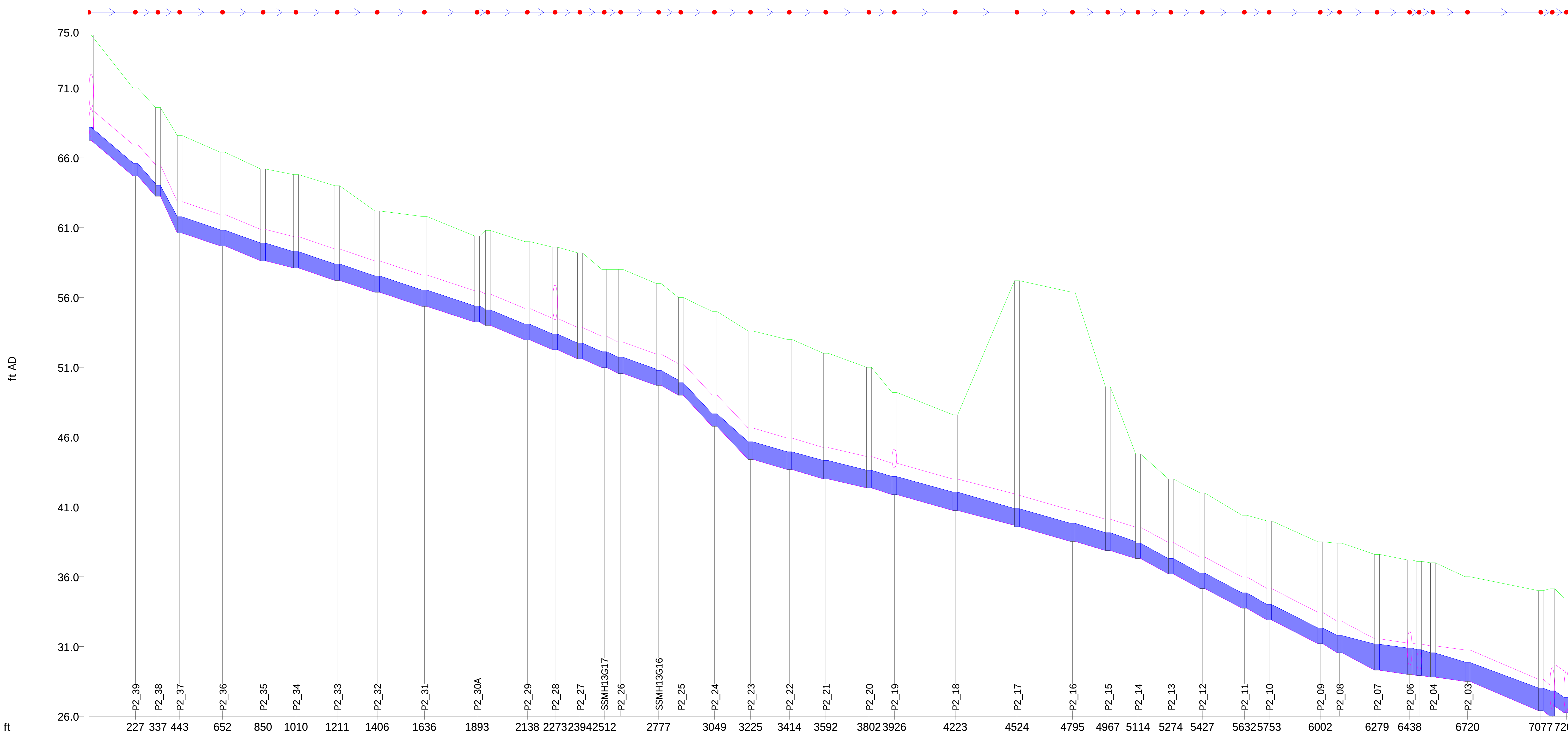


Link	480.1	6032.1	6033.1	6034.1	-	6003.1	6035.1	-	6037.1	6030.1	6022.1	6023.1	6024.1	6025.1
leng	116.0	341.0	249.0	177.0	-	257.0	163.0	-	214.0	56.0	95.0	64.0	162.0	69.0
widt	11.2	11.2	11.2	11.2	-	11.2	11.2	-	12.0	12.4	14.4	14.4	18.0	18.0
us ir	211.690	205.040	189.880	176.130	-	163.660	149.500	-	140.370	131.820	130.030	128.600	127.500	125.200
ds ir	205.040	189.880	176.130	164.960	-	149.500	141.400	-	131.820	130.030	128.600	127.500	125.200	114.700
grac	5.733	4.446	5.522	6.311	-	5.510	4.969	-	3.995	3.196	1.505	1.719	1.420	15.217
pfc (	4.59	4.04	4.50	4.81	-	4.50	4.27	-	4.60	4.49	4.63	4.95	8.09	26.49
DS F	3.91198	4.27723	4.27726	4.27950	-	4.27954	4.27955	-	4.27958	4.27959	4.27958	4.27960	4.90395	4.90398
surc	2.00	2.00	2.00	1.00	-	1.00	2.00	-	2.00	2.00	2.00	2.00	0.66	0.68

Nod	480	6032	6033	6034	6004	6003	6035	279	6037	6030	6022	6023	6024	6025	276
Asse															
grou	-	211.690	205.040	189.880	184.570	173.440	163.660	149.500	145.970	140.370	134.030	132.170	137.100	135.800	-
floo	-3.959	-1.259	-12.466	-10.621	-15.122	-5.447	-9.822	-4.629	-3.039	-5.846	-1.635	-1.687	-8.634	-10.116	-

Appendix G - Crystal Springs/El Cerrito Phase II Sewer Hydraulic Profile Plots

Long Section for Network - FCC_U+FL+CST_Phs II_SST-8_CSTrnk_Press_w/out 36 OF	Print Date - 5/23/2010 2:20:30 PM
Selection - Hillsborough Phase 2 Lower	Hillsborough Crystal Springs Lower Phase 2 trunk sewer



Link	P2_40.2	-	-	P2_37.1	P2_36.1	-	P2_34.1	P2_33.1	P2_32.1	P2_31.1	P2_30.1	-	-	-
leng	227.0	-	-	209.0	198.0	160.0	201.0	195.0	230.0	257.0	193.0	135.0	-	-
widt	27.0	27.0	27.0	27.0	27.0	27.0	27.0	27.0	27.0	27.0	27.0	27.0	27.0	27.0
us ir	67.250	-	-	60.610	59.690	-	58.110	57.220	56.370	55.360	54.000	-	-	-
ds ir	64.700	-	-	59.690	58.620	-	57.220	56.370	55.360	54.230	52.960	-	-	-
grac	1.123	-	-	0.440	0.540	0.319	0.443	0.436	0.439	0.440	0.539	0.526	-	-
pfc (	21.22	-	-	13.28	14.72	11.30	13.32	13.22	13.27	13.27	14.70	14.52	-	-
DS F	7.11969	-	-	7.11965	7.11960	-	7.11948	7.11940	7.11933	7.11929	7.11925	-	-	-
surc	0.42	0.40	0.52	0.52	0.57	0.57	0.52	0.52	0.52	0.52	0.50	0.50	0.50	0.51

Link	-	-	-	-	-	-	-	P2_21.2	-	P2_19.1	P2_18.1	P2_17.1	-	-
leng	-	185.0	-	164.0	176.0	189.0	178.0	210.0	-	297.0	300.5	271.0	172.0	147.0
widt	-	27.0	27.0	27.0	27.0	27.0	27.0	27.0	27.0	27.0	27.0	27.0	27.0	27.0
us ir	-	50.550	-	49.000	46.770	44.400	43.680	43.000	-	41.880	40.740	39.580	38.530	-
ds ir	-	49.700	-	46.770	44.400	43.680	43.000	42.360	-	40.740	39.680	38.530	37.870	-
grac	-	0.459	-	1.360	1.347	0.381	0.382	0.305	-	0.384	0.353	0.387	0.384	0.388
pfc (	-	13.57	-	23.34	23.23	12.36	12.37	11.05	-	12.40	11.89	12.46	12.40	12.47
DS F	-	-	-	-	-	-	-	7.29640	-	7.75654	7.75650	7.75651	-	-
surc	-	0.52	0.48	0.40	0.56	0.57	0.59	0.59	0.58	0.59	0.58	0.58	0.58	0.57

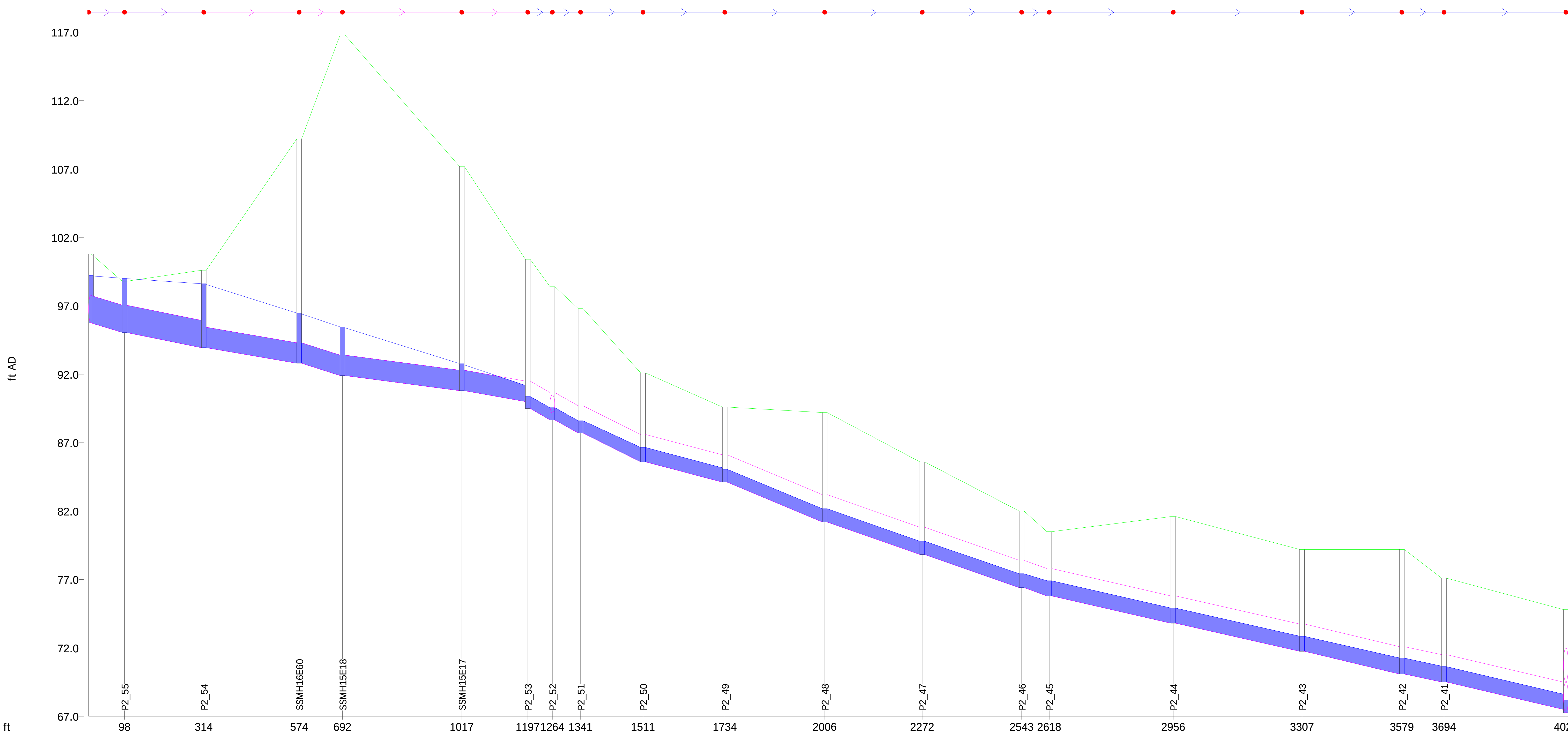
Link	-	-	P2_12.1	-	P2_10.1	-	-	-	-	-	P2_03.1	-	-
leng	160.4	153.0	205.0	-	249.0	-	183.0	159.0	-	169.0	357.0	-	-
widt	27.0	27.0	27.0	27.0	27.0	-	27.0	27.0	-	27.0	27.0	-	-
us ir	-	-	35.150	-	32.900	-	30.550	-	-	28.800	28.500	-	-
ds ir	-	-	33.740	-	31.200	-	29.300	-	-	28.500	26.400	-	-
grac	0.686	0.686	0.688	-	0.683	-	0.683	0.189	-	0.178	0.588	-	-
pfc (	16.58	16.58	16.60	-	16.54	-	16.55	8.70	-	8.43	15.35	-	-
DS F	-	-	7.93354	-	7.93349	-	-	-	-	-	10.18269	-	-
surc	0.49	0.49	0.49	0.49	0.50	-	0.83	0.84	-	0.77	0.72	-	-

Nod	-	-	-	-	P2_36	P2_35	P2_34	P2_33	P2_32	P2_31	-	-	-	-
Asse	-	-				-	-		-					-
grou	-	-	-	-	66.400	-	-	64.000	62.200	61.800	-	-	-	-
floo	-	-	-	-	-5.584	-5.301	-5.516	-5.601	-4.654	-5.266	-	-	-	-

Nod	-	-	-	-	-	-	P2_23	P2_22	P2_21	-	P2_19	P2_18	P2_17	P2_16
Asse	-	-		-	-	-	-		-	-		SSMH8K17		-
grou	-	-	-	-	-	-	-	-	52.000	-	49.200	47.600	57.200	56.400
floo	-	-	-	-	-	-	-7.934	-8.048	-7.674	-	-6.021	-5.539	-16.324	-16.568

Nod	-	-	-	P2_12	-	P2_10	P2_09	-	P2_07	-	-	P2_03	P2_02
Asse		-		-	-	-	-	-	-		-		-
grou	-	-	-	-	-	-	-	-	-	-	-	36.000	35.000
floo	-	-	-	-5.741	-	-5.989	-	-	-	-	-	-6.129	-6.971

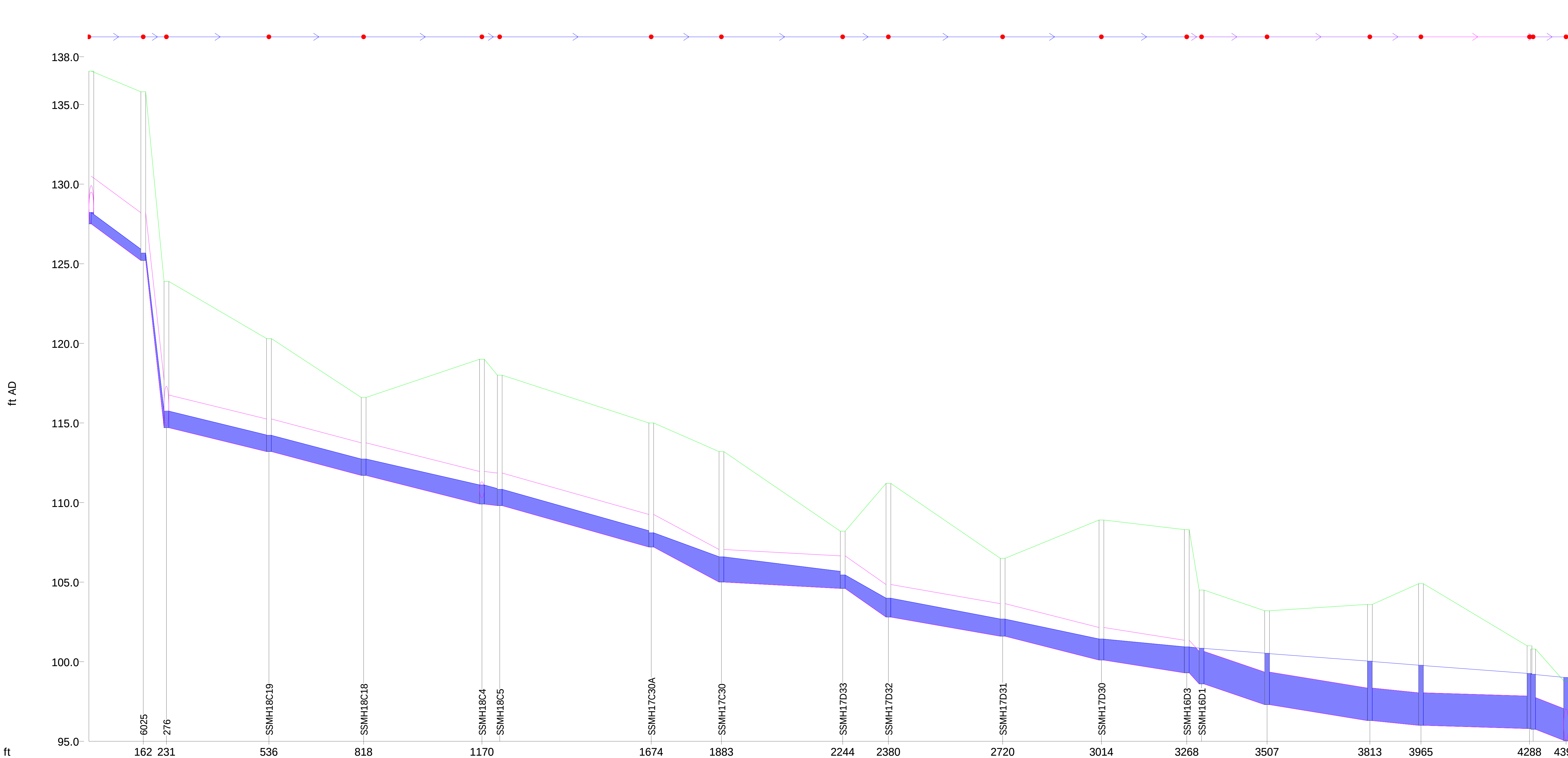
Long Section for Network - FCC_U+FL+CST_Phs II_SST-8_CSTrnk_Press_w/out 36 OF	Print Date - 5/23/2010 2:19:37 PM
Selection - Hillsborough Phase 2 Upper	Hillsborough Crystal Springs Upper Phase 2 trunk sewer



Link	-	P2_55.1	P2_54.1	-	SSMH15E18.1	-	-	-	P2_51.1	P2_50.2	P2_49.1	P2_48.1	P2_47.1	-	P2_45.1	P2_44.1	P2_43.1	P2_42.1	P2_41.1
leng	98.0	216.0	260.0	118.0	325.0	180.0	67.0	77.0	170.0	223.0	272.0	266.0	271.0	75.0	338.0	351.0	272.0	115.0	332.0
widt	24.0	24.0	18.0	18.0	18.0	18.0	24.0	24.0	24.0	24.0	24.0	24.0	24.0	24.0	24.0	24.0	24.0	24.0	24.0
us ir	95.750	95.040	93.940	92.800	91.900	90.800	-	-	87.700	85.600	84.110	81.200	78.820	-	75.800	73.800	71.750	70.090	69.510
ds ir	95.060	93.940	92.800	91.900	90.800	90.000	-	-	85.600	84.110	81.200	78.820	76.400	-	73.800	71.750	70.090	69.510	67.500
grac	0.704	0.509	0.438	0.763	0.338	0.444	-	1.247	1.235	0.668	1.070	0.895	0.893	0.800	0.592	0.584	0.610	0.504	0.605
pfc (	12.27	10.44	4.50	5.93	3.95	4.53	-	16.33	16.25	11.95	15.13	13.83	13.82	13.08	11.25	11.18	11.42	10.39	11.38
DS F	-	6.05605	6.05599	6.05595	6.05595	6.05594	-	-	6.47868	6.47856	6.47854	6.47849	6.47845	-	6.47835	6.47828	6.47836	6.73493	6.73486
surc	1.00	1.00	2.00	2.00	2.00	2.00	0.45	0.45	0.53	0.53	0.49	0.49	0.51	0.55	0.56	0.55	0.59	0.58	0.56

Nod	-	P2_55	P2_54	SSMH16E60	SSMH15E18	SSMH15E17	P2_53	-	P2_51	P2_50	P2_49	P2_48	P2_47	P2_46	P2_45	P2_44	P2_43	P2_42	P2_41	P2_40
Asse	-	SSMH14J3	SSMH14J1	SSMH14J2	SSMH14J13	SSMH13J13	-	-	-	SSMH13J7	SSMH13J20	SSMH13K11	SSMH13K12	SSMH13K5	SSMH12K20	SSMH12K19	SSMH12K8			SSMH12K4
grou	-	98.800	99.600	109.200	116.800	107.200	100.400	-	96.800	92.100	89.600	89.200	85.600	82.000	80.500	81.600	79.200	79.200	77.100	74.800
flooc	-	0.216	-0.987	-12.734	-21.344	-14.428	-10.032	-	-8.197	-5.446	-4.544	-7.024	-5.803	-4.577	-3.591	-6.686	-6.351	-7.934	-6.462	-6.614

Long Section for Network - FCC_U+FL+CST_Phs II_SST-8_CSTrnk_Press_w/out 36 OF	Print Date - 5/23/2010 2:16:57 PM
Selection - Hillsborough CS Phase 1	Hillsborough Crystal Springs Phase 1 trunk sewer upstream of Phase 2



Link	leng	widt	us ir	ds ir	grac	pfc (	DS F	surc
6024.1	162.0	36.0	127.500	125.200	1.420	51.37	5.41299	0.24
-	69.0	36.0	-	-	-	-	-	0.35
276.1	305.0	24.6	114.700	113.200	0.492	10.95	5.66350	0.51
SSMH18C19.1	282.0	24.6	113.200	111.700	0.532	11.39	5.66349	0.51
SSMH18C18.1	352.0	24.6	111.700	109.900	0.511	11.17	5.66347	0.59
-	-	-	-	-	-	-	-	-
SSMH18C5.2	451.0	24.6	109.800	107.200	0.576	11.86	5.96427	0.50
-	209.0	24.6	107.200	105.000	1.053	16.02	5.96423	0.78
SSMH17C30.1	361.0	24.6	105.000	104.600	0.111	5.20	5.96419	0.77
-	136.0	24.6	104.600	102.800	1.324	17.97	5.96418	0.58
SSMH17D32.2	340.0	24.6	102.800	101.600	0.353	9.28	5.96378	0.58
SSMH17D31.2	294.0	24.6	101.600	100.100	0.510	11.16	5.95886	0.65
SSMH17D30.1	254.0	24.6	100.100	99.300	0.315	8.77	5.94431	0.80
-	-	-	-	-	-	-	-	-
SSMH16D1.1	195.0	24.6	98.600	97.300	0.667	12.75	6.05745	1.00
SSMH16D2.1	306.0	24.6	97.300	96.300	0.327	8.93	6.05701	1.00
-	152.0	24.6	96.300	96.000	0.197	6.94	6.05673	1.00
SSMH16D5.1	323.0	24.6	96.000	95.800	0.062	3.89	6.05643	2.00
-	98.0	24.0	-	-	0.704	12.27	-	1.00

Nod	Asse	grou	flooc
-		-	-
6025		-	-
276		123.890	-8.144
SSMH18C19	SSMH18I8	120.300	-6.073
SSMH18C18	SSMH18I9	116.600	-3.863
SSMH18C4	SSMH17I21	119.000	-7.892
SSMH18C5	SSMH17I24	118.000	-7.168
SSMH17C30A	SSMH17I2	115.000	-6.900
SSMH17C30	SSMH17I1	113.200	-6.605
SSMH17D33	SSMH16I9	108.200	-2.746
SSMH17D32	SSMH16I16	111.200	-7.204
SSMH17D31	SSMH16I17	106.500	-3.815
SSMH17D30	SSMH16I18	108.900	-7.468
-	-	108.300	-7.361
-	-	-	-3.648
SSMH16D2	SSMH15J7	103.200	-2.666
SSMH16D4	SSMH15J6	103.600	-3.561
SSMH16D5	SSMH15J5	104.900	-5.119
-	SSMH15J4	101.000	-1.735
-	-	-	-
-	-	-	-