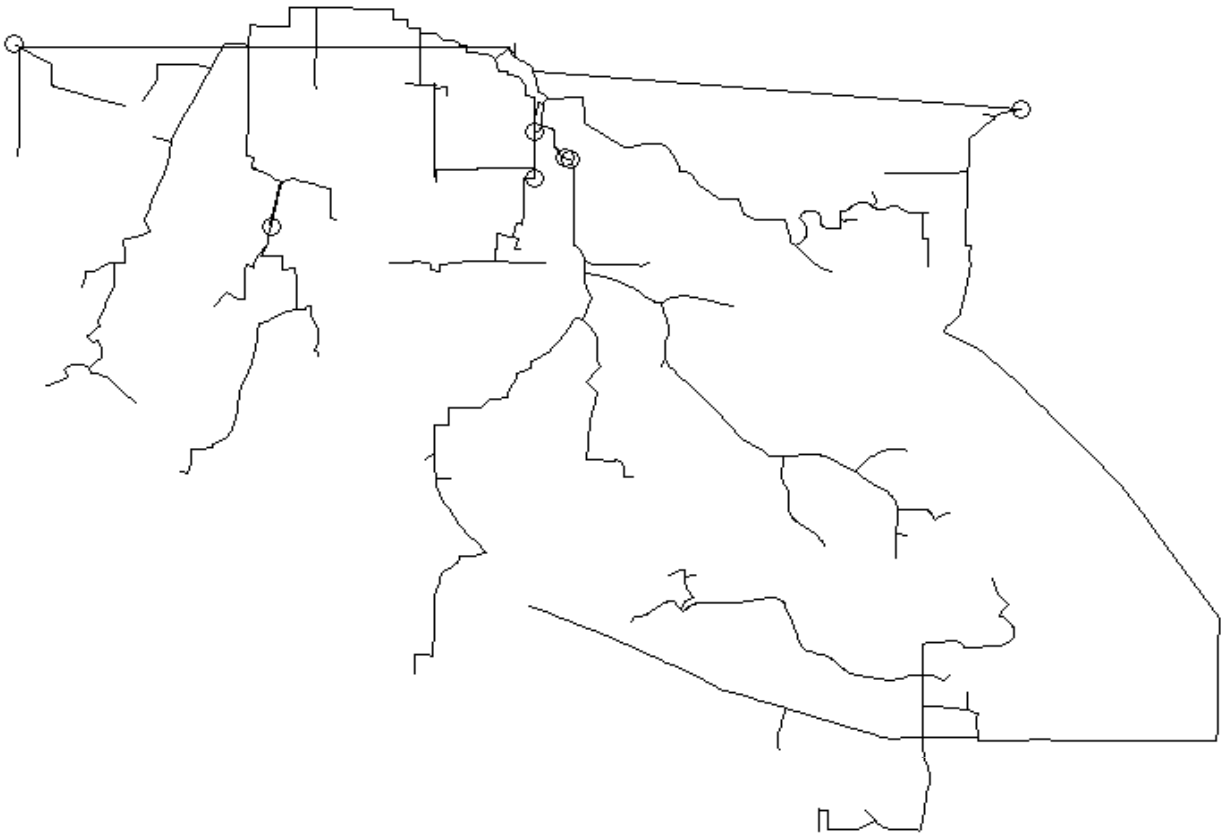
CITY OF ANTIOCH
DEPARTMENT OF PUBLIC WORKS

WASTEWATER COLLECTION SYSTEM MASTER PLAN



ADOPTED
SEPTEMBER 2, 2003

WINZLER & KELLY
CONSULTING ENGINEERS
CREATIVE SOLUTIONS FOR OVER 50 YEARS

01313501

CITY OF ANTIOCH
WASTEWATER COLLECTION SYSTEM MASTER PLAN

ADOPTED
SEPTEMBER 2, 2003

Prepared for:
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CITY OF ANTIOCH WASTEWATER COLLECTION SYSTEM MASTER PLAN

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Chapter I EXECUTIVE SUMMARY

The City of Antioch retained Winzler & Kelly to update the City of Antioch's Wastewater Collection System Master Plan. The purpose of this update is to evaluate the hydraulic capacity of the existing wastewater system and to identify system improvement needs based on current and projected wastewater generation rates. By studying the current and projected population and land use, examining the physical layout of the existing system, and estimating various design flow components from flow monitoring data, Winzler & Kelly projected future wastewater generation rates and identified system capacity deficits based on the hydraulic modeling under various projected development scenarios.

In addition to the City-provided information, including the City of Antioch GIS database that contains an inventory database of the existing sewer system, Winzler & Kelly has performed a wastewater flow measurement and a manhole elevation survey. For the flow monitoring activity, 15 monitoring stations that cover the entire City were installed for a one-month period to collect wet weather and dry weather wastewater flow information. In the manhole elevation survey, 809 manholes included in the wastewater collection system model were surveyed for rim and invert elevation. Please refer to Chapter 3 for details on the existing wastewater collection system information collection effort.

To estimate the future wastewater generation rate, the City of Antioch population and land use projection data from the City's planning subconsultant and the US Census Bureau were used. A total population of 123,500 is projected for the scenario when all the developments within the City's Sphere of Influence are completed. Detailed discussion regarding the estimates is in Chapter 5, Population and Land Use.

In order to calculate the wastewater flow input for various development scenarios in the capacity analysis, data collected for this project such as the flow monitoring data, precipitation data, and land use information from the GIS database were used to estimate unit flow factors for Base Wastewater Flow (BWF), Groundwater Infiltration (GWI) and Rain Dependent Infiltration/Inflow (RDI/I). Chapter 4 documents the unit flow factor analysis and Chapter 6 summarized the unit flow factor results along with design flow calculations, design flow scenarios definitions, and design criteria.

For this study, a computer model was developed to digitally simulate the City of Antioch's wastewater collection system under various development scenarios. The model is constructed using a modeling software package called HYDRA. To optimize the model efficiency, only pipe sections with a diameter of 10 inches or greater are included in the model.

From the wastewater collection system capacity analysis, Winzler & Kelly identified a total of 19 improvement projects with the total planning cost of $31.4 million dollars.

These improvement projects are grouped into six project phases based on the undercapacity level and the timing of the development scenario when the problem occurs. Undercapacity sections that are geographically isolated from the improvement projects are separately listed as hydraulic capacity bottlenecks and negative slope sections. A hydraulic capacity bottleneck is defined as an undercapacity section that is less than 1000 feet long. There are 24 hydraulic capacity bottleneck sections and 45 negative slope sections.

Detailed discussion of the improvement projects, hydraulic capacity bottlenecks and negative slope sections are provided in Chapter 9, Capital Improvement Program. Table 1.1 shows a summary of the recommended improvement projects.

This Master Plan Report documents the entire study including:

- Existing system information collection and evaluation in Chapter 3,
- BWF, GWI and RDI/I Unit flow factor analysis in Chapter 4,
- City population and development forecasts in Chapter 5,
- Design flow calculation and design criteria in Chapter 6,
- Hydraulic model development in Chapter 7,
- Capacity analysis and defective pipeline identification in Chapter 8,
- Prioritized improvement project recommendations and planning level cost estimates in Chapter 9.

In addition, to assist the City in performing additional capacity analyses in the future, Winzler & Kelly will provide the City of Antioch with the wastewater system model created for this study.

TABLE 1.1 - RECOMMENDED PROJECT SUMMARY

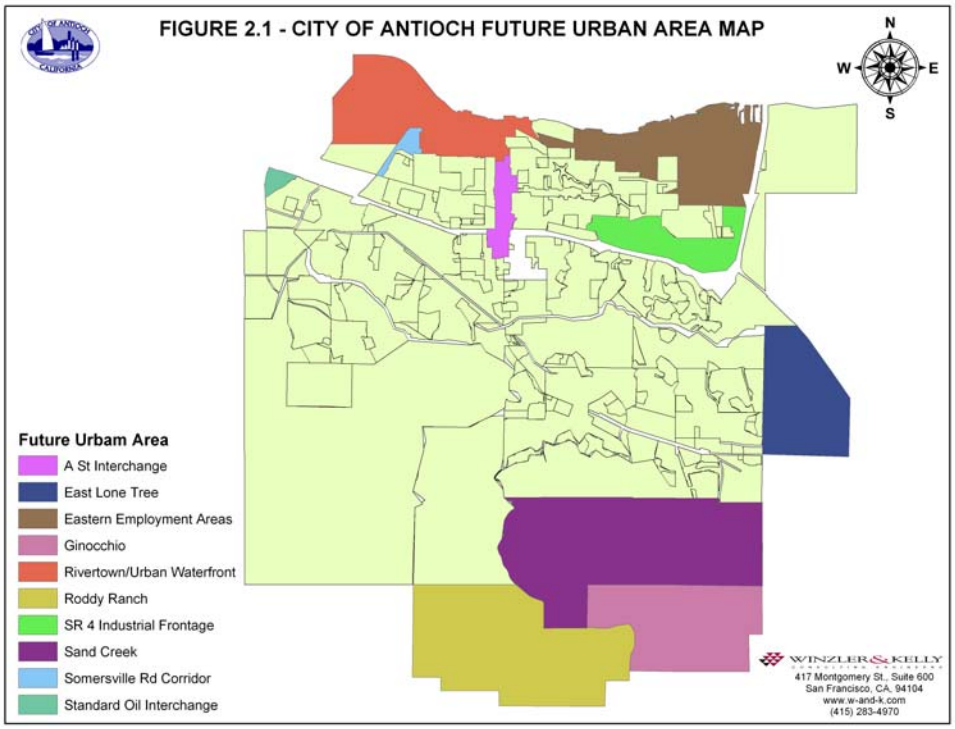
Phase	Project Priority	Length (ft)	Existing Pipe Diameter (in)	New Diameter (in)	
				Replacement	Parallel
1	1a	3,203	12 – 18	24	18
	1b	1,739	16 – 24	21 - 24	12 - 21
	1c	3,191	12 – 15	15	12 - 15
	Subtotal	**8,133**			
2	1d	1,437	12 – 15	15 - 24	8 - 18
	1e	3,737	15 – 18	21	12
	1f	1,445	12 – 15	18	15
	2a	2,644	24	33 , 39*	27 , 33*
	2b	2,728	12 – 18	15 - 21	10 - 15
	Subtotal	**11,991**			
3	2c	7,452	12	18	12
	2d	3,470	10 – 12	15	8 - 12
	Subtotal	**10,922**			
4	2e	3,567	33	39 , 45*	27 , 33*
	4a	2,777	8 – 15	21 , 30*	21 , 30*
	4b	3,712	10 – 12	21 , 30*	21 , 30*
	Subtotal	**10,056**			
5	5a	1,041	20 – 21	24	10
	5b	1,316	12	15	8
	6a	5,306	33	36 , 39*	18 , 27*
	Subtotal	**7,663**			
6	7a	4,193	33	39 , 42*	27 , 30*
	7b	1,759	33	39*	24*
	7c	2,359	33	39*	21*
	Subtotal	**8,311**			
	TOTAL	**57,076**			

***** Recommended pipe size if wastewater from Roddy Ranch area and Ginocchio area are conveyed through the City of Antioch's sewer system.

A. City of Antioch

The City of Antioch is located in Contra Costa County about 40 miles northeast of San Francisco. The city is primarily a suburban, residential community. Population has increased significantly in the last 10 years as a result of economic development in the Bay area: from 62,200 in the 1990 Census to over 90,500 in the 2000 Census.

The City of Antioch is mainly divided between north and south of Highway 4 with distinct development characteristics. The northern area consists of the original City's downtown area and the older residential communities, mostly built before 1970's. The area south of the highway is mainly newer developments in the 1970's and after. Most of the City's developments in the last decade are in the southern area. In addition to the developments within the City boundary, two future development focus areas (Roddy Ranch and Ginocchio) included in the study are located outside the current City limit, at the south of Sand Creek focus area (Future Urban Area-1). Part of these development areas that are outside the City limits are referred to as the South Antioch Planning Area (SAPA) in planning documents prepared by Delta Diablo Sanitation District (DDSD). In this study, potential growth from the Roddy Ranch area and Ginocchio area are analyzed separately from City development within the current City limit. Figure 2.1 shows the City map with the locations of the future development focus areas.



Developments beyond the current City limits will likely expand the City's "Sphere of Influence", the area for which the City will be responsible for providing service. This future addition will increase wastewater loading from the southern area of the City wastewater system and in the Lone Tree Interceptor.

To serve the City's wastewater collection needs, the existing sewer system consists of approximately 280 miles of pipeline and 5,300 manholes, cleanouts, and other access structures. Some parts of the collection system are about a century old since the combined stormwater - wastewater collection system was built in 1900s and was converted to sanitary sewers system in the 1950s. As the City standards preclude use of PVC pipe, most of the City sewer pipelines are made of VCP, while some pipe sections made of RCP, with the pipe diameters range from 4 inch to 68 inch.

In addition to the City owned and operated wastewater system, DDSD has several conveyance facilities to transport wastewater from the City to the DDSD Wastewater Treatment Plant for processing. Refer to Chapter 3 for detailed discussion on the DDSD system.

B. Previous Studies

The City has historically planned for its wastewater system improvements to accommodate desired population and employment growth. Several plans and studies have been prepared in the past, including:

- *Antioch Collection System Master Plan*, CDM, Inc., December 1990.
  This study recommended 28 wastewater system improvement projects in the City of Antioch based on the existing condition at the time and the future needs for the wastewater improvement. Most of the projects are in the northern part of the City and target the deteriorated pipe sections in the area. In addition, the study also recommended improvements on the DDSD system so that sewer flow can be conveyed to the treatment plant without any capacity issues.

- *DDSD Conveyance System Master Plan*. Montgomery Watson, September 1996.
  This study updated the planning of the District's conveyance system based on DDSD land use and flow projections. The study recommended new pipe sections along the Antioch Interceptor and improvements for the Fulton Shipyard Pump Station and Bridgehead Pump Station. The flow projections from the 1996 study were used to independently verify flow projections resulting from this report.

- *City of Antioch General Plan*. December 1988
  This study provides background on the City planning information for population and land use forecast. However, not much data was used from this study since some of the data is outdated.

- Information from *City of Antioch General Plan Update* from the City's planning consultant, LSA Associates.
  The City is currently in the process of updating the General Plan. LSA is the City's consultant for this effort. Population and land use information from LSA was used for population and land use forecast for this Master Plan.

C. Scope of Work

This Master Plan continues the sanitary sewer planning effort for the City of Antioch. The project involved performing the following major tasks.

1. Data Collection. In addition to previous studies and existing wastewater system information from the City including the GIS database, Winzler & Kelly performed wastewater flow monitoring and conducted a City manhole survey to obtain sufficient data for the study (Chapter 3).

2. Planning. This task included identifying the service areas and forecasting wastewater flows to buildout and for intermediate years. The forecasting consists of three specific steps.

   - Developing unit flow factors (Chapter 4)
   - Forecasting population and land use (Chapter 5)
   - Forecasting design flows (Chapter 6)

3. Computer Model. This task consists of developing a hydraulic model of the collection system, calibrating and verifying the model against flow monitoring data, and running the computer model with forecasted wastewater flows superimposed on the existing collection system to identify hydraulically deficient pipeline segments (Chapter 7). Upon completion of the Master Plan, the computer model will be provided to the City and training conducted.

4. Capital Improvement Program (CIP). Based on wastewater generation forecasts from the model, 19 specific improvement projects involving approximately 60,000 linear feet of new pipelines were evaluated and recommended (Chapter 8). Priorities and planning level cost estimates were established. Hydraulic capacity bottlenecks and negative slope sections were identified (Chapter 9).

5. GIS Database Update. This task consists of updating the City's GIS database based on wastewater system data collected throughout the study.

With the exception of the GIS database update, computer model delivery and CMOM compliance analysis, all tasks have been completed and are documented in this report.

Chapter III EXISTING SYSTEM INFORMATION

A. Land Use And Population Data

GIS Database

The City of Antioch maintains a GIS database to inventory the City's planning and utility information. City land use and sewer collection system data from the GIS database was used in the preparation of the hydraulic model. The database information covers the entire City influence zone including the Roddy Ranch and Ginocchio future development focus areas at the south of the City limit. Part of that area is known by Delta Diablo Sanitation District as South Antioch Planning District (SAPA). Information on the sewer collection system includes pipe designation, manhole designation and the physical properties such as size and location.

Land Use Categories

Using land use planning data from the City's planning subconsultant, LSA Associates, the City of Antioch is divided into 16 different land use categories. The classifications are based on land use type and density. The following is the list of land use categories used in the City's general plan and the City's wastewater system model:

- Residential
  - ER – Estate Residential (0.8 du/ac)
  - LR – Low Density Residential (2.6 du/ac)
  - MLDR – Medium Low Density Residential (3.7 du/ac)
  - MDR – Medium Density Residential (6.1 du/ac)
  - HDR – High Density Residential (15.5 du/ac)

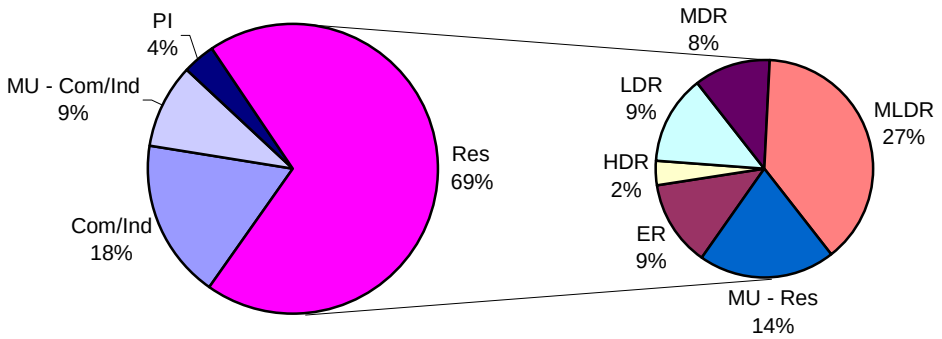
- Commercial / Industrial
  - CC – Community Commercial
  - CN – Neighborhood Commercial
  - CR – Regional Commercial
  - CS – Service Commercial
  - CO – Office
  - IL – Light Industrial
  - IH – Heavy Industrial
  - BP – Industrial / Business Park

- Other
  - MU – Mixed Use Area (Residential & Commercial / Industrial)

- PI – Public Institution (Including School)
- OS – Open Space

Based on the City of Antioch's GIS database, the City's land use categories are proportioned as approximately 69% residential, 27% commercial and industrial, and 4% public institutional. Open space area, which covers about 25% of City's land, is not included in the split because of its minimal sewer generation. The distribution of major sewer-generating land use categories in the City of Antioch is shown in Figure 3.1. The percentage is based on the total area of each land use category within the City.

Figure 3.1
City of Antioch Land Use Distribution
(Excluding Open Space Areas)



Total Land Use **Residential Land Use**

The land use category of each parcel is used to determine the appropriate unit flow factor for sewer flow generation in the hydraulic model. Refer to Chapter 4 for discussion of unit flow definitions.

Population Information

The City of Antioch GIS database contains information on the size of each land use parcel. However, it does not include population-related information. Partial data on city population and population density in each residential land use parcel was obtained from the Antioch General Plan and the City's planning sub-consultant, LSA Associates. Population and density data were then verified and calibrated with Association of Bay Area Governments (ABAG) population forecasts and 2000 U.S. Census data before being applied to sewer flow generation. Refer to Chapter 5 for discussion of the population verification procedure.

B. Flow monitoring activity

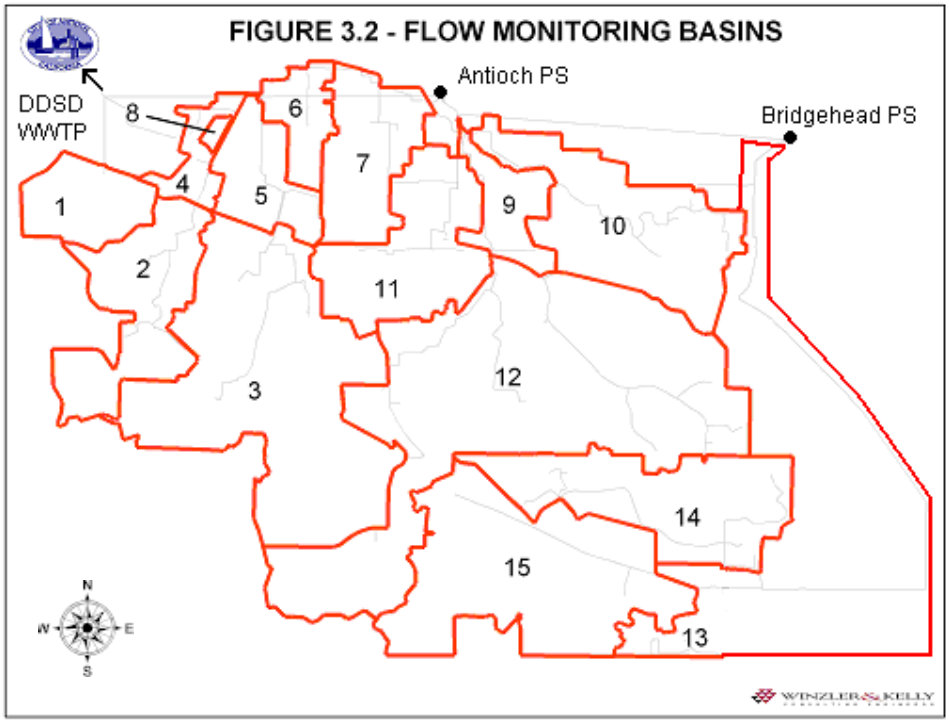
Flow monitoring was conducted by Winzler & Kelly and its subconsultant, V&A Consulting Engineers. The objective of the flow monitoring was to capture real system flow data during the wet weather season to better understand the behavior of the system. This data is also used to calibrate the hydraulic model.

Flow Monitoring Period

Wastewater flow monitoring was conducted over a 1-month period from December 27, 2002 through January 29, 2002. The period was chosen so that a combination of dry weather and wet weather flow data could be obtained to identify rain-dependent infiltration and inflow (RDI/I) in the City sewer system, as well as to determine appropriate unit flow factors associated with specific land use categories. During the monitoring period, there were about 3 major storm events and 2 weeks of dry weather period in the City.

Flow Monitoring Basins

Fifteen flow monitoring sites were selected such that each site could provide a total sewer flow from an isolated basin with relatively homogeneous land use and similar pipe age and condition. Two plugs were strategically placed to control flow splits and maintain consistent monitoring boundaries. Collectively, the flow monitoring measurements covered the sewer generation from the entire City, as shown in Figure 3.2.



In order to evaluate potential infiltration and inflow along the Lone Tree Interceptor at the west side of the City, three monitoring sites were located on the interceptor with two at the upstream and one at the downstream end of the interceptor. Figure 3.3 shows the flow monitoring sites as well as plug locations for basin isolation.

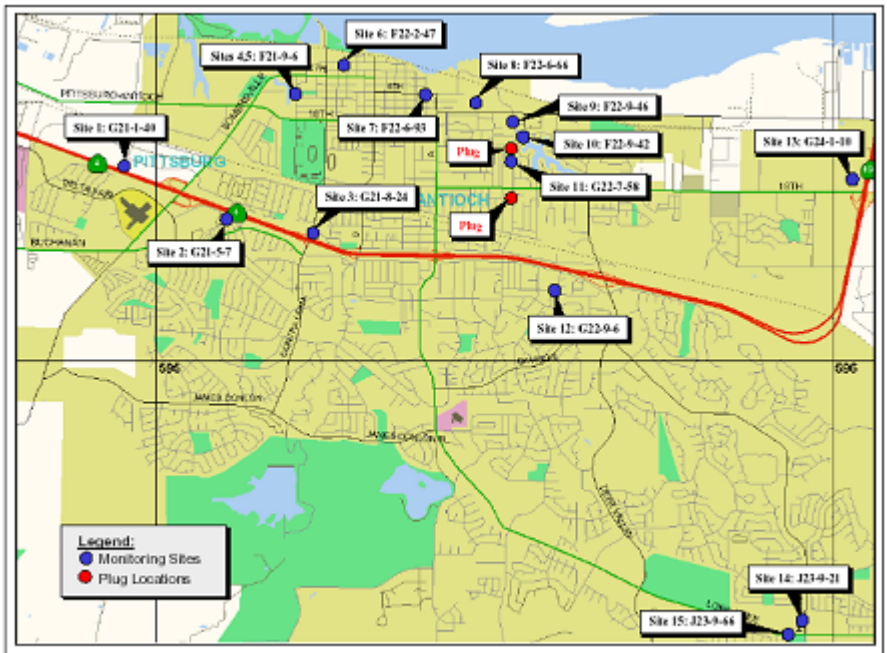


FIGURE 3.3 - CITY OF ANTIOCH FLOW MONOITORING SITES

Flow Monitoring Data

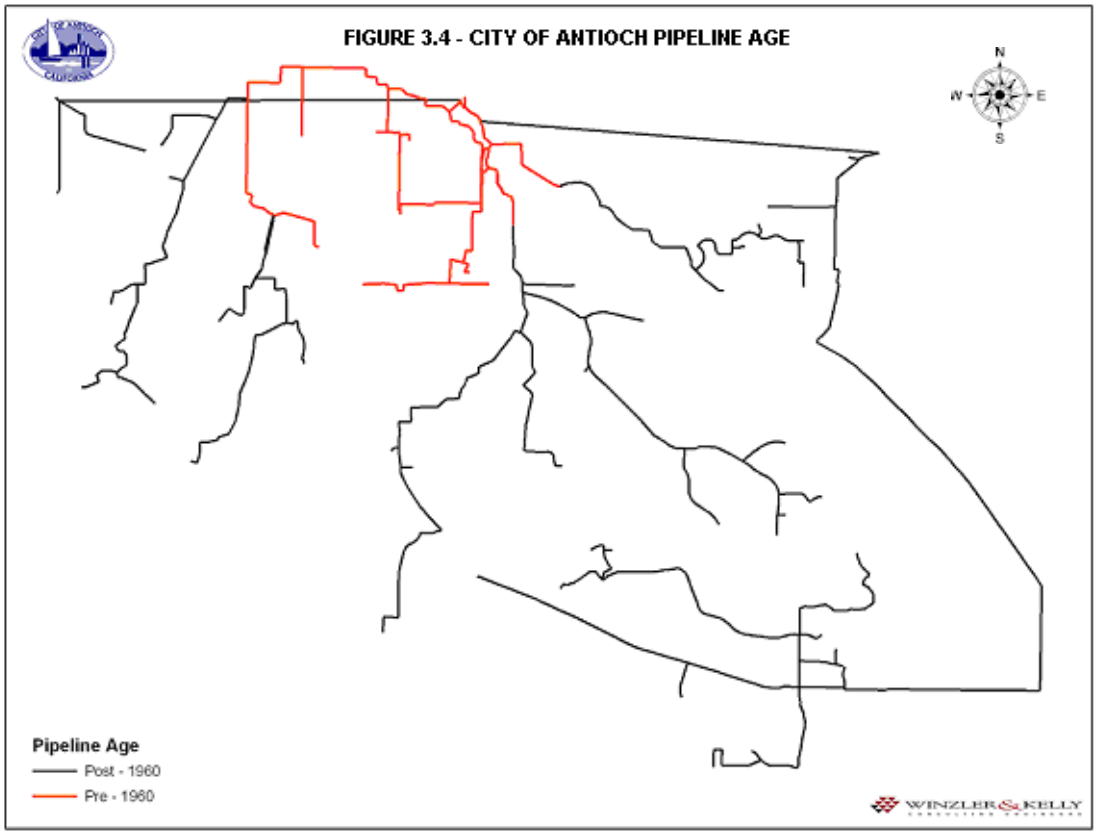
Flow monitoring data is summarized in Table 3.1. Details of the flow monitoring program are included in Appendix A, the City of Antioch Sanitary Sewer Master Plan Flow Monitoring by V&A Consulting Engineers.

TABLE 3.1 - CITY OF ANTIOCH FLOW MONITORING DATA SUMMARY

Flow Monitor Site	Manhole ID	Average Baseline Flow in each basin (MGD)	Total I/I over flow monitoring period (MG)	Site I/I over flow monitoring period (MG)
1	G21-1-40	0.21	N/A	N/A
2	G21-5-7	0.50	N/A	N/A
3	G21-8-24	0.61	N/A	N/A
4	F21-9-6	0.29	0.56	N/A
5	F21-9-6	0.88	0.61	N/A
6	F22-2-47	0.21	0.71	0.71
7	F22-6-93	0.58	0.68	0.68
8	F22-6-66	1.03	3.38	0.82
9	F22-9-46	1.46	N/A	N/A
10	F22-9-42	0.20	0.37	0.37
11	G22-7-58	0.60	0.67	0.67
12	G22-9-7	0.98	0.77	0.77
13	G24-1-8	0.51	9.10	4.27
14	J23-9-21	1.14	3.13	3.13
15	J23-9-66	0.89	1.70	1.70

C. Pipeline Identification

The City of Antioch's wastewater collection system was built beginning in the early 1950's, after the old combined sewer system converted to sanitary sewer system. Because of high groundwater table and leakage from the aged pipe, the City has experienced infiltration and inflow problems, especially in the older areas. To more accurately reflect the reduced efficiency of aged pipes, the sewer system was divided into two sections based on the time of construction. Pipes built in the 1960s and earlier were placed in one group and pipes built after the 1960s were placed in another group because of the change in the type of joint from cement mortar to rubber compression for better leakage protection. Figure 3.4 shows the location of the pipe groups.



Since the City GIS database does not contain age information of the pipe sections, the approximate age of each pipeline was estimated by matching the existing sewer system map to the City's general maps in late 1950s and early 1970s. Pipe age was based on the assumption that land use development would approximately match the sewer system development (i.e., if the area was developed in the 1950s, sewer pipe sections in that area would have been developed in or before the 1950s).

Design criteria for each age group is summarized in Chapter 6, Design Criteria.

D. City Manhole Survey

Manhole Survey

While the City's GIS database contains most of the spatial and physical information needed for a hydraulic model, it contains no elevation information. Since the sewer system is gravity driven, pipe section slopes are important to determine the flow capacity. In order to determine slopes of the lines, invert elevations at the manholes were needed. Accordingly, Winzler & Kelly's subconsultant, Benchmark Consultants, performed a survey of ground and invert elevations for all City manholes in the sewer system model that connect to the pipeline with 10 inch diameter or greater. Of 809 manholes in the model, 58 manholes could not be surveyed because of either access issues or the manhole could not be located.

Based on the manhole survey results, the City GIS database will be updated with the manhole elevation and pipe section slope data.

Missing Data and Assumption

For manholes with no survey data, elevations were approximated using the upstream and downstream manhole elevations. The missing elevation was estimated such that the pipe slopes upstream and downstream of the manhole are consistent. A list of missing manholes is in Appendix B.

Negative Slope Pipe Sections

The manhole survey identified 58 pipe sections with negative slope, listed in Appendix C. The lengths ranged from 30 feet to 800 feet. In general, negative slope pipes are not desirable in a sewer system because they create a pressurized section in the gravity pipeline and reduce overall system capacity. In addition, negative slopes also pose certain modeling issues that may compromise the efficiency and accuracy of the simulation. Detailed discussion of these issues is provided in Chapter 7, System Model.

E. Delta Diablo Sanitation District Conveyance System

Wastewater from the City is collected through the City's sewer system and is discharged into Delta Diablo Sanitation District's (DDSD) conveyance system. There are three main connection points between the City system and the DDSD system:

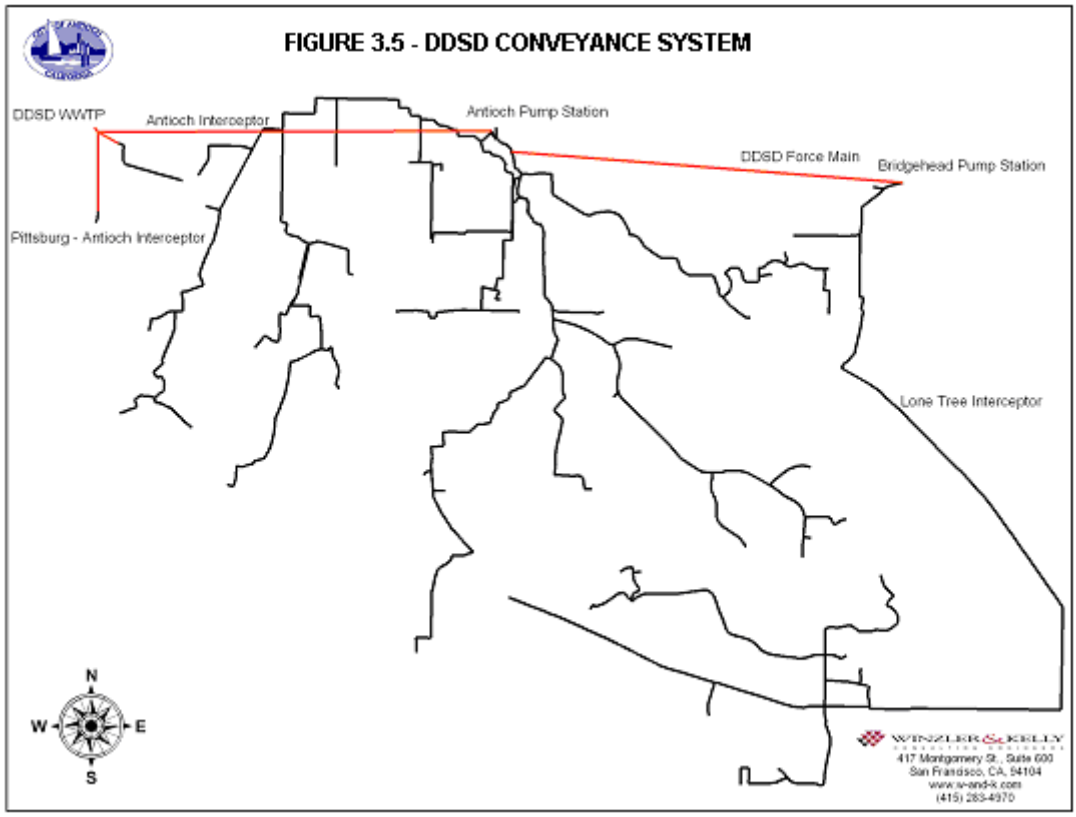
- Bridgehead Pump Station, in the northwest section of the city: Wastewater from the southern part of the City, including Roddy Ranch and Ginocchio future

development focus areas, is transported through the Lone Tree Interceptor to the Bridgehead Pump Station.

- Fulton Shipyard (Antioch) Pump Station, in the north section of the City: Sewage from the central and northern parts of the City is collected at the Fulton Shipyard Pump Station. Sewage from the Bridgehead Pump Station is conveyed to the Fulton Shipyard Pump Station through a DDSD-owned and operated force main and gravity conveyance system. Sewage from the Fulton Shipyard Pump Station is pumped into the Antioch Interceptor and conveyed to the DDSD Wastewater Treatment Plant.

- Pittsburg-Antioch Interceptor, in the northeast section of the City: In addition to sewage from Pittsburg, sewage from the eastern part of Antioch is conveyed to the DDSD Wastewater Treatment Plant through the Pittsburg-Antioch Interceptor.

All of the City of Antioch's collected wastewater is conveyed to the DDSD wastewater treatment plant for processing. Figure 3.5 outlines the DDSD conveyance system in the City of Antioch.



Chapter IV UNIT WASTEWATER FACTORS

A. Design Flow

Three categories of design flow components were established for the capacity evaluation of the existing sewer system:

- Base wastewater flow (BWF): Consists of residential, commercial and industrial wastewater flow generated from the City. BWF is a time dependent parameter and the rate of BWF depends on land use as each land use has different water usage patterns and quantities. The unit flow factor for BWF is defined in terms of land use categories. The fluctuation in BWF throughout a given time period is accounted for by application of peaking factors and diurnal curves.

- Groundwater Infiltration (GWI): When a sewer pipeline is submerged under the groundwater table, groundwater can infiltrate into the sewer system through leaking pipe joints and damaged sections. Older pipe tend to have higher GWI due to deteriorated pipe conditions, but typical design specifications define an allowable rate of infiltration for new pipes.

- Rain Dependent Infiltration and Inflow (RDI/I): During wet weather periods, storm water infiltration can occur even if the groundwater table is below the sewer pipe invert, but pipes that are below the groundwater table typically have higher rates of RDI/I. During a storm event, precipitation infiltrates into the sewer system in a similar fashion as GWI. RDI/I rates have significant variation between the wet and dry seasons. RDI/I can significantly increase flow volume in the sewer system.

Section D, E, and F include additional discussion of each design flow component.

B. Flow Monitoring Data

Flow monitoring data provides the information required to calibrate estimates of unit flow factors for the design flow components. The flow monitoring data set is comprehensive for the entire City of Antioch Wastewater Collection System, including undeveloped areas within the City limits, and is aggregated in the following fashion:

- The flow monitoring period includes both dry weather and wet weather conditions.

- Flow monitoring data was taken from 15 monitoring stations, with each basin comprised of parcels with various land use categories.

- Raw Flow monitoring data is provided as a single value which includes a combination of BWF, GWI and I/I.

Because of the aggregation, data decomposition is required so that the data can be applied to the capacity analysis in terms of unit flow factors. Sections D, E and F describe the data decomposition process and unit flow factor calculation.

C. City of Antioch Precipitation Data

To identify the dry weather period, and to estimate the design storm RDI/I, it is necessary to obtain precipitation data during the flow monitoring period. Precipitation estimates were made using rain gauge data from nearby surface climate monitoring stations. Hourly precipitation data for the City is not directly available because there was no operational rain gauges located in the City during the monitoring period. The choices of surface climate monitoring stations include:

- Mount Diablo (MTD)
- Mallory Ridge (MLR)
- Black Diamond (BKD)
- Brentwood (CIMIS #47)

Figure 4.1 shows the locations of the surface climate monitoring stations.

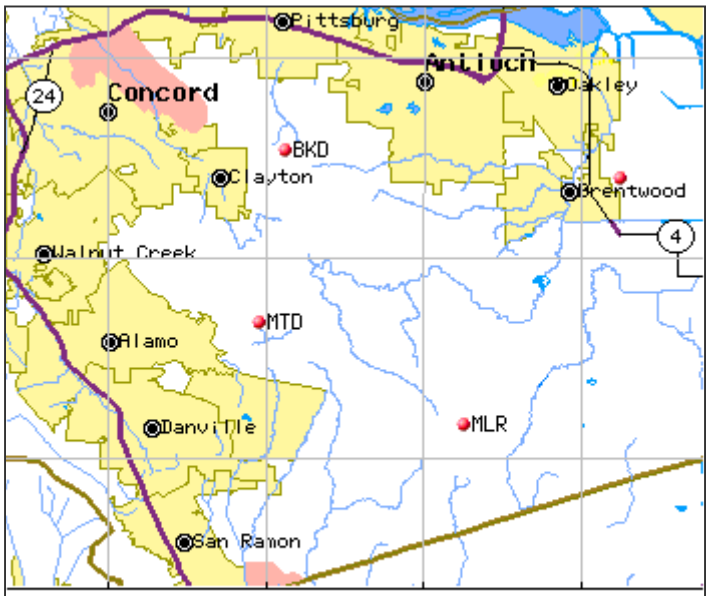


FIGURE 4.1 - CLIMATE STATIONS

Since none of the stations is within the City limits, precipitation data needed to be converted before use. The conversion factor is based on the ratio of mean seasonal precipitation, from Contra Costa County Public Works Department Mean Seasonal Isohyetal Map, between the City of Antioch and the station. Due to seasonal variations,

data transferability needs to be evaluated for each station based on the data collected during the flow monitoring period.

The transferability analysis is to compare the average hourly precipitation ratio between each surface climate monitoring station during the flow monitoring period (Measurement Set). Since the ratio of mean seasonal precipitation from Contra Costa County Public Works Department Mean Seasonal Isohyetal Map (Control Set) would be used, it is desirable to use the data from a station with the minimum difference between the control set and measurement set. Table 4.1 shows that the Black Diamond Station has the lowest variation between the measurement set and the control set. Therefore, the analysis concluded that the Black Diamond Station yields the best accuracy for the City of Antioch precipitation data estimation.

TABLE 4.1 - SUMMARY DATA OF CLIMATE STATION SELECTION ANALYSIS

Control Set

Column/Row	Black Diamond	Mallory Ridge	Mount Diablo	Brentwood
Black Diamond	-	1.05	1.33	0.67
Mallory Ridge	0.95	-	1.27	0.63
Mount Diablo	0.75	0.79	-	0.50
Brentwood	1.50	1.58	2.00	-

Total Precipitation Data Set

Column/Row	Black Diamond	Mallory Ridge	Mount Diablo	Brentwood
Black Diamond	-	1.33	0.60	1.06
Mallory Ridge	0.75	-	0.41	0.78
Mount Diablo	1.68	2.42	-	1.92
Brentwood	0.94	1.28	0.52	-

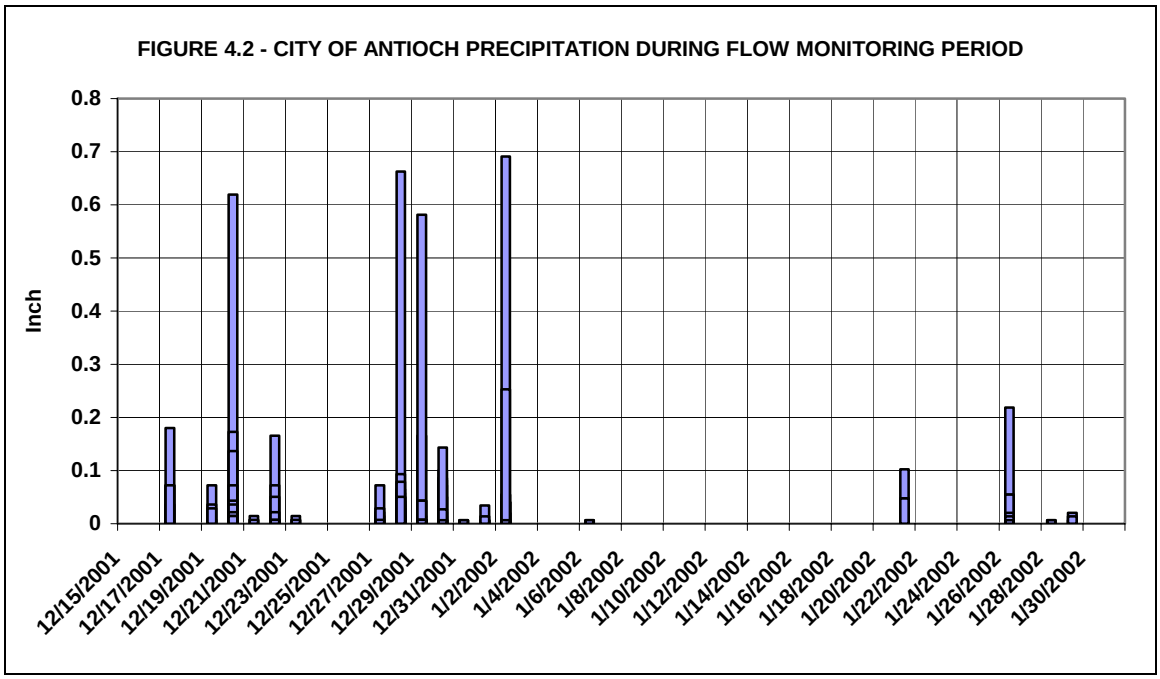
Absolute Percentage Error Between 2 Sets

Column/Row	Black Diamond	Mallory Ridge	Mount Diablo	Brentwood
Black Diamond	-	27%	55%	60%
Mallory Ridge	21%	-	67%	23%
Mount Diablo	124%	206%	-	285%
Brentwood	37%	19%	74%	-
Average	**61%**	113%	71%	154%

There is a complication of using Black Diamond Station as the reference point since it has no data after 19:00hr on December 30th, 2001. Therefore, precipitation data from Mallory Ridge Station was used to fill the data gap in the Black Diamond Station data set during the flow monitoring period. Based on mean seasonal precipitation data from Isohyetal Map, the precipitation conversion factor between Black Diamond Station and

City of Antioch is 0.72. The precipitation conversion factor between Mallory Ridge Station and City of Antioch is 0.68.

Figure 4.2 presents the City of Antioch precipitation patterns during the flow monitoring period. The data shown in Figure 4.2 is aggregated in days.



While the precipitation duration is important to determine the dry weather period, precipitation rate is critical to correlate the monitored RDI/I flows with a desired design storm. Please refer to Section D and Section F on the methodology used to determine dry weather period and design storm RDI/I based on the precipitation data.

D. Base Wastewater Flow (BWF)

Dry Weather Period

Flow data for BWF estimation should be based on dry weather flows in order to minimize contribution from GWI or RDI/I. Although the flow monitoring for this project was conducted during December and January (wet weather season), there were sufficient dry days in the flow monitoring period to estimate BWF. Figure 4.2 shows that the period between 1/7/02 and 1/20/02 has no precipitation in the City. However, the lag time in RDI/I dissipation, which relates to soil permeability and storm water infiltration rates, can prolong RDI/I contributions for several days after the storm. RDI/I dissipation is indicated in the flow monitoring data as a systematic reduction of daily wastewater flow. Using this approach, the period between 1/7/02 and 1/11/02 was not used in determining

the BWF because of possible RDI/I dissipation. Thus, the flow monitoring period between 1/12/02 and 1/20/02 was considered to have no RDI/I and data collected in this period was used to estimate BWF.

BWF for each Flow Monitoring Basin

BWF for each flow monitoring basin was determined by averaging flow monitoring data during the identified dry weather period on an hourly basis, and then subtracting GWI contributions. This calculation was used to generate a diurnal curve for each basin. The average flow from the diurnal curve in the basin was used as the BWF input for unit flow factor estimates. Table 4.2 lists the calculated dry weather BWF for each basin.

TABLE 4.2 - BWF FOR EACH FLOW MONITORING BASIN

	Flow Monitoring Basins														
BWF	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
mgd	0.20	0.51	0.62	0.24	0.77	0.19	0.46	0.77	2.62	0.19	0.54	2.62	0.48	1.03	0.83

BWF Unit Flow Factor Estimation

BWF unit flow factors are defined in terms of land use categories. The goal of the BWF unit flow factor estimation is to determine a representative unit flow factor for each land use category that can be applied to any basin with minimal deviation from the flow monitoring data. Unit flow factors for residential land use categories are in gallons/day/capita. Unit flow factors for commercial and industrial land use categories are in gallons/day/acre.

BWF unit flow factors are determined by distributing basin BWF recorded by basin flow monitors into land use categories. The distribution process is based on the following two factors:

- Within each basin, the proportional area of each land use category.
- For the entire city, the relative difference of sewer generation, per unit area, among the land use categories.

Unit flow factors are calibrated by an iteration process to minimize the variations among different flow monitoring basins. The calibration is done by adjusting the unit flow factors so that unit flow factor for each land use category remains the same in all basins with minimum error between the flow monitoring data and wastewater flow estimate based on unit flow factors.

Since the unit flow factors are estimated in area units (gpd/acre), unit flow factors for residential areas need to be converted from an area basis to a per capita basis. The conversion is based on the calibrated population density data as summarized in Table 4.3. Please refer to Chapter 5 for a description of the population density calibration.

TABLE 4.3 – CITY OF ANTIOCH POPULATION DENSITY

Land Use Category	Population Density	
	capita/dwelling unit	dwelling unit/acre
ER	3.5	0.8
LDR	3.4	2.6
MLDR	3.4	3.7
MDR	2.6	6.1
HDR	2.5	15.5
MU*	2.4	3.8

- Residential area only
- ABAG cites a City-wide average of 3.07 capita/DU

Schools are an example of a land use category that generates wastewater at a different rate than residential and commercial/industrial area. The unit flow factor for schools is estimated based on the number of enrolled students in each school. A unit flow factor of 15 gpd/student was adapted in this Master Plan. For Antioch High School and Deer Valley High School, a unit flow factor of 22.5 gpd/student was used to reflect additional sewer generation for high schools as compared to elementary and middle schools. Table 4.4 summarizes student population information for each school:

TABLE 4.4 – 2001 CITY OF ANTIOCH SCHOOL ENROLLMENT

School	Students	School	Students
Antioch HS	2589	Belshaw ES	779
Learner-Centered Charter	130	Park MS	1490
John Fremont ES	1320	Mno Grant ES	901
Antioch MS	756	John Muir ES	769
Kimball ES	695	London ES	936
John Turner ES	697	Black Diamond MS	1820
Bidwell ES	665	Deer Valley HS	3063
Marsh ES	653	Diablo Vista ES	990
Mission ES	715	John Sutter ES	763

Source: www.greatschools.net

The unit flow factors for commercial and industrial areas are area cited using units of gpd/acre. Therefore, results from Basin BWF distribution and unit flow factors

calibration can be directly applied to the capacity analysis without the need for unit conversion.

The calibrated set of unit flow factors is then re-calibrated in the hydraulic model calibration of flows. The second level calibration is to ensure that the estimated unit flow factors match the flow monitoring data so that the existing system conditions can be accurately simulated in the model. The resultant BWF unit flow factors used for the hydraulic modeling are listed in Table 4.5.

TABLE 4.5 - BWF UNIT FLOW FACTORS

Land Use Category	BWF Unit Flow Factor		Land Use Category	BWF Unit Flow Factor	
	gpd/acre	gpd/capita		gpd/acre	gpd/capita
ER	-	140	**CR**	300	-
LDR	-	140	**CO**	700	-
MLDR	-	75	**CS**	1000	-
MDR / MU	-	70	**CN**	1000	-
HDR	-	55	**CC**	900	-
MU	400*	70**	**IH**	400	-
PI	400	15 – 22.5 ***	**BP**	600	-
OS	1	-	**IL**	500	-

* Commercial / Industrial area
** Residential area
*** gpd/student for schools

Peaking Factor and Diurnal Curve

It is well-established that the wastewater flow in sewer varies during the course of the day. Consistently, sewer flow rates are greatest in the morning hours when many people are getting ready for work, school etc. A second smaller peak consistently occurs in the early evening when people return to their homes to have dinner. This cycle is commonly referred to as the “diurnal pattern” and is quantify as diurnal curve.

The peaking factor is defined as the ratio of peak daily wastewater flow to average daily wastewater flow. The peaking factor is used to estimate peak daily wastewater flow for the capacity analysis. Failure to consider peak flows can lead to underestimation of the required pipeline capacity.

The average daily wastewater flow used for calculation of the peaking factor is determined from the BWF unit flow factor as described above. The peaking daily wastewater flow, for each land use category, is estimated using the method similar to that used for the BWF unit flow factor estimation. Peak dry weather daily flow from the BWF diurnal curves was used as input data. The peaking factor is also based on land use and is categorized into four categories as shown in Table 4.6.

TABLE 4.6 - PEAKING FACTOR	
Land Use Categories	**Peaking Factor**
Residential Area	1.7
Commercial Area	2
Industrial Area	2
School	2.4

Diurnal curves for each peaking factor land use category were developed to allow the capacity analysis to account for peak period offsets among different land use areas. For development of flows for the hydraulic model analysis, both the diurnal curve and the peaking factor are applied to the BWF to develop the peak wastewater flow estimate.

Diurnal curves for each peaking factor land use category are determined by classifying each flow monitoring basin into peaking factor land use categories. By averaging the basin diurnal curves within the same peaking factor land use category, a diurnal curve for each land use category was developed. Figures 4.3 to 4.6 shows the diurnal curves for different peaking factor land use categories. Note that no adjustment on the amplitude of the diurnal curves has been made to reflect the peaking factors. The adjustment is performed in the model automatically, as described in Chapter 7, Wastewater Collection System Model.

FIGURE 4.3 - GENERALIZED DIURNAL CURVE FOR RESIDENTIAL AREAS

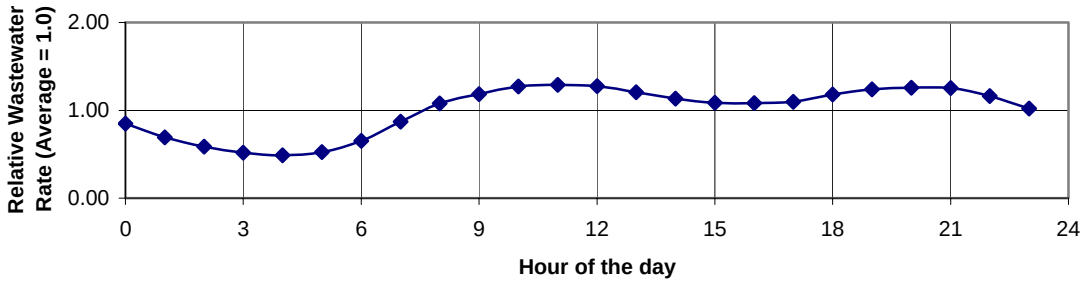


FIGURE 4.4 - GENERALIZED DIURNAL CURVE FOR COMMERICAL AREAS

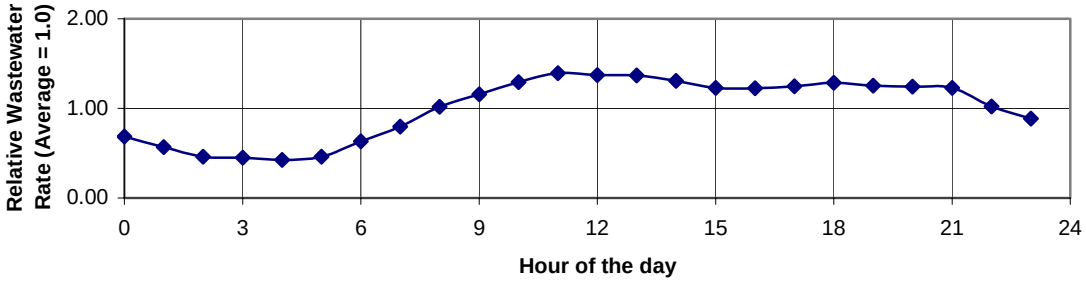


FIGURE 4.5 - GENERALIZED DIURNAL CURVE FOR INDUSTRIAL AREAS

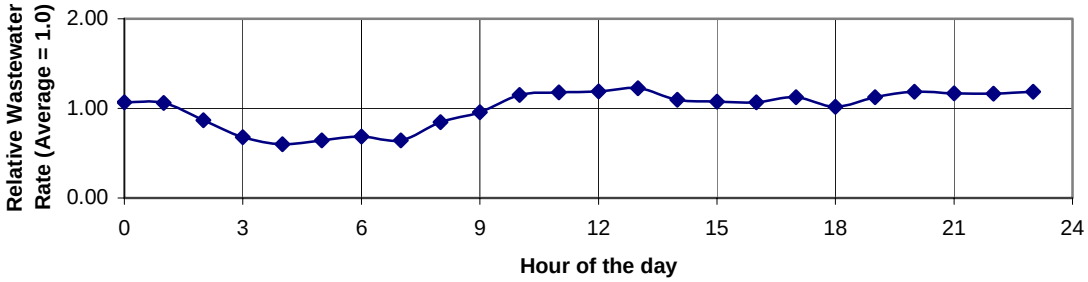
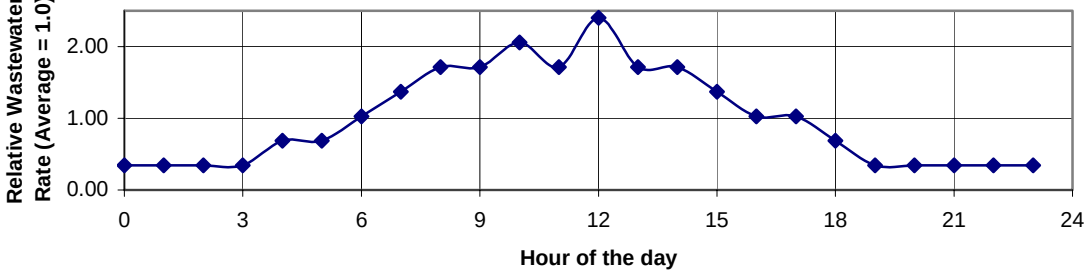


FIGURE 4.6 - GENERALIZED DIURNAL CURVE FOR SCHOOLS



E. Groundwater Infiltration (GWI)

Of the components of the design flow, GWI typically has less contribution to the sewer system load than BWF and RDI/I. Failure to account for GWI, however, may lead to underestimation of required pipeline capacity. GWI mainly depends on local geologic properties, groundwater levels, and the condition of the pipelines, manholes, and building connections in the system. While GWI may have seasonal fluctuations, the effects on the sewer system are not as variable as RDI/I. GWI is estimated as a constant parameter for each flow monitoring basin. The units of GWI are gpd/acre or gpd/capita.

GWI is estimated by assuming 20% of the minimum dry weather flow, determined by considering the measured flow in the early morning between 3:00 and 5:00 am, is GWI. This is equivalent to 20% of the daily minimum flow from the BWF diurnal curve. Table 4.7 summarizes the GWI estimates for each flow monitoring basin.

TABLE 4.7 - GWI ESTIMATE SUMMARY

	Flow Monitoring Basins														
GWI	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
gpd /acre	39	62	22	145	335	104	49	145	149	30	97	149	27	162	64
gpd / capita	2.1	3.4	1.6	4.4	13.8	7.0	2.8	4.4	14.6	2.1	7.3	14.6	2.4	13.8	4.9

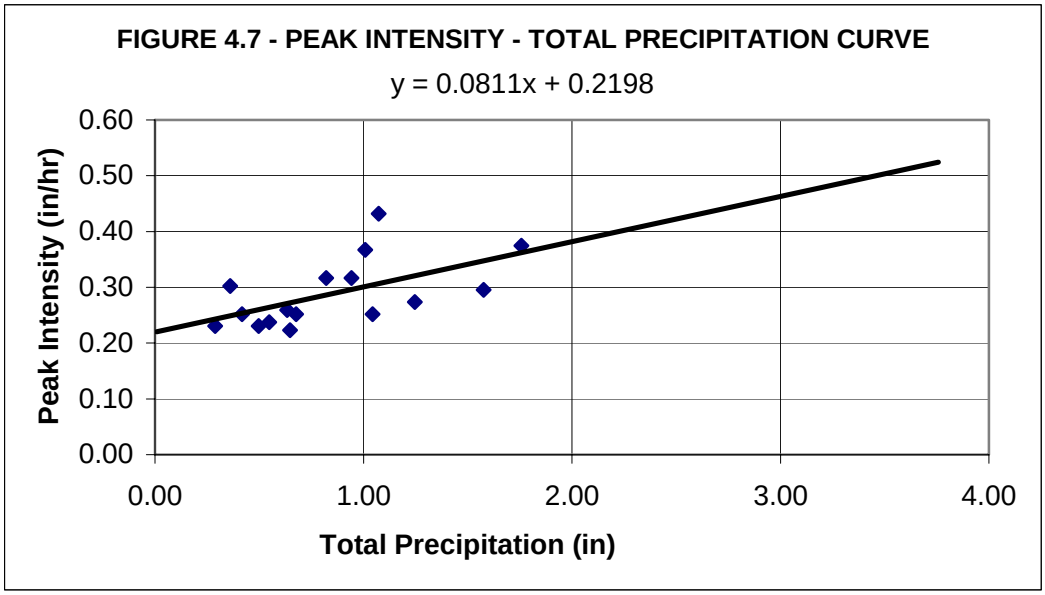
While GWI for each flow monitoring basin has a basin specific unit flow factor, GWI for new pipe is estimated to be 40 gpd/acre, or 3.3 gpd/capita. This is based on the assumption that new pipes will have better joint sealant, better pipeline materials, and better construction than older, existing pipes, and as such, infiltration will be minimized.

F. Rain Dependent Infiltration/Inflow (RDI/I)

Design Storm Analysis

Three design storm scenarios are considered in the peak wet weather capacity analysis: 5-year storm, 25-year storm and 100-year storm. It is necessary to estimate the design storm intensity in order to estimate the RDI/I for each analysis scenario. Storm intensity is derived from historical precipitation data.

Hourly rain data between April 28, 1997 and June 7, 2002 were used for estimation. Storm events with high peak storm intensity or large total precipitation were identified and plotted on a peak intensity - total precipitation curve. The curve was then fitted using linear regression, as shown in Figure 4.7.



Design storm duration, peak intensity and total precipitation were estimated iteratively by matching the design storm peak intensity estimated from two sources:

- Figure 4.7, Peak Intensity – Total Precipitation Curve, and
- Contra Costa County Flood Control and Water Conservation District Precipitation Duration Frequency Depth Curve and Rainfall Distribution Coefficient data.

The objective is to determine a design storm duration for which estimates from both sources agree with each other. The results are summarized in Table 4.10.

TABLE 4.8 – DESIGN STORM SUMMARY		
Year	Precipitation	Peak Intensity
	Inch	Inch/Hour
5	2.25	0.38
25	3.05	0.52
100	4.10	0.70
Note: Design Storm Duration is 24 hours		

The findings are consistent with the design storm parameters used for the Delta Diablo Sanitation District Conveyance System Master Plan (September 1996) as well as the Central Contra Costa Sanitary District Waste Water Collection System Master Plan (October 1986).

RDI/I from Flow Monitoring Data

During the flow monitoring period, monitoring data from three storm events were used to estimate RDI/I:

Storm 1: December 28, 2001 06:00hr to December 29, 2001 04:00hr (0.82" in 22 hrs.)
Storm 2: December 30, 2001 13:00hr to December 31, 2001 00:00hr (0.65" in 11 hrs.)
Storm 3: January 1, 2002 21:00hr to January 2, 2002 17:00hr (0.70" in 20 hrs.)

Storm 1 was actually a combination of two storms with a 2-hour gap. Since the two storm events are so close in time, RDI/I could not be identified for each individual storm and therefore they are combined into a single storm in the calculation of RDI/I.

Total RDI/I for each storm event at each monitoring service area can be determined by RDI/I flow hydrograph summation. RDI/I flow hydrographs were calculated by subtracting the flow monitoring data from BWF and GWI hydrographs for each flow monitoring basin. RDI/I hydrographs were calculated separately for weekdays and weekends due to significant differences in BWF patterns, especially for residential areas. Average RDI/I for the storm events are as follows:

Storm 1: 302 gpd/acre
Storm 2: 264 gpd/acre
Storm 3: 287 gpd/acre

RDI/I for Design Storms

RDI/I for design storms was estimated using the following equation:

RDI/I (design storm) = P_d * Median (RDI/I / P_s)

where: P_d = Total Precipitation of the design storm
RDI/I = RDI/I of the storm events during flow monitoring period
P_s = Total Precipitation of the storm events during flow monitoring period

Table 4.11 summarizes RDI/I estimates for various design storms for each flow monitoring basin. RDI/I in per area unit (gpd/acre) and in per capita unit (gpd/capita) are shown.

TABLE 4.9 - RDI/I FOR DESIGN STORMS

RDI/I (gpd/acre)	Flow Monitoring Basins														
Design Storm	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
5-yr storm	106	208	87	405	653	1953	1612	405	22	188	982	22	2417	2232	1061
25-yr storm	143	282	117	549	886	2647	2184	549	30	255	1332	30	3277	3025	1439
100-yr storm	193	379	158	738	1190	3559	2937	738	40	343	1790	40	4405	4067	1934
RDI/I (gpd/capita)	**Flow Monitoring Basins**														
Design Storm	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
5-yr storm	5.8	11.6	6.2	12.4	27.0	132.2	94.2	12.4	2.2	13.1	73.9	2.2	211.3	190.8	80.8
25-yr storm	7.9	15.7	8.4	16.8	36.5	179.2	127.8	16.8	2.9	17.8	100.2	2.9	286.4	258.6	109.5
100-yr storm	10.6	21.2	11.2	22.5	49.1	240.9	171.7	22.5	4.0	23.9	134.7	4.0	385.0	347.6	147.2

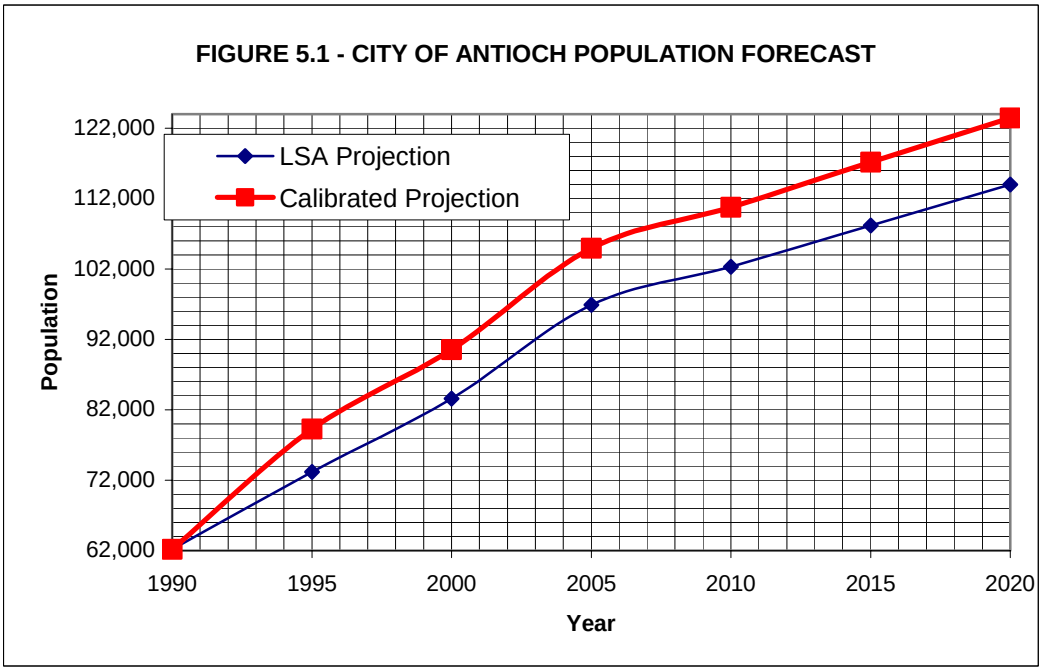
While RDI/I for each flow monitoring basin has a basin specific unit flow factor, the RDI/I for new pipe is 400 gpd/acre, or 33.3 gpd/capita. Similar to the approach to determining GWI, RDI/I for future development is based on the assumption that new pipes will have better joint sealant, better pipeline material and better construction such that infiltration will be minimized.

A. Population Data

Since unit flow factors for residential areas are calculated on a per capita basis, accurate population data is required to determine the residential design flow for capacity analysis. Population data for the City of Antioch is available from two sources:

- City of Antioch's planning consultant, LSA Associates. Projection data from LSA estimation in 2002 (LSA's forecast) is based on a study done by ABAG in December 1999. The time frame of the projection is from 1990 to 2020.
- 2000 Census data for the City of Antioch, from the national census conducted by the U.S. Department of Commerce.

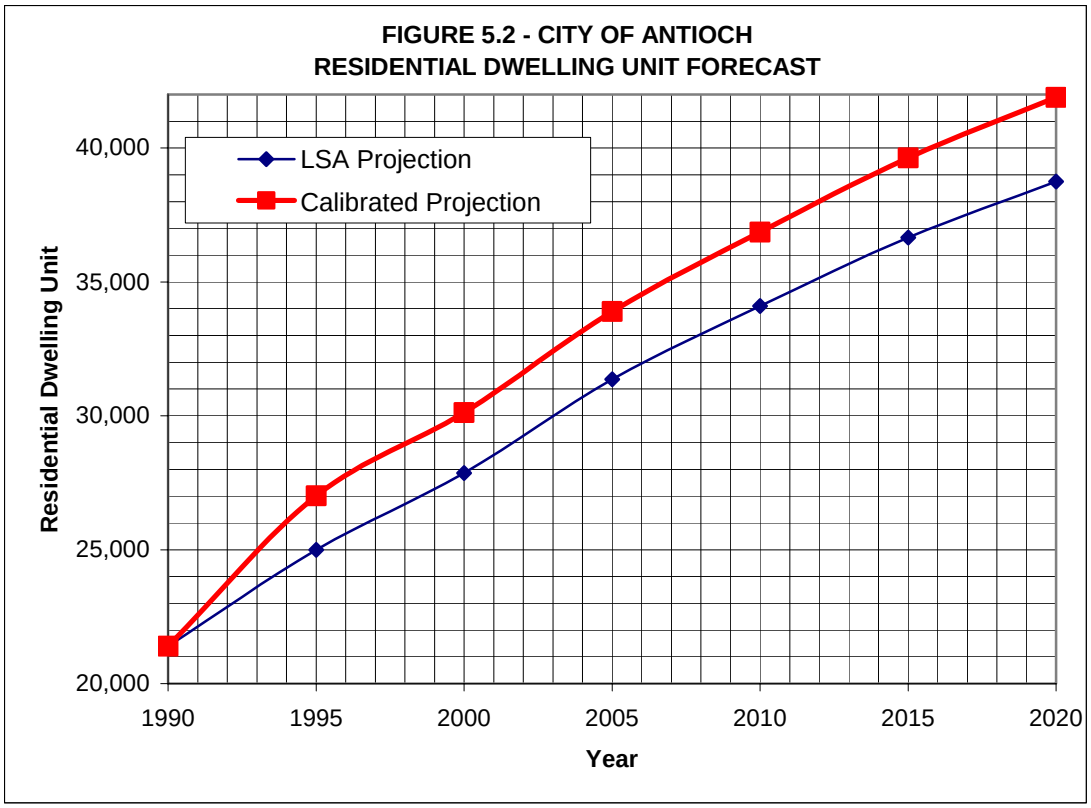
Population projections from LSA were made using 1990 Census data. When comparing LSA population projections with 2000 Census data, LSA's forecasts for City population at year 2000 was about 7000 people less than the U.S. census data. For purposes of determining the population to use for this project's hydraulic modeling, LSA's forecast is calibrated based on population data from the 2000 Census. However, the rate of population growth is assumed to remain the same as LSA original projections. Figure 5.1 shows the population forecasts from LSA as well as the calibrated population projection used for this Master Plan.



Note that the population projections only include developments within the current City limits, which includes Future Urban Area 1 (FUA-1) in the Sand Creek area. Future developments outside the current City limit including Roddy Ranch and Ginocchio areas are not considered in the projection.

B. Residential Dwelling Unit Data

In addition to population data, LSA's forecast also contains residential dwelling unit projections. Based on 2000 Census data, LSA's forecast was calibrated in a similar manner as the population projection calibration. Both projections are shown in Figure 5.2. The calibrated projections of residential dwelling units are used in the hydraulic modeling calculations for present wastewater flow and future flow projections.



C. Planning Horizon

Population and residential dwelling unit forecasts are based on 2000 Census data with projection time steps of 5 years, up to year 2020. In this Master Plan, in addition to years 2002, 2007 and 2012 planning time steps, a buildout scenario that includes all of the

City's planned developments is also considered. Although there is no specific development schedule for the buildout scenario, population and residential dwelling unit projections at year 2020 were used for the buildout scenario capacity analysis. Table 5.1 summarizes population and residential dwelling unit projections at each time step used in the Master Plan.

TABLE 5.1 - POPULATION AND RESIDENTIAL DWELLING UNIT PROJECTIONS

	Planning Scenario (date)			
	2002	2007	2012	Buildout
Population (persons)	96,300	108,000	113,500	123,500
Residential Dwelling Unit (RDU)	31,600	35,000	38,000	41,900

D. Population Density

Population densities of residential land use categories were estimated using existing City of Antioch land use distribution information and 2002 population and residential dwelling unit data as determined by calibration of LSA's projections (described in Sections A and B above).

Estimating population density was approached as an iterative process. The objective was to match the population and residential dwelling unit data with the value calculated from population density and total area of each residential land use category by adjusting the density at each iteration. The initial population density set was taken from the 1990 City of Antioch General Plan.

The calculated City of Antioch population density is summarized in Table 5.2.

TABLE 5.2 – CITY OF ANTIOCH POPULATION DENSITY

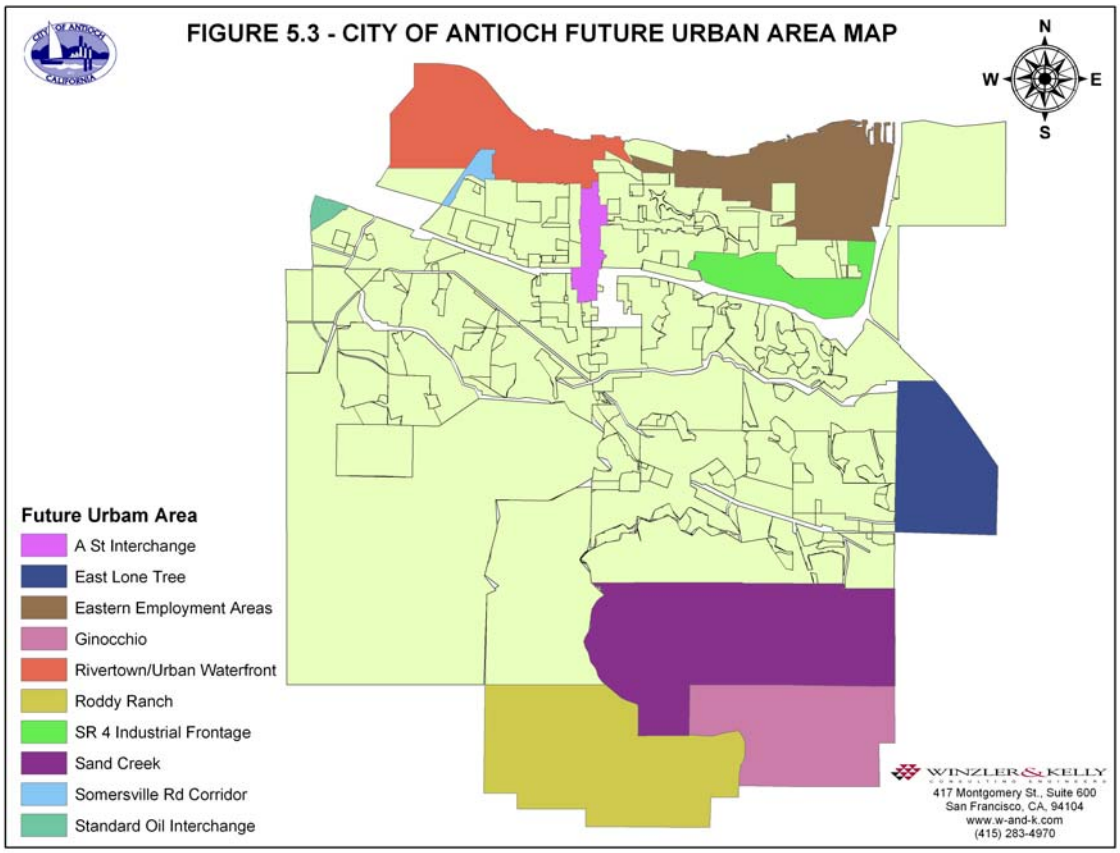
Land Use Category	Population Density	
	capita/dwelling unit	dwelling unit/acre
ER	3.5	0.8
LDR	3.4	2.6
MLDR	3.4	3.7
MDR / MU	2.6	6.1
HDR	2.5	15.5
MU*	2.4	3.8

* Residential area only

As to verify the result, the estimated average population density in 2002 is 3.03 capita/dwelling unit. It is closely match to ABAG's density estimate of 3.07 capita/dwelling unit for 2000.

E. Land Use Projection

The City of Antioch has experienced significant development in the last decade. The development focus has been mainly in the southern part of the City. Based on the City's planning information, the development focus for the next 10 to 20 years will continue to be in the southern part of the City. In addition, it is expected that the western part of the City and the waterfront area will have significant redevelopment and expansion. On the eastern part of the City, it is anticipated that commercial and industrial development will undergo improvement and expansion along Highway 4. The City of Antioch has organized the future development into 10 focus areas, as summarized in Figure 5.3.



Note that the Roddy Ranch and Ginocchio future urban areas are outside of the current City limit, but within the City's planning limit. Because of the recent adjustment of Urban Limit Line (ULL), Roddy Ranch and Ginocchio future urban areas are now outside of ULL. Hence it may become undevelopable in the future. Therefore, in the

capacity analysis, projected wastewater flows from these two areas are analyzed separately from total wastewater flow in the City so that their influence to the City wastewater collection system can be included or eliminated in the future.

To develop the future scenarios for capacity analysis, total population growth and non-residential land use expansion were distributed in focus areas based on existing land use designation, total area of the focus area, current population, and the areas of developed non-residential parcels.

Since the development time frame depends on various uncertainties such as local economy, housing demand, development regulations and City funding, it is difficult to estimate an exact development plan in terms of land use distribution and development time frame for each focus area. Development projections are generalized for residential and non-residential areas, as described in the following sub-sections. The Mixed Use (MU) land use category is assigned to focus areas that currently have no specific land use plan. In Mixed Use areas, it is assumed that 40% of the total area is for non-residential use while 60% of the total area is for medium and medium-low density residential development.

Residential Development Projection

Residential development projections are based on City population projections, residential dwelling unit projections, and population densities of residential land use categories. Population growth is distributed among focus areas so that the total population and the residential dwelling unit increases match the projected population and residential dwelling unit data in Table 5.1.

Non-residential Development Projection

Non-residential development projections are based on an assertion that in the buildout scenario all available land with residential, commercial or industrial designations will be developed in accordance with the general plan. By comparing the total commercial and industrial areas between the existing condition and the buildout scenario, the total area of non-residential development to be developed at buildout can be calculated.

LSA's forecast projected a linear job market growth in the City of Antioch between 2000 and 2020, as shown in Figure 5.4. Since job creation is usually proportional to non-residential development, the total non-residential developed area is assumed to linearly increase between 2000 and 2020. The resultant non-residential development projections are shown in Figure 5.5.

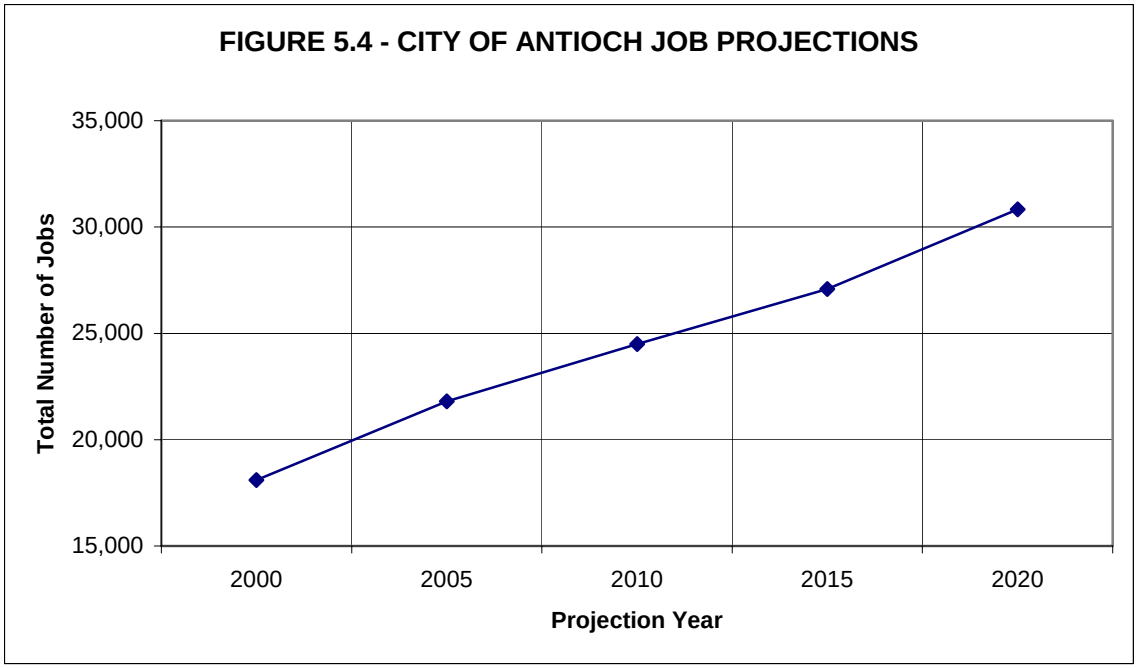
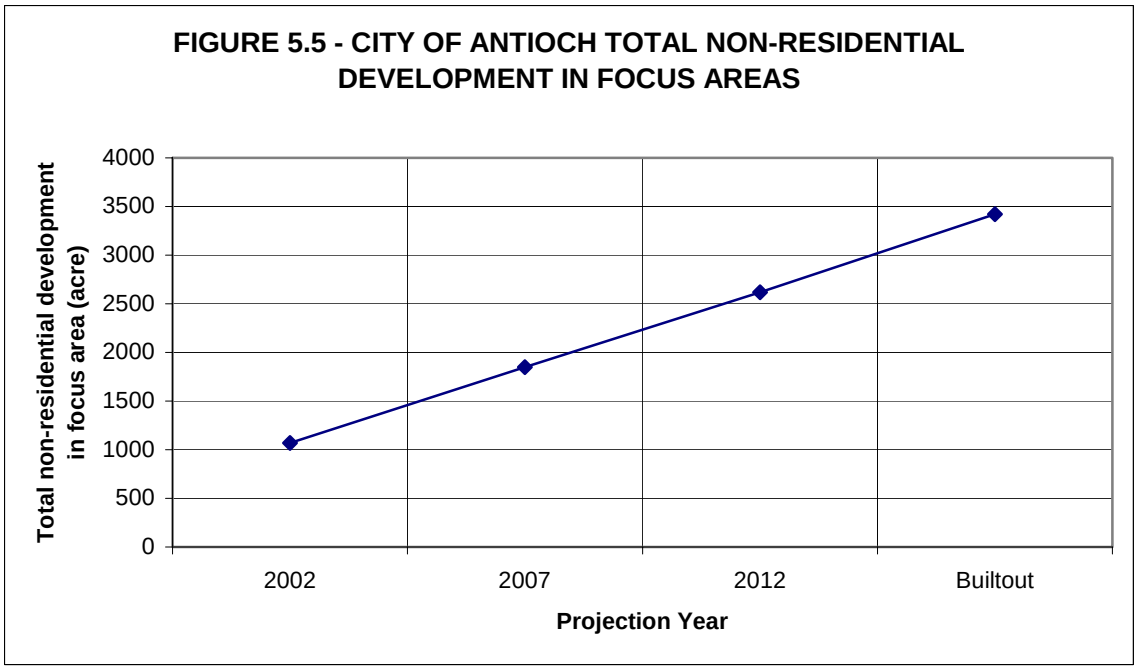


Figure 5.5 summarized total non-residential area in focus areas within the City limit for each future scenario.



Chapter VI DESIGN FLOWS AND DESIGN CRITERIA

A. Design Flows

In the capacity analysis, design flows are calculated based on the following equations:

- Residential Wastewater Flow = population x BWF unit wastewater factor in gpd/capita
- Non-residential Wastewater Flow = commercial/ industrial land use in acres x BWF unit wastewater factor in gpd/acre
- Groundwater Infiltration = population x GWI unit flow factor
- Rain Dependent Infiltration and Inflow = population x RDI/I unit flow factor

The forecasts are based on unit flow factors as described in Chapter 4, and population and land use forecasts as described in Chapter 5. Tables 6.1 and 6.2 summarize unit flow factors for BWF, GWI and RDI/I from Chapter 4.

TABLE 6.1 - BWF UNIT FLOW FACTORS

Land Use Category	BWF Unit Flow Factor		Land Use Category	BWF Unit Flow Factor	
	gpd/acre	gpd/capita		gpd/acre	gpd/capita
ER	-	140	**CR**	300	-
LDR	-	140	**CO**	700	-
MLDR	-	75	**CS**	1000	-
MDR / MU	-	70	**CN**	1000	-
HDR	-	55	**CC**	900	-
MU	400*	70**	**IH**	400	-
PI	400	15 – 22.5 ***	**BP**	600	-
OS	1	-	**IL**	500	-

* Commercial / Industrial area
** Residential area
*** gpd/student for schools

TABLE 6.2 - SUMMARY OF GWI AND RDI/I ESTIMATES																
Design Storm	**Flow Monitoring Basins**															
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**NEW**
GWI (gpd/capita)																
All	2	3	2	4	14	7	3	4	15	2	7	15	2	14	5	3
RDI/I (gpd/capita)																
5-yr storm	6	12	6	12	27	132	94	12	2	13	74	2	211	191	81	33
25-yr storm	8	16	8	17	37	179	128	17	3	18	100	3	286	259	110	33
100-yr storm	11	21	11	23	49	241	172	23	4	24	135	4	385	348	147	33

In capacity analysis, unit flow factors, population and land use information are substituted into design flow equations. Design flow equations calculate design flow for each land use parcel, and are summed up and inserted into the wastewater system model to simulate varies design flow scenarios. The procedure is outlined in the following section.

B. Design Flow Scenarios

Design flows from different forecast years and different design storms are combined to create design flow scenarios for the capacity analysis. There are five design flow scenarios considered in this Master Plan in each of the five planning scenarios. Design flow scenarios in each forecast year are defined based on the following wastewater generation assumptions:

- Average Dry Weather Flow = [Residential Wastewater Flow] + [Non-residential Wastewater Flow] + [Groundwater Infiltration]

- Peak Dry Weather Flow = [Residential Wastewater Flow] x [Peaking Factors in Diurnal Curve] + [Non-residential Wastewater Flow] x [Peaking Factors in Diurnal Curve] + [Groundwater Infiltration]

- Peak Wet Weather Flow (Design Storm) = [Residential Wastewater Flow] x [Peaking Factors in Diurnal Curve] + [Non-residential Wastewater Flow] x [Peaking Factors in Diurnal Curve] + [Groundwater Infiltration] + [Rain Dependent Infiltration and Inflow (Design Storm)]

In each forecast year, Peak Wet Weather Flow scenarios for 5-year, 25-year and 100-year design storms were developed. Peaking factors for different land uses are summarized in Table 6.3. Please refer to Chapter 4 for details on peaking factors and diurnal curves estimation.

TABLE 6.3. - PEAKING FACTOR	
Peaking Factor Land Use Categories	**Peaking Factor**
Residential Area	1.7
Commercial Area	2
Industrial Area	2
School	2.4

Table 6.4 summarizes total flow generation in each design flow scenario.

TABLE 6.4 - DESIGN FLOW SCENARIOS SUMMARY					
Design Flow Scenario	**2002**	**2007**	**2012**	**Buildout**	**Buildout***
Total Wastewater Flow from south Antioch through Bridgehead Pump Station (mgd)					
Average Dry Weather Flow	2.6	3.7	4.8	6.0	8.1
Peak Dry Weather Flow	4.4	6.3	8.3	10.4	14.4
Peak Wet Weather Flow with 5-year Storm	7.2	9.7	12.3	15.0	19.9
Peak Wet Weather Flow with 25-year Storm	8.2	10.9	13.7	16.4	21.9
Peak Wet Weather Flow with 100-year Storm	9.5	12.4	15.4	18.5	24.4
Total Wastewater Flow from Other Parts of the City (mgd)					
Average Dry Weather Flow	5.1	5.8	6.3	6.8	6.8
Peak Dry Weather Flow	9.6	10.3	11.2	12.1	12.2
Peak Wet Weather Flow with 5-year Storm	12.7	13.7	14.6	15.6	15.7
Peak Wet Weather Flow with 25-year Storm	13.2	14.1	15.2	16.1	16.3
Peak Wet Weather Flow with 100-year Storm	13.9	14.9	15.9	16.9	17.1
Total Wastewater Flow from City of Antioch (mgd)					
Average Dry Weather Flow	7.7	9.6	11.2	12.8	14.9
Peak Dry Weather Flow	13.9	16.7	19.5	22.5	26.6
Peak Wet Weather Flow with 5-year Storm	19.9	23.3	26.9	30.5	35.6
Peak Wet Weather Flow with 25-year Storm	21.4	25.0	28.8	32.5	38.2
Peak Wet Weather Flow with 100-year Storm	23.3	27.3	31.3	35.4	41.5
Buildout* includes Roddy Ranch and Ginocchio future urban areas that are currently outside City limit.					

After the design flow scenarios are calibrated and verified with the flow monitoring data (as discussed in Chapter 7, Wastewater Collection System Model), to verify the accuracy of the design flow scenarios, estimates from this Master Plan were compared to flow projections from the DDSD Conveyance System Master Plan. Specifically, design flows from Fulton Shipyard Pump Station and Bridgehead Pump Station in Buildout scenarios in the DDSD Master Plan were used for verification, as summarized in Table 6.5.

TABLE 6.5 DDSD CONVEYANCE SYSTEM MASTER PLAN DATA		
DDSD Conveyance System Master Plan		
Location	**Peak Dry Weather Flow (mgd)**	**Peak Wet Weather Flow (mgd)**
Bridgehead Pump Station	10.5	9.7
Fulton Shipyard Pump Station	12.8	13.9
City of Antioch Wastewater Master Plan		
Location	**Peak Dry Weather Flow (mgd)**	**Peak Wet Weather Flow (mgd)**
Total Wastewater Flow from south Antioch through Bridgehead Pump Station	10.4	15
Total Wastewater Flow from other parts of the City	12.1	15.6

The comparison shows that the flow estimates agree with DDSD's estimates except for peak wet weather flow. The deviation is due to different definitions of peak wet weather flow in the two studies. This Master Plan includes peak BWF in the peak wet weather flow calculation while DDSD uses average BWF for their peak wet weather flow estimates.

C. Design Criteria

The design criteria are estimated based on the existing condition of the sewer system and typical values that are commonly used in sewer pipeline design. The following pipeline and manhole properties are established as the design criteria for capacity analysis and CIP development:

- Standard manhole diameter: 4 feet

- Friction factors based on pipeline material and relative age (as defined in Chapter 3):

	VCP Pipe	**RCP Pipe**
New Pipe	0.013	0.015
Old Pipe	0.017	0.016

- Maximum new pipe design capacity in terms of d/D (sewer depth/ pipe diameter):

	Pipe Diameter < 12”	**Pipe Diameter >= 12”**
d/D	0.75	0.9

- Minimum pipe flow velocity: 2.0 feet / second

- Minimum diameter for new and replacement pipe: 8 inches

In capacity analysis, friction factors and standard manhole size are input into the model so that capacity deviation due to different pipe material and manhole headloss can be accurately simulated. In CIP development, maximum capacity, minimum diameter and minimum velocity are used as a guideline to determine the appropriate new pipe size recommendations.

Chapter VII WASTEWATER COLLECTON SYSTEM MODEL

A. Modeling Software

A major component of the Master Plan is to develop a computer model to simulate present and future sanitary sewer system conditions and evaluate pipeline capacity. Results are used to identify pipelines and manholes that need upgrading in the Capital Improvement Program.

Given the importance of the hydraulic modeling in the Master Plan, it is important to select a cost effective modeling software that will provide an accurate and efficient modeling platform as well as flexibility for model expansion. In addition, since the City will use the model for the sanitary sewer system analysis after the Master Plan project is completed, the modeling software must be compatible with the City's GIS system so that the City can easily update the model in the future.

Four modeling software options were evaluated:

- SEWERCAD 5.0 by Haestad Methods
- H_2OMAP Sewer 2.5 by MWH Soft, Inc.
- Sanitary Sewers V2000 Q4 by Eagle Point Software Corporate
- HYDRA 6.2 by Pizer, Inc.

After careful consideration of modeling capability, compatibility with various input and output formats, expandability for future use, and cost, Winzler & Kelly recommends HYDRA 6.2 from Pizer, Inc for hydraulic modeling in the Master Plan.

HYDRA 6.2, an industry standard developed in 1973, outperforms other modeling software options at a much lower cost. It supports models with unlimited numbers of pipelines; it has unique features in flow generation, peaking factor calculation, and infiltration analysis; it is fully compatible with the City's GIS database for easy data transfer; it provides comprehensive technical support, and maintenance and upgrade service. The cost of HYDRA 6.2 is $4,500 per individual license, plus $1,250 per year for maintenance and upgrade privileges.

B. Model Structure

Sewer System

The City of Antioch's sewer system consists of approximately 282 miles of pipeline ranging from 4-inches to 68-inches in diameter and 5,300 manholes, cleanouts, and other

access structures. For this master plan, however, only 43 miles of pipeline, five diversion structures (flow split) and 803 manholes are included in the model. For the purposes of this analysis, only major pipelines were modeled (mostly 10-inch diameter and larger) because deficiency of these sections would have significant impacts on the overall system performance. A small number of pipe sections with smaller diameters were included in the model to resolve model discontinuity.

The diversion structures are modeled as an overflow pipe in a manhole. The upstream pipe enters the manhole and two pipes are available to carry the flow downstream. The input data describe the percent of flow spilt between the two downstream pipes based on pipe diameter.

In addition to the City's sewer system, components of the DDSD conveyance system, as described in Chapter 3, are included in the model to enhance system integrity. This model expansion allows a more complete analysis of the sewer system so that the City can better evaluate capital improvement needs for future development.

Figure 7.1 shows the City of Antioch sewer system modeled in HYDRA. Geometry and most of the sewer system data are directly imported into HYDRA from the City's GIS database, with field verification provided by Winzler & Kelly, as needed.

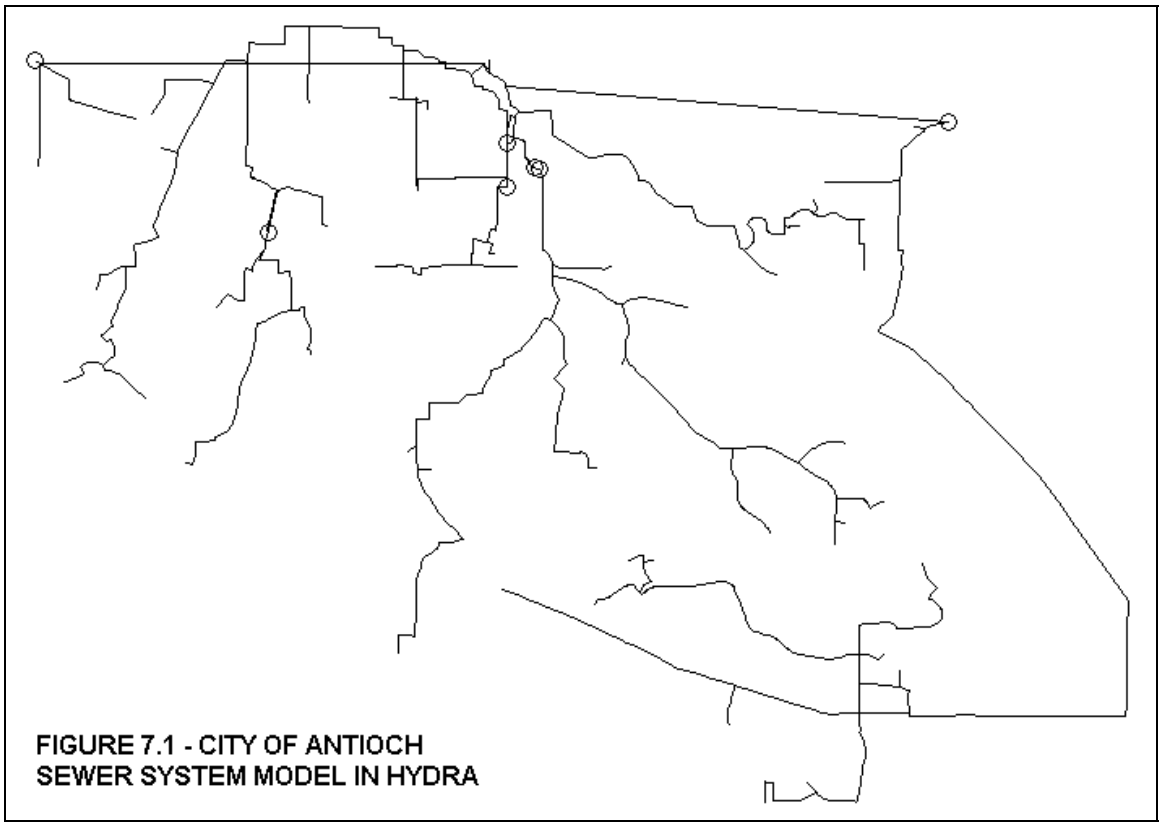


FIGURE 7.1 - CITY OF ANTIOCH SEWER SYSTEM MODEL IN HYDRA

Flow Generation

In addition to the sewer system layout shown in Figure 7.1, the sewer system model also has land use area and sanitary service area information that is used for wastewater generation. This data is shown in Figures 7.2 and 7.3. The dots represent the centroid of the areas defined for land use and sewer service area, and serve as the point of application in the model.

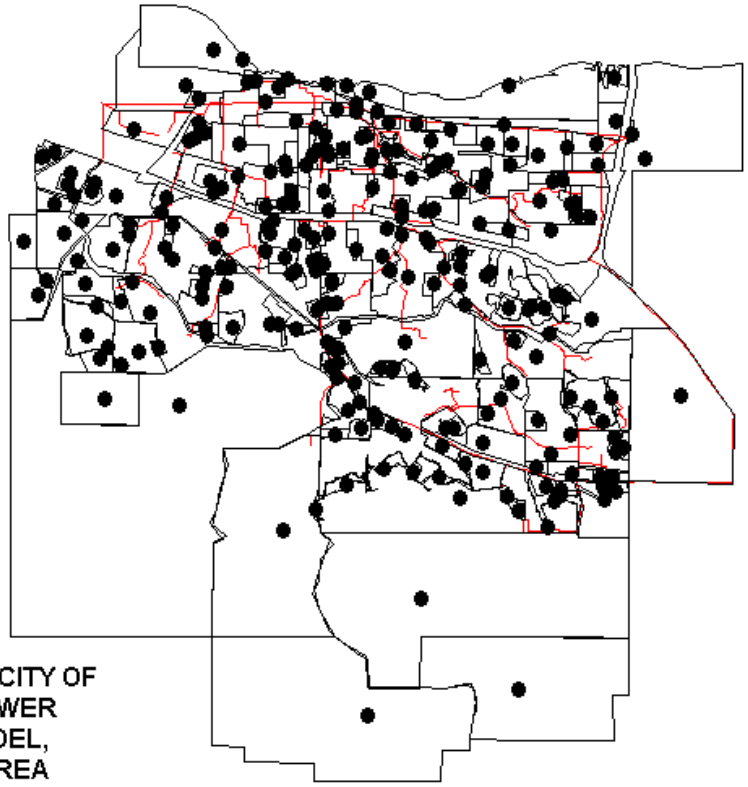


FIGURE 7.2 - CITY OF ANTIOCH SEWER SYSTEM MODEL, LAND USE AREA

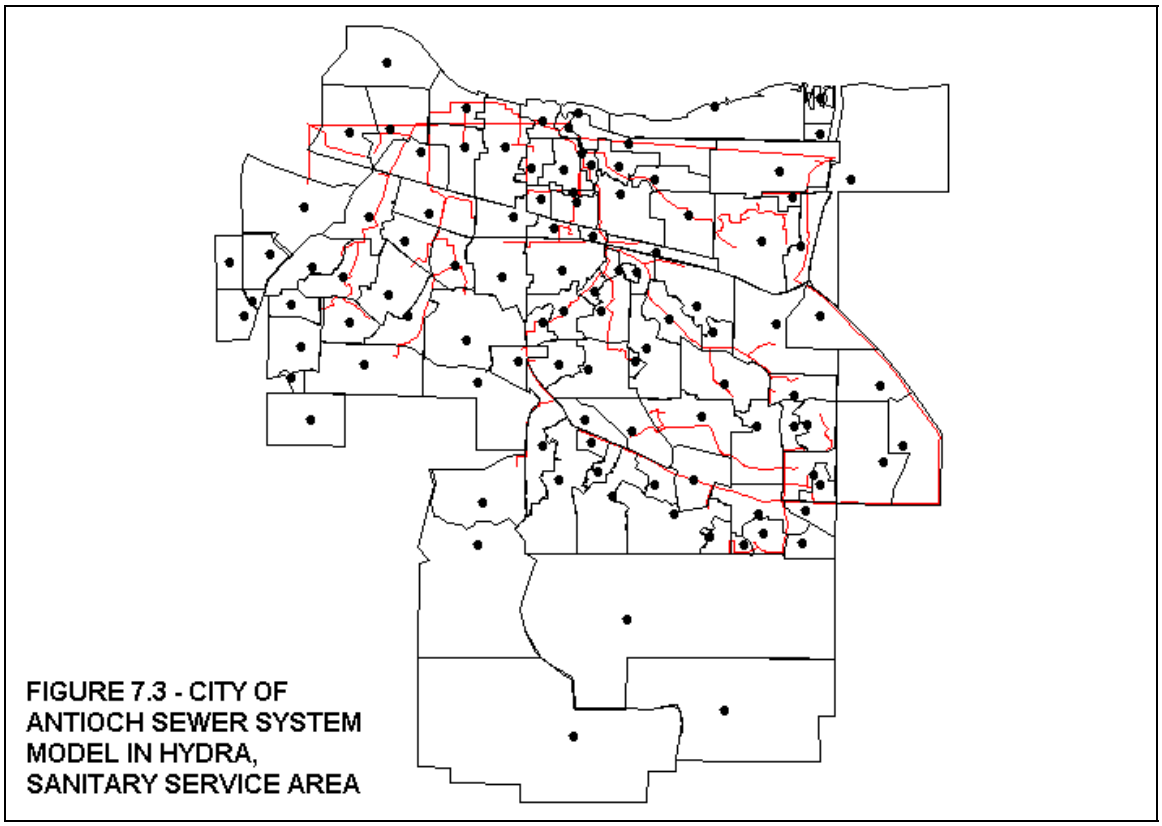


FIGURE 7.3 - CITY OF ANTIOCH SEWER SYSTEM MODEL IN HYDRA, SANITARY SERVICE AREA

In the HYDRA model, BWF is generated within each land use parcel in the land use area layer. The algorithm is outlined in Chapter 6 under design flow section. BWF in each land use parcel is routed from land use areas into sanitary service areas. Each sanitary service area collects BWF from the portions of land use parcels within its collection boundary, and then the total flow is calculated for each sanitary service area. The inputs for this calculation are based on BWF input and land use-based diurnal curves.

Total BWF in each sanitary service area is then injected into the system through the centroid connector. The centroid connector is a modeling tool (dummy link) that connects a sanitary service area parcel to the sewer collection system. The selection of the centroid connection point in the sewer system depends on the specific pipe configurations in each parcel. In general, to ensure the capacity analysis is conservative, it is desirable to locate the connection point as far upstream in the portion of collection system within each service area as possible. Figure 7.4 shows typical centroid connectors in the model.

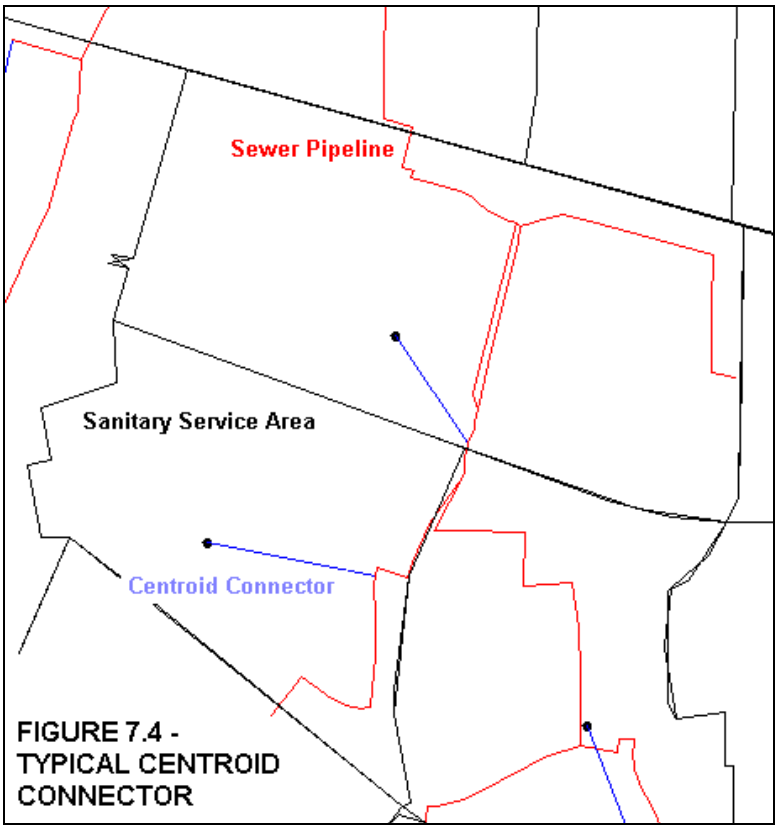


FIGURE 7.4 - TYPICAL CENTROID CONNECTOR

For infiltration and inflow (I/I) -related flow including GWI and RDI/I, the point injection method was used to input the flow into the system. Total I/I for each sanitary service area was injected into the same point in the system as the location of the centroid connector.

Pipe Sections with Negative Slope

Pipe sections with negative slope are a rare and undesirable configuration in a gravity sewer system since all negative sections need to be surcharged and pressurized in order to build up enough head to transport wastewater through the section. This results in very low wastewater velocities, solid deposition, and excessive maintenance requirements. While HYDRA calculates capacity required for negative slope sections, it does not calculate improvement recommendations. Therefore, all negative slope sections in the sewer system were modeled with minimal positive slope (0.0003) so that the model can generate improvement recommendations. Manual interpretation of these sections is required. Figure 7.5 shows the sections with negative slope that were adjusted for modeling purposes. A listing of negative slope sections is included in Appendix C.

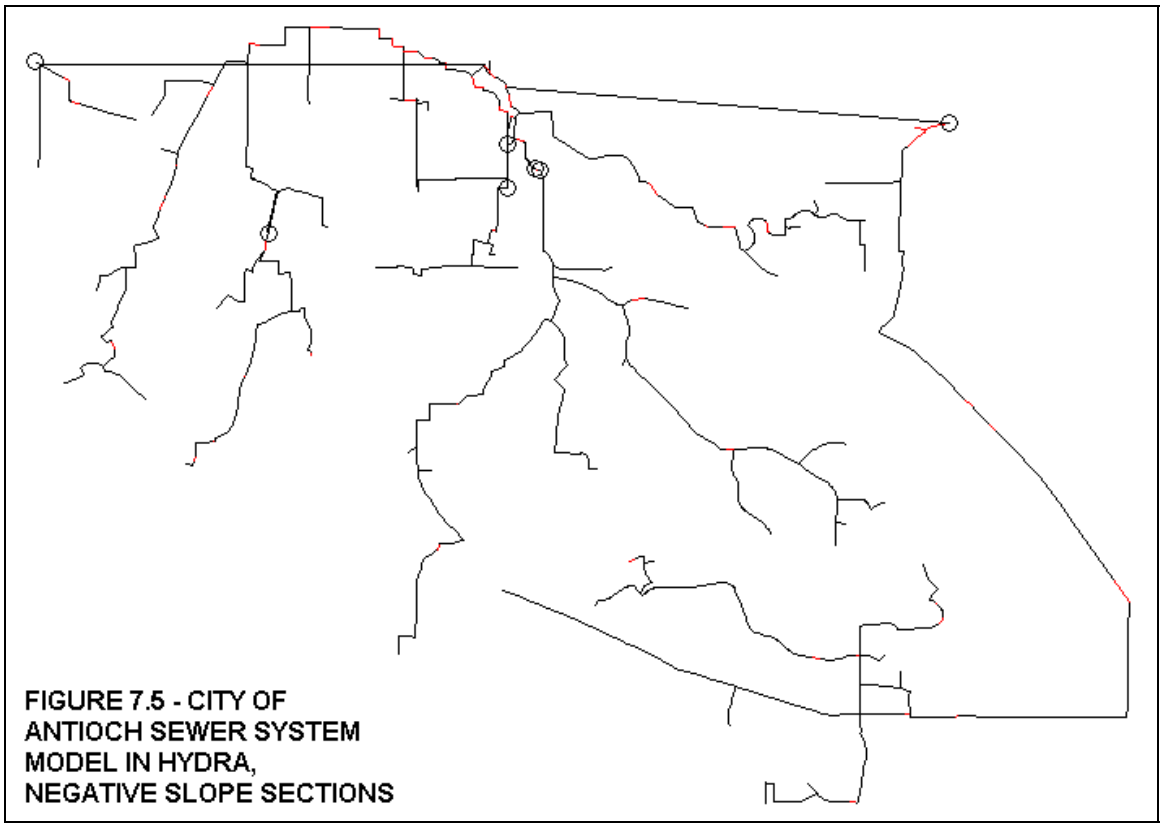


FIGURE 7.5 - CITY OF ANTIOCH SEWER SYSTEM MODEL IN HYDRA, NEGATIVE SLOPE SECTIONS

C. Model Calibration

Calibration of the sewer model was accomplished by comparing the results of the computer runs with flow monitoring data. Table 7.1 summarizes the calibration results.

TABLE 7.1 - CITY OF ANTIOCH SEWER MODEL CALIBRATION RESULTS SUMMARY

Flow Monitoring Site	Flow Monitoring MH ID	Model ID	Flow Monitoring Data (mgd)	Model Output (mgd)	Different (mgd)	Absolute Percentage Error
1	G21-1-040	4	0.21	0.27	0.07	31.59%
2	G21-5-007	236	0.55	0.51	-0.04	6.61%
3	G21-8-024	277	0.66	0.80	0.14	20.63%
4	F21-9-006 w	745	0.81	0.71	-0.10	12.34%
5	F21-9-006 s	801	1.54	1.58	0.05	3.02%
6	F22-2-047	83	0.21	0.22	0.00	1.51%
7	F22-6-093	104	0.59	0.48	-0.11	19.02%
8	F22-6-066	114	3.04	3.16	0.12	3.84%
9	F22-9-046	188	3.22	2.72	-0.51	15.68%
10	F22-9-042	190	0.20	0.36	0.16	78.02%

TABLE 7.1 - CITY OF ANTIOCH SEWER MODEL CALIBRATION RESULTS SUMMARY						
11	G22-7-058	162	0.61	0.55	-0.05	8.72%
12	G22-9-007	362	1.02	1.15	0.13	12.52%
13	G24-1-008	795	2.58	2.32	-0.26	10.17%
14	J23-9-021	723	1.17	0.90	-0.27	22.81%
15	J23-9-066	690	0.91	1.08	0.17	18.17%
				Model Calibration Error		**17.64%**
* Calibration scenario: 2002 average wastewater flow						

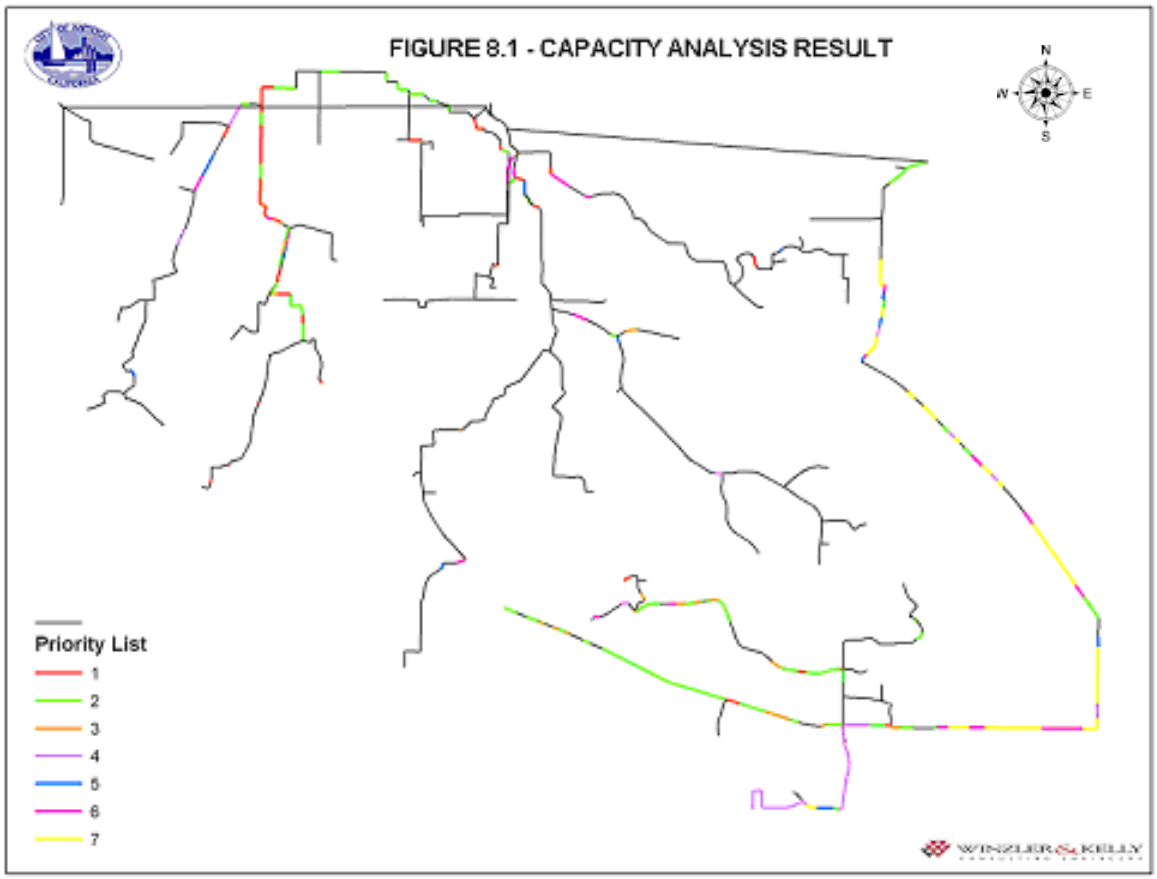
Based on the 2002 average wastewater flow scenario, the average error between the flow monitoring data and the model calculation is 17.64%. The following factors contributed to the model error:

- Heterogeneous land use distribution in flow monitoring data. Ideally, each flow monitoring basin should be smaller and have only one land use type.
- Possible error in flow monitoring data, which is used as calibration standard.
- Possible error in manhole survey, and the estimate of missing survey data.
- Unit flow factor estimation error, including BWF, GWI and RDI/I.
- Population density and land use distribution error. While parcels in each residential land use category have similar population density, density deviation still exists.
- Modeling assumption of negative slope sections.
- Miscellaneous errors including estimation errors, and round off errors in model algorithm.
- Combinations of all of the above factors.

Since the typical allowable model error is 20%, the accuracy of the model is acceptable.

A. Undercapacity Pipe Sections

To determine the hydraulic capacity of the system, wastewater flows from various design flow scenarios were superimposed on the existing system. Under existing flow and future flow conditions, there are sections of the existing system that are projected to be undercapacity. Undercapacity is defined as any pipe section with wastewater flowing at greater than 100% capacity. Undercapacity sections indicate backwater problems and surcharges and can potentially impact upstream sections including flooding, increased O&M, and development limitation. In order to minimize pipeline capacity problems and to enhance the overall sewer system efficiency, undercapacity sections in the City of Antioch sewer model are identified as candidates for pipeline improvements. The locations of undercapacity sections identified by the hydraulic modeling are shown in Figure 8.1.



There are 211 sections with a total length of approximately 60,100 feet identified as undercapacity. Another 31 sections, with a total length of approximately 11,500 feet, are projected to be undercapacity if development in the Roddy Ranch and Ginocchio future urban areas, south of current city limit, occurs. The majority of undercapacity sections are in the northwestern part of the City, especially along Enea Way, L St. and O St, where sewers are older and where the bulk of the City's flow is conveyed. In addition, there are also undercapacity sections in the southeastern part of the City along Lone Tree Way. The Lone Tree interceptor has several sections that are undercapacity, but these are considered to be primarily caused by infiltration along the pipeline and not necessarily excessive wastewater flow. It should be noted, however, that there have been extensive developments in the last decade and there are significant future developments planned for FUA-1 and southern areas which will add to the capacity problems in the Lone Tree interceptor.

The undercapacity sections identified by the model are prioritized into seven categories of design flow scenarios, based on when the undercapacity first occurs. The summary of capacity analysis and the prioritization schedule are shown in Table 8.1.

TABLE 8.1 - UNDERCAPACITY PIPELINES PRIORITIZATION SUMMARY

Priority	Scenario	Sections	Length (ft)	% Section	% Length
1	2002 ADWF	20	3,248	9%	5%
	2002 PDWF	24	6,516	11%	11%
	Subtotal	**44**	**9,764**	**21%**	**16%**
2	2002 PWWF (5-yr Storm)	75	24,421	36%	41%
	Subtotal	**75**	**24,421**	**36%**	**41%**
3	2002 PWWF (5-yr Storm)	21	4,475	10%	7%
	Subtotal	**21**	**4,475**	**10%**	**7%**
4	2007 PDWF	13	3,756	6%	6%
	2007 PWWF (5-yr Storm)	12	3,007	6%	5%
	2007 PWWF (5-yr Storm)	7	2,487	3%	4%
	Subtotal	**32**	**9,250**	**15%**	**15%**
5	2012 PDWF	2	295	1%	0%
	2012 PWWF (5-yr Storm)	8	2,004	4%	3%
	2012 PWWF (5-yr Storm)	5	1,682	2%	3%
	Subtotal	**15**	**3,981**	**7%**	**7%**
6	Buildout PDWF	1	178	0%	0%
	Buildout PWWF (5-yr Storm)	9	3,214	4%	5%
	Buildout PWWF (5-yr Storm)	14	4,823	7%	8%
	Subtotal	**24**	**8,215**	**11%**	**14%**
	Total	**211**	**60,106**	**100%**	**100%**
7	Buildout* PDWF	1	365	0%	1%
	Buildout* PWWF (5-yr Storm)	28	10,389	13%	17%
	Buildout* PWWF (5-yr Storm)	2	719	1%	1%
	Subtotal	**31**	**11,473**	**15%**	**19%**

Buildout* includes wastewater flow from Roddy Ranch area and Ginocchio area

ADWF = Average Dry Weather Flow
PDWF = Peak Dry Weather Flow
PWWF = Peak Wet Weather Flow

B. Classification of improvement needs

Pipe sections that showed greater than 100% of capacity were considered candidates for replacement or supplementary parallel sections. In such cases, the HYDRA program calculates sizes for both replacement and parallel pipelines with no slope changes. "Replacement" refers to a new pipeline that will handle the entire flow in that section, implying that the existing pipe section could be abandoned. A "Parallel" pipeline is the size that will carry only the flow greater than 100% capacity in that section, presumably with an upstream diversion structure. In either alternative, pipe size recommendations are based on the capacity requirements at the full buildout scenario to avoid multiple construction projects.

Undercapacity sections from the capacity analysis is organized and combined into three improvement action categories:

- Improvement Projects – The majority of undercapacity sections are grouped into projects based on geographic proximity of sections with similar priority. Improvement recommendations from the model will be re-evaluated on the overall project level to ensure that the recommendations are feasible to implement (see Chapter IX).

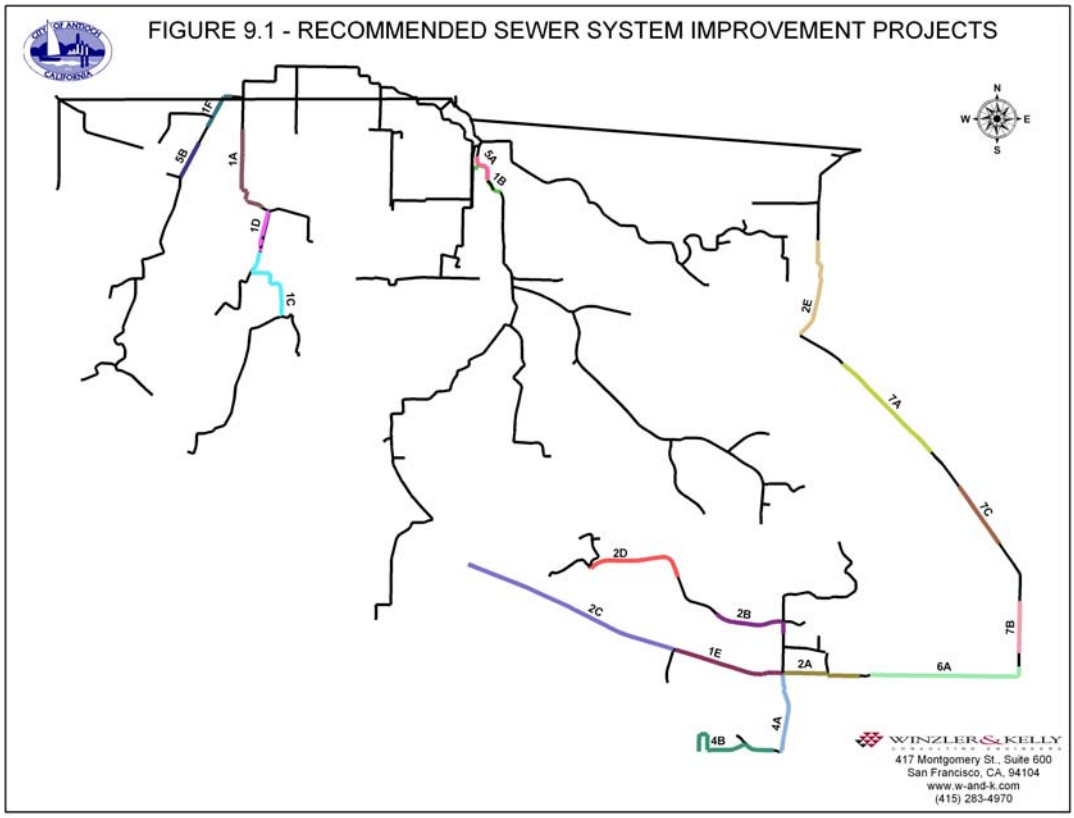
- Hydraulic Capacity Bottlenecks – Undercapacity sections that are located in an isolated area, which makes it difficult to combine with other improvement projects, are classified in this category. These sections are typically short in length (less than 1,000 feet), so the improvements are smaller and less expensive than improvement projects in the first category.

- Negative Slope Sections – Sections with negative slope that are not included in any improvement projects are classified in this category. Pipe sections in this category are not necessarily undercapacity. However, since negative slope sections are not desirable in any gravity sewer system, all negative slope sections that are not included in any improvement projects are listed in this category. It is suggested that the City field verify the need for improvement prior to including these identified negative slope sections in a project.

The results of the evaluation are documented in Chapter 9, Capital Improvement Program.

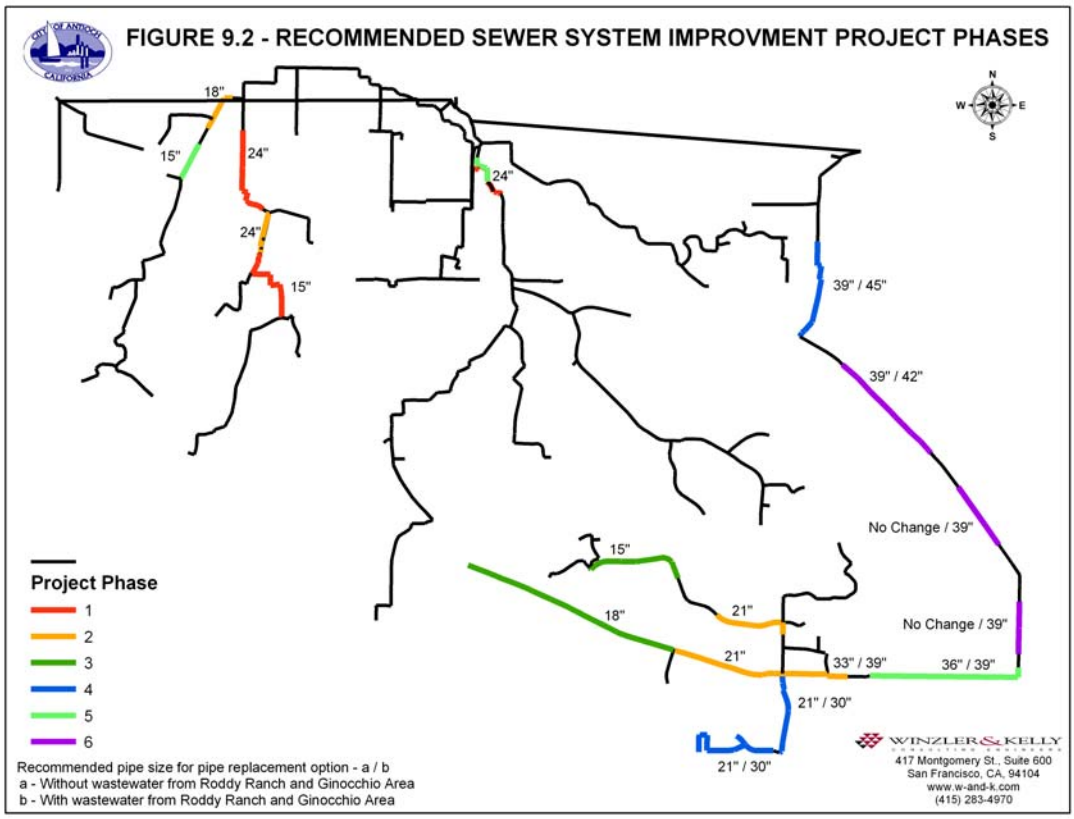
A. Recommended Improvement Projects

Based on the evaluation methodology outlined in Chapter 8, Evaluation of Sewer System, 19 improvement projects have been identified as a result of the hydraulic modeling. These improvement projects will correct deficiencies in the existing system under buildout conditions. The projects are shown in Figure 9.1.



The projects are classified into six implementation phases, as shown by the first character of the project name. The second character of the project name defines the project priority within each implementation phase.

Each implementation phase includes three to five projects that could be carried out in a number of years. The exact project schedule for each phase is flexible and will vary according to development schedules and the availability of City budget and resources. Figure 9.2 summarizes the recommended pipe sizes (based on the pipe replacement option) for each improvement project. Projects shown in Figure 9.2 are color-coded by implementation phase.



Two future development areas, Roddy Ranch and Ginocchio, are outside current City Limits. To assist the City in understanding the potential impact of City expansion on the sewer system, projects in the southeastern part of the City, which handle flow from south Antioch areas, have been considered. This has resulted in additional improvement recommendations that assume the wastewater system in the Roddy Ranch area and Ginocchio area are within future City limits and are connected to the existing system at Oneida Way.

If wastewater from the Roddy Ranch area and Ginocchio area is not conveyed through the City of Antioch sewer system, Projects 7b and 7c could be eliminated. Project 7a would be reduced to a 2,422 linear foot project that could be combined with Phase 5 projects.

Recommended improvements for Project 1A have been modified due to ongoing construction. The section from West 10th Street and O Street to West 4th Street and L Street has been removed from Project 1A because the sections are currently being upsized by the City.

Table 9.1 summarizes the recommended projects, including improvement alternatives for pipe replacement and parallel pipe addition.

TABLE 9.1 - RECOMMENDED PROJECT SUMMARY					
Phase	**Project Priority**	**Length (ft)**	**Existing Pipe Diameter (in)**	**New Diameter (in)**	
				Replacement	**Parallel**
1	1a	3,203	12 – 18	24	18
	1b	1,739	16 – 24	21 - 24	12 - 21
	1c	3,191	12 – 15	15	12 - 15
	Subtotal	**8,133**			
2	1d	1,437	12 – 15	15 - 24	8 - 18
	1e	3,737	15 – 18	21	12
	1f	1,445	12 – 15	18	15
	2a	2,644	24	33 , 39*	27 , 33*
	2b	2,728	12 – 18	15 - 21	10 - 15
	Subtotal	**11,991**			
3	2c	7,452	12	18	12
	2d	3,470	10 – 12	15	8 - 12
	Subtotal	**10,922**			
4	2e	3,567	33	39 , 45*	27 , 33*
	4a	2,777	8 – 15	21 , 30*	21 , 30*
	4b	3,712	10 – 12	21 , 30*	21 , 30*
	Subtotal	**10,056**			
5	5a	1,041	20 – 21	24	10
	5b	1,316	12	15	8
	6a	5,306	33	36 , 39*	18 , 27*
	Subtotal	**7,663**			
6	7a	4,193	33	39 , 42*	27 , 30*
	7b	1,759	33	39*	24*
	7c	2,359	33	39*	21*
	Subtotal	**8,311**			
	TOTAL	**57,076**			

***** Recommended pipe size if wastewater from Roddy Ranch area and Ginocchio area is conveyed through the City of Antioch's sewer system.

Table 9.2 presents information on each project's location. A detailed section-by-section description of the recommended projects is included in Appendix C.

TABLE 9.2 – LOCATION OF RECOMMENDED PROJECTS					
Phase	**Project**	**Length (ft)**	**Start Point**	**Alignment**	**End Point**
1	1a	3,203	Peppertree Way & Sycamore Dr.	Sycamore Dr., CCC Fairground, O St., W. 4th St.	W. 4th St. & L St.
	1b	1,739	Alhambra Dr. & S. Lake Dr.	S. Lake Dr., W. Lake Dr., Inland Ct.	Inland Ct. & Cavallo Rd.
	1c	3,191	Putnam St. & Enea Way	Enea Way, Frances Dr., Fitzuren Rd., Contra Loma Blvd.	Contra Loma Blvd. & North of Hwy. 4 (G21-8-026)
Subtotal		**8,133**			
2	1d	1,437	Claudia St. & L. St.	L St. (except the 15" parallel pipe in L St.)	L St. & Sycamoe Dr.
	1e	3,737	Sagebrush Dr. & Lone Tree Way	Lone Tree Way	Lone Tree Way & Hillcrest Ave.
	1f	1,445	North of Aster Dr. & Poppy Way (F21-9-036)	Poppy Way (cont. across private property), 6th St.	6th St. & West of O St. (F21-9-003)
	2a	2,644	Hillcrest Ave. & Lone Tree Way	Lone Tree Way	Lone Tree Way & Heidorn Ranch Rd.
	2b	2,728	Shannondale Dr. & Country Hills Dr.	Country Hills Dr., Hillcrest Ave.	Hillcrest Ave. & South of Country Hills Dr. (J23-8-033)
Subtotal		**11,991**			
3	2c	7,452	Dallas Ranch Road & Lone Tree Way	Lone Tree Way	Lone Tree Way & Sagebrush Drive
	2d	3,470	Deer Valley Rd. & Country Hills Dr.	Country Hills Dr.	Country Hills Dr. & Wolverine Way
Subtotal		**10,922**			

TABLE 9.2 – LOCATION OF RECOMMENDED PROJECTS

Phase	Project	Length (ft)	Start Point	Alignment	End Point
4	2e	3,567	SPRR & Hwy. 4	along West of Hwy. 4	West of Hwy.4 & South of E. 18th St. (G24-2-002)
	4a	2,777	Prewett Ranch Rd. & Hillcrest Ave.	Hillcrest Ave.	Hillcrest Ave. & Lone Tree Way
	4b	3,712	Navajo Way & Oneida Way	Oneida Way, Prewett Ranch Rd., Grass Valley Way, Stagecoach Way, Prewett Ranch Rd.	Prewett Ranch Rd. & Hillcrest Ave.
Subtotal		**10,056**			
5	5a	1,041	S. Lake Dr. & W. Lake Dr.	W. Lake Dr.	W. Lake Dr. & W. Lake Pl.
	5b	1,316	SPRR & South of Poppy Way (G21-4-025)	Poppy Way (cont. across private property)	Poppy Way & South of Aster Dr. (F21-9-035)
	6a	5,306	Heidorn Ranch Rd. & Lone Tree Way	Lone Tree Way, Empire Ave.	Empire Ave. & North of Lone Tree Way (J24-9-003)
Subtotal		**7,663**			
6	7a*	4,193	MH H24-5-005	Lone Tree Interceptor (Neroly Rd., North of Laurel Rd.)	MH H24-1-004
	7b*	1,759	MH J24-9-002	Lone Tree Interceptor (Empire Ave.)	MH J24-8-003
	7c*	2,359	MH J24-7-002	Lone Tree Interceptor (Neroly Rd., South of Laurel Rd.)	MH H24-6-004
Subtotal		**8,311**			
Total Length		**57,076**			

* Projects include those resulting from inclusion of the Roddy Ranch area and Ginocchio area within the City service area in the future. If not developed or not included, the improvement project can be reduced to a 2,442 foot project and could be moved to Phase 5.

B. Hydraulic Capacity Bottlenecks and Negative Slope Sections

Hydraulic Capacity Bottlenecks

Short undercapacity sections that are isolated from other recommended projects are defined as hydraulic capacity bottlenecks. The sewer system evaluation identified 24 bottleneck sections with a total length of approximately 7,500 linear feet. Improvement recommendations are made for these sections based on no slope adjustments. However, many of the recommended pipe sizes could be dramatically reduced if a slope adjustment is physically possible by replacing contiguous upstream and/or downstream pipe sections. Therefore the recommended pipe size and length of replacement should be confirmed during the predesign phase of each project to explore alternatives related to the feasibility of upstream and downstream slope adjustments. Table 9.4 summarizes the recommendations for all hydraulic capacity bottlenecks. The minimum allowable pipe size recommendation is 8", as defined in the design criteria.

TABLE 9.3 - HYDRAULIC CAPACITY BOTTLENECKS

Priority	City ID	Length (ft)	Slope	Existing Pipe Diameter (in)	Replacement (in)	Parallel (in)
1	G22-7-088SS	198	0.00090	12	18	12
2	F22-9-049SS	101	0.00029	21	24	15
2	G23-3-039SS	192	0.00078	18	21	15
2	K23-7-007SS	202	0.00029	12	33 , 42*	30 , 42*
2	F24-3-001SS	715	0.00029	33	54 , 60*	42 , 54*
2	J24-2-030SS	94	0.00032	10	15	10
3	F22-6-042SS	95	0.00273	10	12	8
3	J23-1-034SS	254	0.00177	10	12	8
4	J23-1-060SS	245	0.00281	10	12	8
4	J24-9-003SS	440	0.00054	33	42 , 48*	30 , 39*
5	G21-8-022SS	431	0.00192	15	18	8
5	J24-8-003SS	304	0.00111	33	36 , 42*	21 , 30*
5	G23-3-040SS	241	0.00078	18	21	10
5	G23-8-003SS	106	0.00065	10	15	10
6	G21-8-021SS	415	0.00197	15	18	8
6	G22-7-058SS-SF1	479	0.00056	21	24	8
6	G23-3-036SS	460	0.00158	18	21	8
6	J23-1-064SS	169	0.00314	10	12	8
6	H24-6-004SS	464	0.00161	33	36 , 39*	8 , 24*
6	J24-7-003SS	414	0.00157	33	36 , 39*	8 , 24*
6	G22-7-060SS	401	0.00044	21	24	8
6	G22-7-086SS	657	0.00222	12	15	8
6	J22-4-005SS	246	0.00223	12	15	8
6	G23-1-037SS	177	0.00202	12	15	8

Note: The recommendations are based on no slope changes.
* Recommended pipe size if wastewater from Roddy Ranch area and Ginocchio area is conveyed through the City of Antioch's sewer system.

Similar to the listing of recommended improvement projects, we have separately identified sections (marked with *) for projects that result from potential City expansion in the Roddy Ranch area and Ginocchio area in the southern portion of the City.

Negative Slope Sections

In addition to hydraulic capacity bottlenecks, isolated sections of pipeline with negative slopes were also identified and categorized separately. In addition to the 13 negative slope sections included in the recommended improvement projects, there are an additional 45 negative slope sections (approximately 10,500 linear feet total length) in the City of Antioch sewer system. Of the 45 isolated sections, 36 of them have capacity problems at various priority levels. Table 9.5 lists all 45 negative slope sections identified.

TABLE 9.4 - NEGATIVE SLOPE SECTIONS

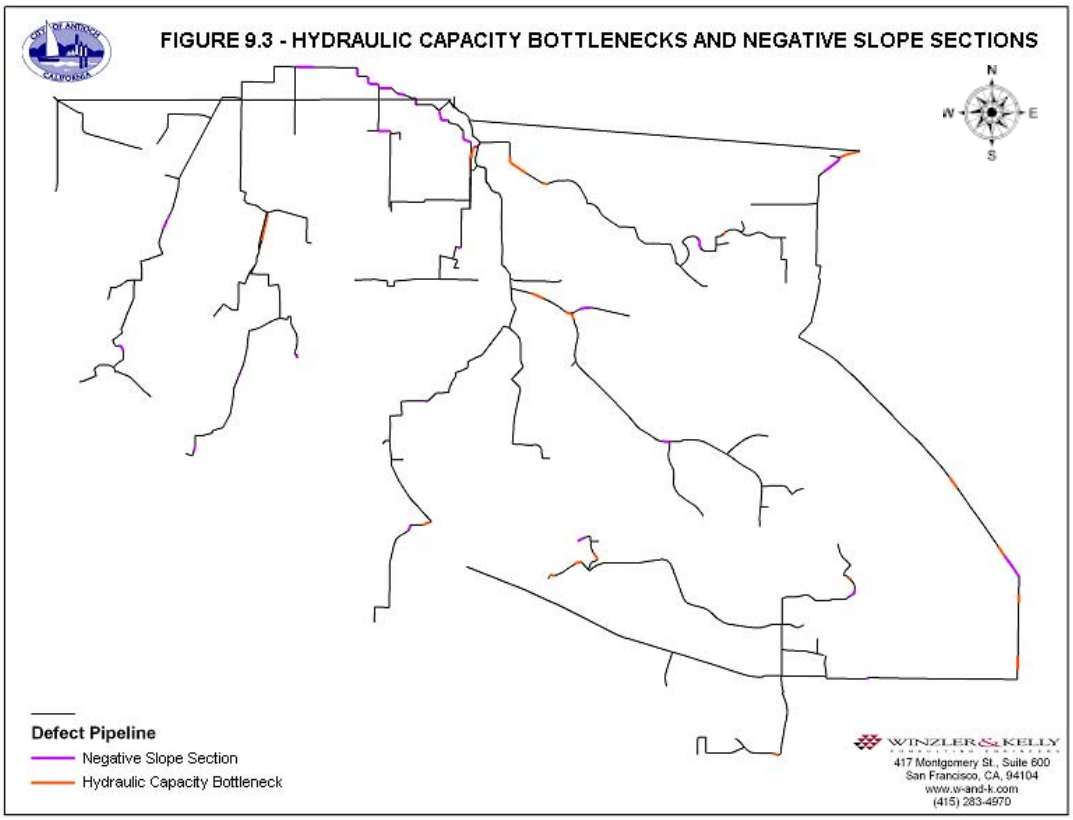
					Design Capacity, PWWF(25 yr)	
Priority	City ID	Length (ft)	Slope	Pipe Diameter (in)	Buildout	Buildout*
1	F22-6-040SS	367	-0.00057	10	0.9	0.9
1	F22-9-047SS	41	-0.01553	21	7.9	7.9
1	H21-8-034SS	37	-0.02166	10	1.5	1.5
1	H21-8-026SS	138	-0.01979	10	1.5	1.5
1	J23-1-018SS	252	-0.02742	10	1.1	1.1
1	G22-8-007SS	111	-0.00817	12	0.9	0.9
1	H21-7-054SS	71	-0.00182	12	1.8	1.8
1	F22-6-063SS	332	-0.00243	21	3.3	3.3
1	F22-6-062SS	241	-0.00331	21	3.3	3.3
1	F22-9-061SS	117	-0.04123	21	3.3	3.3
1	H22-1-044SS	124	-0.04375	12	1.7	1.7
1	G23-5-037SS	347	-0.00864	10	0.9	0.9
2	F22-2-064SS	257	-0.00093	33	10.3	10.3
2	F22-2-049SS	596	-0.00020	33	10.3	10.3
2	F22-6-101SS	214	-0.00121	36	12.4	12.4
2	F22-5-015SS	289	-0.00006	33	10.2	10.2
2	F22-5-016SS	88	-0.00135	33	10.2	10.2
2	F22-5-017SS	163	-0.00159	33	10.2	10.2
2	F22-5-009SS	436	-0.00199	36	12.5	12.5
2	F22-5-007SS	232	-0.00245	36	12.4	12.4
2	F22-9-060SS	262	-0.03998	21	3.0	3.0
2	J24-2-025SS	260	-0.00150	10	0.6	0.6
2	J24-7-004SS	412	-0.00007	33	21.2	29.3
2	J24-7-005SS	419	-0.05315	33	21.2	29.3
2	J24-3-005SS	98	-0.00020	33	20.5	28.7
2	G24-1-011SS	254	-0.00668	33	23.9	32.5

TABLE 9.4 - NEGATIVE SLOPE SECTIONS						
					Design Capacity, PWWF(25 yr)	
Priority	City ID	Length (ft)	Slope	Pipe Diameter (in)	Buildout	Buildout*
2	G24-1-012SS	439	-0.01331	33	23.9	32.5
3	F22-6-102SS	26	-0.01405	36	12.5	12.5
3	H22-5-007SS	71	-0.00126	18	2.7	2.7
3	G23-3-013SS	375	-0.00082	12	0.6	0.6
4	G21-5-004SS	128	-0.01219	18	2.6	2.6
4	G21-5-007SS	254	-0.02242	18	2.6	2.6
4	H23-5-012SS	248	-0.00032	18	2.5	2.5
4	F22-9-051SS	117	-0.01537	21	2.7	2.7
5	H21-4-044SS	237	-0.08488	15	1.3	1.3
5	J22-4-007SS	188	-0.00244	12	1.3	1.3
N/A	G21-4-017SS	38	-0.05053	21	ok	ok
N/A	F21-6-022SS	226	-0.00066	15	ok	ok
N/A	F22-9-045SS	388	-0.01925	42	ok	ok
N/A	G23-1-005SS	469	-0.00580	18	ok	ok
N/A	F22-9-006SS	112	-0.00124	48	ok	ok
N/A	F22-9-003SS	430	-0.00151	48	ok	ok
N/A	G23-5-006SS	349	-0.00025	15	ok	ok
N/A	G23-5-004SS	88	-0.00169	15	ok	ok
N/A	G22-7-055SS	161	-0.00961	18	ok	ok

Note:
Negative slope sections in the recommended improvement projects are excluded from this list
Negative slope sections shown with a priority ranking also have capacity deficits.
Buildout* includes wastewater flow from Roddy Ranch area and Ginocchio area

The table includes two sets of design capacities for each negative slope section. One is based on peak wet weather flow at 25-year storm under the buildout scenario, and the other is based on peak wet weather flow at 25-year storm under the buildout scenario including developments in the Roddy Ranch area and Ginocchio area in the southern portion of the City.

Figure 9.3 shows the locations of hydraulic capacity bottlenecks and negative slope sections in the City of Antioch's sewer system.



C. Estimates of Probable Costs

Pipeline Construction Unit Cost

Table 9.8 shows the pipe construction unit cost (per linear foot of pipe) used for the replacement pipe alternative and the parallel pipe addition alternatives. These unit costs are based on recent construction costs for similar pipeline projects in the vicinity and are tied to an ENR Construction Cost Index (CCI) of 6640.06 for February 2003.

The estimated probable construction costs include mobilization / demobilization, sheeting/ shoring / bracing, pipe replacement using open-cut construction methods, replacement of manholes, lateral reconnections, traffic control, dewatering, flow bypassing, abandonment of the existing sewers, and an allowance for miscellaneous pavement replacement and over excavation.

TABLE 9.5 - UNIT COST FOR PIPELINE CONSTRUCTION		
Pipe Diameter (inch)	**Pipe Replacement Cost ($/ft)**	**Parallel Pipe Addition Cost ($/ft)**
8	170	145
10	195	170
12	215	185
15	235	205
18	255	235
21	280	255
24	310	275
27	335	300
30	360	320
33	385	340
36	415	360
39	440	380
42	465	400
45	495	425
48	515	-
54	545	465
60	570	-

Estimate of Probable Costs for Recommended Improvement Projects

Budget cost estimates were prepared for each improvement project using the pipe replacement alternative and the parallel pipe alternative, as summarized in Table 9.6. For planning purposes, project costs using the pipe replacement option should be used since a pipe replacement option is usually more expensive than a parallel pipe addition option. The total budget cost for all projects is approximately $24.2 million. The cost estimate is based on present values in February 2003 and includes a 20% construction contingency and a 35% project contingency. The project cost contingency includes engineering, construction management, and related services, and the breakdown of contingency is shown in the table notes.

In addition, project costs for each improvement alternative are estimated based on City development scenarios that include full development in the Roddy Ranch area and Ginocchio area. The planning level cost for all recommended projects, with the additional southern development included, is approximately $31.4 million

TABLE 9.6 – ESTIMATE OF PROBABLE PROJECT COSTS FOR RECOMMENDED IMPROVEMENT PROJECTS

Phase	Project Priority	Length (ft)	Replacement Cost	Replacement Cost After City Expansion *	Parallel Cost	Parallel Cost After City Expansion *
1	1a	3,203	$1,610,000	$1,610,000	$1,220,000	$1,220,000
	1b	1,739	$800,000	$800,000	$540,000	$540,000
	1c	3,191	$1,200,000	$1,200,000	$970,000	$970,000
Subtotal		**8,133**	**$3,610,000**	**$3,610,000**	**$2,730,000**	**$2,730,000**
2	1d	1,437	$560,000	$560,000	$350,000	$350,000
	1e	3,737	$1,700,000	$1,700,000	$1,120,000	$1,120,000
	1f	1,445	$600,000	$600,000	$480,000	$480,000
	2a	2,644	$1,650,000	$1,890,000	$1,290,000	$1,460,000
	2b	2,728	$1,070,000	$1,070,000	$870,000	$870,000
Subtotal		**11,991**	**$5,580,000**	**$5,820,000**	**$4,110,000**	**$4,280,000**
3	2c	7,452	$3,080,000	$3,080,000	$2,230,000	$2,230,000
	2d	3,470	$1,320,000	$1,320,000	$1,010,000	$1,010,000
Subtotal		**10,922**	**$4,400,000**	**$4,400,000**	**$3,240,000**	**$3,240,000**
4	2e	3,567	$1,860,000	$2,860,000	$1,270,000	$1,960,000
	4a	2,777	$1,260,000	$1,620,000	$1,150,000	$1,440,000
	4b	3712	$1,680,000	$2,170,000	$1,530,000	$1,920,000
Subtotal		**10,056**	**$4,800,000**	**$6,650,000**	**$3,950,000**	**$5,320,000**
5	5a	1,041	$520,000	$520,000	$330,000	$330,000
	5b	1,316	$500,000	$500,000	$310,000	$310,000
	6a	5,306	$3,050,000	$3,780,000	$1,720,000	$2,580,000
Subtotal		**7,663**	**$4,070,000**	**$4,800,000**	**$2,360,000**	**$3,220,000**
6	7a	4,193	$1,730,000	$3,160,000	$1,180,000	$2,170,000
	7b	1,759	$0	$1,250,000	$0	$780,000
	7c	2,359	$0	$1,680,000	$0	$980,000
Subtotal		**8,311**	**$1,730,000**	**$6,090,000**	**$1,180,000**	**$3,930,000**
	Totals	**57,076**	**$24,190,000**	**$31,370,000**	**$17,570,000**	**$22,720,000**

Construction Cost Contingency = 20%
Project Cost Contingency = 35%

12% Engineering
4% Construction Management
5% Geotechnical Services
3% Survey
5% Administrative Cost
6% Unforeseen Items (easement, archaeology studies, etc.)

TABLE 9.6 – ESTIMATE OF PROBABLE PROJECT COSTS FOR RECOMMENDED IMPROVEMENT PROJECTS
Notes: 1. All costs shown are Project Costs. 2. Costs are tied to ENR Construction Cost Index (CCI) of 6640.06 in February 2003. 3. Project 1a does not include the section from 10th St. & O St. to O St. & L St. (currently under construction). * Expand the City service area limit to include Roddy Ranch area and Ginocchio area.

Estimate of Probable Costs for Hydraulic Capacity Bottlenecks

For hydraulic capacity bottlenecks, project costs are estimated in the same way as recommended improvement projects. Table 9.7 summarizes the cost estimates for the hydraulic capacity bottlenecks, assuming replacement of only the pipeline sections identified as deficient.

TABLE 9.7 – ESTIMATE OF PROBABLE COSTS FOR HYDRAULIC CAPACITY BOTTLENECKS

Priority	City ID	Length (ft)	Replacement Cost	Replacement Cost After City Expansion *	Parallel Cost	Parallel Cost After City Expansion *
1	G22-7-088SS	198	$82,000	NC	$59,000	NC
2	F22-9-049SS	101	$51,000	NC	$34,000	NC
2	G23-3-039SS	192	$87,000	NC	$64,000	NC
2	K23-7-007SS	202	$126,000	$279,000	$105,000	$236,000
2	F24-3-001SS	715	$631,000	$660,000	$463,000	$631,000
2	J24-2-030SS	94	$36,000	NC	$26,000	NC
3	F22-6-042SS	95	$33,000	NC	$22,000	NC
3	J23-1-034SS	254	$89,000	NC	$60,000	NC
4	J23-1-060SS	245	$85,000	NC	$58,000	NC
4	J24-9-003SS	440	$331,000	$367,000	$228,000	$499,000
5	G21-8-022SS	431	$178,000	NC	$101,000	NC
5	J24-8-003SS	304	$204,000	$433,000	$126,000	$284,000
5	G23-3-040SS	241	$109,000	NC	$66,000	NC
5	G23-8-003SS	106	$41,000	NC	$29,000	NC
6	G21-8-021SS	415	$171,000	NC	$98,000	NC
6	G22-7-058SS-SF1	479	$240,000	NC	$113,000	NC
6	G23-3-036SS	460	$209,000	NC	$108,000	NC
6	J23-1-064SS	169	$59,000	NC	$40,000	NC
6	H24-6-004SS	464	$312,000	$643,000	$109,000	$316,000
6	J24-7-003SS	414	$278,000	$573,000	$97,000	$281,000
6	G22-7-060SS	401	$201,000	NC	$94,000	NC
6	G22-7-086SS	657	$250,000	NC	$155,000	NC
6	J22-4-005SS	246	$94,000	NC	$58,000	NC
6	G23-1-037SS	177	$68,000	NC	$42,000	NC
	Totals	**7500**	$3,965,000	$2,955,000	$2,355,000	$2,247,000

Notes:
1. This list does not include the undercapacity sections in the recommended improvement projects.
2. Assume no slope adjustments for new pipe size recommendations.
3. Costs are tied to ENR Construction Cost Index (CCI) of 6640.06 in February 2003.
4. The project costs include 20% construction contingency and 35% project contingency.
5. NC = No Change

* Expand City limit to include Roddy Ranch area and Ginocchio area.

APPENDIX A

City of Antioch Sanitary Sewer Master Plan Flow Monitoring, by V&A Consulting Engineers

CITY OF ANTIOCH

SANITARY SEWER MASTER PLAN

FLOW MONITORING

Prepared for:

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Prepared By:

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March 2002

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EXECUTIVE SUMMARY

V & A Consulting Engineers (V & A) has completed sanitary sewer flow monitoring within the City of Antioch as a part of the City of Antioch Sanitary Sewer Master Plan currently being completed by Winzler & Kelly Consulting Engineers (W & K). Flow monitoring was conducted over a 1-month period from December 27, 2002 through January 29, 2002 at fifteen flow monitoring sites selected by W & K. The fifteen flow monitoring sites are shown in Figures 4 and 5.

V & A encountered the following problems with respect to the acquisition of flow monitoring data:

- Site 1: The level and velocity sensor failed immediately following installation. A replacement sensor could not be installed until January 8, 2002.

This final report includes descriptions of the flow monitoring sites and graphically presents the data collected over the monitoring period. Tables of all collected data are included in an Excel Spreadsheet with the compact disk included with this report.

During the flow monitoring, there was a sensor malfunction at Site 1. The sensor was replaced and data was collected from January 8, 2002.

The following table summarizes the data over the monitoring period for each of the flow monitoring sites. Please refer to the ***Flow Monitoring Sites*** section of this report for a more thorough presentation of the flow data.

Site Number	City Manhole Number	Pipe Diameter (in)	Average Baseline Flow (MGD)	Peak Measured Flow (MGD)	Peak-to-Average Ratio	Notes
1	G21-1-40	10	0.21	0.47	2.27	
2	G21-5-7	18	0.50	1.01	2.00	
3	G21-8-24	15	0.61	1.46	2.39	
4	F21-9-6	21	0.79	1.47	1.86	Infiltration visible entering through manhole walls.
5	F21-9-6	21	1.49	2.59	1.74	Infiltration visible entering through manhole walls.
6	F22-2-47	15	0.21	0.76	3.63	
7	F22-6-93	14	0.58	1.41	2.42	Infiltration visible entering through manhole walls.
8	F22-6-66	36	2.99	6.65	2.23	Infiltration visible entering through manhole walls.
9	F22-9-46	42	3.24	5.91	1.82	Infiltration visible entering through manhole walls.
10	F22-9-42	14	0.20	0.57	2.84	Infiltration visible entering through manhole walls.
11	G22-7-58	18	0.60	1.56	2.58	
12	G22-9-7	21	0.98	1.86	1.91	
13	G24-1-8	33	2.54	5.57	2.19	
14	J23-9-21	18	1.14	2.16	1.89	
15	J23-9-66	18	0.89	1.85	2.08	

INTRODUCTION

V & A was retained by Winzler & Kelly Consulting Engineers (W&K) to conduct sanitary sewer flow monitoring for the City of Antioch Sanitary Sewer Master Plan. The scope of work includes the following tasks:

- Install flow monitoring equipment and analyze the flow data to determine existing dry weather flows and wet weather flows at fifteen pre-determined site locations over the course of the flow monitoring period.

Site locations were determined by W&K. This final report includes descriptions of the flow monitoring sites and graphically presents the data collected over the monitoring period. Tables of all collected data are included in an Excel Spreadsheet with the compact disk included with this report. Please note that this report intends to present the data collected in a useful manner, but does not intend to recommend improvements or draw conclusions as to the condition of the collection system, or the master planning effort.

METHODS AND PROCEDURES

Meter Installation

Fifteen ISCO 2150 flow meters were installed by V & A in the 15 sewer manhole locations shown in Figures 4 and 5. ISCO meters use a pressure transducer to collect depth readings, and ultrasonic Doppler sensors on the probe determine the average fluid velocity. Figure 1 shows a sketch of a typical flow meter installation set-up.

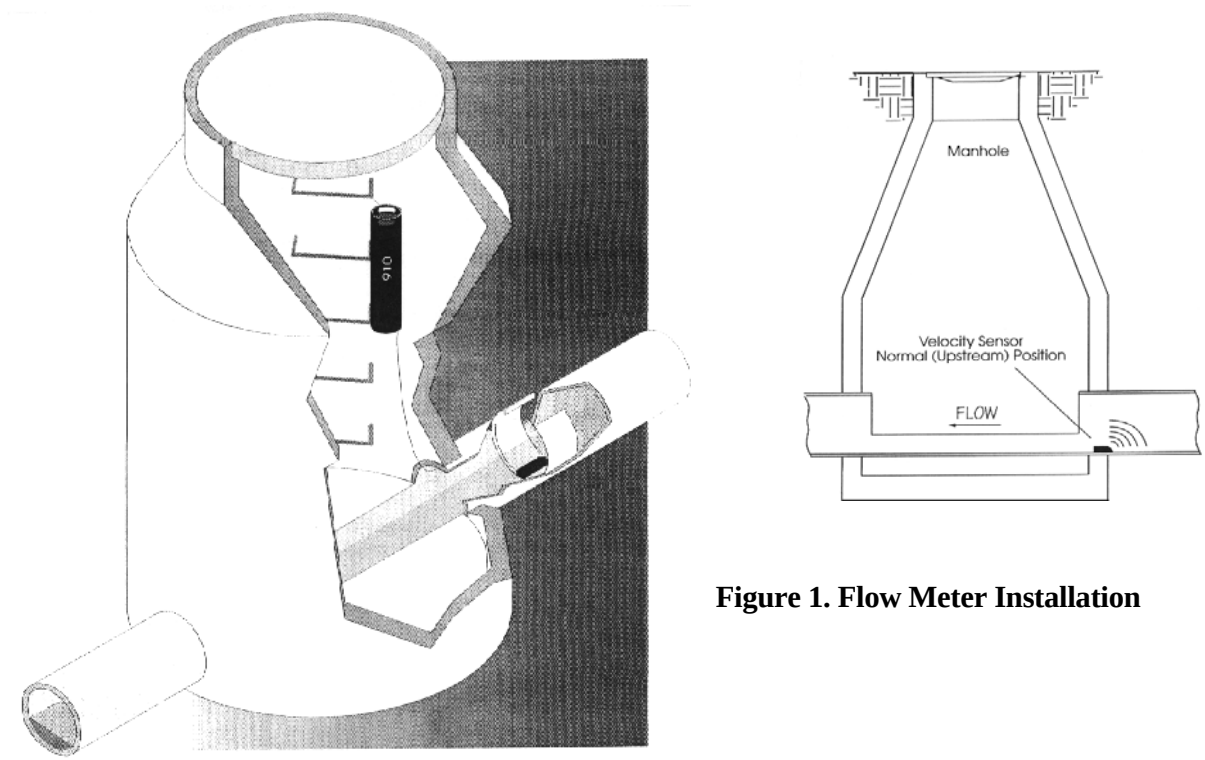

Figure 1. Flow Meter Installation

Continuous depth and velocity readings were recorded by the flow meters in 15-minute increments and downloaded into a computer spreadsheet program where the data could be analyzed and made report ready. Manual level and velocity readings were taken in the field during the flow meter installation, calibration, and again when it was removed, and compared to the readings of the flow meters to ensure proper calibration and accuracy.

Explanation of Report Graphs and Definition of Terms

Flow versus time graphs are created by interpolating the data recorded by the flow meter in 15-minute intervals, and represent the **diurnal flow curve** recorded over a given monitoring period. These graphs represent the data in its rawest form. Figure 2 shows a typical diurnal flow curve and identified on this graph are the hypothetical **peak**, **low**, and **average** flows recorded over an example monitoring period. These graphs are useful in identifying the extreme limits of the flows being monitored, and spotting any trends that might be occurring at a particular site.

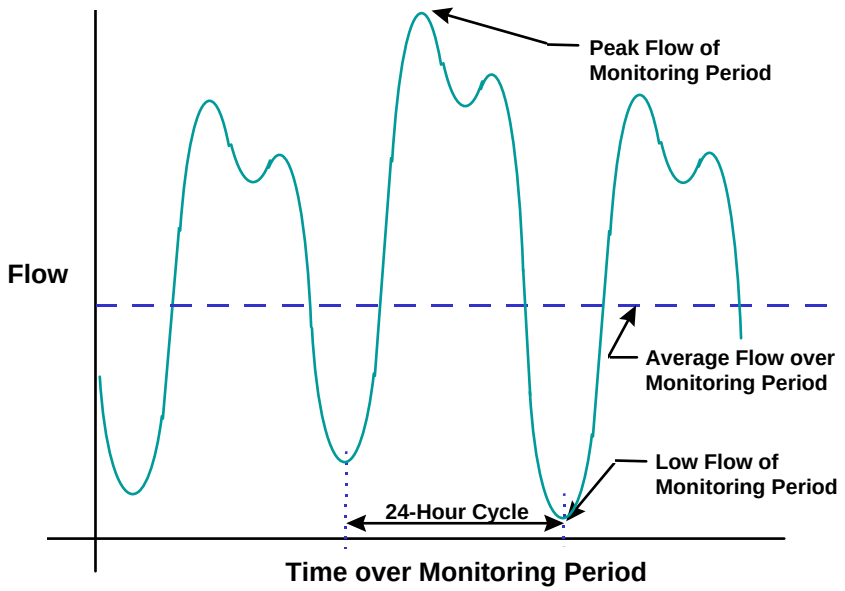

Figure 2. Diagram of Hypothetical Diurnal Flow over Monitoring Period

For this study, the data recorded within the flow monitoring period is a combination of dry weather and wet weather flow.

FLOW MONITORING SITES AND PRESENTATION OF DATA

Figure 3 shows a rough schematic of the flow monitoring sites in relation to the treatment plant and collection system.

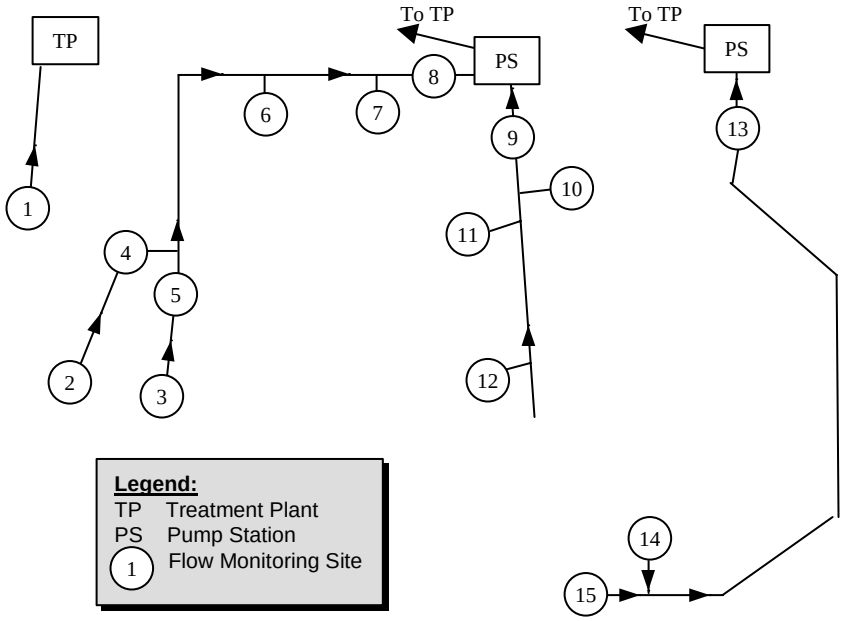

Figure 3. Schematic of Collection System and Monitoring Sites of the City of Antioch

Basins 4, 5, 8, 9 and 13 **include** the flow from other basins in this study; therefore, a subtraction of flows needs to be accomplished to determine the flow of that basin. The appropriate formulas are as follows:

- Basin 4 Flow = (Site 4) – (Site 2)
- Basin 5 Flow = (Site 5) – (Site 3)
- Basin 8 Flow = (Site 8) – (Site 7) – (Site 6) – (Site 5) – (Site 4)
- Basin 9 Flow = (Site 9) – (Site 10) – (Site 11) – (Site 12)
- Basin 13 Flow = (Site 13) – (Site 14) – (Site 15)

All flow data presented forthwith in regards to the flow monitoring sites, with the exception of Figure 5, is the **total** flow through that site and does not provide for any subtraction of flows.

Table 1 lists the flow monitoring site locations and summarizes some of the flow monitoring data. Flow monitoring locations were provided to V&A by Winzler & Kelly.

Table 1. Flow Monitoring Site Locations Summary

Site Number	City Manhole Number	Pipe Diameter (in)	Average Baseline Flow (MGD)	Peak Measured Flow (MGD)	Peak-to-Average Ratio	Notes
1	G21-1-40	10	0.21	0.47	2.27	
2	G21-5-7	18	0.50	1.01	2.00	
3	G21-8-24	15	0.61	1.46	2.39	
4	F21-9-6	21	0.79	1.47	1.86	Infiltration visible entering through manhole walls.
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12	G22-9-7	21	0.98	1.86	1.91	
13	G24-1-8	33	2.54	5.57	2.19	
14	J23-9-21	18	1.14	2.16	1.89	
15	J23-9-66	18	0.89	1.85	2.08	

The *Average Baseline Flow* is the average dry weather flow. Flows from January 12, 13, 19 and 20, 2002 were used to compute the baseline (dry weather) weekend flow, and flows from January 14 through 18, and January 21 through 25 were used to compute the baseline weekday flow. The *Peak Measured Flow* was the peak flow recorded by the flow meters over the monitoring period. A high *Peak-to-Average Ratio* may indicate high volumes of inflow.

During the flow monitoring, there was a sensor malfunction at Site 1. The sensor was replaced and data was collected from January 8, 2002.

Figure 6 shows a general site map of the project area and all of the site locations. Two plugs were installed to help in basin isolation. Figure 7 shows the isolated basins corresponding with the flow monitoring sites. The pages following the Site Maps contain a thorough description of each site location including photographs, along with more detailed flow data.

Wet Weather Events

Figure 4 shows the wet weather events that occurred over the flow monitoring period. Wet weather data was taken from the California Department of Water Resources – Division of Flood Management web site. Hourly rainfall data was available from the Black Diamond Mines metering site through January 2, 2002. Due to unavailable data, past January 2, 2002, rainfall data was extrapolated from the Mount Diablo metering site. Please note that this data is presented here to indicate the relative intensity of storms around Antioch and to help with the I/I study, but that gathering rainfall data was not in the scope-of-services and V & A does not attest to the accuracy of the rainfall data. The rainfall data collected can be found at: <http://cdec.water.ca.gov/cgi-progs/mapper?level=2&map=23&quad=1>

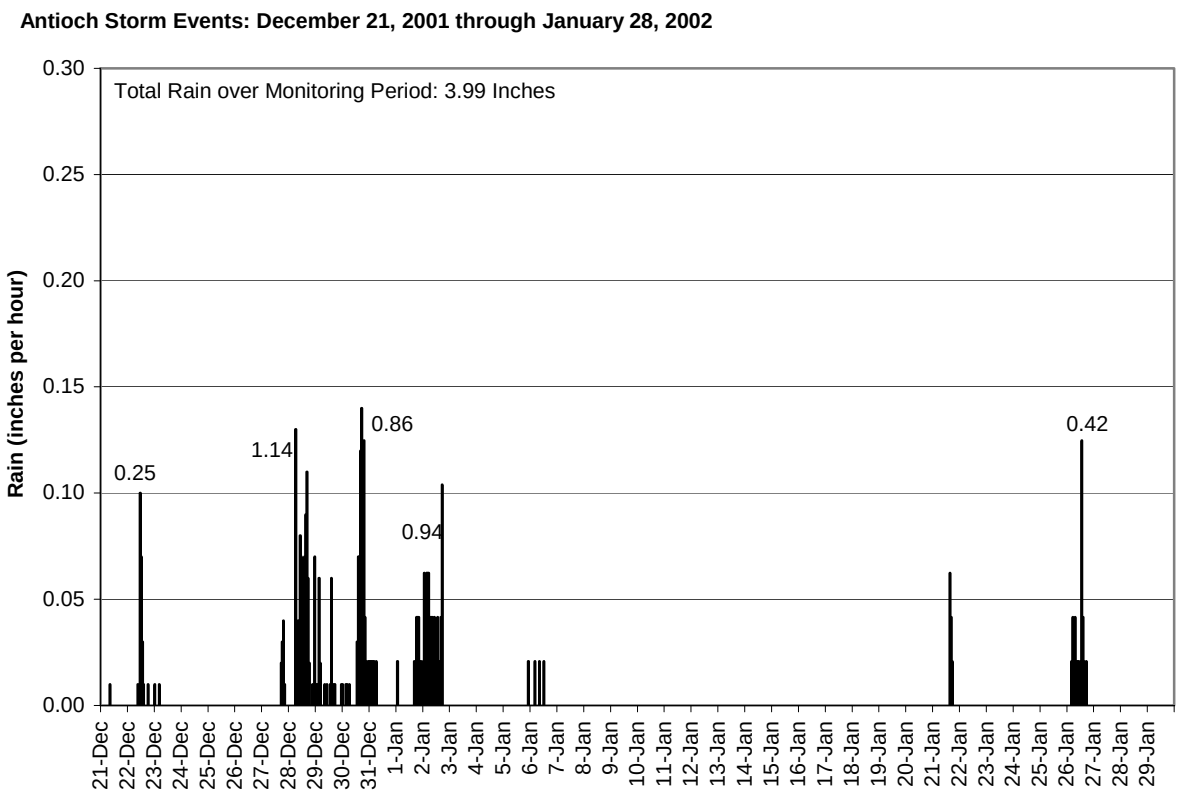


Figure 4. Antioch Storm Events over Monitoring Period

Inflow/Infiltration

Figure 5 summarizes the infiltration/inflow contribution-by-basin over the two-week period from December 27, 2001 to January 10, 2002. Over this two-week period, approximately 3.19 inches of rain fell in Antioch.

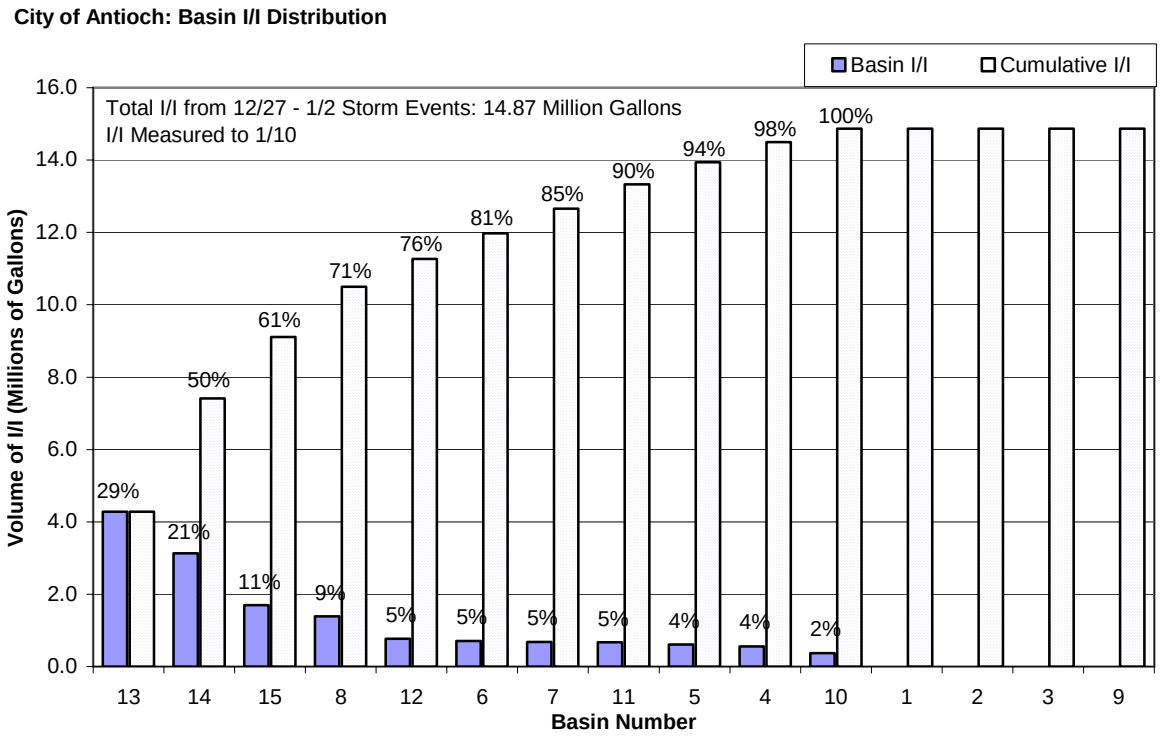


Figure 5. Basin I/I Contribution Summary

Inflow/Infiltration (I/I) flow contribution is determined by subtracting the expected baseline flow from the real-time recorded flow. During a storm event, any additional flow over the baseline flow may be rain-dependent inflow and/or infiltration. The graph above is intended to demonstrate the basins contributing the most I/I. The above graphic does not take into account the relative size of each basin. I/I flow was taken from December 27, 2001 through January 10, 2002 and analyzed on a case-by-case basis. An I/I flow for Basins 1, 2, 3 and 9 could not be determined. Lastly, the infiltration for basins dependent on the flow from other basins (Basins 4, 5, 8, 9, and 13) was calculated by subtraction of I/I totalized flows. This graphic is not intended to replace modeling programs or other proven techniques of I/I analysis, but only intends to give a quick "snapshot" of the initial flow data.

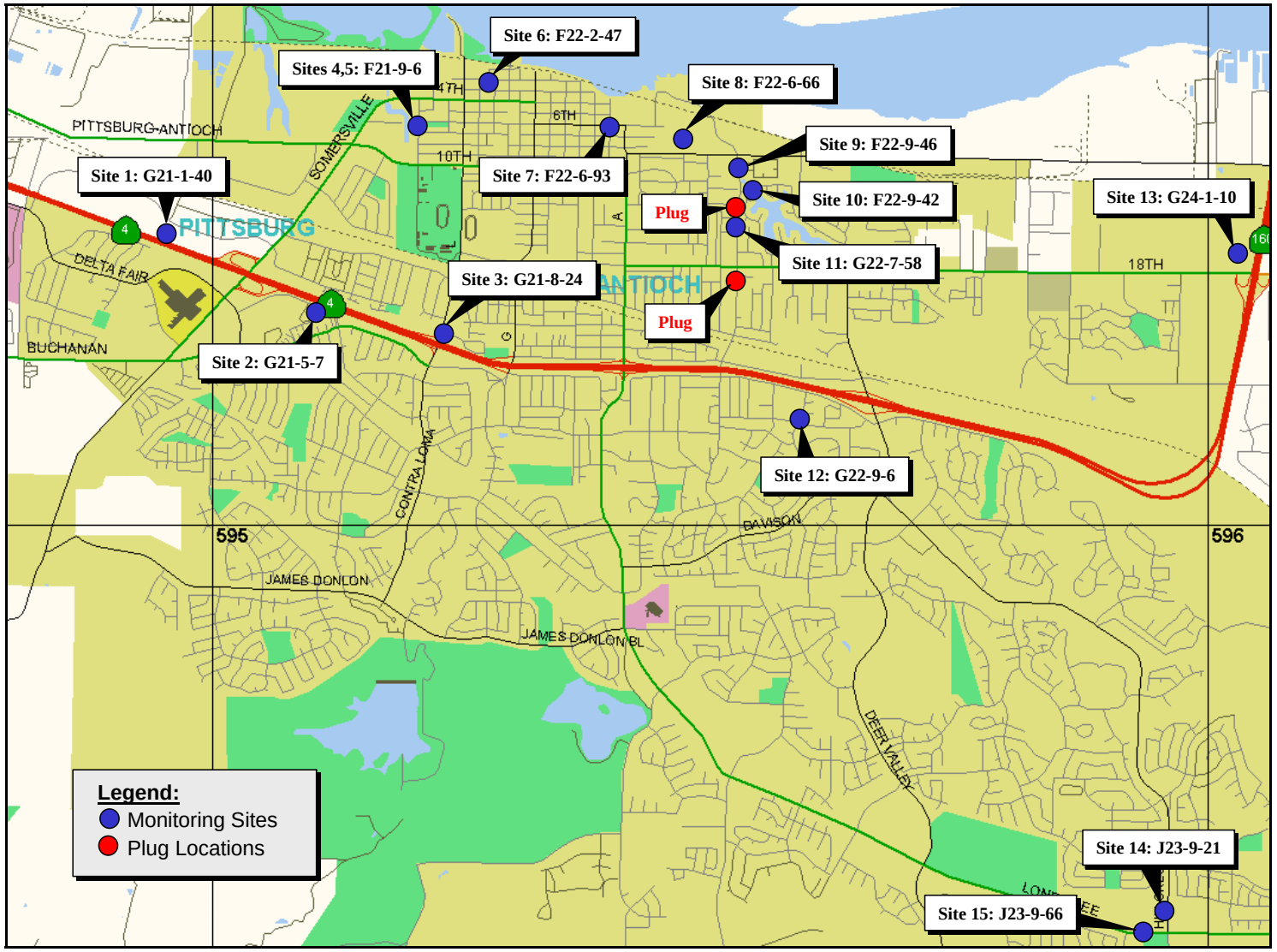


Figure 6. Flow Monitoring Sites

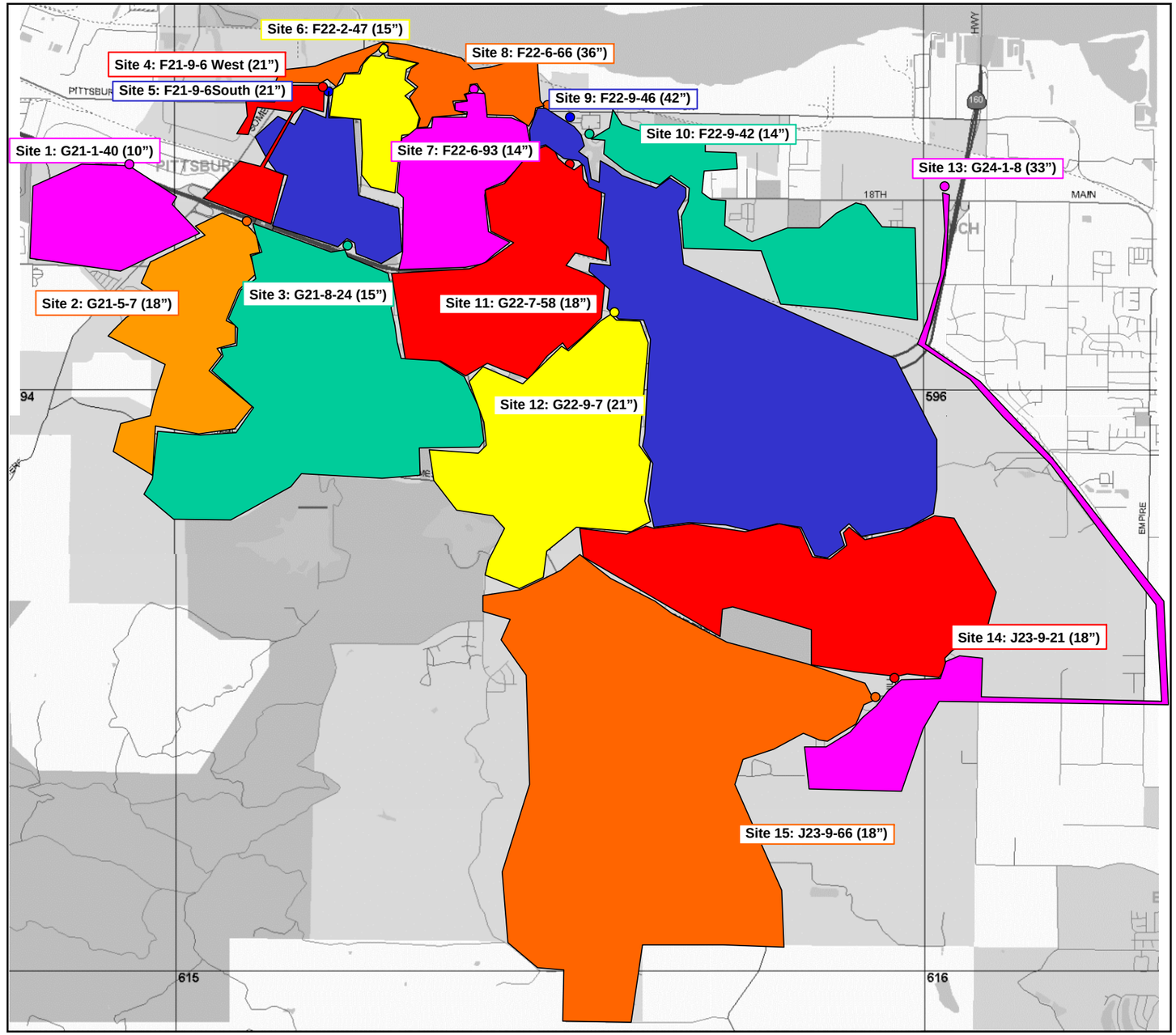


Figure 7. Isolated Flow Basins

Site 1

City Manhole Number: G21-1-40
Location Description: In dirt field west of Century Boulevard, north of Hwy 4
Pipe Diameter: 10 inches

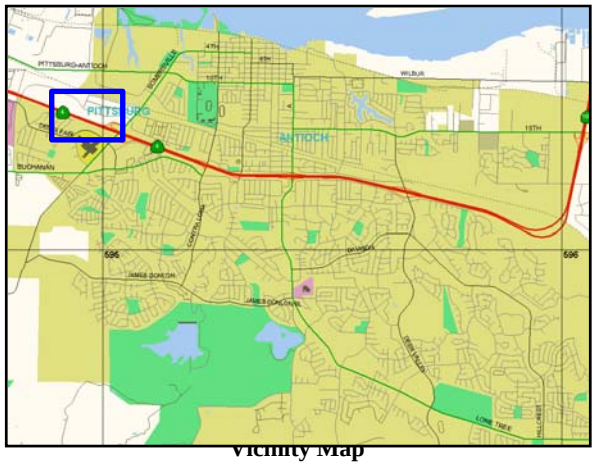
Average Baseline Flow: 0.21 MGD
Peak Baseline Flow: 0.35 MGD *1:00 PM weekends*

Peak Daily Flow: 0.26 MGD
January 24, 2002

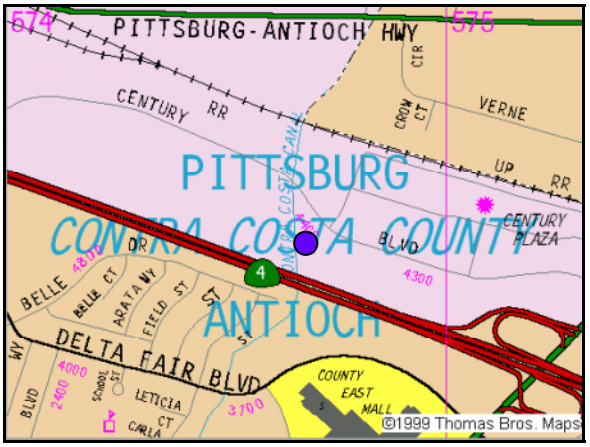
Peak Flow: 0.47 MGD
January 12, 2002, 2:00 PM

Percent Peak Flow vs. Ave. Baseline Flow: 227 %

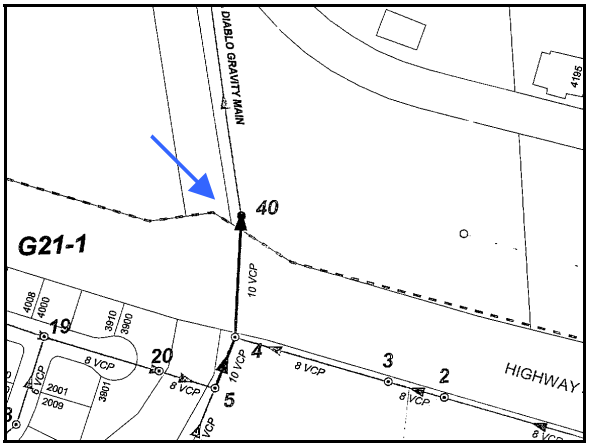
Total Volume of I/I over Monitoring Period: Undetermined



Vicinity Map



Street Map



Sanitary Sewer Map

View from Above

Plan View

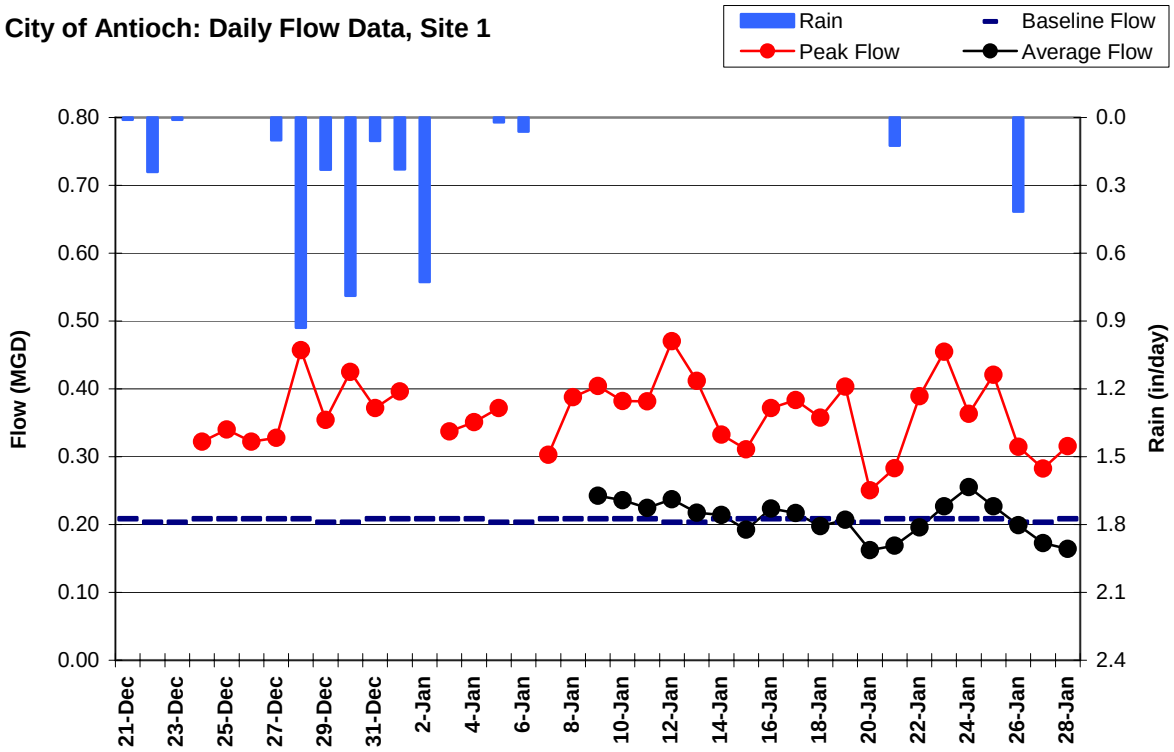


Figure 8. Site 1 Daily Flows

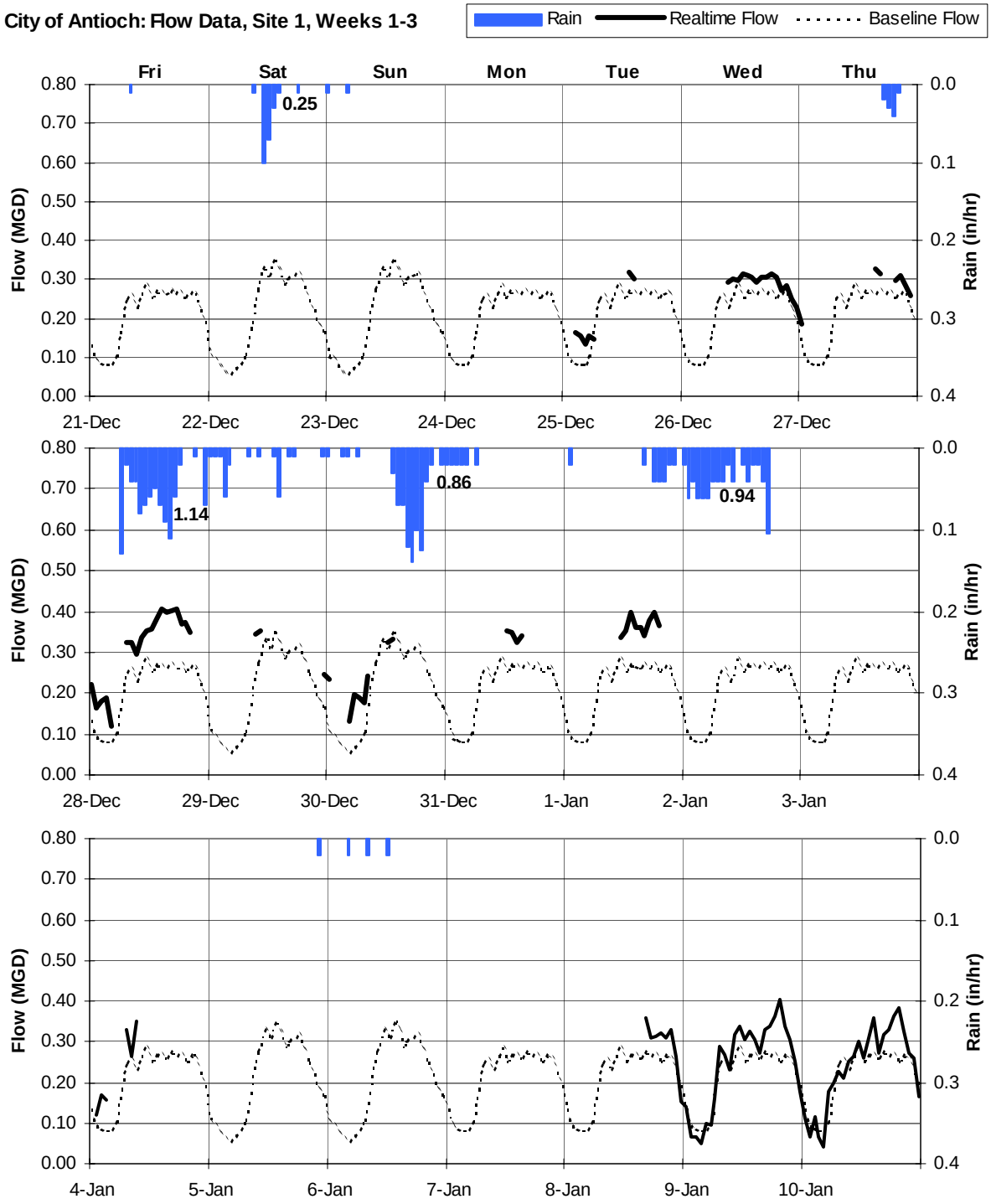


Figure 9. Site 1 Flow Data, Weeks 1-3

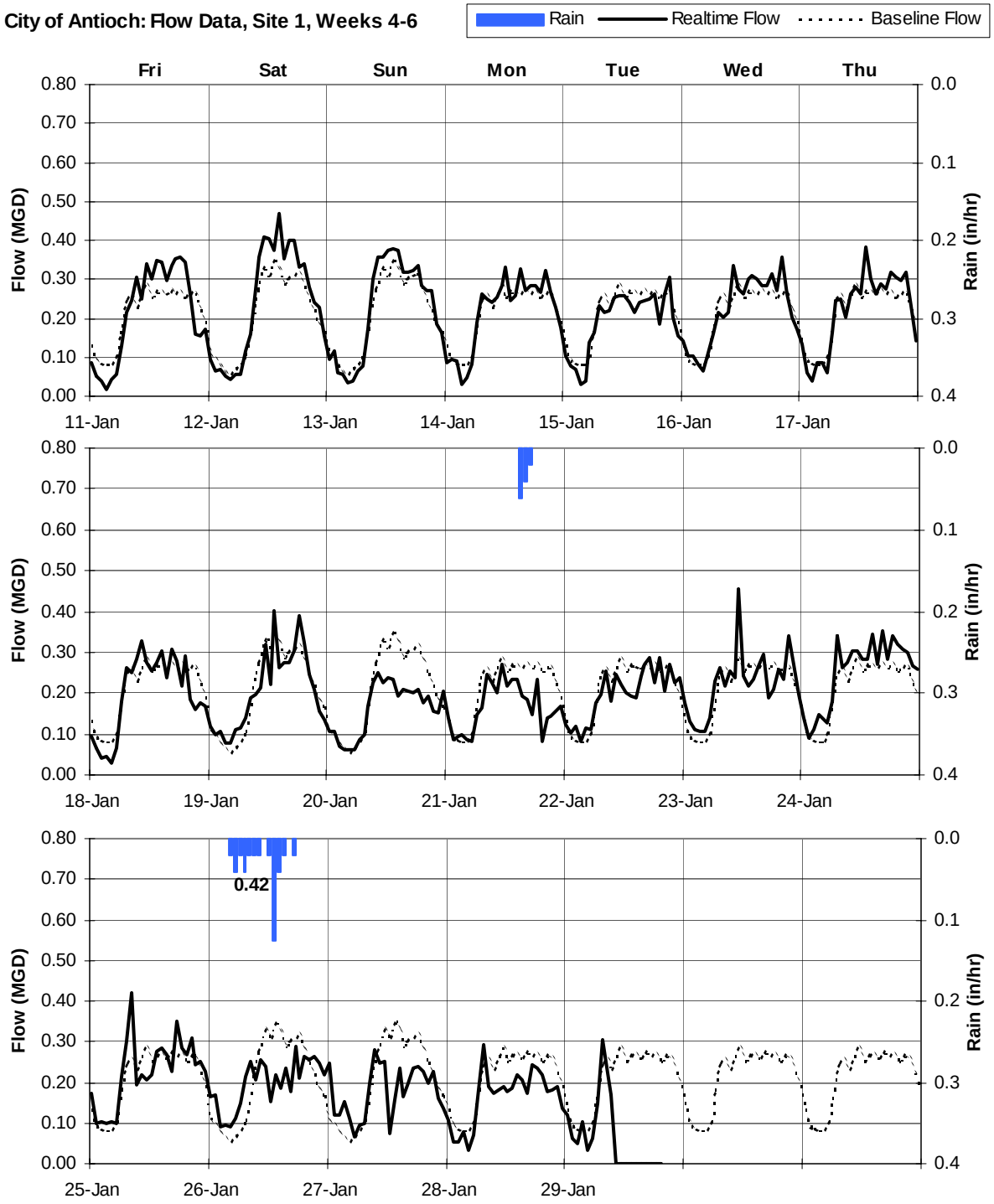


Figure 10. Site 1 Flow Data, Weeks 4-6

Site 2

City Manhole Number: G21-5-7
Location Description: San Jose Drive, west of Buchanan
Pipe Diameter: 18 inches

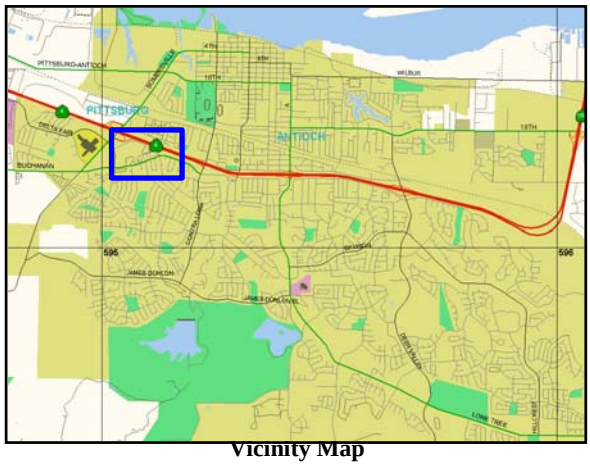
Average Baseline Flow: 0.50 MGD
Peak Baseline Flow: 0.88 MGD *1:00 PM weekends*

Peak Daily Flow: 0.59 MGD
January 13, 2002

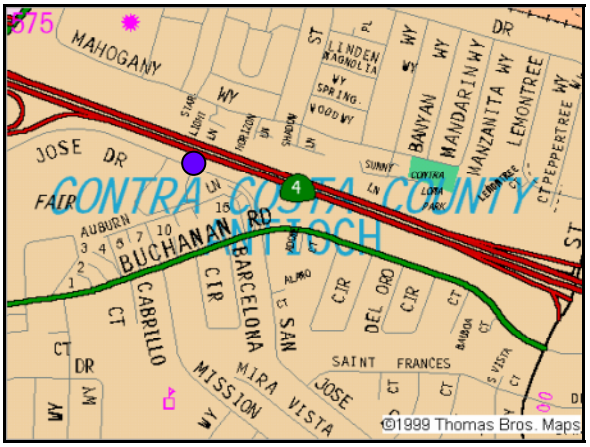
Peak Flow: 1.01 MGD
December 28, 2001, 6:00 PM

Percent Peak Flow vs. Ave. Baseline Flow: 200 %

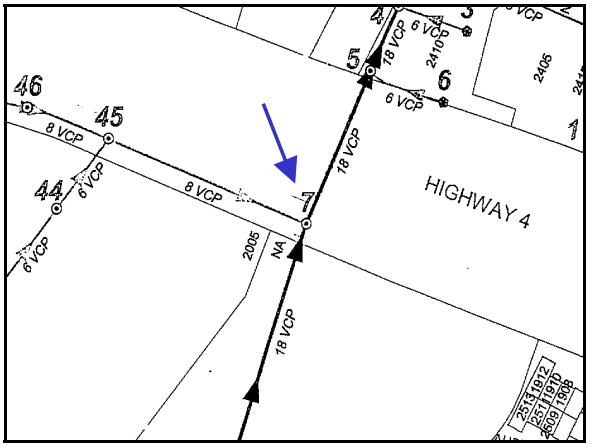
Total Volume of I/I over Monitoring Period: undetermined



Vicinity Map



Street Map



Sanitary Sewer Map

View from Above

Plan View

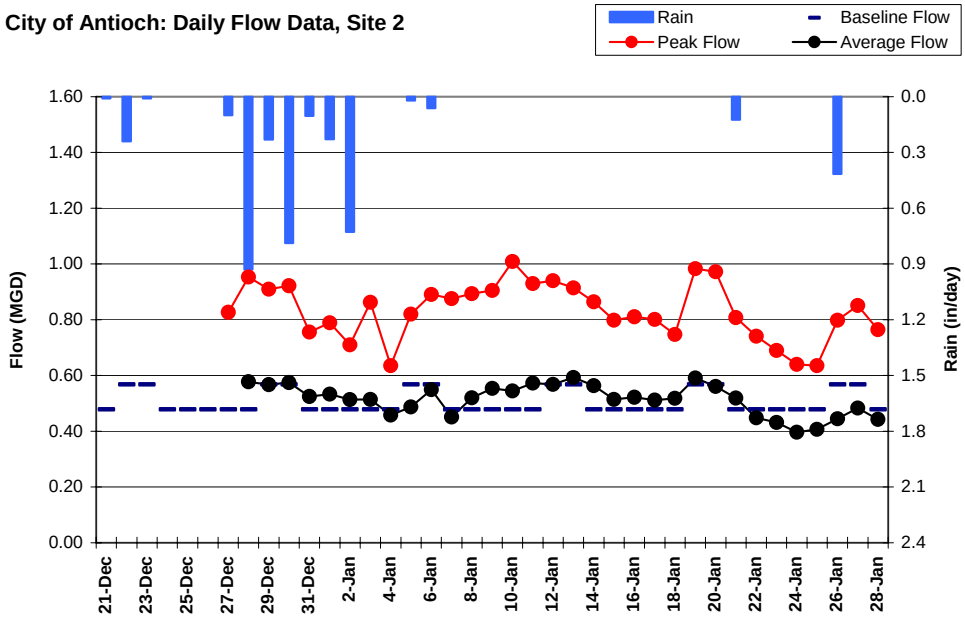


Figure 11. Site 2 Daily Flows

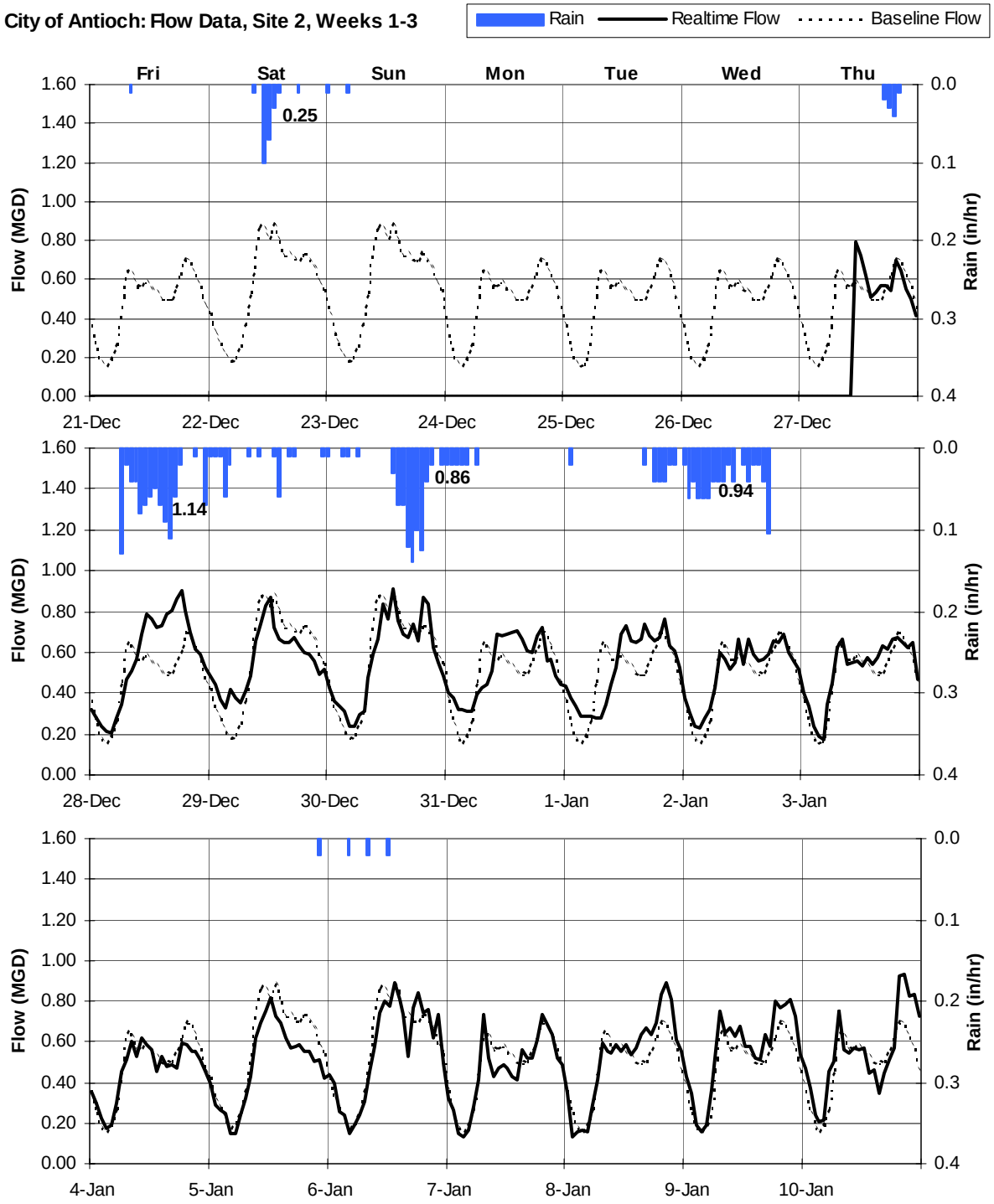


Figure 12. Site 2 Flow Data, Weeks 1-3

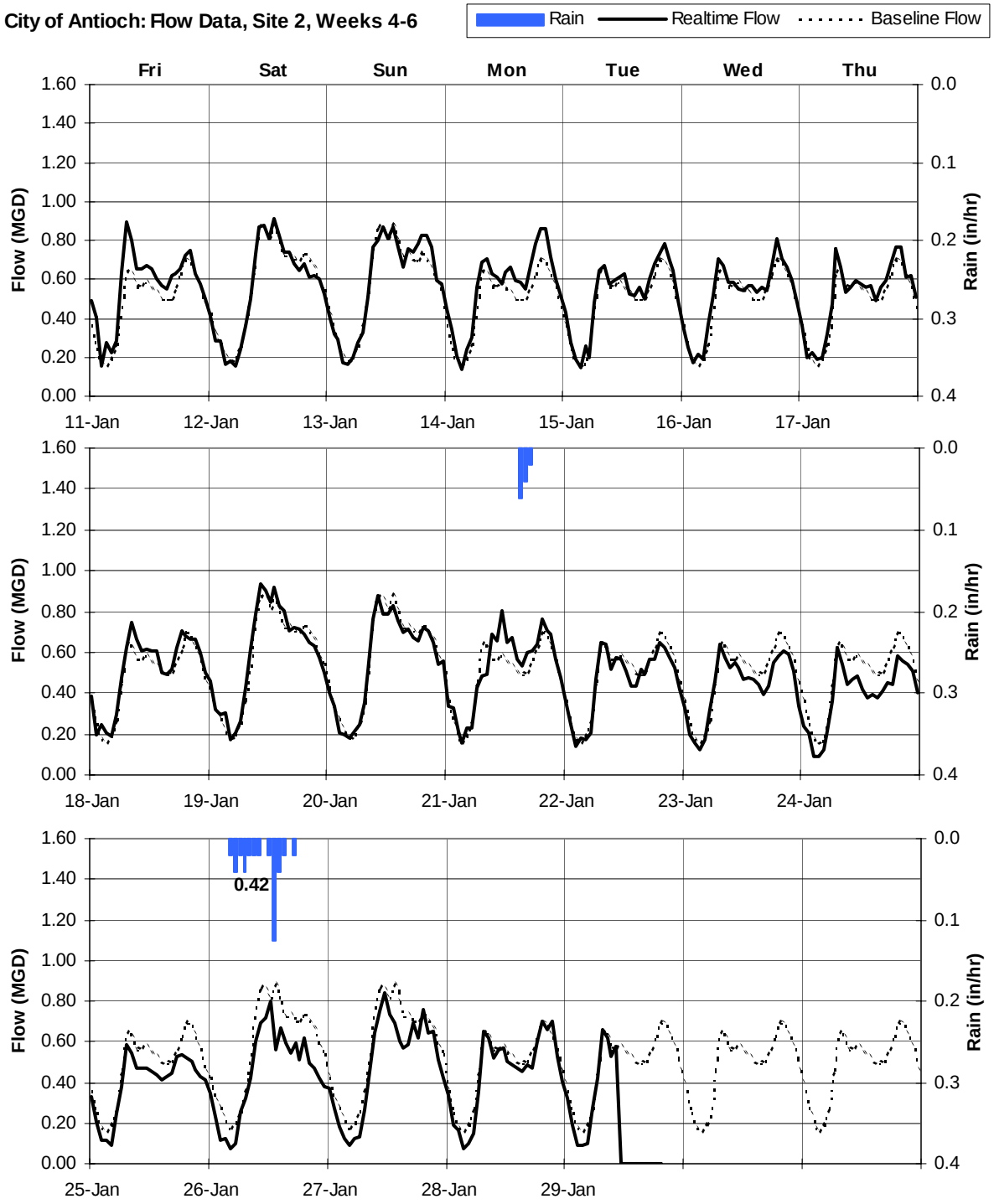


Figure 13. Site 2 Flow Data, Weeks 4-6

Site 3

City Manhole Number: G21-8-24
Location Description: Contra Loma Blvd at Claudia Court, north of Hwy 4
Pipe Diameter: 15 inches

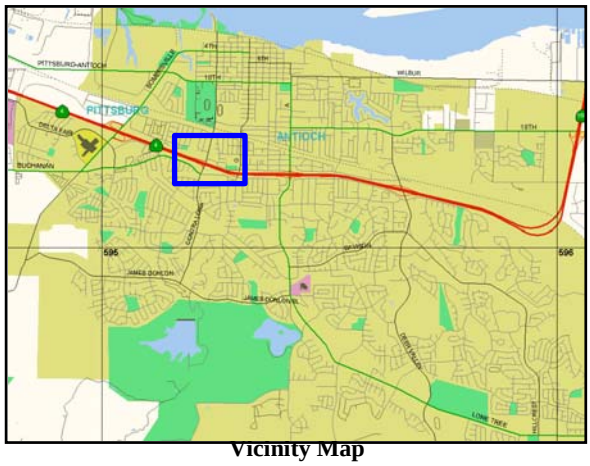
Average Baseline Flow: 0.61 MGD
Peak Baseline Flow: 1.31 MGD *12:00 PM weekends*

Peak Daily Flow: 0.81 MGD
January 6, 2002

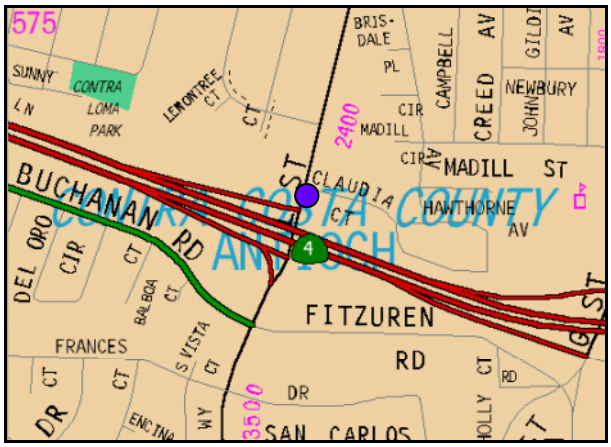
Peak Flow: 1.46 MGD
January 13, 2002, 12:00 PM

Percent Peak Flow vs. Ave. Baseline Flow: 239 %

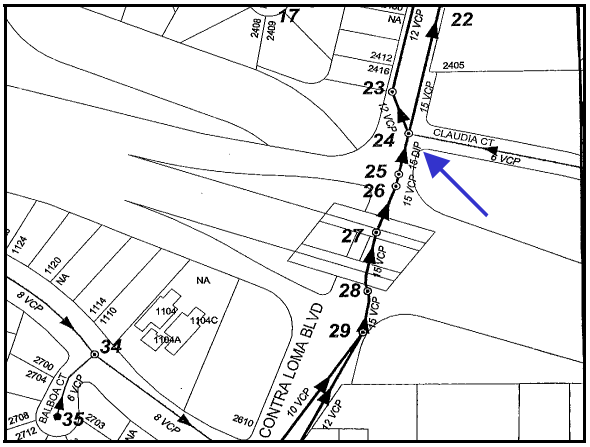
Total Volume of I/I over Monitoring Period: undetermined



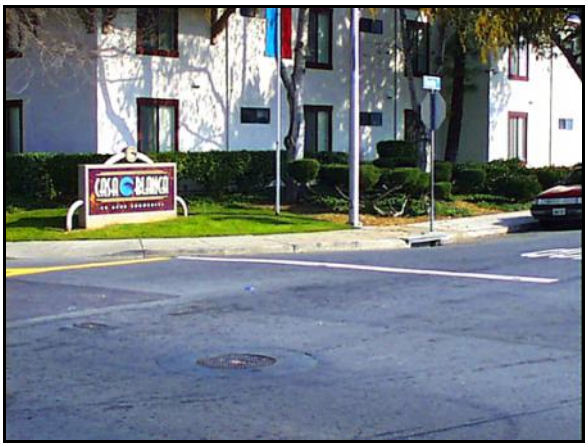
Vicinity Map



Street Map



Sanitary Sewer Map



View from Above

Plan View

Detail

Detail

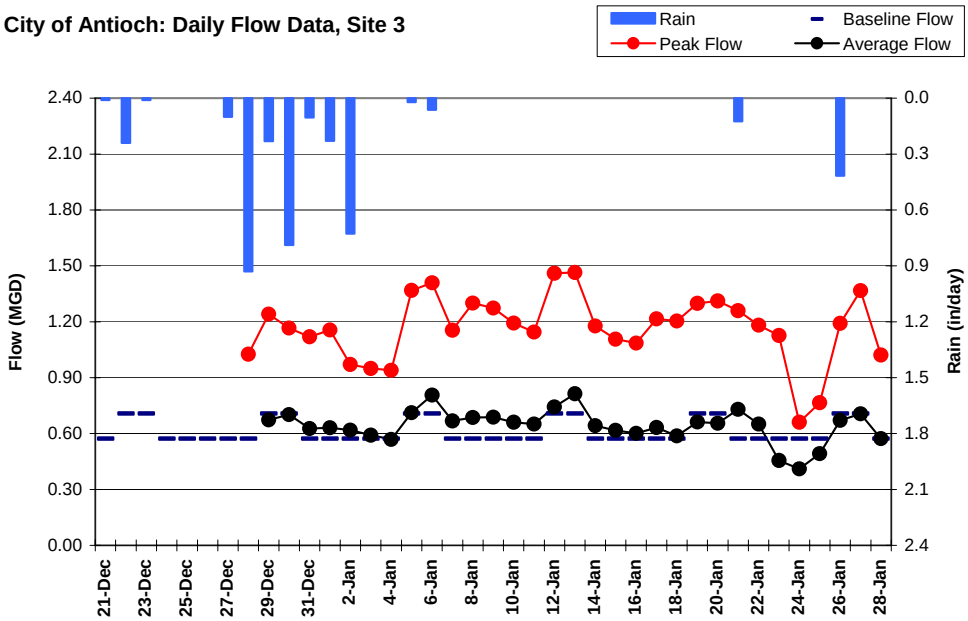


Figure 14. Site 3 Daily Flows

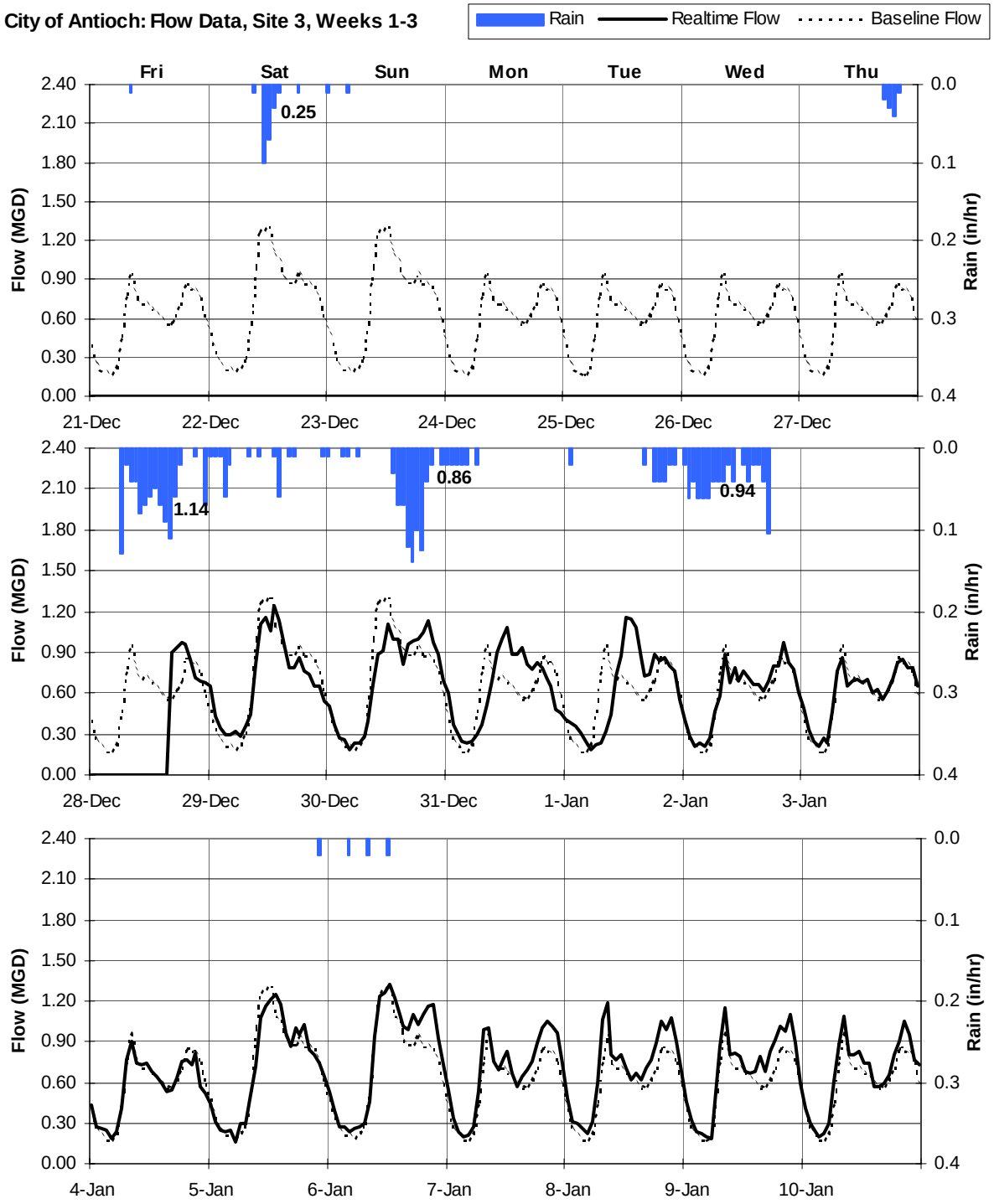


Figure 15. Site 3 Flow Data, Weeks 1-3

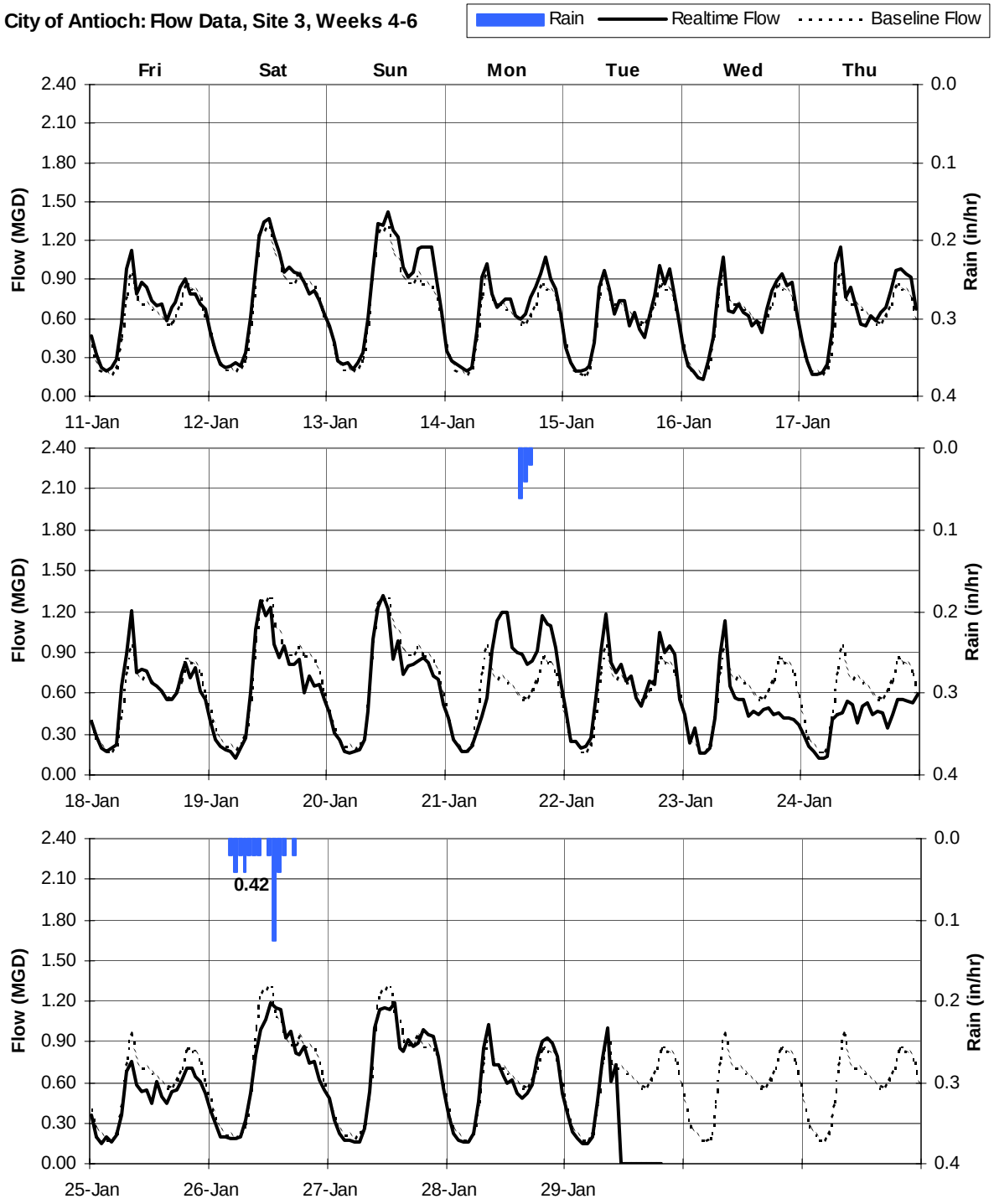


Figure 16. Site 3 Flow Data, Weeks 4-6

Site 4

City Manhole Number: F21-9-6
Location Description: O Street and 6th Street
Pipe Diameter: 21 inches (note: map incorrectly says 15 inches)

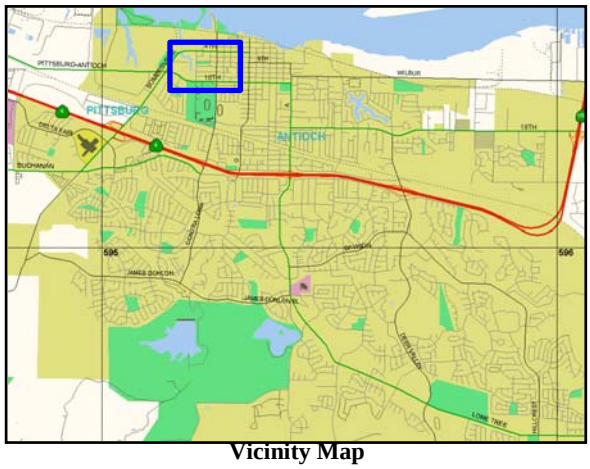
Average Baseline Flow: 0.79 MGD
Peak Baseline Flow: 1.35 MGD *12:00 PM weekends*

Peak Daily Flow: 0.94 MGD
December 28, 2001

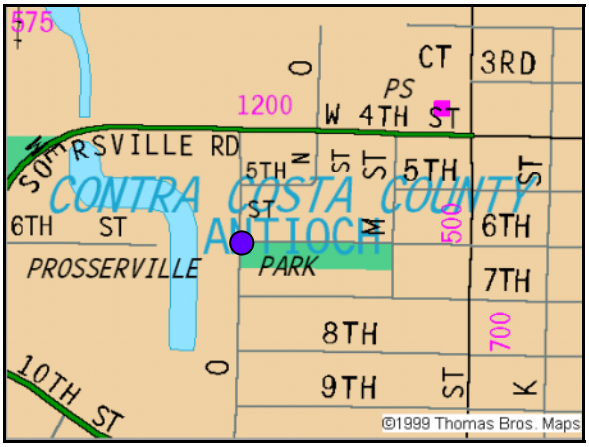
Peak Flow: 1.47 MGD
December 28, 2001, 6:00 PM

Percent Peak Flow vs. Ave. Baseline Flow: 186%

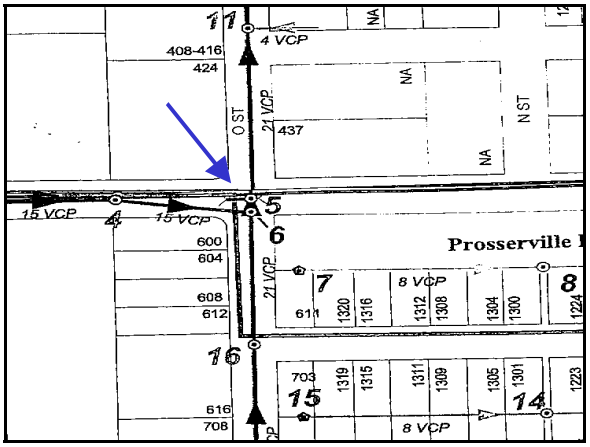
Total Volume of I/I over Monitoring Period: 0.56 MG



Vicinity Map



Street Map



Sanitary Sewer Map

View from Above

Plan View

Detail, Infiltration

Detail, Infiltration

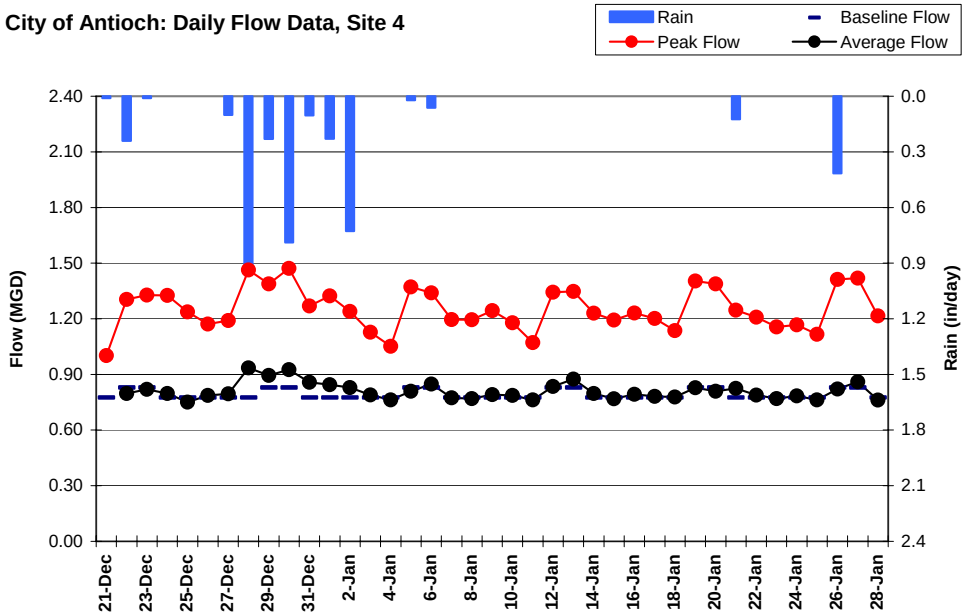


Figure 17. Site 4 Daily Flows

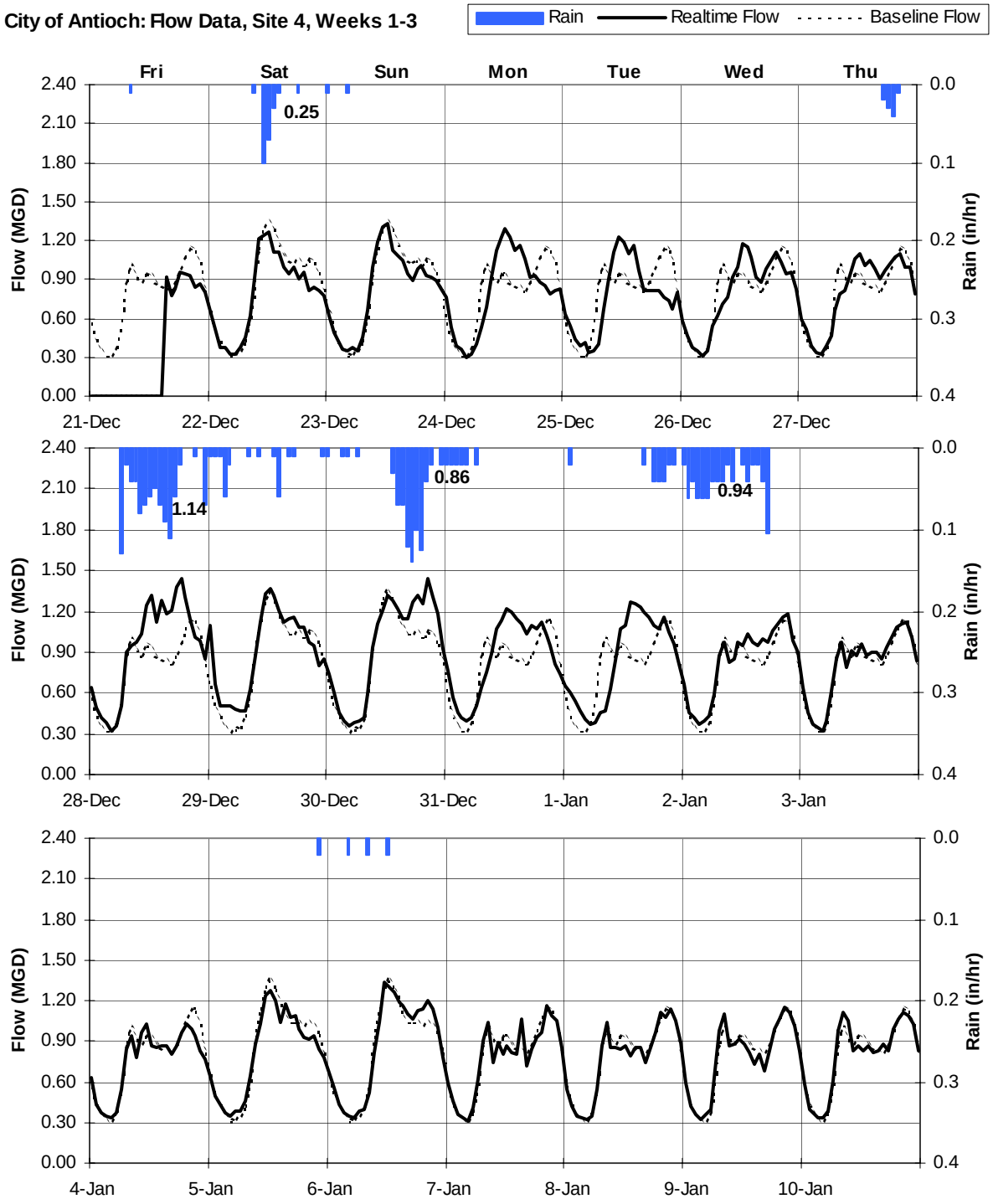


Figure 18. Site 4 Flow Data, Weeks 1-3

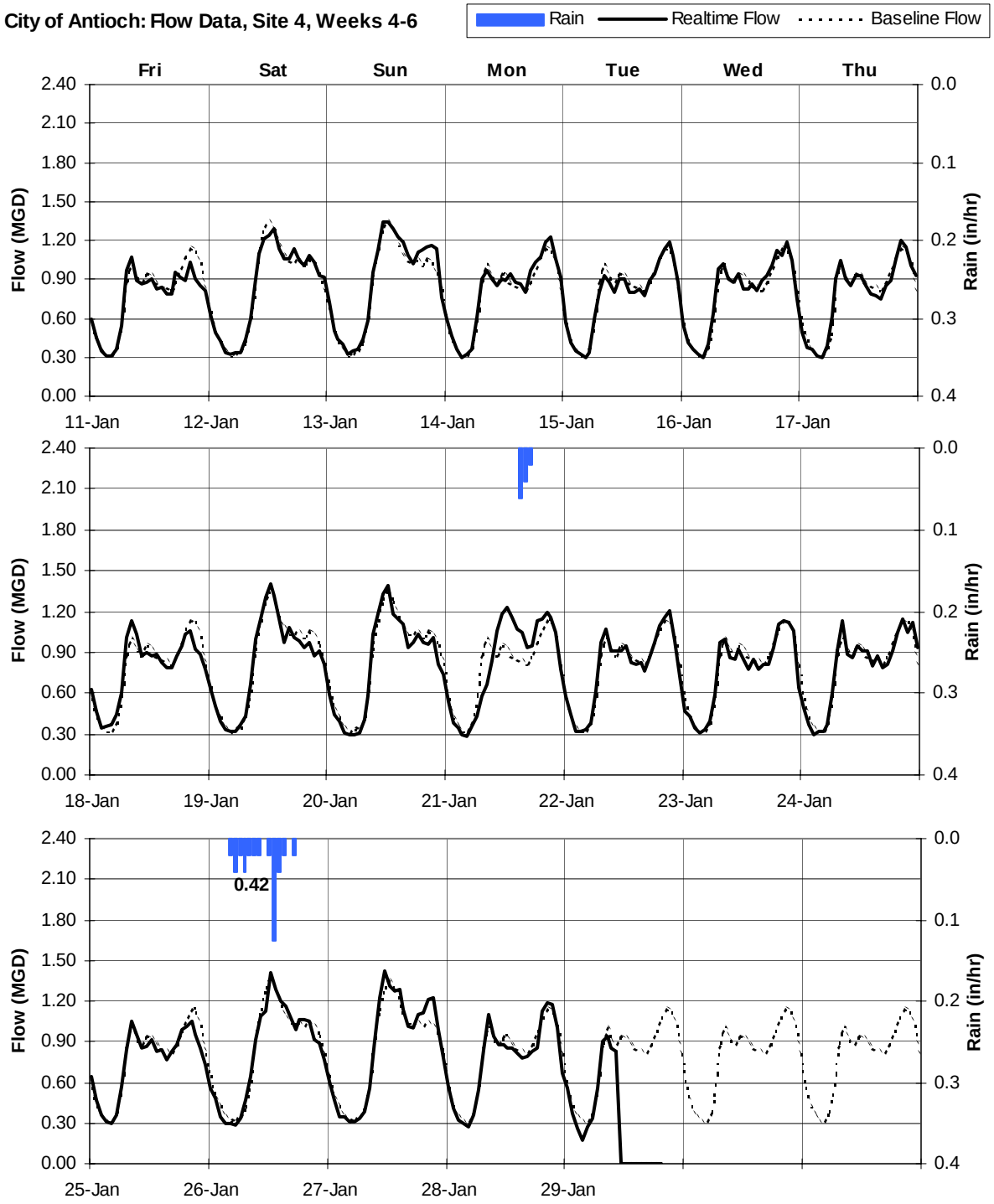


Figure 19. Site 4 Flow Data, Weeks 4-6

Site 5

City Manhole Number: F21-9-6
Location Description: O Street and 6th Street
Pipe Diameter: 21 inches

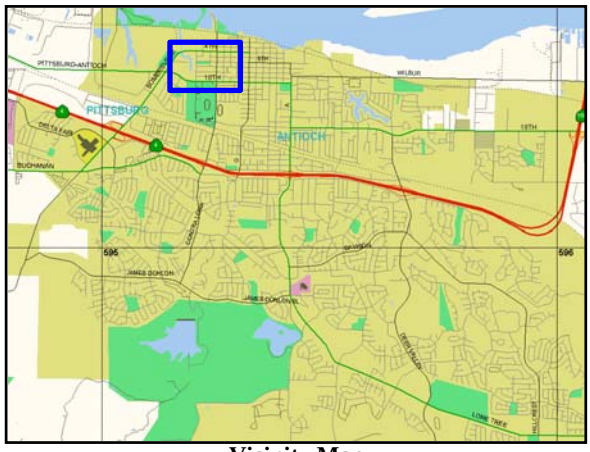
Average Baseline Flow: 1.49 MGD
Peak Baseline Flow: 2.35 MGD *11:00 AM weekends*

Peak Daily Flow: 1.72 MGD
December 30, 2001

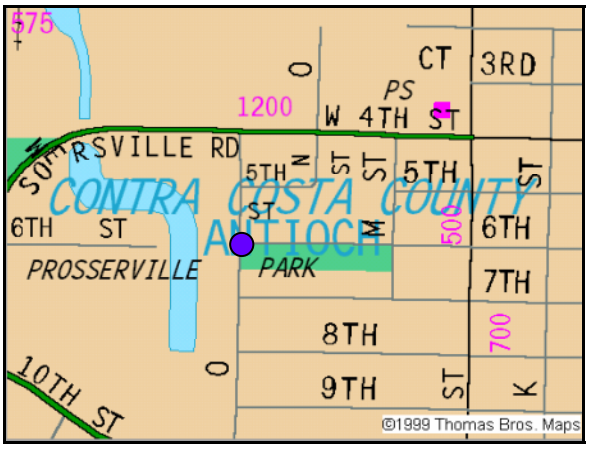
Peak Flow: 2.59 MGD
December 29, 2001, 12:00 PM

Percent Peak Flow vs. Ave. Baseline Flow: 174%

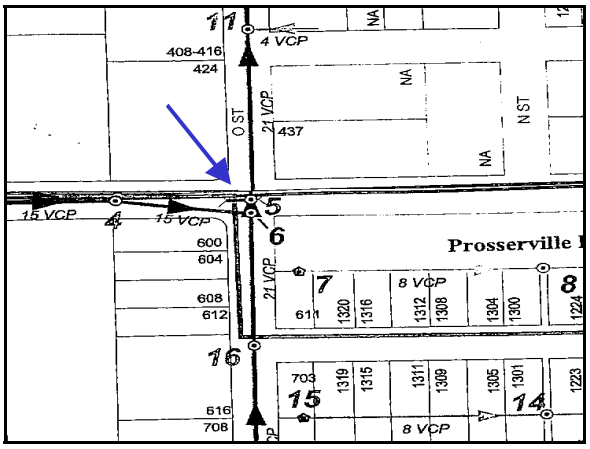
Total Volume of I/I over Monitoring Period: 0.61 MG



Vicinity Map



Street Map



Sanitary Sewer Map

View from Above

Plan View

Detail, Infiltration

Detail, Infiltration

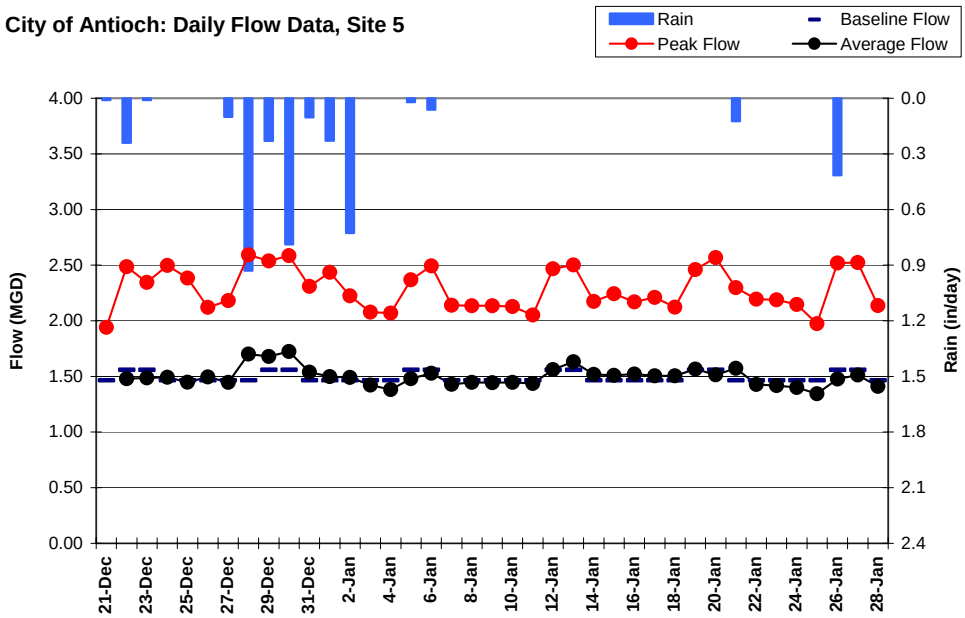


Figure 20. Site 5 Daily Flows

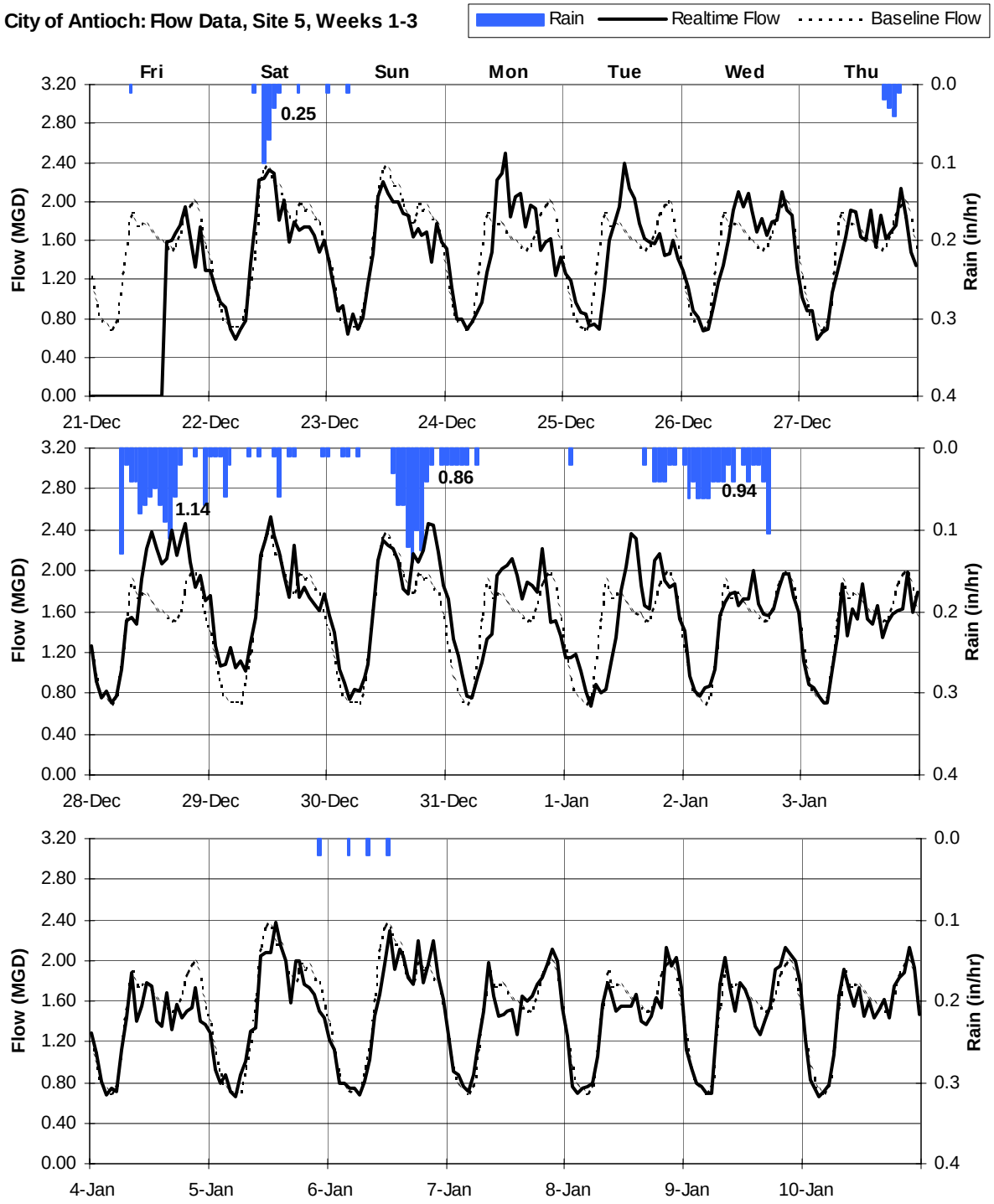


Figure 21. Site 5 Flow Data, Weeks 1-3

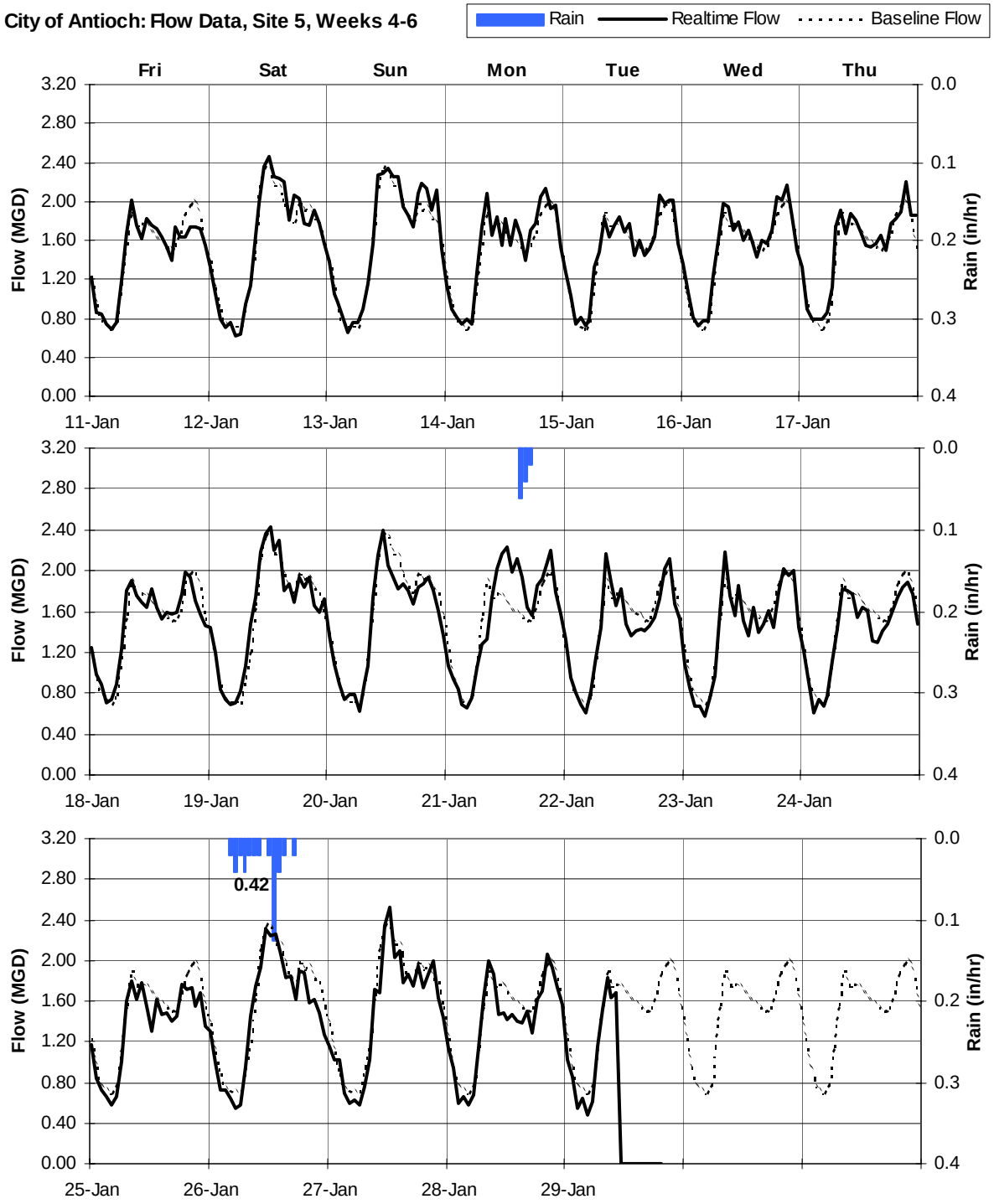


Figure 22. Site 5 Flow Data, Weeks 4-6

Site 6

City Manhole Number: F22-2-47
Location Description: J Street and 2nd Street
Pipe Diameter: 15 inches

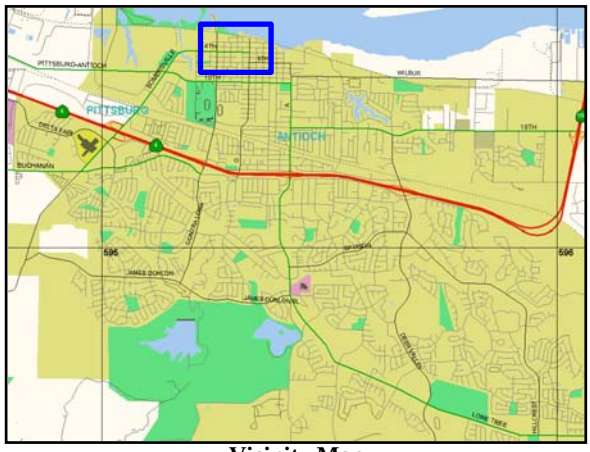
Average Baseline Flow: 0.21 MGD
Peak Baseline Flow: 0.32 MGD *11:00 AM weekends*

Peak Daily Flow: 0.35 MGD
December 28, 2001

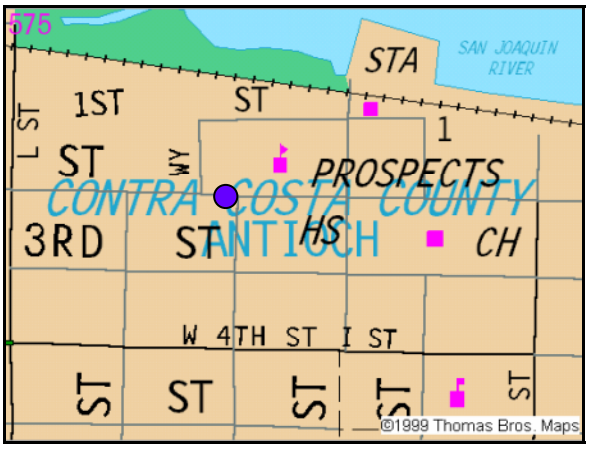
Peak Flow: 0.76 MGD
December 30, 2001, 8:00 PM

Percent Peak Flow vs. Ave. Baseline Flow: 362%

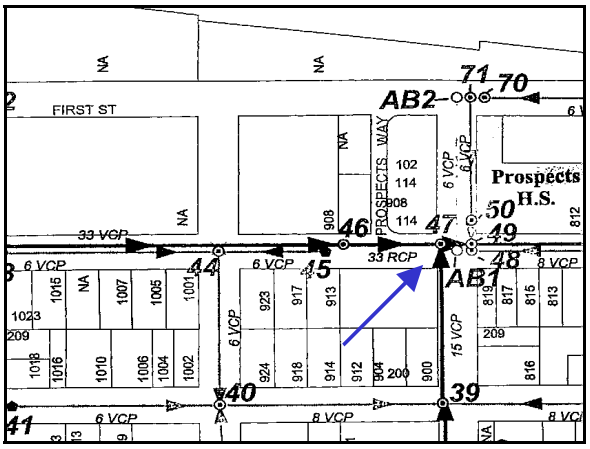
Total Volume of I/I over Monitoring Period: 0.71 MG



Vicinity Map



Street Map



Sanitary Sewer Map

View from Above

Plan View

Detail

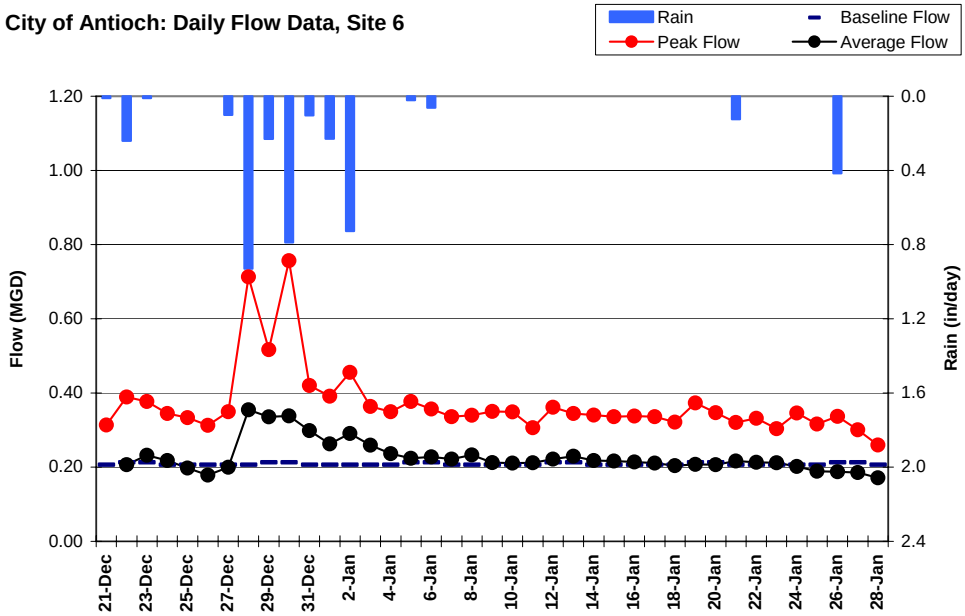


Figure 23. Site 6 Daily Flows

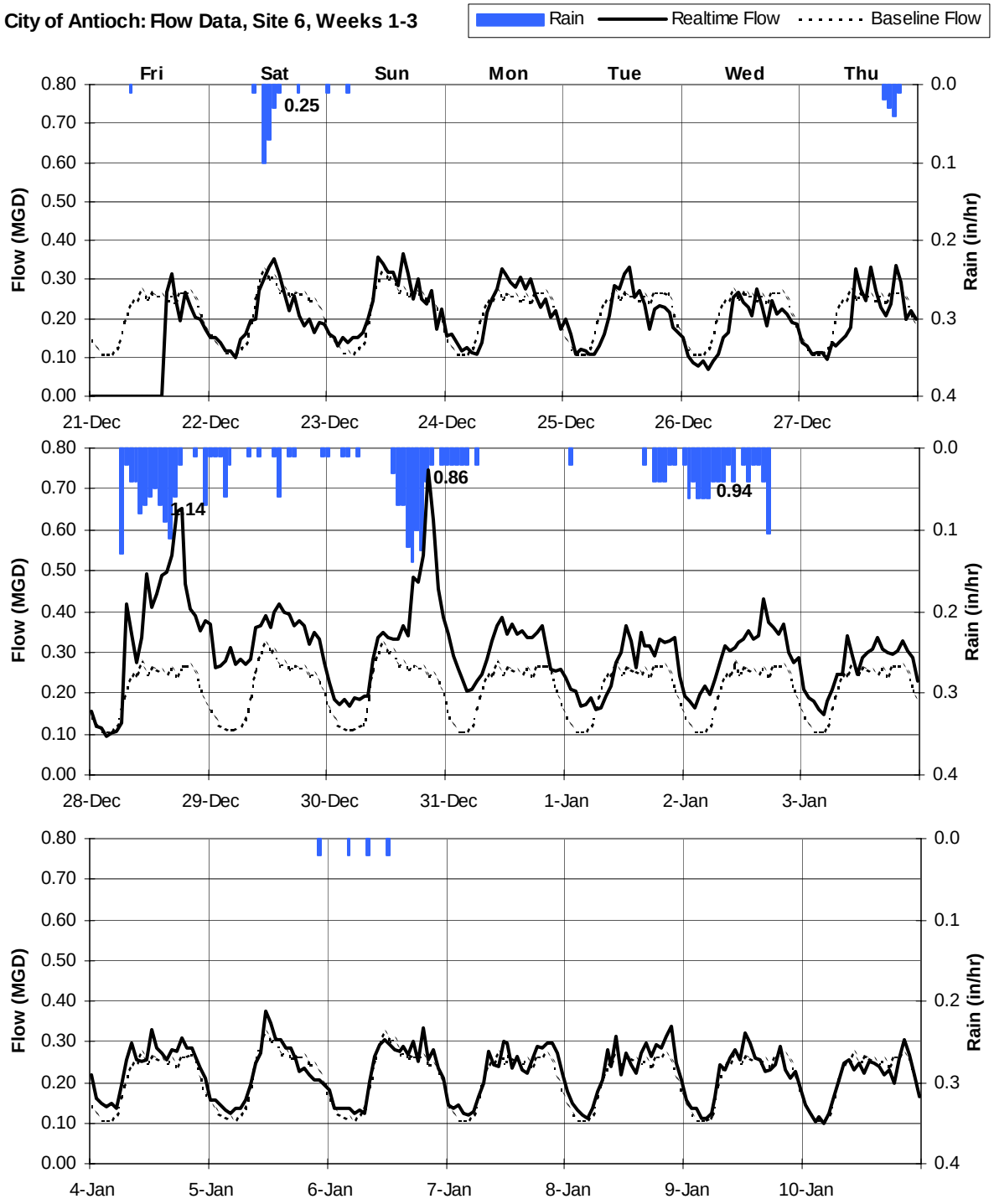


Figure 24. Site 6 Flow Data, Weeks 1-3

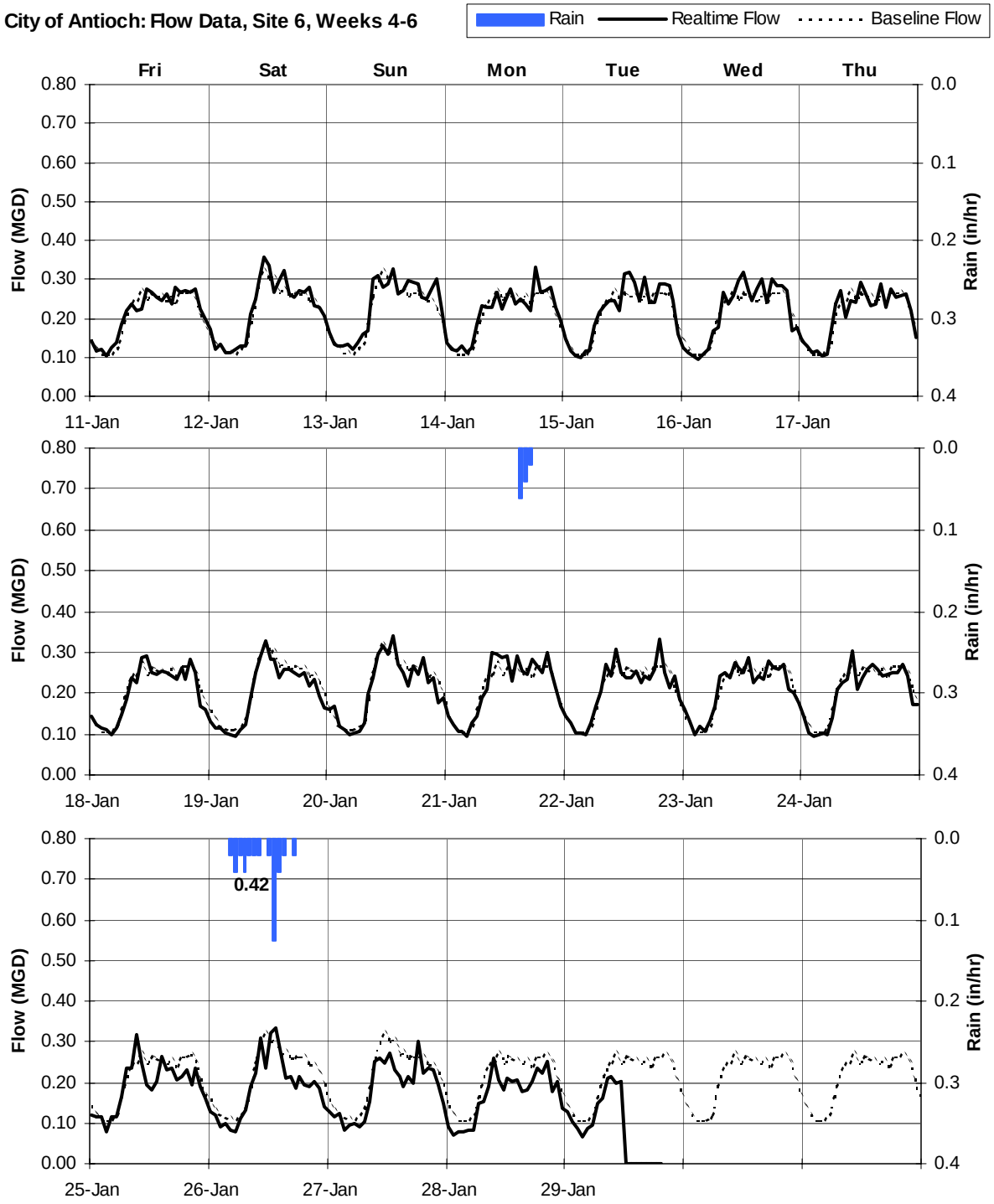


Figure 25. Site 6 Flow Data, Weeks 4-6

Site 7

City Manhole Number: F22-6-93
Location Description: B Street and 6th Street
Pipe Diameter: 14 inches

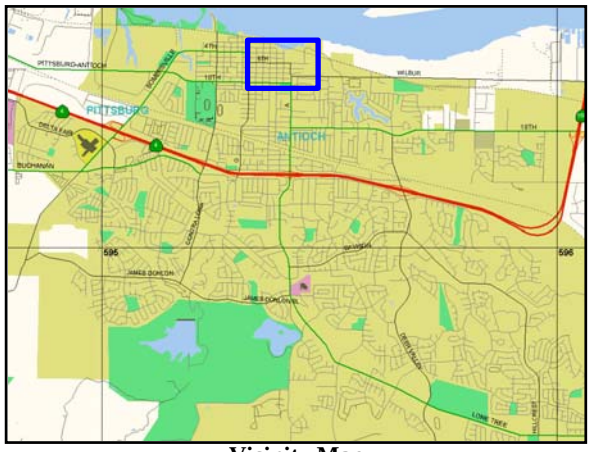
Average Baseline Flow: 0.58 MGD
Peak Baseline Flow: 0.92 MGD *11:00 AM weekends*

Peak Daily Flow: 0.82 MGD
December 28, 2001

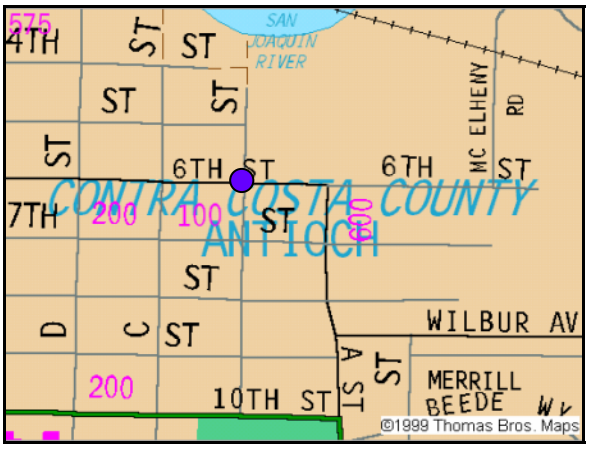
Peak Flow: 1.41 MGD
December 28, 2001, 11:00 AM

Percent Peak Flow vs. Ave. Baseline Flow: 242 %

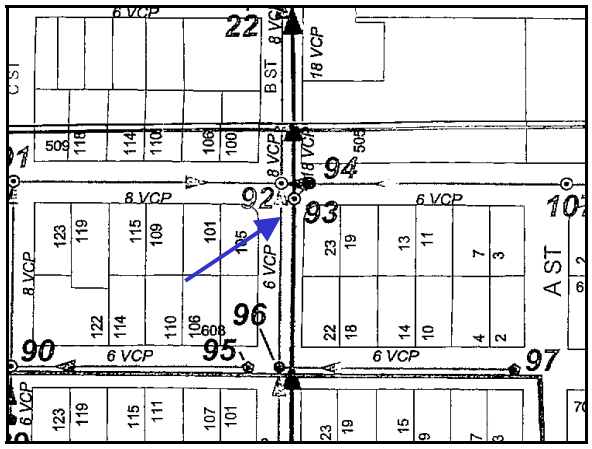
Total Volume of I/I over Monitoring Period: 0.68 MG



Vicinity Map



Street Map



Sanitary Sewer Map

View from Above

Plan View

Detail

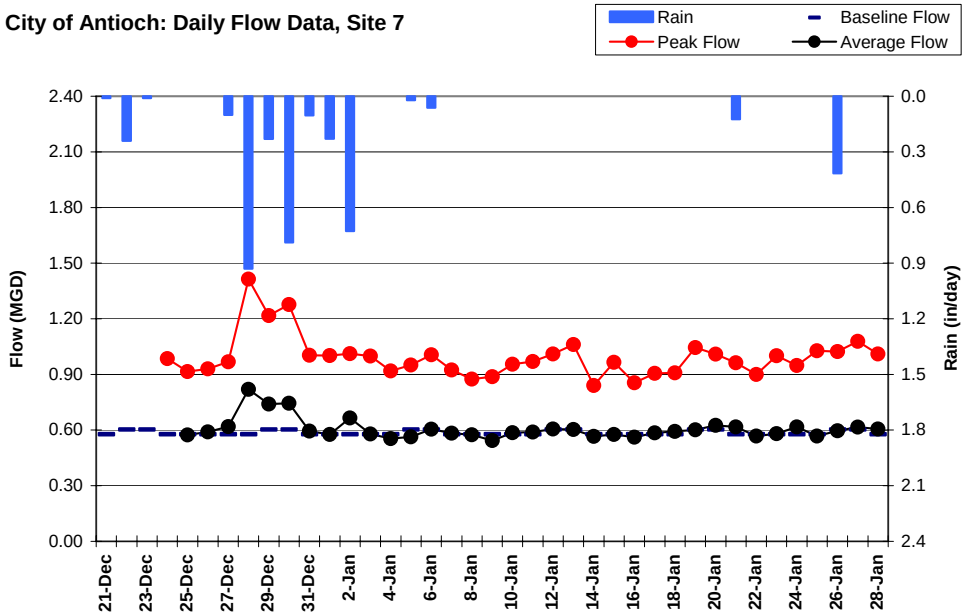


Figure 26. Site 7 Daily Flows

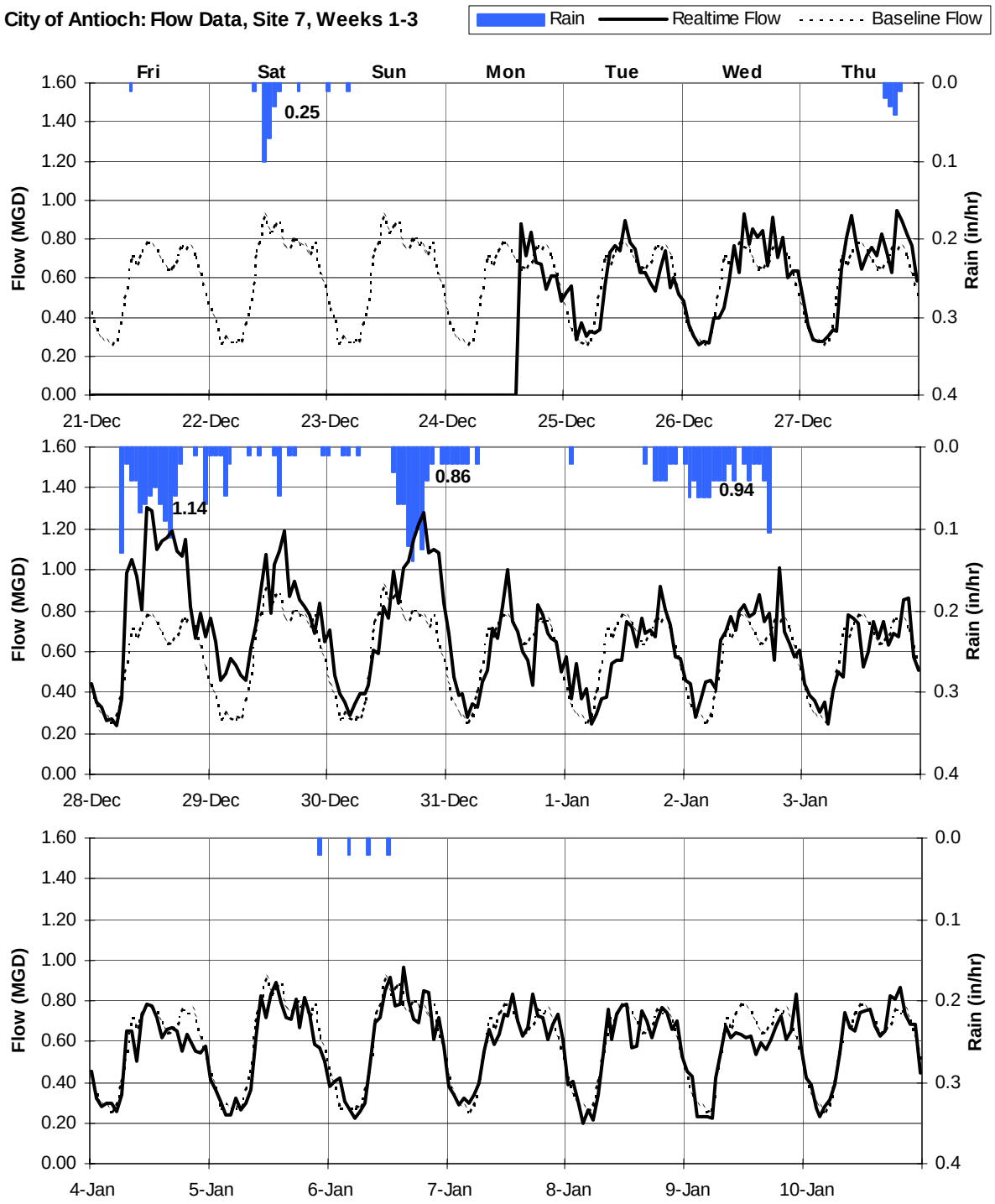


Figure 27. Site 7 Flow Data, Weeks 1-3

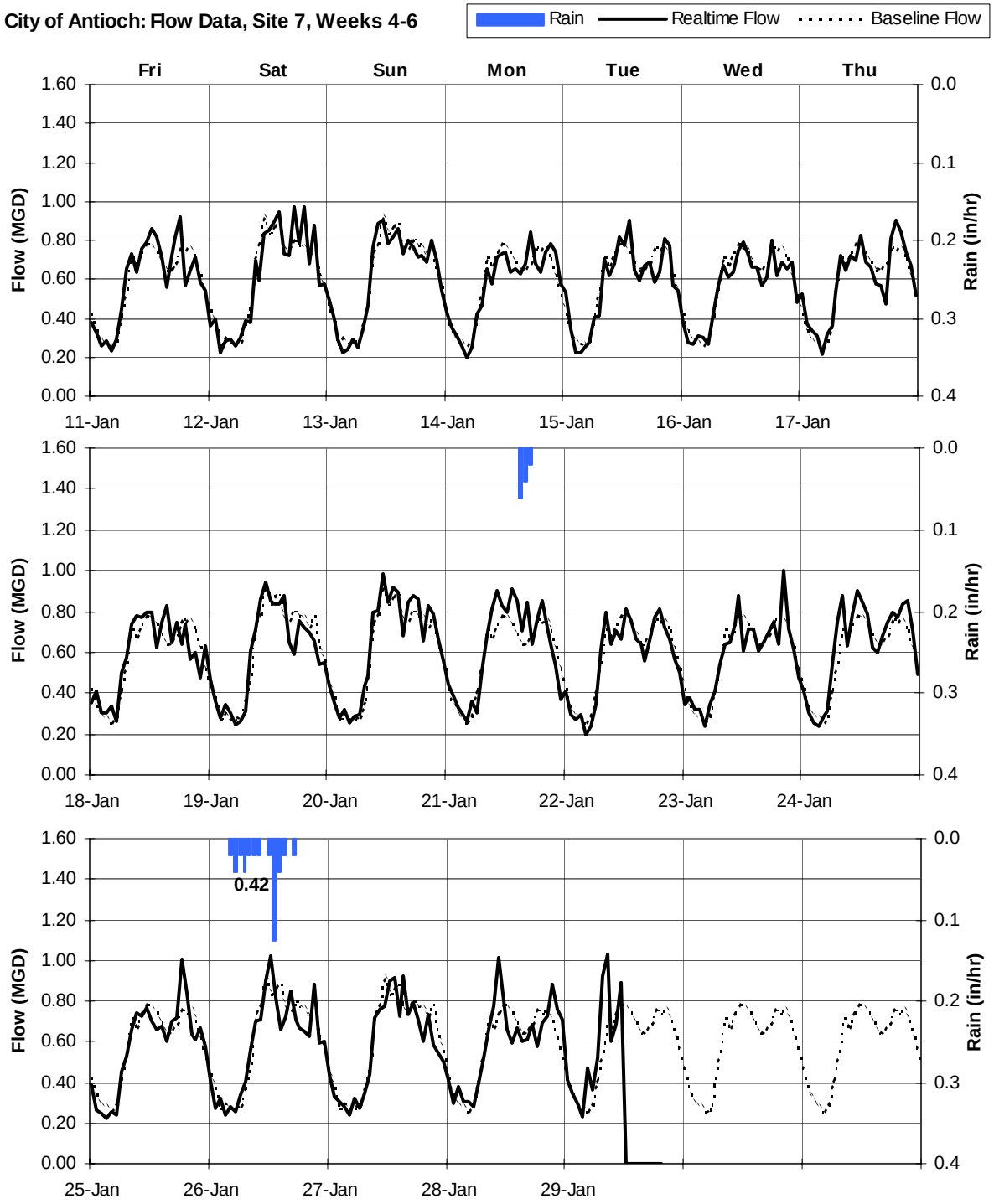


Figure 28. Site 7 Flow Data, Weeks 4-6

Site 8

City Manhole Number: F22-6-66
Location Description: North of Wilbur Avenue, in 735 Wilber Apartments parking lot
Pipe Diameter: 36 inches

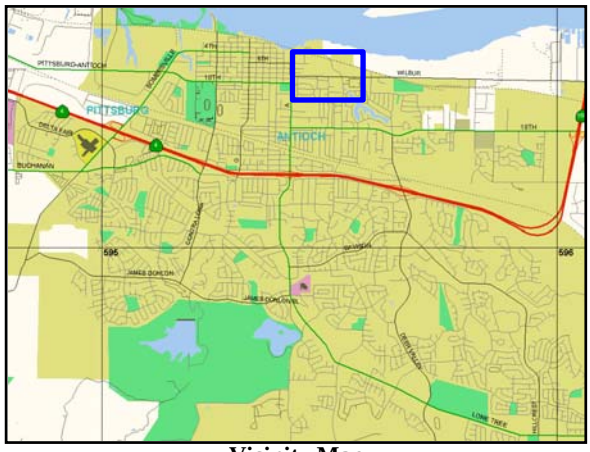
Average Baseline Flow: 2.99 MGD
Peak Baseline Flow: 4.70 MGD *12:00 PM weekends*

Peak Daily Flow: 3.76 MGD
December 28, 2001

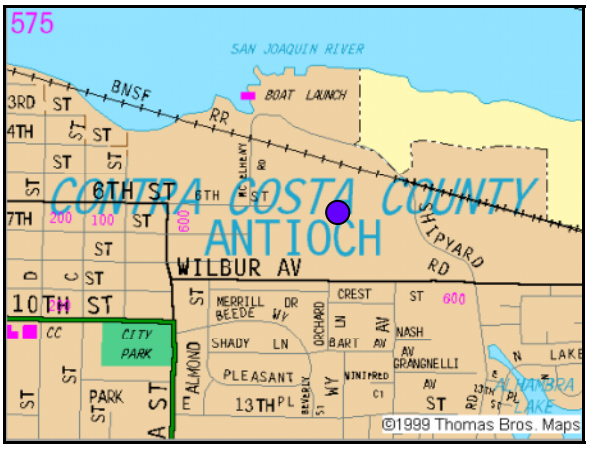
Peak Flow: 6.65 MGD
December 30, 2001, 9:00 PM

Percent Peak Flow vs. Ave. Baseline Flow: 223 %

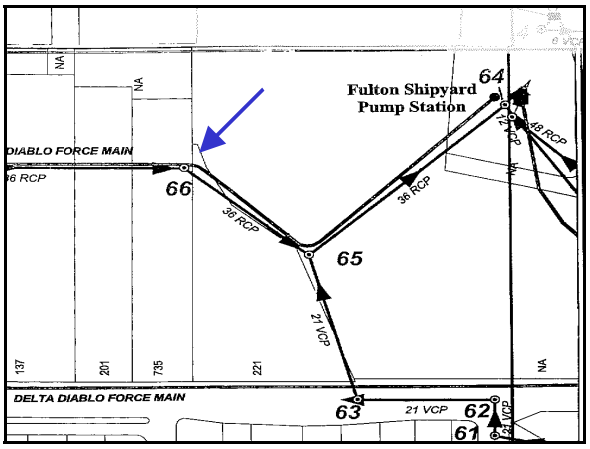
Total Volume of I/I over Monitoring Period: 3.38 MG



Vicinity Map



Street Map



Sanitary Sewer Map

View from Above

Plan View

Detail, Infiltration

Detail, Infiltration

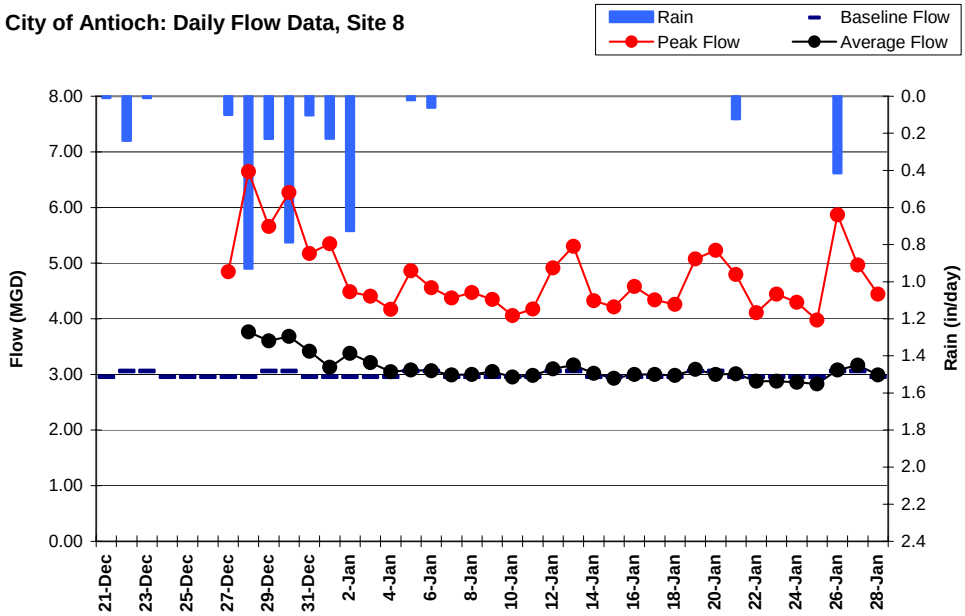


Figure 29. Site 8 Daily Flows

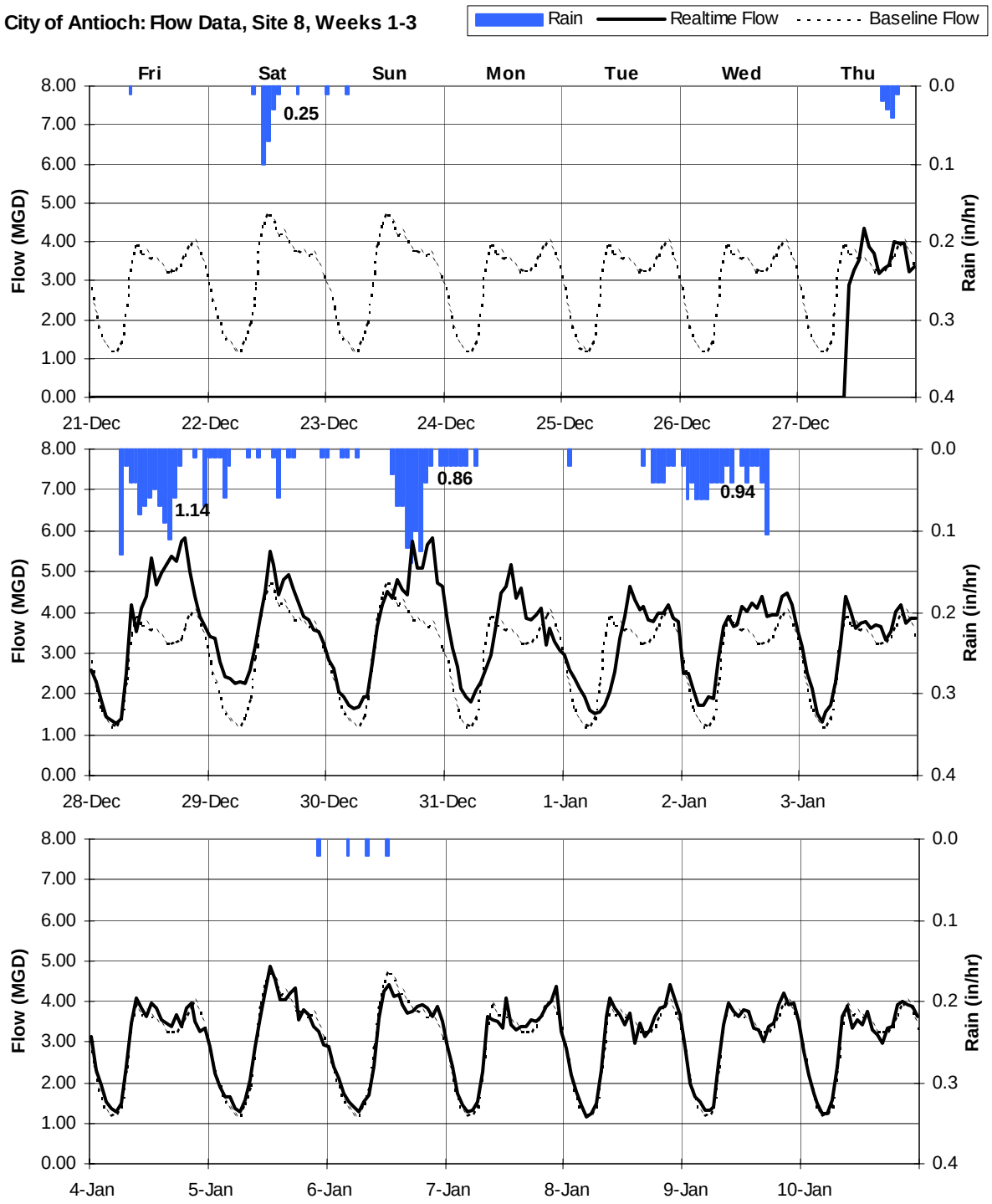


Figure 30. Site 8 Flow Data, Weeks 1-3

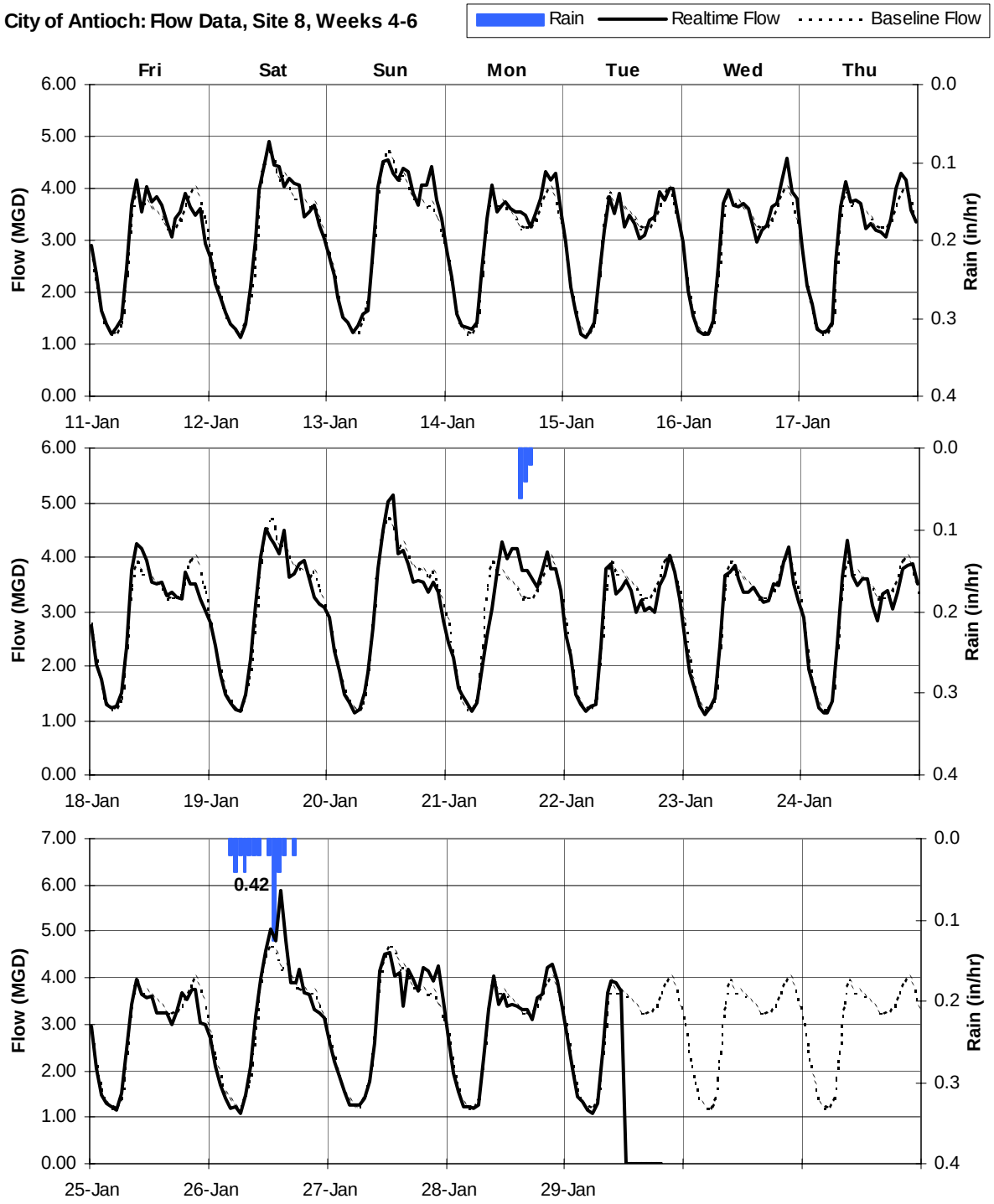


Figure 31. Site 8 Flow Data, Weeks 4-6

Site 9

City Manhole Number: F22-6-93
Location Description: Cavallo Road, south of Wilbur Avenue
Pipe Diameter: 42 inches

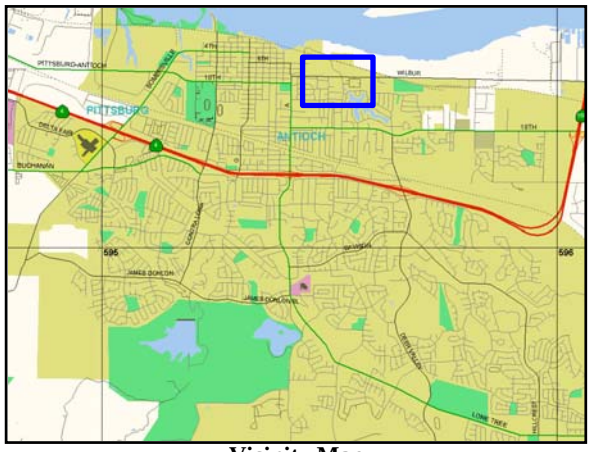
Average Baseline Flow: 3.24 MGD
Peak Baseline Flow: 4.61 MGD *10:00 AM weekends*

Peak Daily Flow: 3.61 MGD
January 23, 2002

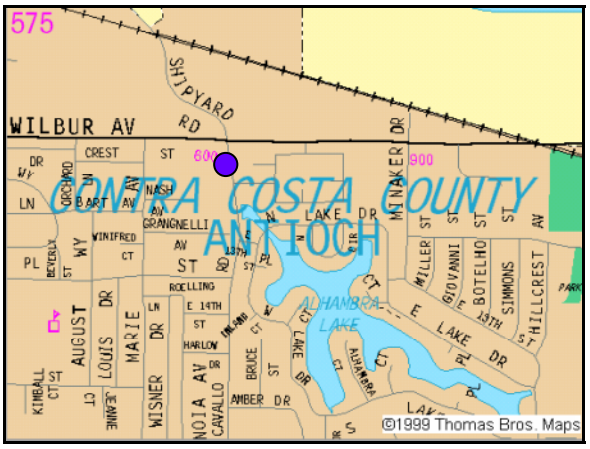
Peak Flow: 5.91 MGD
January 19, 2002, 10:00 AM

Percent Peak Flow vs. Ave. Baseline Flow: 182 %

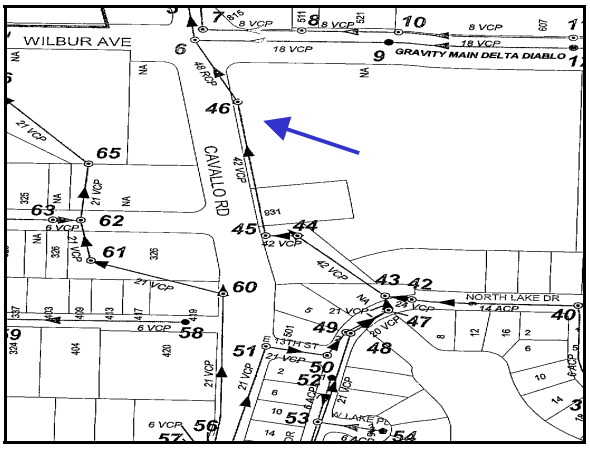
Total Volume of I/I over Monitoring Period: undetermined



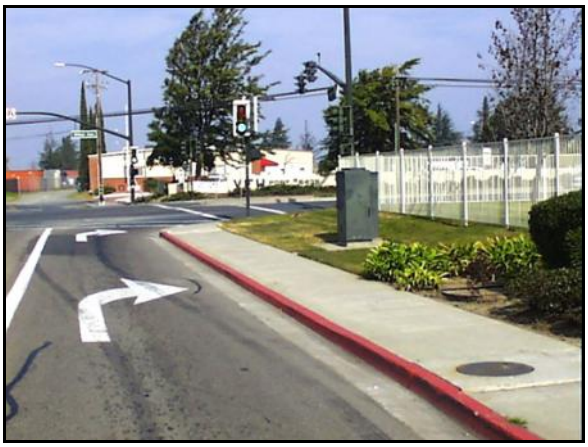
Vicinity Map



Street Map



Sanitary Sewer Map



View from Above

Plan View

Detail, Infiltration

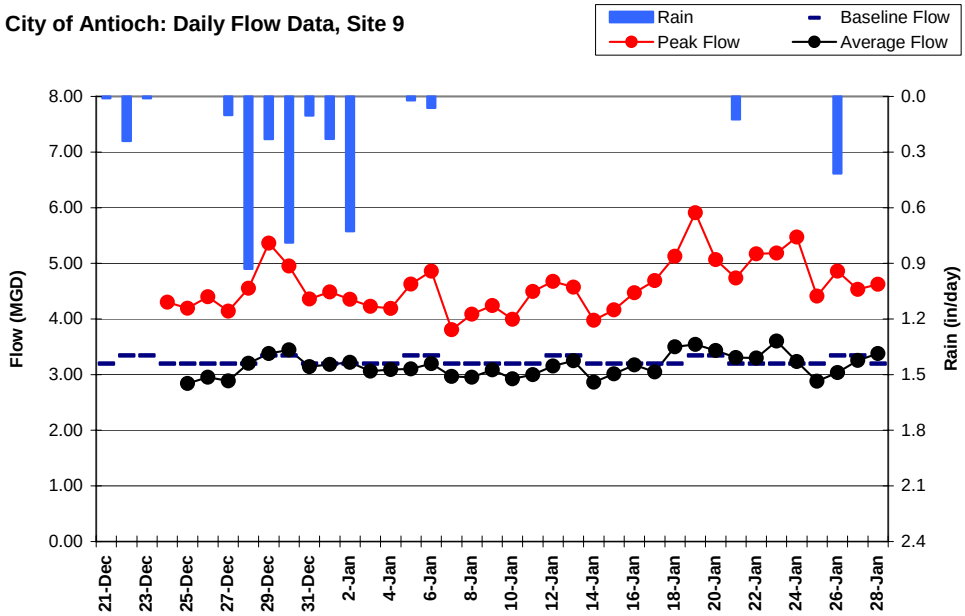


Figure 32. Site 9 Daily Flows

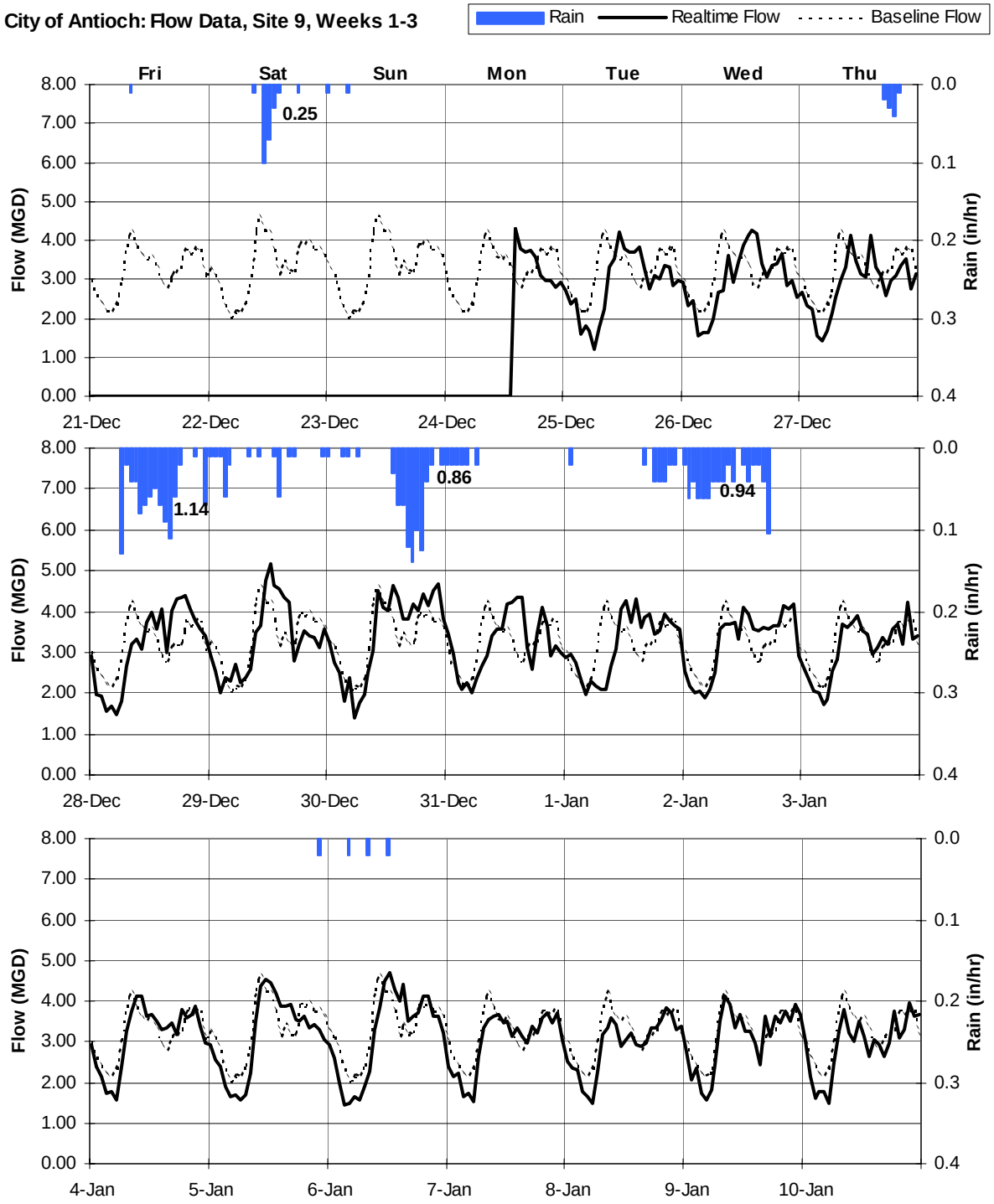


Figure 33. Site 9 Flow Data, Weeks 1-3

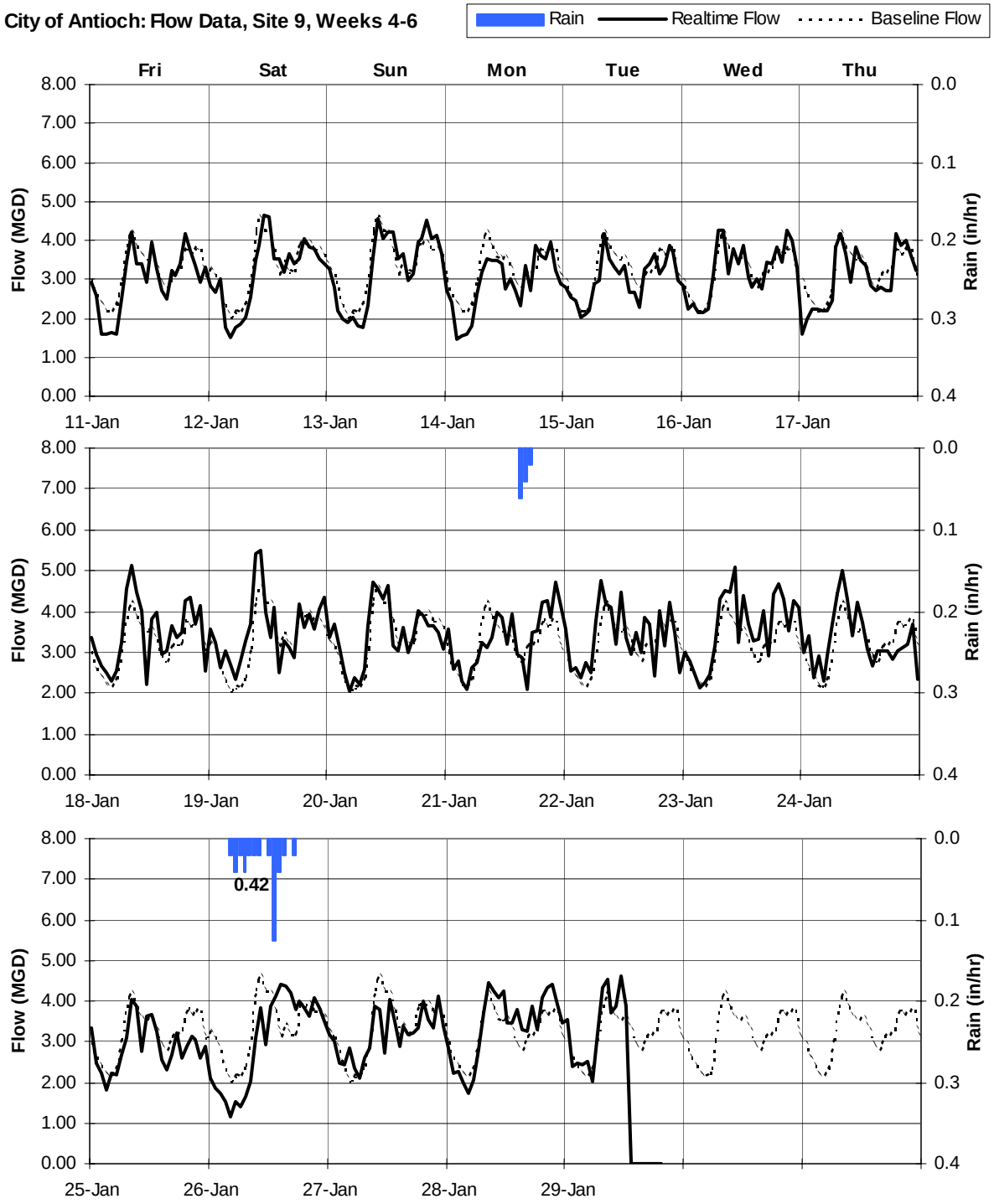


Figure 34. Site 9 Flow Data, Weeks 4-6

Site 10

City Manhole Number: F22-9-42
Location Description: North Lake Drive
Pipe Diameter: 14 inches

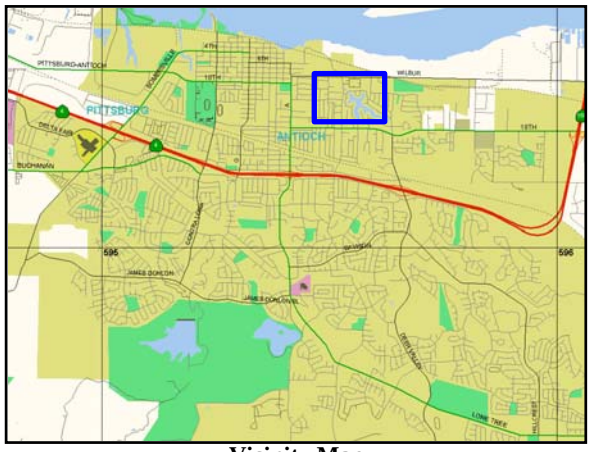
Average Baseline Flow: 0.20 MGD
Peak Baseline Flow: 0.40 MGD *11:00 AM weekends*

Peak Daily Flow: 0.30 MGD
December 29, 2001

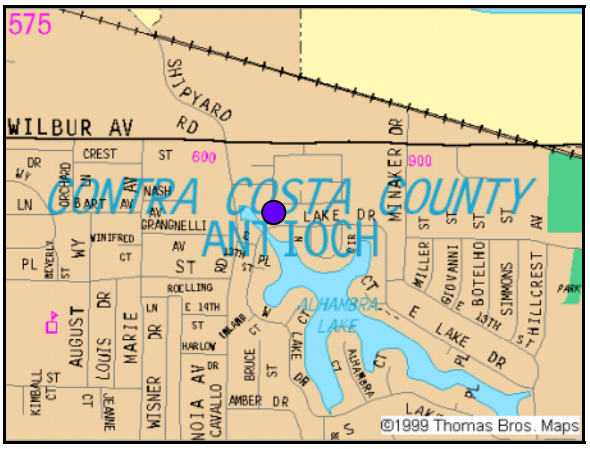
Peak Flow: 0.57 MGD
December 29, 2001, 11:00 AM

Percent Peak Flow vs. Ave. Baseline Flow: 284 %

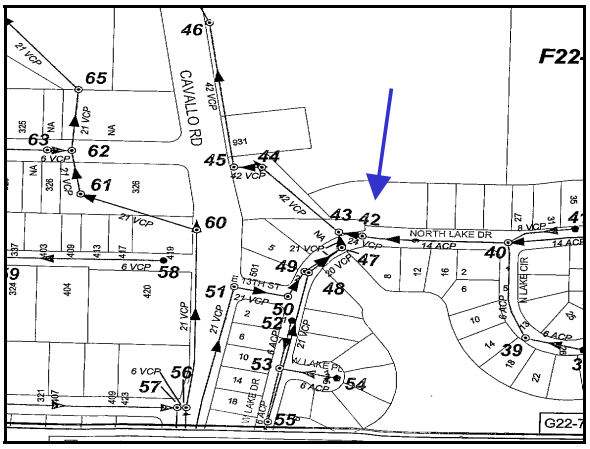
Total Volume of I/I over Monitoring Period: 0.37 MG



Vicinity Map



Street Map



Sanitary Sewer Map

View from Above

Plan View

Detail

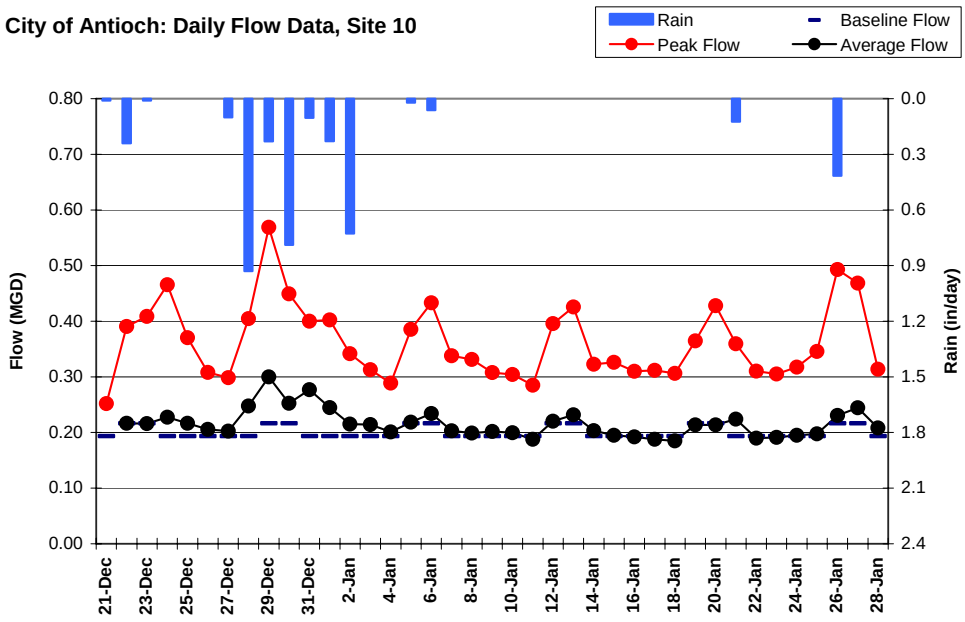


Figure 35. Site 10 Daily Flows

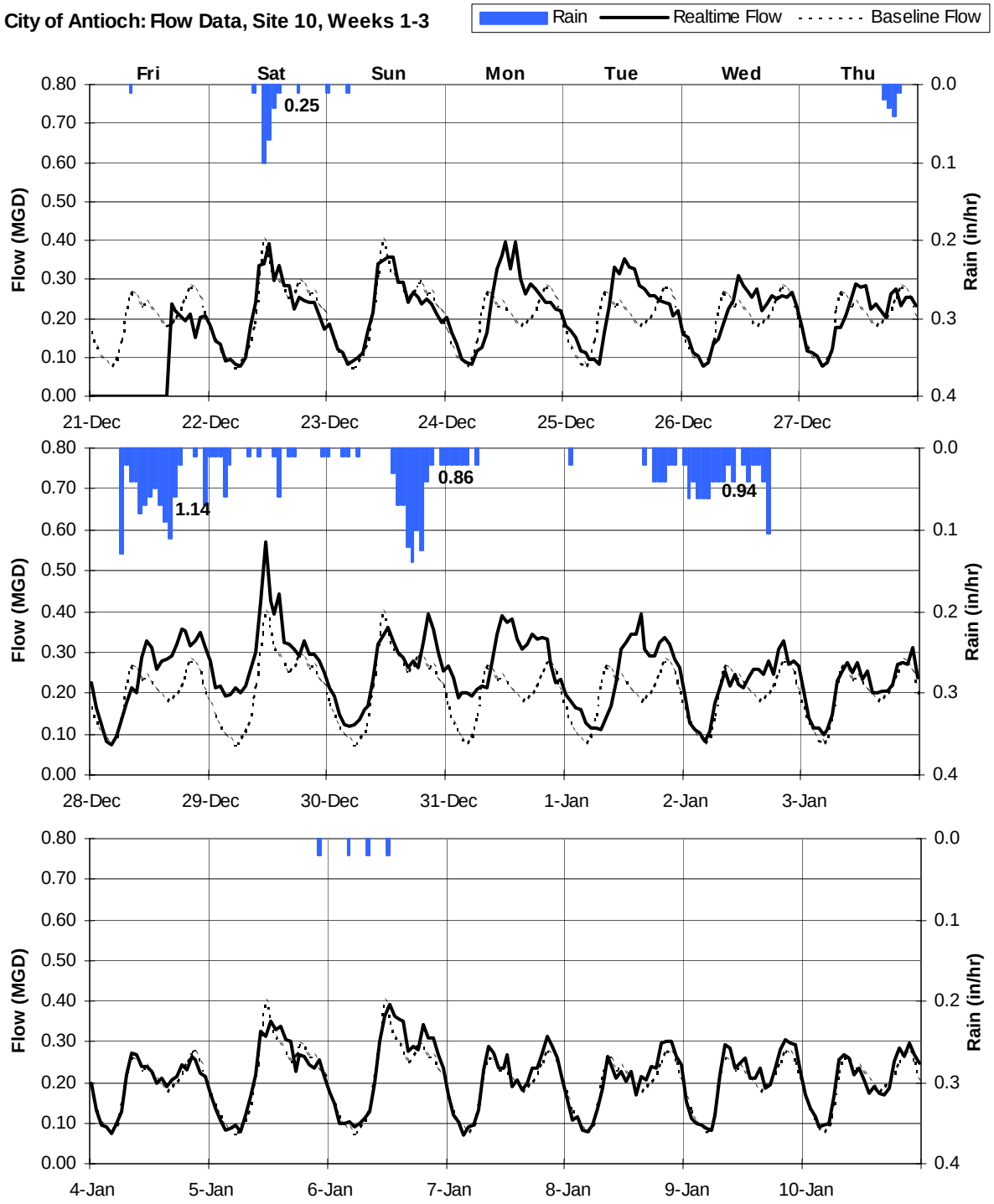


Figure 36. Site 10 Flow Data, Weeks 1-3

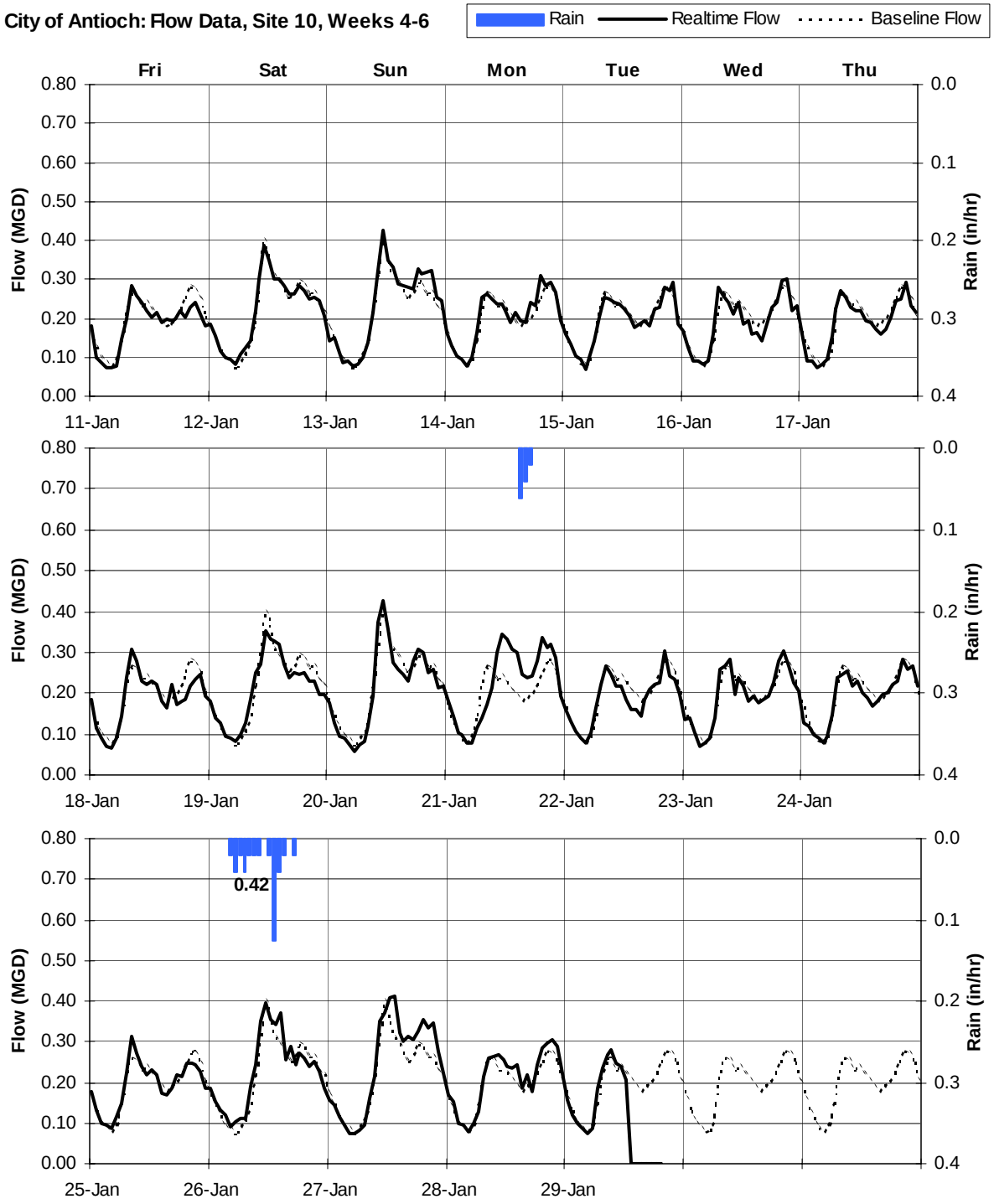


Figure 37. Site 10 Flow Data, Weeks 4-6

Site 11

City Manhole Number: G22-7-58
Location Description: Cavallo Road, south of E. 14th Street
Pipe Diameter: 18 inches

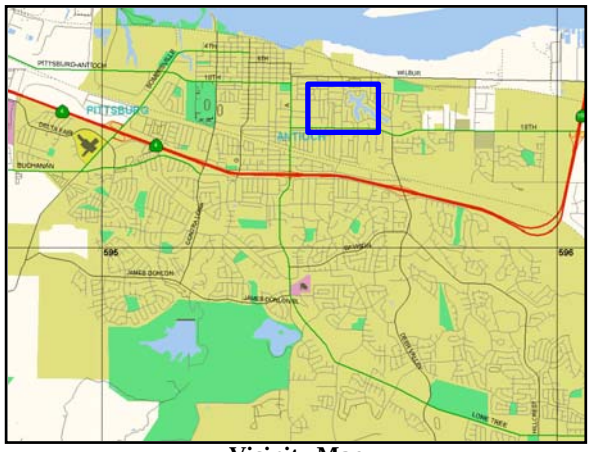
Average Baseline Flow: 0.60 MGD
Peak Baseline Flow: 0.93 MGD *11:00 AM weekends*

Peak Daily Flow: 0.79 MGD
December 30, 2001

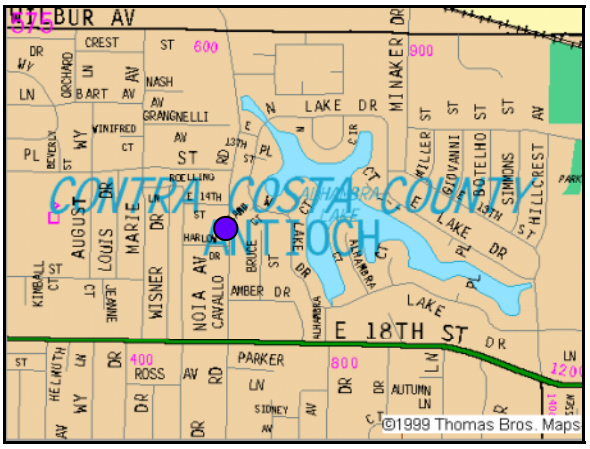
Peak Flow: 1.56 MGD
December 30, 2001, 8:00 PM

Percent Peak Flow vs. Ave. Baseline Flow: 258 %

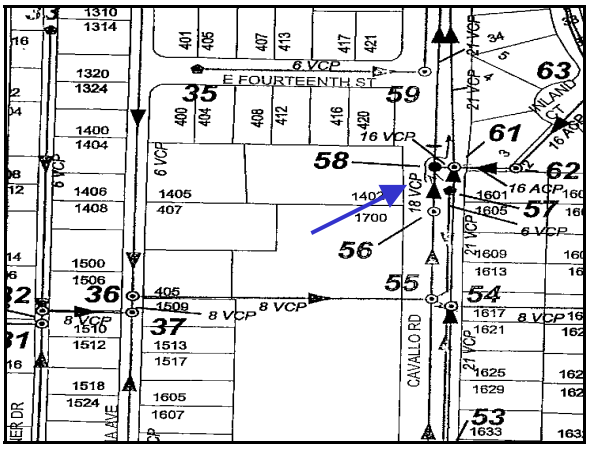
Total Volume of I/I over Monitoring Period: 0.67 MG



Vicinity Map



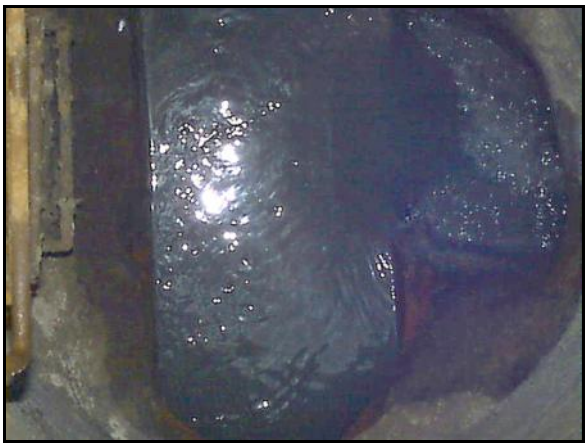
Street Map



Sanitary Sewer Map

View from Above

Plan View



Detail

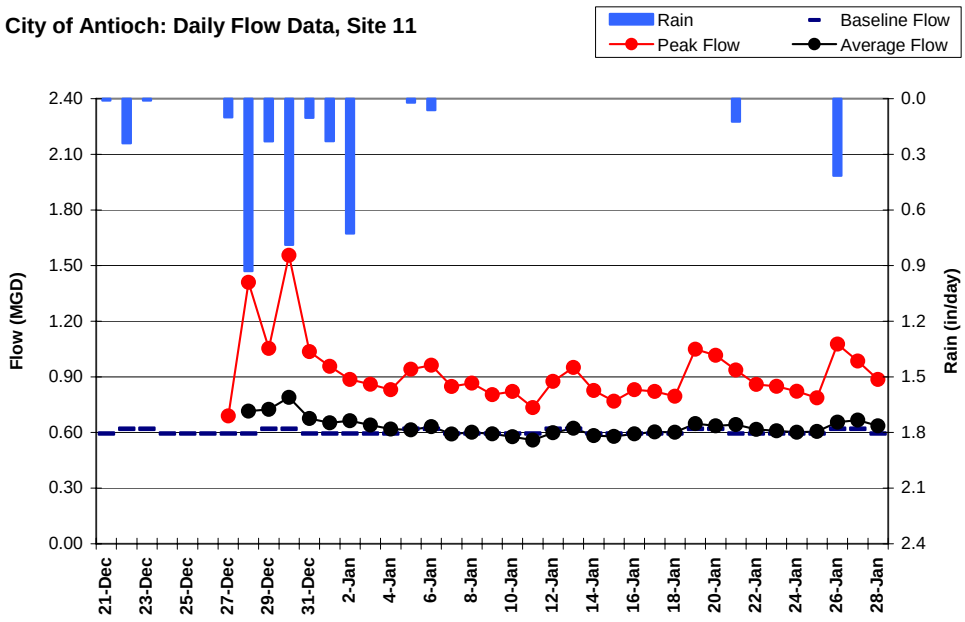


Figure 38. Site 11 Daily Flows

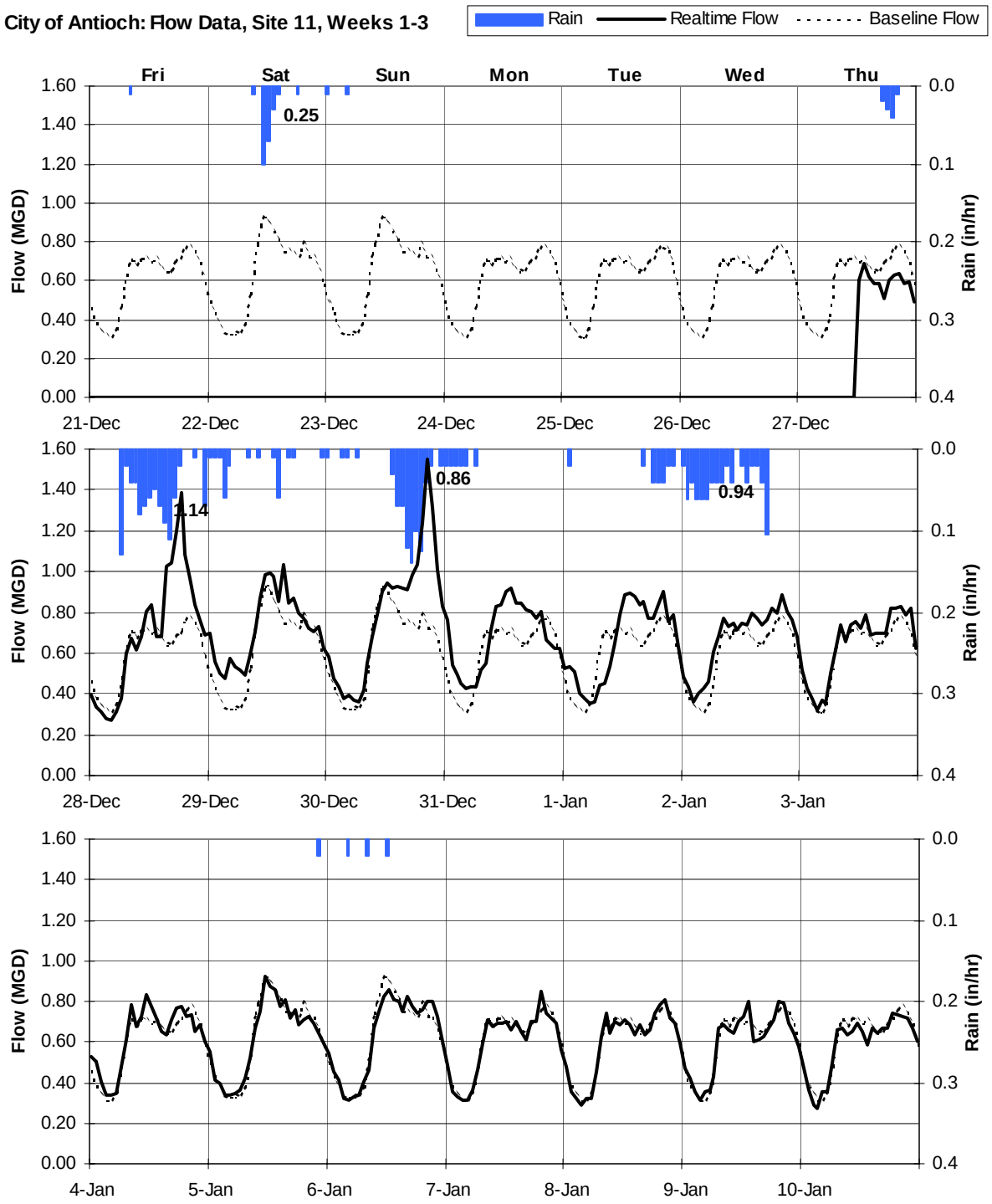


Figure 39. Site 11 Flow Data, Weeks 1-3

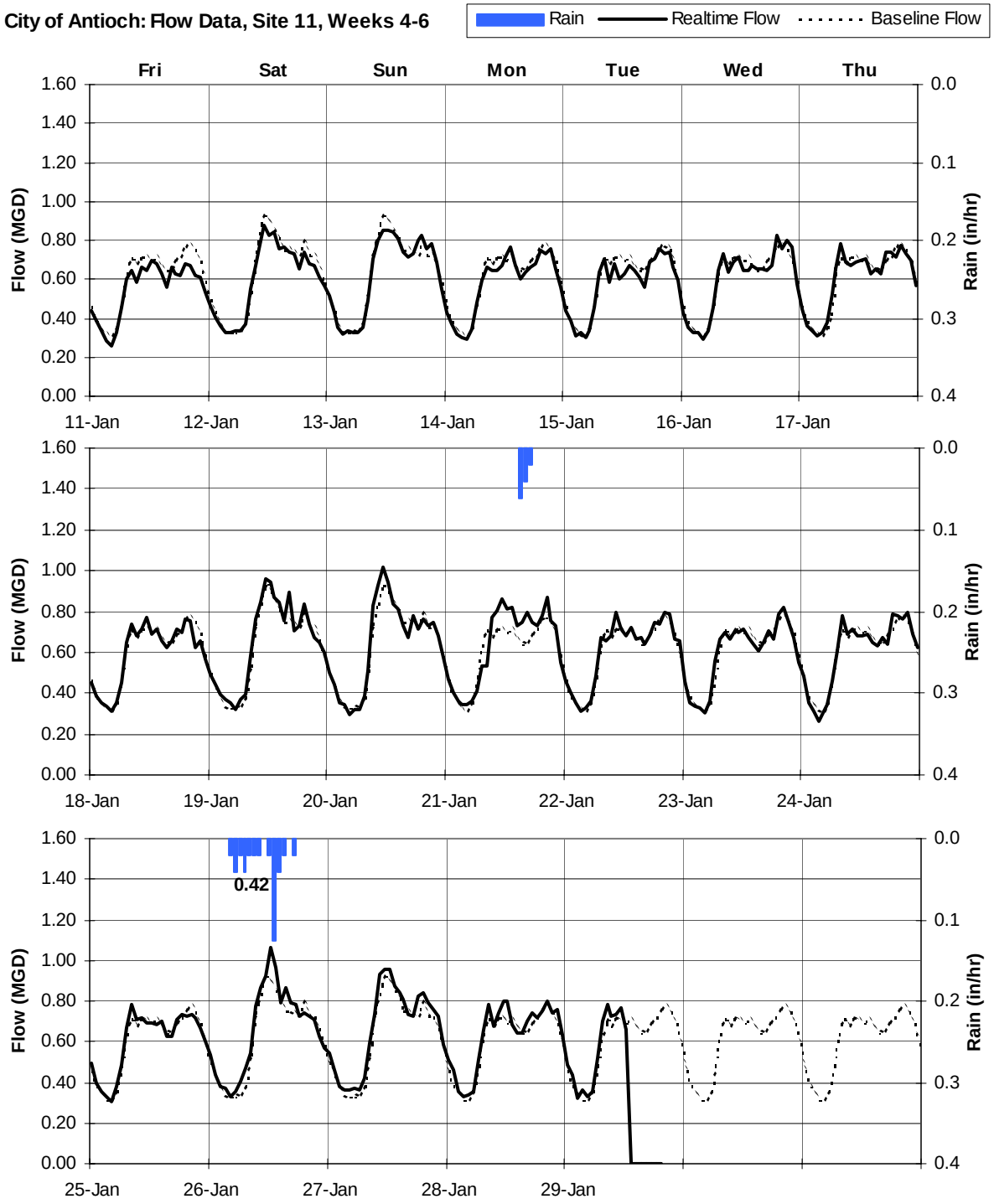


Figure 40. Site 11 Flow Data, Weeks 4-6

Site 12

City Manhole Number: G22-9-7
Location Description: Harbour Drive, North of Shaddick Drive
Pipe Diameter: 21 inches

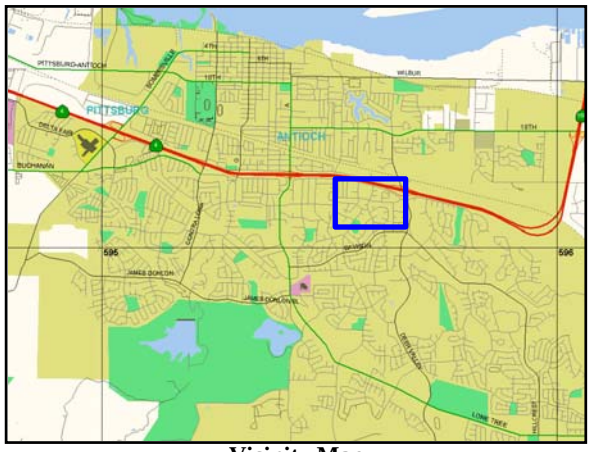
Average Baseline Flow: 0.98 MGD
Peak Baseline Flow: 1.63 MGD *10:00 AM weekends*

Peak Daily Flow: 1.15 MGD
December 30, 2001

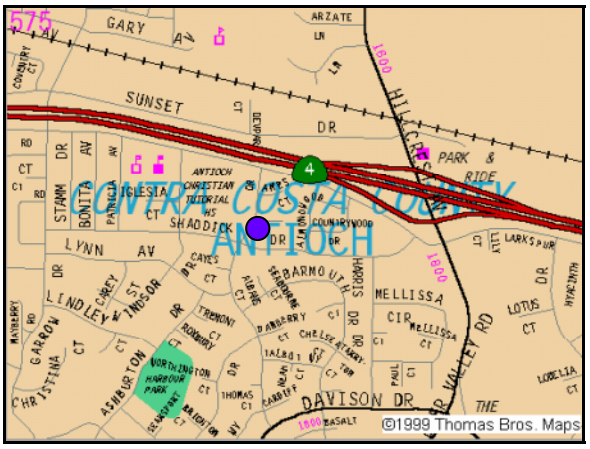
Peak Flow: 1.86 MGD
December 29, 2001, 11:00 AM

Percent Peak Flow vs. Ave. Baseline Flow: 191 %

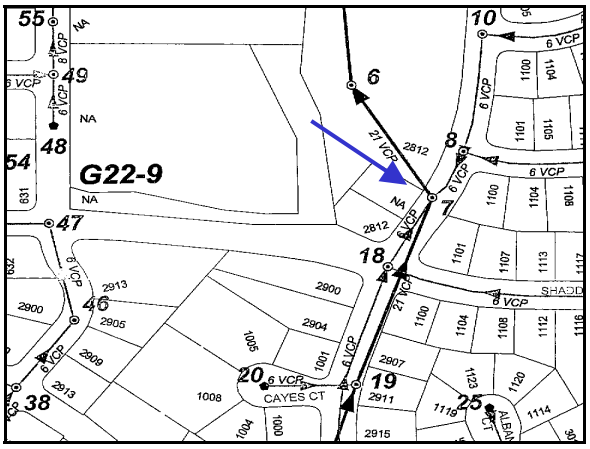
Total Volume of I/I over Monitoring Period: 0.77 MG



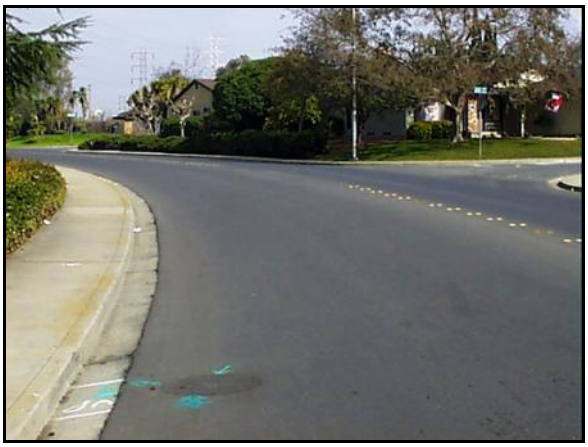
Vicinity Map



Street Map



Sanitary Sewer Map



View from Above

Plan View

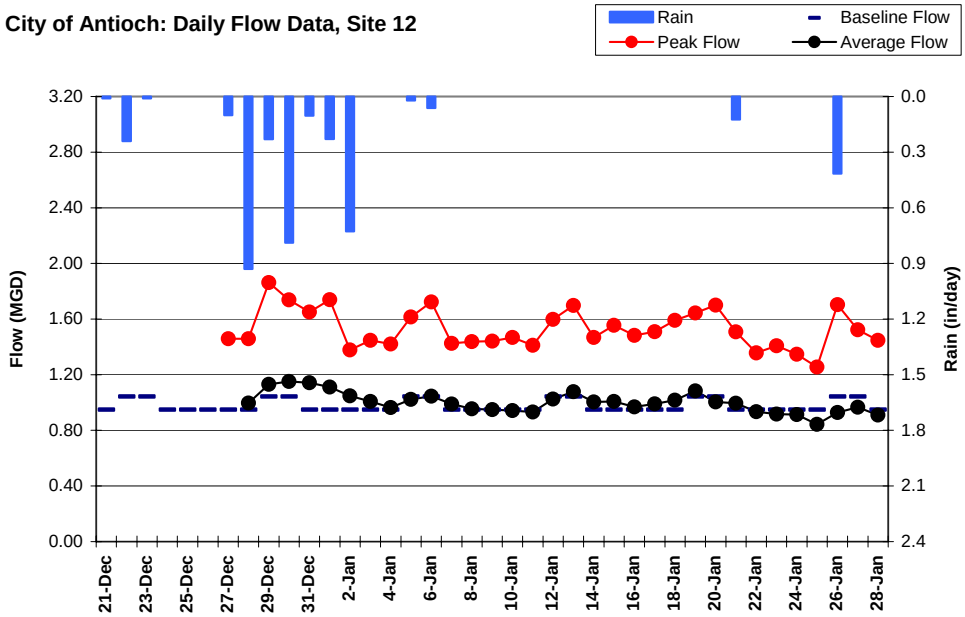


Figure 41. Site 12 Daily Flows

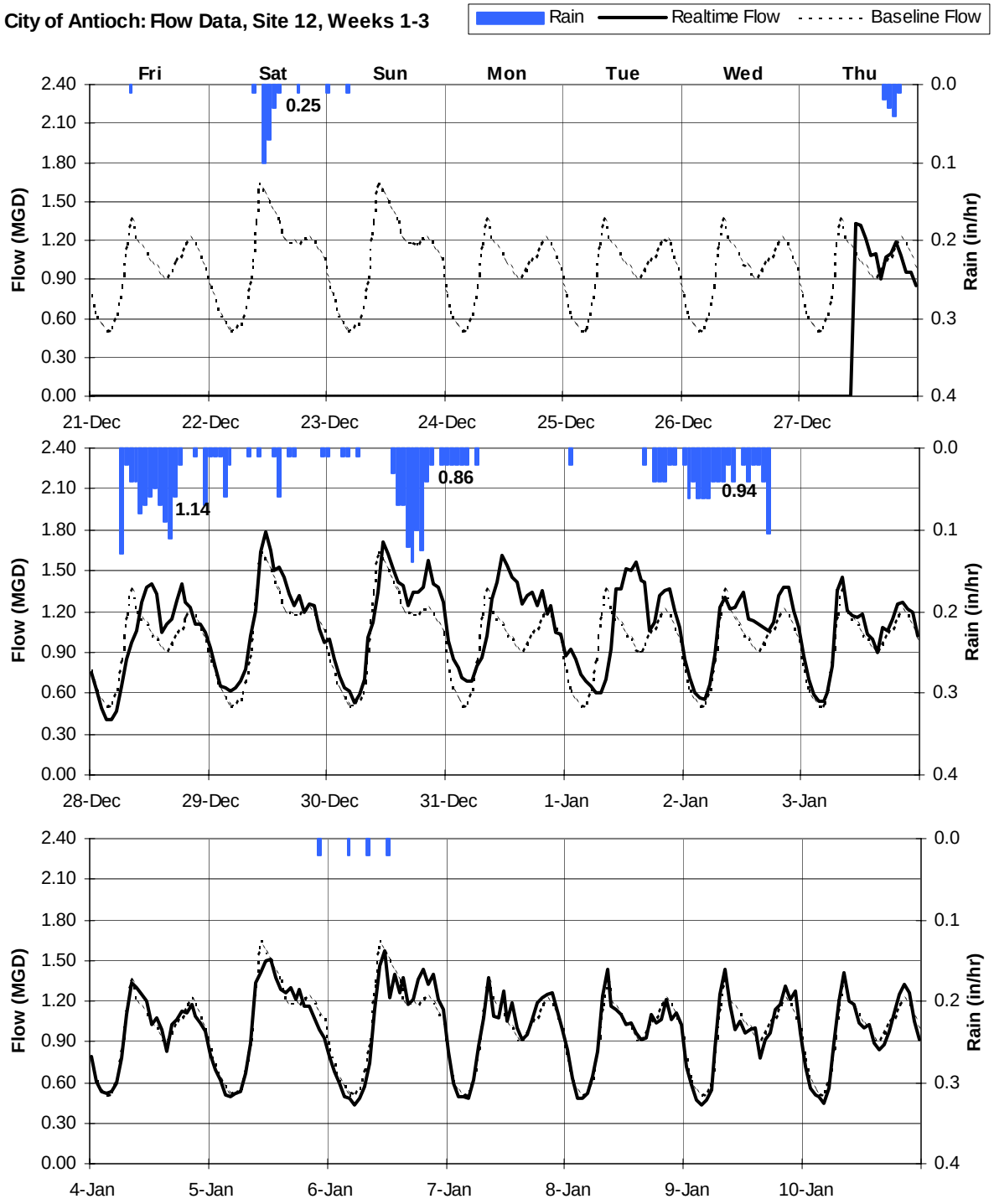


Figure 42. Site 12 Flow Data, Weeks 1-3

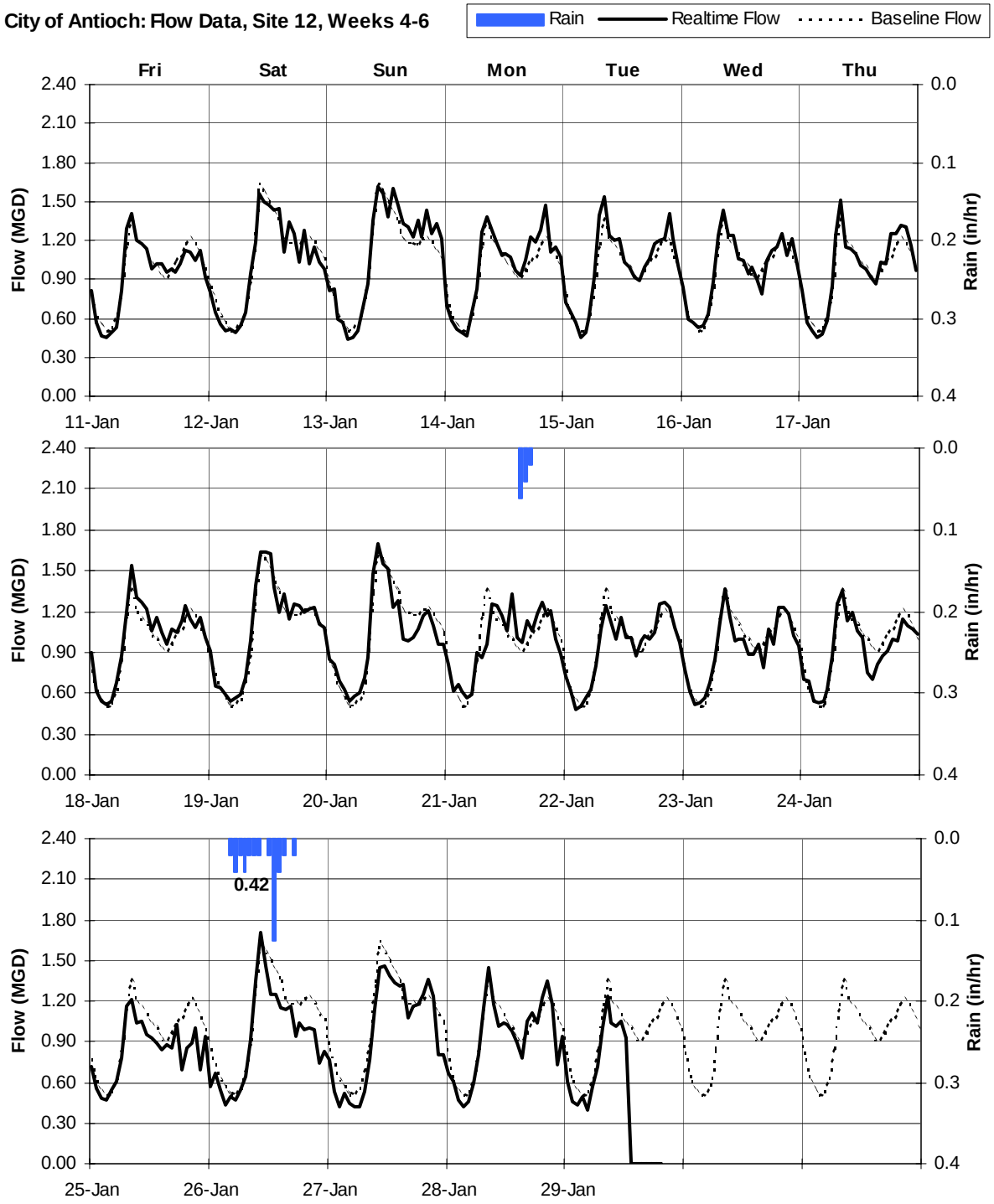


Figure 43. Site 12 Flow Data, Weeks 4-6

Site 13

City Manhole Number: G24-1-8
Location Description: End of Holub Avenue
Pipe Diameter: 33 inches

Average Baseline Flow: 2.54 MGD
Peak Baseline Flow: 3.55 MGD *1:00 PM weekends*

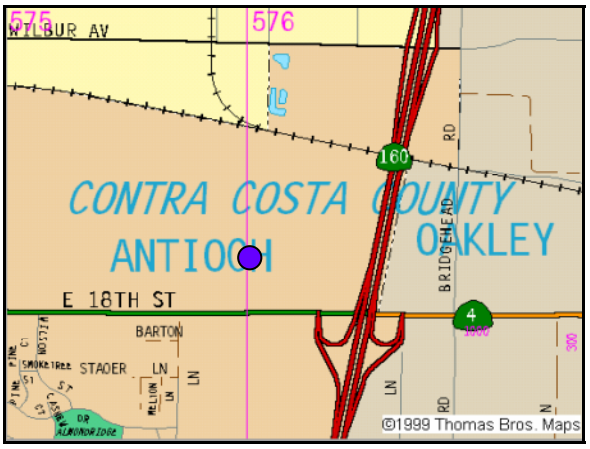
Peak Daily Flow: 3.84 MGD
December 31, 2001

Peak Flow: 5.57 MGD
December 30, 2001, 8:00 PM

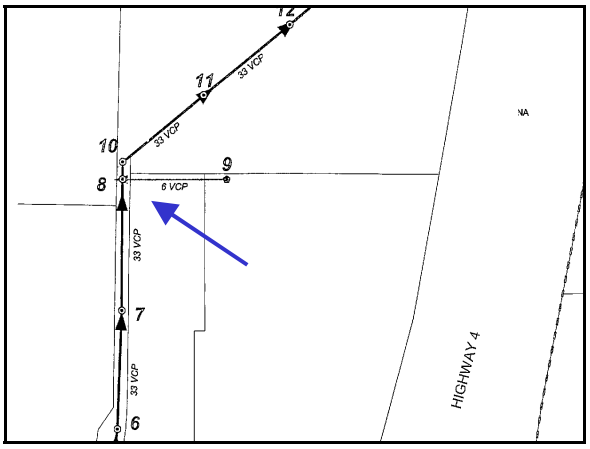
Percent Peak Flow vs. Ave. Baseline Flow: 219 %

Total Volume of I/I over Monitoring Period: 9.10 MG

Vicinity Map



Street Map



Sanitary Sewer Map

View from Above

Plan View

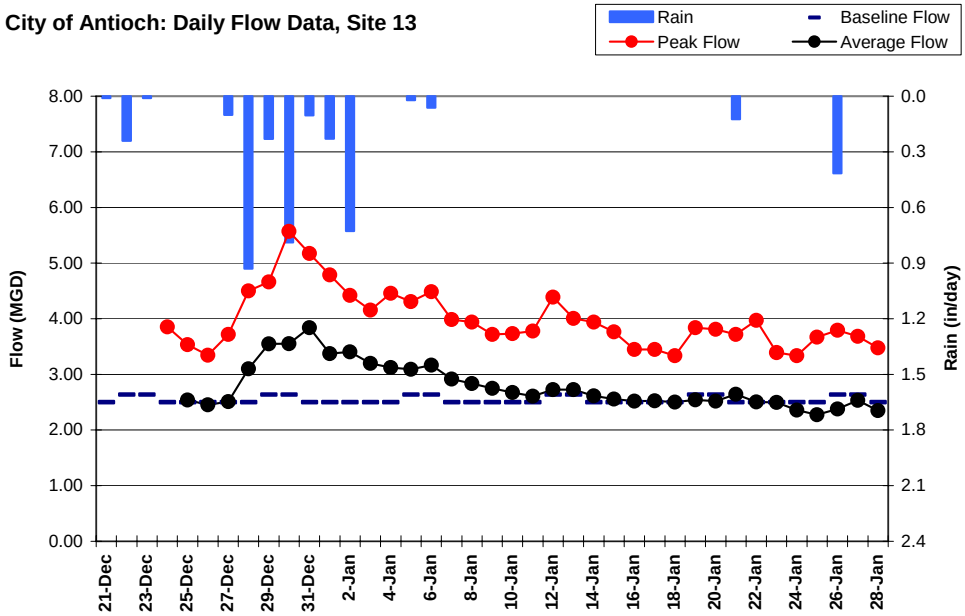


Figure 44. Site 13 Daily Flows

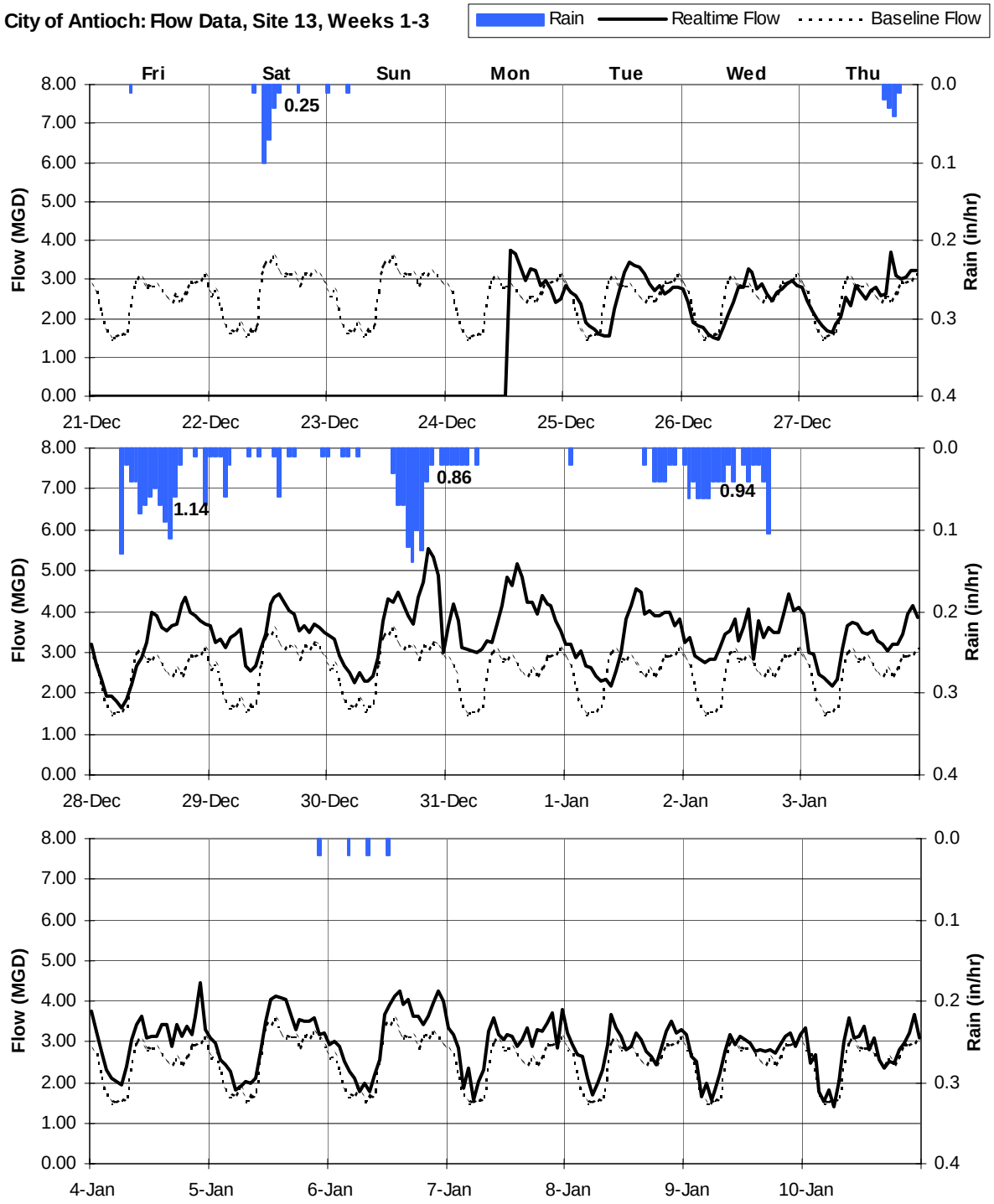


Figure 45. Site 13 Flow Data, Weeks 1-3

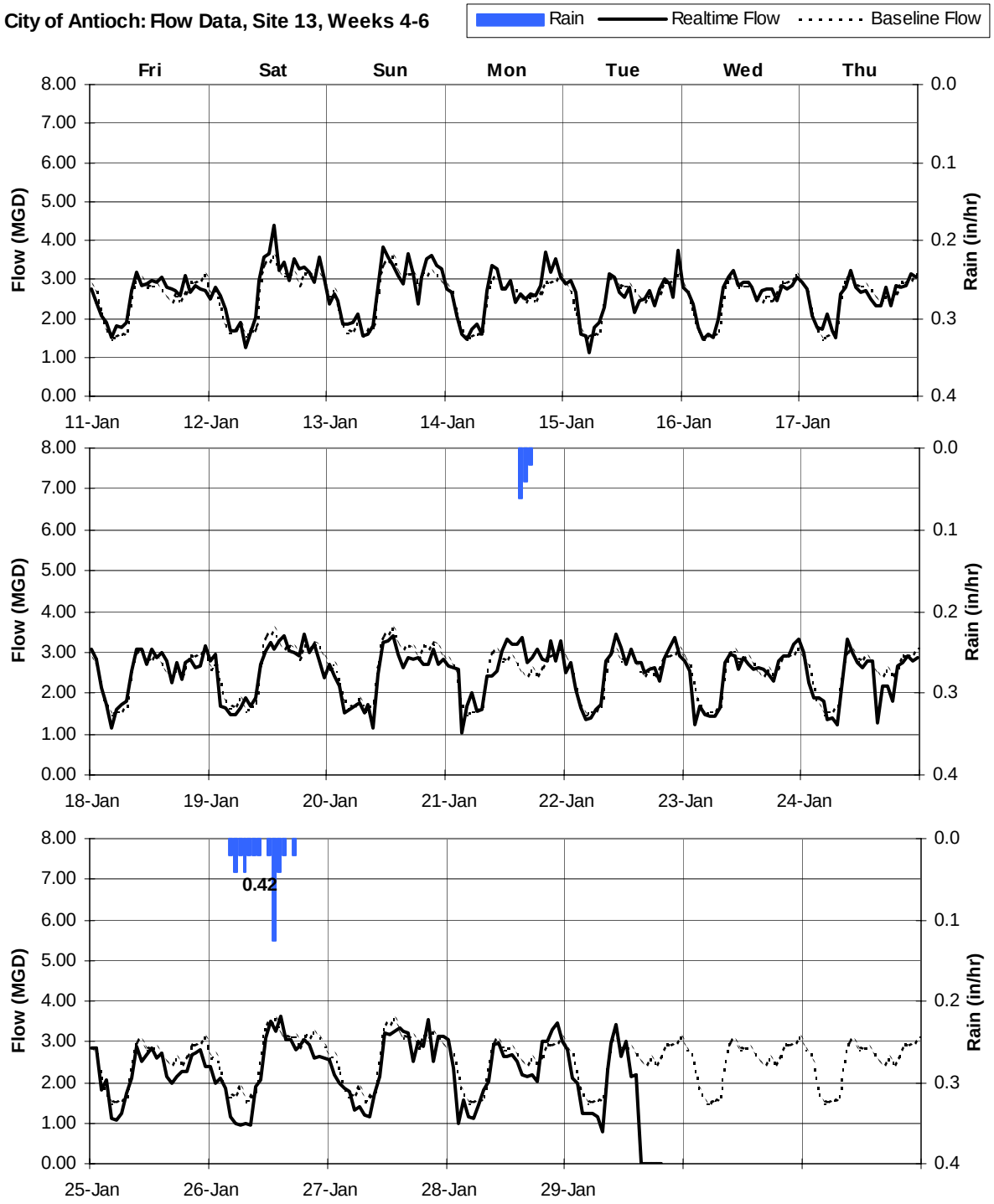


Figure 46. Site 13 Flow Data, Weeks 4-6

Site 14

City Manhole Number: J23-9-21
Location Description: Hillcrest Avenue, north of Lone Tree Way
Pipe Diameter: 18 inches

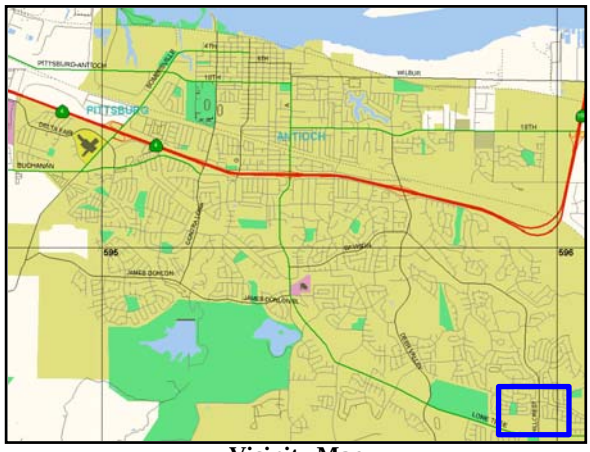
Average Baseline Flow: 1.14 MGD
Peak Baseline Flow: 1.72 MGD *11:00 AM weekends*

Peak Daily Flow: 1.57 MGD
January 1, 2002

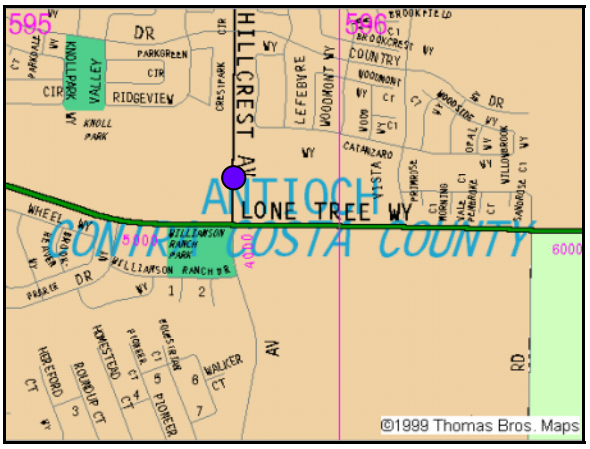
Peak Flow: 2.16 MGD
January 1, 2002, 2:00 PM

Percent Peak Flow vs. Ave. Baseline Flow: 189 %

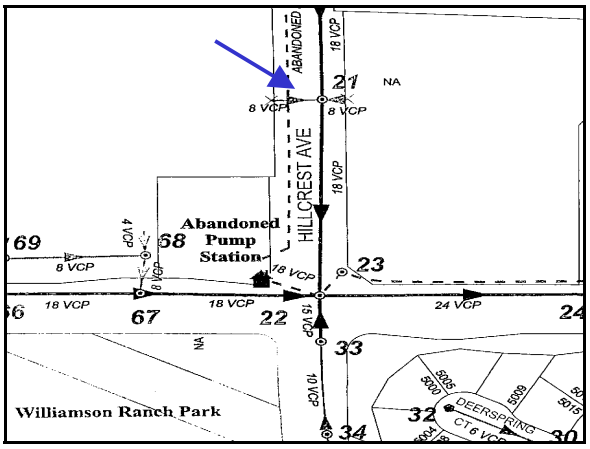
Total Volume of I/I over Monitoring Period: 3.13 MG



Vicinity Map



Street Map



Sanitary Sewer Map

View from Above

Plan View

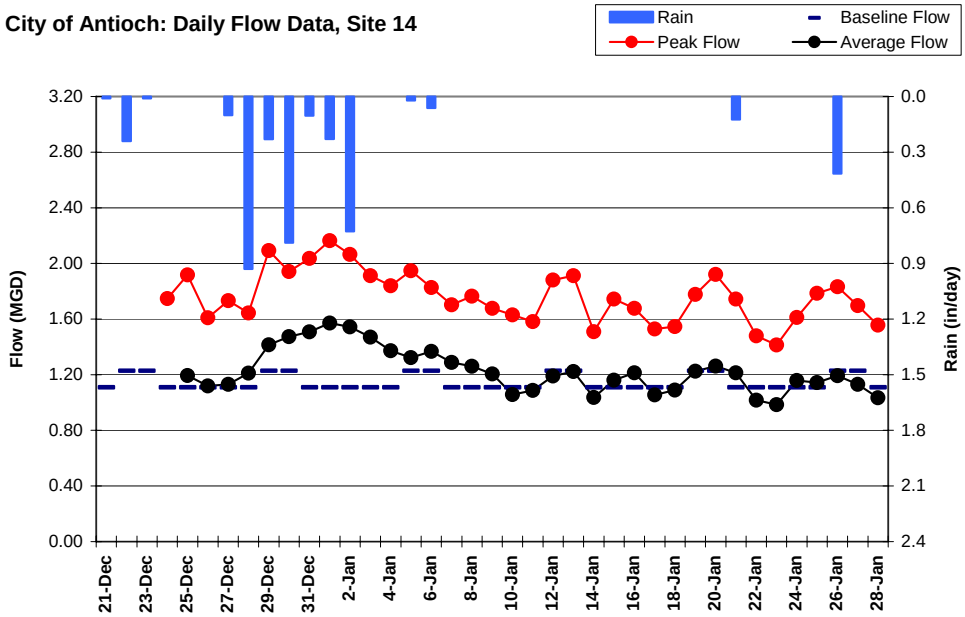


Figure 47. Site 14 Daily Flows

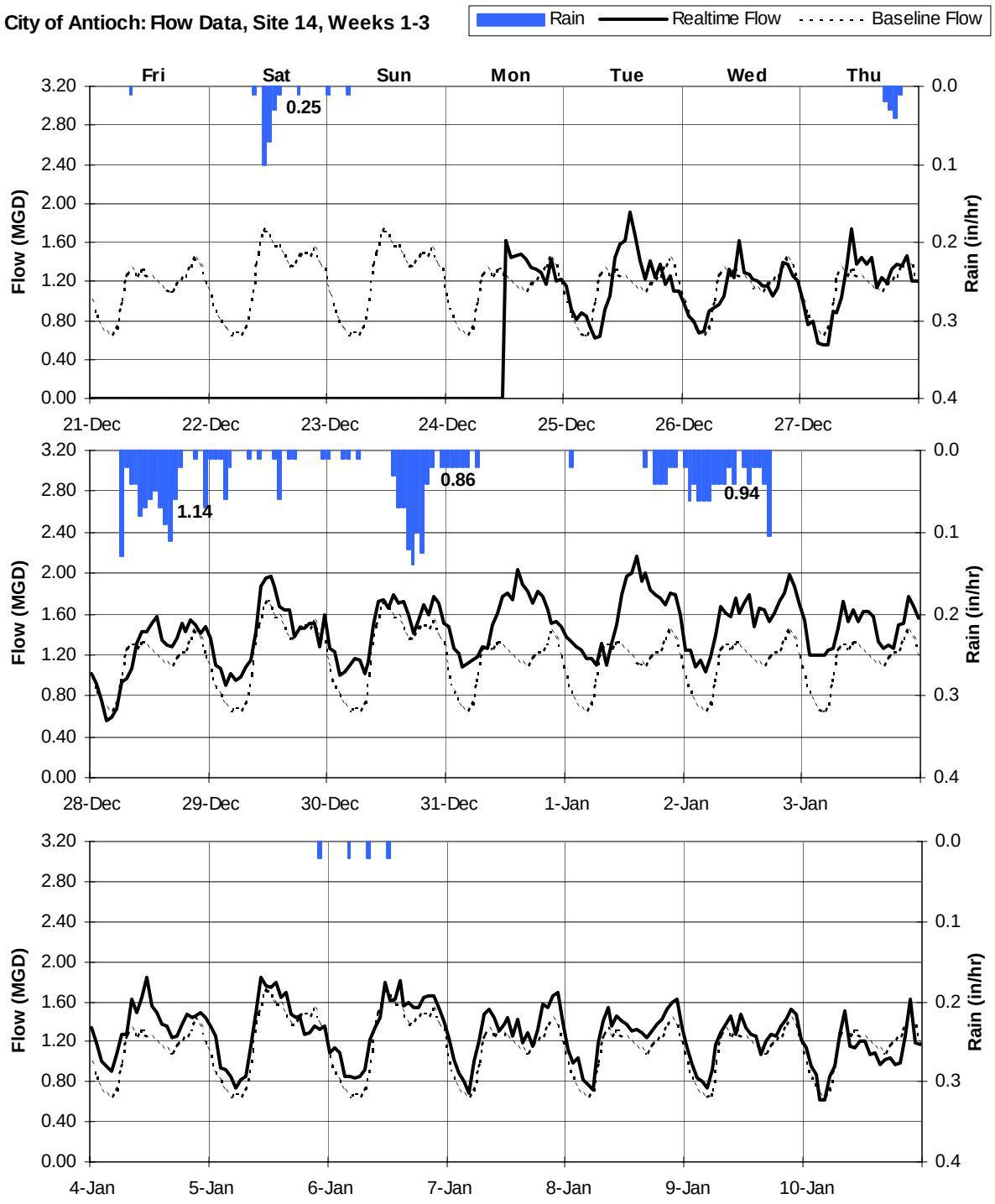


Figure 48. Site 14 Flow Data, Weeks 1-3

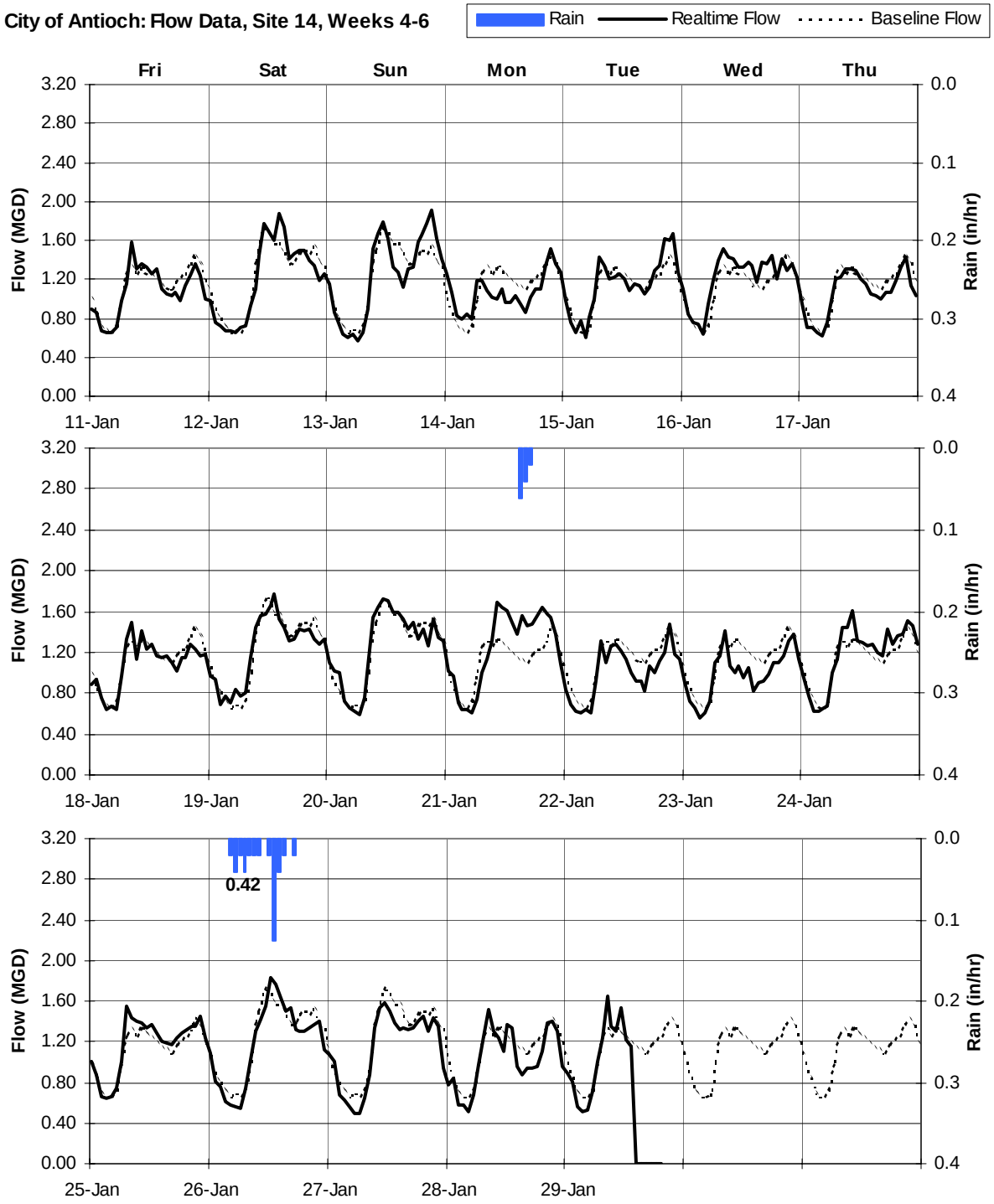


Figure 49. Site 14 Flow Data, Weeks 4-6

Site 15

City Manhole Number: J23-9-66
Location Description: Lone Tree Way, west of Hillcrest Avenue
Pipe Diameter: 18 inches

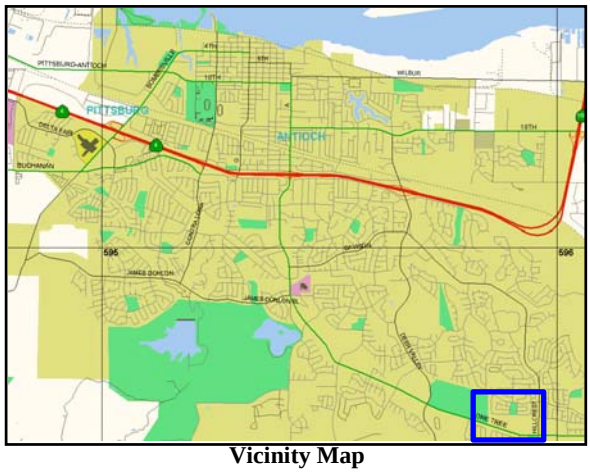
Average Baseline Flow: 0.89 MGD
Peak Baseline Flow: 1.63 MGD *11:00 AM weekends*

Peak Daily Flow: 1.16 MGD
December 30, 2001

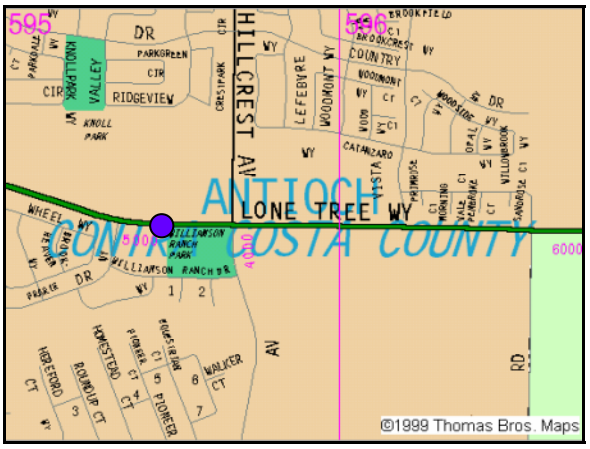
Peak Flow: 1.85 MGD
December 29, 2001, 12:00 PM

Percent Peak Flow vs. Ave. Baseline Flow: 208 %

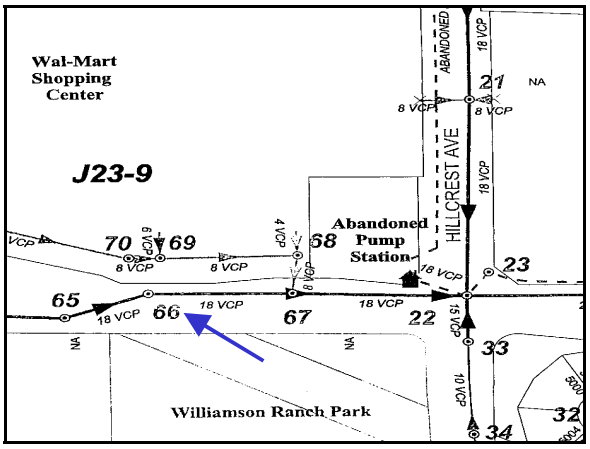
Total Volume of I/I over Monitoring Period: 1.70 MG



Vicinity Map



Street Map



Sanitary Sewer Map

View from Above

Plan View

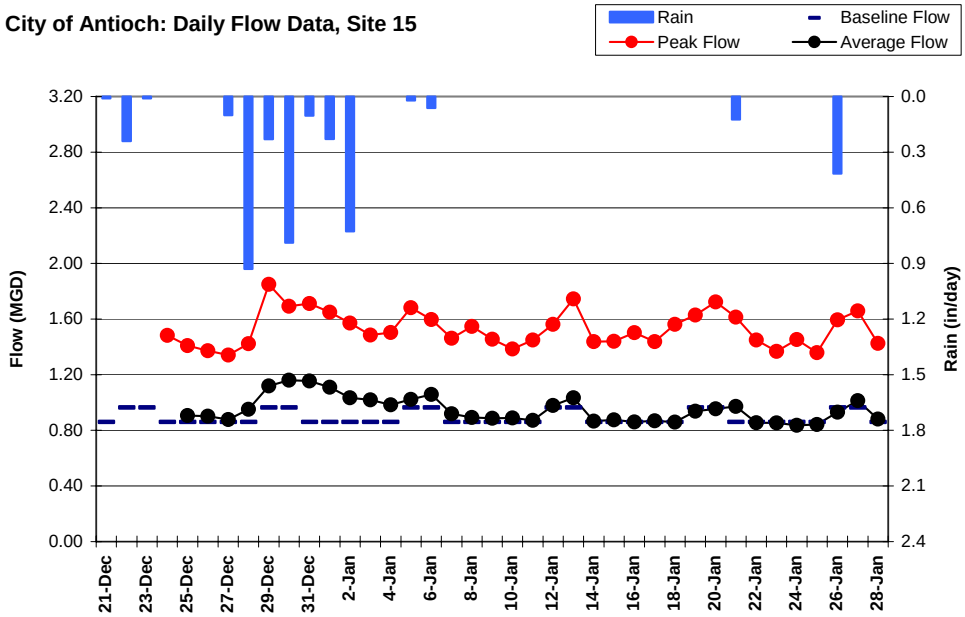


Figure 50. Site 15 Daily Flows

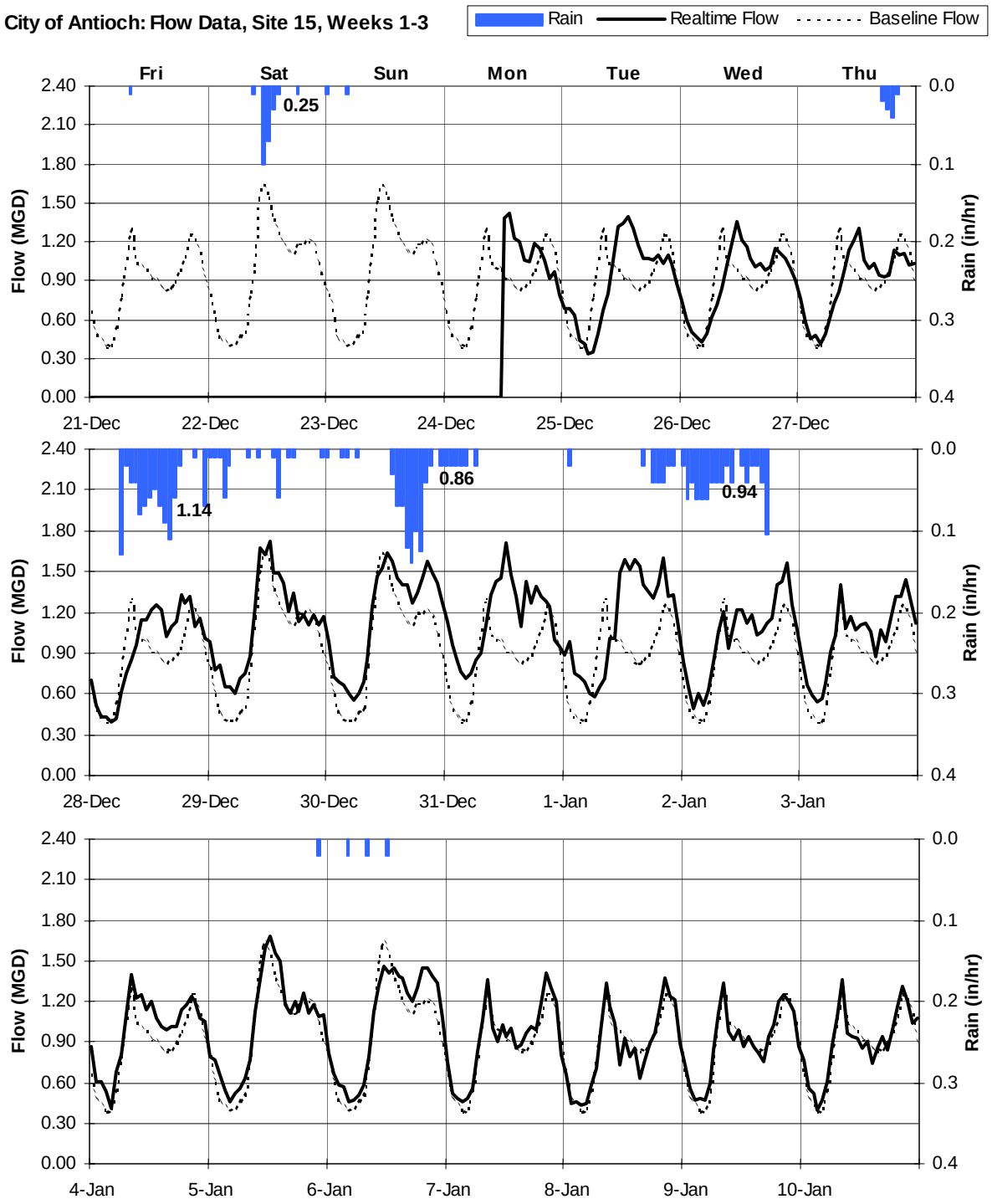


Figure 51. Site 15 Flow Data, Weeks 1-3

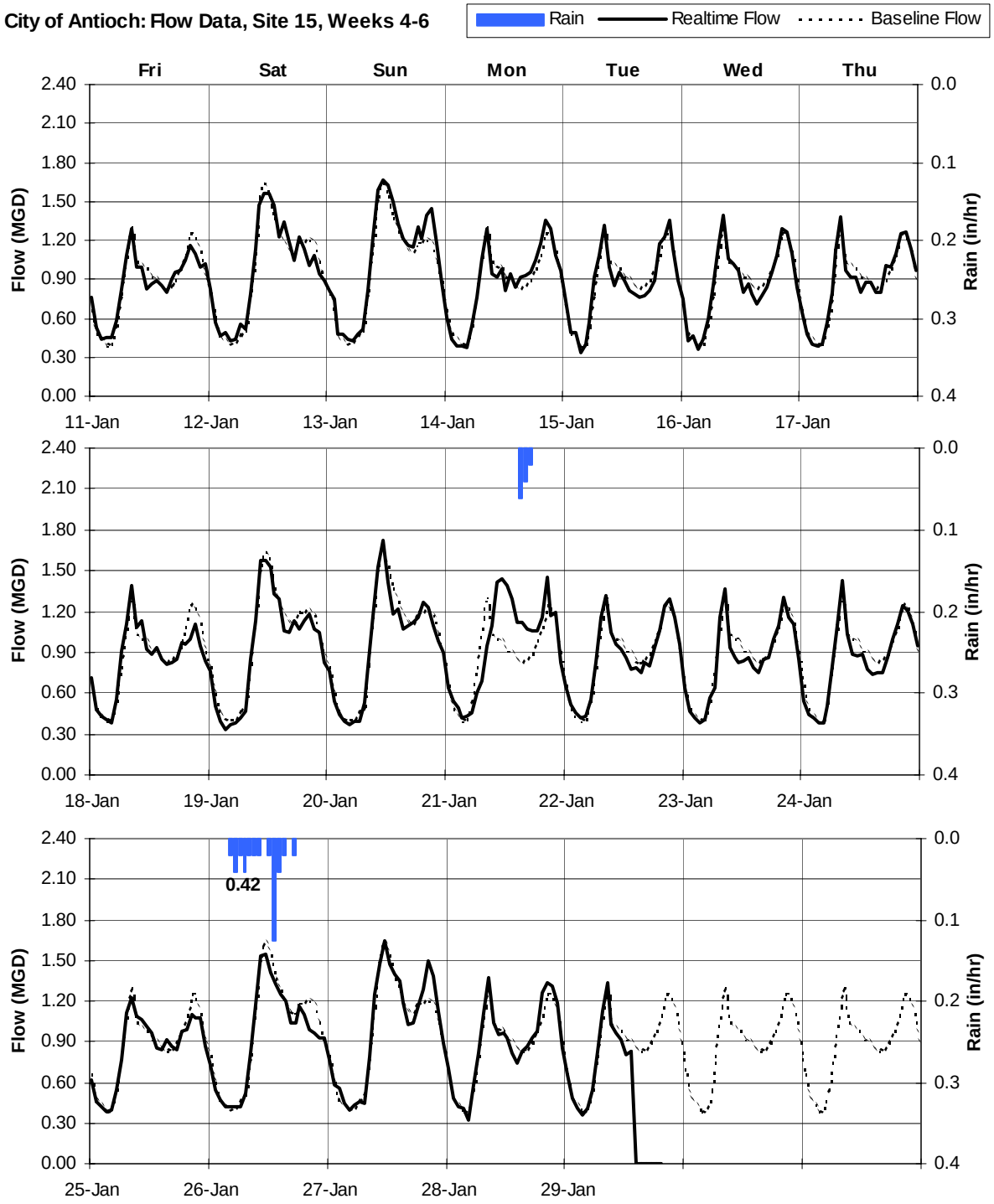


Figure 52. Site 15 Flow Data, Weeks 4-6

APPENDIX B

City of Antioch Wastewater Master Plan Manhole Elevation Estimates for Manholes with No Survey Information

&

Additional Elevation Assumptions for Modeling Purposes

CITY OF ANTIOCH WASTEWATER MASTER PLAN MANHOLE ELEVATION ESTIMATES FOR MANHOLES WITH NO SURVEY INFORMATION

City ID	Rim Elevation (ft)	Invert Elevation (ft)	City ID	Rim Elevation (ft)	Invert Elevation (ft)
F21-3-004	24.81	21.41	G23-3-041	-	52.12
F21-3-005	24.81	21.36	G23-5-012	-	21.01
F21-8-011	-	1.50	G24-1-007	25.63	10.68
F21-9-005	-	1.86	G24-3-006	-	37.00
F21-9-006	-	1.89	H21-4-046	117.68	109.26
F21-9-016	-	2.17	H-21-4-059	124.89	106.30
F21-9-017	-	2.62	H21-8-036	107.37	90.87
F22-9-061	19.56	6.16	H22-1-044	-	43.73
F22-9-065	21.52	7.33	H22-5-041	-	104.61
F22-9-066	16.58	1.40	H22-6-032	-	127.79
F24-3-001	18.73	-0.09	H22-6-034	-	47.03
F24-3-002P	18.73	5.63	H22-7-076	76.87	66.29
G21-1-004	65.50	50.93	H22-7-077	73.31	63.34
G21-1-005	67.72	52.37	H23-1-024	-	82.69
G21-4-024	47.64	37.42	H23-1-033	-	61.91
G21-5-024	66.81	58.98	H23-1-034	-	63.27
G21-5-025	67.36	59.85	H23-5-015	-	107.88
G21-7-011	30.46	13.56	H23-8-002	-	110.39
G21-7-048	23.87	11.74	H23-9-001	139.40	115.80
G21-7-049	26.62	12.50	H23-9-042	154.06	139.61
G21-8-027	31.23	22.99	H29-3-045	163.40	155.98
G21-8-028	31.66	22.67	J23-9-022	-	113.00
G22-3-068	53.33	40.73	J23-9-064	-	115.91
G22-7-023	18.05	0.74	J23-9-065	-	114.82
G22-7-062	13.21	-3.27	J24-3-006	-	98.22
G22-8-011	25.09	5.14	J24-8-001	86.01	68.27
G22-8-016	20.76	2.43	K23-7-004	-	165.79
G22-8-027	-	12.90	K23-7-005	-	168.19
G22-9-006	51.46	34.80	K23-7-006	-	171.03

ADDITIONAL ELEVATION ASSUMPTIONS FOR MODELING PURPOSES

City ID	Rim Elevation (ft)	Invert Elevation (ft)	Comment
K23-7-002	-	157.54	changed invert to avoid negative slope
K23-7-003	-	161.49	changed invert to avoid negative slope
Antioch Pump Station	9.32	-7.27	connect to DDSD system
Bridgehead Pump Station	18.73	5.63	connect to DDSD system
Hillcrest Ave / Prewett Ranch Pump Station	182.69	171.94	same elevation as K23-7-007

APPENDIX C

Negative Slope Sections in City of Antioch Wastewater Collection System

NEGATIVE SLOPE SECTIONS IN CITY OF ANTIOCH WASTEWATER COLLECTION SYSTEM								
City ID	Model ID	Length	Rim Elevation		Invert Elevation		Slope	Estimated Downstream Invert Elevation for 0.03% slope
			Upstream	Downstream	Upstream	Downstream		
G21-4-017SS	13	37.99	39.28	41.70	23.73	25.65	-0.0505	23.72
F21-6-022SS	22	226.21	34.65	33.00	22.15	22.30	-0.0007	22.08
F21-9-036SS	50	363.64	16.68	16.47	9.23	9.33	-0.0003	9.12
F22-2-064SS	73	257.32	8.99	13.55	-3.79	-3.55	-0.0009	-3.87
F22-2-049SS	77	595.75	6.52	22.36	-1.86	-1.74	-0.0002	-2.04
F22-6-040SS	101	367.09	14.10	14.10	8.19	8.40	-0.0006	8.08
F22-6-102SS	111	26.33	10.01	14.73	-5.29	-4.92	-0.0141	-5.30
F22-6-101SS	113	213.99	6.19	5.28	-5.63	-5.37	-0.0012	-5.69
F22-6-063SS	117	332.33	16.82	9.95	-6.14	-5.33	-0.0024	-6.24
F22-6-062SS	119	241.22	8.74	16.82	-6.88	-6.08	-0.0033	-6.95
F22-5-015SS	123	288.84	25.90	17.32	-4.15	-4.13	-0.0001	-4.24
F22-5-016SS	124	88.25	22.83	25.90	-4.17	-4.05	-0.0014	-4.20
F22-5-017SS	125	163.05	5.97	22.83	-3.88	-3.62	-0.0016	-3.93
F22-5-009SS	127	435.76	30.55	10.15	-5.40	-4.53	-0.0020	-5.53
F22-5-007SS	129	232.37	20.20	16.92	-5.20	-4.63	-0.0025	-5.27
G22-7-075SS-SF1	156	91.88	9.58	9.02	-0.13	0.02	-0.0016	-0.16
G22-7-074SS	158	69.93	9.02	9.49	-0.38	0.19	-0.0082	-0.40
G22-7-066SS	169	281.68	8.72	8.13	-2.18	-1.67	-0.0018	-2.26
F22-9-060SS	176	262.37	8.64	19.56	-4.33	6.16	-0.0400	-4.41
F22-9-061SS	177	116.88	19.56	24.43	6.16	10.98	-0.0412	6.12
F22-9-047SS	184	41.20	9.05	9.53	-6.11	-5.47	-0.0155	-6.12
F22-9-045SS	188	387.90	0.43	10.62	-13.75	-6.28	-0.0193	-13.87
G23-1-005SS	194	468.58	15.37	14.74	4.12	6.84	-0.0058	3.98
H21-4-044SS	216	236.66	113.48	128.74	99.78	119.87	-0.0849	99.71
G21-5-004SS	233	127.88	43.75	46.25	33.91	35.47	-0.0122	33.87
G21-5-007SS	234	254.13	52.90	57.06	39.20	44.90	-0.0224	39.12
H21-8-034SS	248	36.92	107.20	107.50	91.45	92.25	-0.0217	91.44
G21-8-029SS	273	96.82	31.96	31.66	22.45	22.67	-0.0023	22.42
G21-8-028SS	274	139.09	31.66	31.23	22.67	22.99	-0.0023	22.63
G21-8-027SS	275	114.62	31.23	30.87	22.99	23.25	-0.0023	22.96
H22-1-044SS	295	123.87	73.23	78.65	43.73	49.15	-0.0438	43.69
H22-5-007SS	306	71.42	105.67	104.76	93.42	93.51	-0.0013	93.40
G23-3-013SS	373	375.27	68.30	66.91	53.18	53.49	-0.0008	53.07
G23-5-037SS	396	347.04	42.09	41.00	30.55	33.55	-0.0086	30.45
F22-9-006SS	405	112.48	10.62	9.18	-6.76	-6.62	-0.0012	-6.79
F22-9-003SS	412	430.42	10.33	10.08	-7.57	-6.92	-0.0015	-7.70
J24-2-025SS	457	259.97	154.85	157.41	143.40	143.79	-0.0015	143.32
J23-8-034SS	470	87.66	135.53	136.17	118.26	118.37	-0.0013	118.23
H21-8-026SS	489	138.43	120.71	122.35	110.81	113.55	-0.0198	110.77
J23-1-018SS	505	251.94	169.74	169.88	153.92	160.83	-0.0274	153.84
J22-4-007SS	526	187.99	173.10	171.03	158.12	158.58	-0.0024	158.06
J23-9-039SS	534	47.53	141.78	141.80	133.48	133.68	-0.0042	133.47
G23-5-006SS	568	349.26	29.03	26.16	14.53	14.62	-0.0003	14.43
G23-5-004SS	570	88.47	23.25	23.55	12.05	12.20	-0.0017	12.02
H24-2-001SS	602	278.31	78.13	74.55	52.23	53.40	-0.0042	52.15
H24-5-001SS	606	326.29	75.35	91.78	53.79	73.48	-0.0603	53.69
J24-7-004SS	622	411.74	93.94	93.44	75.59	75.62	-0.0001	75.47
J24-7-005SS	623	418.57	71.04	93.94	53.39	75.64	-0.0532	53.26
J24-3-005SS	636	97.62	129.11	128.61	97.19	97.21	-0.0002	97.16
H23-5-012SS	705	247.99	127.25	124.88	104.95	105.03	-0.0003	104.88
J24-3-011SS	729	165.74	132.41	131.21	109.26	110.01	-0.0045	109.21
G22-8-007SS	746	111.26	18.82	27.63	5.92	6.83	-0.0082	5.89
F21-8-006SS	749	360.42	12.32	12.37	1.26	1.31	-0.0001	1.15
F22-9-051SS	751	117.10	9.99	9.93	-5.83	-4.03	-0.0154	-5.87
H21-7-054SS	757	71.42	80.98	81.11	74.58	74.71	-0.0018	74.56
G22-7-055SS	764	161.25	9.50	12.80	-3.35	-1.80	-0.0096	-3.40
G24-1-011SS	799	254.40	15.66	18.16	-1.54	0.16	-0.0067	-1.62
G24-1-012SS	800	438.71	18.16	18.73	0.04	5.88	-0.0133	-0.09

APPENDIX D-1

City of Antioch Wastewater Collection System Master Plan Recommended Improvement Projects (organized by Project ID)

CITY OF ANTIOCH WASTEWATER COLLECITON SYSTEM MASTER PLAN RECOMMENDED IMPROVEMENT PROJECTS (organized by Project ID)

Phase	Project ID	Priority	Over Capacity Scenario	Model ID	City ID	Length (ft)	Pipe Diameter (in)	Replacement (in)	Parallel (in)	Current Capacity (cfs)	Design Capacity, PWWF(25 yr)		% Over Capacity in terms of d/D	
											Buildout	Buildout*	Buildout	Buildout*
1	1a	3	02 25	34	G21-7-004SS	73	18	24	18	4.8	5.3	5.3	10%	10%
	1a	1	02 dry	35	G21-7-006SS	316	18	24	18	3.1	5.3	5.3	70%	70%
	1a	6	Bu 25	36	G21-7-007SS	170	18	24	18	5.1	5.3	5.3	4%	4%
	1a	0	Below Capacity	37	G21-7-009SS	48	18	24	18	9.5	Current Capacity	Current Capacity	0%	0%
	1a	1	02 dry	38	G21-7-010SS	82	15	24	18	3.0	5.3	5.3	76%	76%
	1a	1	02 dry	39	G21-7-011SS	285	15	24	18	3.0	5.3	5.3	74%	74%
	1a	1	02 dry	40	G21-7-050SS	204	15	24	18	3.0	5.3	5.3	74%	74%
	1a	1	02 dry	41	G21-7-049SS	402	15	24	18	3.0	5.3	5.3	75%	75%
	1a	1	02 dry	42	G21-7-048SS	397	12	24	18	2.7	5.3	5.3	96%	96%
	1a	2	02 5	43	G21-7-047SS	452	18	24	18	4.0	5.3	5.3	33%	33%
	1a	1	02 dry	45	F21-9-025SS	772	18	24	18	3.6	5.3	5.3	47%	47%
*	1a	1	02 dry	46	F21-9-024SS	445	21	24	18	4.2	5.8	5.8	37%	37%
*	1a	2	02 5	47	F21-9-017SS	372	21	24	18	4.2	5.8	5.8	36%	36%
*	1a	1	02 dry	53	F21-9-005SS	295	21	30	24	4.2	9.3	9.3	119%	119%
*	1a	2	02 5	57	F21-8-004SS	709	24	30	24	6.8	9.4	9.4	37%	37%
*	1a	1	02 dry	58	F21-8-011SS	236	21	30	24	4.2	9.3	9.3	122%	122%
*	1a	N	Negative Slope	749	F21-8-006SS	360	24	30 S	24 S	N/A	9.3	9.3	N/A	N/A
*	1a	1	02 dry	801	F21-9-016SS	236	21	30	24	4.2	5.8	5.8	38%	38%
*	1a	1	02 dry	802	F21-9-006SS	24	21	30	24	4.3	9.3	9.3	117%	117%
* Under Construction					Total	5881								
1	1b	N	Negative Slope	156	G22-7-075SS-SF1	92	18	24 S	18 S	N/A	4.6	4.6	N/A	N/A
	1b	1	02 dry	157	G22-7-075SS-SF2	92	18	24	18	2.6	4.6	4.6	75%	75%
	1b	N	Negative Slope	158	G22-7-074SS	70	24	24 S	21 S	N/A	9.2	9.2	N/A	N/A
	1b	0	Below Capacity	161	G22-7-073SS-SF1	81	16	21	12	5.7	Current Capacity	Current Capacity	0%	0%
	1b	2	02 5	164	G22-7-070SS	398	16	21	12	3.1	4.0	4.0	31%	31%
	1b	2	02 5	166	G22-7-068SS	449	16	21	12	2.9	4.0	4.0	39%	39%
	1b	1	02 ave	168	G22-7-065SS	286	16	21 S	12 S	1.6	4.0	4.0	143%	143%
	1b	2	02 5	170	G22-7-063SS	189	16	21	12	3.0	4.0	4.0	34%	34%
	1b	2	02 5	762	G22-7-062SS	82	16	21	12	3.0	4.0	4.0	34%	34%
					Total	1739								
1	1c	3	02 25	260	G21-8-031SS	178	12	15	12	3.1	3.7	3.7	19%	19%
	1c	2	02 5	261	G22-3-059SS	330	12	15	12	2.9	3.7	3.7	30%	30%
	1c	2	02 5	262	G21-9-001SS	366	12	15	12	2.8	3.7	3.7	34%	34%
	1c	1	02 dry	263	G21-8-030SS	437	12	15	12	2.3	3.7	3.7	61%	61%
	1c	2	02 5	272	G21-8-032SS	410	12	15	12	2.8	3.7	3.7	34%	34%
	1c	N	Negative Slope	273	G21-8-029SS	97	15	15 Parallel	15	N/A	4.5	4.5	N/A	N/A
	1c	N	Negative Slope	274	G21-8-028SS	139	15	15 Parallel	15	N/A	4.5	4.5	N/A	N/A
	1c	N	Negative Slope	275	G21-8-027SS	115	15	15 Parallel	15	N/A	5.2	5.2	N/A	N/A
	1c	2	02 5	283	G22-3-060SS	322	12	15	12	2.7	3.7	3.7	40%	40%
	1c	1	02 dry	284	G22-3-061SS	256	12	15	12	2.3	3.7	3.7	63%	63%
	1c	2	02 5	285	G22-3-067SS	541	12	15	12	2.7	3.7	3.7	37%	37%
					Total	3191								
2	1d	1	02 ave	32	G21-7-002SS	34	15	24	18	1.2	2.9	2.9	146%	146%
	1d	2	02 5	44	G21-8-020SS	411	12	15	8	1.8	2.3	2.3	31%	31%
	1d	2	02 5	276	G21-8-024SS-SF1	103	12	15	8	2.0	2.3	2.3	17%	17%
	1d	2	02 5	278	G21-8-023SS	325	12	15	8	1.9	2.3	2.3	24%	24%
	1d	3	02 25	280	G21-8-019SS	465	12	15	8	2.0	2.3	2.3	15%	15%
	1d	1	02 dry	804	G21-8-025SS	99	15	21	15	3.0	5.3	5.3	74%	74%
					Total	1437								
2	1e	1	02 dry	680	J23-6-005SS	411	15	21 S	12 S	2.2	5.5	5.5	147%	147%
	1e	2	02 5	681	J23-6-006SS	447	15	21	12	3.8	5.5	5.5	45%	45%
	1e	2	02 5	682	J23-6-007SS	368	15	21	12	3.7	5.5	5.5	50%	50%
	1e	3	02 25	683	J23-6-008SS	419	18	21	12	5.0	5.5	5.5	11%	11%
	1e	3	02 25	684	J23-9-061SS	401	18	21	12	5.0	5.5	5.5	10%	10%
	1e	2	02 5	685	J23-9-062SS	310	18	21	12	4.5	5.5	5.5	24%	24%
	1e	0	Below Capacity	686	J23-9-063SS	338	18	21	12	5.8	Current Capacity	Current Capacity	0%	0%

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CITY OF ANTIOCH WASTEWATER COLLECITON SYSTEM MASTER PLAN RECOMMENDED IMPROVEMENT PROJECTS (organized by Project ID)

Phase	Project ID	Priority	Over Capacity Scenario	Model ID	City ID	Length (ft)	Pipe Diameter (in)	Replacement (in)	Parallel (in)	Current Capacity (cfs)	Design Capacity, PWWF(25 yr)		% Over Capacity in terms of d/D	
											Buildout	Buildout*	Buildout	Buildout*
	1e	0	Below Capacity	687	J23-9-064SS	365	18	21	12	5.8	Current Capacity	Current Capacity	0%	0%
	1e	2	02 5	689	J23-9-067SS	278	18	21	12	4.7	6.0	6.0	27%	27%
	1e	3	02 25	690	J23-9-065SS	149	18	21	12	5.8	6.0	6.0	4%	4%
	1e	2	02 5	808	J23-9-066SS	252	18	21	12	4.7	6.0	6.0	28%	28%
					Total	3737								
2	1f	N	Negative Slope	50	F21-9-036SS	364	12	18 S	15 S	N/A	3.2	3.2	N/A	N/A
	1f	4	07 5	51	F21-9-037SS	236	12	18	15	2.7	3.6	3.6	34%	34%
	1f	2	02 5	52	F21-8-012SS	288	15	18	15	2.2	3.6	3.6	61%	61%
	1f	4	07 5	54	F21-9-038SS	558	12	18	15	2.7	3.6	3.6	34%	34%
					Total	1445								
2	2a	4	07 25	688	J23-9-022SS	450	24	33 , 39*	27 , 33*	12.7	18.3	26.5	44%	108%
	2a	4	07 25	727	J23-9-024SS	414	24	33 , 39*	27 , 33*	13.4	18.3	26.5	37%	97%
	2a	2	02 5	728	J23-9-025SS	466	24	33 , 39*	27 , 33*	8.9	18.3	26.4	105%	196%
	2a	N	Negative Slope	729	J24-3-011SS	166	24	33 S , 39* S	27 S , 33* S	N/A	18.2	26.4	N/A	N/A
	2a	0	Below Capacity	730	J24-3-010SS	66	24	33 , 39*	27 , 33*	31.9	Current Capacity	Current Capacity	0%	0%
	2a	3	02 25	741	J24-3-009SS	288	24	33 , 39*	27 , 33*	11.0	19.1	27.2	73%	147%
	2a	2	02 5	742	J24-3-008SS	399	24	33 , 39*	27 , 33*	8.6	19.0	27.2	122%	217%
	2a	0	Below Capacity	743	J24-3-007SS	395	24	33 , 39*	27 , 33*	33.7	Current Capacity	Current Capacity	0%	0%
					Total	2644								
2	2b	3	02 25	464	J23-5-026SS	344	12	15	10	3.2	3.7	3.7	15%	15%
	2b	2	02 5	465	J23-8-047SS	529	12	15	10	3.0	3.7	3.7	21%	21%
	2b	1	02 ave	466	J23-8-043SS	256	12	15 S	10 S	0.6	3.7	3.7	480.0%	480.0%
	2b	2	02 5	467	J23-8-042SS	260	12	15	10	2.5	3.7	3.7	45%	45%
	2b	2	02 5	468	J23-8-041SS	472	12	15	10	2.8	3.7	3.7	34%	34%
	2b	2	02 5	469	J23-8-035SS	363	12	15	10 S	2.2	3.7	3.7	66%	66%
	2b	N	Negative Slope	470	J23-8-034SS	88	12	15 S	10 S	N/A	3.7	3.7	N/A	N/A
	2b	2	02 5	724	J23-8-032SS	415	18	21	15	3.4	4.6	4.6	34%	34%
					Total	2728								
3	2c	2	02 5	416	J22-7-059SS	300	12	18	12	1.9	2.5	2.5	29%	29%
	2c	3	02 25	417	J22-8-025SS	183	12	18	12	2.3	2.6	2.6	12%	12%
	2c	2	02 5	418	J22-8-026SS	242	12	18	12	1.5	2.6	2.6	74%	74%
	2c	2	02 5	658	J22-7-054SS	432	12	18	12	1.9	2.5	2.5	30%	30%
	2c	0	Below Capacity	659	J22-7-058SS	319	12	18	12	2.5	Current Capacity	Current Capacity	0%	0%
	2c	2	02 5	660	J22-8-006SS	108	12	18	12	1.9	2.5	2.5	30%	30%
	2c	3	02 25	661	J22-8-007SS	191	12	18	12	2.1	2.5	2.5	16%	16%
	2c	0	Below Capacity	662	J22-8-008SS	284	12	18	12	2.5	Current Capacity	Current Capacity	0%	0%
	2c	3	02 25	663	J22-8-027SS	144	12	18	12	2.4	2.6	2.6	7%	7%
	2c	0	Below Capacity	664	J22-8-028SS	134	12	18	12	3.5	Current Capacity	Current Capacity	0%	0%
	2c	0	Below Capacity	665	J22-8-029SS	305	12	18	12	3.5	Current Capacity	Current Capacity	0%	0%
	2c	2	02 5	666	J23-2-017SS	275	12	18	12	2.2	2.8	2.8	24%	24%
	2c	0	Below Capacity	667	J23-2-016SS	386	12	18	12	3.9	Current Capacity	Current Capacity	0%	0%
	2c	2	02 5	668	J23-2-015SS	424	12	18	12	2.6	3.9	3.9	50%	50%
	2c	2	02 5	669	J23-2-014SS	416	12	18	12 S	1.8	3.9	3.9	118%	118%
	2c	2	02 5	670	J23-2-013SS	321	12	18	12	2.0	3.9	3.9	94%	94%
	2c	2	02 5	671	J23-2-012SS	321	12	18	12	2.0	3.9	3.9	95%	95%
	2c	2	02 5	672	J23-2-011SS	321	12	18	12	1.9	3.9	3.9	105%	105%
	2c	2	02 5	673	J23-2-010SS	381	12	18	12	2.2	3.9	3.9	79%	79%
	2c	2	02 5	674	J23-2-009SS	400	12	18	12	2.1	4.1	4.1	99%	99%
	2c	2	02 5	675	J23-3-022SS	401	12	18	12	2.7	4.1	4.1	55%	55%
	2c	2	02 5	676	J23-6-001SS	399	12	18	12	2.8	4.1	4.1	47%	47%
	2c	2	02 5	677	J23-6-002SS	401	12	18	12	2.6	4.1	4.1	58%	58%
	2c	2	02 5	678	J23-6-003SS	362	12	18	12	2.5	4.1	4.1	66%	66%
					Total	7452								
3	2d	2	02 5	490	J23-4-024SS	196	12	15	12	1.8	2.2	2.2	27%	27%
	2d	2	02 5	491	J23-4-025SS	315	12	15	12	1.3	2.2	2.2	70%	70%

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											Buildout	Buildout*	Buildout	Buildout*
	2d	2	02 5	492	J23-4-026SS	263	12	15	12	1.8	2.2	2.2	23%	23%
	2d	3	02 25	493	J23-4-036SS	100	12	15	12	2.0	2.2	2.2	13%	13%
	2d	3	02 25	494	J23-4-037SS	186	12	15	12	2.0	2.2	2.2	12%	12%
	2d	3	02 25	495	J23-1-044SS	272	12	15	12	2.0	2.3	2.3	11%	11%
	2d	2	02 5	496	J23-4-047SS	282	12	15	12	1.7	2.2	2.2	34%	34%
	2d	3	02 25	497	J23-4-045SS	199	12	15	12	1.9	2.2	2.2	19%	19%
	2d	2	02 5	498	J23-4-046SS	56	12	15	12	1.3	2.2	2.2	77%	77%
	2d	0	Below Capacity	499	J23-4-034SS	127	12	15	12	2.4	Current Capacity	Current Capacity	0%	0%
	2d	2	02 5	500	J23-4-035SS	96	12	15 S	12	1.2	2.2	2.2	86%	86%
	2d	6	Bu 25	501	J23-1-043SS	224	12	15	12	2.2	2.3	2.3	1%	1%
	2d	0	Below Capacity	502	J23-1-053SS	303	12	15	12	2.3	Current Capacity	Current Capacity	0%	0%
	2d	2	02 5	503	J23-1-057SS	456	12	15	12	1.3	2.2	2.2	75%	75%
	2d	2	02 5	504	J23-1-054SS	335	12	15	8	1.8	2.3	2.3	25%	25%
	2d	3	02 25	515	J23-1-058SS	61	10	15	8	2.0	2.7	2.7	32%	32%
					Total	3470								
4	2e	7	Sa 5	580	G24-2-003SS	400	33	45*	33*	25.7	Current Capacity	32.6	0%	27%
	2e	7	Sa 5	581	G24-2-004SS	406	33	45*	33*	27.8	Current Capacity	32.7	0%	17%
	2e	7	Sa 5	582	G24-2-005SS	151	33	45*	33*	24.0	Current Capacity	32.5	0%	35%
	2e	6	Bu 5	583	G24-2-006SS	254	33	39 , 45*	27 , 33*	20.5	24.0	32.5	17%	58%
	2e	5	12 5	584	G24-3-001SS	240	33	39 , 45*	27 , 33*	17.1	24.0	32.4	40%	90%
	2e	2	02 5	585	G24-3-002SS	282	33	39 S , 45* S	27 S , 33* S	8.4	23.9	32.4	187%	287%
	2e	7	Sa 5	586	G24-3-003SS	271	33	39 , 45*	27 , 33*	26.0	Current Capacity	32.6	0%	25%
	2e	5	12 5	587	G24-3-004SS	305	33	39 , 45*	27 , 33* S	16.1	24.0	32.5	50%	102%
	2e	4	07 5	588	G24-3-005SS	307	33	39 S , 45* S	27 S , 33* S	13.2	24.0	32.4	82%	146%
	2e	7	Sa 5	589	G24-3-006SS	299	33	39 , 45*	27 , 33*	24.7	Current Capacity	32.6	0%	32%
	2e	7	Sa 5	590	G24-3-007SS	386	33	39 , 45*	27 , 33*	24.7	Current Capacity	32.6	0%	32%
	2e	6	Bu 5	591	G24-3-008SS	122	33	39 , 45*	27 , 33*	19.8	24.1	32.5	22%	64%
	2e	5	12 25	592	H24-1-000SS	143	33	39 , 45*	27 , 33*	18.3	24.1	32.5	32%	78%
					Total	3567								
4	4a	6	Bu 5	439	J23-9-038SS	72	8	21 , 30*	21 , 30*	5.3	8.5	16.7	61%	215%
	4a	4	07 dry	527	K23-7	98	8	21 , 30*	21 , 30*	1.1	7.6	15.8	572%	1286%
	4a	4	07 dry	528	K23-7-006SS	289	8	21 , 30*	21 , 30*	1.2	7.7	15.8	539%	1217%
	4a	4	07 dry	529	K23-7-005SS	245	8	21 , 30*	21 , 30*	1.2	7.7	15.8	540%	1219%
	4a	4	07 dry	530	K23-7-004SS	439	8	21 , 30*	21 , 30*	1.2	7.7	15.8	539%	1218%
	4a	4	07 dry	531	K23-7-003SS	404	8	21 , 30*	21 , 30*	1.2	7.7	15.8	540%	1219%
	4a	4	07 dry	532	K23-7-002SS	287	8	21 , 30*	21 , 30*	1.2	7.7	15.8	539%	1217%
	4a	4	07 25	533	K23-7-001SS	412	8	21 , 30*	21 , 30*	2.7	8.0	16.1	194%	493%
	4a	N	Negative Slope	534	J23-9-039SS	48	8	21 S , 30* S	21 S , 30* S	N/A	7.4	15.6	N/A	N/A
	4a	5	12 5	535	J23-9-036SS	46	10	21 , 30*	21 , 30*	3.8	8.2	16.4	114%	326%
	4a	4	07 5	536	J23-9-035SS	129	10	21 , 30*	21 , 30*	2.6	8.0	16.1	204%	515%
	4a	4	07 5	537	J23-9-034SS	204	10	21 , 30*	21 , 30*	2.0	7.8	16.0	291%	696%
	4a	6	Bu 25	538	J23-9-033SS	102	15	21 , 30*	21 , 30*	7.2	7.5	15.6	4%	117%
					Total	2777								
4	4b	4	07 5	420	K23-4-021SS	126	10	21 , 30*	21 , 30*	1.6	6.3	14.4	302%	821%
	4b	4	07 dry	421	K23-4-022SS	235	10	21 , 30*	21 , 30*	1.2	6.2	14.3	433%	1130%
	4b	4	07 dry	422	K23-4-023SS	234	10	21 S , 30*	21 , 30*	1.0	6.3	14.5	551%	1387%
	4b	4	07 5	423	K23-4-024SS	261	10	21 , 30*	21 , 30*	1.6	6.5	14.6	303%	810%
	4b	4	07 dry	429	K23-4-016SS	271	10	21 , 30*	21 , 30*	1.2	6.4	14.5	426%	1096%
	4b	4	07 dry	430	K23-4-018SS	253	10	21 , 30*	21 , 30*	1.6	6.5	14.6	310%	825%
	4b	4	07 dry	431	K23-4-020SS	445	10	21 , 30*	21 , 30*	1.4	6.4	14.5	371%	968%
	4b	4	07 25	432	K23-7-040SS	456	10	21 , 30*	21 , 30*	2.2	6.8	14.9	211%	585%
	4b	4	07 dry	433	K23-7-038SS	421	10	21 , 30*	21 , 30*	1.4	6.6	14.7	381%	974%
	4b	4	07 dry	434	K23-7-037SS	132	10	21 , 30*	21 , 30*	1.4	7.0	15.2	401%	980%
	4b	7	Sa dry	435	K23-7-035SS	365	10	21 , 30*	21 , 30*	9.1	Current Capacity	16.8	0%	85%
	4b	5	12 5	436	K23-7-026SS	256	12	21 , 30*	21 , 30*	3.4	6.8	14.9	98%	336%
	4b	5	12 5	437	K23-7-025SS	256	12	21 , 30*	21 , 30*	4.0	6.8	14.9	68%	269%
					Total	3712								

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Phase	Project ID	Priority	Over Capacity Scenario	Model ID	City ID	Length (ft)	Pipe Diameter (in)	Replacement (in)	Parallel (in)	Current Capacity (cfs)	Design Capacity, PWWF(25 yr)		% Over Capacity in terms of d/D	
											Buildout	Buildout*	Buildout	Buildout*
5	5a	5	12 25	167	G22-7-069SS	463	21	24	10	4.7	5.3	5.3	12%	12%
	5a	N	Negative Slope	169	G22-7-066SS	282	21	24 S	10 S	N/A	5.3	5.3	N/A	N/A
	5a	6	Bu 25	181	G22-7-064SS	297	20	24	10	5.1	5.3	5.3	4%	4%
					Total	1041								
5	5b	6	Bu 5	15	G21-4-025SS	553	12	15	8	3.1	3.2	3.2	2%	2%
	5b	5	12 25	29	G21-7-034SS	341	12	15	8	2.8	3.2	3.2	13%	13%
	5b	5	12 5	48	F21-9-034SS	422	12	15	8	2.7	3.2	3.2	17%	17%
					Total	1316								
5	6a	7	Sa 5	632	J24-9-004SS	336	33	39*	27*	25.5	Current Capacity	29.5	0%	15%
	6a	7	Sa 5	633	J24-9-005SS	440	33	39*	27*	23.0	Current Capacity	29.4	0%	28%
	6a	6	Bu 25	634	J24-9-006SS	432	33	36 , 39*	18 , 27*	19.8	21.3	29.4	8%	49%
	6a	6	Bu 25	637	J24-3-004SS	351	33	36 , 39*	18 , 27*	19.2	20.6	28.8	8%	50%
	6a	7	Sa 5	638	J24-3-003SS	352	33	36 , 39*	18 , 27*	22.4	Current Capacity	28.8	0%	28%
	6a	7	Sa 5	639	J24-3-002SS	295	33	36 , 39*	18 , 27*	24.1	Current Capacity	28.8	0%	20%
	6a	6	Bu 5	640	J24-3-001SS	480	33	36 , 39* S	18 , 27* S	17.6	20.6	28.8	17%	63%
	6a	7	Sa 5	641	J24-6-006SS	462	33	36 , 39*	18 , 27*	21.2	Current Capacity	28.8	0%	36%
	6a	7	Sa 25	642	J24-6-005SS	437	33	36 , 39*	18 , 27*	27.5	Current Capacity	28.9	0%	5%
	6a	7	Sa 5	643	J24-6-004SS	445	33	36 , 39*	18 , 27*	23.2	Current Capacity	29.4	0%	27%
	6a	7	Sa 5	644	J24-6-003SS	444	33	36 , 39*	18 , 27*	22.8	Current Capacity	29.4	0%	29%
	6a	6	Bu 25	645	J24-6-002SS	446	33	36 , 39*	18 , 27*	20.5	21.3	29.4	4%	43%
	6a	6	Bu 5	646	J24-6-001SS	385	33	36 , 39* S	18 , 27* S	18.1	21.3	29.4	17%	62%
					Total	5306								
NOTE: Projects 7a - 7c mainly focus on additional capacity needed to handle sewer flow from Sommersville Road Corridor area and Standard Oil Interchange area. Otherwise, Projects 7a - 7c can be combined into a single project.														
6	7a	7	Sa 5	597	H24-1-005SS	323	33	42*	30*	26.5	Current Capacity	30.6	0%	15%
	7a	0	Below Capacity	598	H24-1-006SS	322	33	42*	30*	30.7	Current Capacity	Current Capacity	0%	0%
	7a	7	Sa 25	599	H24-1-007SS	282	33	42*	30*	28.4	Current Capacity	30.6	0%	8%
	7a	7	Sa 5	600	H24-1-008SS	350	33	42*	30*	26.3	Current Capacity	30.6	0%	16%
	7a	0	Below Capacity	601	H24-1-009SS	241	33	42*	30*	56.4	Current Capacity	Current Capacity	0%	0%
	7a	N	Negative Slope	602	H24-2-001SS	278	33	39 S , 42* S	27S , 30* S	N/A	22.1	30.5	N/A	N/A
	7a	4	07 25	603	H24-2-002SS	246	33	39 , 42* S	27 , 30* S	14.3	22.2	30.5	55%	113%
	7a	7	Sa 5	604	H24-2-003SS	246	33	39 , 42*	27 , 30*	22.4	Current Capacity	30.6	0%	36%
	7a	0	Below Capacity	605	H24-2-004SS	205	33	39 , 42*	27 , 30*	167.1	Current Capacity	Current Capacity	0%	0%
	7a	N	Negative Slope	606	H24-5-001SS	326	33	39 S , 42* S	27S , 30* S	N/A	22.2	30.4	N/A	N/A
	7a	6	Bu 5	607	H24-5-002SS	445	33	39 , 42*	27 , 30*	19.6	22.3	30.5	13%	56%
	7a	7	Sa 5	608	H24-5-003SS	411	33	39 , 42*	27 , 30*	22.2	Current Capacity	30.6	0%	38%
	7a	4	07 25	609	H24-5-004SS	264	33	39 , 42* S	27 , 30* S	13.8	21.5	29.8	55%	115%
	7a	7	Sa 5	610	H24-5-005SS	253	33	42*	30*	24.0	Current Capacity	29.9	0%	24%
					Total	4193								
6	7b	7	Sa 5	627	J24-8-004SS	440	33	39*	24*	23.9	Current Capacity	29.5	0%	23%
	7b	7	Sa 5	628	J24-8-005SS	439	33	39*	24*	21.2	Current Capacity	29.4	0%	39%
	7b	7	Sa 5	629	J24-9-001SS	440	33	39*	24*	23.5	Current Capacity	29.4	0%	26%
	7b	7	Sa 5	630	J24-9-002SS	441	33	39*	24*	21.7	Current Capacity	29.4	0%	35%
					Total	1759								
6	7c	7	Sa 5	615	H24-6-005SS	356	33	39*	21*	25.3	Current Capacity	29.9	0%	18%
	7c	7	Sa 5	616	H24-6-006SS	356	33	39*	21*	23.4	Current Capacity	29.9	0%	28%
	7c	7	Sa 5	617	H24-6-007SS	412	33	39*	21*	26.4	Current Capacity	29.9	0%	13%
	7c	7	Sa 5	618	J24-4-001SS	410	33	39*	21*	22.8	Current Capacity	29.4	0%	29%
	7c	7	Sa 5	619	J24-7-001SS	411	33	39*	21*	24.7	Current Capacity	29.5	0%	19%
	7c	7	Sa 5	620	J24-7-002SS	414	33	39*	21*	24.7	Current Capacity	29.5	0%	19%
					Total	2359								

* - Buildout* includes wastewater flow from Roddy Ranch area and Ginocchio area
S - Slope adjustment is required for the recommended pipe size

APPENDIX D-2

City of Antioch Wastewater Collection System Master Plan Recommended Improvement Projects (organized by City Pipeline ID)

CITY OF ANTIOCH WASTEWATER COLLECITON SYSTEM MASTER PLAN RECOMMENDED IMPROVEMENT PROJECTS (organized by CITY PIPELINE ID)

City ID	Phase	Project ID	Priority	Over Capacity Scenario	Model ID	Length (ft)	Pipe Diameter (in)	Replacement (in)	Parallel (in)	Current Capacity (cfs)	Design Capacity, PWWF(25 yr)		% Over Capacity in terms of d/D	
											Buildout	Buildout*	Buildout	Buildout*
F21-8-004SS	1**	1a	2	02 5	57	709	24	30	24	6.8	9.4	9.4	37%	37%
F21-8-006SS	1**	1a	N	Negative Slope	749	360	24	30 S	24 S	N/A	9.3	9.3	N/A	N/A
F21-8-011SS	1**	1a	1	02 dry	58	236	21	30	24	4.2	9.3	9.3	122%	122%
F21-8-012SS	2	1f	2	02 5	52	288	15	18	15	2.2	3.6	3.6	61%	61%
F21-9-005SS	1**	1a	1	02 dry	53	295	21	30	24	4.2	9.3	9.3	119%	119%
F21-9-006SS	1**	1a	1	02 dry	802	24	21	30	24	4.3	9.3	9.3	117%	117%
F21-9-016SS	1**	1a	1	02 dry	801	236	21	30	24	4.2	5.8	5.8	38%	38%
F21-9-017SS	1**	1a	2	02 5	47	372	21	24	18	4.2	5.8	5.8	36%	36%
F21-9-024SS	1**	1a	1	02 dry	46	445	21	24	18	4.2	5.8	5.8	37%	37%
F21-9-025SS	1	1a	1	02 dry	45	772	18	24	18	3.6	5.3	5.3	47%	47%
F21-9-034SS	5	5b	5	12 5	48	422	12	15	8	2.7	3.2	3.2	17%	17%
F21-9-036SS	2	1f	N	Negative Slope	50	364	12	18 S	15 S	N/A	3.2	3.2	N/A	N/A
F21-9-037SS	2	1f	4	07 5	51	236	12	18	15	2.7	3.6	3.6	34%	34%
F21-9-038SS	2	1f	4	07 5	54	558	12	18	15	2.7	3.6	3.6	34%	34%
G21-4-025SS	5	5b	6	Bu 5	15	553	12	15	8	3.1	3.2	3.2	2%	2%
G21-7-002SS	2	1d	1	02 ave	32	34	15	24	18	1.2	2.9	2.9	146%	146%
G21-7-004SS	1	1a	3	02 25	34	73	18	24	18	4.8	5.3	5.3	10%	10%
G21-7-006SS	1	1a	1	02 dry	35	316	18	24	18	3.1	5.3	5.3	70%	70%
G21-7-007SS	1	1a	6	Bu 25	36	170	18	24	18	5.1	5.3	5.3	4%	4%
G21-7-009SS	1	1a	0	Below Capacity	37	48	18	24	18	9.5	Current Capacity	Current Capacity	0%	0%
G21-7-010SS	1	1a	1	02 dry	38	82	15	24	18	3.0	5.3	5.3	76%	76%
G21-7-011SS	1	1a	1	02 dry	39	285	15	24	18	3.0	5.3	5.3	74%	74%
G21-7-034SS	5	5b	5	12 25	29	341	12	15	8	2.8	3.2	3.2	13%	13%
G21-7-047SS	1	1a	2	02 5	43	452	18	24	18	4.0	5.3	5.3	33%	33%
G21-7-048SS	1	1a	1	02 dry	42	397	12	24	18	2.7	5.3	5.3	96%	96%
G21-7-049SS	1	1a	1	02 dry	41	402	15	24	18	3.0	5.3	5.3	75%	75%
G21-7-050SS	1	1a	1	02 dry	40	204	15	24	18	3.0	5.3	5.3	74%	74%
G21-8-019SS	2	1d	3	02 25	280	465	12	15	8	2.0	2.3	2.3	15%	15%
G21-8-020SS	2	1d	2	02 5	44	411	12	15	8	1.8	2.3	2.3	31%	31%
G21-8-023SS	2	1d	2	02 5	278	325	12	15	8	1.9	2.3	2.3	24%	24%
G21-8-024SS-SF1	2	1d	2	02 5	276	103	12	15	8	2.0	2.3	2.3	17%	17%
G21-8-025SS	2	1d	1	02 dry	804	99	15	21	15	3.0	5.3	5.3	74%	74%
G21-8-027SS	1	1c	N	Negative Slope	275	115	15	15 Parallel	15	N/A	5.2	5.2	N/A	N/A
G21-8-028SS	1	1c	N	Negative Slope	274	139	15	15 Parallel	15	N/A	4.5	4.5	N/A	N/A
G21-8-029SS	1	1c	N	Negative Slope	273	97	15	15 Parallel	15	N/A	4.5	4.5	N/A	N/A
G21-8-030SS	1	1c	1	02 dry	263	437	12	15	12	2.3	3.7	3.7	61%	61%
G21-8-031SS	1	1c	3	02 25	260	178	12	15	12	3.1	3.7	3.7	19%	19%
G21-8-032SS	1	1c	2	02 5	272	410	12	15	12	2.8	3.7	3.7	34%	34%
G21-9-001SS	1	1c	2	02 5	262	366	12	15	12	2.8	3.7	3.7	34%	34%
G22-3-059SS	1	1c	2	02 5	261	330	12	15	12	2.9	3.7	3.7	30%	30%
G22-3-060SS	1	1c	2	02 5	283	322	12	15	12	2.7	3.7	3.7	40%	40%
G22-3-061SS	1	1c	1	02 dry	284	256	12	15	12	2.3	3.7	3.7	63%	63%
G22-3-067SS	1	1c	2	02 5	285	541	12	15	12	2.7	3.7	3.7	37%	37%
G22-7-062SS	1	1b	2	02 5	762	82	16	21	12	3.0	4.0	4.0	34%	34%
G22-7-063SS	1	1b	2	02 5	170	189	16	21	12	3.0	4.0	4.0	34%	34%
G22-7-064SS	5	5a	6	Bu 25	181	297	20	24	10	5.1	5.3	5.3	4%	4%
G22-7-065SS	1	1b	1	02 ave	168	286	16	21 S	12 S	1.6	4.0	4.0	143%	143%
G22-7-066SS	5	5a	N	Negative Slope	169	282	21	24 S	10 S	N/A	5.3	5.3	N/A	N/A
G22-7-068SS	1	1b	2	02 5	166	449	16	21	12	2.9	4.0	4.0	39%	39%
G22-7-069SS	5	5a	5	12 25	167	463	21	24	10	4.7	5.3	5.3	12%	12%
G22-7-070SS	1	1b	2	02 5	164	398	16	21	12	3.1	4.0	4.0	31%	31%
G22-7-073SS-SF1	1	1b	0	Below Capacity	161	81	16	21	12	5.7	Current Capacity	Current Capacity	0%	0%
G22-7-074SS	1	1b	N	Negative Slope	158	70	24	24 S	21 S	N/A	9.2	9.2	N/A	N/A
G22-7-075SS-SF1	1	1b	N	Negative Slope	156	92	18	24 S	18 S	N/A	4.6	4.6	N/A	N/A
G22-7-075SS-SF2	1	1b	1	02 dry	157	92	18	24	18	2.6	4.6	4.6	75%	75%
G24-2-003SS	4	2e	7	Sa 5	580	400	33	45*	33*	25.7	Current Capacity	32.6	0%	27%
G24-2-004SS	4	2e	7	Sa 5	581	406	33	45*	33*	27.8	Current Capacity	32.7	0%	17%
G24-2-005SS	4	2e	7	Sa 5	582	151	33	45*	33*	24.0	Current Capacity	32.5	0%	35%
G24-2-006SS	4	2e	6	Bu 5	583	254	33	39 , 45*	27 , 33*	20.5	24.0	32.5	17%	58%
G24-3-001SS	4	2e	5	12 5	584	240	33	39 , 45*	27 , 33*	17.1	24.0	32.4	40%	90%
G24-3-002SS	4	2e	2	02 5	585	282	33	39 S , 45* S	27 S , 33* S	8.4	23.9	32.4	187%	287%

** - Sections currently under construction
* - Buildout* includes wastewater flow from Roddy Ranch area and Ginocchio area
S - Slope adjustment is required for the recommended pipe size

CITY OF ANTIOCH WASTEWATER COLLECITON SYSTEM MASTER PLAN RECOMMENDED IMPROVEMENT PROJECTS (organized by CITY PIPELINE ID)

City ID	Phase	Project ID	Priority	Over Capacity Scenario	Model ID	Length (ft)	Pipe Diameter (in)	Replacement (in)	Parallel (in)	Current Capacity (cfs)	Design Capacity, PWWF(25 yr)		% Over Capacity in terms of d/D	
											Buildout	Buildout*	Buildout	Buildout*
G24-3-003SS	4	2e	7	Sa 5	586	271	33	39 , 45*	27 , 33*	26.0	Current Capacity	32.6	0%	25%
G24-3-004SS	4	2e	5	12 5	587	305	33	39 , 45*	27 , 33* S	16.1	24.0	32.5	50%	102%
G24-3-005SS	4	2e	4	07 5	588	307	33	39 S , 45* S	27 S , 33* S	13.2	24.0	32.4	82%	146%
G24-3-006SS	4	2e	7	Sa 5	589	299	33	39 , 45*	27 , 33*	24.7	Current Capacity	32.6	0%	32%
G24-3-007SS	4	2e	7	Sa 5	590	386	33	39 , 45*	27 , 33*	24.7	Current Capacity	32.6	0%	32%
G24-3-008SS	4	2e	6	Bu 5	591	122	33	39 , 45*	27 , 33*	19.8	24.1	32.5	22%	64%
H24-1-000SS	4	2e	5	12 25	592	143	33	39 , 45*	27 , 33*	18.3	24.1	32.5	32%	78%
H24-1-005SS	6	7a	7	Sa 5	597	323	33	42*	30*	26.5	Current Capacity	30.6	0%	15%
H24-1-006SS	6	7a	0	Below Capacity	598	322	33	42*	30*	30.7	Current Capacity	Current Capacity	0%	0%
H24-1-007SS	6	7a	7	Sa 25	599	282	33	42*	30*	28.4	Current Capacity	30.6	0%	8%
H24-1-008SS	6	7a	7	Sa 5	600	350	33	42*	30*	26.3	Current Capacity	30.6	0%	16%
H24-1-009SS	6	7a	0	Below Capacity	601	241	33	42*	30*	56.4	Current Capacity	Current Capacity	0%	0%
H24-2-001SS	6	7a	N	Negative Slope	602	278	33	39 S , 42* S	27S , 30* S	N/A	22.1	30.5	N/A	N/A
H24-2-002SS	6	7a	4	07 25	603	246	33	39 , 42* S	27 , 30* S	14.3	22.2	30.5	55%	113%
H24-2-003SS	6	7a	7	Sa 5	604	246	33	39 , 42*	27 , 30*	22.4	Current Capacity	30.6	0%	36%
H24-2-004SS	6	7a	0	Below Capacity	605	205	33	39 , 42*	27 , 30*	167.1	Current Capacity	Current Capacity	0%	0%
H24-5-001SS	6	7a	N	Negative Slope	606	326	33	39 S , 42* S	27S , 30* S	N/A	22.2	30.4	N/A	N/A
H24-5-002SS	6	7a	6	Bu 5	607	445	33	39 , 42*	27 , 30*	19.6	22.3	30.5	13%	56%
H24-5-003SS	6	7a	7	Sa 5	608	411	33	39 , 42*	27 , 30*	22.2	Current Capacity	30.6	0%	38%
H24-5-004SS	6	7a	4	07 25	609	264	33	39 , 42* S	27 , 30* S	13.8	21.5	29.8	55%	115%
H24-5-005SS	6	7a	7	Sa 5	610	253	33	42*	30*	24.0	Current Capacity	29.9	0%	24%
H24-6-005SS	6	7c	7	Sa 5	615	356	33	39*	21*	25.3	Current Capacity	29.9	0%	18%
H24-6-006SS	6	7c	7	Sa 5	616	356	33	39*	21*	23.4	Current Capacity	29.9	0%	28%
H24-6-007SS	6	7c	7	Sa 5	617	412	33	39*	21*	26.4	Current Capacity	29.9	0%	13%
J22-7-054SS	3	2c	2	02 5	658	432	12	18	12	1.9	2.5	2.5	30%	30%
J22-7-058SS	3	2c	0	Below Capacity	659	319	12	18	12	2.5	Current Capacity	Current Capacity	0%	0%
J22-7-059SS	3	2c	2	02 5	416	300	12	18	12	1.9	2.5	2.5	29%	29%
J22-8-006SS	3	2c	2	02 5	660	108	12	18	12	1.9	2.5	2.5	30%	30%
J22-8-007SS	3	2c	3	02 25	661	191	12	18	12	2.1	2.5	2.5	16%	16%
J22-8-008SS	3	2c	0	Below Capacity	662	284	12	18	12	2.5	Current Capacity	Current Capacity	0%	0%
J22-8-025SS	3	2c	3	02 25	417	183	12	18	12	2.3	2.6	2.6	12%	12%
J22-8-026SS	3	2c	2	02 5	418	242	12	18	12	1.5	2.6	2.6	74%	74%
J22-8-027SS	3	2c	3	02 25	663	144	12	18	12	2.4	2.6	2.6	7%	7%
J22-8-028SS	3	2c	0	Below Capacity	664	134	12	18	12	3.5	Current Capacity	Current Capacity	0%	0%
J22-8-029SS	3	2c	0	Below Capacity	665	305	12	18	12	3.5	Current Capacity	Current Capacity	0%	0%
J23-1-043SS	3	2d	6	Bu 25	501	224	12	15	12	2.2	2.3	2.3	1%	1%
J23-1-044SS	3	2d	3	02 25	495	272	12	15	12	2.0	2.3	2.3	11%	11%
J23-1-053SS	3	2d	0	Below Capacity	502	303	12	15	12	2.3	Current Capacity	Current Capacity	0%	0%
J23-1-054SS	3	2d	2	02 5	504	335	12	15	8	1.8	2.3	2.3	25%	25%
J23-1-057SS	3	2d	2	02 5	503	456	12	15	12	1.3	2.2	2.2	75%	75%
J23-1-058SS	3	2d	3	02 25	515	61	10	15	8	2.0	2.7	2.7	32%	32%
J23-2-009SS	3	2c	2	02 5	674	400	12	18	12	2.1	4.1	4.1	99%	99%
J23-2-010SS	3	2c	2	02 5	673	381	12	18	12	2.2	3.9	3.9	79%	79%
J23-2-011SS	3	2c	2	02 5	672	321	12	18	12	1.9	3.9	3.9	105%	105%
J23-2-012SS	3	2c	2	02 5	671	321	12	18	12	2.0	3.9	3.9	95%	95%
J23-2-013SS	3	2c	2	02 5	670	321	12	18	12	2.0	3.9	3.9	94%	94%
J23-2-014SS	3	2c	2	02 5	669	416	12	18	12 S	1.8	3.9	3.9	118%	118%
J23-2-015SS	3	2c	2	02 5	668	424	12	18	12	2.6	3.9	3.9	50%	50%
J23-2-016SS	3	2c	0	Below Capacity	667	386	12	18	12	3.9	Current Capacity	Current Capacity	0%	0%
J23-2-017SS	3	2c	2	02 5	666	275	12	18	12	2.2	2.8	2.8	24%	24%
J23-3-022SS	3	2c	2	02 5	675	401	12	18	12	2.7	4.1	4.1	55%	55%
J23-4-024SS	3	2d	2	02 5	490	196	12	15	12	1.8	2.2	2.2	27%	27%
J23-4-025SS	3	2d	2	02 5	491	315	12	15	12	1.3	2.2	2.2	70%	70%
J23-4-026SS	3	2d	2	02 5	492	263	12	15	12	1.8	2.2	2.2	23%	23%
J23-4-034SS	3	2d	0	Below Capacity	499	127	12	15	12	2.4	Current Capacity	Current Capacity	0%	0%
J23-4-035SS	3	2d	2	02 5	500	96	12	15 S	12	1.2	2.2	2.2	86%	86%
J23-4-036SS	3	2d	3	02 25	493	100	12	15	12	2.0	2.2	2.2	13%	13%
J23-4-037SS	3	2d	3	02 25	494	186	12	15	12	2.0	2.2	2.2	12%	12%
J23-4-045SS	3	2d	3	02 25	497	199	12	15	12	1.9	2.2	2.2	19%	19%
J23-4-046SS	3	2d	2	02 5	498	56	12	15	12	1.3	2.2	2.2	77%	77%
J23-4-047SS	3	2d	2	02 5	496	282	12	15	12	1.7	2.2	2.2	34%	34%

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City ID	Phase	Project ID	Priority	Over Capacity Scenario	Model ID	Length (ft)	Pipe Diameter (in)	Replacement (in)	Parallel (in)	Current Capacity (cfs)	Design Capacity, PWWF(25 yr)		% Over Capacity in terms of d/D	
											Buildout	Buildout*	Buildout	Buildout*
J23-5-026SS	2	2b	3	02 25	464	344	12	15	10	3.2	3.7	3.7	15%	15%
J23-6-001SS	3	2c	2	02 5	676	399	12	18	12	2.8	4.1	4.1	47%	47%
J23-6-002SS	3	2c	2	02 5	677	401	12	18	12	2.6	4.1	4.1	58%	58%
J23-6-003SS	3	2c	2	02 5	678	362	12	18	12	2.5	4.1	4.1	66%	66%
J23-6-005SS	2	1e	1	02 dry	680	411	15	21 S	12 S	2.2	5.5	5.5	147%	147%
J23-6-006SS	2	1e	2	02 5	681	447	15	21	12	3.8	5.5	5.5	45%	45%
J23-6-007SS	2	1e	2	02 5	682	368	15	21	12	3.7	5.5	5.5	50%	50%
J23-6-008SS	2	1e	3	02 25	683	419	18	21	12	5.0	5.5	5.5	11%	11%
J23-8-032SS	2	2b	2	02 5	724	415	18	21	15	3.4	4.6	4.6	34%	34%
J23-8-034SS	2	2b	N	Negative Slope	470	88	12	15 S	10 S	N/A	3.7	3.7	N/A	N/A
J23-8-035SS	2	2b	2	02 5	469	363	12	15	10 S	2.2	3.7	3.7	66%	66%
J23-8-041SS	2	2b	2	02 5	468	472	12	15	10	2.8	3.7	3.7	34%	34%
J23-8-042SS	2	2b	2	02 5	467	260	12	15	10	2.5	3.7	3.7	45%	45%
J23-8-043SS	2	2b	1	02 ave	466	256	12	15 S	10 S	0.6	3.7	3.7	480.0%	480.0%
J23-8-047SS	2	2b	2	02 5	465	529	12	15	10	3.0	3.7	3.7	21%	21%
J23-9-022SS	2	2a	4	07 25	688	450	24	33 , 39*	27 , 33*	12.7	18.3	26.5	44%	108%
J23-9-024SS	2	2a	4	07 25	727	414	24	33 , 39*	27 , 33*	13.4	18.3	26.5	37%	97%
J23-9-025SS	2	2a	2	02 5	728	466	24	33 , 39*	27 , 33*	8.9	18.3	26.4	105%	196%
J23-9-033SS	4	4a	6	Bu 25	538	102	15	21 , 30*	21 , 30*	7.2	7.5	15.6	4%	117%
J23-9-034SS	4	4a	4	07 5	537	204	10	21 , 30*	21 , 30*	2.0	7.8	16.0	291%	696%
J23-9-035SS	4	4a	4	07 5	536	129	10	21 , 30*	21 , 30*	2.6	8.0	16.1	204%	515%
J23-9-036SS	4	4a	5	12 5	535	46	10	21 , 30*	21 , 30*	3.8	8.2	16.4	114%	326%
J23-9-038SS	4	4a	6	Bu 5	439	72	8	21 , 30*	21 , 30*	5.3	8.5	16.7	61%	215%
J23-9-039SS	4	4a	N	Negative Slope	534	48	8	21 S , 30* S	21 S , 30* S	N/A	7.4	15.6	N/A	N/A
J23-9-061SS	2	1e	3	02 25	684	401	18	21	12	5.0	5.5	5.5	10%	10%
J23-9-062SS	2	1e	2	02 5	685	310	18	21	12	4.5	5.5	5.5	24%	24%
J23-9-063SS	2	1e	0	Below Capacity	686	338	18	21	12	5.8	Current Capacity	Current Capacity	0%	0%
J23-9-064SS	2	1e	0	Below Capacity	687	365	18	21	12	5.8	Current Capacity	Current Capacity	0%	0%
J23-9-065SS	2	1e	3	02 25	690	149	18	21	12	5.8	6.0	6.0	4%	4%
J23-9-066SS	2	1e	2	02 5	808	252	18	21	12	4.7	6.0	6.0	28%	28%
J23-9-067SS	2	1e	2	02 5	689	278	18	21	12	4.7	6.0	6.0	27%	27%
J24-3-001SS	5	6a	6	Bu 5	640	480	33	36 , 39* S	18 , 27* S	17.6	20.6	28.8	17%	63%
J24-3-002SS	5	6a	7	Sa 5	639	295	33	36 , 39*	18 , 27*	24.1	Current Capacity	28.8	0%	20%
J24-3-003SS	5	6a	7	Sa 5	638	352	33	36 , 39*	18 , 27*	22.4	Current Capacity	28.8	0%	28%
J24-3-004SS	5	6a	6	Bu 25	637	351	33	36 , 39*	18 , 27*	19.2	20.6	28.8	8%	50%
J24-3-007SS	2	2a	0	Below Capacity	743	395	24	33 , 39*	27 , 33*	33.7	Current Capacity	Current Capacity	0%	0%
J24-3-008SS	2	2a	2	02 5	742	399	24	33 , 39*	27 , 33*	8.6	19.0	27.2	122%	217%
J24-3-009SS	2	2a	3	02 25	741	288	24	33 , 39*	27 , 33*	11.0	19.1	27.2	73%	147%
J24-3-010SS	2	2a	0	Below Capacity	730	66	24	33 , 39*	27 , 33*	31.9	Current Capacity	Current Capacity	0%	0%
J24-3-011SS	2	2a	N	Negative Slope	729	166	24	33 S , 39* S	27 S , 33* S	N/A	18.2	26.4	N/A	N/A
J24-4-001SS	6	7c	7	Sa 5	618	410	33	39*	21*	22.8	Current Capacity	29.4	0%	29%
J24-6-001SS	5	6a	6	Bu 5	646	385	33	36 , 39* S	18 , 27* S	18.1	21.3	29.4	17%	62%
J24-6-002SS	5	6a	6	Bu 25	645	446	33	36 , 39*	18 , 27*	20.5	21.3	29.4	4%	43%
J24-6-003SS	5	6a	7	Sa 5	644	444	33	36 , 39*	18 , 27*	22.8	Current Capacity	29.4	0%	29%
J24-6-004SS	5	6a	7	Sa 5	643	445	33	36 , 39*	18 , 27*	23.2	Current Capacity	29.4	0%	27%
J24-6-005SS	5	6a	7	Sa 25	642	437	33	36 , 39*	18 , 27*	27.5	Current Capacity	28.9	0%	5%
J24-6-006SS	5	6a	7	Sa 5	641	462	33	36 , 39*	18 , 27*	21.2	Current Capacity	28.8	0%	36%
J24-7-001SS	6	7c	7	Sa 5	619	411	33	39*	21*	24.7	Current Capacity	29.5	0%	19%
J24-7-002SS	6	7c	7	Sa 5	620	414	33	39*	21*	24.7	Current Capacity	29.5	0%	19%
J24-8-004SS	6	7b	7	Sa 5	627	440	33	39*	24*	23.9	Current Capacity	29.5	0%	23%
J24-8-005SS	6	7b	7	Sa 5	628	439	33	39*	24*	21.2	Current Capacity	29.4	0%	39%
J24-9-001SS	6	7b	7	Sa 5	629	440	33	39*	24*	23.5	Current Capacity	29.4	0%	26%
J24-9-002SS	6	7b	7	Sa 5	630	441	33	39*	24*	21.7	Current Capacity	29.4	0%	35%
J24-9-004SS	5	6a	7	Sa 5	632	336	33	39*	27*	25.5	Current Capacity	29.5	0%	15%
J24-9-005SS	5	6a	7	Sa 5	633	440	33	39*	27*	23.0	Current Capacity	29.4	0%	28%
J24-9-006SS	5	6a	6	Bu 25	634	432	33	36 , 39*	18 , 27*	19.8	21.3	29.4	8%	49%
K23-4-016SS	4	4b	4	07 dry	429	271	10	21 , 30*	21 , 30*	1.2	6.4	14.5	426%	1096%
K23-4-018SS	4	4b	4	07 dry	430	253	10	21 , 30*	21 , 30*	1.6	6.5	14.6	310%	825%
K23-4-020SS	4	4b	4	07 dry	431	445	10	21 , 30*	21 , 30*	1.4	6.4	14.5	371%	968%
K23-4-021SS	4	4b	4	07 5	420	126	10	21 , 30*	21 , 30*	1.6	6.3	14.4	302%	821%
K23-4-022SS	4	4b	4	07 dry	421	235	10	21 , 30*	21 , 30*	1.2	6.2	14.3	433%	1130%

** - Sections currently under construction

* - Buildout* includes wastewater flow from Roddy Ranch area and Ginocchio area

S - Slope adjustment is required for the recommended pipe size

CITY OF ANTIOCH WASTEWATER COLLECITON SYSTEM MASTER PLAN RECOMMENDED IMPROVEMENT PROJECTS (organized by CITY PIPELINE ID)

City ID	Phase	Project ID	Priority	Over Capacity Scenario	Model ID	Length (ft)	Pipe Diameter (in)	Replacement (in)	Parallel (in)	Current Capacity (cfs)	Design Capacity, PWWF(25 yr)		% Over Capacity in terms of d/D	
											Buildout	Buildout*	Buildout	Buildout*
K23-4-023SS	4	4b	4	07 dry	422	234	10	21 S , 30*	21 , 30*	1.0	6.3	14.5	551%	1387%
K23-4-024SS	4	4b	4	07 5	423	261	10	21 , 30*	21 , 30*	1.6	6.5	14.6	303%	810%
K23-7	4	4a	4	07 dry	527	98	8	21 , 30*	21 , 30*	1.1	7.6	15.8	572%	1286%
K23-7-001SS	4	4a	4	07 25	533	412	8	21 , 30*	21 , 30*	2.7	8.0	16.1	194%	493%
K23-7-002SS	4	4a	4	07 dry	532	287	8	21 , 30*	21 , 30*	1.2	7.7	15.8	539%	1217%
K23-7-003SS	4	4a	4	07 dry	531	404	8	21 , 30*	21 , 30*	1.2	7.7	15.8	540%	1219%
K23-7-004SS	4	4a	4	07 dry	530	439	8	21 , 30*	21 , 30*	1.2	7.7	15.8	539%	1218%
K23-7-005SS	4	4a	4	07 dry	529	245	8	21 , 30*	21 , 30*	1.2	7.7	15.8	540%	1219%
K23-7-006SS	4	4a	4	07 dry	528	289	8	21 , 30*	21 , 30*	1.2	7.7	15.8	539%	1217%
K23-7-025SS	4	4b	5	12 5	437	256	12	21 , 30*	21 , 30*	4.0	6.8	14.9	68%	269%
K23-7-026SS	4	4b	5	12 5	436	256	12	21 , 30*	21 , 30*	3.4	6.8	14.9	98%	336%
K23-7-035SS	4	4b	7	Sa dry	435	365	10	21 , 30*	21 , 30*	9.1	Current Capacity	16.8	0%	85%
K23-7-037SS	4	4b	4	07 dry	434	132	10	21 , 30*	21 , 30*	1.4	7.0	15.2	401%	980%
K23-7-038SS	4	4b	4	07 dry	433	421	10	21 , 30*	21 , 30*	1.4	6.6	14.7	381%	974%
K23-7-040SS	4	4b	4	07 25	432	456	10	21 , 30*	21 , 30*	2.2	6.8	14.9	211%	585%

** - Sections currently under construction
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S - Slope adjustment is required for the recommended pipe size