City of Riverside

WASTEWATER COLLECTION AND TREATMENT FACILITIES INTEGRATED MASTER PLAN

VOLUME 3: WASTEWATER COLLECTION SYSTEM
CHAPTER 1: WASTEWATER COLLECTION SYSTEM

FINAL
February 2008

carollo
Engineers...Working Wonders With Water™

10540 TALBERT AVENUE, SUITE 200 EAST • FOUNTAIN VALLEY, CALIFORNIA 92708 • (714) 593-5100 • FAX (714) 593-5101

City of Riverside

WASTEWATER COLLECTION AND TREATMENT FACILITIES INTEGRATED MASTER PLAN

VOLUME 3: WASTEWATER COLLECTION SYSTEM
CHAPTER 1: WASTEWATER COLLECTION SYSTEM

Page No.

1.1 PURPOSE 1-1
1.2 RECOMMENDATIONS 1-1
1.3 BACKGROUND 1-2
1.4 FLOW MEASUREMENTS 1-4
1.4.1 Metering Methods 1-4
1.4.2 Monitoring Periods 1-5
1.5 LAND USE AND FLOW ESTIMATES 1-5
1.5.1 Unit Flows and Peaking Factors 1-6
1.5.2 Existing and Future Land Use Characteristics 1-6
1.5.3 Existing and Future Average Dry Weather Flows 1-7
1.5.4 Dry Weather Flow Calibration 1-9
1.5.5 Infiltration and Inflow 1-10
1.5.6 Flow Comparison at RWQCP 1-10
1.6 WASTEWATER COLLECTION SYSTEM MODEL 1-12
1.6.1 Model Structure 1-12
1.6.2 Performance Criteria 1-13
1.7 CAPITAL IMPROVEMENT PLAN 1-13
1.8 CAPITAL IMPROVEMENT PLAN COST ESTIMATES 1-19
1.8.1 Unit Costs 1-19
1.8.2 Methods 1-20
1.8.3 Cost Estimates 1-21

APPENDIX A – SPRUCE STREET SEWER CAPACITY STUDY
APPENDIX B – TEQUESQUITE TRUNK SEWER STUDY
APPENDIX C – ARLANZA TRUNK SEWER STUDY
APPENDIX D – PHOENIX TRUNK SEWER STUDY
APPENDIX E – NORTHSIDE TRUNK SEWER STUDY
APPENDIX F – INFILTRATION AND INFLOW STUDY
APPENDIX G – COLLECTION SYSTEM COSTS

LIST OF TABLES

Table 1.1 Flow Monitoring Periods 1-5
Table 1.2 Basin Land Use 1-6
Table 1.3 Existing and Future ADWFs 1-9
Table 1.4 Comparison of CSMP Flows to RWQCP Flows - 2006 1-10
Table 1.5 Comparison of CSMP Flows to RWQCP Flows - 2020 1-11
Table 1.6 Modeled Sewer System Statistics 1-12

Table 1.7 Unit Cost Estimates 1-19
Table 1.8 Cost Estimation Methods 1-20
Table 1.9 Collection System Cost Estimates by Year 1-21

LIST OF FIGURES

Figure 1.1 Wastewater Collection System Layout 1-3
Figure 1.2 Land Use Statistics by Basin 1-8
Figure 1.3 Arlanza Basin CIP Improvements 1-14
Figure 1.4 Phoenix Basin CIP Improvements 1-15
Figure 1.5 Northside Basin CIP Improvements 1-16
Figure 1.6 Spruce Basin CIP Improvements 1-17
Figure 1.7 Tequesquite Basin CIP Improvements 1-18

WASTEWATER COLLECTION SYSTEM

1.1 PURPOSE

The purpose of the wastewater collection system volume is to summarize the collection system master plans (CSMPs) that were completed by PBS&J between 2002 and 2006. The capital improvements and costs that were proposed in the CSMPs are updated in this volume to reflect completed projects, and future project costs are adjusted and scheduled out to 2025 based on detailed costs and projects provided by the City. The projects and costs were not laid out like a typical master plan, but reconfigured by the City to calculate rate schedules.

1.2 RECOMMENDATIONS

The following recommendations should be considered by the City to further develop the CSMPs and associated capital improvement projects:

- Update the CSMPs by incorporating infiltration and inflow (I/I) into the collection system model and adjusting the capital improvement projects accordingly. The five CSMPs and the I/I Study provide a basis for estimating collection system costs for the City of Riverside. However, most CSMPs need to be updated approximately every five years. The Spruce Basin CSMP is already five years old. The five CSMPs also did not explicitly include I/I flows in the analysis. Depending on the City's actual rehabilitation and replacement (R&R) plan, I/I could get worse in the future if deterioration of existing sewers, especially sewers older than 50 years, is not kept in check. It is recommended that the collection system model be updated to include I/I and calibrated to the two significant rain events measured during the I/I study. Since quantifying I/I using the monitored wet weather data may increase the scope and cost of certain capital improvements, future capital improvements should be adjusted based on these results.
- Further investigate I/I in specific areas that suffer from significant I/I. Although I/I does not appear to be significant throughout the system, specific areas that suffer from significant I/I should be further investigated.
- Use the Sewer System Management Plan (SSMP) as the basis for future updates of current collection system studies. For the System Evaluation and Capacity Assurance Plan (SECAP), one component of the SSMP, the City will need to utilize the results of the I/I study and project flows based on a design storm (e.g., 10-year storm) to update projects in the Capital Improvement Plan (CIP). This further analysis should be completed within a schedule defined by the SSMP. Since I/I is not excessive throughout the collection system, it is unlikely that extensive changes to the CIP will

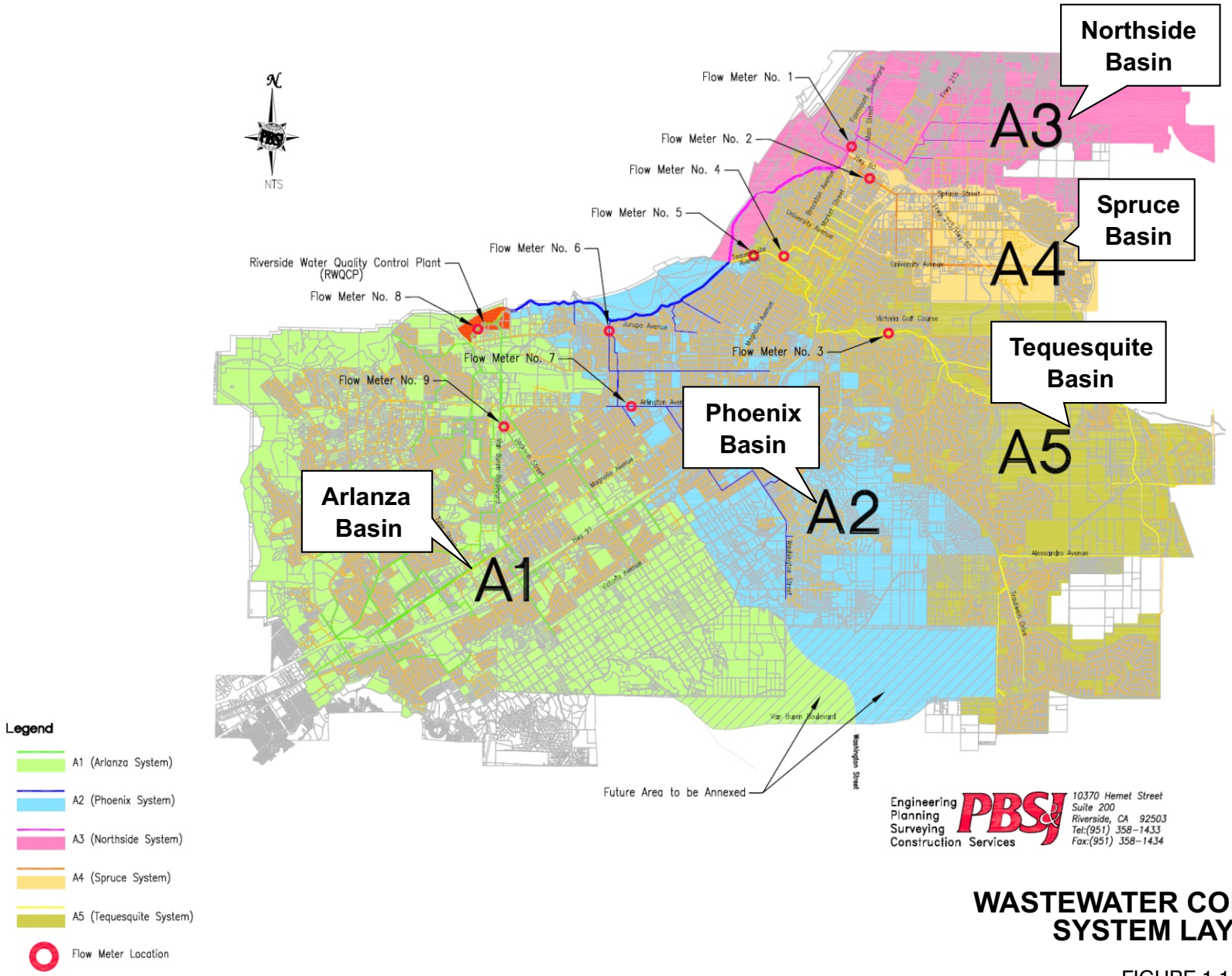
be needed. However, the scope of certain projects could be extended, as well as the need for some additional projects.

- Complete a more detailed analysis of the City's pipe R&R needs and costs. The R&R estimates made for this Integrated MP are a good start at determining the need and cost of system-wide pipeline upgrades due to pipelines exceeding their useful life. However, the costs associated with these initial estimates are based on a fairly simple analysis and could be improved with a more detailed analysis of the City's R&R needs. Details from the City's inspection programs should be coupled with probabilistic methods to comprehensively determine the most cost effective plan for R&R. A comprehensive R&R plan could significantly reduce the estimated costs of the current plan.
- Document the calibration results for the CSMPs. The CSMPs for the five basins mention that dry weather flow (DWF) calibration was completed. However, these documents do not include tables, statistics, or figures that illustrate the results of calibration. It is recommended that the results of the calibration of the DWFs be documented.
- Update the collection system model and capital projects with new flow metering data. The City should consider remonitoring the flows in the Basins on a rotating schedule or on a permanent basis. This effort does not have to start immediately, but the flows monitored for Spruce Basin are already five years old. Coupled with the flow metering problems detailed later in this chapter, the City could use the new flow metering data to update the model, update the CIP, and refine future projects. Better flow information along with more accurate model results will provide increased confidence in determining the need for projects and can avoid significant capital costs that may not be necessary.

1.3 BACKGROUND

The City of Riverside (City) has an extensive collection system that was divided into five basins for the purpose of master planning. PBS&J completed collection system master plans for each basin. Figure 1.1 illustrates the wastewater collection system layout with the five basins color-coded and labeled. The basins, the date of report completion, and the appendix in which these reports are documented are summarized below:

- Spruce Basin, June 2002, Appendix A.
- Tequesquite Basin, December 2003, Appendix B.
- Arlanza Basin, August 2006, Appendix C.
- Phoenix Basin, August 2006, Appendix D.
- Northside Basin, September 2006, Appendix E.



Engineering
Planning
Surveying
Construction Services
PBSJ
10370 Hemet Street
Suite 200
Riverside, CA 92503
Tel:(951) 358-1433
Fax:(951) 358-1434

WASTEWATER COLLECTION SYSTEM LAYOUT

FIGURE 1.1

carollo
Engineers...Working Wonders With Water™

WASTEWATER COLLECTION AND TREATMENT FACILITIES INTEGRATED MASTER PLAN

CITY OF RIVERSIDE

A separate Infiltration and Inflow (I/I) study was also completed by PBS&J for all five basins in the collection system in May 2005. This report is included in Appendix F. The results of the I/I study were not incorporated into the collection system master plans.

The City is currently completing a Sewer System Management Plan (SSMP). Components of the SSMP that directly influence the collection system studies include the requirements for a System Evaluation and Capacity Assurance Plan (SECAP) and a Rehabilitation and Replacement (R&R) Plan. A SECAP is basically a master plan with a detailed CIP, and requires the incorporation of I/I into the analysis to size future pipe improvements. To update projects in the collection system CIP, the City will need to utilize the results of the I/I study and project flows based on a design storm (e.g., 10-year storm).

1.4 FLOW MEASUREMENTS

Monitoring existing flows provides a basis for examining existing discharges from residential, commercial, and industrial customers. Calibration of the collection system model also requires measured flows. Flow metering was conducted throughout each basin to provide hourly flow data and hourly rainfall data (during the I/I study). Metering methods and monitoring periods are discussed below.

1.4.1 Metering Methods

Measurement of sewer flows can be accomplished using several methods. Most treatment plants use Parshall flumes to measure influent and effluent flows. However, permanent flumes are not cost effective for temporary metering programs. Therefore, portable meters that measure depth and velocity measurements were used for the CSMPs.

Downstream Services (DS) measured flows throughout the collection system as a subcontractor to PBS&J. They installed portable flow meters that measured depth (to compute flow area) and velocity. Flow rates are typically calculated by multiplying flow area by velocity. However, DS and PBS&J found inconsistencies in many of the velocity measurements and decided to calculate flows using Manning's equation. Manning's equation is an empirical equation that allows flow calculations based on pipe diameter, pipe slope, and measured depth of flow. Pipe slope was calculated using record drawings of pipes upstream and downstream of the meter locations, and a Manning's n of 0.013 was assumed.

While the use of Manning's equation is standard practice for designing pipes, this equation can produce inaccurate estimates of flow based on measured depths because it assumes the flow regime is uniform. Uniform flow is usually not the case in actual sewers (e.g., a single depth can produce different flow rates because the velocities will be different if the flow is subcritical or supercritical). Estimating Manning's n for an existing sewer is also a best guess and may not represent the specific friction losses due to field conditions.

However, when velocity measurements are in error, the only option (other than remonitoring) is to use Manning's equation. For the purposes of dry weather flow (DWF) measurements, Manning's equation probably provides acceptable estimates of flow assuming there were no obstructions near the sensors. During the winter monitoring periods, as described in the I/I study, the majority of the flow calculations did use velocity measurements. Therefore, the dry weather flows measured during the I/I study could be compared to identify if the DWF's estimated using Manning's equation are in error.

1.4.2 Monitoring Periods

Flow metering was generally conducted during dry periods to capture DWF and during the winter to capture I/I. DWF monitoring in all but the Spruce Basin was completed during a period with minimal base infiltration. In total, 31 meters measured DWF. This monitoring period ranged from two to three weeks per basin.

The I/I monitoring period was conducted over an eight and one-half week period using nine meters. Each basin included one to three meters. Table 1.1 summarizes the flow monitoring periods and statistics.

Table 1.1 Flow Monitoring Periods
Wastewater Collection and Treatment Facilities Integrated Master Plan
City of Riverside

Statistics	Arlanza Basin	Phoenix Basin	Northside Basin	Spruce Basin	Tequesquite Basin
Dry Weather Flow Monitoring Period					
Number of Sites	8	5	3	10	5
Weeks Monitored	2.5	3	2	2	2
Dates	10/3/05 - 10/20/05	10/1/05 - 10/19/05	9/30/04 - 10/13/04	11/20/01 - 12/4/01	7/29/03 - 8/5/03
Infiltration/Inflow (I/I) Monitoring Period					
Number of Sites	2	2	1	1	3
Weeks Monitored	8.5	8.5	8.5	8.5	8.5
Dates	01/7/05 - 02/28/05	01/7/05 - 02/28/05	01/7/05 - 02/28/05	01/7/05 - 02/28/05	01/7/05 - 02/28/05

1.5 LAND USE AND FLOW ESTIMATES

This section describes the unit flows and peaking factors reported in the CSMPs. Existing and future land use, ADWF, DWF calibration, and I/I are also discussed. This section concludes with a comparison of CSMP flows to flows at the RWQCP.

1.5.1 Unit Flows and Peaking Factors

Unit flows and peaking factors are typically used to estimate the flows from new development. The City publishes guidelines for estimating these flows entitled, "*Criteria for Sewer Facility Design, City of Riverside Public Works Department, Engineering Diversion*" (updated May 2004). Specific guidelines for estimating flows from residential, commercial, and industrial sources are summarized below:

- Flow estimates based on land use from the City's General Plan.
- Per capita living unit should be taken from recent census (no less than 2.75 capita per unit).
- Unit flows of 65 gallons per capita per day (gpcd).
- Peaking factors (PF) taken from curve based on population or average dry weather flow (ADWF) (range from 1.5 to 3.0).
- Industrial peak flow (PF): 0.012 cfs/acre.
- Commercial PF: 0.010 cfs/acre.
- Offices and Schools unit flows: 30 gpcd.
- Laundromat: 580 gal/machine/day.

These numbers were used in the CSMPs. These factors provide a starting point for estimating existing flows and comparing to measured flows. More discussion on DWF calibration is included in section 1.4.4.

1.5.2 Existing and Future Land Use Characteristics

The five CSMPs reported both existing and future land use based on General Plan estimates. Existing land use was represented by the year 2005 and future land use as 2020 for the Arlanza, Phoenix, and Northside basins. The Spruce and Tequesquite basins were completed several years earlier, so the existing estimates came from 2001 and 2003 respectively. The future land use for these two basins were projected to 2015 and 2018 respectively. Table 1.2 summarizes the land use statistics by basin and year.

Table 1.2 Basin Land Use
Wastewater Collection and Treatment Facilities Integrated Master Plan
City of Riverside

Statistics	Arlanza	Phoenix	Northside	Spruce	Tequesquite
Existing Land Use (Year)	**2005**	**2005**	**2005**	**2001**	**2003**
Single-Family Residential (acres)	7,220	4,500	700	1,136	6,744
Multi-Family Residential (acres)	880	76	72	189	241

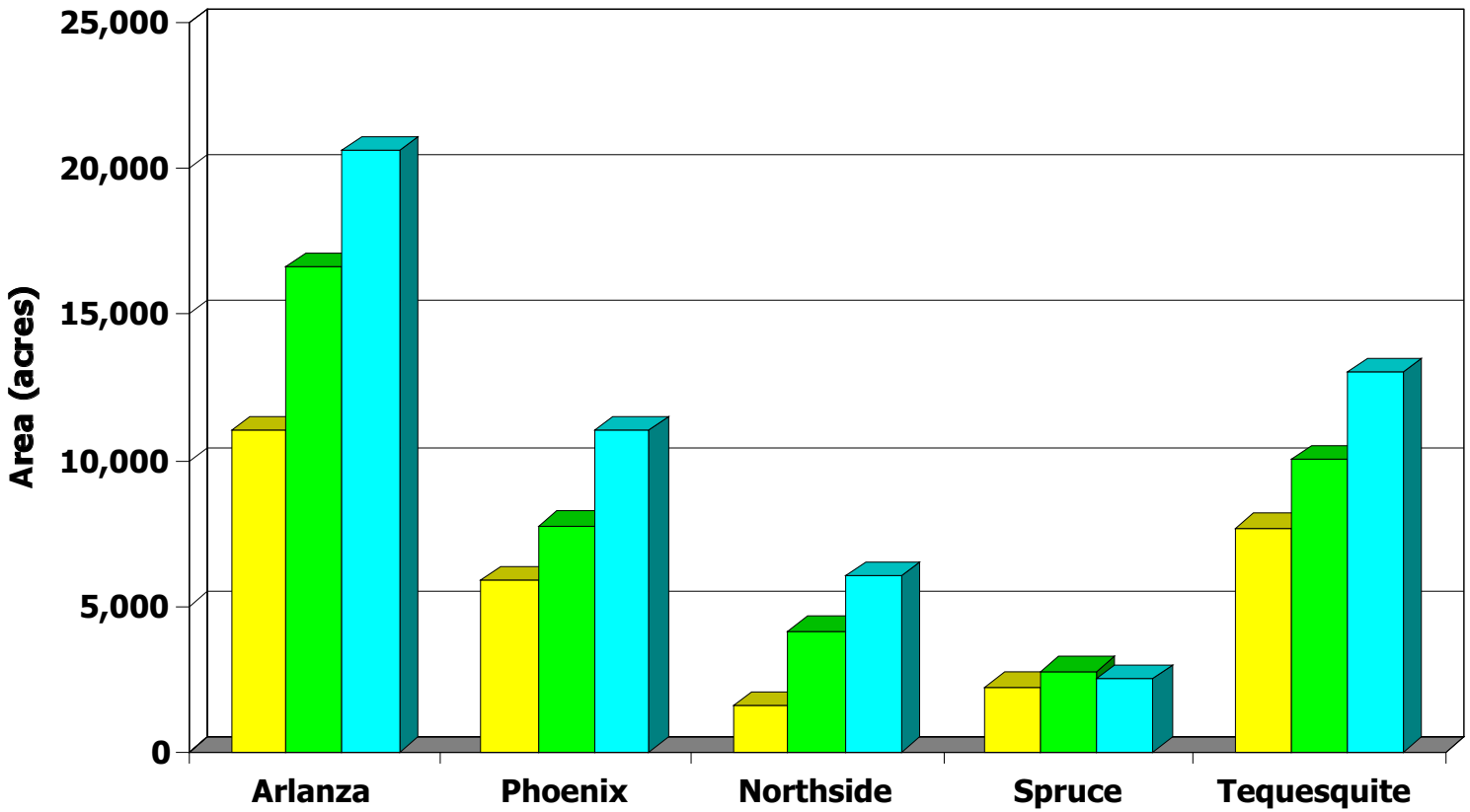
Table 1.2 Basin Land Use Wastewater Collection and Treatment Facilities Integrated Master Plan City of Riverside					
Statistics	**Arlanza**	**Phoenix**	**Northside**	**Spruce**	**Tequesquite**
Commercial (acres)	2,735	1,100	108	284	849
Industrial (acres)	190	190	738	170	54
University of CA, Riverside (acres)	-	-	-	471	-
Total (acres)	11,025	5,866	1,618	2,250	7,671
Future Land Use (Year)	**2020**	**2020**	**2020**	**2015**	**2018**
Single-Family Residential (acres)	12,240	6,230	2,250	1,294	7,530
Multi-Family Residential (acres)	960	78	157	203	274
Commercial (acres)	3,190	1,210	213	377	2,191
Industrial (acres)	215	215	1,512	170	60
University of CA, Riverside (acres)	-	-	-	706	-
Total (acres)	16,605	7,733	4,132	2,750	10,055
Total Basin Area (acres)	20,650	11,000	6,000	2,500	13,000

Notes:
(1) All statistic above provided by the City based on CSMPs.

According to the future total acreage, and the total basin acreages estimated from the CSMP study areas, the City has additional area to expand beyond the 2020 estimates, except in the Spruce Basin. Details on the Spruce Basin expansion can be found in Appendix A. Figure 1.2 illustrates a summary of the land use statistics by basin.

1.5.3 Existing and Future Average Dry Weather Flows

The total population in the service area is estimated to increase by approximately 28 percent from 2005 to 2025. The total ADWF in the service area is estimated to increase from 32.8 mgd in 2005 to 49.5 mgd in 2020, approximately a 51 percent increase. These statistics indicate a significant increase in commercial and/or industrial growth in the service area. Table 1.2 illustrates a significant anticipated increase in commercial acreage in the future which accounts for this flow increase (industrial acreage is estimated to change little in future years).



Total Developed Area (acres)

Existing Year	**2005**	**2005**	**2005**	**2001**	**2003**	**28,450**
Future Year	**2020**	**2020**	**2020**	**2015**	**2018**	**41,275**

Total System Area (acres) = 53,150

- Existing Developed Area
- Future Developed Area
- Total Basin Area

LAND USE STATISTICS BY BASIN

FIGURE 1.2

carollo
Engineers...Working Wonders With Water™

WASTEWATER COLLECTION AND TREATMENT FACILITIES INTEGRATED MASTER PLAN

CITY OF RIVERSIDE

Table 1.3 summarizes the population and flow statistics by basin and in total for the service area. The statistics listed in Table 1.3 are not included in the individual CSMPs. These numbers were provided to Carollo by the City and are based on the CSMPs.

Table 1.3 Existing and Future ADWFs
Wastewater Collection and Treatment Facilities Integrated Master Plan
City of Riverside

Statistics	Arlanza Basin	Phoenix Basin	Northside Basin	Spruce Basin	Tequesquite Basin	Total
Existing Flows (Year 2005)(1)						
Population	103,620	51,590	9,680	46,380	64,899	276,169
ADWF (mgd)(3)	9.7	12.8	1.1	2.5	6.7	32.8
Calculated(4) average gallons per capita per day (gpcd)	94	248	114	54	103	119
PHF (mgd)(5)	18.4	24.4	1.6	6.7	12.5	63.6
PHF/ADWF	1.9	1.9	1.9	1.9	1.9	1.9
Future Flows (Year 2020)(1)						
Population(2)	128,696	64,075	12,023	68,000	80,604	353,398
ADWF (mgd)(3)	12.5	18.4	3.8	3.4	11.4	49.5
Calculated(4) average gallons per capita per day (gpcd)	97	287	316	50	141	140
PHF (mgd)(5)	23.6	35.1	3.1	6.4	21.6	89.8
PHF/ADWF	1.9	1.9	1.9	1.9	1.9	1.8

Notes:
(1) Flows do not include estimates for Inflow/Infiltration (I/I).
(2) Population projected to year 2025.
(3) ADWF = Average Dry Weather Flow.
(4) Calculated gpcd = ADWF (gallons)/population.
(5) PHF = Peak Hour Flow.
(6) All data provide by the City based on CSMPs.

1.5.4 Dry Weather Flow Calibration

Calibration of a collection system model to measured DWFs is necessary to provide confidence in model results. Typical steps in the DWF calibration process include:

- Compile existing and future land use and population.
- Estimate unit flow factors for each type of land use and match model generated DWFs on an hourly basis with measured DWFs for existing conditions.
- Adjust unit flow factors by basin to account for variations in basin land use.

- Report statistics of calibrations to evaluate fit between measured and modeled flows (e.g., tables comparing peaks, averages, R^2, and hourly graphs).
- Project future DWFs based on calibrated unit flow factors.

The CSMPs for the five basins mention that DWF calibration was completed. However, these documents do not include tables, statistics, or figures that illustrate the results of calibration. It is recommended that the results of the calibration of DWFs be documented.

1.5.5 Infiltration and Inflow

PBS&J completed an I/I study for the City in May 2005, separate from the CSMPs. The monitoring effort captured four storms, two of which were significant. Based on the two large storm events, the report found I/I to be significant in certain areas of the system. Refer to the I/I Study in Appendix F for details. Because this study was done after the first of the CSMPs, it was decided that the results would not be included in the basin CSMPs at this time. No modeling of the I/I was completed as part of the I/I study or the CSMPs.

I/I tends to be average to above average throughout most of the system, while specific areas suffer from significant I/I and should be further investigated. The City has taken an initial step to account for I/I in these areas by qualitatively examining I/I through historic inspections. The City has adjusted potential capital improvements based on this qualitative analysis. However, the system has not been examined using a design storm approach (e.g., 5-year storm event). Therefore, it is recommended that the model be updated to include the I/I and calibrated to the two significant events measured during the I/I study. Future capital improvements can then be adjusted based on these results, especially since quantifying I/I using the monitored wet weather data may increase the scope and cost of certain capital improvements.

1.5.6 Flow Comparison at RWQCP

A flow comparison was completed between the flows estimated in the CSMPs and those estimated by Carollo at the Regional Water Quality Control Plant (RWQCP) (see Volume 2, Chapter 3 - Population and Flow Projections). The flows from the collection system should correlate well with the flows measured at the RWQCP. Because the analyses were completed independently, some differences are expected. Table 1.4 summarizes the comparison of flows for 2006 and Table 1.5 summarizes the comparison flows for 2020.

Table 1.4 Comparison of CSMP Flows to RWQCP Flows - 2006
Wastewater Collection and Treatment Facilities Integrated Master Plan
City of Riverside

Statistics	RWQCP	Total from CSMPs	Percent Difference(3)
ADWF (mgd)	-	32.8	
AADF (mgd)	33.5	-	2%(1)

Table 1.4	Comparison of CSMP Flows to RWQCP Flows - 2006 Wastewater Collection and Treatment Facilities Integrated Master Plan City of Riverside		
Statistics	**RWQCP**	**Total from CSMPs**	**Percent Difference(3)**
PDWF (mgd)	60.3	63.6	-5%
DWF Peaking Factor (PDWF/ADWF)	1.8	1.9	-
Peak Wet Weather Flow (mgd)(2)	73.7	-	-
WWF Peaking Factor (PWWF/ADWF)	2.2	-	-

Notes:
(1) Percent difference between AADF and ADWF.
(2) Based on historical flow analysis (Carollo, Vol. 2, Ch. 3).
(3) Percent Difference = (RWQCP - CSMP)/(RWQCP) flows.

Table 1.5	Comparison of CSMP Flows to RWQCP Flows - 2020 Wastewater Collection and Treatment Facilities Integrated Master Plan City of Riverside		
Statistics	**RWQCP**	**Total from CSMPs**	**Percent Difference(3)**
ADWF (mgd)	-	49.5	
AADF (mgd)	45.8	-	-8%(1)
PDWF (mgd)	86.1	89.8	-4%
DWF Peaking Factor (PDWF/ADWF)	1.8	1.8	-
Peak Wet Weather Flow (mgd)(2)	105.2	-	-
WWF Peaking Factor (PWWF/ADWF)	2.2	-	-

Notes:
(1) Percent difference between AADF and ADWF.
(2) Based on historical flow analysis (Carollo, Vol. 2, Ch. 3).
(3) Percent Difference = (RWQCP - CSMP)/(RWQCP) flows.

The ADWF for 2006 estimated in the CSMPs is 32.8 mgd, while the average annual daily flow (AADF) estimated at the RWQCP is 33.5 mgd. This is a difference of about 2 percent. The AADF contains I/I and should be greater than the ADWF since the ADWF is estimated during the dry season where little I/I should be present in the sewers. The ADWF for 2020 is estimated at 49.5 mgd for the collection system, while the AADF is estimated at 45.8 mgd at the RWQCP. This is a difference of about -8 percent. These comparisons show that the compared flows, from different data sources, are relatively close.

The PDWF estimated for the collection system is approximately 5 percent higher than that estimated at the RWQCP for 2006, and approximately 4 percent higher for 2020. Since I/I was not accounted for in the collection system flow estimates, peak wet weather flows (PWWF) were not reported in the CSMPs.

1.6 WASTEWATER COLLECTION SYSTEM MODEL

A collection system model was constructed for each basin to route flows and analyze hydraulics within the system. The software XP SWMM version 9.1 was used. This software allows for dynamic simulation of flows to account for attenuation, time of travel, surcharge, etc. The specifics of the model structure as well as the performance criteria used to identify deficiencies are included in this section.

1.6.1 Model Structure

The collection system hydraulic model includes the main interceptors and trunk sewers in the system, but does not include every pipe in the system. This type of representation of the system is typical in collection system modeling to simplify the model results and reduce run times. The majority of the system improvements due to hydraulic deficiencies can usually be identified with this type of “backbone” system.

The modeled system consists of 101.1 miles of gravity pipeline, 7.2 miles of force main, and 1,795 manholes. The pipe diameters range from 8-inches to 51-inches. Two pump stations are simulated and include Pierce Street lift station in the Arlanza basin and Wood Road lift station in Tequesquite basin. There are a total of 121 subbasins where flows are input to the modeled system and average about 235 acres per subbasin. Table 1.6 summarizes the statistics for each basin.

Table 1.6 Modeled Sewer System Statistics
Wastewater Collection and Treatment Facilities Integrated Master Plan
City of Riverside

Statistics	Arlanza Basin	Phoenix Basin	Northside Basin	Spruce Basin	Tequesquite Basin
Gravity Sewer Length (miles)	38.0	23.0	10.0	8.3	21.8
Force Main Length (miles)	5.6	-	-	-	1.6
Sewer Diameters (inches)	8 - 51	8 - 48	8 - 36	8 - 18	8 - 42
No. of Manholes	691	379	176	152	397
No. of Pump Stations	1	-	-	-	1

Table 1.6 Modeled Sewer System Statistics Wastewater Collection and Treatment Facilities Integrated Master Plan City of Riverside					
Statistics	**Arlanza Basin**	**Phoenix Basin**	**Northside Basin**	**Spruce Basin**	**Tequesquite Basin**
Subbasins (flow input points)	34	21	26	9	31
Notes: (1) Total modeled gravity sewer length = 101.1 miles. (2) Total modeled force main length = 7.2 miles. (3) Total modeled manholes = 1,795.					

1.6.2 Performance Criteria

The hydraulic model is used to analyze the hydraulics of existing and future flows. Performance criteria are used to judge the capacity deficiencies within pipelines. The assumptions for the CSMPs are summarized below:

- "Deficient" if pipes flowing at greater than 90 percent full.
- "Marginally Deficient" if pipes flowing between 75 percent and 90 percent full.
- "Velocity Deficient" if velocities are less than 2 feet per second (fps) or greater then 10 fps.

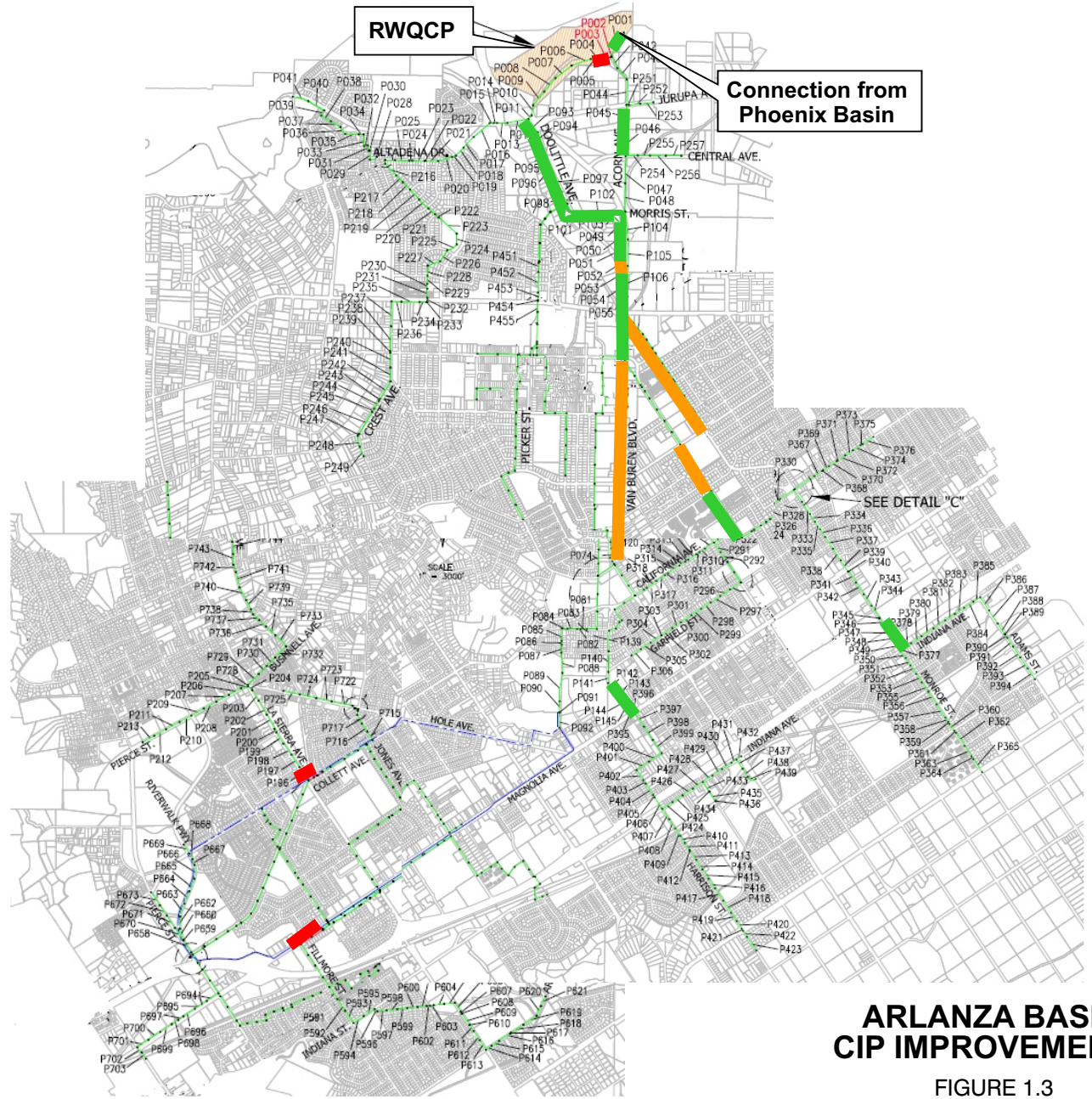
These criteria were used to examine existing and future flow conditions, and identify the pipelines in need of upgrades. Deficient sewer lines were classified into three priority groups, as follows:

- "Priority A" pipes were "deficient" at the time of the study: 2002 for Spruce, 2003 for Tequesquite, and 2005 for the remaining basins.
- "Priority B" pipes were projected to be "deficient" by 2015.
- "Priority C" pipes were projected to be "marginally deficient" by 2020.

Pipeline improvement projects were identified in each CSMP according to these priorities, along with a schedule for replacement/rehabilitation of deficient pipes.

1.7 CAPITAL IMPROVEMENT PLAN

A CIP was developed in the CSMPs to identify pipeline projects that required upgrades based on the modeling and the above performance criteria. The CIP projects identified by the CSMPs are illustrated in Figures 1.3 through 1.7. The pipeline improvements are color coded for the three priorities defined above. The specifics on each project can be found in the accompanying reports included in the appendices.



Legend

- Priority A
- Priority B
- Priority C

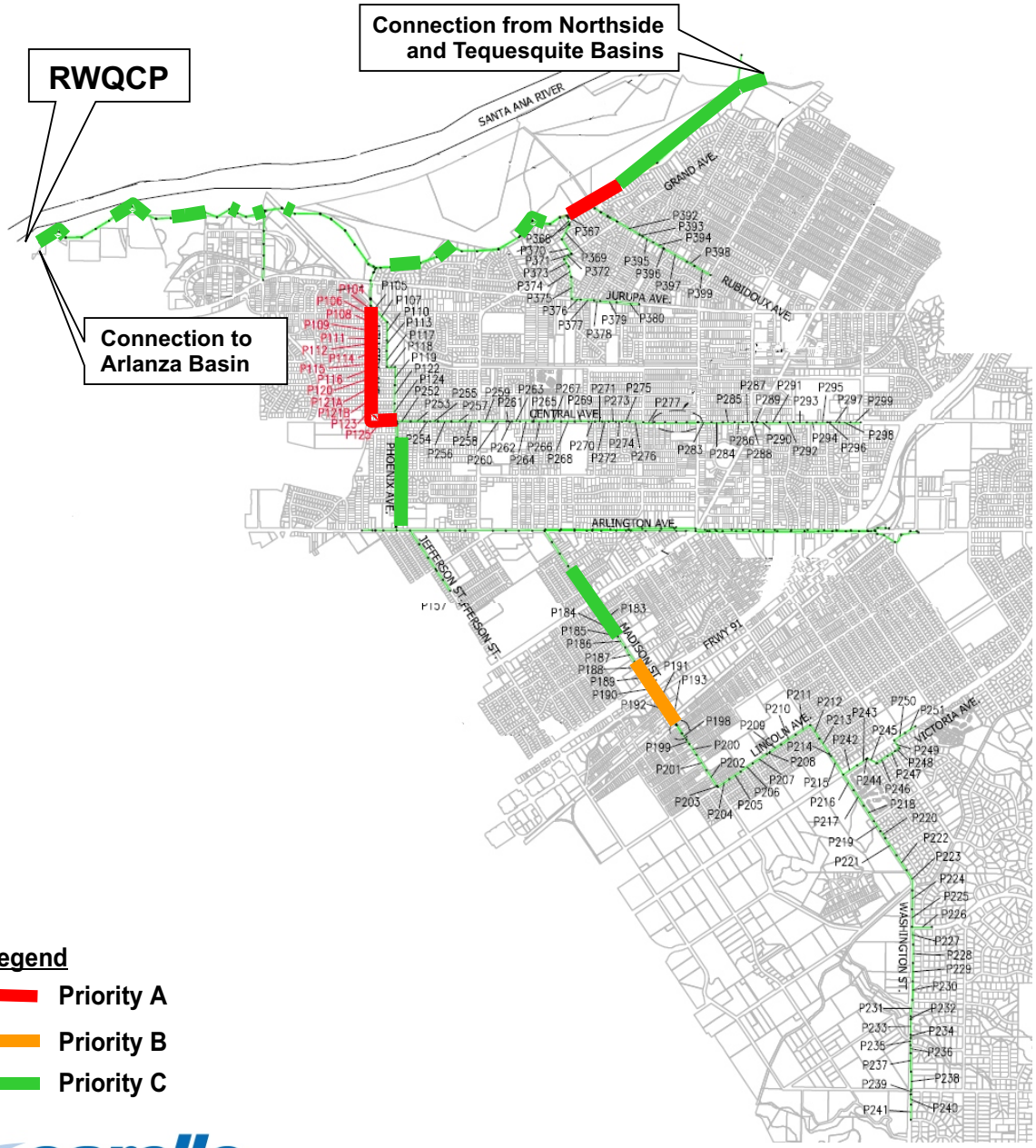
ARLANZA BASIN CIP IMPROVEMENTS

FIGURE 1.3

carollo
Engineers...Working Wonders With Water™

WASTEWATER COLLECTION AND TREATMENT FACILITIES INTEGRATED MASTER PLAN

CITY OF RIVERSIDE



Legend

- Priority A
- Priority B
- Priority C

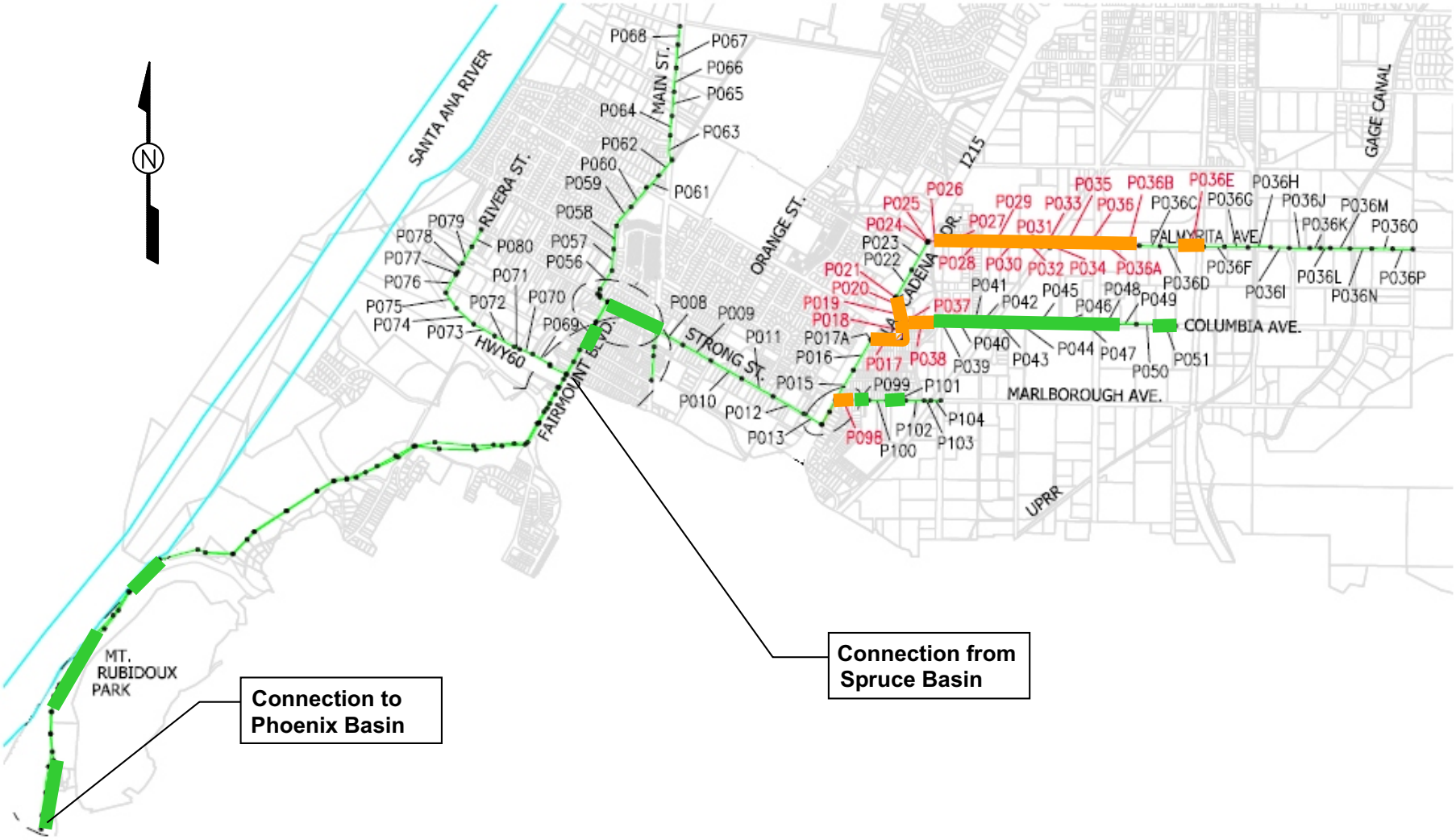
PHOENIX BASIN CIP IMPROVEMENTS

FIGURE 1.4

carollo
Engineers...Working Wonders With Water™

WASTEWATER COLLECTION AND TREATMENT FACILITIES INTEGRATED MASTER PLAN

CITY OF RIVERSIDE



Legend

- Priority A
- Priority B
- Priority C

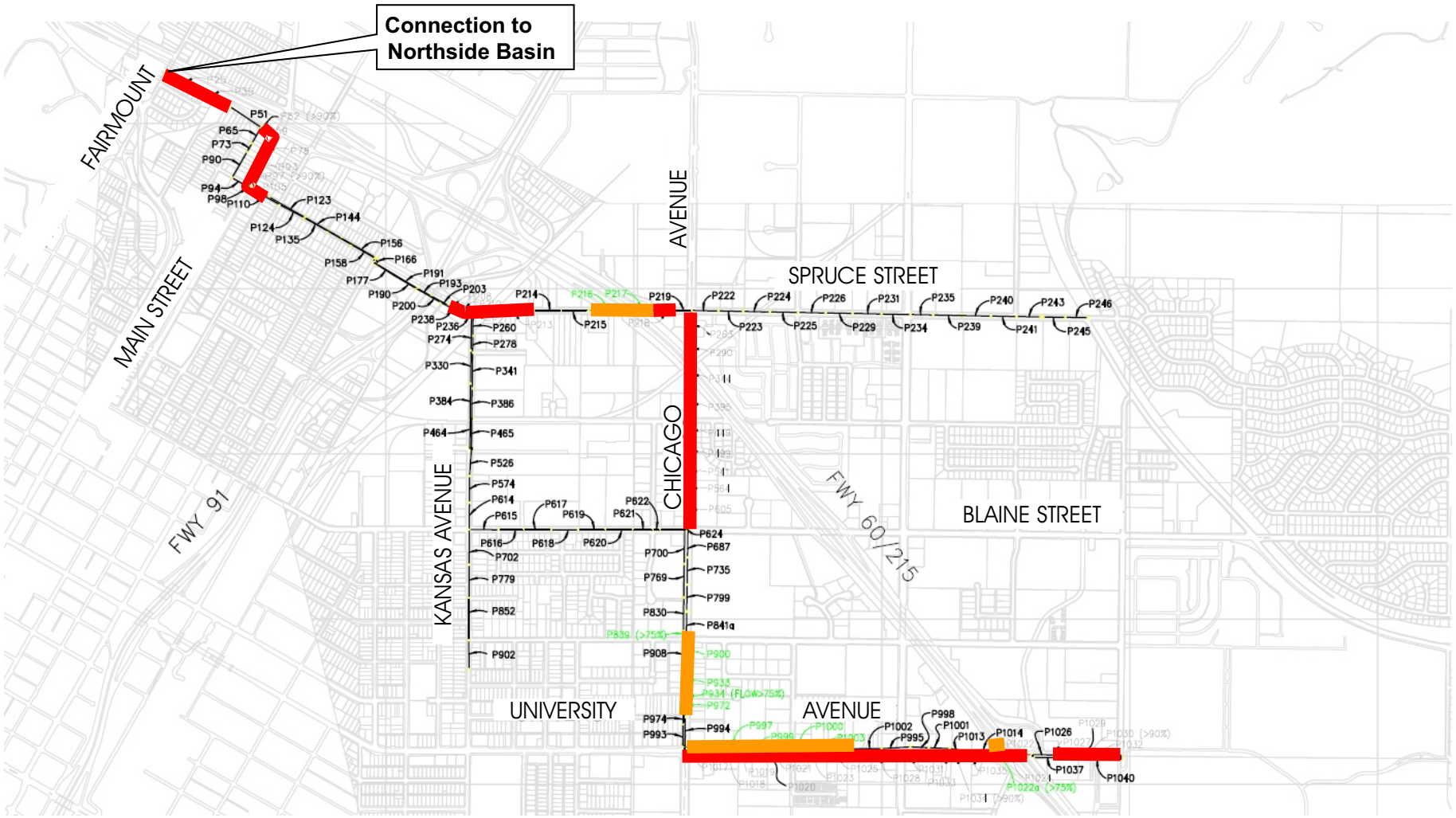
NORTHSIDE BASIN CIP IMPROVEMENTS

FIGURE 1.5

carollo
Engineers...Working Wonders With Water™

WASTEWATER COLLECTION AND TREATMENT FACILITIES INTEGRATED MASTER PLAN

CITY OF RIVERSIDE



Legend

- Priority A
- Priority B
- Priority C

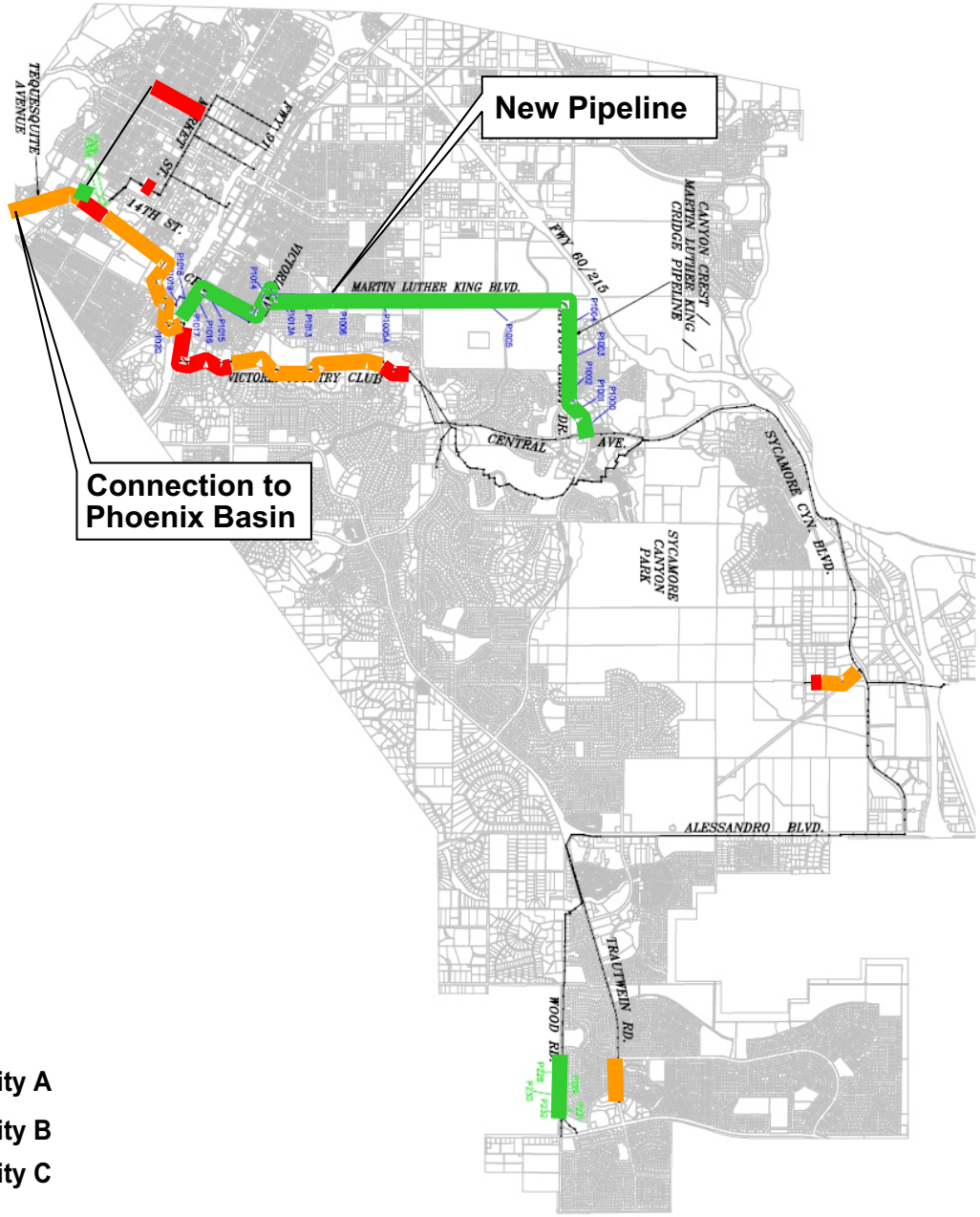
SPRUCE BASIN CIP IMPROVEMENTS

FIGURE 1.6

carollo
Engineers...Working Wonders With Water™

WASTEWATER COLLECTION AND TREATMENT FACILITIES INTEGRATED MASTER PLAN

CITY OF RIVERSIDE



Legend

- Priority A
- Priority B
- Priority C

TEQUESQUITE BASIN CIP IMPROVEMENTS

FIGURE 1.7

carollo
Engineers...Working Wonders With Water™

WASTEWATER COLLECTION AND TREATMENT FACILITIES INTEGRATED MASTER PLAN

CITY OF RIVERSIDE

Since the Spruce and Tequesquite CSMPs were completed several years ago, the City has already completed several of the proposed projects. These projects include:

- Spruce Street East Kansas and Sewer Easement Northbend (Spruce Basin)
- 13th Street (Tequesquite Basin).
- 5th Street Upgrade and New Pipeline (Tequesquite Basin).
- Brockton Avenue (Tequesquite Basin).

Other projects identified in the CSMPs are assumed to be needed in the future, although further investigation is recommended before these projects go into design.

1.8 CAPITAL IMPROVEMENT PLAN COST ESTIMATES

CIP cost estimates are included in each of the CSMPs. This section compares the pipe unit costs and cost estimation methods, and reports the total year cost estimates for the collection system CIP, and rehabilitation and replacement (R&R). The cost estimates included in this section are based on information provided by the City based on the CSMPs.

1.8.1 Unit Costs

The pipeline unit costs developed for the CSMPs are included in Table 1.7. These unit costs were compared to those estimated by Carollo for the Riverside area. Generally, the unit costs are similar. Therefore, the direct costs estimated in the CSMPs were retained for the CIP cost estimates.

Table 1.7 Unit Cost Estimates
Wastewater Collection and Treatment Facilities Integrated Master Plan
City of Riverside

Item	Unit	Unit Cost[(1)]
Pipe (Diameter)		
8-inch	LF	-
10-inch	LF	$100
12-inch	LF	$110
15-inch	LF	$115
18-inch	LF	$145
21-inch	LF	$170
24-inch	LF	$200
27-inch	LF	$205
30-inch	LF	$220
33-inch	LF	$245

Table 1.7	Unit Cost Estimates Wastewater Collection and Treatment Facilities Integrated Master Plan City of Riverside	
Item	**Unit**	**Unit Cost[1]**
36-inch	LF	$260
39-inch	LF	$275
42-inch	LF	$300
45-inch	LF	$320
48-inch	LF	$340
51-inch	LF	$360
54-inch	LF	$390
Manhole	EA	$5,500
Lateral (reconnection)	EA	$1,650

Notes:
(1) PBS&J unit cost estimates for year 2005, used for Arlanza, Northside and Phoenix CSMPs.

1.8.2 Methods

The cost estimation methods used for the CSMPs differed from the methods applied to projects that are evaluated for other volumes of the Integrated Master Plan. Table 1.8 summarizes the items that are accounted for in each method. The cost estimates in the CSMPs ended at the construction costs and did not include site work, sales tax, bid market allowance, engineering, management, legal, escalation, R&R, and O&M, which are all included in the Integrated MP method. The Integrated MP method was therefore applied to the CSMP direct costs (based on unit costs described above) to determine total project costs. Costs were escalated to August 2006 dollars using the Engineering News Record Construction Cost Index (ENR CCI) for Los Angeles.

Table 1.8	Cost Estimation Methods Wastewater Collection and Treatment Facilities Integrated Master Plan City of Riverside	
Item	**CSMP Method[1]**	**Integrated MP Method**
Site Work	None	10%
General Conditions	15%	10%
Contractor's overhead and profit	15%	15%
Construction contingency[2]	25%	30%
Sales Tax	None	7.75%
Bid Market Allowance (of total construction costs)	None	15%

Table 1.8	Cost Estimation Methods Wastewater Collection and Treatment Facilities Integrated Master Plan City of Riverside	
Item	**CSMP Method[(1)]**	**Integrated MP Method**
Engineering, Mgmt, Legal (of total construction cost)	None	30%
Escalation[(3)]	None	6% (first 5 yrs), 4% (after)
R&R and O&M costs	None	Yes

Notes:
(1) Percentages applied to Arlanza, Northside and Phoenix CSMPs.
(2) Does not include ROW acquisition, permits, soil remediation, and bypass pumping.
(3) First 5 years are 2007 through 2011.

1.8.3 Cost Estimates

The total cost estimates for years 2008 through 2025 are included in Table 1.9. These estimates include costs derived from the projects listed in the CSMPs, costs for replacement and rehabilitation of pipes that are greater than 50 years old, and total costs by year. These costs were provided by the City. On the direction of the City, these costs were adjusted using the Integrated MP method detailed in Table 1.8. The costs that are derived from the projects listed in the CSMPs are distributed evenly over a 10-year period from 2008 through 2017. These costs were escalated at a rate of 6 percent through 2011 and then 4 percent for the remaining years. The total estimated CSMP project costs over the 10-year period are $53.35 million. Details on the cost estimates can be found in Appendix G.

Table 1.9 Collection System Cost Estimates by Year
Wastewater Collection and Treatment Facilities Integrated Master Plan
City of Riverside

Year	CSMP Project Costs (millions)	Replacement and Rehabilitation Project Costs (millions)	Total Costs (millions)
2008	$4.24	$8.85	$13.09
2009	$4.49	$9.39	$13.88
2010	$4.76	$9.95	$14.71
2011	$5.05	$10.54	$15.59
2012	$5.25	$10.97	$16.21
2013	$5.46	$11.41	$16.86
2014	$5.68	$11.86	$17.54
2015	$5.90	$12.34	$18.25
2016	$6.14	$12.83	$18.96
2017	$6.39	$13.34	$19.73

Table 1.9	Collection System Cost Estimates by Year Wastewater Collection and Treatment Facilities Integrated Master Plan City of Riverside		
Year	**CSMP Project Costs (millions)**	**Replacement and Rehabilitation Project Costs (millions)**	**Total Costs (millions)**
2018	-	$13.88	$13.88
2019	-	$14.43	$14.43
2020	-	$15.01	$15.01
2021	-	$15.61	$15.61
2022	-	$16.23	$16.23
2023	-	$16.88	$16.88
2024	-	$17.56	$17.56
2025	-	$18.26	$18.26
Totals	$53.35	$239.29	$292.64

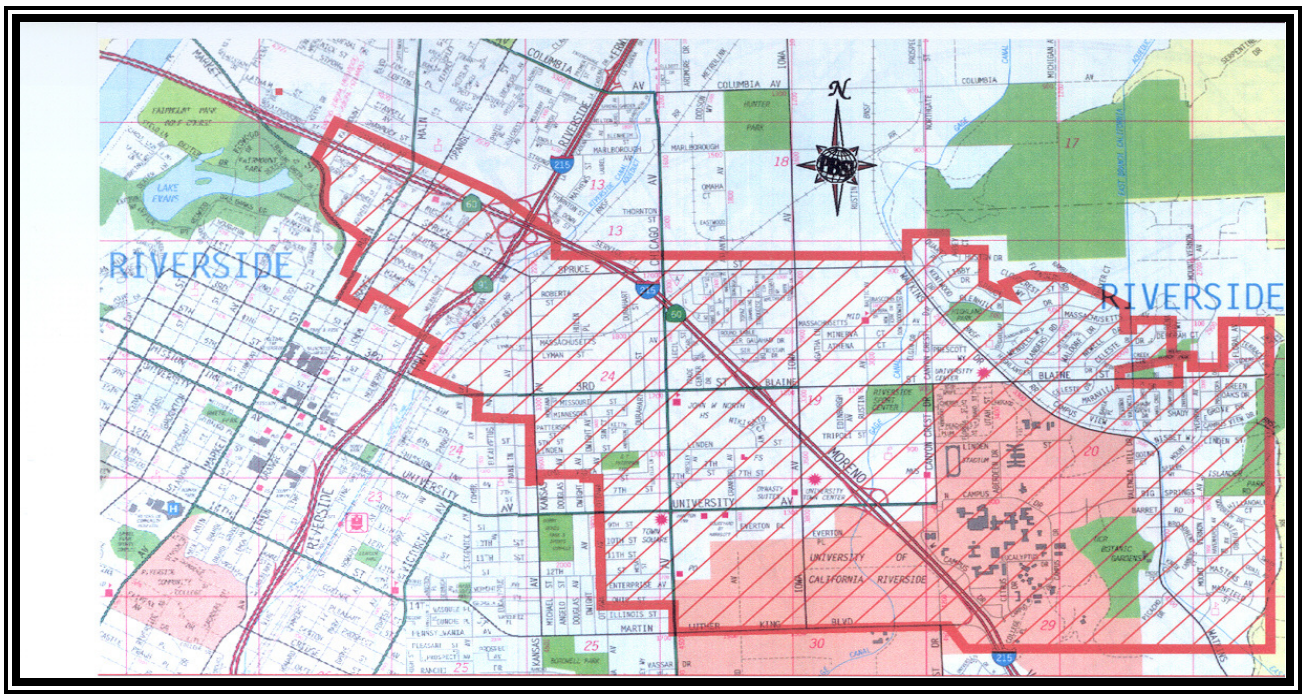
Notes:
(1) Budgeted.
(2) Costs beyond FY 2015 were not supplied by the City.
(3) All costs provided the City.

The rehabilitation and replacement costs summarized in Table 1.9 were provided by the City, using a replacement strategy based on pipe age. Pipes were categorized as either being constructed before 1943, or between 1944 and 1956 as documented in the City's geographic information system (GIS). All pipes that are 50 years or older were assumed to be replaced. These pipes were sorted by diameter and the lengths were reported. Unit costs for the pipeline diameters and manholes documented in Table 1.7 were then applied. These construction costs were then increased according to the Integrated MP method detailed in Table 1.8. Costs were distributed evenly over 50 years, and were escalated at 6 percent through 2011 and 4 percent thereafter. The total rehabilitation and replacement costs for the period from 2008 through 2025 are $239.29 million dollars. Details on the rehabilitation and replacement cost estimates can be found in Appendix G.

The total cost of collection system projects over the next ten years (2008 through 2017) are estimated at $164.80 million. Since the CSMP project costs are only estimated over this 10-year period, the total costs after 2017 may not be all inclusive.

Appendix A
SPRUCE STREET SEWER CAPACITY STUDY

City of Riverside
Spruce Street Sewer Capacity Study



Prepared By:

3610 Central Avenue, Suite 500
Riverside, CA 92506
(909) 341-6380

June 15, 2002

SPRUCE STREET
SEWER CAPACITY STUDY

City of Riverside

Client Representative: Sandy Caldwell

PBS&J

Project Manager Louis Atwell

Technical Advisory: Gary Eikermann

Technical Support: Dave Youngblood
Barmeshwar Rai

J.N. 590031

June 15, 2002

PBS&J 3610 Central Avenue, Suite 500, Riverside, CA 92506

TABLE OF CONTENTS

		Page Number
	Executive Summary	EX-1
1.0	*Introduction*	1
	1.1 Background	1
	1.2 Study Area	1
	1.3 Objective	1
	1.4 Scope and Study Approach	1
2.0	*Land Use*	4
	2.1 Existing Land Use	4
	2.2 Proposed Land Use	4
	2.3 UCR Existing Land Use	5
	2.4 Draft UCR Long Range Development Plan (LRDP)	5
3.0	*Existing Sewer System*	6
	3.1 System Overview	6
	3.2 Collection System	6
	3.3 System Hydraulics	7
	3.4 Tributary Areas	9
4.0	*Determination of Sewer Flows*	11
	4.1 Flow Monitoring	11
	4.2 Results of Flow Monitoring	12

5.0 *Estimated Ultimate Flow* 15

5.1 Methodology 15

5.2 Flow Coefficients 15

5.3 Representative Diurnal Hydrographs 17

6.0 *Computer Model Simulation Analysis* 18

6.1 Methodology 18

6.2 Limitations of Modeling 19

7.0 *Conclusions* 20

7.1 Deficient and Marginally Deficient Pipes 20

7.2 Project Prioritization Methodology 20

7.3 Improvement Plan for Problem Areas 21

7.4 Grouping of Projects 21

7.5 Construction Schedule 21

7.6 Alternatives 21

7.7 Cost Estimate 22

LIST OF TABLES

Page Follows/On

2-A Summary of Wastewater Generating Land Use 4

3-1 Summary of Modeled Sewer Lines within Study Area 7

3-2 Tributary Areas and Land Use 10

5-1 Theoretical Flow Summary Based on Land Use 16

5-2 Current Flow from Land Use Categories 17

5-3 Future Flow from Land Use Categories 17

7-1 Sewer Analysis Results 20

7-2 Proposed Construction Prioritization 20

7-3 Improvement Plan for Problem Areas..... 21

7-4 Cost Estimate Priority "A" Alternative – 1 22

7-5 Cost Estimate for Priority "A" Alternative -2 22

7-6 Cost Estimate Priority "B" 22

7-7 Cost Estimate Priority "C" 22

LIST OF FIGURES

Follows Page

1 Vicinity Map 1

2 Study Area 1

3 General Plan Land Use 6

4 University of California Riverside Land Use Plan 6

5 Tributary Areas and Monitoring Stations 6

6A Sewer System and Pipe Diameters 7

6B Existing Manholes 7

7-14 Adjusted Flows at Meters 13

15-18 Representative Diurnal Hydrographs 17

19 Existing and Ultimate Flow Contributions 17

20 Existing System Deficiencies 20

21 Ultimate System Deficiencies 20

22 Priority "A" Alternative 1 22

23 Priority "A" Alternative 2 22

APPENDIX

Appendix A – Flow Data at Meter Locations

Appendix B – City of Riverside, Sewer Design Guidelines

Appendix C - UCR Student Population

Executive Summary

This report presents the results of a comprehensive Sewer System Capacity Study of the Spruce Street Trunk System prepared by PBS&J for the City of Riverside. The report contains recommendations regarding system deficiencies as identified by hydraulic model XP-SWMM (XP Software, Version 8.0).

The City of Riverside is located in the County of Riverside at the intersection of three major freeways; Route 91, Route 60 and Route 215. The study area encompasses approximately 2,500 acres of mixed land use development and is generally bounded by Spruce Street to the North, Watkins Drive to the East, Martin Luther King Boulevard to the South and Fairmount Boulevard to the West. The study area is essentially a fully developed community, comprising single family residential, multi family residential, commercial and light industrial areas with small pockets of vacant land to be developed in future. The University of Riverside, California (UCR) is one of the major contributors of wastewater flow to the sewer system.

The existing trunk sewer system within the study area is comprised of approximately 8.3 miles of sewer main ranging in size from 8 inches to 36 inches in diameter, and 152 manholes. The sewers are essentially VCP and the manholes are typically brick lined. The City of Riverside owns and operates the sewer system.

For determination of current wastewater flows, flow monitoring was performed at ten strategic locations. These meter locations were chosen to observe actual flow characteristics for various sub areas with a distinct land use pattern within the study area. The flow monitoring was accomplished over a two-week period. The flow results were carefully evaluated for their accuracy and some adjustments have been made based on depth of flow at meter locations.

A theoretical estimate of current and future wastewater flow was estimated based on factors from the City of Riverside “Criteria for Sewer Facility Design”. Residential wastewater flow was determined by using current and future projected population, whereas commercial and industrial flow was determined based on acreage and City estimated flow coefficients. Flow from UCR was estimated using the Draft Long Range Development Plan of University of California, Riverside.

The Computer Model Simulation Analysis involved evaluation of available capacity in the existing collection system under present and future development conditions. Based on the results of model runs, system deficiencies were identified and a phased facility improvement plan was developed to allow for the projected growth within the study area.

Deficient and marginally deficient pipes were identified from the results of model runs. The pipes currently flowing more than 90% full under maximum flow conditions are grouped in priority “A”, pipes flowing more than 90% full in the future under maximum flow conditions are priority “B” and pipes flowing between 75% full and 90% full in future under maximum flow conditions are classified as priority “C”. Some adjustment of priorities and combining of improvements was done based on the need for continuity and efficiency of implementation. Within priority “A”, two alternatives were evaluated to identify the most feasible solution. Alternative 2 was recommended as the preferred alternative.

The time phased improvements for various priorities are listed in table 7-2. The approximate cost of recommended improvements is summarized in tables 7-5, 7-6 and 7-7.

Under existing flow conditions, a total of 1,935 linear feet of priority “A” deficiencies were identified, requiring near term attention. Additional deficiencies predicted under ultimate flow conditions (Priority “B”) include an additional 9,660 linear feet of inadequate sewer lines. The estimated capital cost to remedy these identified deficiencies (in year 2000 $’s) is $686,500 for Priority “A” and $2,200,000 for priority “B”. However, it may be that not all of the priority “B” improvements will need to be actually implemented. Only those where surcharging and other problems are deemed imminent. Periodic flow monitoring is also recommended to verify anticipated deficiencies and need for improvements.

1.0 INTRODUCTION

1.1 Background

On 10/16/2001 the City of Riverside retained PBS&J to prepare a Sewer System Capacity Study. The study is necessitated by the fact that the City is experiencing sewer capacity issues along the Spruce Street Sewer Trunk Line and its adjoining areas.

1.2 Study Area

The City of Riverside is located in the northwest corner of the County of Riverside at the intersection of three major freeways; Route 91, Route 60 and Route 215. Founded in 1870, the City is known for its citrus industry, world famous Mission Inn and other historical monuments. Figure-1 is a Vicinity Map depicting the City's location and its accessibility. Figure 2 shows the study area. The study area shown in Figure 2 encompasses approximately 2,500 acres and is generally bounded by Spruce Street to the North, Fairmount Boulevard to the West, Martin Luther King Boulevard to the South and Watkins Drive to the East. The area has been divided into nine tributary sub-areas, where downstream sub-areas intercept sewage flow from upstream sub-areas. To obtain "real" flow information for this study, sewage flow meters were placed at strategic locations to monitor flows contributed from the tributary sub-areas.

In general, the study area is considered to be a mature community comprised of single family residential, multi-family residential, commercial and light industrial uses. The University of California, Riverside (UCR) is one of the major contributors of the sewage flow within the study area.

1.3 Objective

The objective of this Sewer System Capacity Study is to provide a comprehensive evaluation of the capacity of the sewer system within the study area, identify deficiencies in the current system, and evaluate alternatives to enhance the conveyance capacity to accommodate ultimate wastewater flows anticipated to be generated in the study area.

1.4 Scope and Study Approach

Specific work tasks under this study are summarized as follows:

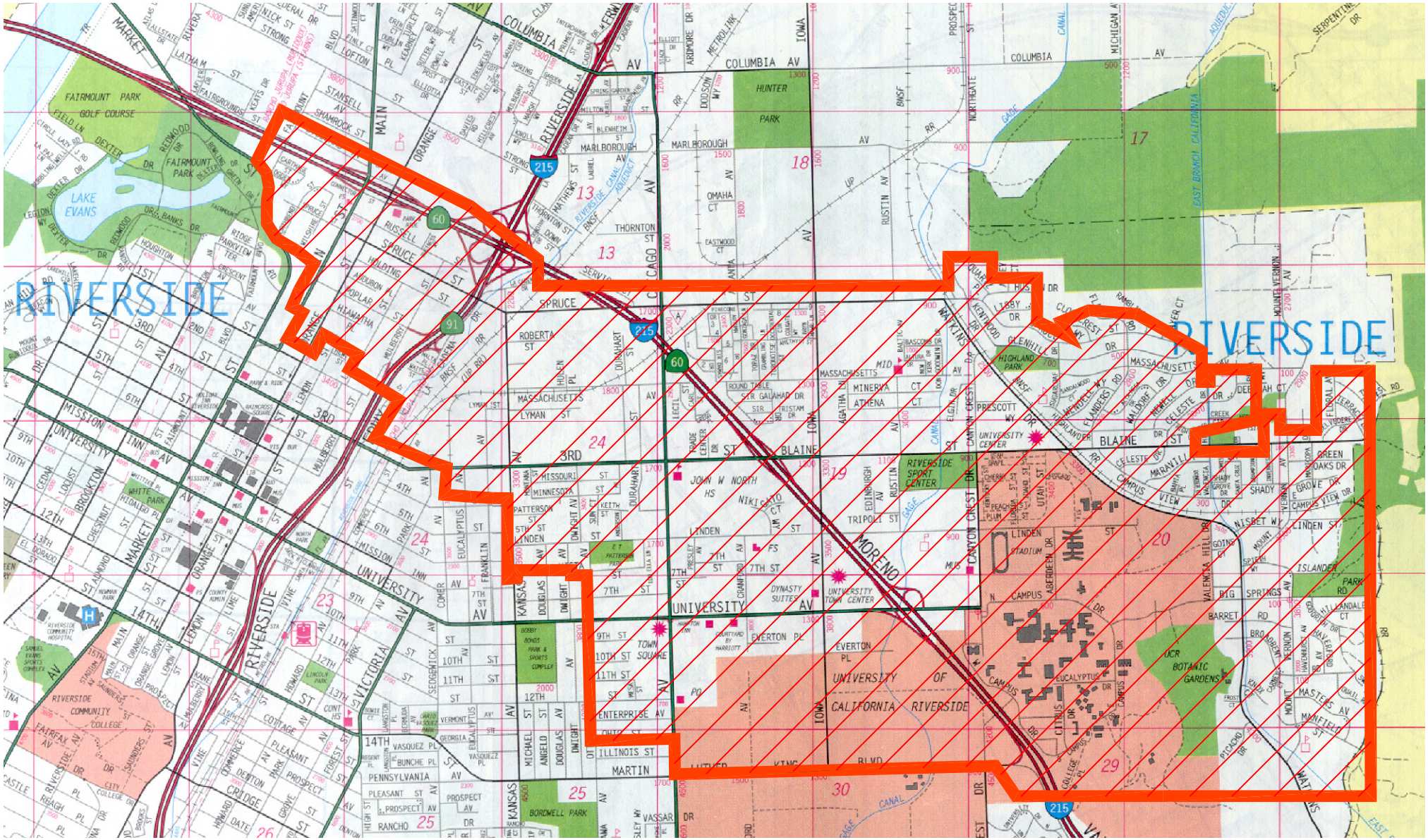
Engineering
Planning
Surveying
Construction Services
PBSJ
3610 Central Avenue
Suite 500
Riverside, CA 92506
Tel:(909) 341-6380
Fax:(909) 341-6389

CITY OF RIVERSIDE
SPRUCE STREET SEWER

VICINITY MAP

JUNE 2002

FIGURE 1



LEGEND

STUDY AREA

N

Engineering
Planning
Surveying
Construction Services

PBSJ

3610 Central Avenue
Suite 500
Riverside, CA 92506
Tel:(909) 341-6380
Fax:(909) 341-6389

CITY OF RIVERSIDE
SPRUCE STREET SEWER

STUDY AREA

JUNE 2002

FIGURE 2

H:\Client\Riversid_SAOW\7472A00\Rpt\Volume 03\Appendices\Ch01-AppxA-Spruce Report.pdf

- Kickoff Meeting

  The initial meeting to introduce PBS&J personnel and sub-contractors working on this project to the City, discussion of project scope, communication protocol, scheduling of flow monitoring dates and explanation of methodology involved, and field data and other digital files to be provided by the City.

- Progress Meetings

  Monthly Project Progress Meetings to discuss on going issues and progress of study.

- Flow Monitoring and Hydrograph Development

  The sub-consultant, Downstream Services is to install, maintain, and collect flow data from ten monitoring stations throughout the study area. They would then submit the collected raw data in electronic/hard copy format to PBS&J. PBS&J would then process this information and create a hydrologic database. The City is to provide a copy of City's General Plan for estimation of current and future flows. Other information like Long Range Development Plan (LRDP) of University of California, Riverside and Traffic Analysis Zones (TAZ) data is to be considered for making future flow projections.

- Model Development

  Model development includes input data collection, conversion of data and calibration. The City's GIS staff would make available data pertaining to roads, sewers, land use and other utilities in Arc/View format on a CD. As built plans for trunk line sewer is to be reviewed. Data available from GIS system and as built plans is placed in a database system (MS Access 2000) as a pre-processor for XP-SWMM model development. Calibration of model is done after construction of the model and additional data input.

- Draft Report

  Based on the calibrated model and City's criteria for Sewer Facility Design, a Draft Report is to be prepared which would summarize existing and future capacity problems. Alternatives are to be suggested for additional or alternate sewer improvements along with probable costs. The draft report is to be reviewed by the City personnel for their comments and suggestions.

- Final Report

  Draft Report review comments from the City are to be incorporated into the Final Report along with and additional information or research in order to reflect a final level of study completion. The Final Report will include data and information assembled, alternatives evaluated, capital improvement recommendations to remediate anticipated deficiencies, and approximate cost.

A comprehensive evaluation of the sewage collection system to accomplish the above summarized scope entails the following multi-step approach:

- Review of as built plans provided by the City to determine system configuration, inverts, pipe sizes and slopes.
- Use of detailed database provided by the City in Arcview format.
- Creation of computer hydraulic model using existing sewer system to study project area.
- Identification of flow monitoring station locations.
- Identification of tributary areas contributing sewage flow to meter locations.
- Installation of flow meters and monitoring of flows at the selected locations on continuous basis for two-week period.
- Review of current land use in study area per GIS information from the City and determination of existing land use, population and vacant land.
- Assessment of ultimate land use and projected population.
- Review of current land use pattern for UCR, student population.
- Review of Long - Range Development Plan, future land use pattern for UCR and student population.
- Review and evaluation of metered data from flow monitoring stations.
- Development of flow coefficients and representative diurnal flow patterns based on typical curves for various land uses and observed flows from monitored sub areas which are dominated by a specific land use.
- Modeling of sewer system, deficiency identification, and model simulation of remedial alternatives using above -mentioned information as input data.
- Evaluation of alternatives, optimization, cost comparison.
- Prioritization of recommended improvements, including identification of critical pipelines which need immediate attention.
- Draft Report and recommendations including phased improvements and costs.
- Review by the City, comments and discussion.
- Final Report

2.0 LAND USE

2.1 Existing Land Use

Land use is the basis for estimating sewage flow from the majority of the study area. The land use pattern for this study (with the exception of UCR) was developed from the GIS information provided by the City. Figure 3 shows land use for the City (non-UCR) portion of the study area based on the City's "Ultimate Land Use" GIS layer. For the purposes of this study, land uses in the study area have been broadly classified into five categories: Single Family Residential (SFR), Multi Family Residential (MFR), Commercial, Industrial and University of California Riverside (UCR) Academic and Residential.

2.2 Proposed Land Use

The study area is primarily a mature community. With the exception of UCR owned property, there is very little vacant land (approximately 265 acres). The majority of the remaining growth is planned to take place as part of the UCR expansion. UCR is currently developing a "Long Range Development Plan" (LRDP) projecting through year 2015. Based on an estimate of student population (approximately 25,000 by 2015), the University remains a major contributor of sewage flow within the Spruce Street Sewer System. It is assumed that the majority of vacant lots within the study area would be fully developed by year 2015. Wastewater generating (developed) land use within the study area is generally summarized in the following table:

Table 2-A
Summary of Wastewater
Generation based on Land Use
(Acres)

Category	Existing	Future (Year 2015)	Change
Single-Family Residential (SFR)	1,136	1,294	+158
Multi-Family Residential (MFR)	189	203	+14
Commercial	284	377	+93
Industrial	170	170	0
University of California (UCR)	471	706	+235

2.3 UCR Existing Land Use

Existing land use within the UCR campus is a mixture of academic facilities (and related support), as well as, housing (including residence halls and apartments and related support). UCR owns approximately 1,106 acres generally bounded by Chicago Street on the west, Watkins Drive on the east, Blaine Street on the north, and a line extending east from La Conte Drive on the south. As shown in table 2A, 471 acres is currently developed. Most of the developed campus area is located east of I-215/Hwy 60, whereas large sections of UCR owned vacant land located west of the I-215/Hwy 60 is slated to become part of the developed campus in the future.

Existing campus population is approximately 23,000, of which 14,000 are students and 9,000 are faculty and support personnel.

2.4 Draft UCR Long Range Development Plan (LRDP)

The UCR campus is experiencing rapid growth, which is expected to continue into the future. Expected "build-out" or ultimate capacity is projected to occur in the year 2015 to 2020 timeframe.

To accommodate the expected growth, UCR is in the process of updating its Long-Range Development Plan, which was last updated in 1990. The LRDP planning process is a comprehensive evaluation of facility needs to support the objectives set forth in the UCR Academic Plan. The previous 1990 LRDP addressed a projected student population of 18,050, while the current LRDP contemplates a population of 25,000. Both versions acknowledge a possible ultimate student population of 30,000. For purposes of this sewer capacity evaluation, a 2015 build-out population of 25,000 students and 15,000 faculty and support personnel is used. After interviews with UCR planning personnel and research of other similar universities, a 50/50 split was assumed for student on-campus housing and off-campus housing. Thus, approximately 12,500 students would be living on-campus and approximately 12,500 students would be living off campus, but within the study area.

A preliminary land use plan for ultimate UCR development is shown in Figure 4. Note that both academic and residential facilities are added west of the I-215/Hwy 60, while many of the existing older residential and academic facilities east of the I-215/Hwy 60 are expanded or replaced. No development is shown south of Martin Luther King Jr. Boulevard. Also, approximately 93 acres of University-owned property west of Iowa Avenue is considered to be developed in future. However, this acreage may one day become part of a future expansion, perhaps to support an LRDP amendment which would bring the campus to a capacity of 30,000 students.

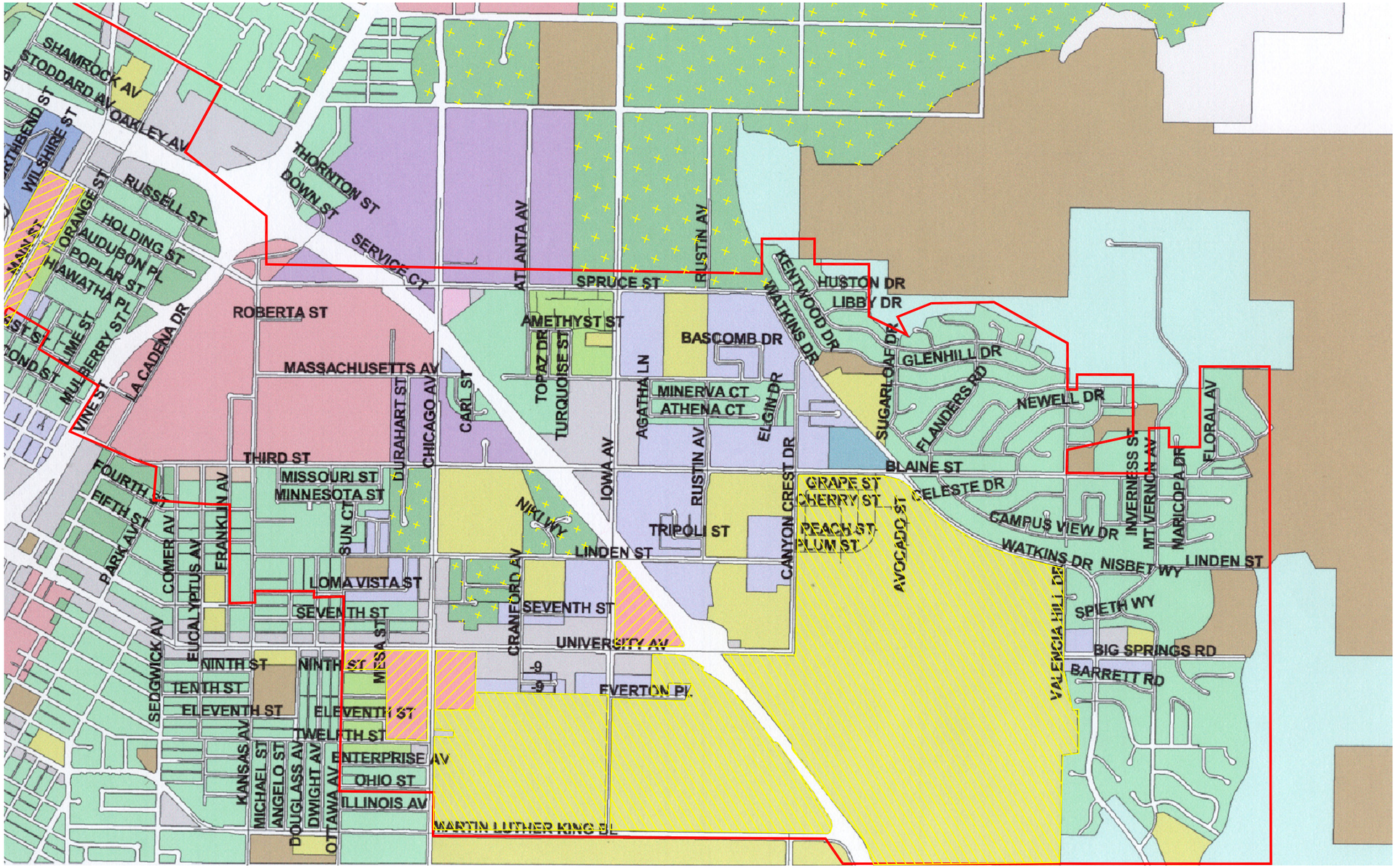
3.0 EXISTING SEWER SYSTEM

3.1 System Overview

As previously described, the Spruce Street Trunk Sewer System serves approximately 2,500 acres, which, for this study, has been divided into nine tributary sub-areas (See Figure 5); each area contributing sewage flow to a meter location or multiple meter locations (accumulated sub-area flows). The modeled gravity conveyance system is approximately 44,000 linear feet (8.33 miles), with pipe sizes varying from 8 inches to 18 inches in diameter (See Figure 6). The majority of pipelines within the system are vitrified clay (VCP).

3.2 Collection System

The wastewater generated within the study area flows in a northerly or westerly direction depending on general topography. The major trunk lines are along Spruce Street, University Avenue, and Chicago Avenue. The trunk line in Chicago Avenue picks up sewage flow from Single Family Residences in the Box Springs Area, UCR and some commercial/multi family residences along University Avenue. The trunk lines in Spruce Street east of Chicago Avenue convey flow from single-family residences north-east of Watkins Avenue, multi family residences east of the I-215/60 Freeway and some commercial/industrial areas south of Spruce Street. The trunk line in Kansas Avenue conveys sewage flow generated by medium to high-density single-family residences north of Martin Luther King Boulevard and some commercial and industrial properties on both sides of Third Street. The majority of flow from the study area converges into two parallel trunk lines along Spruce Street west of Kansas Avenue. The sewer lines along University Avenue, Chicago Avenue and Kansas Avenue have parallel lines in some of the reaches and split flow situations at some manhole locations. Pipe size, length, and number of manholes have been tabulated for each major segment of the modeled trunk system (See Table 3-1).



LEGEND

- INDUSTRIAL–LIGHT
- INDUSTRIAL BUSINESS PARK
- PARKS PUBLIC
- RESIDENTIAL HILLSIDE
- INDUSTRIAL GENERAL
- PUBLIC FAC. & OPEN SPACE
- MIXED USE OFFICE
- COMMERCIAL CENTER
- RESIDENTIAL MEDIUM DENSITY
- RESIDENTIAL MEDIUM HIGH DENSITY
- COMMERCIAL BUSINESS OFFICE
- RESIDETIAL HIGH DENSITY
- STUDY AREA BOUNDARY

SOURCE – CITY OF RIVERSIDE GIS

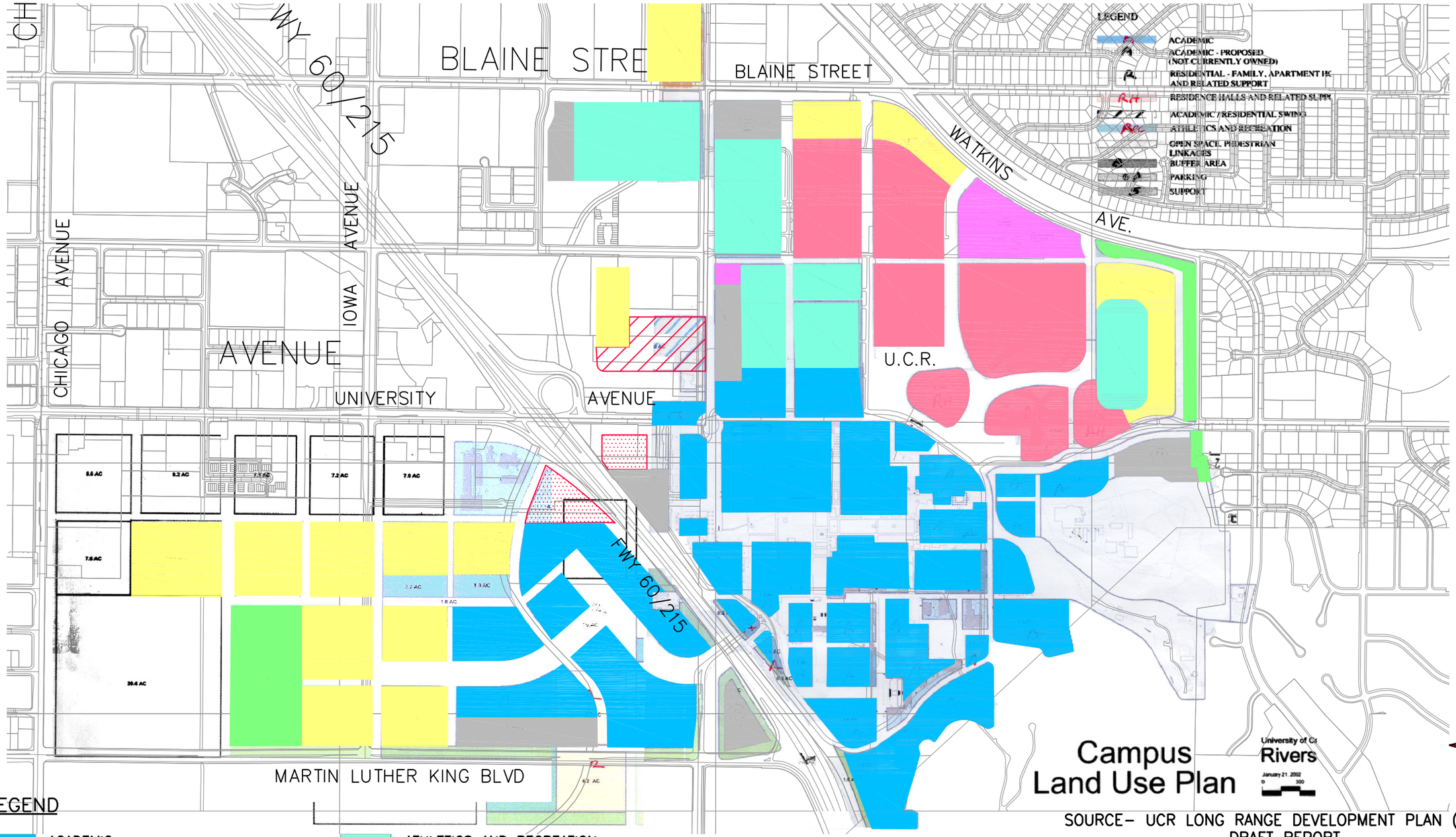
Engineering
Planning
Surveying
Construction Services
PBSJ
3610 Central Avenue
Suite 500
Riverside, CA 92506
Tel:(909) 341–6380
Fax:(909) 341–6389

CITY OF RIVERSIDE
SPRUCE STREET SEWER

GENERAL LAND USE PLAN

JUNE 2002

FIGURE 3



SOURCE– UCR LONG RANGE DEVELOPMENT PLAN (LRDP) DRAFT REPORT

LEGEND

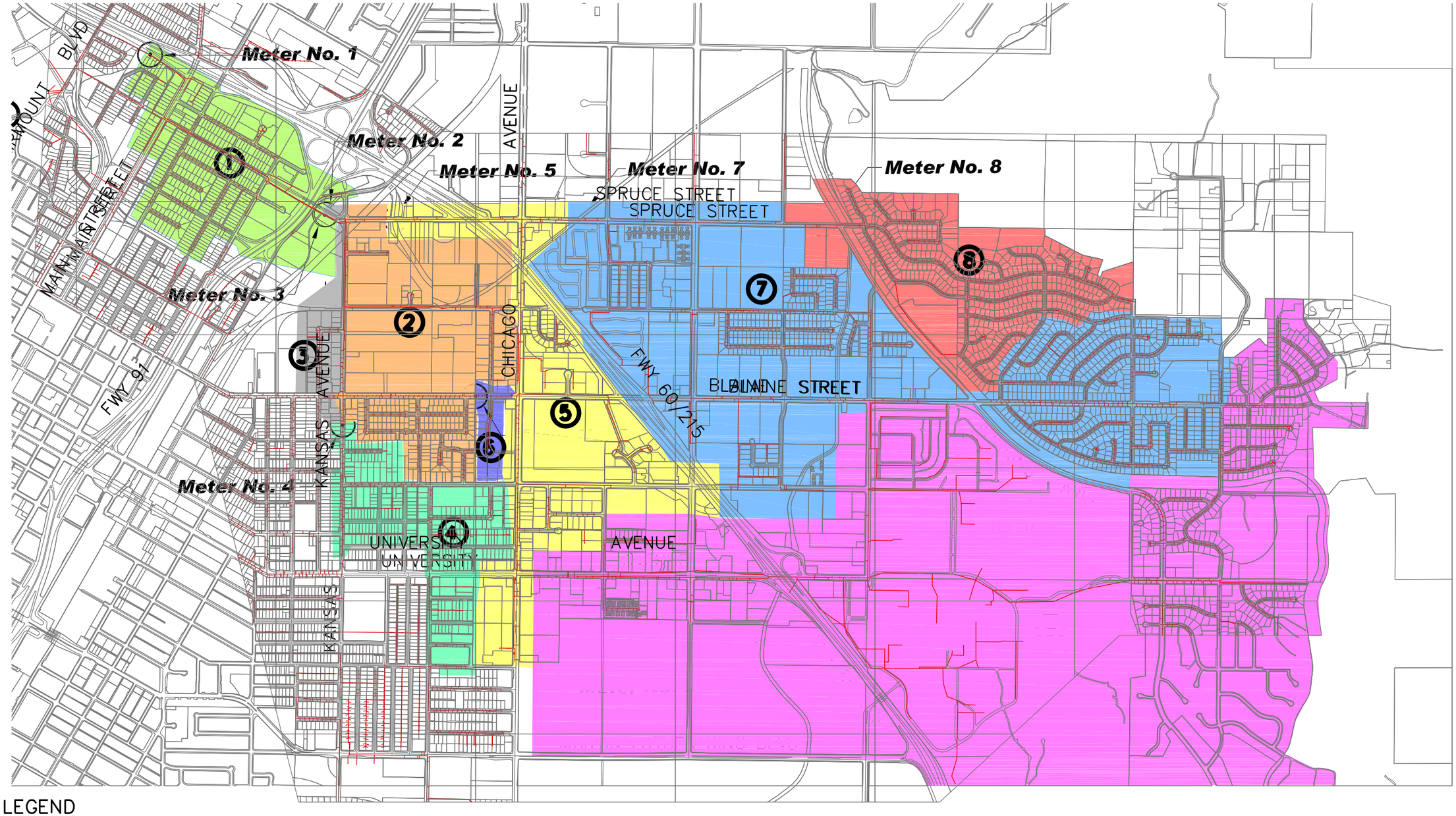
- ACADEMIC
- ACADEMIC–PROPOSED (NOT CURRENTLY OWNED)
- RESIDENTIAL–FAMILY. APARTMENT NO. AND RELATED SUPPORT
- RESIDENCE HALLS AND RELATED SUPPO
- ACADEMIC/RESIDENTIAL SWING
- ATHLETICS AND RECREATION
- OPEN SPACE. PEDESTRIAN LINKAGES
- BUFFER AREA
- PARKING
- SUPPORT

Engineering
Planning
Surveying
Construction Services
PBSJ
3610 Central Avenue
Suite 500
Riverside, CA 92506
Tel:(909) 341-6380
Fax:(909) 341-6389

CITY OF RIVERSIDE
SPRUCE STREET SEWER

UNIVERSITY OF CALIFORNIA LAND USE PLAN

JUNE 2002 | FIGURE 4



LEGEND

①	SUB AREA 1
②	SUB AREA 2
③	SUB AREA 3
④	SUB AREA 4
⑤	SUB AREA 5
⑥	SUB AREA 6
⑦	SUB AREA 7
⑧	SUB AREA 8
⑨	SUB AREA 9

N

GRAPHIC SCALE

1500 0 750 1500

(IN FEET)

1 inch = 1500 ft.

Engineering
Planning
Surveying
Construction Services
PBSJ
3610 Central Avenue
Suite 500
Riverside, CA 92506
Tel:(909) 341-6380
Fax:(909) 341-6389

CITY OF RIVERSIDE
SPRUCE STREET SEWER CAPACITY STUDY

TRIBUTARY AREAS AND MONITORING STATIONS

JUNE 2002

FIGURE 5

Table 3-1

City of Riverside
Summary of Modeled Sewer Lines within Study Area

Location	Pipe Dia. (Inches)	Length (Feet)	Number of Manholes
University Avenue	8	4,480	16
	12	3,847	13
	15	1,460	6
Spruce Street	8	2,149	9
	10	5,540	19
	15	2,997	8
	18	6,360	24
Chicago Avenue	10	1,413	6
	12	2,143	8
	15	1,850	6
	18	2,598	8
Third Street	10	2,649	10
Kansas Avenue	8	1,688	4
	10	2,597	9
	15	1,653	6
TOTAL		**43,784**	**152**

3.3 System Hydraulics

The existing trunk sewer system, which is the subject of this evaluation, is shown on Figure 6A and 6B. The sewer collection system was constructed over a period of many years as needed; to accommodate increasing sewer flows. The as-built plans provided by the City were studied to ascertain characteristics of the system. The sewer system, from upstream to downstream end, is briefly described as follows:

- *University Avenue Study Area Sewer Line*: The sewer lines along University Avenue begin just west of Canyon Crest Avenue with a 15-inch diameter UCR trunk line flowing from the east. Two parallel sewer lines (15-inch on the northern side and 8-inch on the southern side) run along University Avenue. They both then converge at manhole No. 1024 (east of Freeway I-215/60) where a single 15-inch diameter sewer line picks up their flows and crosses the I-215/60 freeway. Upon crossing the freeway, the 15-

Meter No. 1
Meter No. 2
Meter No. 3
Meter No. 4
Meter No. 5
Meter No. 6
Meter No. 7
Meter No. 8
Meter No. 9
Meter No. 10

FAIRMOUNT BLVD
FAIRMOUNT
MAIN STREET
FWY 91
SPRUCE STREET
SPRUCE
STREET
AVENUE
CHICAGO
3RD. STREET
KANSAS AVENUE
KANSAS
UNIVERSITY
AVENUE
UNIVERSITY
AVENUE
BLAINE STREET
FWY 60/215
WATKINS AVE.
U.C.R.
MARTIN LUTHER KING BLVD

MODELLED TRUNK LINES
- 8" DIA. PIPE
- 10" DIA. PIPE
- 12" DIA. PIPE
- 15" DIA. PIPE
- 18" DIA. PIPE
- 36" DIA. PIPE

LEGEND
- EXISTING SEWER
- STUDY AREA BOUNDARY
- METER

N

GRAPHIC SCALE
600 0 300 600 1200 2400
(IN FEET)
1 inch = 600 ft.

Engineering
Planning
Surveying
Construction Services
PBSJ
3610 Central Avenue
Suite 500
Riverside, CA 92506
Tel:(909) 341-6380
Fax:(909) 341-6389

CITY OF RIVERSIDE
SPRUCE STREET SEWER CAPACITY STUDY

SEWER SYSTEM AND PIPE DIAMETERS

JUNE 2002

FIGURE 6A

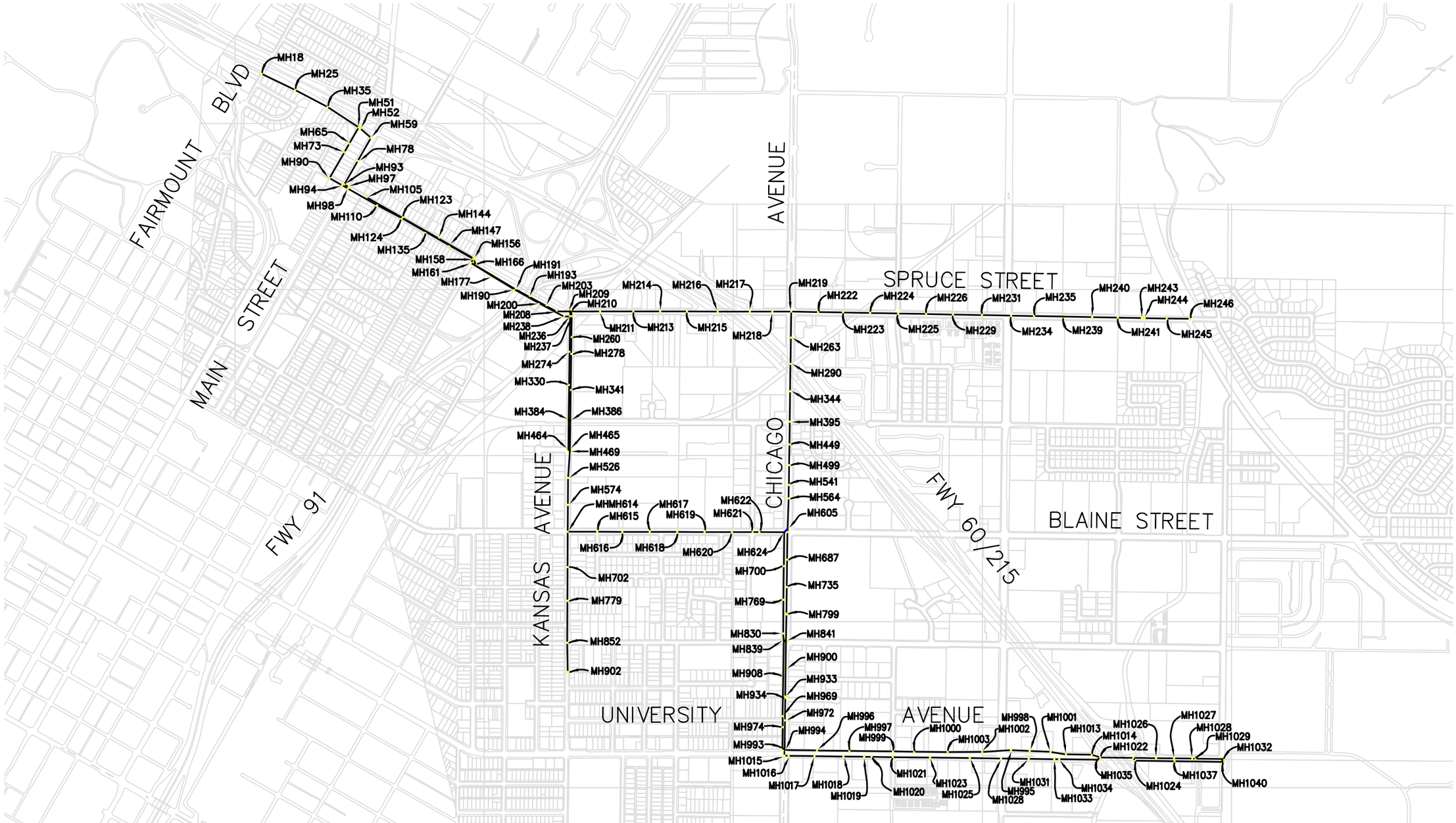
inch line connects to manhole No. 1022 where once again, the flow splits between two pipes (8-inch and 12-inch). Manhole No. 1022 has a split flow weir which diverts part of the flow into the 8-inch sewer line once the depth of flow reaches 3 inches in the 15-inch sewer line. Metered flow at meter locations 9 and 10 indicate that approximately 60% of total flow through manhole No. 1022 passes through the 12-inch sewer line, while about 40% passes through the 8-inch sewer line. The two pipes then continue to parallel one another along University Avenue flowing towards the west with the 12-inch line on the north side and the 8-inch on the south side of the street.

- *Chicago Avenue Study Area Sewer Line*: In Chicago Avenue, between University Avenue and Third Street, two parallel sewer lines flow to the north; however, there are two flow split situations – one at manhole No. 994 (intersection of University Avenue and Chicago Avenue) and another at manhole No. 841 (intersection of Linden Street and Chicago Avenue). From Linden Street, the flows continue north along Chicago Avenue, where they converge at manhole No. 605. From manhole No. 605, flows continue north in a single 12-inch diameter pipe to manhole No. 499. From manhole No. 499, the flows continue north in a 15-inch diameter pipe to Spruce Street, where they empty into the Spruce Street Trunk Sewer.

- *Third Street Study Area Sewer Line*: The sewer line along Third Street between manhole Nos. 624 and 614 is a 10-inch diameter VCP which collects wastewater flow from a commercial/light industrial area. Flow is in a westerly direction.

- *Kansas Avenue Study Area Sewer Line*: The sewer line along Kansas Street begins north of University Avenue at manhole No. 902. The wastewater flows northerly in a pipe, which progressively increases in size from a 8-inch to 10-inch to 12-inch to 15-inch diameter. The 8-inch pipe is from manhole No. 902 to manhole No. 614; the 10-inch from manhole No. 614 to manhole No. 237; 12-inch from manhole No. 469 to manhole No. 384 and 15-inch in the reach 384-236. There are three flow split situations at manhole Nos. 469, 386 and 236 respectively, thereby creating a parallel pipe scenario from approximately Lyman Street to Spruce Street.

- *Spruce Street Study Area Sewer Line*: The line along Spruce Street begins just west of Watkins Avenue and



N

GRAPHIC SCALE

1200 0 600 1200

(IN FEET)

1 inch = 1200 ft.

Engineering
MHlanning
Surveying
Construction Services

PBSJ

3610 Central Avenue
Suite 500
Riverside, CA 92506
Tel:(909) 341-6380
Fax:(909) 341-6389

CITY OF RIVERSIDE
SPRUCE STREET SEWER CAPACITY STUDY

EXISTING MANHOLES

JUNE 2002

FIGURE 6B

ends just east of Fairmount Boulevard. The flow in this sewer line is generally in a westerly direction. The sewer trunk line along Spruce Street collects the majority of its flows from the trunk lines along Chicago Avenue and Kansas Avenue. The pipe sizes vary from 8-inch to 18-inches in diameter. The diameter of pipe from manhole No. 246 to manhole No. 234 is 8-inch; from manhole No. 234 to manhole No. 225 is 10 inch; from manhole No. 225 to manhole No. 215 is 15 inch, and from manhole No. 215 to manhole No. 18 is 18 inch. Parallel pipe conditions exist from Kansas Avenue to where the pipes converge at the intersection of Wilsher Street and the 60 Freeway (City has an easement adjacent and parallel to the freeway). The pipe on the north of Spruce Street is 18 inches in diameter from manhole No. 210 to manhole No. 251, while the pipe on the south side is 10-inches in diameter and runs from manhole No. 236 to manhole No. 251. The 15-inch diameter pipe runs from manhole No. 51 to manhole No. 35 (parallel to Freeway I-215/60). The 18-inch diameter pipe runs from manhole No. 35 to manhole No. 18 (parallel to Freeway I-215/60).

3.4 Tributary Areas

The identified sewer tributary sub-areas are distinct areas characterized by the sewer system draining to a particular meter location (Meter locations were selected based on tributary areas) (See Figure 5). However, some meter locations (meters 1,2,5, and 7) measure flows from several tributary sub-areas (cumulative flows). Because of their strategic locations, meters upstream of a cumulative meter can be subtracted out to deduct cumulative effects. Following is a listing of tributary sub-areas contributing to each meter location, starting with the upstream sub areas.

- Sub-area 8 is tributary to meter No. 8 at Spruce Street.
- Sub-area 8 and 7 are tributary to meter No. 7 at Spruce Street.
- Sub-area 9 is tributary to meter No. 9 and No. 10 at University Avenue (Split flow situation).
- Sub-area 8, 9, 7 and 5 are tributary to meter No. 5 at Spruce Street.
- Sub-area 6 is tributary to meter No. 6 at Third Street. (Split flow situation).
- Sub-area 3, 4 and 6 are tributary to meter No. 3 at Spruce Street (Split flow situation).
- Sub-area 2, 5, 7, 8 and 9 are tributary to meter No. 2 at Spruce Street.
- Sub-area 1, 2, 3, 4, 5, 6, 7, 8, and 9 are tributary to meter No. 1 (parallel to freeway 215 on south side)

Within each sub-area is generally a distinct mixture of land uses, which generates a unique quantity and diurnal pattern of wastewater flows. UCR has been characterized as a separate land use pattern based on its unique wastewater generation quality. For identification of land use patterns, data provided by the City of Riverside in GIS Arcview format was used. The following table summarizes land uses within each sub-basin.

Table 3-2

Tributary Areas and Current Land Use

Sub Area	SFR (Acres)	MFR (Acres)	Commercial (Acres)	Industrial (Acres)	UCR (Acres)	Total (Acres)
1	1,295	201	377	171	471	2,515
2	1,124	165	291	141	471	2,192
3	75	39	39	6		159
4	75	39	4			118
5	1,020	188	277	56	471	2,012
6			6	6		12
7	523	141	89			753
8	189					189
9	454	34			471	1,014

SFR – Single Family Residential
MFR – Multi Family Residential

4.0 DETERMINATION OF SEWER FLOWS

4.1 Flow Monitoring

Flow Monitoring was conducted at ten sites in order to accomplish the following: (See Figures 5 and 6 for locations of Flow Monitoring Stations).

- Establish current flow levels.
- Verify or adjust flow coefficients.
- Establish characteristic flow patterns (Diurnal Curves) for the model (See Figures 15, 16, 17, 18).
- Confirm peak to average flow relationships.
- Help prioritize recommend improvements.

Meter locations were chosen to observe actual flow characteristics for the various sub-basins and to provide a continuous record of measured flows over a period of time (two weeks for this study). Meter locations were also chosen in such a manner that current flow quantities along the Spruce Street Trunk Sewer could be quantitatively determined. Following is an amplification of the logic for placement of each flow meter.

- Meter No. 1 location (adjacent to I-215/60 Freeway, west of Main Street) - This location was chosen because it carries all of the flow generated within the study area.

- Meter No. 2 and 3 location (South of Spruce Street Bridge, east of 91 Freeway) - These locations were chosen to measure all of flows within the sub area east of Freeway 91. Also, by subtracting flows for meter location No. 4 and No. 5 from this flow, flow for the area generally bounded by north of Linden Street, south of Spruce Street, west of Chicago Avenue and east of Kansas Avenue could be determined.

- Meter No. 4 location (On Kansas Ave. south of Third Street) - This location was chosen to measure flow generated by the area generally bounded by south of Third Street, north of Martin Luther King Boulevard, east of Chicago Avenue east of Kansas Street and west of Chicago Avenue. The land use within its tributary area is primarily medium to high density residential.

- Meter No. 5 location (on Spruce Street just west of I-215/60 Freeway) - This location was chosen to determine sewage flow generated by the area generally bounded by east of Chicago Avenue, west of I-215/60 Freeway and north of

Seventh Street. The land use within its tributary area is characterized by light and business park industrial, open space commercial and mixed use. Very few residences are located within this sub-basin.

- Meter No. 6 location (on Third Street west of Durahart Street) - This location was chosen to verify flow exchange from Meter Number 5 sub-basin west of Chicago Avenue. The land use in this area is primarily industrial and commercial.

- Meter No. 7 location (On Spruce Street, west of Atlanta Avenue) - This location was chosen to measure sewage flow generated by the area generally bounded by south of Spruce Street, east of 215/60 Freeway, north of Linden Avenue and west of Canyon Crest Drive. The land use within its tributary area is primarily single family residential with some multi family residential and light commercials.

- Meter No. 8 location (On Spruce Street, near Watkins Drive) - This location was chosen to determine flow generated by the area generally bounded by north of Massachusetts Avenue (extended Massachusetts Avenue east beyond Watkins), south of Spruce Street, west of Spruce Street. The land use within this sub basin is primarily Single Family Residential.

- Meter No. 9 and 10 locations (On University Avenue, west of Cranford Avenue) - These meter locations were chosen to measure sewage flow primarily generated by University of California, Riverside. The area is generally bounded by Martin Luther King Boulevard on south side, Third Street on north side and Spruce Street on east side. Although the sub-basin is comprised mostly of UCR properties some City single-family residential acreages is served on the east side.

4.2 Results of Flow Monitoring

Measurement of sewer flows is an imprecise science, as the in-line equipment is placed in a harsh environment and is subject to solids interference, calibration, solids, and turbulence and other problems, which can impede the accuracy. Installed equipment must be frequently inspected and maintained, and monitoring results interpreted, evaluated for reasonableness, and sometimes adjusted. In this particular application, metered flow information was generally quite good. However, some flows at specific meter locations did not display consistent values. Graphical results at each site were carefully reviewed for consistency and reasonableness, using the following general guidelines.

- Where the magnitude or daily pattern varies significantly from one non-holiday weekday to the next, the data is likely to be flawed.
- Where the base (low) flows are rising during the flow monitoring period, the data is suspect.
- Where the algebraic sum of flows from meters in series are significantly out of sync, the data from one or more meters may be faulty.
- Where minimum (nighttime) flows are abnormally high or algebraically inconsistent, the data is suspect.

Metered flows displaying one or more of the above flaws were purged or adjusted based on reasonable assumptions.

At each meter location the flow-monitoring device measures depth of flow and velocity. Upon reviewing the report submitted by Downstream Services, and from discussions with their staff, it was determined that the depth-of-flow reading was more reliable than the velocity data. By using depth of flow readings and inputting pipe characteristics (slope, size and roughness "n" values), sewage flow can be calculated using Manning's equation. These values more closely resemble theoretically sewage flows calculated using land use information and flow coefficients. It was determined to perform additional flow monitoring for sub-area 2 at two different locations for a period of two days. Flow data have been included in the Appendix.

The flow monitoring hydrographs at each meter site, adjusted based on the depth measurement, are shown in Figures 7 through 14. The following relevant observations were made from evaluation of the measured flows:

- Flows from the study area are atypical in many ways, probably due to the dominating influence of UCR.

- Weekend hydrographs show generally smaller flows and lesser peaks than weekday patterns, probably due to a slightly lesser study area population on weekends. Weekday flows (with UCR in session) thus produce the critical modeling values in this area.

- Holiday flows (i.e., Thanksgiving occurred during the metering period) generally exhibit increased values in most developed areas around the nation; however, in this study, the holiday and preceding week displayed depressed flows; again likely due to the net out-migration of the resident population (influenced by UCR) during the days surrounding the holiday.

Figure 7

Adjusted Flow at Meter 2

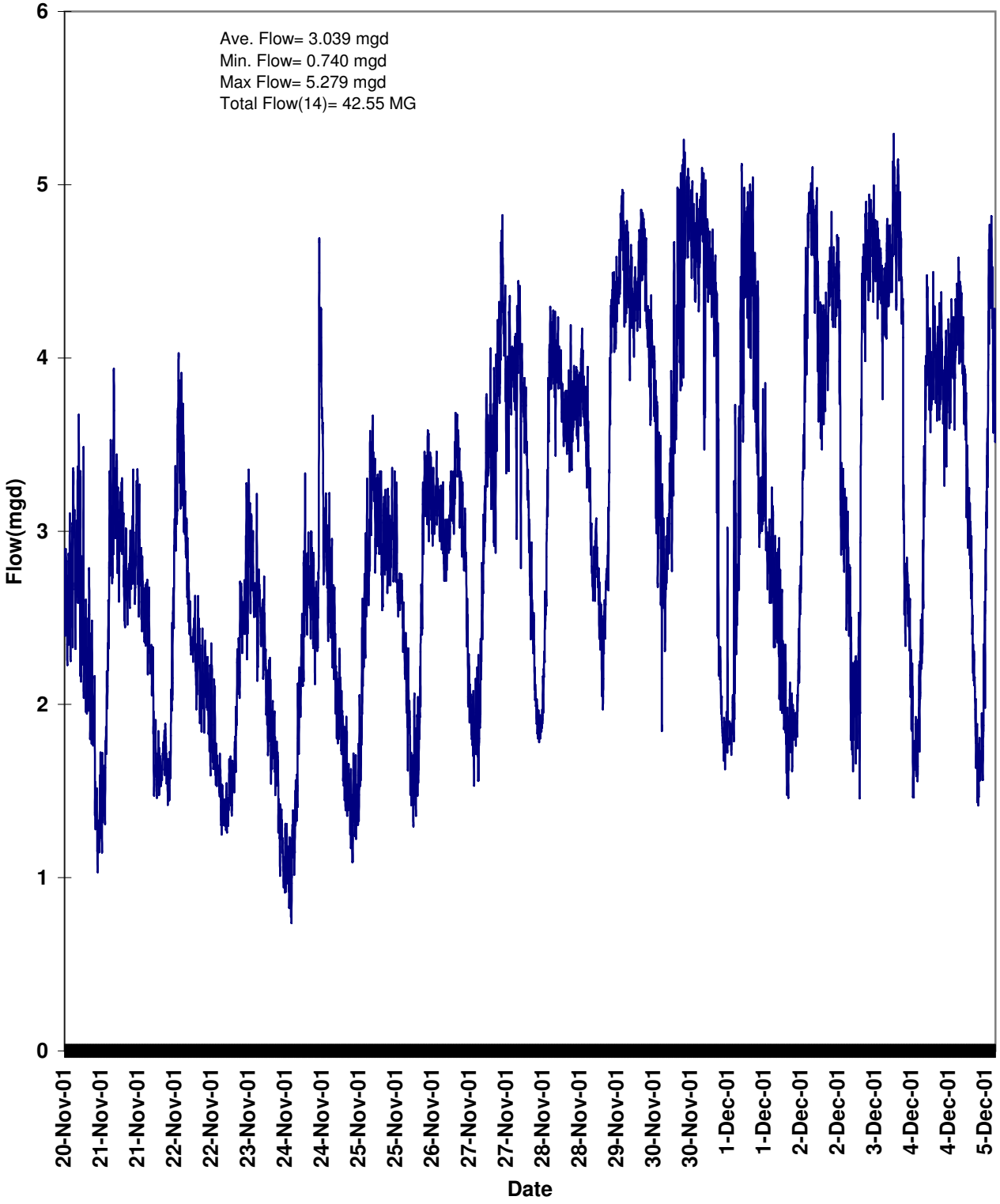


Figure 8

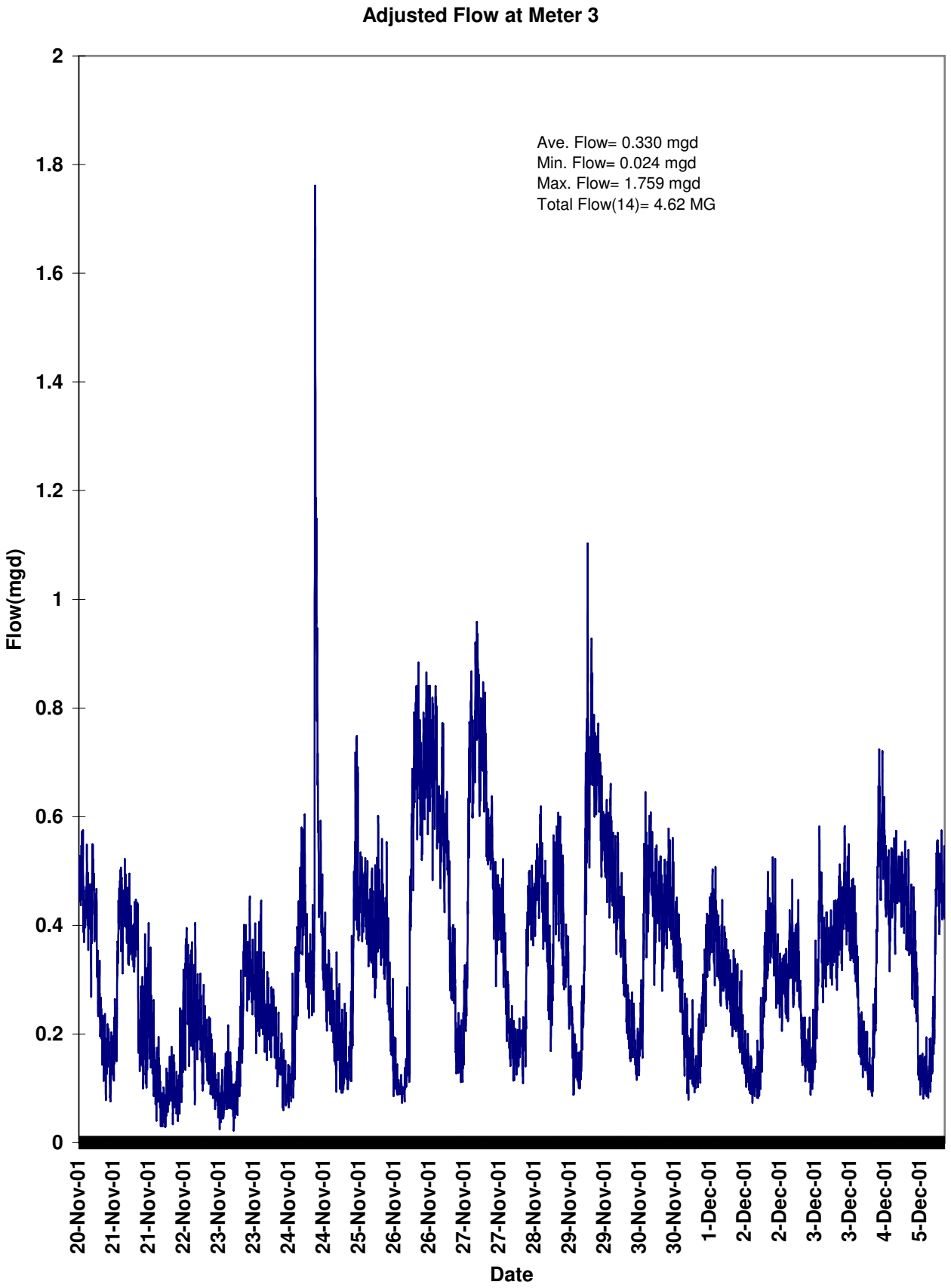

Adjusted Flow at Meter 3
Ave. Flow= 0.330 mgd
Min. Flow= 0.024 mgd
Max. Flow= 1.759 mgd
Total Flow(14)= 4.62 MG
Flow(mgd)
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
20-Nov-01
21-Nov-01
21-Nov-01
22-Nov-01
23-Nov-01
23-Nov-01
24-Nov-01
24-Nov-01
25-Nov-01
26-Nov-01
26-Nov-01
27-Nov-01
27-Nov-01
28-Nov-01
29-Nov-01
29-Nov-01
30-Nov-01
30-Nov-01
1-Dec-01
2-Dec-01
2-Dec-01
3-Dec-01
3-Dec-01
4-Dec-01
5-Dec-01
Date

Figure 9

Adjusted Flow at Meter 4

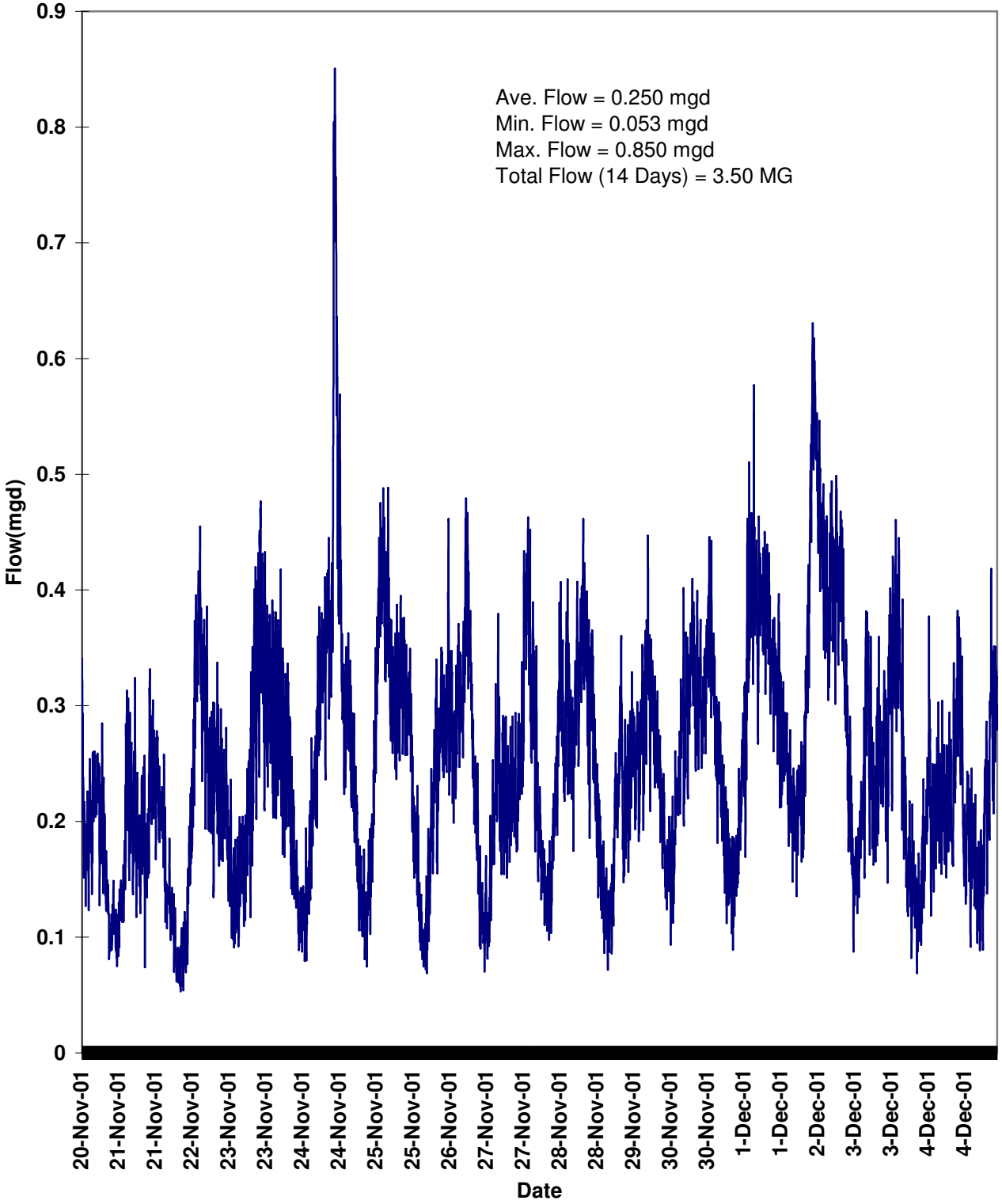


Figure 10

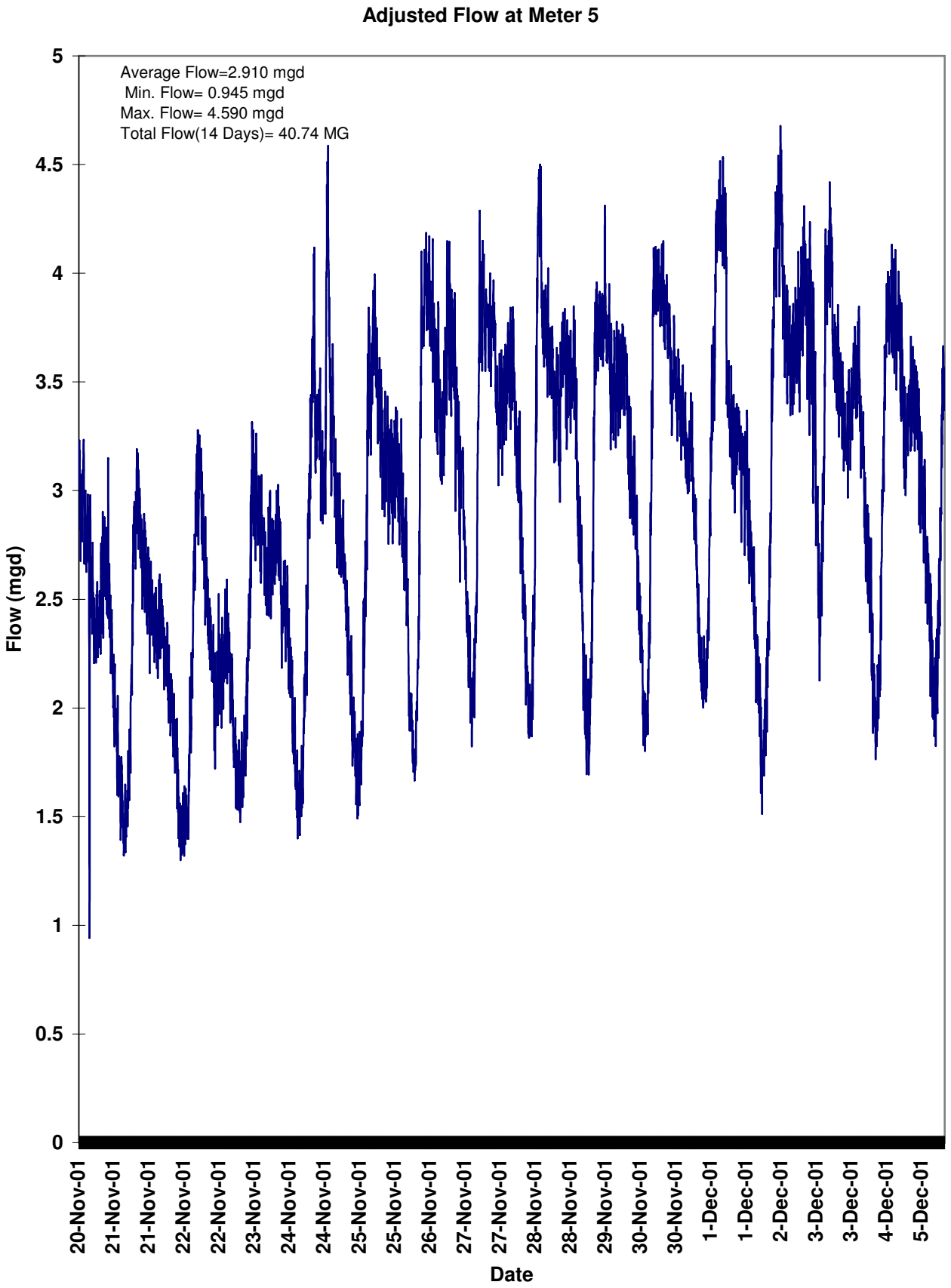

Adjusted Flow at Meter 5
Average Flow=2.910 mgd
Min. Flow= 0.945 mgd
Max. Flow= 4.590 mgd
Total Flow(14 Days)= 40.74 MG
Flow (mgd)
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
20-Nov-01
21-Nov-01
21-Nov-01
22-Nov-01
22-Nov-01
23-Nov-01
24-Nov-01
24-Nov-01
25-Nov-01
25-Nov-01
26-Nov-01
27-Nov-01
27-Nov-01
28-Nov-01
28-Nov-01
29-Nov-01
30-Nov-01
30-Nov-01
1-Dec-01
1-Dec-01
2-Dec-01
3-Dec-01
3-Dec-01
4-Dec-01
5-Dec-01
Date

Figure 11

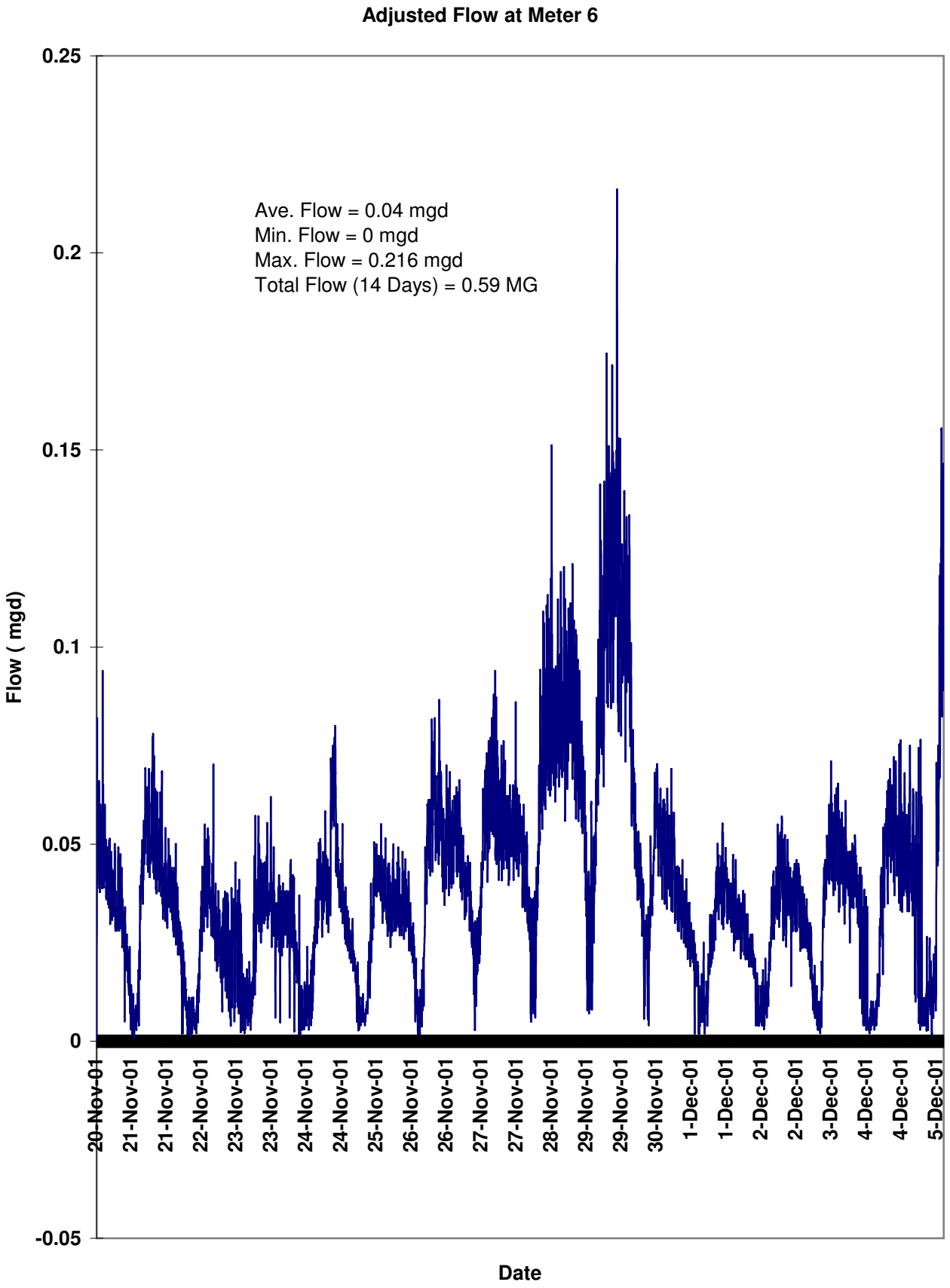

Adjusted Flow at Meter 6
Ave. Flow = 0.04 mgd
Min. Flow = 0 mgd
Max. Flow = 0.216 mgd
Total Flow (14 Days) = 0.59 MG
Flow (mgd)
0.25
0.2
0.15
0.1
0.05
0
-0.05
20-Nov-01
21-Nov-01
21-Nov-01
22-Nov-01
23-Nov-01
23-Nov-01
24-Nov-01
24-Nov-01
25-Nov-01
26-Nov-01
26-Nov-01
27-Nov-01
27-Nov-01
28-Nov-01
29-Nov-01
29-Nov-01
30-Nov-01
1-Dec-01
1-Dec-01
2-Dec-01
2-Dec-01
3-Dec-01
4-Dec-01
4-Dec-01
5-Dec-01
Date

Figure 12

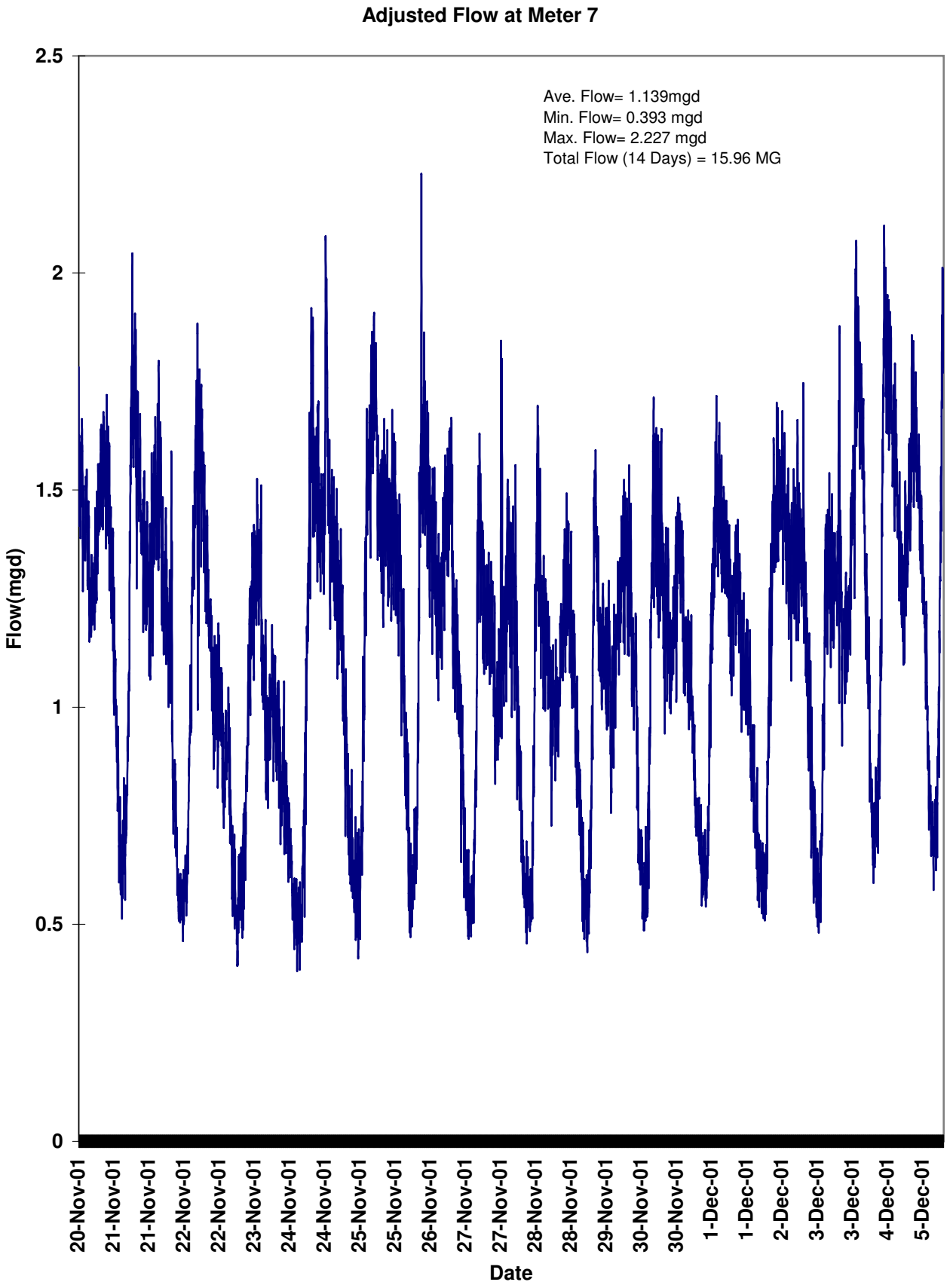

Adjusted Flow at Meter 7
Ave. Flow= 1.139mgd
Min. Flow= 0.393 mgd
Max. Flow= 2.227 mgd
Total Flow (14 Days) = 15.96 MG
Flow(mgd)
2.5
2
1.5
1
0.5
0
20-Nov-01
21-Nov-01
21-Nov-01
22-Nov-01
22-Nov-01
23-Nov-01
24-Nov-01
24-Nov-01
25-Nov-01
25-Nov-01
26-Nov-01
27-Nov-01
27-Nov-01
28-Nov-01
28-Nov-01
29-Nov-01
30-Nov-01
30-Nov-01
1-Dec-01
1-Dec-01
2-Dec-01
3-Dec-01
3-Dec-01
4-Dec-01
5-Dec-01
Date

Figure 13

Adjusted Flow at Meter 8

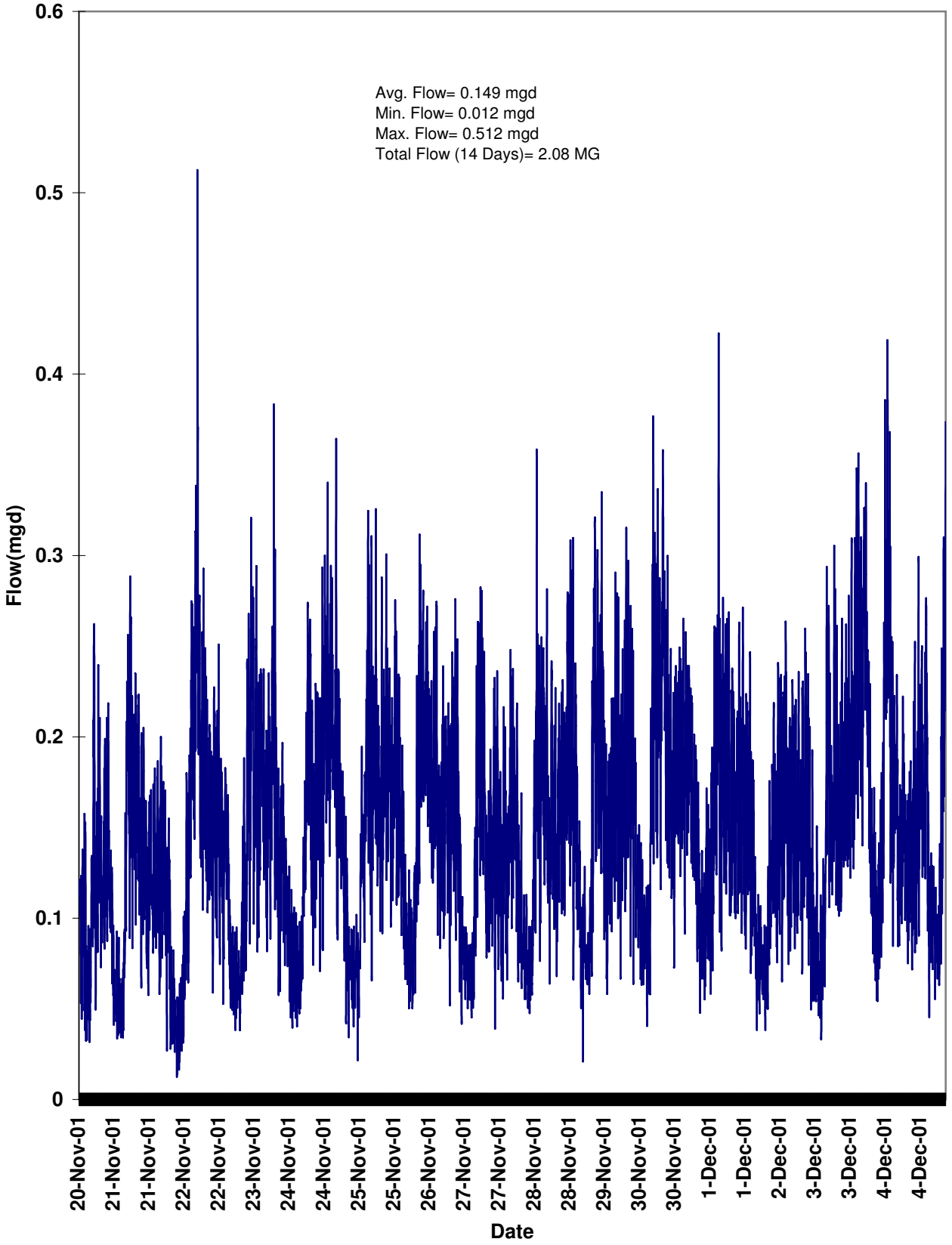
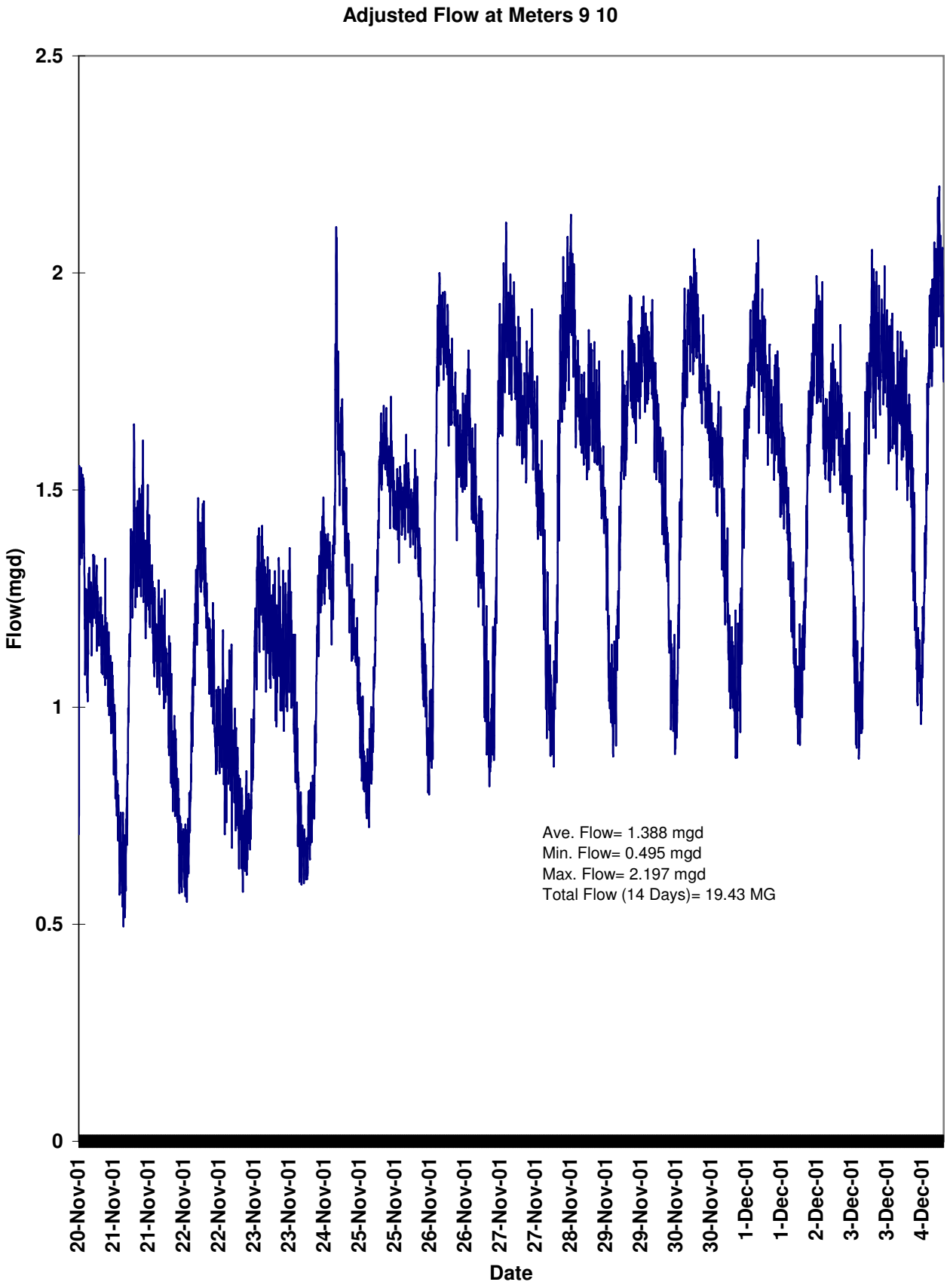


Figure 14


Adjusted Flow at Meters 9 10
2.5
2
1.5
1
0.5
0
Flow(mgd)
Ave. Flow= 1.388 mgd
Min. Flow= 0.495 mgd
Max. Flow= 2.197 mgd
Total Flow (14 Days)= 19.43 MG
20-Nov-01
21-Nov-01
21-Nov-01
22-Nov-01
22-Nov-01
23-Nov-01
23-Nov-01
24-Nov-01
25-Nov-01
25-Nov-01
26-Nov-01
26-Nov-01
27-Nov-01
27-Nov-01
28-Nov-01
29-Nov-01
29-Nov-01
30-Nov-01
30-Nov-01
1-Dec-01
1-Dec-01
2-Dec-01
3-Dec-01
3-Dec-01
4-Dec-01
Date

- Diurnal flow patterns reveal a surprising duration and magnitude of nighttime flows, particularly for high density residential and UCR. This can probably be explained by the general nocturnal habits of the student population in and around the UCR campus.

- From the storm which occurred on November 24, a brief rainfall "spike" was evident at several of the meters (meter Nos. 3, 4, 5 and 10), indicating that there is some rainfall-generated inflow to the system; possibly from inundated manhole covers or illicit connections (roof drains, etc.).

- Observed flows at Meter No. 4 are significantly higher than expected from land use. This is likely attributable to a higher than anticipated resident population, or "overcrowding" in this particular area. The recent U.S. census data reveals somewhat greater numbers than would be expected in this zoning category. Actual population may be even higher, due to residents who did not report. An upward adjustment was made to the land use/population in this tributary area to account for the higher occupancy. However, sub-area 4 is relatively minor in its contribution to flows in the trunk system.

5.0 ESTIMATED ULTIMATE FLOW

5.1 Methodology

Future wastewater flows in the study area are estimated by applying unit (per acre or per capita) flow factors to the projected "ultimate" land use acreage or population in each sub area. As discussed in Section 2, ultimate land uses within the study area are estimated based on the City's current General Plan (which governs future development/redevelopment), and the UCR Long Range Plan (currently being updated). As shown in Figure 5, the growth potential within the City (non UCR) portion of the study area is relatively small, limited by the available land, while the planned growth for UCR is substantial (See Figure 4).

Since this study does not evaluate the internal collection system within the UCR campus, the composite flow at the point where UCR flows enter the City's trunk system (on University Avenue) constitutes key input to the model. Flows from on-campus uses are estimated based on population rather than land use. This is appropriate since the ultimate specific facilities and locations have not been firmly established, but the student population and on-campus resident numbers are essentially agreed upon.

Thus, future wastewater flows are estimated based on a hybrid methodology which employs population-based coefficients for the UCR portion, and land use-based coefficients for the remainder of the study area.

5.2 Flow Coefficients

A review of commonly used flow coefficients (or unit factors) was made to arrive at preliminary criteria which would be an appropriate starting point for the study area.

Flow coefficients are commonly expressed in terms of cubic feet per second (cfs) of average dry weather flow (ADWF) per acre of a specific land use type. For population based estimates, flows are expressed in gallons per capita per day (gpcd). Peak flow generation rates estimated by applying peaking factors to the average flow, (with factors often based on observed peak-to-average ratios from previous studies) are of little value in simulating flows within the collection system, since peaks for various uses are not simultaneous, but rather staggered throughout the day. Also, peaks are blended and attenuated by lag times and in-pipe storage as the flows move downstream. Notwithstanding the above, diurnal peaking factors are also

estimated for each land use type to estimate peak generation rates.
For preliminary estimation of wastewater flow, the document "Criteria for Sewer Facility Design, Public Works Department, City of Riverside" was used. The following is a general guideline for estimation of theoretical wastewater flows within the study area:

Flows from Land Use Categories:

Residential sewage flows are determined by using the following sources of information and criteria:

- Land use shown in the City's General Plan.
- Based on land use determine the number of living units per acre.
- Persons per living unit determined from the latest census data for the study area. However, it should not be less than an average of 2.75 persons per living unit.
- Average wastewater flow based on 65 gallons per capita per day.
- Peak to average flows to be determined from the graphs.

Peak flows from non-residential developments shall be

determined using the following criteria:

- Industrial Developments – 0.012 cfs/acre
- Commercial Developments – 0.010 cfs/acre
- Offices – 30 gallons per capita (employee on site) per day
- Schools – 30 gallons per capita per day
- Laundromat – 580 gallons per machine per day.

The City of Riverside Criteria for Sewer Facility Design is attached as Appendix B.

UCR Flows

Per capita flow from student population living on campus is 65 gallons per capita per day

Per capita flow from faculty and visitors who reside off campus - 30 gallons per capita per day

Peaking Factor - City of Riverside, population vs. peaking factor chart

As previously discussed, based on meetings with UCR Planning staff, a student population of 13,930 plus 8,700 faculty and visitors was assumed for year 2001. According to the draft Long Range Development Plan for year 2015, a student population of 25,000

Table 5-1
Summary of Theoretical Flow

METER	CONTRIBUTORY AREA	LANDUSE FLOW												Total Peak Flow
		Residential (SFR & MFR)				Commercial		Industrial		UCR				
	(ac)	Pop.	Avg. flow	PF	Peak flow	area	Peak flow	area	Peak flow	Pop.	Avg. flow	PF	Peak flow	
CURRENT FLOW:(Year 2001)			(cfs)		(cfs)	(ac)	(cfs)	(ac)	(cfs)		(cfs)		(cfs)	(cfs)
8	164	922	0.093	3.0	0.278	0.00	0.000	0.00	0.000					0.278
7	645	9,694	0.975	2.3	2.242	87.74	0.877	0.00	0.000					3.119
9 &10	947	4,152	0.418	3.0	1.253	38.43	0.384	0.00	0.000	23,200	1.31	1.6	2.100	3.736
5	1,812	14,938	1.502	1.9	2.854	235.47	2.355	56.18	0.674	23,200	1.31	1.6	2.100	7.982
2	1,971	14,938	1.502	1.9	2.854	229.91	2.299	141.18	1.694	23,200	1.31	1.6	2.100	8.947
3	145	4,485	0.451	3.0	1.353	37.84	0.378	6.25	0.075					1.81
4	104	4,055	0.408	3.0	1.223	2.71	0.027	0.00	0.000					1.250
6	11	0	0.000	3.0	0.000	5.13	0.051	6.25	0.075					0.13
1	2,249	20,845	2.096	1.7	3.459	283.57	2.836	170.47	2.046	23,200	1.31	1.6	2.100	10.439
FUTURE FLOW:(Year 2015)														
8	189	1,097	0.110	3.0	0.331	0.00	0.000	0.00	0.000					0.331
7	753	11,536	1.160	2.2	2.552	88.74	0.887	0.00	0.000					3.439
9 &10	1,014	4,941	0.497	3.0	1.490	55.20	0.552	0.00	0.000	40,000	2.53	1.5	3.800	5.842
5	2,012	17,776	1.787	1.8	3.217	277.30	2.773	56.18	0.674	40,000	2.53	1.5	3.800	10.464
2	2,192	17,776	1.787	1.8	3.217	291.22	2.912	141.18	1.694	40,000	2.53	1.5	3.800	11.624
3	159	5,337	0.537	3.0	1.610	38.53	0.385	6.25	0.075					2.070
4	118	4,825	0.485	3.0	1.456	3.40	0.034	0.00	0.000					1.490
6	11	0	0.000	3.0	0.000	5.13	0.051	6.25	0.075					0.13
1	2,500	24,806	2.494	1.6	3.866	376.64	3.766	170.47	2.046	40,000	2.53	1.5	3.800	13.478

Notes:

For flow calculation of SFR and MFR population count as per City of Riverside GIS has been used.
For population growth a 12.65% growth for every ten year has been assumed based on population data for City of Riverside.
Per capita sewage flow- 65 gpcd
Commercial Peak Flow- 0.01 cfs/ac
Industrial Peak Flow- 0.012 cfs/ac
Peaking Factor as per City of Riverside Population vs Peak to Average Ratio Chart.
For calculation of sewage flow from UCR following assumptions have been made:
Per capita average flow from student population on campus - 65 gpcd = 0.0001005 cfs/capita.
Average flow from faculty and visitors - 30 gpcd = 0.0000464 cfs/capita.
For year 2001, flow has been calculated based on student population of
14,500 students and 8,700 faculty and visitors. (30% students live on campus.)
For year 2015 flow has been calculated based on 25,000 student population and 15,000
faculty and visitors. 50% students live on campus.

UCR Avg. Flow Calculation:

Present:(Year 2001)

Residential	**0.44**	**cfs**
Academics	**0.87**	**cfs**

Future:(Year 2015)

Residential	**1.26**	**cfs**
Academics	**1.28**	**cfs**

Abbreviations:

Pop. - Population, Avg. - Average, PF - Peaking Factor, cfs - Cubic feet per second, ac - Acre, SFR - Single Family Residential, MFR - Multi Family Residential
UCR - University of California, Riverside.

plus 15,000 faculty and visitors is assumed. It is further assumed, based on input from UCR Planning, that 50% of the students will reside on campus. Official numbers received from UCR for student population is attached as Appendix –C.

Table 5-1 summarizes present and future sewage flow quantities based on land use. For Single Family and Multi-Family residential, sewage flow generated in a sub-area has been calculated based on land use converted to population. Flows for commercial/industrial are computed based on land use acreage and representative flow coefficients.

5.3 Representative Diurnal Hydrographs

The study area is comprised of a variety of unique land uses. For the purpose of defining characteristic diurnal patterns, flow from each sub-basin was analyzed and percentage of flow contribution from each land use type was estimated. Tables 5-2 and 5-3 summarize percentage of flow from each land use category contributing to each meter location for current and future conditions, respectively. Although none of the tributary sub areas flowing to the meter locations are comprised of a single land use category, several are dominated by one or two categories, and are thus selected as being representative to the diurnal flow patterns for those land uses. Based on this table, the following diurnal patterns were used for the modeled peak flow evaluation.

- Flow at meter location 8 : Single Family Residential (SFR).
- Flow at meter location 7 : Multi-Family Residential (MFR).
- Flow at meter location 6 : Commercial / Industrial.
- Flow at meter location 9 : UCR.

These representative diurnal hydrographs are shown in Figures 15-18. The flow patterns are used in the model to estimate for each land use type; the percentage of Average Dry Weather Flow (ADWF) contributed at specific times throughout the day.

Figure 19 graphically depicts the existing and future conditions and illustrates the increasing influence of UCR-contributed flows.

Table 5-2

Current(2001) Peak Flow and Percentage Contribution from Different Land Use Categories

METER	LOCATION	Current Trib. Area (ac)	Vacant Area (ac)	Total Area (ac)	Current Peak Flow (cfs)	Land Use Categories Peak Flows							
						Residential		Commercial		Industrial		UCR	
						(cfs)	%	(cfs)	%	(cfs)	%	(cfs)	%
8	MH-245 AT SPRUCE STREET	164	24	189	0.278	0.278	100	0.000	0	0.000	0	0.000	0
7	MH-224 AT SPRUCE STREET	645	108	753	2.924	2.047	70	0.877	30	0.000	0	0.000	0
9 &10	MH-996 AT UNIVERSITY AVE.	947	67	1,014	3.679	1.253	34	0.384	10	0.000	0	2.042	56
5	MH-213 AT SPRUCE STREET	1,812	201	2,012	7.870	2.854	36	2.299	29	0.674	9	2.042	26
2	MH-203 AT SPRUCE STREET	1,971	221	2,192	8.945	2.854	32	2.355	26	1.694	19	2.042	23
3	MH-200 AT SPRUCE STREET	145	14	159	1.806	1.353	75	0.378	21	0.075	4	0.000	0
4	MH-702 AT KANSAS AVE.	104	14	118	1.250	1.223	98	0.027	2	0.000	0	0.000	0
6	MH-620 AT THIRD STREET	11	-	11	0.126	0.000	0	0.051	41	0.075	59	0.000	0
1	MH-35 AT SWR LINE 59-18	2,249	251	2,500	10.382	3.459	33	2.836	27	2.046	20	2.042	20

Table 5-3

Future(2015) Peak Flow and Percentage Contribution from Different Land Use Categories

METER	LOCATION	Current Trib. Area (ac)	Vacant Area (ac)	Future Trib Area (ac)	Future Peak Flow (cfs)	Land Use Categories Peak Flows							
						Residential		Commercial		Industrial		UCR	
						(cfs)	%	(cfs)	%	(cfs)	%	(cfs)	%
8	MH-245 AT SPRUCE STREET	164	24	189	0.331	0.331	100	0.000	0	0.000	0	0.000	0
7	MH-224 AT SPRUCE STREET	645	108	753	3.207	2.320	72	0.887	28	0.000	0	0.000	0
9 &10	MH-996 AT UNIVERSITY AVE.	947	67	1,014	5.842	1.490	26	0.552	9	0.000	0	3.800	65
5	MH-213 AT SPRUCE STREET	1,812	201	2,012	10.464	3.217	31	2.773	26	0.674	6	3.800	36
2	MH-203 AT SPRUCE STREET	1,971	221	2,192	11.624	3.217	28	2.912	25	1.694	15	3.800	33
3	MH-200 AT SPRUCE STREET	145	14	159	2.070	1.610	78	0.385	19	0.075	4	0.000	0
4	MH-702 AT KANSAS AVE.	104	14	118	1.490	1.456	98	0.034	2	0.000	0	0.000	0
6	MH-620 AT THIRD STREET	11	-	11	0.126	0.000	0	0.051	41	0.075	59	0.000	0
1	MH-35 AT SWR LINE 59-18	2,249	251	2,500	13.478	3.866	29	3.766	28	2.046	15	3.800	28

Note:

Residential peak flow was determined by population rather than landuse because of demographics of the area.

Abbreviations:

Trib. Area - Tributary Area
ac - Acre
cfs - Cubic feet per second.
UCR - University of California, Riverside.
SWR - Sewer
AVE. - Avenue

Table 5.2
Table 5.3

Figure 15

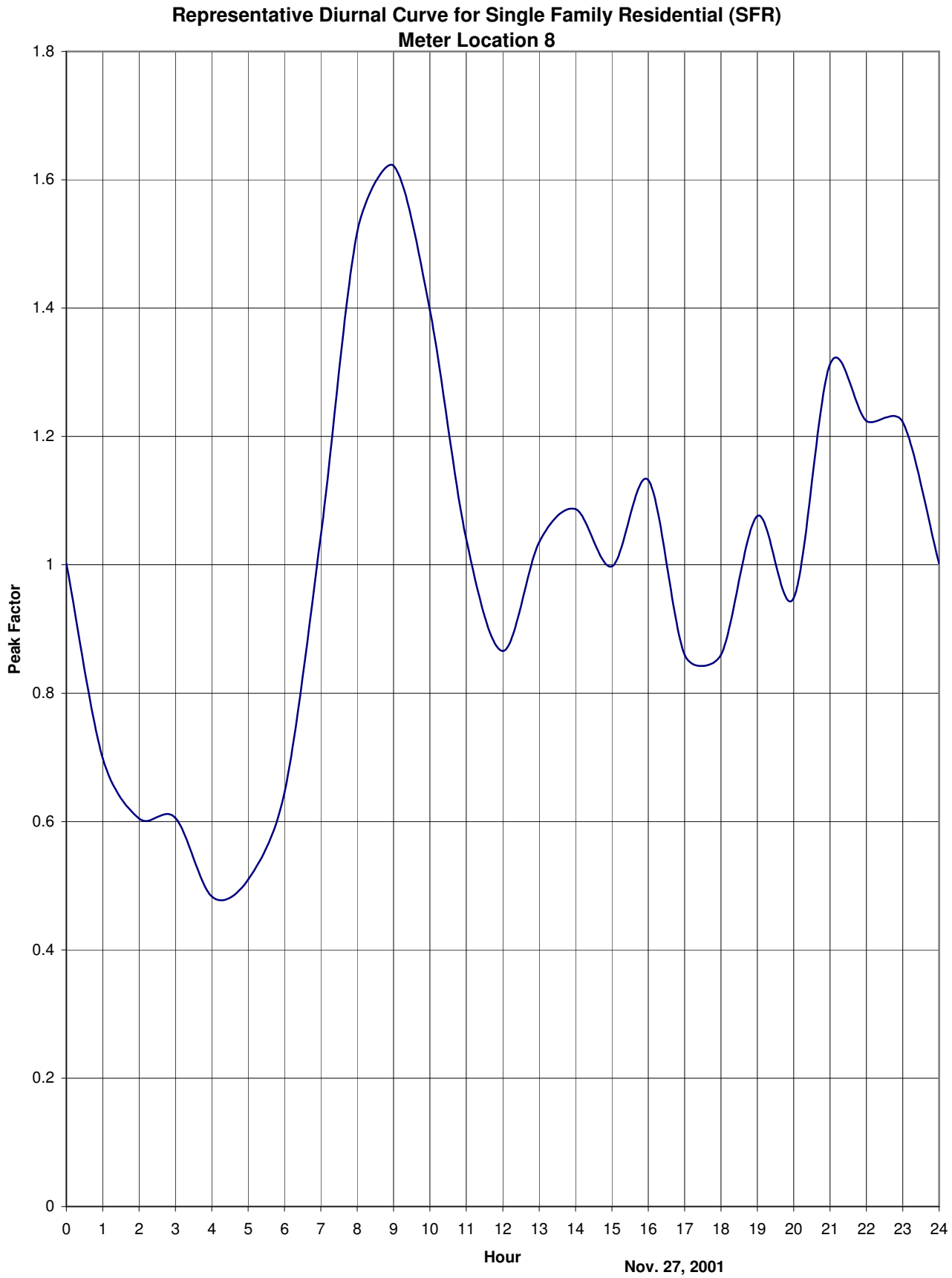

Representative Diurnal Curve for Single Family Residential (SFR)
Meter Location 8
Peak Factor
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Hour
Nov. 27, 2001

Figure 16

Representative Diurnal Curve for Multi-Family Residential (MFR)
Meter Location 7

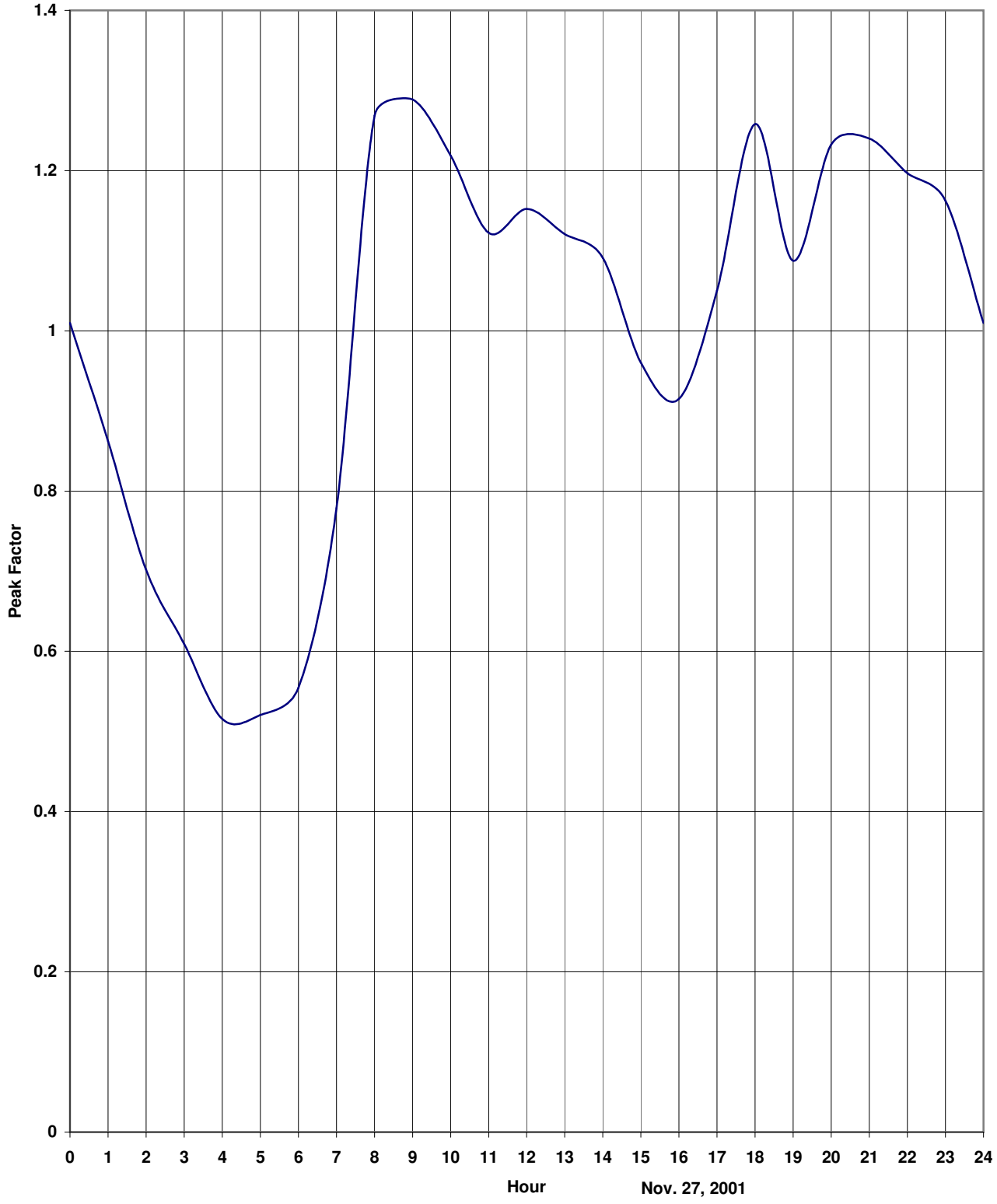
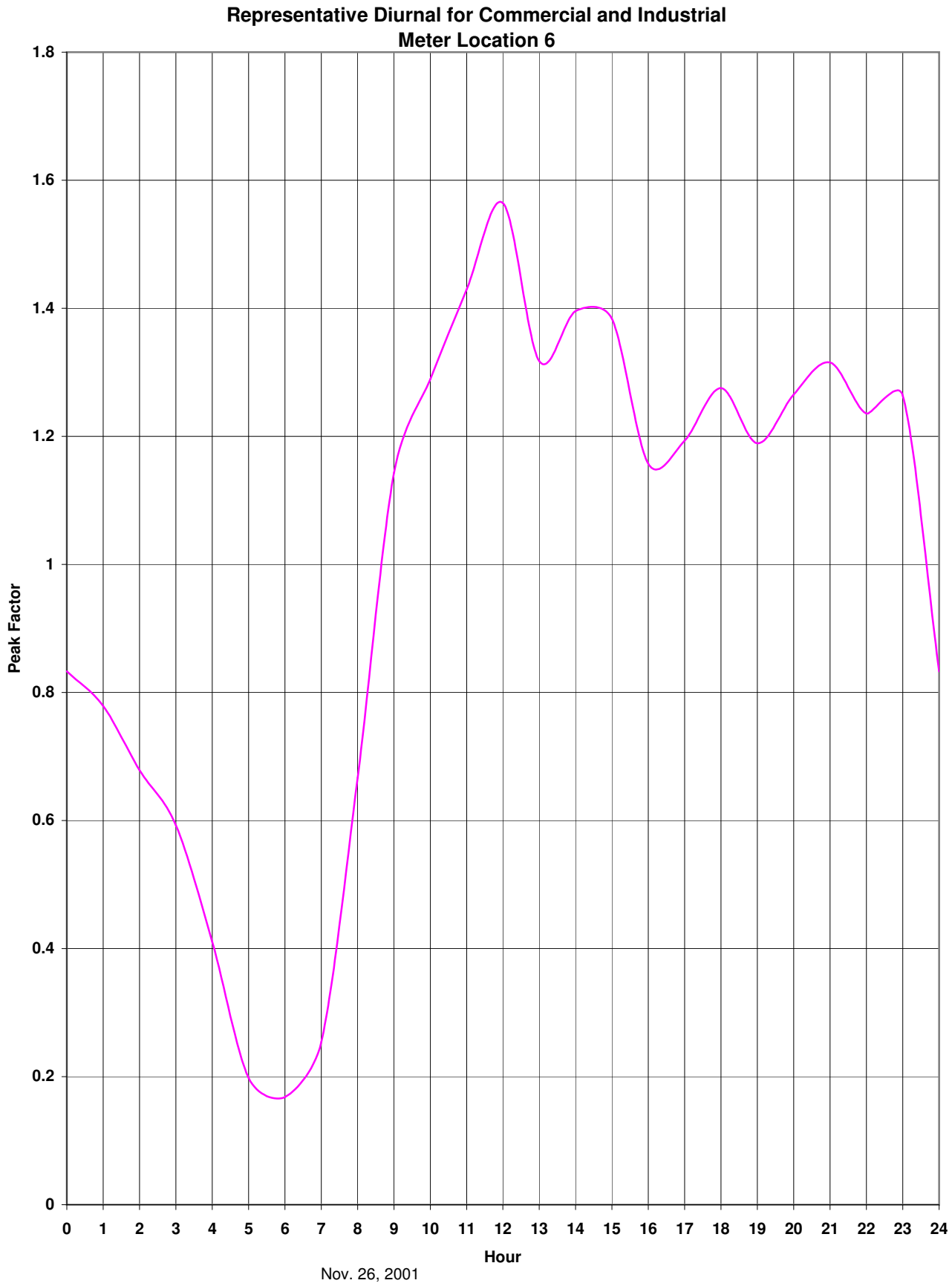


Figure 17



Nov. 26, 2001

Figure 18

Representative Diurnal Curve for UCR
Meter Locations 9 and 10

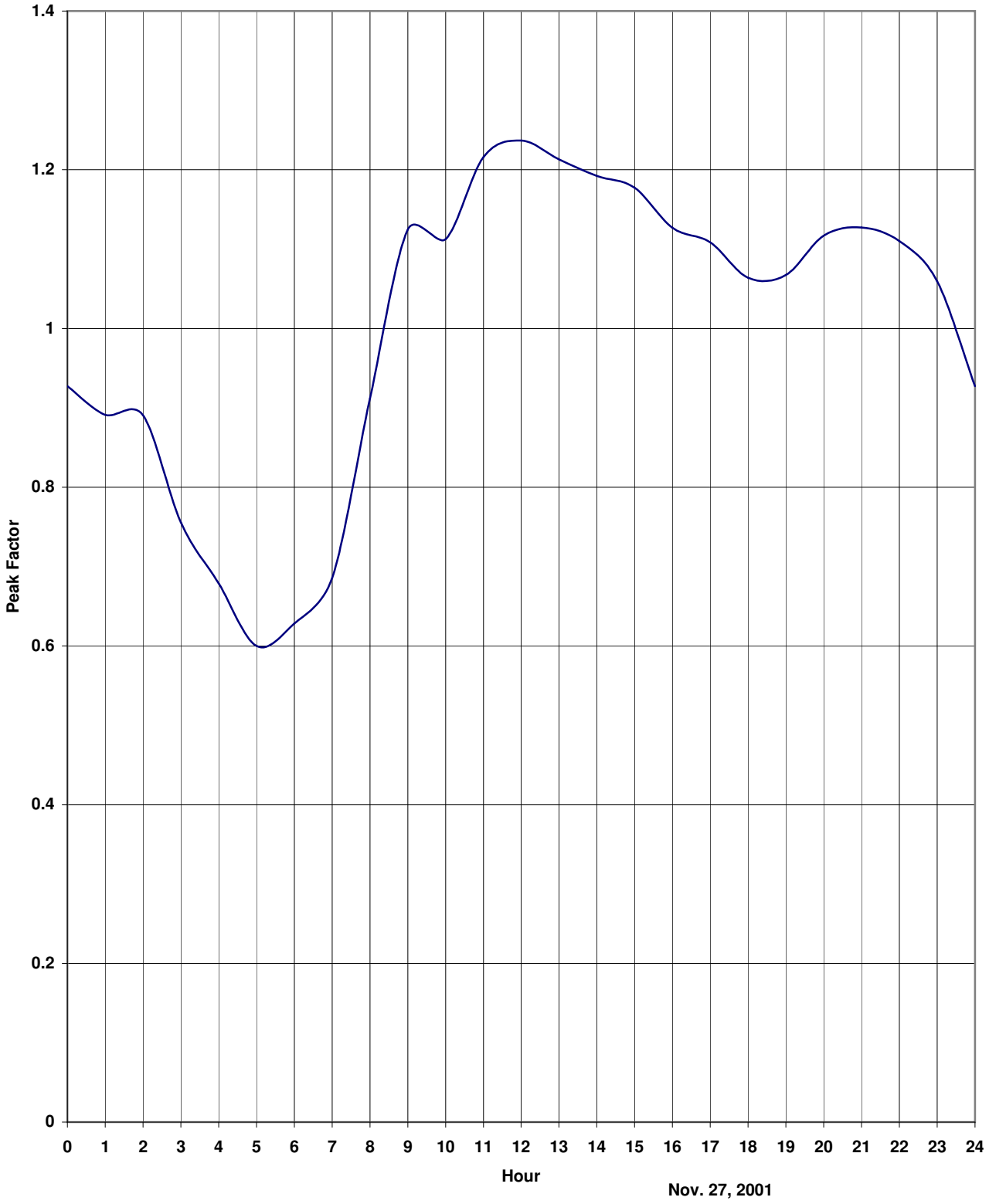
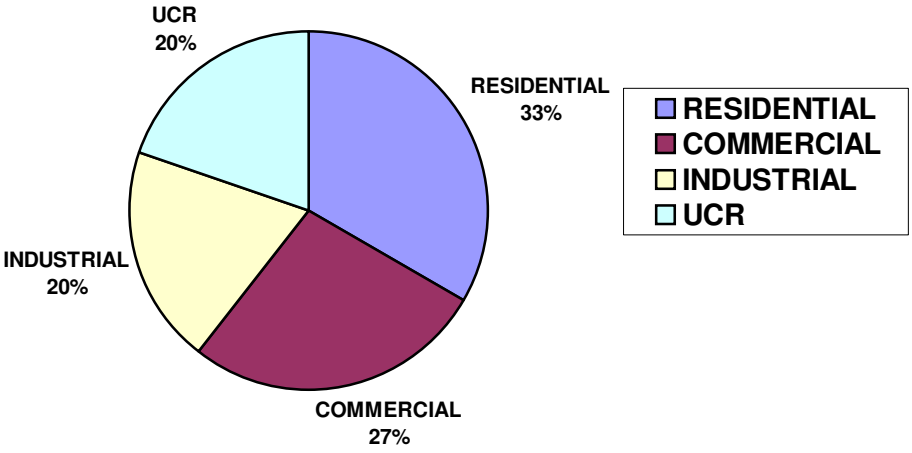
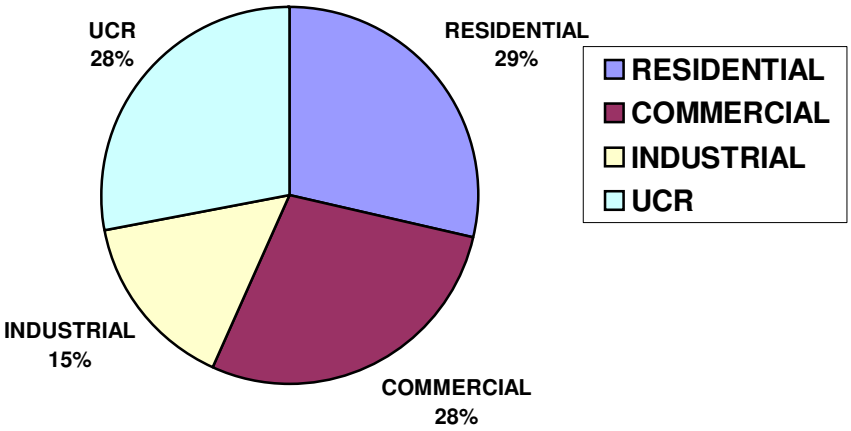


Figure 19
Existing and Ultimate Flow Contributions from Various Land Uses
Meter Location 1

EXISTING (2001) CONTRIBUTING FLOWS AT METER LOCATION 1



FUTURE (2015) CONTRIBUTING FLOWS AT METER LOCATION 1



6.0 COMPUTER MODEL SIMULATION ANALYSIS

6.1 Methodology

Capacity analysis involved evaluation of the available capacity in the existing collection system under present and future development conditions. Based on results of the analysis, phased facility improvements were identified to allow for projected growth within the service area.

This Section describes the analytical methodology and hydraulic model development, and summarizes the results of the analyses.

The principal tool utilized in the capacity analysis was a hydraulic model that simulates flow conditions using demand and piping characteristic input data. With this input information, the model is able to output sewage depth of flow, rate of flow, and velocity of flow, within selected pipes and manholes during different times of the day. The model selected for use in this study is XP-SWMM (XP Software, Version 8.0); this modeling software belongs to a class of software referred to as “dynamic wave models”. These types of models provide an accurate simulation of hydraulic flow conditions over an extended period of time.

Data required to create the model include information describing the physical wastewater collection system, such as pipe diameters and reach lengths, manhole invert elevations, and estimated pipe roughness coefficients. Additionally, data describing the sewage loading at selected manholes, expressed as a varying flow rate over time (i.e. a diurnal curve), must be provided. Model output consists of a variety of hydraulic parameters, most importantly peak flow depths and discharge rates.

Calibration of the model consisted of simulating existing sewer flow conditions and comparing the modeled and recorded flows at the meter locations. The assumed diurnal curves that serve as input to the model were iteratively adjusted until the simulated and recorded sewage flow hydrographs achieved reasonable agreement.

Simulations of future sewage flow conditions were performed by developing input data sets that included sewage generation projections for the assumed ultimate conditions. Pipe reaches in which simulated peak flows exceeded a specified trigger criteria were identified as potential improvement reaches. Improvements required to provide adequate capacity for projected flows are then determined through an iterative modeling process. The process

consists of simulating flow conditions after increasing the diameter of downstream portions of the identified reaches. In subsequent iterations, additional lengths of pipe are increased in diameter until the projected peak flow can be conveyed through the reach without exceeding the specified design flow criteria.

6.2 Limitations of Modeling

The hydraulic model, which was utilized as the primary planning tool for the sewer capacity analysis, provides an accurate simulation of actual flow conditions within a sanitary sewer system in response to existing and future sewage loading. The accuracy of the simulation, however, is directly related to the accuracy of the model input data, including physical parameters and sewage loading projections. For example, in a case where roots had entered the pipeline, thereby causing a restriction of flow, the model would be unable to predict the reduction in flow through this obstruction. Consequently, a general understanding of the data sources is critical in interpreting the modeling results.

The physical parameters of the model, including pipe diameter, slope, and roughness coefficients were based principally on City database information. Where this data appeared to be inaccurate, construction drawings were reviewed and the input data corrected. Network connectivity refers to the flow path followed by sewage within the sewer system. The connectivity is a function of the relative slope of each sewer pipe and the relative invert elevations of the incoming and outgoing sewer pipes at manholes. For example, a manhole may have two or more sewer pipes, which could convey flow away from the manhole. If the invert (bottom) of one of these pipes is lower than the other, the downstream flow path at this manhole would follow the lower pipe.

Sewage loading projections were based on calibrated flow rates. As previously described, flow rates used for calibration were based on actual monitored flows at key points in the trunk system over a 2-week period in November 2001. This period included the Thanksgiving holiday as well as two weekends. Additional flow anticipated to enter the sewer system due to wet weather infiltration was not considered, and is assumed to be accommodated by surplus hydraulic capacity in the pipelines or temporary dampening in the manholes.

Since a degree of uncertainty exists in both the physical data and the sewage loading projections used as model inputs, reaches identified by model simulations as near or at capacity should be subject to additional engineering evaluation prior to improvement. Such evaluation may include field inspection, video monitoring, and flow metering.

7.0 CONCLUSIONS

7.1 Deficient and Marginally Deficient Pipes

The City's design criteria for sewer lines allows pipes to flow at a ratio of 75% of "full" hydraulic capacity. Assuming that "full" capacity is the maximum hydraulic capacity of a pipe flowing under gravity (non-pressure) conditions, Mannings equation shows that maximum flow occurs when a pipe reaches a flow depth ratio of about 95% d/D.

Pipe reaches which fail the "75% full" criteria for both existing and future flow conditions are shown in Table 7-1 and Figures 20 and 21. It is seen that portions of the modeled trunk system are already flowing at greater than "75% full", and several reaches are computed to be over 100% full (surcharge conditions). At ultimate conditions, numerous additional reaches are shown to surcharge or exceed the "75% full" criteria.

7.2 Project Prioritization Methodology

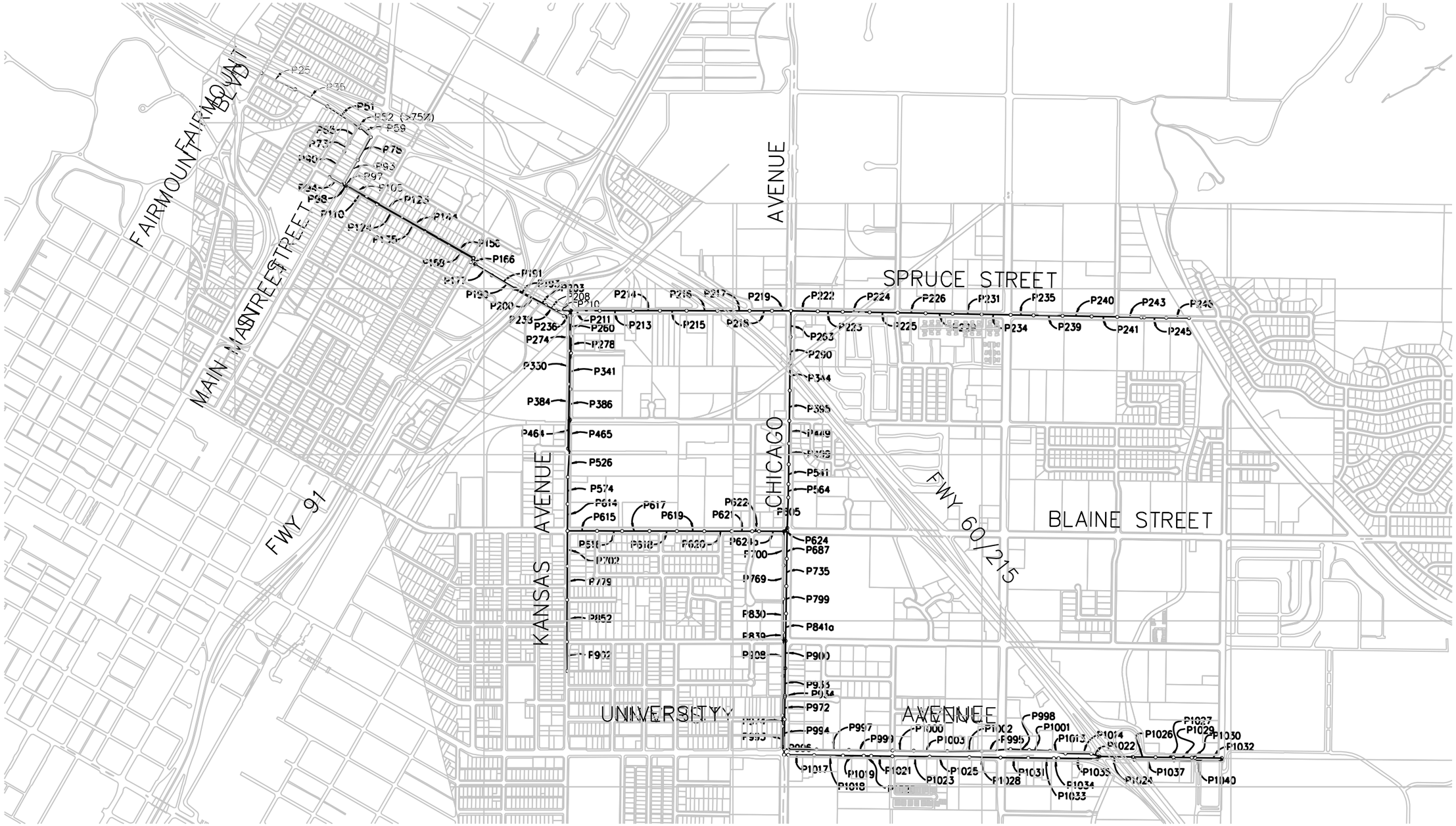
The 75% full criteria is useful for analyzing deficient pipes and as a basis for sizing new facilities. However, the criteria is not necessarily the trigger point for replacement or augmentation of an existing sewer line.

In most cases, a sewer entity would not implement a relief project until capacity problems are actually observed or known to be imminent.

A recommended system of project prioritization is the categorization of deficient sewer lines in different priorities, where the "A" priority projects are imminently needed and the "B" and "C" projects require further considerations for replacement. Priority classifications are described as follows:

Priority "A" – The pipes listed within this priority are currently deficient and are flowing more than 90% full under maximum flow condition. These pipes need immediate replacement.

Priority "B" – The pipes listed in this priority would be flowing more than 90% full in the future under maximum flow condition. These pipes need evaluation as new development takes place in the tributary area. Flow monitoring of the pipes within 5 years might be considered and the priority ranking re-evaluated.



LEGEND

EXCEEDS 90% FULL

EXCEEDS 75% FULL

N

GRAPHIC SCALE

1200 0 600 1200

(IN FEET)

1 inch = 1200 ft.

Engineering
Planning
Surveying
Construction Services

PBSJ

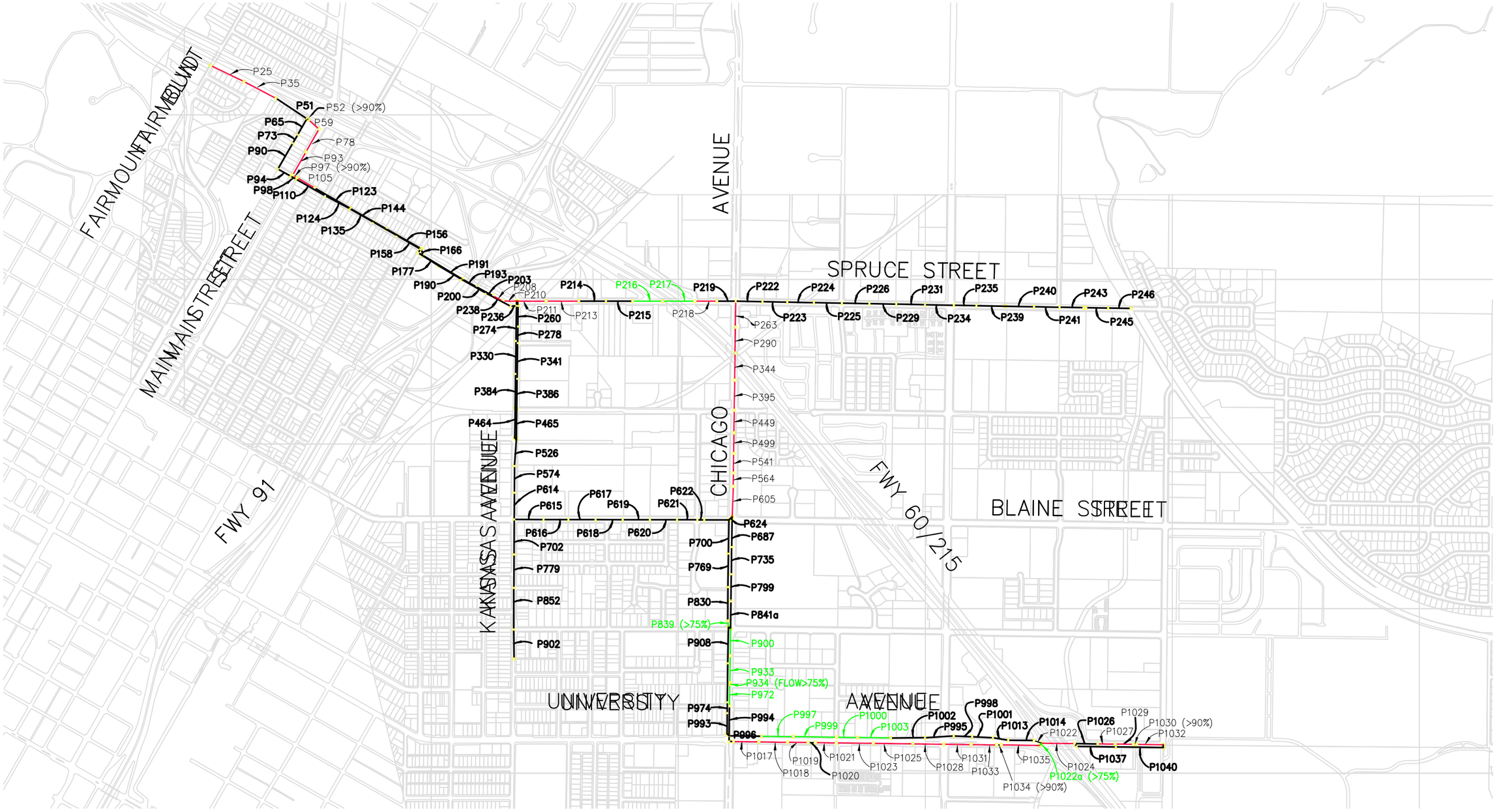
3610 Central Avenue
Suite 500
Riverside, CA 92506
Tel:(909) 341-6380
Fax:(909) 341-6389

CITY OF RIVERSIDE
SPRUCE STREET SEWER CAPACITY STUDY

EXISTING SYSTEM DEFICIENCIES

JUNE 2002

FIGURE 20



LEGEND

EXCEEDS 90% FULL

EXCEEDS 75% FULL

N

GRAPHIC SCALE

1200 0 600 1200

(IN FEET)

1 inch = 1200 ft.

Engineering
Planning
Surveying
Construction Services

PBSJ

3610 Central Avenue
Suite 500
Riverside, CA 92506
Tel:(909) 341-6380
Fax:(909) 341-6389

CITY OF RIVERSIDE
SPRUCE STREET SEWER CAPACITY STUDY

ULTIMATE SYSTEM DEFICIENCIES

JUNE 2002

FIGURE 21

Priority "C" – The pipes listed under this priority would be flowing between 75% to 90% full in future under maximum flow condition. Periodic flow monitoring or visual inspection should be considered for these pipes every five years.

7.3 Improvement Plan for Problem Areas

Table 7-3 lists project priority, project location, problem, solution and approximate cost for problem reaches. This table identifies immediate and future problems in the sewer lines and suggested solutions for that. The approximate project cost is in year 2002.

7.4 Grouping of Projects

Proposed improvements under different priorities have been combined or grouped into projects to improve deficient and marginally deficient pipes based on following criteria:

- Pipes identified as either deficient (Priority A) or marginally deficient (Priority B), located geographically close to one another and requiring improvements within 1 to 5 years (year 2002-2007) are grouped to reduce improvement costs.
- Some pipe reaches identified as marginally deficient (Priority B) and marginally deficient in future (Priority C) are grouped together for the same reason as mentioned above. However, improvements of these reaches would not be required until approximately before year 2007.

7.5 Construction Schedule

A summary of proposed construction prioritization and recommended scheduling is shown in table 7-2. This table lists construction priorities and the year in which these pipes will flow 90% full as per model run. The pipes falling under priority "A" need immediate replacement whereas priority "B" and "C" pipes would need re-evaluation before their replacement.

7.6 Alternatives

A surcharge condition exists in the pipes P25 and P35 for maximum flow conditions. The sewer lines within priority "A" need

Table 7-1
Sewer Analysis Results
Deficient Pipe Summary
(Existing and Ultimate Conditions)

Name	Diameter, ft	Slope (%)	Theoretical Full Flow Capacity (cfs)	Modeled Existing Max Flow (cfs)	Existing % Full	Modeled Future Max Flow (cfs)	Future % Full	Replacement Diameter (ft)	Theoretical New "Full" Flow Capacity (cfs)[1]	Theoretical New % Full
P25	1.50	0.53	7.63	7.45	98%	9.94	130%	1.67	15.80	63%
P35	1.50	0.53	7.66	7.45	97%	9.94	130%	1.67	15.87	63%
P36	3.00	0.23	31.78	7.45	23%	9.94	31%			
P48	3.00	0.22	30.98	7.45	24%	9.94	32%			
P51	1.25	4.25	13.27	8.02	60%	9.44	71%			
P52	1.50	0.72	8.89	6.78	76%	9.15	103%	1.75	14.45	63%
P59	1.50	0.74	9.01	6.78	75%	9.15	101%	1.75	14.65	62%
P65	0.83	0.66	1.75	0.28	16%	0.30	17%			
P73	0.83	0.36	1.30	0.28	21%	0.30	23%			
P78	1.50	0.76	9.16	6.78	74%	9.15	100%	1.75	14.89	61%
P90	0.83	1.30	2.46	0.28	11%	0.30	12%			
P93	1.50	0.72	8.90	6.78	76%	9.15	103%	1.75	14.46	63%
P94	0.83	0.61	1.69	0.28	16%	0.30	18%			
P97	1.50	0.72	8.89	6.78	76%	9.15	103%	1.75	14.45	63%
P98	0.83	0.49	1.52	0.28	18%	0.30	20%			
994a	1.25	2.00	9.11	2.03	22%	3.48	38%			
P105	1.50	0.72	8.90	6.78	76%	9.15	103%	1.75	14.47	63%
P110	0.83	1.44	2.59	0.28	11%	0.30	12%			
P123	1.50	1.48	12.75	6.78	53%	9.16	72%			
P124	0.83	0.49	1.52	0.28	18%	0.30	20%			
P135	0.83	1.44	2.59	0.28	11%	0.30	12%			
P144	1.50	1.48	12.76	6.78	53%	9.15	72%			
P147	0.83	1.43	2.58	0.28	11%	0.30	12%			
P156	1.50	1.40	12.41	6.78	55%	9.15	74%			
P158	0.83	1.44	2.59	0.28	11%	0.30	12%			
P161	0.83	1.74	2.85	0.28	10%	0.30	11%			
P166	1.50	2.18	15.47	6.78	44%	9.15	59%			
P177	0.83	1.64	2.76	0.28	10%	0.30	11%			
P190	0.83	1.53	2.67	0.28	10%	0.30	11%			
P191	1.50	1.70	13.67	6.78	50%	9.15	67%			
P193	1.50	1.79	14.00	6.78	48%	9.15	65%			
P200	0.83	2.44	3.37	0.28	8%	0.30	9%			
P203	1.50	2.67	17.12	6.78	40%	9.15	53%			
P208	1.50	0.66	8.51	6.34	75%	8.50	100%	1.75	13.83	61%
P210	1.50	0.66	8.51	6.34	75%	8.50	100%	1.75	13.83	61%
P211	1.50	0.66	8.52	6.16	72%	8.31	97%	1.75	13.84	60%
P213	1.50	0.67	8.54	6.16	72%	8.31	97%	1.75	13.89	60%
P214	1.50	0.88	9.81	4.84	49%	6.84	70%			
P215	1.50	0.89	9.89	4.84	49%	6.84	69%			
P216	1.25	1.41	7.65	4.84	63%	6.85	89%	1.50	13.40	51%
P217	1.25	1.41	7.65	4.84	63%	6.84	89%	1.50	13.41	51%
P218	1.25	1.12	6.81	4.84	71%	6.85	100%	1.50	11.94	57%
P219	1.25	3.25	11.60	4.84	42%	6.84	59%			
P222	1.25	0.88	6.03	2.11	35%	2.27	38%			
P223	1.25	1.15	6.91	2.10	30%	2.27	33%			
P224	1.25	1.74	8.50	2.10	25%	2.27	27%			
P225	1.25	1.17	6.97	0.16	2%	0.18	3%			
P226	0.83	2.66	3.52	0.16	4%	0.18	5%			
P229	0.83	2.22	3.21	0.16	5%	0.18	5%			
P231	0.83	2.72	3.56	0.16	4%	0.18	5%			
P234	0.83	1.85	2.93	0.16	5%	0.18	6%			
P235	0.67	2.31	1.85	0.16	8%	0.18	9%			
P236	0.83	1.88	2.96	0.28	9%	0.30	10%			
P237	0.67	6.55	3.12	0.18	6%	0.21	7%			
P238	0.83	1.68	2.80	0.28	10%	0.30	11%			
P239	0.67	2.30	1.85	0.16	8%	0.18	10%			
P240	0.67	2.30	1.85	0.16	8%	0.18	10%			
P241	0.67	2.26	1.83	0.16	9%	0.18	10%			
P243	0.67	3.46	2.27	0.16	7%	0.18	8%			
P244	0.67	3.61	2.31	0.16	7%	0.18	8%			

Table 7-1
Sewer Analysis Results
Deficient Pipe Summary
(Existing and Ultimate Conditions)

Name	Diameter, ft	Slope (%)	Theoretical Full Flow Capacity (cfs)	Modeled Existing Max Flow (cfs)	Existing % Full	Modeled Future Max Flow (cfs)	Future % Full	Replacement Diameter (ft)	Theoretical New "Full" Flow Capacity (cfs)[1]	Theoretical New % Full
P245	0.67	3.30	2.21	0.16	7%	0.18	8%			
P246	0.67	2.37	1.88	0.00	0%	0.00	0%			
P260	0.83	0.53	1.57	0.18	12%	0.20	13%			
P263	1.25	0.65	5.20	2.91	56%	4.80	92%	1.50	9.10	53%
P274	1.25	0.49	4.53	0.28	6%	0.30	7%			
P278	0.83	0.56	1.62	0.18	11%	0.20	12%			
P290	1.25	0.66	5.23	2.91	56%	4.81	92%	1.50	9.17	52%
P330	1.25	0.49	4.52	0.28	6%	0.30	7%			
P341	0.83	0.51	1.54	0.18	12%	0.20	13%			
P344	1.25	0.66	5.24	2.91	56%	4.84	92%	1.50	9.19	53%
P384	1.25	0.47	4.41	0.28	6%	0.30	7%			
P386	0.83	5.69	5.15	0.18	4%	0.20	4%			
P395	1.25	0.66	5.24	2.91	56%	4.86	93%	1.50	9.18	53%
P449	1.25	0.66	5.23	2.91	56%	4.86	93%	1.50	9.16	53%
P464	1.00	1.14	3.79	0.28	7%	0.30	8%			
P465	0.83	1.10	2.26	0.18	8%	0.20	9%			
P469	0.83	0.56	1.61	0.18	11%	0.20	13%			
P499	1.25	0.66	5.24	2.91	56%	4.86	93%	1.50	9.19	53%
P526	0.83	0.94	2.09	0.46	22%	0.51	24%			
P541	1.00	2.24	5.31	2.91	55%	4.86	92%	1.25	10.38	47%
P564	1.00	2.13	5.18	2.91	56%	4.86	94%	1.25	10.12	48%
P574	0.83	0.50	1.53	0.46	30%	0.51	33%	1.00	2.71	19%
P605	1.00	2.16	5.22	2.91	56%	4.86	93%	1.25	10.20	48%
P614	0.83	0.53	1.57	0.46	29%	0.51	32%			
P615	0.83	1.37	2.52	0.10	4%	0.10	4%			
P616	0.83	2.22	3.25	0.10	3%	0.10	3%			
P617	0.83	2.00	3.08	0.10	3%	0.10	3%			
P618	0.83	1.14	2.31	0.10	4%	0.10	4%			
P619	0.83	1.14	2.30	0.10	4%	0.10	4%			
P620	0.83	1.10	2.26	0.10	4%	0.10	4%			
P621	0.83	1.64	2.79	0.00	0%	0.00	0%			
P622	0.83	1.64	2.79	0.00	0%	0.00	0%			
P623	1.00	1.83	4.79	0.44	9%	0.70	15%			
P624	1.25	1.45	7.75	2.47	32%	4.16	54%			
P687	0.83	0.60	1.67	0.44	26%	0.70	42%			
P700	1.50	0.32	5.91	2.47	42%	4.17	71%			
P702	0.67	1.80	1.63	0.38	24%	0.43	26%			
P735	0.83	0.50	1.53	0.44	29%	0.70	46%			
P769	1.50	0.32	5.94	2.47	42%	4.18	70%			
P779	0.67	1.06	1.25	0.00	0%	0.00	0%			
P799	1.00	0.20	1.59	0.44	28%	0.70	44%			
P830	1.50	0.32	5.91	2.47	42%	4.18	71%			
P839	1.50	0.25	5.24	2.47	47%	4.18	80%	1.75	8.51	49%
P841	1.00	0.20	1.59	0.44	28%	0.70	44%			
P852	0.67	1.05	1.25	0.00	0%	0.00	0%			
P900	1.00	0.20	1.59	0.88	56%	1.39	88%	1.25	3.10	45%
P902	0.67	0.53	0.88	0.00	0%	0.00	0%			
P908	1.50	0.43	6.84	2.03	30%	3.48	51%			
P933	1.00	0.20	1.59	0.88	56%	1.39	88%	1.25	3.10	45%
P934	1.00	0.20	1.57	0.88	56%	1.39	89%	1.25	3.10	45%
P969	1.50	0.45	6.99	2.03	29%	3.48	50%			
P972	0.83	0.56	1.62	0.88	55%	1.39	86%	1.00	2.86	49%
P974	1.50	0.47	7.15	2.03	28%	3.48	49%			
P993	1.50	0.44	6.96	2.03	29%	3.48	50%			
P994	0.83	0.76	1.90	0.88	46%	1.39	73%			
P995	1.00	1.85	4.83	2.46	51%	3.33	69%			
P996	1.00	2.26	5.33	2.46	46%	3.32	62%			
P997	1.00	1.50	4.35	2.46	57%	3.32	76%	1.25	8.50	39%
P998	1.00	1.85	4.83	2.46	51%	3.33	69%			
P999	1.00	1.50	4.34	2.46	57%	3.32	76%	1.25	8.49	39%
P1000	1.00	1.50	4.35	2.46	57%	3.32	76%	1.25	8.50	39%
P1001	1.00	1.87	4.85	2.46	51%	3.33	69%			
P1002	1.00	1.85	4.83	2.46	51%	3.33	69%			
P1003	1.00	1.52	4.37	2.46	56%	3.32	76%	1.25	8.55	39%
P1013	1.00	1.85	4.83	2.46	51%	3.34	69%			
P1014	1.00	1.85	4.83	2.46	51%	3.34	69%			
P1015	0.83	1.56	2.69	0.46	17%	1.57	58%			

Table 7-1
Sewer Analysis Results
Deficient Pipe Summary
(Existing and Ultimate Conditions)

Name	Diameter, ft	Slope (%)	Theoretical Full Flow Capacity (cfs)	Modeled Existing Max Flow (cfs)	Existing % Full	Modeled Future Max Flow (cfs)	Future % Full	Replacement Diameter (ft)	Theoretical New "Full" Flow Capacity (cfs)[1]	Theoretical New % Full
P1016	0.67	10.52	3.95	0.46	12%	1.57	40%			
P1017	0.67	1.38	1.43	0.46	32%	1.57	110%	0.83	2.73	57%
P1018	0.67	1.45	1.47	0.46	32%	1.57	107%	0.83	2.80	56%
P1019	0.67	1.45	1.47	0.46	32%	1.57	107%	0.83	2.80	56%
P1020	0.67	1.46	1.47	0.46	31%	1.57	106%	0.83	2.81	56%
P1021	0.67	1.45	1.47	0.46	32%	1.57	107%	0.83	2.80	56%
P1022	1.00	1.08	3.69	2.46	67%	3.34	90%	1.25	7.21	46%
P1023	0.67	1.69	1.58	0.32	20%	1.42	90%	0.83	3.02	47%
P1024	1.25	0.50	4.53	2.78	61%	4.82	106%	1.50	7.94	61%
P1025	0.67	1.68	1.58	0.32	20%	1.42	90%	0.83	3.02	47%
P1026	1.25	1.42	7.68	2.66	35%	4.67	61%			
P1027	1.25	0.51	4.60	2.66	58%	4.43	96%	1.50	8.06	55%
P1028	0.67	1.71	1.59	0.32	20%	1.43	90%	0.83	3.04	47%
P1029	1.25	0.51	4.60	2.66	58%	4.41	96%	1.50	8.06	55%
P1030	1.25	0.54	4.73	2.66	56%	4.40	93%	1.50	8.30	53%
P1031	0.67	1.69	1.58	0.32	20%	1.44	91%	0.83	3.02	48%
P1032	1.25	0.51	4.60	2.66	58%	4.38	95%	1.50	8.06	54%
P1033	0.67	1.66	1.57	0.32	20%	1.45	92%	0.83	3.00	48%
P1034	0.67	1.67	1.58	0.32	20%	1.46	93%	0.83	3.01	49%
P1035	0.67	1.66	1.57	0.32	20%	1.47	93%	0.83	3.00	49%
P1036	0.67	3.43	2.25	0.12	5%	0.43	19%			
P1037	0.67	1.13	1.29	0.12	9%	0.38	29%			
P1040	0.67	0.25	0.61	0.12	20%	0.38	62%			
P469a	1.00	1.39	4.18	0.28	7%	0.30	7%			
P841a	1.00	0.20	1.59	0.44	28%	0.70	44%			
P1022a	0.67	3.13	2.16	0.32	15%	1.68	78%	0.83	4.11	41%
P1040a	0.67	1.15	1.31	0.12	9%	0.38	29%			

1. n value in Manning's equation for a PVC pipe is assumed 0.013 , per manufacturer's request.

Table 7-2
Proposed Construction Prioritization and Schedule

Pipe Name	Existing % Full	Future % Full	Priority	Approximate Replacement Year (Flowing 90% Full)
P25	98%	130%	A	2002
P35	97%	130%	A	2002
P36	23%	31%		
P48	24%	32%		
P51	60%	71%		
P52	76%	103%	B	2002_1
P59	75%	101%	B	2002_1
P65	16%	17%		
P73	21%	23%		
P78	74%	100%	B	2002_1
P90	11%	12%		
P93	76%	103%	B	2002_1
P94	16%	18%		
P97	76%	103%	B	2002_1
P98	18%	20%		
994a	22%	38%		
P105	76%	103%	B	2002_1
P110	11%	12%		
P123	53%	72%		
P124	18%	20%		
P135	11%	12%		
P144	53%	72%		
P147	11%	12%		
P156	55%	74%		
P158	11%	12%		
P161	10%	11%		
P166	44%	59%		
P177	10%	11%		
P190	10%	11%		
P191	50%	67%		
P193	48%	65%		
P200	8%	9%		
P203	40%	53%		
P208	75%	100%	B	2010
P210	75%	100%	B	2010
P211	72%	97%	B	2010
P213	72%	97%	B	2010
P214	49%	70%		
P215	49%	69%		
P216	63%	89%	C	2010_2
P217	63%	89%	C	2010_2
P218	71%	100%	B	2010
P219	42%	59%		
P222	35%	38%		
P223	30%	33%		

Table 7-2
Proposed Construction Prioritization and Schedule

Pipe Name	Existing % Full	Future % Full	Priority	Approximate Replacement Year (Flowing 90% Full)
P224	25%	27%		
P225	2%	3%		
P226	4%	5%		
P229	5%	5%		
P231	4%	5%		
P234	5%	6%		
P235	8%	9%		
P236	9%	10%		
P237	6%	7%		
P238	10%	11%		
P239	8%	10%		
P240	8%	10%		
P241	9%	10%		
P243	7%	8%		
P244	7%	8%		
P245	7%	8%		
P246	0%	0%		
P260	12%	13%		
P263	56%	92%	B	2015
P274	6%	7%		
P278	11%	12%		
P290	56%	92%	B	2015
P330	6%	7%		
P341	12%	13%		
P344	56%	92%	B	2015
P384	6%	7%		
P386	4%	4%		
P395	56%	93%	B	2015
P449	56%	93%	B	2015
P464	7%	8%		
P465	8%	9%		
P469	11%	13%		
P499	56%	93%	B	2015
P526	22%	24%		
P541	55%	92%	B	2015
P564	56%	94%	B	2015
P574	30%	33%		
P605	56%	93%	B	2015
P614	29%	32%		
P615	4%	4%		
P616	3%	3%		
P617	3%	3%		
P618	4%	4%		
P619	4%	4%		
P620	4%	4%		
P621	0%	0%		
P622	0%	0%		

Table 7-2
Proposed Construction Prioritization and Schedule

Pipe Name	Existing % Full	Future % Full	Priority	Approximate Replacement Year (Flowing 90% Full)
P623	9%	15%		
P624	32%	54%		
P687	26%	42%		
P700	42%	71%		
P702	24%	26%		
P735	29%	46%		
P769	42%	70%		
P779	0%	0%		
P799	28%	44%		
P830	42%	71%		
P839	47%	80%	C	
P841	28%	44%		
P852	0%	0%		
P900	56%	88%	C	
P902	0%	0%		
P908	30%	51%		
P933	56%	88%	C	
P934	56%	89%	C	
P969	29%	50%		
P972	55%	86%	C	
P974	28%	49%		
P993	29%	50%		
P994	46%	73%		
P995	51%	69%		
P996	46%	62%		
P997	57%	76%	C	
P998	51%	69%		
P999	57%	76%	C	
P1000	57%	76%	C	
P1001	51%	69%		
P1002	51%	69%		
P1003	56%	76%	C	
P1013	51%	69%		
P1014	51%	69%		
P1015	17%	58%		
P1016	12%	40%		
P1017	32%	110%	B	2015
P1018	32%	107%	B	2015
P1019	32%	107%	B	2015
P1020	31%	106%	B	2015
P1021	32%	107%	B	2015
P1022	67%	90%	B	2015
P1023	20%	90%	B	2015
P1024	61%	106%	B	2010
P1025	20%	90%	B	2015
P1026	35%	61%		
P1027	58%	96%	B	2015

Table 7-2
Proposed Construction Prioritization and Schedule

Pipe Name	Existing % Full	Future % Full	Priority	Approximate Replacement Year (Flowing 90% Full)
P1028	20%	90%	B	2015
P1029	58%	96%	B	2015
P1030	56%	93%	B	2015
P1031	20%	91%	B	2015
P1032	58%	95%	B	2015
P1033	20%	92%	B	2015
P1034	20%	93%	B	2015
P1035	20%	93%	B	2015
P1036	5%	19%		
P1037	9%	29%		
P1040	20%	62%		
P469a	7%	7%		
P841a	28%	44%		
P1022a	15%	78%	C	2010_2
P1040a	9%	29%		

Project Priorities	
Priority A	>90% Full Flow in Existing Model
Priority B	>90% Full Flow in Future Model
Priority C	>75% Full and <90% Full Flow in Future Model

Note:
1. Although pipes P52, P59, P78, P93, P97 and P105 are flowing more than 75% full but not more than 90% full, it would be advantageous to replace these pipes in conjunction with adjacent priority "A" pipes.
2. Although pipes P216, P217, P1022a would not be flowing 90% full, these are proposed to be under priority "B" to maintain continuity and maintain efficiency of improvements.

Table 7-3
Improvement Plan for Problem Areas

Priority No.	Location	From / To	Problem	Solution	Total Project Cost (2002$'s)
A	Spruce Street East of Kansas Ave., Sewer easement east of Northbend St.	Manhole 105-48	Immediate Capacity Problem in the reach 35-18 due to flat slopes, Future Capacity Problem in reach 105-51 due to flat slopes and increasing flow from UCR , surcharge within manholes 35,25 and 18	Replace existing pipes P105 and P97 with a 21" PVC pipe, new 21" PVC pipe in the reach 93-84, replace pipes P84, P77,P69, P61 and P56 with an 18" PVC pipe and connect reaches 45-48 with a 21" PVC pipe.	$686,500
B	Spruce Street, Chicago Ave., University Ave.	Manhole 218-215, Manhole 213-203, Manhole 624- 219, Manhole 1032-1022, Manhole 1022-1014, Manhole 1022-1016	Future Capacity Problem due to increased flow in the system. Main contributor will be UCR.	Replace future deficient pipes with PVC pipes. See table 7-6 for replacement diameter of pipes. A flow monitoring within 5 years should be considered to re-evaluate the system.	$2,199,200
C	Chicago Ave., University Ave.	Manhole 1003-996, Manhole 972-839	Future Capacity Problem due to increased flow in the system. Main contributor will be UCR.	Replace future deficient pipes with PVC pipes. See table 7-7 for replacement diameter of pipes. Visual inspection of the system and inspection every five years should be done.	$450,000

replacement at the earliest possible time. Two alternatives were considered to replace these currently deficient pipes. Alternative 1 features replacement of pipes P25 and P35 by pipe bursting and replacement of pipes P105, P97, P93, P78, P59 and P52 by open trench cutting. Pipe bursting was considered for reach 35-18 due to its proximity to freeway, access problems and pipeline running close to back yard fences of houses in that reach. Total cost of this alternative is $822,200. See figure 22 for pipe layout exhibit and table 7-4 for approximate cost estimate. Alternative 2 features diversion of wastewater flow from Spruce Street Trunk Sewer along Spruce Street, the sewer easement and finally connecting to the 36-inch trunk sewer line along Fairmount Boulevard. These pipes are proposed to be replaced by conventional open trench cutting. Additional sewer easement would be required in the reach 69-56 to accommodate new sewer line. See figure 23 for pipe layout exhibit and table 7-5 for approximate cost estimate.

7.7 Cost Estimate

Unit costs of pipes are based on rates obtained from the contractors over telephone, bid prices for similar projects and from web site www.get-a-quote.net. The cost of construction includes labor, materials, excavation, backfill and all other items associated with pipe laying. To estimate total cost, cost of mobilization / demobilization (7%), traffic control (7%), bond (1%), contractor's profit (15%) and construction contingency (20%) is added to the cost of construction. For priorities "B" and "C", the cost estimate is based on current year prices and no escalation has been added to estimate future cost. Following is the summary of cost for the various priorities. See tables 7-4, 7-5, 7-6 and 7-7 for a breakdown of these costs.

- Priority "A", Alternative 1 - $822,200
- Priority "A", Alternative 2 - $686,500
- Priority "B" - $2,200,000
- Priority "C" - $450,000

Table 7-4
Cost Estimate For Priority "A" Projects (Alternative 1)

Location	Description	Existing Diameter (inch)	New Diameter (inch)	Unit	Quantity	Unit Cost	Approx Total Cost(2002 $'s)
Reach 35-18	Replace Pipe P35 by pipe bursting	18	20	LF	440	$400	$176,000
(Parallel to Fwy)	Replace Pipe P25 by pipe bursting	18	20	LF	447	$400	$178,800
Reach 105-51	Replace pipe P105	18	21	LF	248	$110	$27,280
(Spruce St./Main St)	Replace pipe P97	18	21	LF	62	$110	$6,820
	Replace pipe P93	18	21	LF	326	$110	$35,860
	Replace pipe P78	18	21	LF	218	$110	$23,980
	Replace pipe P59	18	21	LF	169	$110	$18,590
	Replace pipe P52	18	21	LF	25	$110	$2,750
	Replace Manholes			EA	10	$3,000	$30,000
	Drainage Ditch Rehabilitation			LS			$25,000
	Reconnect sewer laterals			EA	4	$500	$2,000
						Total =	$527,080
Mobilization / Demobilization (7%)							$36,896
Traffic Control (7%)							$36,896
Bond (1%)							$5,271
Contractor's Profit(15%)							$79,062
Subtotal:							$685,204
Construction Contingency(20%)							$137,041
Total Cost							**$822,245**

Table 7-5
Cost Estimate For Priority "A" Projects (Alternative 2)

Location	Description	Existing Diameter (inch)	New Diameter (inch)	Unit	Quantity	Unit Cost	Approx Total Cost(2002 $'s)
Reach 105-48	Replace pipe P105	18	21	LF	248	$110	$27,280
(Spruce St.)	Replace pipe 97	18	21	LF	62	$110	$6,820
	New Pipe (MH93 - MH84)		21	LF	430	$110	$47,300
	Replace pipe P84	8	18	LF	201	$95	$19,095
	Replace pipe P77	8	18	LF	218	$95	$20,710
	Replace pipe P69	8	18	LF	220	$95	$20,900
	Replace pipe P61	8	18	LF	127	$95	$12,065
	Replace pipe P56	8	18	LF	297	$95	$28,215
	New pipe (MH45 - MH48)		21	LF	38	$110	$4,180
	Rehab / Replace Manhole			EA	12	$3,000	$36,000
	Reconnect Sewer Laterals			EA	35	$500	$17,500
	Land Acquisition for Sewer Easement			LS			$200,000
						Total =	$440,065
Mobilization / Demobilization (7%)							$30,805
Traffic Control (7%)							$30,805
Bond (1%)							$4,401
Contractor's Profit(15%)							$66,010
Subtotal:							$572,085
Construction Contingency(20%)							$114,417
Total Cost							**$686,501**

Table 7-6
Cost Estimate For Priority "B" Projects (Replace Future Deficient Pipe)

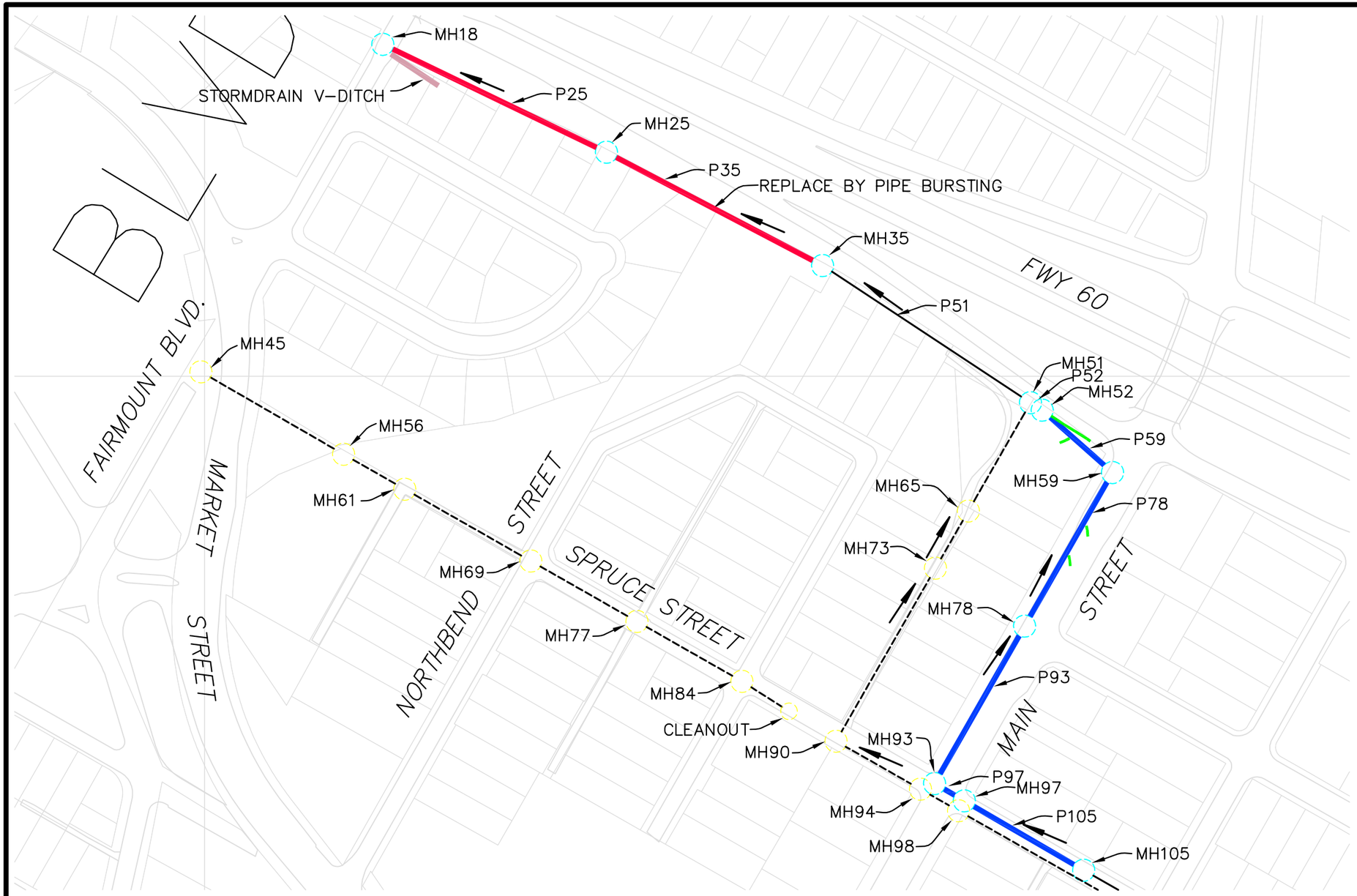
Location	Description	Existing Diameter (inch)	New Diameter (inch)	Unit	Quantity	Unit Cost	Approx Total Cost (2002$'s)
Spruce Street	Replace Pipe P208	18	21	LF	138	$110	$15,180
	Replace Pipe P210	18	21	LF	177	$110	$19,470
	Replace Pipe P211	18	21	LF	348	$110	$38,280
	Replace Pipe P213	18	21	LF	400	$110	$44,000
	Replace Pipe P216	15	18	LF	388	$95	$36,860
	Replace Pipe P217	15	18	LF	269	$95	$25,555
	Replace Pipe P218	15	18	LF	269	$95	$25,555
	Rehab / Replace Manhole			EA.	12	$3,000	$36,000
	Reconnect Sewer Laterals			EA.	6	$500	$3,000
	Jack and bore for railroad crossing -Pipe211			LF	348	$900	$313,200
Chicago Ave.	Replace Pipe P263	15	18	LF	315	$95	$29,925
	Replace Pipe P290	15	18	LF	315	$95	$29,925
	Replace Pipe P344	15	18	LF	330	$95	$31,350
	Replace Pipe P395	15	18	LF	366	$95	$34,770
	Replace Pipe P449	15	18	LF	274	$95	$26,030
	Replace Pipe P499	15	18	LF	250	$95	$23,750
	Replace Pipe P541	12	15	LF	238	$90	$21,420
	Replace Pipe P564	12	15	LF	162	$90	$14,580
	Replace Pipe P605	12	15	LF	367	$90	$33,030
	Rehab / Replace Manhole			EA.	17	$3,000	$51,000
	Reconnect Sewer Laterals			EA.	18	$500	$9,000
University Ave.	Replace Pipe P1017	8	10	LF	311	$80	$24,880
	Replace Pipe P1018	8	10	LF	347	$80	$27,760
	Replace Pipe P1019	8	10	LF	249	$80	$19,920
	Replace Pipe P1020	8	10	LF	89	$80	$7,120
	Replace Pipe P1021	8	10	LF	253	$80	$20,240
	Replace Pipe P1022	12	15	LF	105	$90	$9,450
	Replace Pipe P1023	8	10	LF	449	$80	$35,920
	Replace Pipe P1024	15	18	LF	400	$95	$38,000
	Replace Pipe P1025	8	10	LF	478	$80	$38,240
	Replace Pipe P1027	15	18	LF	215	$95	$20,425
	Replace Pipe P1028	8	10	LF	374	$80	$29,920
	Replace Pipe P1029	15	18	LF	221	$95	$20,995
	Replace Pipe P1030	15	18	LF	37	$95	$3,515
	Replace Pipe P1031	8	10	LF	333	$80	$26,640
	Replace Pipe P1032	15	18	LF	323	$95	$30,685
	Replace Pipe P1033	8	10	LF	309	$80	$24,720
	Replace Pipe P1034	8	10	LF	58	$80	$4,640
	Replace Pipe P1035	8	10	LF	465	$80	$37,200
	Replace Pipe P1022a	8	10	LF	39	$80	$3,120
	Rehab / Replace Manhole			EA.	35	$3,000	$105,000
	Reconnect Sewer Laterals			EA.	39	$500	$19,500
						Total =	$1,409,770

Table 7-6
Cost Estimate For Priority "B" Projects (Replace Future Deficient Pipe)

Location	Description	Existing Diameter (inch)	New Diameter (inch)	Unit	Quantity	Unit Cost	Approx Total Cost (2002$'s)
Mobilization / Demobilization (7%)							$98,684
Traffic Control (7%)							$98,684
Bond (1%)							$14,098
Contractor's Profit(15%)							$211,466
Subtotal:							$1,832,701
Construction Contingency(20%)							$366,540
Total Cost							**$2,199,241**

Table 7-7
Cost Estimate For Priority "C" Projects (Replace Future Deficient Pipe)

Location	Description	Existing Diameter (inch)	New Diameter (inch)	Unit	Quantity	Unit Cost	ApproxTotal Cost(2002$'s)
Chicago Ave.	Replace Pipe P839	18	21	LF	76	$110	$8,360
	Replace Pipe P900	12	15	LF	330	$90	$29,700
	Replace Pipe P933	12	15	LF	330	$90	$29,700
	Replace Pipe P934	12	15	LF	17	$90	$1,530
	Replace Pipe P972	10	12	LF	269	$85	$22,865
	Rehab / Replace Manhole			EA	9	$3,000	$27,000
	Reconnect Sewer Laterals			EA	28	$500	$14,000
University Ave.	Replace Pipe P997	12	15	LF	389	$90	$35,010
	Replace Pipe P999	12	15	LF	526	$90	$47,340
	Replace Pipe P1000	12	15	LF	254	$90	$22,860
	Replace Pipe P1003	12	15	LF	405	$90	$36,450
	Rehab / Replace Manhole			EA	7	$3,000	$21,000
	Reconnect Sewer Laterals			EA	28	$500	$14,000
						Total =	$295,815
Mobilization / Demobilization (7%)							$20,707
Traffic Control (7%)							$20,707
Bond (1%)							$2,958
Contractor's Profit(15%)							$20,707
Subtotal:							$374,894
Construction Contingency(20%)							$74,979
Total Cost of Construction							**$449,873**



LEGEND

- PROPOSED 20" HDPE PIPE
- PROPOSED 21" PVC PIPE
- SEWER LATERAL
- EXISTING PIPE
- EXISTING MANHOLE
- MANHOLE TO BE REPLACED

N

GRAPHIC SCALE

200 0 100 200

(IN FEET)

1 inch = 200 ft.

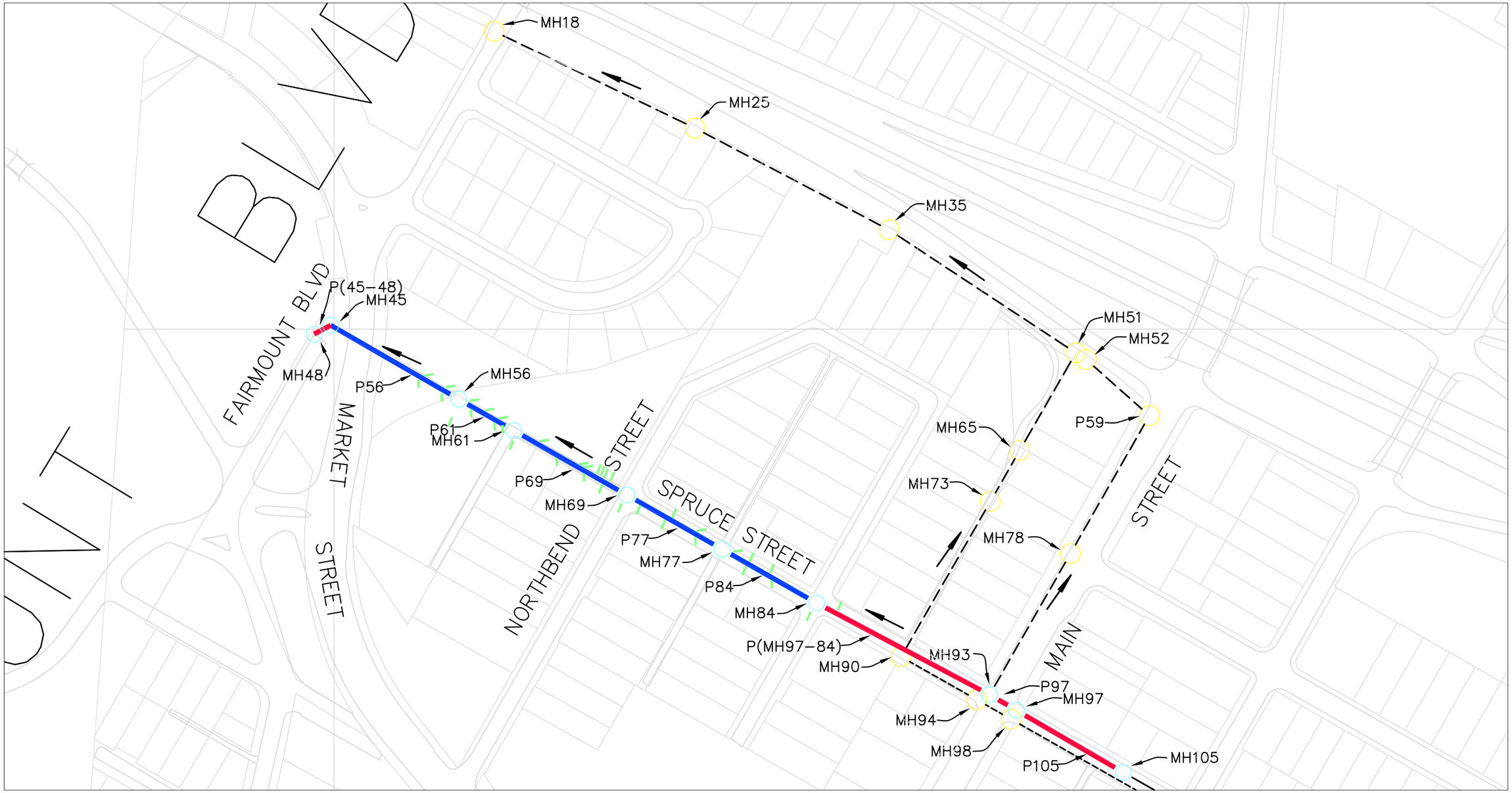
Engineering
Planning
Surveying
Construction Services
PBSJ
3610 Central Avenue
Suite 500
Riverside, CA 92506
Tel:(909) 341-6380
Fax:(909) 341-6389

CITY OF RIVERSIDE
SPRUCE STREET SEWER CAPACITY STUDY

PRIORITY "A" – ALTERNATIVE 1

JUNE 2002

FIGURE 22



LEGEND

- PROPOSED 21" PIPE
- PROPOSED 18" PIPE
- SEWER LATERAL
- MANHOLE TO BE REPLACED

N

GRAPHIC SCALE

200 0 100 200

(IN FEET)

1 inch = 200 ft.

Engineering
Planning
Surveying
Construction Services

PBSJ

3610 Central Avenue
Suite 500
Riverside, CA 92506
Tel:(909) 341-6380
Fax:(909) 341-6389

CITY OF RIVERSIDE
SPRUCE STREET SEWER CAPACITY STUDY

PRIORITY "A" – ALTERNATIVE 2

JUNE 2002

FIGURE 23

Appendix B
TEQUESQUITE TRUNK SEWER STUDY

City of Riverside
Tequesquite Trunk Sewer Study

Prepared By:

3610 Central Avenue, Suite 500
Riverside, CA 92506
(909) 341-6380

December, 2003

TEQUESQUITE TRUNK SEWER STUDY

City of Riverside

Client Representative L.F.(Sandy) Caldwell, P.E.

PBS&J

Project Manager Louis Atwell, P.E.

Technical Advisory Mark Iverson, P.E.

Project Engineer Barmeshwar Rai, P.E.

J.N. 590065

December, 2003

PBS&J 3610 Central Avenue, Suite 500, Riverside, CA 92506

TABLE OF CONTENTS

		Page Number
Executive Summary		*Ex-1*
ES.1	Introduction……	*Ex-1*
ES.2	Existing Sewer System ……..	*Ex-1*
ES.3	Methodology…….	*Ex-1*
ES.4	Project Priorities and Cost……..	*Ex-2*
1.0	*Introduction*	1
	1.1 Background	1
	1.2 Study Area	1
	1.3 Objective	1
	1.4 Scope and Study Approach	2
2.0	*Land Use*	4
	2.1 Existing Land Use	4
	2.2 Industrial Business Park	4
	2.3 Proposed Land use	4
3.0	*Existing Sewer System*	5
	3.1 System Overview	5
	3.2 Collection System	5
	3.3 System Hydraulics	8

3.4 Tributary Areas 14

4.0 Determination of Sewer Flows 16

4.1 Flow Monitoring 16

4.2 Results of Flow Monitoring 17

5.0 Estimated Ultimate Flow 19

5.1 Methodology 19

5.2 Flow Coefficients 19

5.3 Representative Diurnal Hydrographs 20

6.0 Computer Model Simulation Analysis 22

6.1 Methodology 22

6.2 Limitations of Modeling 23

7.0 *Deficiencies and Solutions*..... 24

7.1 Deficient and Marginally Deficient Pipes 24

7.2 Project Prioritization Methodology 24

7.3 Recommended Improvements 25

7.4 Grouping of Projects 25

7.5 Construction Schedule 26

7.6 Alternatives 26

7.7 Cost Estimate 26

LIST OF TABLES

Page Follows/On

Ex-1	Summary of Priorities	*Ex-3*
2-1	Summary of Wastewater Generating Land Use	5
3-1	Summary of Modeled Sewer Lines within Study Area	6
3-2	Tributary Areas and Land Use	15
5-1	Theoretical Flow Summary Based on Land Use	21
5-2	Current Flow from Land Use Categories	21
5-3	Future Flow from Land Use Categories	21
7-1-A	Sewer Analysis Results (Existing Conditions)	23
7-1-B	Sewer Analysis Results (Future Conditions)	23
7-2	Proposed Construction Prioritization	24
7-3	Summary of Improvement Plans for Problem Areas	25
7-7-A	Cost Estimate for Priority "A" Projects	27
7-7-B	Cost Estimate for Priority "B" Projects	27
7-7-C	Cost Estimate for Priority "C" Projects	27

LIST OF FIGURES

Follows Page

1	Vicinity Map	1
2	Study Area	1

3 Land Use Plan 4

4 Flow Monitoring Stations 4

5 Sewer System and Pipe Diameters 5

6 Existing Manholes 8

7 Existing Pipes 8

8 Tributary Areas 15

9A to12 Adjusted Flows at Meters 18

13 Existing and Ultimate Landuse Flow Contributions 20

14 to17 Representative Diurnal Hydrographs 21

18 Existing Flow Conditions 24

19 Existing System Deficiencies (Velocity) 24

20 Ultimate Flow Conditions 24

21 Priority "A" 27

22 Priority "B" 27

23 Priority "C" 27

APPENDIX

Appendix A – Flow Data at Meter Locations

Appendix B – City of Riverside, Sewer Design Guidelines

Appendix C – Market Street Trunk Sewer Study

Executive Summary

ES.1 Introduction

This report presents the results of the Tequesquite Trunk Sewer System Capacity Study prepared by PBS&J for the City of Riverside. The report contains recommendations regarding system deficiencies as identified by hydraulic model XP-SWMM (XP Software, Version 2000).

The City of Riverside is located in the County of Riverside at the intersection of three major freeways; Route 91, Route 60 and Route 215. The study area encompasses approximately 13,000 acres of mixed land use development and is generally bounded by University of California (UCR) to the North, Tequesquite Avenue to the West, Van Buren Boulevard to the South and Freeway 215 to the East. The study area is essentially a fully developed community, comprising single family residential, multi family residential, commercial and light industrial areas with vacant lands to be developed in the future. The areas not falling under the City's jurisdiction are not part of this study. The vacant area designated as Industrial Business Park (IBP) in Sycamore Canyon Park Neighborhood would be one of the major contributors of future sewage flow to the system.

ES.2 Existing Sewer System

The existing trunk sewer system within the study area is comprised of approximately 21.8 miles of gravity sewer main and 1.6 miles of force main. The gravity sewer main lines range in sizes from 8-inch to 42-inch in diameter and there are 397 manholes. These sewer lines are essentially VCP and the manholes are typically brick lined. The force main line is a 16-inch ductile iron pipe. The City of Riverside owns and operates the sewer system.

ES.3 Methodology

For determination of current wastewater flows, flow monitoring was performed at five (5) strategic locations. These meter locations were chosen to observe actual flow characteristics for various sub areas with a distinct land use pattern within the study area. The flow monitoring was accomplished over a two-week period. The flow results were carefully evaluated for their accuracy and some adjustments were made based on depth of flow at meter locations. The readings at meter no. 2 were discarded for inconsistencies. The flow data received from the City for the Pepsi Plant, Ralph Storage Facility and Edgemont Community were also evaluated and used for flow calculation.

A theoretical estimate of current and future wastewater flow was estimated based on factors from the City of Riverside "Criteria for Sewer Facility Design". Residential wastewater flow was determined by using

current and future projected population, whereas commercial and industrial flow was determined based on acreage and City estimated flow coefficients.

The Computer Model Simulation Analysis involved evaluation of available capacity in the existing collection system under present and future development conditions. Based on the results of model runs, system deficiencies were identified on a priority basis and a phased facility improvement plan was developed to allow for the projected growth within the study area.

ES.4 Project Priorities and Cost

Deficient and marginally deficient pipes were identified from the results of model runs and were prioritized for replacement / re-habilitation purpose. The pipes that are currently flowing more than 90% full under modeled existing maximum flow conditions and needing near term (2004-2007) replacement / re-habilitations are grouped under priority "A". The pipes that would flow more than 90% full in modeled years 2008-2013 under anticipated maximum future flow conditions are classified as priority "B".

The future development of IBP in the Sycamore Canyon Park Community would be a prominent source of wastewater generation. The existing trunk sewer system would require major replacement / re-habilitation to accommodate this anticipated flow. So, an alternative system was studied and recommended to divert flow through a "new" proposed trunkline system.

This system would begin at the Central Avenue and Canyon Crest Drive intersection, move along Canyon Crest Drive, Martin Luther King Boulevard, Pennsylvania Avenue, Victoria Avenue and Cridge Street before joining the existing trunk sewer system west of Hwy 91. The future pipelines within this alternative, and existing pipes flowing more than 75% full under future maximum flow conditions are grouped under priority "C". Some adjustment of priorities and combining of improvements was done for continuity and efficiency of improvements.

The time phased improvements for various priorities are listed in Table 7-2. The approximate cost of recommended improvements is summarized in Tables 7-7-A, 7-7-B and 7-7-C.

Under existing flow conditions, a total of 8,000 linear feet of priority "A" deficiencies were identified, requiring near term (2004-2007) attention. Additional deficiencies predicted under ultimate flow conditions (Priority "B") include an additional 17,000 linear feet of inadequate sewer lines. The estimated capital cost to remedy these identified deficiencies (in year 2003 $'s) is approximately $2,757,000 for Priority "A" and approximately $6,734,000 for Priority "B". The total length of pipelines under Priority "C" would be approximately 24,000 feet and the cost of Priority "C" projects would be approximately $8,400,000. However, it may be that not all of the

Priority "B" and Priority "C" improvements will need to be actually implemented. Only those where surcharging (within manhole) and other problems are deemed imminent should be considered for improvement. Periodic flow monitoring is also recommended to verify anticipated deficiencies and need for improvements. The priorities are summarized in the table Ex-1:

Table Ex-1
Summary of Priorities

Priority	Approximate Pipeline Length (feet)	Location	Replacement Year	Total Project Cost (year 2003$'s)
"A"	8,000	Tequesquite Avenue, Near Hwy 91, Victoria Country Club, Eastridge Avenue, 13th Street, 5th Street	2004-2007	$2,757,000
"B"	17,000	Tequesquite Avenue, Riverside Community College, Victoria Country Club, Trautwein Road, Eastridge Avenue	2008-2013	$6,734,000
"C"	24,000	Canyon Crest Drive, Martin Luther King Boulevard, Pennsylvania Avenue, Victoria Avenue, Cridge Avenue, Wood Road, Brockton Avenue	2014-2018	$8,400,000

1.0 INTRODUCTION

1.1 Background

On May 12, 2003 the City of Riverside (City) retained PBS&J to prepare a Trunk Sewer System Study. The study is necessitated by the fact that the City is experiencing sewer capacity issues along the Tequesquite Avenue Trunk Sewer Line and its other tributary sewers.

1.2 Study Area

The City of Riverside is located in the northwest corner of the County of Riverside at the intersection of three major freeways; Route 91, Route 60 and Route 215. Founded in 1870, the City is known for its citrus industry, world famous Mission Inn and other historical monuments. Figure-1 is a Vicinity Map depicting the City's location and its accessibility. Figure 2 shows the study area. The study area shown in Figure 2 encompasses approximately 13,000 acres and is generally bounded by University of California (UCR) to the North, Tequesquite Avenue to the West, Van Buren Boulevard to the South and Freeway 215 to the East. The areas not falling within City's jurisdiction are not part of this study. For purpose of this study, the area has been divided into 29 tributary sub-areas, where downstream sub-areas intercept sewage flow from upstream sub-areas. To obtain "real" flow information for this study, sewage flow meters were placed at strategic locations to monitor cumulative flows contributed from the tributary sub-areas.

In general, the study area is considered to be a mature community comprised of single family residential, multi-family residential, commercial and light industrial uses. The vacant area designated as Industrial Business Park in Sycamore Canyon Neighborhood would be one of the major contributors of future sewage flow within the study area. Another area marked as Sycamore Canyon Park is a reserved area.

1.3 Objective

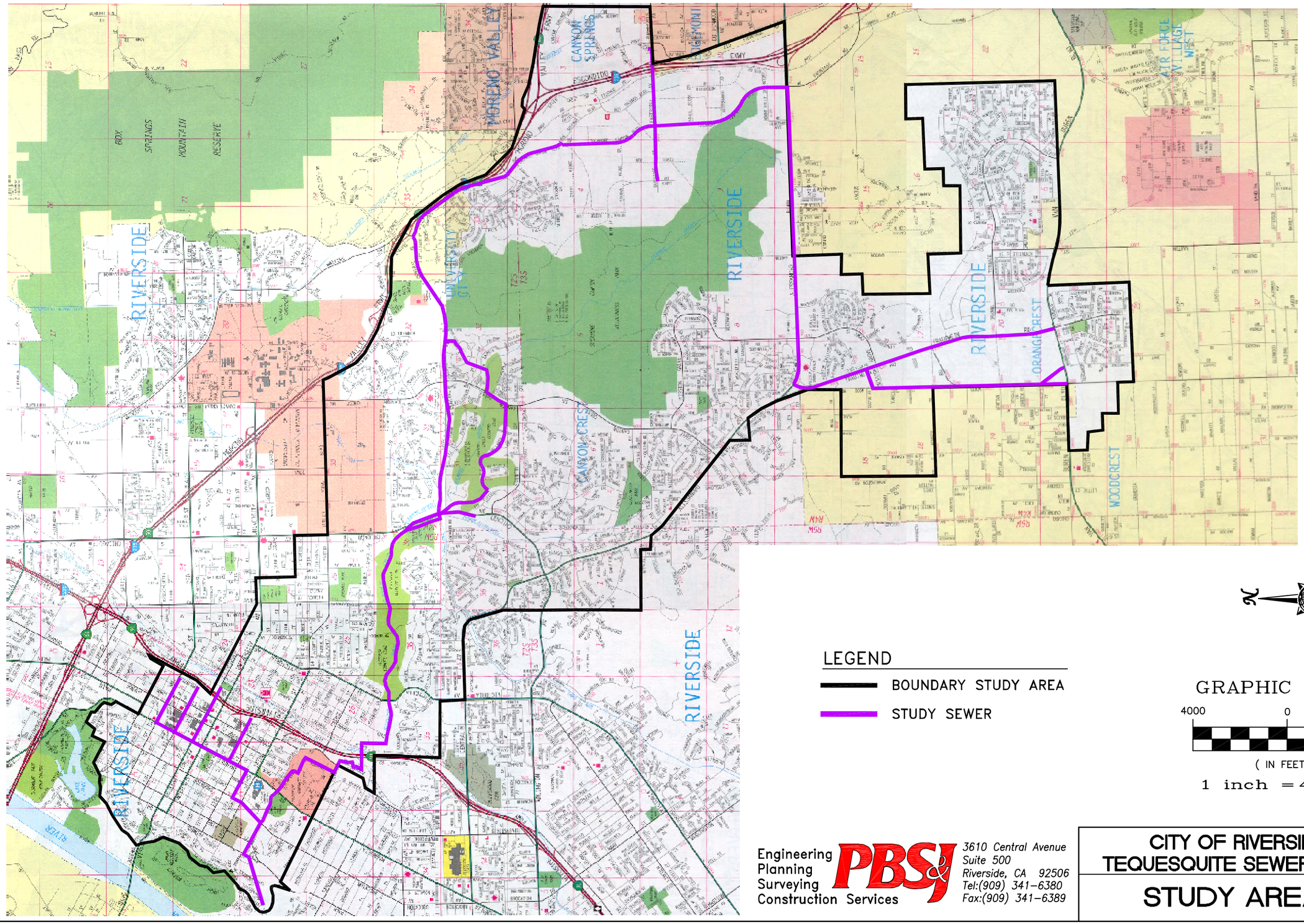
The objective of this Sewer System Capacity Study is to provide a comprehensive evaluation of the capacity of the sewer system within the study area, identify deficiencies in the current system,

Engineering
Planning
Surveying
Construction Services
PBSJ
3610 Central Avenue
Suite 500
Riverside, CA 92506
Tel:(909) 341-6380
Fax:(909) 341-6389

CITY OF RIVERSIDE
TEQUESQUITE SEWER STUDY

FIGURE 1

VICINITY MAP



Engineering
Planning
Surveying
Construction Services

PBSJ

3610 Central Avenue
Suite 500
Riverside, CA 92506
Tel:(909) 341-6380
Fax:(909) 341-6389

CITY OF RIVERSIDE
TEQUESQUITE SEWER STUDY

FIGURE 2

STUDY AREA MAP

and evaluate alternatives to enhance the conveyance capacity to accommodate ultimate wastewater flows anticipated to be generated in the study area.

1.4 Scope and Study Approach

Specific work tasks undertaken for this study are summarized as follows:

- Kickoff Meeting

  An initial meeting was held between PBS&J and the City to discuss project scope, communication protocol, scheduling of flow monitoring dates and explanation of methodology involved, and field data and other digital files to be provided by the City.

- Progress Meetings

  Informal Project Progress Meetings were held to discuss on going issues and progress of study.

- Flow Monitoring and Hydrograph Development

  The sub-consultant, Downstream Services Inc, installed, maintained, and collected flow data from five (5) monitoring stations throughout the study area. They submitted the collected raw data in electronic/hard copy format to PBS&J. PBS&J then processed and reviewed this information and created a hydraulic database. The City provided a copy of City's General Plan for estimation of current and future flows. Other information like as-built plans of wastewater facilities were provided by the City as and when requested by PBS&J.

- Model Development

  Model development included input data collection, conversion of data and calibration. The City's GIS staff made available data pertaining to roads, sewers, land use and other utilities in ArcView format on a CD. As built plans for trunk line sewer were reviewed. Data available from GIS system and as built plans were placed in a database system (MS Excel) as a pre-processor for XP-SWMM model development. Calibration of model was done after construction of the model and additional data input.

- Draft Report

  Based on the calibrated model and City's criteria for Sewer Facility Design, a Draft Report was prepared that summarizes existing and future capacity problems. Alternatives were suggested for additional or alternate sewer improvements along with probable costs. The draft report was reviewed by the City personnel for their comments and suggestions.

- Final Report

  Draft Report review comments from the City were incorporated into the Final Report along with any additional information or research in order to reflect a final level of study completion. The Final Report includes data and information assembled, alternatives evaluated, capital improvement recommendations to remediate anticipated deficiencies, and approximate cost.

A comprehensive evaluation of the sewage collection system to accomplish the above-summarized scope entailed the following multi-step approach:

- Review of as built plans provided by the City to determine system configuration, inverts, pipe sizes and slopes.
- Use of detailed database provided by the City in Arcview format.
- Creation of computer hydraulic model using existing sewer system to study project area.
- Identification of flow monitoring station locations.
- Identification of tributary areas contributing sewage flow to meter locations.
- Installation of flow meters and monitoring of flows at the selected locations on continuous basis for two-week period.
- Review of current land use in study area per GIS information from the City and determination of existing land use, population and vacant land.
- Assessment of ultimate land use and projected population.
- Review and evaluation of metered data from flow monitoring stations.
- Development of flow coefficients and representative diurnal flow patterns based on typical curves for various land uses and observed flows from monitored sub areas which are dominated by a specific land use.
- Modeling of sewer system, deficiency identification, and model simulation of remedial alternatives using above -mentioned information as input data.
- Evaluation of alternatives, optimization, cost comparison.
- Prioritization of recommended improvements, including identification of critical pipelines which need immediate attention.

- Draft Report and recommendations including phased improvements and costs.
- Review by the City, comments and discussion.
- Final Report

2.0 LAND USE

2.1 Existing Land Use

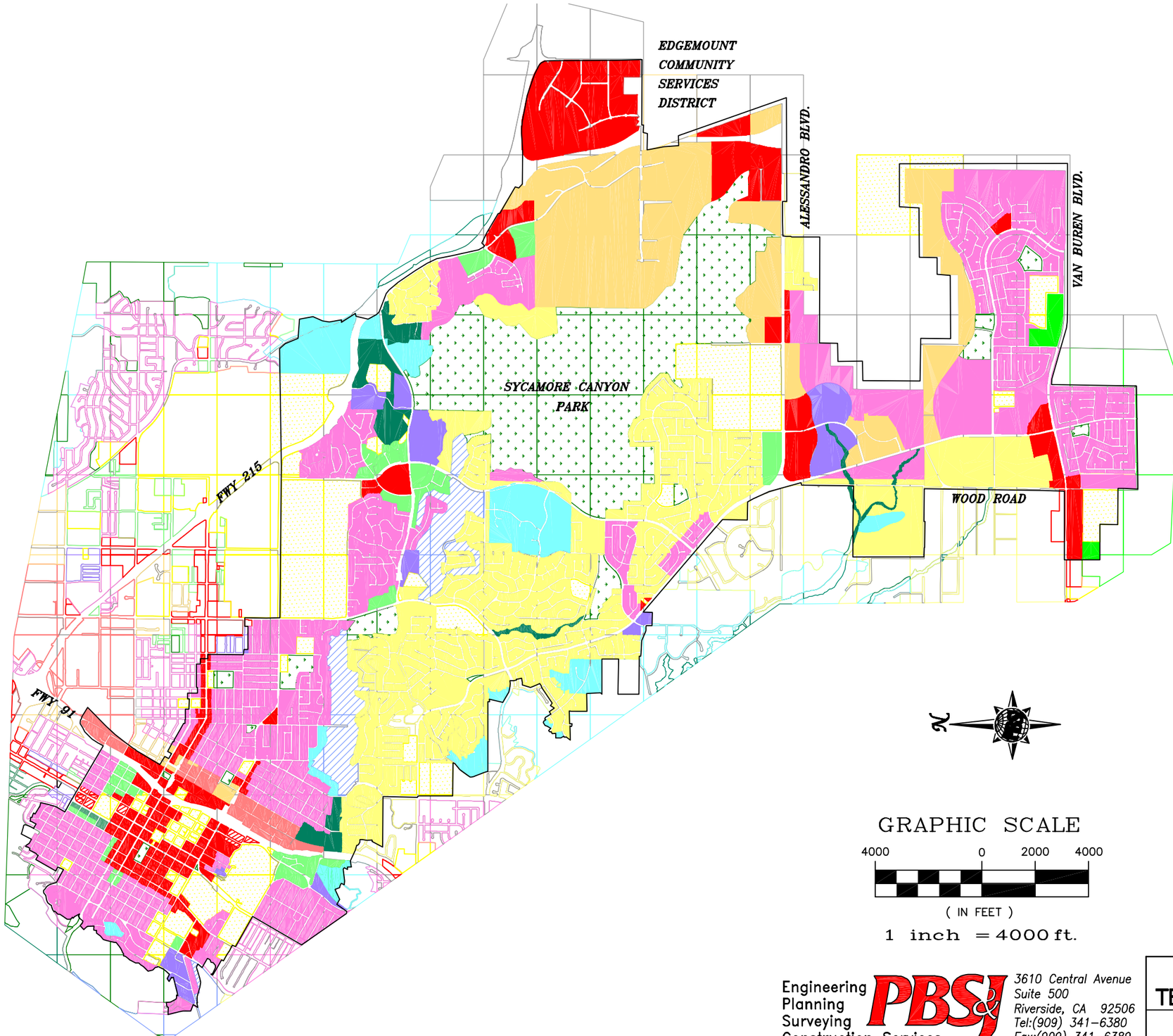
Land use is the basis for estimating sewage flow from the majority of the study area. The land use pattern for this study was developed from the GIS information provided by the City. Figure 3 shows land use for the City portion of the study area based on the City's "Land Use" GIS layer. For the purpose of this study, land uses in the study area have been broadly classified into four categories: Single Family Residential (SFR), Multi Family Residential (MFR), Commercial and Industrial. Sycamore Canyon Park, which is marked as Public Facilities and Open Space is a non -flow generating area. Table 2-1 summarizes the areas within the study area that would generate wastewater flow.

2.2 Industrial Business Park (IBP)

The City has designated approximately 800 Acres of land to be developed as Industrial Business Park in Sycamore Canyon Park Community. This area is north of Alessandro Boulevard and west of Freeway 215. This area was designated to house a large shopping mall in addition to many business developments. When fully developed, it would be a major contributor of sewage flow in the Tequesquite Trunk Sewer System.

2.3 Proposed Land Use

The study area is primarily a mature community. With the exception of the area designated as Industrial Business Park near the 215 Freeway, there is little vacant land remaining for future development. The majority of the remaining growth is planned to take place as part of the Industrial Business Park development north of Alessandro Boulevard, along Sycamore Canyon Boulevard. It is assumed that the majority of vacant lots within the study area would be fully developed by year 2018.



LEGEND

- INDUSTRIAL BUSINESS PARK
- PARKS PUBLIC (RESERVED AREAS)
- RESIDENTIAL HILLSIDE
- INDUSTRIAL GENERAL
- PUBLIC FAC. & OPEN SPACE
- RESIDENTIAL LOW DENSITY – (SFR)
- RESIDENTIAL MEDIUM DENSITY – (SFR)
- RESIDENTIAL HIGH DENSITY – (MFR)
- RESIDENTIAL MEDIUM DENSITY – (MFR)
- AGRICULTURE
- COMMERCIAL BUSINESS OFFICE
- MIXED USE – OFFICE EMPHASIS – (COMM)
- MIXED USE – RESIDENTIAL EMPHASIS – (SFR)
- PKO – PARK OTHER RECREATION

N

GRAPHIC SCALE

4000 0 2000 4000

(IN FEET)

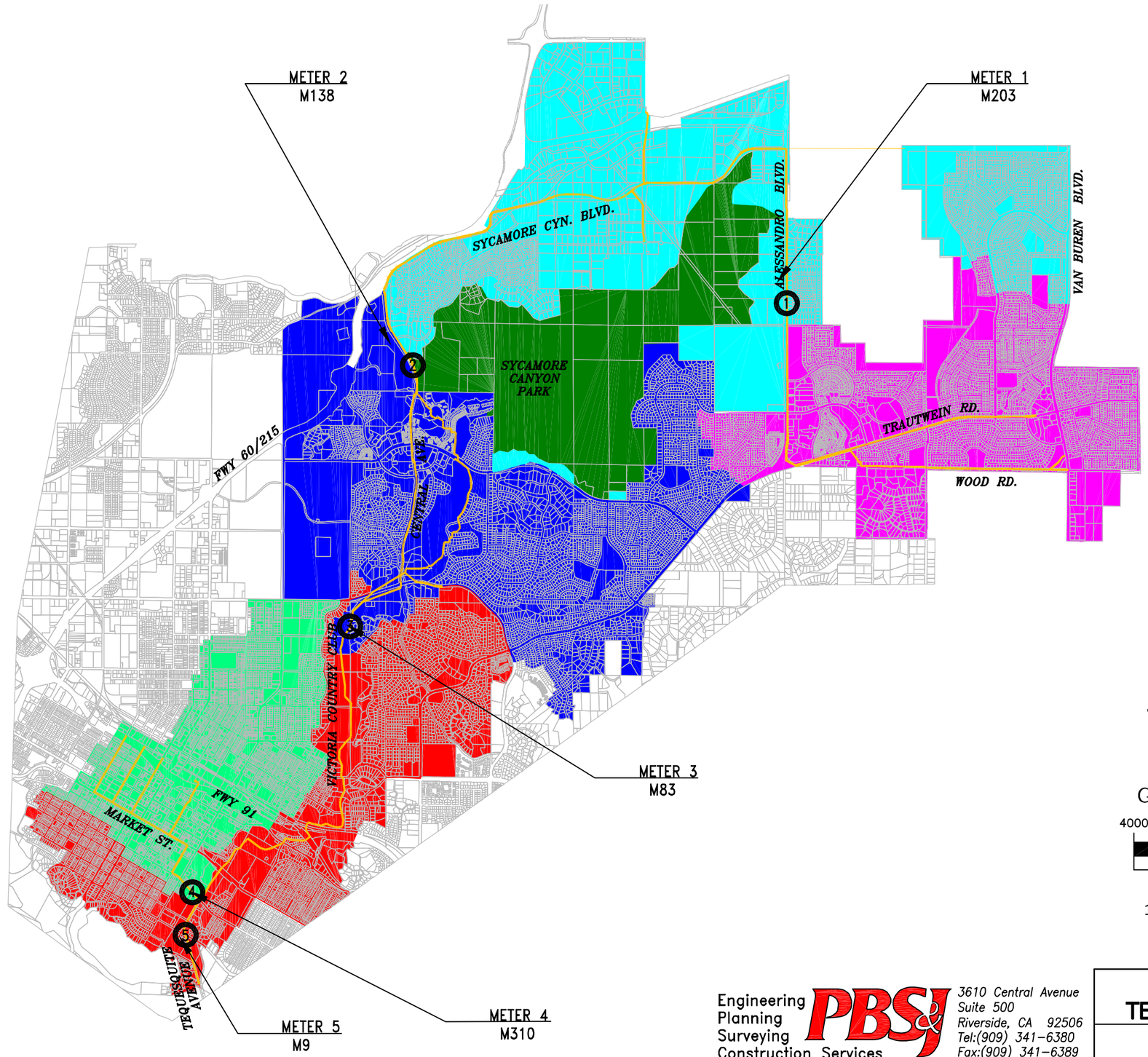
1 inch = 4000 ft.

Engineering
Planning
Surveying
Construction Services
PBSJ
3610 Central Avenue
Suite 500
Riverside, CA 92506
Tel:(909) 341-6380
Fax:(909) 341-6389

CITY OF RIVERSIDE
TEQUESQUITE TRUNK SEWER STUDY

FIGURE 3

GENERAL LAND USE PLAN



LEGEND

- METER 1 FLOW AREA
- METER 2 FLOW AREA (PART)
- METER 3 FLOW AREA (PART)
- METER 4 FLOW AREA
- METER 5 FLOW AREA (PART)
- STUDY SEWER
- SYCAMORE CANYON PARK

N

GRAPHIC SCALE

4000 0 2000 4000

(IN FEET)

1 inch = 4000 ft.

Engineering
Planning
Surveying
Construction Services

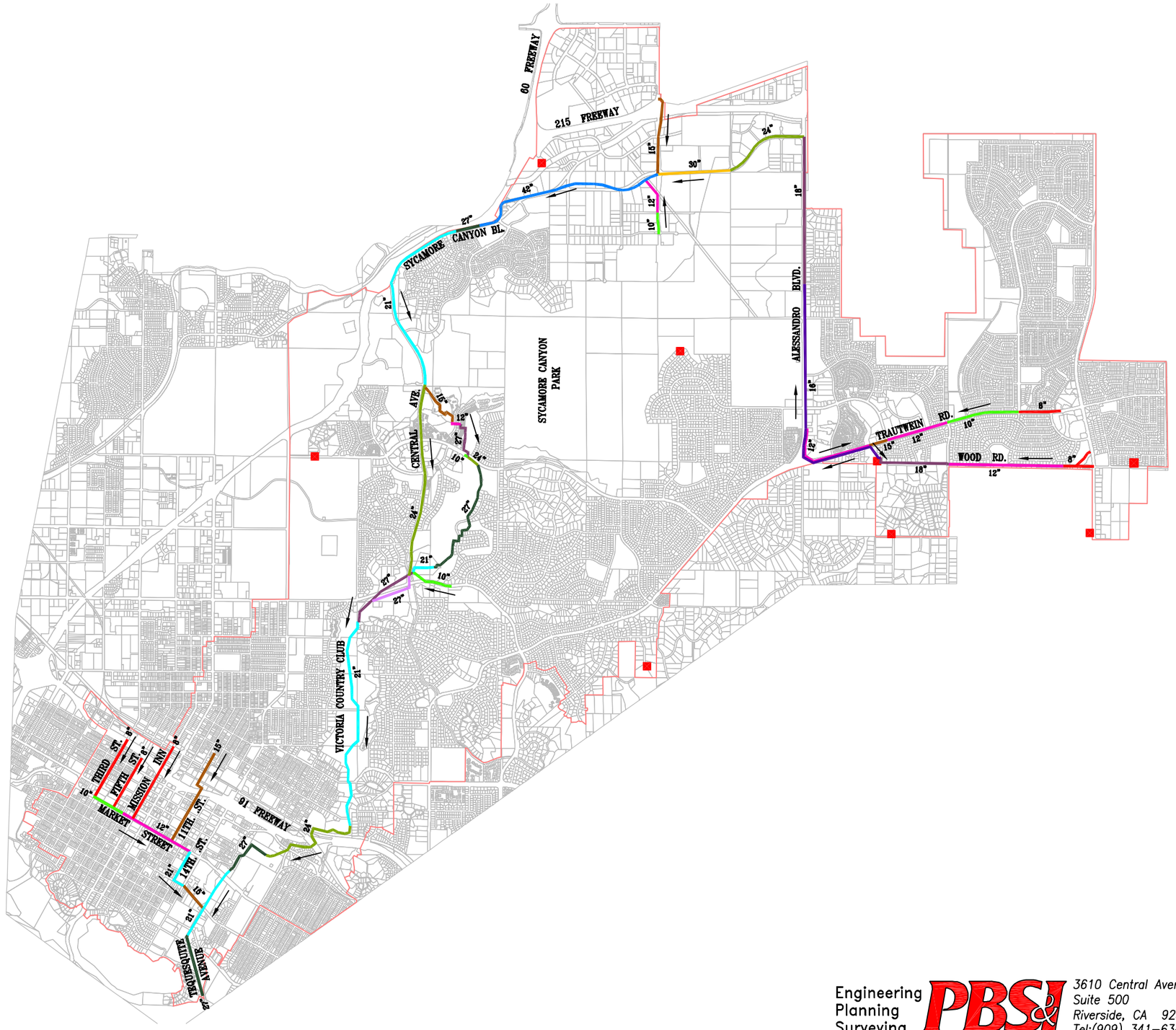
PBSJ

3610 Central Avenue
Suite 500
Riverside, CA 92506
Tel:(909) 341-6380
Fax:(909) 341-6389

CITY OF RIVERSIDE
TEQUESQUITE SEWER STUDY

FIGURE 4

FLOW MONITORING STATIONS



N

GRAPHIC SCALE

40 0 20 40

(IN FEET)

1 inch = 40 ft.

MODELED TRUNK LINES

- 8" DIA. PIPE
- 10" DIA. PIPE
- 12" DIA. PIPE
- 15" DIA. PIPE
- 16" DIA. PIPE (FORCE MAIN)
- 18" DIA. PIPE
- 21" DIA. PIPE
- 24" DIA. PIPE
- 27" DIA. PIPE
- 30" DIA. PIPE
- 33" DIA. PIPE
- 42" DIA. PIPE
- LIFT STATIONS
- BOUNDARY STUDY AREA
- DIRECTION OF FLOW

Engineering
Planning
Surveying
Construction Services

PBS&J

3610 Central Avenue
Suite 500
Riverside, CA 92506
Tel:(909) 341-6380
Fax:(909) 341-6389

CITY OF RIVERSIDE
TEQUESQUITE SEWER STUDY

FIGURE 5

SEWER SYSTEM AND PIPE DIAMETERS

Table 2-1
Land Use that would produce Wastewater Flow within the Study Area (Acres)

Category	Existing (Year 2003)	Future (Year 2018)	Change
Single-Family Residential (SFR)	6,744	7,530	786 (11.7%)
Multi-Family Residential (MFR)	241	274	33 (13.9%)
Commercial (Includes IBP)	849	2,191	1,342(158%)
Industrial	54	60	6 (10.4%)

The areas that are marked as reserved areas or open space public facilities in Figure 3 are not included in Table 2-1because of zero wastewater flow generation. Sycamore Canyon Park is a reserved area.

.

3.0 EXISTING SEWER SYSTEM

3.1 System Overview

As previously described the Tequesquite Trunk Sewer System Study covers approximately 13,000 acres, which has been divided into 31 tributary sub-areas (See Figure 8). The wastewater flow generated from a sub-area can be measured at a meter location or can be reasonably assessed based on land use plan of that sub area. The location of meter locations can be seen on Figure-4. The modeled gravity conveyance system is approximately 115,000 linear feet (21.8 miles) of gravity sewer system, with pipe sizes varying from 8 inches to 42 inches in diameter (See Figure 5). The most of the gravity sewer lines within the system are vitrified clay (VCP). The force main sewer system, located in Trautwein Road and Alessandro Boulevard is a 16-inch ductile iron pipe and is approximately 8,200 feet (1.55 miles) in length.

3.2 Collection System

The wastewater generated within the study area flows in a northerly or westerly direction depending on general topography. The major trunk lines are along Wood Road, Trautwein Road, Alessandro Boulevard, Sycamore Canyon Boulevard, Central Avenue, Canyon Crest Country Club, Victoria Country Club, Market Street, Brockton Avenue and Tequesquite Avenue. The trunk line in Wood Road accepts sewage flow from Single Family Residences north of Van Buren Boulevard. The trunk line in

Trautwein Road picks up flow from Orangecrest area north of Van Buren Boulevard. The trunk sewer line in Alessandro Boulevard conveys sewage flow generated by single-family residences north and south of Alessandro Boulevard and some multi family residences and commercial establishments at the intersection of Alessandro Boulevard and Mission Grove Parkway. The trunk sewer line in Sycamore Canyon Boulevard conveys almost all wastewater generated from the area between Alessandro Boulevard and Van Buren Boulevard, and from commercial and business park areas on both sides of Freeway 215. The trunk sewer line in Central Avenue conveys wastewater flow from Sycamore Highlands and Canyon Crest areas. Another trunk sewer line parallel to Central Avenue trunk lines runs through Canyon Crest Country Club and it re-joins the main trunk sewer line near Chicago Avenue. The trunk line in Victoria Country Club runs through a sewer easement inside the Golf Course and it conveys sewage flow coming out of Victoria Neighborhood. The sewer line in Riverside Community College (RCC) conveys sewage generated from RCC and other adjoining commercial and residential areas. The downtown sewer line along Market Street convey sewage flow from Riverside downtown area. Finally, the Tequesquite trunk sewer line accumulates total sewage flow generated from the entire study area and conveys it to the Wastewater Treatment Plant. Pipe sizes, lengths, and number of manholes have been tabulated for major segments of the modeled trunk system (See Table 3-1).

Table 3-1

City of Riverside
Summary of Modeled Sewer Lines within Study Area

Location	Pipe Dia. (Inches)	Length (Feet)	Number of Manholes
Wood Road	8	705	4
	10	806	3
	12	4,716	13
	18	2,656	11
Trautwein Road	8	1,550	7
	10	2,553	8
	12	5,922	20
	15	690	2
	16	3,254	(Force Main)
	18	565	2
Alessandro Bl.	16	4,924	(Force Main)

Location	Pipe Dia. (Inches)	Length (Feet)	Number of Manholes
	18	6,665	16
	24	521	1
Sycamore Canyon Bl.	2-20	200	2
	21	2,445	6
	24	3,266	7
	27	2,221	6
	30	2,621	8
	42	6,660	16
Eastridge Avenue	10	733	3
	12	1,352	4
	15	1,738	6
Central Avenue	21	3,424	9
	24	7,953	14
	33	172	1
Canyon Crest Country Club	12	392	3
	15	2,734	14
	18	3,467	9
	21	677	3
	24	501	2
	27	4,767	23
Chicago Avenue	8	1,000	2
	10	546	2
Victoria Country Club	18	1,251	8
	21	7,221	20
	24	1,205	6
	27	739	3
	33	2,253	6
Riverside Community College	18	372	2
	24	1,478	9
	27	2,858	15
Downtown Area	8	7,296	34
	10	1,615	8
	12	3,275	14
	14	33	
	15	4,453	22
	18	248	3
	21	761	3

Location	Pipe Dia. (Inches)	Length (Feet)	Number of Manholes
Tequesquite Avenue	15	97	2
	21	654	3
	24	314	2
	27	3,717	15
	30	73	1
TOTAL		**1,23,200 (23.3 miles)**	**397**

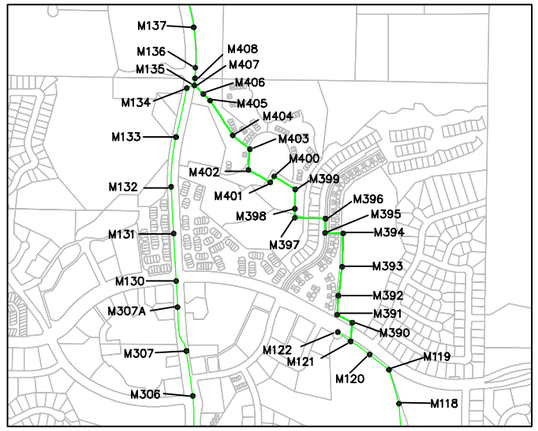
Approximate Gravity System Length: 115,000 feet
Approximate Force Main System Length: 8,200 feet

3.3 System Hydraulics

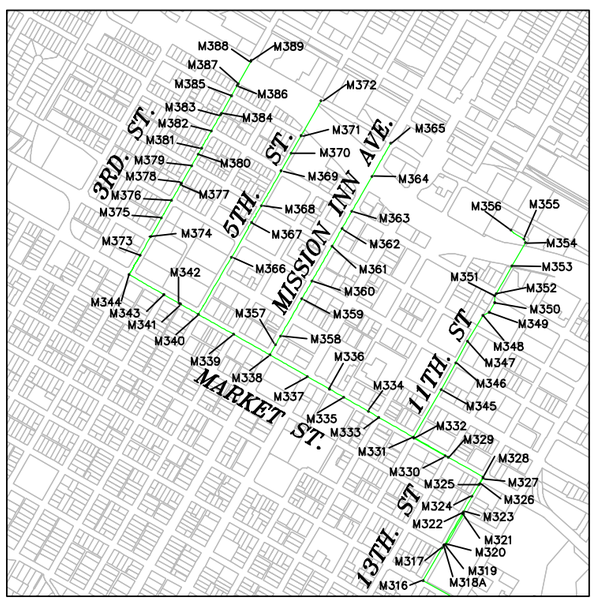
The existing trunk sewer system, which is the subject of this evaluation, is shown on Figure-5. The sewer collection system was constructed over a period of years (possibly 60 plus years) as needed; to accommodate development within the City. The GIS data and as-built plans provided by the City were studied to ascertain characteristics of the system. The existing sewer manholes and sewer lines can be see in Figure-6 and Figure-7 respectively. The sewer system, from upstream to downstream end, is briefly described as follows:

- *Wood Road Study Area Sewer Lines:* The sewer line along Wood Road begins just north of Van Buren Boulevard with an 8-inch diameter line flowing north. At manhole No. 232 (M232) it picks up flow coming from a 10-inch sewer line flowing northwest along reach M238 to M232. Beginning at M232 a 12-inch line picks up flow from these two sewer reaches and continues north of John Kennedy Drive at M218. North of M218 the size of sewer line changes to 18-inch till M207 where it joins another trunk line north of Zomora Way. Sewage flow in Wood Road sewer line is in northerly direction till M206, which is a lift station. From this location, sewage is pumped through a force main line, that is described seperately.

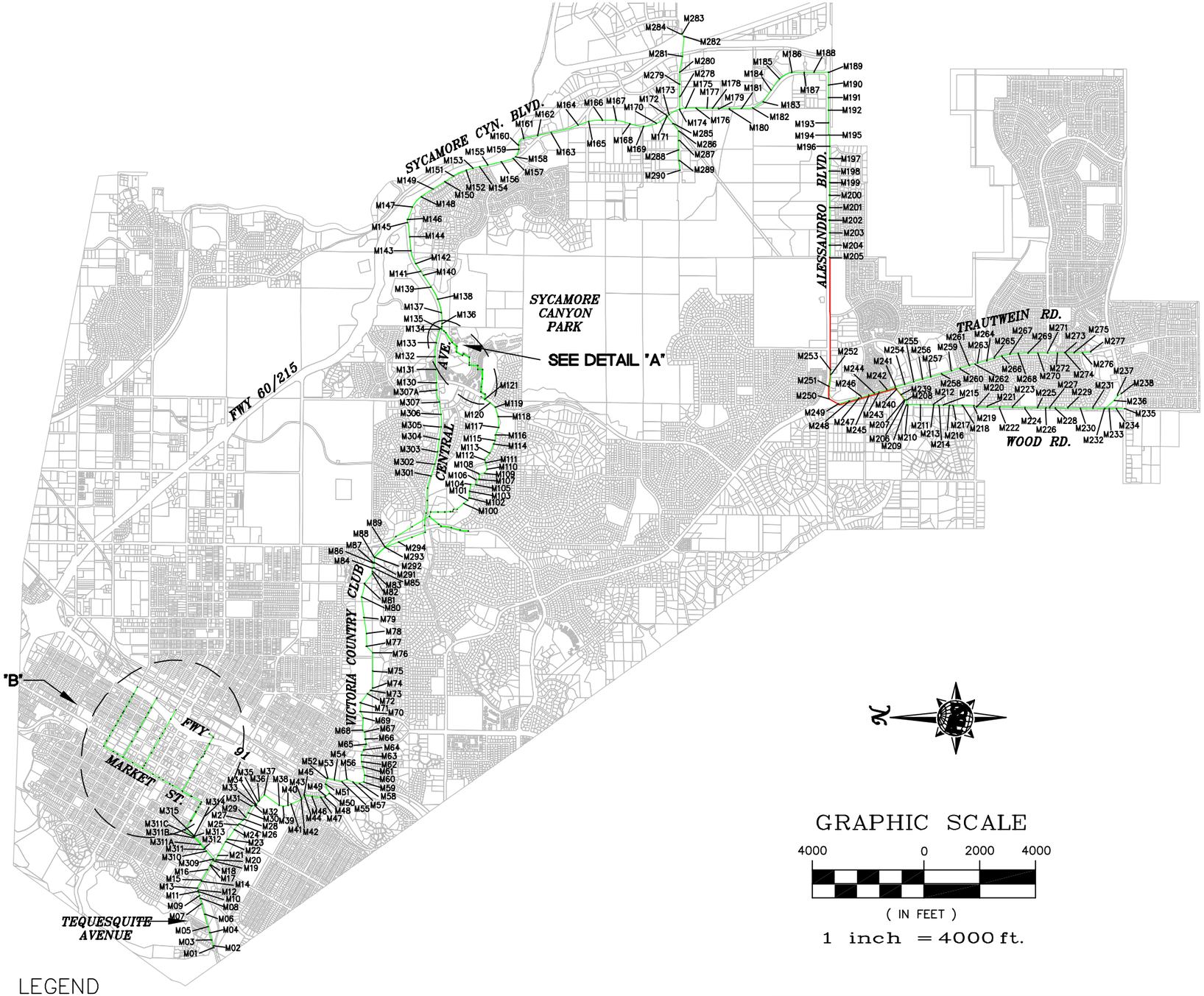
- *Trautwein Road Study Area Sewer Line*: Trautwein Road sewer lines may broadly be divided in two parts, one flowing in northwesterly direction beginning north of Van Buren Boulevard and other flowing in southeasterly direction beginning north of Alessandro Boulevard. An 8-inch sewer line beginning north of Van Buren Boulevard at M277 picks up flow from the Orangecrest neighborhood. The size of this line changes to a 10-inch line north of M271. This line meets another 12-inch line coming in



DETAIL "A"
NOT TO SCALE



DETAIL "B"
NOT TO SCALE



GRAPHIC SCALE

4000 0 2000 4000

(IN FEET)

1 inch = 4000 ft.

LEGEND

	FORCE MAIN
	GRAVITY SEWER
M01	MANHOLE NUMBER

Engineering
Planning
Surveying
Construction Services

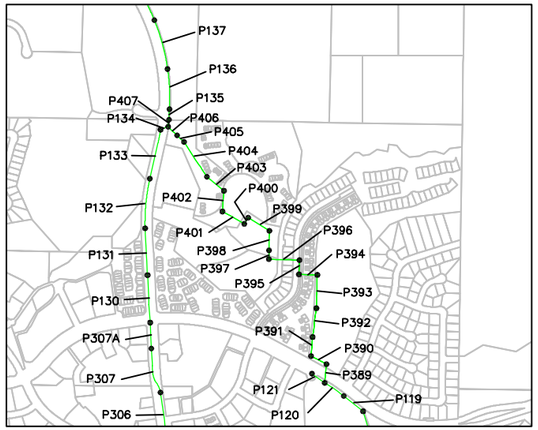
PBSJ

3610 Central Avenue
Suite 500
Riverside, CA 92506
Tel:(909) 341-6380
Fax:(909) 341-6389

CITY OF RIVERSIDE
TEQUESQUITE SEWER STUDY

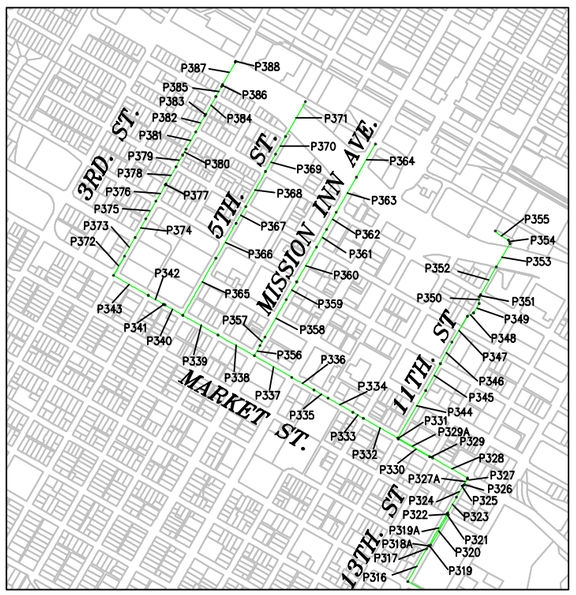
FIGURE 6

EXISTING MANHOLES



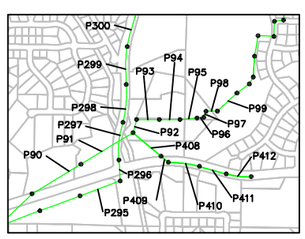
DETAIL "A"

NOT TO SCALE



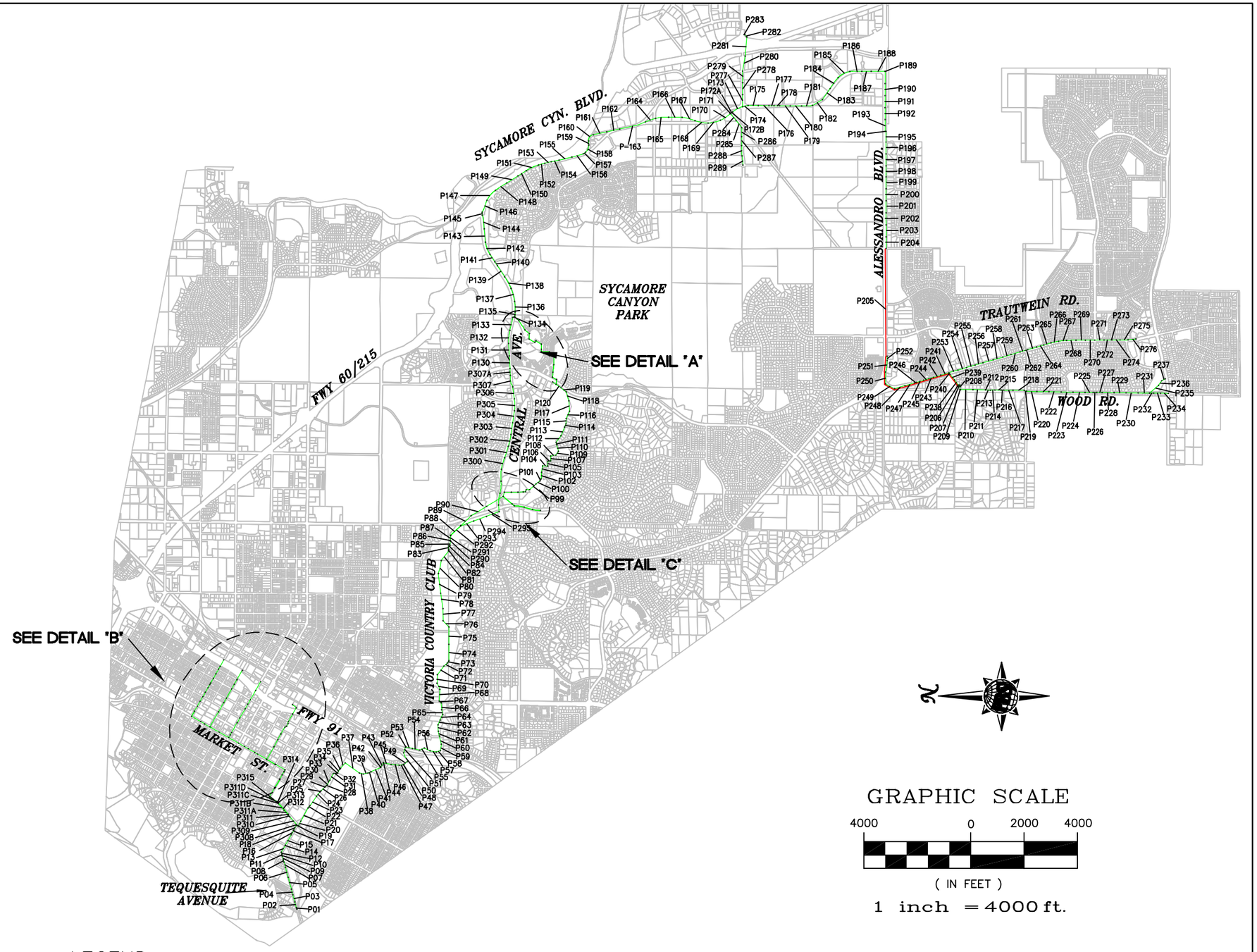
DETAIL "B"

NOT TO SCALE



DETAIL "C"

NOT TO SCALE



GRAPHIC SCALE

4000 0 2000 4000

(IN FEET)

1 inch = 4000 ft.

LEGEND

	FORCE MAIN
	GRAVITY SEWER
P01	PIPE NUMBER

Engineering
Planning
Surveying
Construction Services

PBS&J

3610 Central Avenue
Suite 500
Riverside, CA 92506
Tel:(909) 341-6380
Fax:(909) 341-6389

CITY OF RIVERSIDE
TEQUESQUITE SEWER STUDY

FIGURE 7

EXISTING PIPES

southeasterly direction at M241. Thereafter, the flow is in westerly direction to the lift station at M206.

The second 12-inch trunk sewer line in Trautwein Road begins at M253 at Alessandro Boulevard and continues west till the intersection of Trautwein Road and Alessandro Boulevard (M250). Then a 12-inch line continues in southeasterly direction till M241, which is the confluence point of these two study sewers in Trautwein Road. From M241, an 18-inch sewer line continues in westerly direction to M206, which is a lift station.

- *Alessandro Boulevard Study Area Sewer Line*: The 18-inch gravity sewer lines along Alessandro Boulevard begins at M205 at Barton Street and continues in easterly direction towards the intersection of Alessandro Boulevard and Sycamore Canyon Boulevard. The sewage flow from 16-inch force main line along Alessandro Boulevard discharges into M205 and thereafter it flows by gravity in easterly direction. The sewer line along Alessandro Boulevard is generally in the southern portion of the street except after M195 where it turns north and continues in northern portion of street. It meets the trunk sewer line at M189.

- *Sycamore Canyon Boulevard Study Area Sewer Line*: This portion of sewer line begins at M189, continues in northerly direction and generally follows the alignment of Sycamore Canyon Boulevard. A 24-inch sewer line begins at M189 and continues till M182 where it turns into a 30-inch sewer line. This 30-inch sewer line continues to M174 at the intersection of Sycamore Canyon Boulevard and Eastridge Avenue. A 42-inch sewer line beginning at M174 continues in northwesterly direction. It splits into two 20-inch CIP sewer lines at M173. In between M173 and M172 reach California Aqueduct crosses over the sewer line. Two 20-inch CIP lines join at M172 and a 42-inch sewer line continues northeast of this manhole location till M157, northwest of Fair Isle Drive and Sycamore Canyon Boulevard intersection. The whole reach of 42-inch sewer line passes through flat terrain, so the pipe slopes in this reach are at a minimum possible value. The pipeline between M162 and M158 is not within the street right of way; it passes through a sewer easement between Sycamore Canyon Boulevard and Freeway 60/215. Beginning M157, a 27-inch sewer line continues along Sycamore Canyon Boulevard down to M151. Beyond M151, a 21-inch sewer line continues up to M146 at the intersection of Sycamore Canyon Boulevard and Central Avenue.

- *Eastridge Avenue Study area Sewer Lines:* There are two segments of contributory sewer lines to the main trunk sewer line along Sycamore Canyon Boulevard; one coming from the east and another from the west. The east segment of the sewer line along Eastridge Avenue begins at M284, east of Freeway 215. A 15-inch line continues westerly, crosses the freeway and joins the trunk sewer line at M174. This sewer line picks up flow from the Edgemont/Canyon Springs area. The west segment of sewer line begins at M290; a 10-inch sewer line continues east till M288 where the line size changes into a 12-inch sewer. Thereafter, a 12-inch sewer line continues in an easterly/northeasterly direction parallel to the California Aqueduct to M171 of the trunk sewer line along Sycamore Canyon Boulevard. The western segment of Eastridge Avenue sewer line picks up wastewater flow from industrial/light commercial area west of Freeway 215, which includes Pepsi Bottling Plant and Ralphs Grocery Company.

- *Central Avenue Study Area Sewer Line:* The trunk sewer line along Central Avenue begins at M145 at the intersection of Central Avenue and Sycamore Canyon Boulevard. The sewer line along Central Avenue is at a relatively steep slope and has been laid at minimum cover following finished surface profile of the street. A 21-inch sewer line begins at M145 and continues westerly to M139 where the size increases 24-inches. After M138 the size changes to 21-inches and continues to M134. The sewer size remains 24-inches in the reach between M139 and M297. The trunk sewer line in Central Avenue picks up wastewater flow from part of Canyon Crest area, multi family residential and commercial areas near Canyon Crest and Central Avenue intersection.

- *Canyon Crest Country Club Study Area Sewer Line:* This sewer line begins at Central Avenue, east of Canyon Crest Drive at M408. A 12-inch line continues through the apartment complex building, crosses Via La Paloma and joins the trunk line at M120. The size of the sewer line changes from 12-inch to 18-inch in the reach M408 to M390. After M120, the sewer line continues along Canyon Crest Drive up to M118 and then it generally traverses through Canyon Crest Country Club. The size of the

sewer line ranges from 24-inch to 27-inch in the reach from M120 to M96. After M96 the sewer line continues in northwesterly direction, crosses Central Avenue and joins Central Avenue trunk sewer line at M86. This trunk sewer line picks up wastewater flow from Canyon Crest area.

- *Chicago Avenue Study Area Sewer Line:* This study trunk sewer line along Chicago Avenue begins at M413 near the intersection of Country Club Drive and Chicago Avenue. These sewer lines are laid at relatively steeper slopes. An 8-inch sewer line begins at M413 and continues in northerly direction to M410 where the size changes to10-inch and continues to M92. This sewer line picks up wastewater flow from single family residential areas on the east and west sides of Alessandro Boulevard and south of Chicago Avenue.

- *Victoria Country Club Study Area Sewer Line:* The trunk sewer line in Victoria Country Club passes through a sewer easement and generally, is parallel to Tequesquite Canyon passing through Victoria Golf Course. An 18-inch sewer line begins at M86 and continues westerly to M81. Beyond M81 a 21-inch line continues in westerly direction to M60. It turns into a northerly direction after M59 and a 24-inch line continues north to M56. North of M56, a 27-inch line continues to M52 where it turns west. A 24-inch sewer line continues to the east side of Hwy 91 at M51. Beyond M51, an 18-inch CIP sewer line continues in westerly direction under Hwy 91 to M50. The sewage flow at this location is under siphon action. This trunk sewer line generally picks up wastewater flow from Victoria area.

- *Riverside Community College (R.C.C.) Study Area Sewer Line:* A 24-inch study sewer line begins at M50 west of Hwy 91 and continues along Brooks Street to the intersection of Olivewood Avenue and City College Drive. Thereafter, it traverses within the boundary of RCC generally parallel to Saunders Street. The size of the sewer line within the RCC campus is 27-inch. The wastewater flow is in northwesterly direction. Pipe P48 (M49 to M48) has a steep slope to avoid excessive earthwork in that reach. This trunk sewer line continues westerly till M26. This trunk sewer line picks up flow from RCC and adjoining residential and commercial areas.

- *Downtown Area Sewer Line:* The study sewer lines in downtown area include trunk and tributary sewer lines along Brockton Avenue, 13th street, Market Street, 11th Street, Mission Inn Avenue, 5th Street and 3rd Street. The sewer sizes range from 8-inch to 21-inch. In general, the wastewater flow is in the southwesterly direction except for the tributary sewer lines in 3rd Street, 5th Street, Mission Inn Avenue and 11th Street, which flow, in northwesterly direction.

  - The study sewer line along 3rd Street begins at M389 just east of Hwy 91. The size of sewer line is 8-inch and the flow is in northwesterly direction. The sewer line joins trunk sewer line along Market Street at M344. This sewer line picks up wastewater flow from commercial and multi-family residential areas along 3rd Street.

  - The Fifth Street sewer line begins at M372 east of Hwy 91. An 8-inch size sewer line continues in northwesterly direction to the M340 at the intersection of 5th Street and Market Street. This contributory sewer line picks up flow from commercial/high density residential areas along 5th Street.

  - The study sewer line along Mission Inn Avenue begins at M365 at Vine Street, east of Hwy 91 and continues northwestwards towards Market Street. The size of sewer line is 8-inch and the direction of flow is in northwesterly direction. This contributory sewer line picks up wastewater flow from generally commercial areas in the vicinity of Mission Inn Avenue.

  - The 11th Street study sewer line begins at M356 east of Hwy 91 near Vine Street. It crosses Hwy 91 and continues in northwesterly direction to M332 at the intersection of 11th Street and Market Street. The size of the sewer line is 15-inch in between M356 and M350, 18-inch in between M350 and M348 and 15-inch in between M348 and M332. This sewer line picks up sewage flow from commercial area along 11th Street in downtown, and residential area east of Hwy 91, up to Chicago Avenue.

  - The trunk sewer line along Market Street begins at M344 at the intersection of 3rd and Market Street. It continues in southwesterly direction till M339. From M339 a 12-inch sewer line continues along Market Street till M330 where a split flow situation occurs. A 15-inch VCP line branches off at M330 to re-join the

trunk sewer line at M329. A 12-inch line continues till M328 at the intersection of Market Street and 13th Street.

- 13th Street trunk line begins at M328 and continues in northwesterly direction. This sewer line has two split flow situations. A 12-inch line begins at M328 and continues to M325. Another 10-inch line, which begins at M328, converts into a 15-inch sewer line after M327 and re-joins 12-inch at M325. From M325, a 12-inch line continues in northwesterly direction till M323. A 10-inch sewer line branches off at M323 to re-join at M319. A 21-inch line continues after M317 to M316 at the intersection of 13th Street and Brockton Avenue.

- Brockton Avenue study sewer lines begin at M316 and continue in southwesterly direction to M315. At M315, there is a split flow situation. A 15-inch line begins at this manhole and continues till M311. Another 10-inch line branches off and joins the main line at M311. Beyond M311 a 15-inch line continues to the trunk sewer line at M19 at the intersection of Tequesquite Avenue and Brockton Avenue.

- *Tequesquite Avenue Study Area Sewer Line:* The Tequesquite Avenue sewer lines begin at M26, west of Magnolia Avenue. A 27-inch sewer line continues southwest of Riverside Community Hospital Campus along a sewer easement to M21. Beyond M21 a 24-inch line continues to M20 where it splits into two 15-inch pipes. The reach between M20 and M19 has siphon action. Two 15-inch sewer lines branch off at M20 and rejoin at MH-19. Thereafter a 24-inch sewer line continues westwards to M18. The sewer lines between M18 and M15 are 21-inches in size and flow in northwesterly direction. In the reach between M12 M10, the flow is in southwesterly direction and the size of pipe is 30-inches. Beyond M10 the size of pipe is 27-inch and the flow is in southwesterly direction to M1. The trunk sewer line in Tequesquite Avenue picks up wastewater flow from the areas southeast of Mount Rubidoux Park and commercial and residential areas around Riverside Community Hospital.

3.4 Tributary Areas

The study area was divided into 31 sub-areas; each area having its distinct land use pattern. These sub-areas are tributary to a particular meter location either individually or collectively. Because of their strategic locations, meters upstream to a cumulative meter can be subtracted out to deduct cumulative effect. See Figure-8 for details of tributary sub-areas. Following is the listing of tributary sub-areas and their contribution to a particular meter location.

1. Sub-areas A-14, A-12, A-11, A-10, A-9, A-8 are tributary to meter No. 1, located in Alessandro Boulevard, east of Barton Street.
2. All the sub-areas mentioned above and sub-areas A-7, A-13, A-6-1, A-6-3, A-6-4, A-6-5, A-5-1 and A-5-2 are tributary to meter No. 2 located in Central Avenue.
3. All the sub-areas as mentioned in (1) and (2) and sub-areas A-4-1, A-4-2, A-4-3 are tributary to meter No. 3 located in Victoria Country Club area.
4. Sub-areas No. A-2-1, A-2-2, A-2-3, A-2-4, A-2-5, A-2-6 and A-2-7 are tributary to meter No. 4, located in Brockton Avenue.
5. All the sub-areas as mentioned in (1) to (4) and sub-areas A-1-1, A-1-2, A-2-8 and A-3 are tributary to meter No. 5, located in Tequesquite Avenue. This meter picks up almost entire flow from the study area.

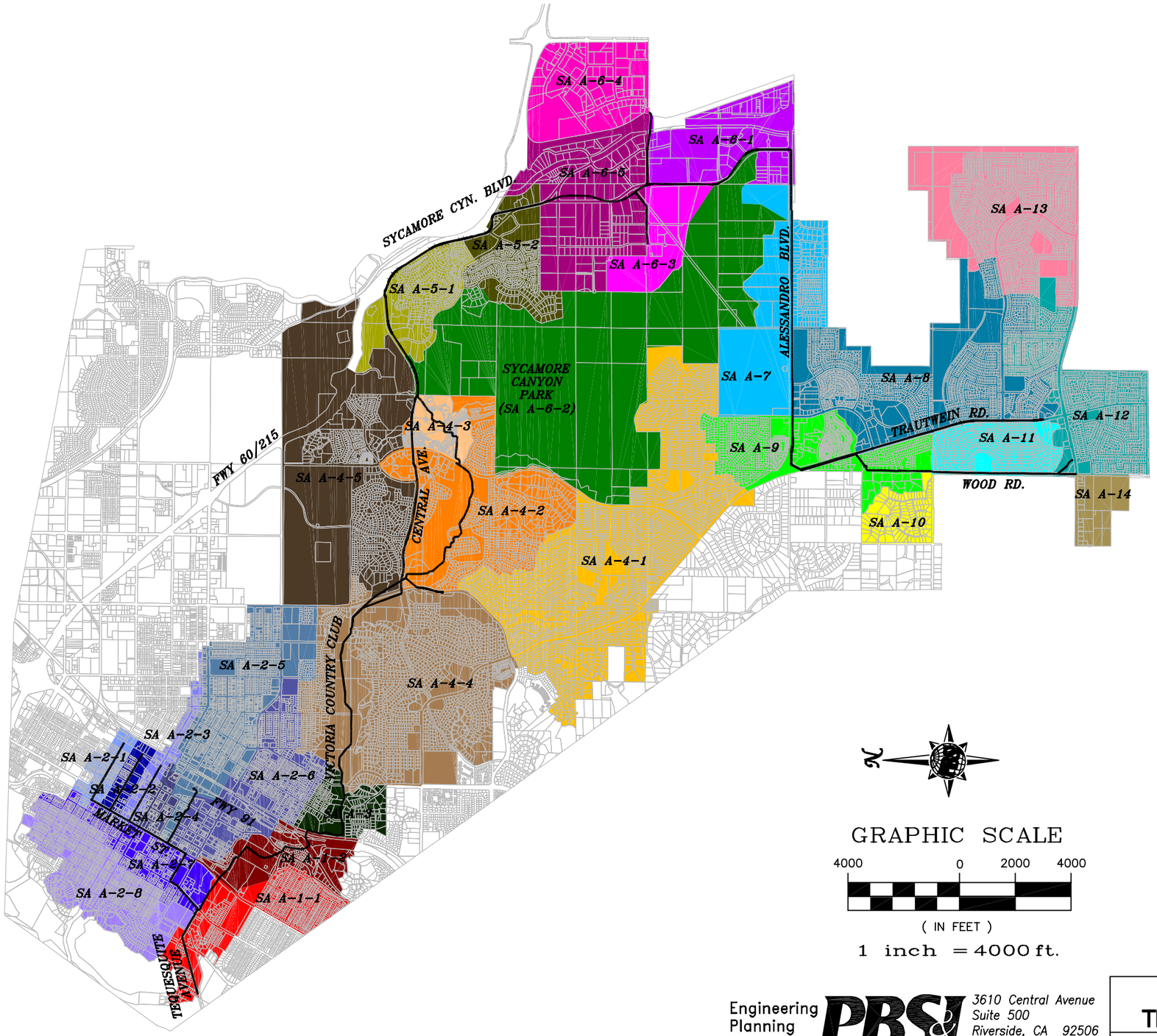
Within each sub-area there is generally a distinct mixture of land uses, which generates a unique quantity and diurnal pattern of wastewater flows. For identification of land use patterns, data provided by the City of Riverside in GIS Arcview format was used. The following table summarizes land uses within a particular sub-area.

Table 3-2

Developed Tributary Areas and Current Wastewater Generating Land Use

Sub Area	SFR (Acres)	MFR (Acres)	Commercial (Acres)	Industrial (Acres)	School (Acres)	Total (Acres)
A-1-1	261	40	-	1	-	302
A-1-2	-	-	31	-	98	129
A-2-1	-	39	10	-	-	49
A-2-2	20	-	37	-	-	57
A-2-3	44	2	33	-	-	79
A-2-4		-	27	-	-	27
A-2-5	418	23	53	-	-	494
A-2-6	248	5	53	43	-	349
A-2-7	145	42	-	-	-	187
A-2-8	319	-	44	-	-	363
A-3	96	-	11	-	-	107
A-4-1	1205	11	-	-	-	1216
A-4-2	225	2	-	-	3	230
A-4-3	61	32	-	-	-	93
A-4-4	845	-	68	-	-	913
A-4-5	221	6	23			250
A-5-1	111	-	-	-	-	111
A-5-2	292	29	14	-	-	335
A-6-1	-	-	44	-	-	44
A-6-3	-	-	110	-	-	110
A-6-4	-	-	70	-	-	70
A-6-5	-	-	94	-	-	94
A-7	146	-	3	1	-	150
A-8	363	-	-	5	-	368
A-9	269	10	36	-	-	315
A-10	119	-	-	-	-	119
A-11	169	-	-	-	-	169
A-12	393	-	2	-	17	412
A-13	490	-	20	-	-	510
A-14	-	-	3	4	-	7

SFR – Single Family Residential
MFR – Multi Family Residential
The areas do not include undeveloped and reserved areas. Sub Area A-6-2 is a Reserved Area (Sycamore Canyon Park).



LEGEND

- SUB AREA A-1-1
- SUB AREA A-1-2
- SUB AREA A-2-1
- SUB AREA A-2-2
- SUB AREA A-2-3
- SUB AREA A-2-4
- SUB AREA A-2-5
- SUB AREA A-2-6
- SUB AREA A-2-7
- SUB AREA A-2-8
- SUB AREA A-3
- SUB AREA A-4-1
- SUB AREA A-4-2
- SUB AREA A-4-3
- SUB AREA A-4-4
- SUB AREA A-4-5
- SUB AREA A-5-1
- SUB AREA A-5-2
- SUB AREA A-6-1
- SUB AREA A-6-3
- SUB AREA A-6-4
- SUB AREA A-6-5
- SUB AREA A-7
- SUB AREA A-8
- SUB AREA A-9
- SUB AREA A-10
- SUB AREA A-11
- SUB AREA A-12
- SUB AREA A-13
- SUB AREA A-14
- SYCAMORE CANYON PARK (SUB AREA A-6-2)
- STUDY SEWER

GRAPHIC SCALE

4000 0 2000 4000

(IN FEET)

1 inch = 4000 ft.

Engineering
Planning
Surveying
Construction Services

PBSJ

3610 Central Avenue
Suite 500
Riverside, CA 92506
Tel:(909) 341-6380
Fax:(909) 341-6389

CITY OF RIVERSIDE
TEQUESQUITE SEWER STUDY

FIGURE 8

TRIBUTARY AREAS

4.0 DETERMINATION OF SEWER FLOWS

4.1 Flow Monitoring

Flow Monitoring was conducted at five (5) sites in order to accomplish the following: (See Figures 4 for locations of Flow Monitoring Stations).

- Establish current flow levels.
- Verify or adjust flow coefficients.
- Establish characteristic flow patterns (Diurnal Curves) for the model (See Figures 13-16).
- Confirm peak to average flow relationships.
- Help prioritize recommend improvements.

Meter locations were chosen to observe actual flow characteristics for the various sub-areas and to provide a continuous record of measured flows over a period of time (two weeks for this study). Meter locations were also chosen in such a manner that current flow quantities along the Tequesquite Avenue Trunk Sewer could be quantitatively determined. Following is an amplification of the logic for placement of each flow meter.

- Meter No. 1; location on Alessandro Boulevard east of Barton Street – This location was chosen because it carries all the flow generated from Orangecrest area which is primarily a residential area. Also, the flow being pumped through the force main line from the sewage lift station at Wood Road can be measured at this location.

- Meter No. 2; location on Central Avenue west of Lochmoor Avenue – This location was chosen to observe flow generated from the area north and south of Alessandro Avenue and west of Freeway 215. The City of Riverside has flow data for Pepsi and Ralph commercial units and Edgemont community. This data, along with data from meter No. 1 and 2 can be manipulated to assess flow coming to the system at strategic locations.

- Meter No. 3; location Victoria Country Club west of Chicago Avenue – This location was chosen to measure the flow from the area generally bounded by Chicago Avenue on west, Martin Luther King Boulevard on north, Freeway 60/215 on east and Van Buren Boulevard on south. The land use within this area is mixture of residential and commercial. A typical

diurnal pattern for this mixed-use land pattern would be derived from the flow monitoring data at this meter location.

- Meter No. 4; location Brockton Avenue north of Tequesquite Avenue – This location was chosen to measure the flow generated from the downtown area of the City of Riverside. The area covers a multiple land use patterns comprising residential (medium to high density), commercial, and office buildings. The maintenance and operation staff of the City indicated that some flow-surcharging problem is being experienced in the Market Street sewer line north of 13th Street. The flow data from meter location No. 4 would be evaluated for possible cause of flow problems in the Market Street sewer line.

- Meter No. 5; location Tequesquite Avenue west of Brockton Avenue - This location was chosen because the trunk sewer line at this location carries almost the entire flow generated from the study area.

4.2 Results of Flow Monitoring

Measurement of sewer flows is an imprecise science, as the in-line equipment is placed in a harsh environment and is subject to solids interference, calibration, turbulence and other problems, which can impede the accuracy. Installed equipment must be frequently inspected and maintained, and monitoring results interpreted, evaluated for reasonableness, and sometimes adjusted. In this particular application, metered flow information was generally quite good. However, some flows at specific meter locations did not display consistent values. Graphical results at each site were carefully reviewed for consistency and reasonableness, using the following general guidelines.

- Where the magnitude or daily pattern varies significantly from one non-holiday weekday to the next, the data is likely to be flawed.
- Where the base (low) flows are rising during the flow monitoring period, the data is suspect.
- Where the algebraic sum of flows from meters in series are significantly out of sync, the data from one or more meters may be faulty.
- Where minimum (nighttime) flows are abnormally high or algebraically inconsistent, the data is suspect.
- Where the measured depth data and velocity data are inconsistent the data is suspect.

Metered flows displaying one or more of the above flaws were purged or abandoned adjusted based on reasonable assumptions.

At each meter location the flow-monitoring device measures depth of flow and velocity. Upon reviewing the report submitted by Downstream Services, and from discussions with their staff, it was determined that the depth-of-flow reading was more reliable than the velocity data. By using depth of flow readings and inputting pipe characteristics from record drawings (slope, size and roughness "n" values), sewage flow can be calculated using Manning's equation. These values more closely resemble theoretically sewage flows calculated using land use information and flow coefficients. The flow data for meter No. 2 is inconsistent so it was not used for estimation of wastewater flow. Flow data have been included in the Appendix A.

The flow monitoring hydrographs at each meter site, adjusted based on the depth measurement, are shown in Figures 9A through 12. The following relevant observations were made from evaluation of the measured flows:

- Flows from the Orangecrest / Alessandro study area are atypical because of the major lift station in the system. Meter No. 1 shows an inconsistent flow pattern due to pumping action at the lift station.

- Weekend hydrographs show generally smaller flows and lesser peaks than weekday patterns, for the Downtown area, usually due to closure of offices during the weekends.

- Diurnal flow patterns reveal a consistent high flow during night - time hours due to mixed land use pattern in the study area. This can be explained by the general nocturnal habits of people living in high-density residential areas. The people working in these areas usually work in multiple shifts and use the wastewater facilities in inconsistent ways.

- Observed flows at meter No. 5 show slightly higher values than the land use. This may be attributed to higher occupancy of people than the census data predicts. This happens in the high-density areas where census data is typically flawed.

Figure 9A

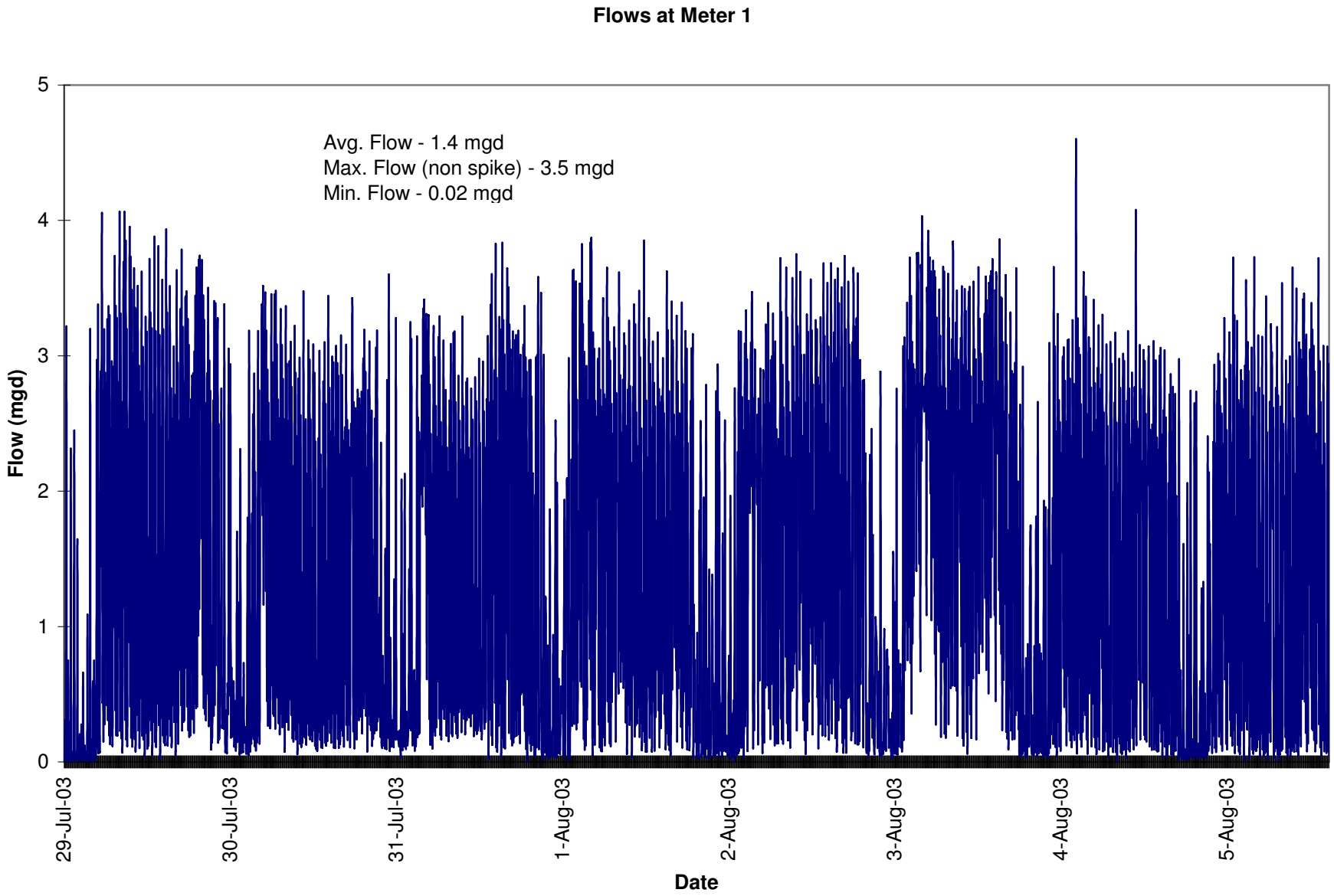

Flows at Meter 1
Avg. Flow - 1.4 mgd
Max. Flow (non spike) - 3.5 mgd
Min. Flow - 0.02 mgd
Flow (mgd)
0
1
2
3
4
5
29-Jul-03
30-Jul-03
31-Jul-03
1-Aug-03
2-Aug-03
3-Aug-03
4-Aug-03
5-Aug-03
Date

Figure 9B

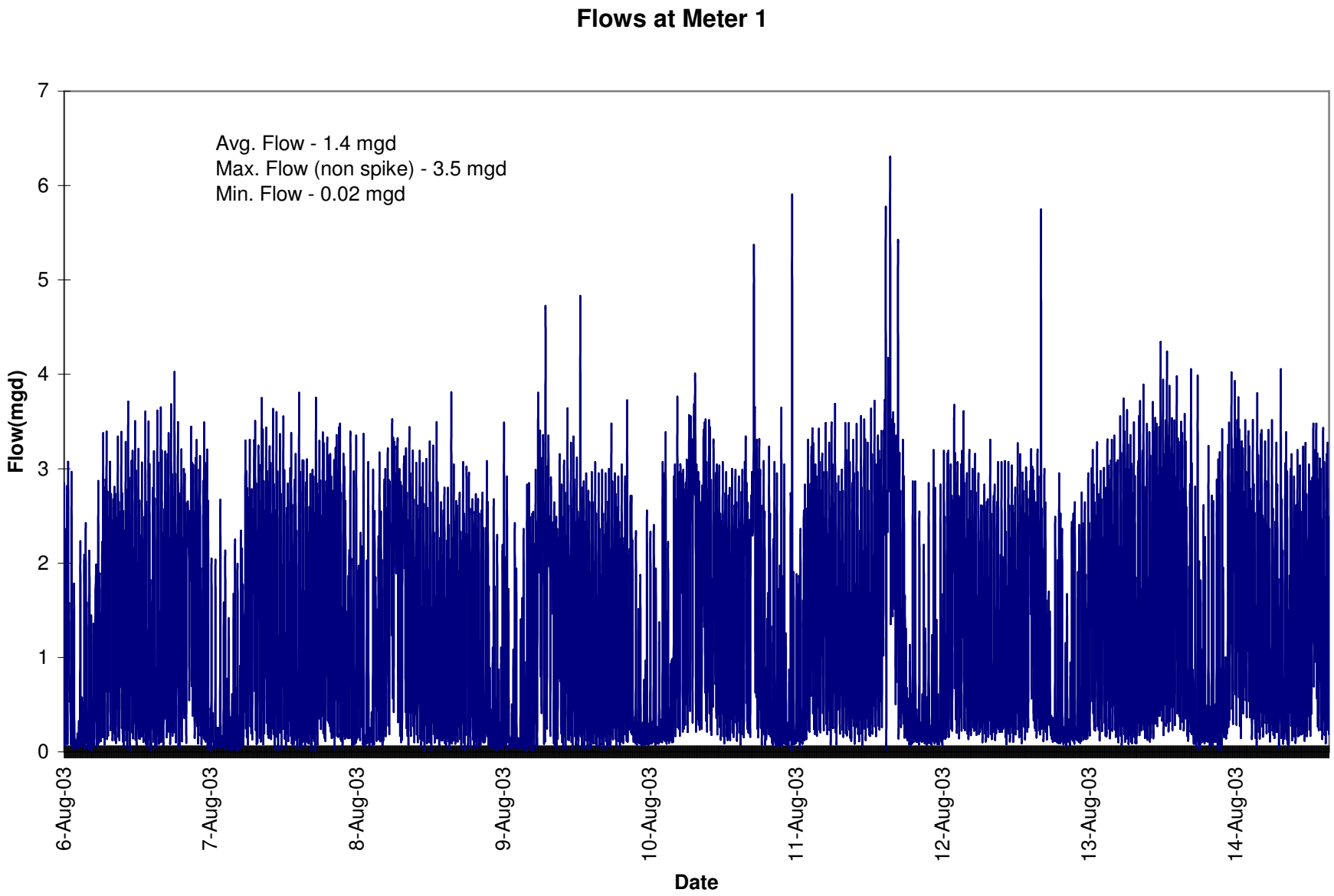

Flows at Meter 1
Avg. Flow - 1.4 mgd
Max. Flow (non spike) - 3.5 mgd
Min. Flow - 0.02 mgd
Flow(mgd)
0
1
2
3
4
5
6
7
6-Aug-03
7-Aug-03
8-Aug-03
9-Aug-03
10-Aug-03
11-Aug-03
12-Aug-03
13-Aug-03
14-Aug-03
Date

Figure 10

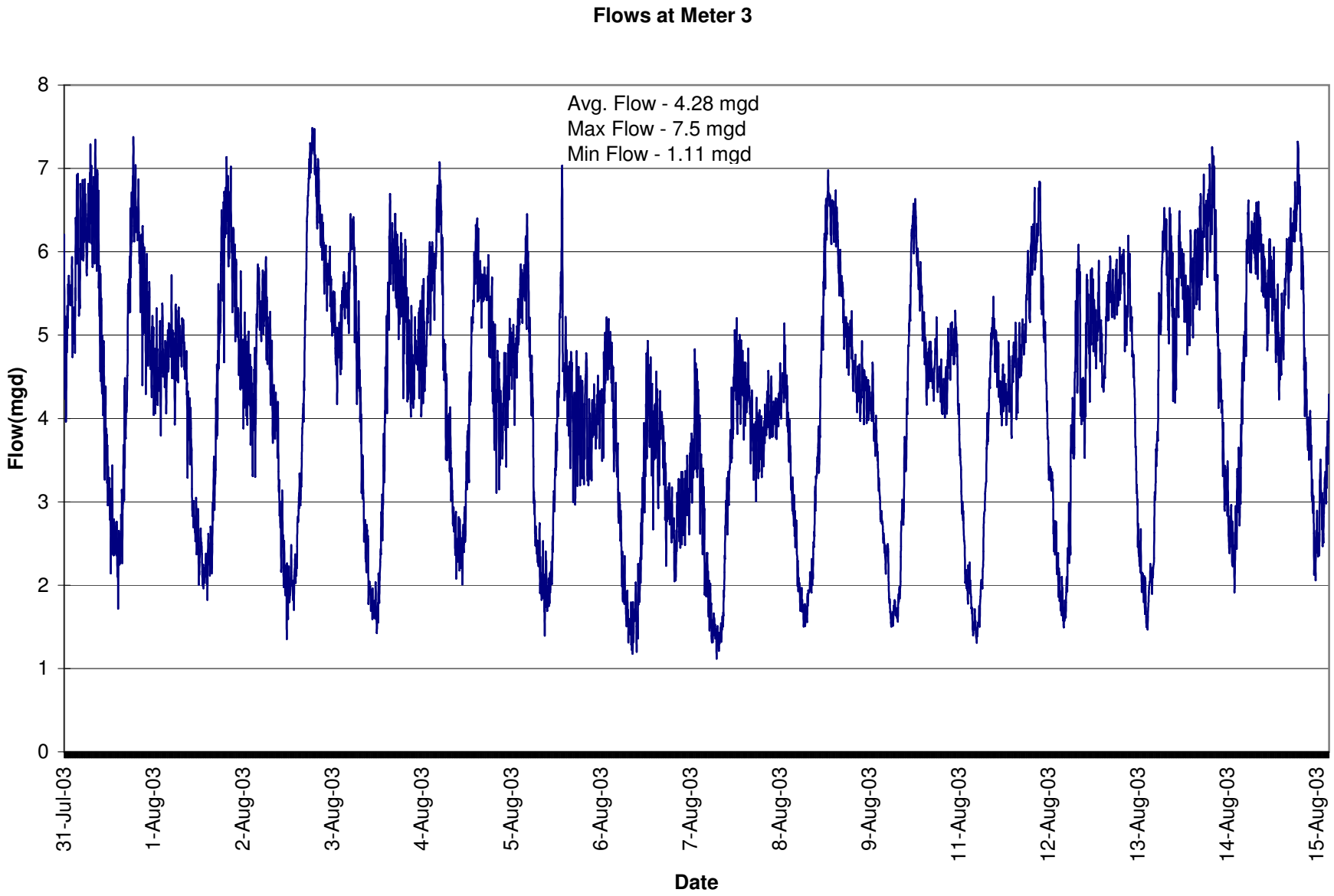

Flows at Meter 3
Avg. Flow - 4.28 mgd
Max Flow - 7.5 mgd
Min Flow - 1.11 mgd
Flow(mgd)
0
1
2
3
4
5
6
7
8
31-Jul-03
1-Aug-03
2-Aug-03
3-Aug-03
4-Aug-03
5-Aug-03
6-Aug-03
7-Aug-03
8-Aug-03
9-Aug-03
11-Aug-03
12-Aug-03
13-Aug-03
14-Aug-03
15-Aug-03
Date

Figure 11

Flows at Meter No. 4

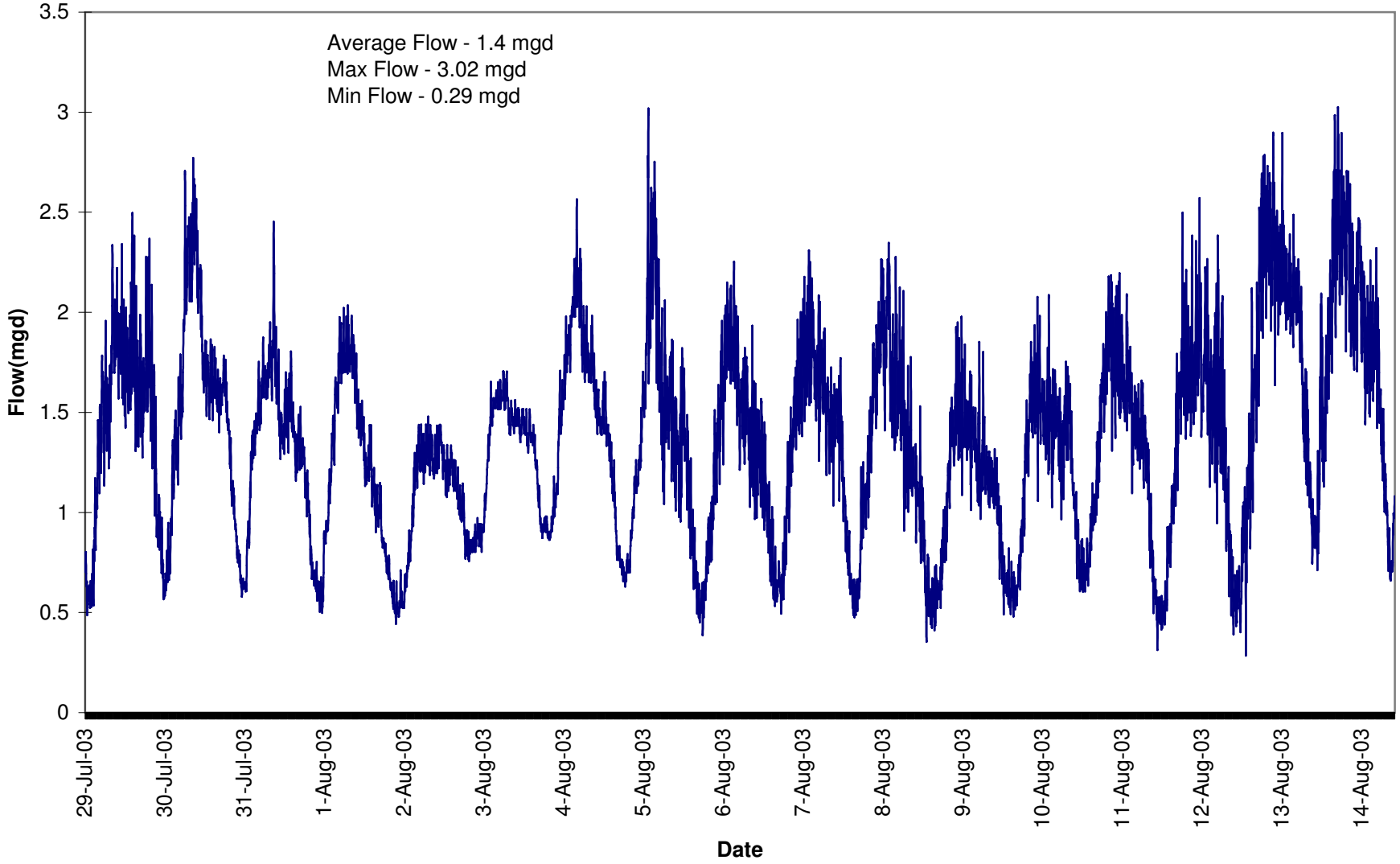
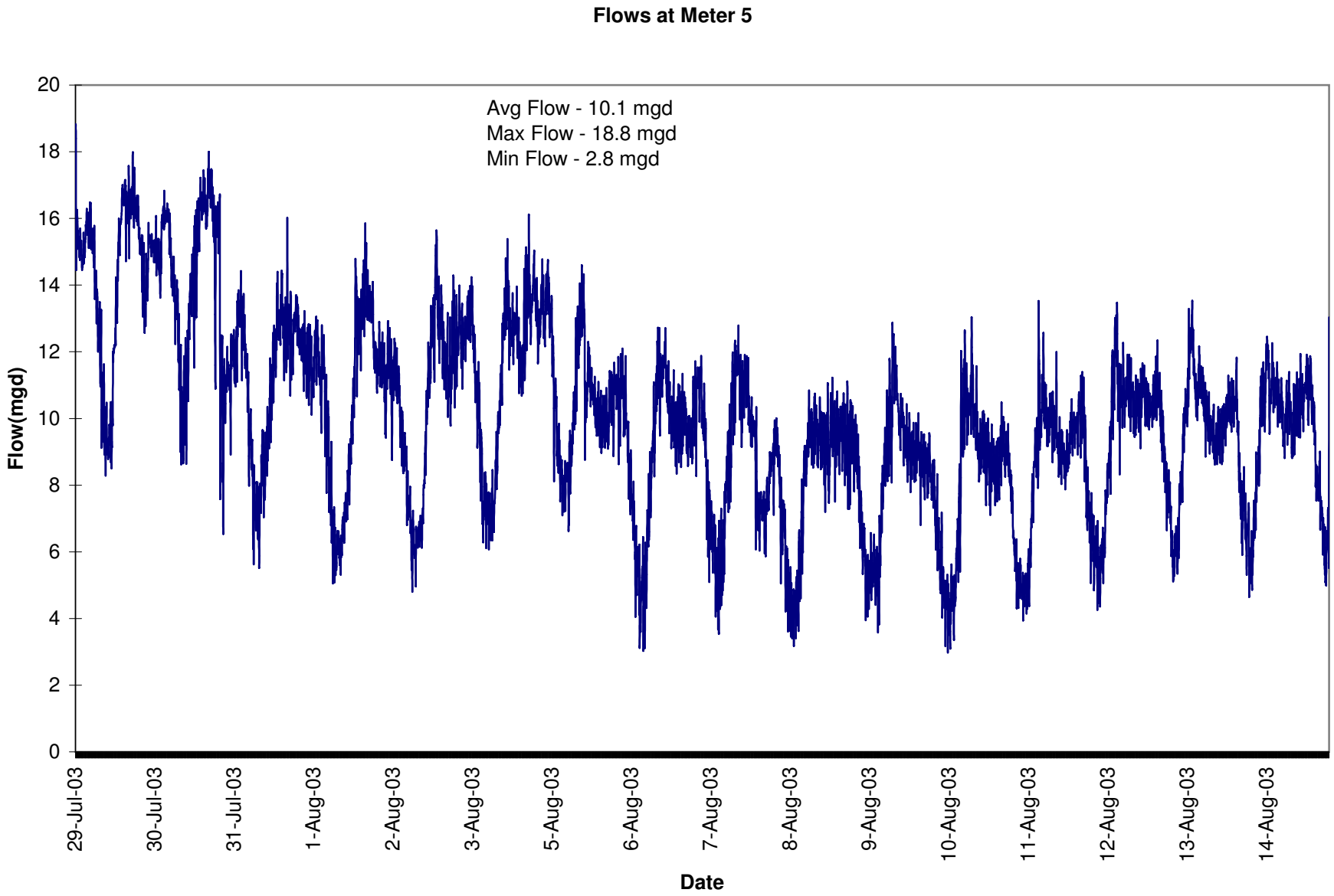


Figure 12


Flows at Meter 5
Avg Flow - 10.1 mgd
Max Flow - 18.8 mgd
Min Flow - 2.8 mgd
Flow(mgd)
20
18
16
14
12
10
8
6
4
2
0
29-Jul-03
30-Jul-03
31-Jul-03
1-Aug-03
2-Aug-03
3-Aug-03
5-Aug-03
6-Aug-03
7-Aug-03
8-Aug-03
9-Aug-03
10-Aug-03
11-Aug-03
12-Aug-03
13-Aug-03
14-Aug-03
Date

5.0 ESTIMATED ULTIMATE FLOW

5.1 Methodology

Future wastewater flows in the study area are estimated by applying unit (per acre or per capita) flow factors to the projected "ultimate" land use acreage or population in each sub area. As discussed in Section 2, ultimate land uses within the study area are estimated based on the City's current General Plan (which governs future development/redevelopment). The major contributor of the wastewater flow in the future would be undeveloped industrial business park area in the eastern portion of study areas. For purpose of this study it has been assumed that this area would most likely be developed by the year 2015. Future wastewater flows are estimated using land used base coefficients for the City.

5.2 Flow Coefficients

A review of commonly used flow coefficients (or unit factors) was performed to arrive at preliminary criteria, which would be an appropriate starting point for the study area.

Flow coefficients are commonly expressed in terms of cubic feet per second (cfs) of average dry weather flow (ADWF) per acre of a specific land use type. For population based estimates, flows are expressed in gallons per capita per day (gpcd). Peak flow generation rates estimated by applying peaking factors to the average flow, (with factors often based on observed peak-to-average ratios from previous studies) are of little value in simulating flows within the collection system, since peaks for various uses are not simultaneous, but rather staggered throughout the day. Also, peaks are blended and attenuated by lag times and in-pipe storage as the flows move downstream. Notwithstanding the above, diurnal peaking factors are also estimated for each land use type to estimate peak generation rates.
For preliminary estimation of wastewater flow, the document "Criteria for Sewer Facility Design, Public Works Department, City of Riverside" was used, a copy can be found in Appendix "B". The following is a general guideline for estimation of theoretical wastewater flows within the study area:

Flows from Land Use Categories:

Residential sewage flows are determined by using the following sources of information and criteria:

- Land use shown in the City's General Plan.
- No. of dwelling units per acre within a certain land use.
- Persons per living unit determined from the latest census data for the study area. However, it should not be less than an average of 2.75 persons per living unit.
- Average wastewater flow based on 65 gallons per capita per day.
- Peak to average flows to be determined from the graphs.

Peak flows from non-residential developments shall be determined using the following criteria:

- Industrial Developments – 0.012 cfs/acre
- Commercial Developments – 0.010 cfs/acre
- Offices – 30 gallons per capita (employee on site) per day
- Schools – 30 gallons per capita per day
- Laundromat – 580 gallons per machine per day.
- For Multi Family Residential a flow co-efficient of 0.014 cfs/acre has been assumed (The City of Anaheim uses a coefficient of 0.014 cfs per acre).
- For Industrial Business Parks a coefficient of 0.010 cfs/acre (same as commercial developments) has been used.

The City of Riverside Criteria for Sewer Facility Design is attached as Appendix "B".

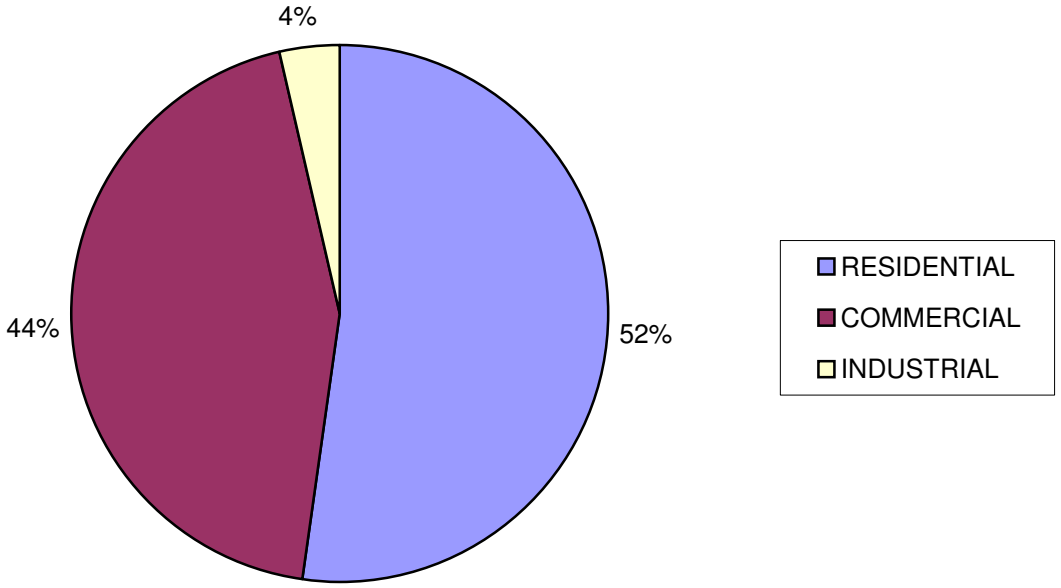
.

5.3 Representative Diurnal Hydrographs

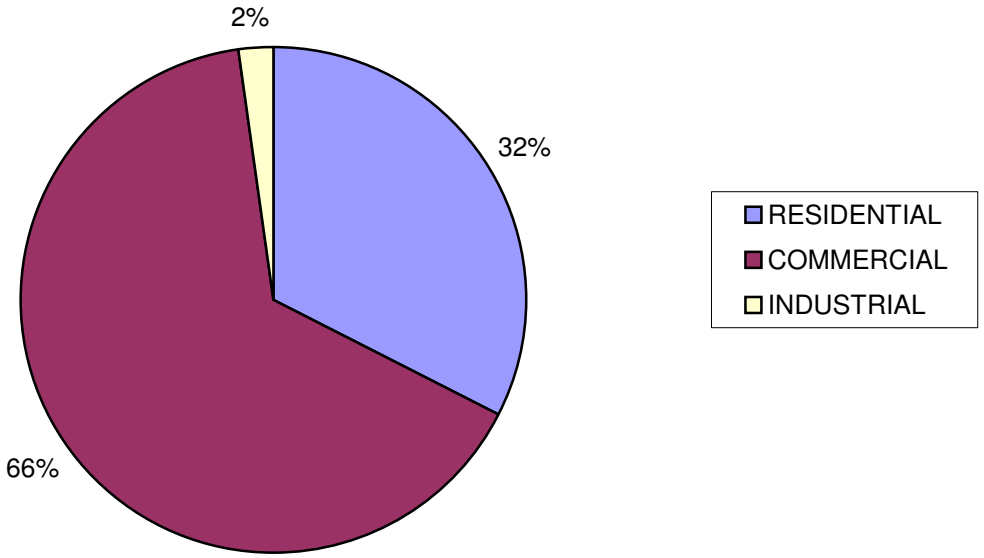
The study area is comprised of a variety of unique land uses. For the purpose of defining characteristic diurnal patterns, flow from each sub-basin was analyzed and percentage of flow contribution from each land use type was estimated. Tables 5-1 summarizes flows from different land use categories contributing to each meter location for current and future conditions, respectively. Table 5-2 and 5-3 summarize theoretical wastewater percentage flow contributions to each meter locations. Figure 13 shows percentage of flow contribution from different land categories at meter location 5. Although none of the tributary sub areas flowing to the meter locations are comprised of a single land use category, several are dominated by one or two categories, and are thus selected as being representative to the diurnal flow patterns for those land uses. In addition Spruce Street Sewer Capacity Study (June 2002) was used to determine flow pattern for Single Family Residential (SFR) units. Based on this table, the following diurnal patterns were used for the modeled peak flow evaluation.

Figure 13
Existing and Future Flow Contributions from Various Land Uses
Meter Location 5

Existing (2003) Contributing Flows at Meter Location 5



Future (2018) Contributing Flows at Meter Location 5



- Flow at meter location 1: Lift station pattern (SFR)
- Flow at meter location 3: Mixed used Commercial/Residential.
- Flow at meter location 4: Downtown.
- Flow at meter location 5: Mixed-use pattern.
- Flow at meter location 8 : SFR (From Spruce Study)

These representative diurnal hydrographs are shown in Figures 14-17. The flow patterns are used in the model to estimate for each land use type; the percentage of Average Dry Weather Flow (ADWF) contributed at specific times throughout the day.

Figure 13 graphically depicts the existing and future conditions and illustrates the increasing influence of proposed industrial business park development near Fwy 215.

Table 5-1
Summary of Theoretical Flow

METER	CONTRIBUTORY AREA (ac)	LANDUSE FLOW								Total Peak Flow
		Residential (SFR & MFR)				Commercial		Industrial		
		Pop.	Avg. flow	PF	Peak flow	area	Peak flow	area	Peak flow	
CURRENT FLOW:(Year 2003)			(cfs)		(cfs)	(ac)	(cfs)	(ac)	(cfs)	(cfs)
1	2698	13,609	1.368	2.0	2.737	61.00	0.610	10.00	0.120	3.47
2	6584	22,545	2.267	1.6	3.514	359.00	3.590	10.00	0.120	7.22
3	8289	36,941	3.715	1.5	5.572	361.00	3.610	10.00	0.120	9.30
4	1,296	13,341	1.342	2.1	2.817	214.00	2.140	43.00	0.516	5.47
5	12,968	62,432	6.278	1.5	9.417	796.00	7.960	55.00	0.660	18.04
FUTURE FLOW:(Year 2018)										
1	2,698	16,107	1.620	1.9	3.077	207.00	2.070	15.00	0.180	5.33
2	6,584	28,010	2.817	1.5	4.225	1649.00	16.490	15.00	0.180	20.89
3	8,289	42,656	4.289	1.5	6.434	1651.00	16.510	15.00	0.180	23.12
4	1,296	13,419	1.349	1.9	2.564	214.00	2.140	43.00	0.516	5.22
5	12,968	71,434	7.183	1.5	10.775	2168.00	21.680	60.00	0.720	33.17

Notes:

For flow calculation of SFR and MFR population a 2.75 capita per dwelling unit has been used as per City of Riverside guideli
For population growth a 12.65% growth for every ten year has been assumed based on population data for City of Riverside.
Per capita sewage flow- 65 gpcd
Commercial Peak Flow- 0.01 cfs/ac
Industrial Peak Flow- 0.012 cfs/ac
Peaking Factor as per City of Riverside Population vs Peak to Average Ratio Chart.

Abbreviations:

Pop. - Population, Avg. - Average, PF - Peaking Factor, cfs - Cubic feet per second, ac - Acre, SFR - Single Family Residenti
MFR - Multi Family Residential

Table 5-2
Current(2003) Peak Flow and Percentage Contribution from Different Land Use Categories

METER	LOCATION	Total Area	Current Trib. Area	Vacant Area	Current Peak Flow	Land Use Categories Peak Flows					
						Residential		Commercial		Industrial	
		(ac)	(ac)	(ac)	(cfs)	(cfs)	%	(cfs)	%	(cfs)	%
1	MH-203 AT ALESSANDRO BL.	2,698	1,540	1,158	3.467	2.737	79	0.610	18	0.120	3
2	MH-138 AT CENTRAL AVENUE	6,584	2,687	3,897	7.224	3.514	49	3.590	50	0.120	2
3	MH-83 AT VICTORIA COUNTRY	9,600	4,849	4,751	9.302	5.572	60	3.610	39	0.120	1
4	MH-310 AT BROCKTON AVE.	1,296	1,225	71	5.473	2.817	51	2.140	39	0.516	9
5	MH-9 AT TEQUESQUITE AVE.	12,992	7,888	5,104	18.037	9.417	52	7.960	44	0.660	4

Table 5-3
Future(2018) Peak Flow and Percentage Contribution from Different Land Use Categories

METER	LOCATION	Future Total Area	Future Trib. Area	Vacant Area	Future Peak Flow	Land Use Categories Peak Flows					
						Residential		Commercial		Industrial	
		(ac)	(ac)	(ac)	(cfs)	(cfs)	%	(cfs)	%	(cfs)	%
1	MH-203 AT ALESSANDRO BL.	2,698	1,995	703	5.327	3.077	58	2.070	39	0.180	3
2	MH-138 AT CENTRAL AVENUE	6,584	4,592	1,992	20.895	4.225	20	16.490	79	0.180	1
3	MH-83 AT VICTORIA COUNTRY	9,600	6,785	2,815	23.124	6.434	28	16.510	71	0.180	1
4	MH-310 AT BROCKTON AVE.	1,296	1,233	63	5.220	2.564	49	2.140	41	0.180	3
5	MH-9 AT TEQUESQUITE AVE.	12,992	10,055	2,936	33.175	10.775	32	21.680	65	0.720	2

Note:
Residential peak flow was determined by population rather than landuse because of demographics of the area.
Commercial flow includes flow from Industrial Business Park.

Abbreviations:

Trib. Area - Tributary Area
ac - Acre
cfs - Cubic feet per second.
SWR - Sewer
AVE. - Avenue
BL. - Boulevard

Figure 14

Representative Diurnal Curve for Lift Station Flow, Meter Location 1

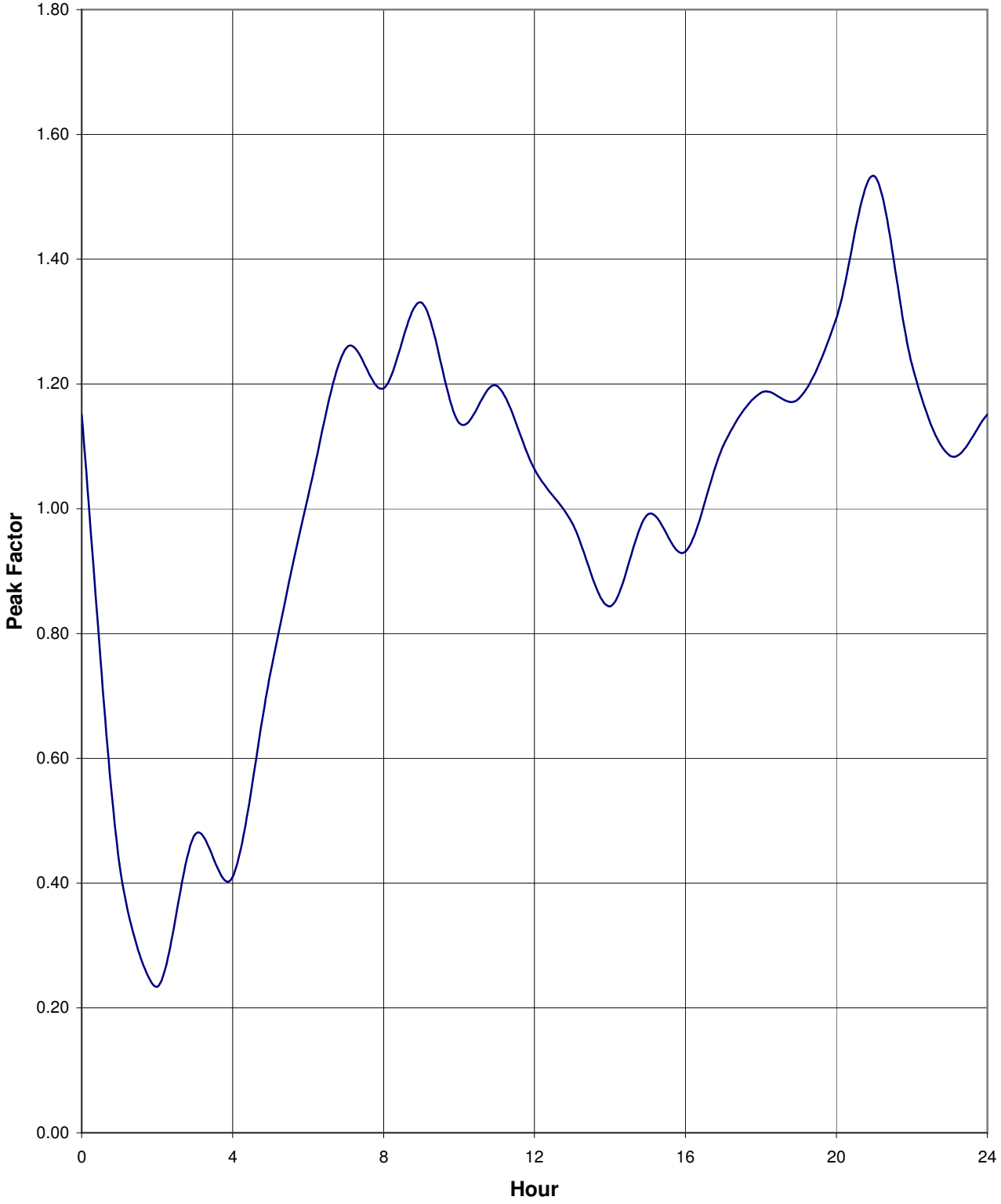


Figure 15

Representative Diurnal Curve for Mixed Land Use (Residential and Commercial), Meter Location 3

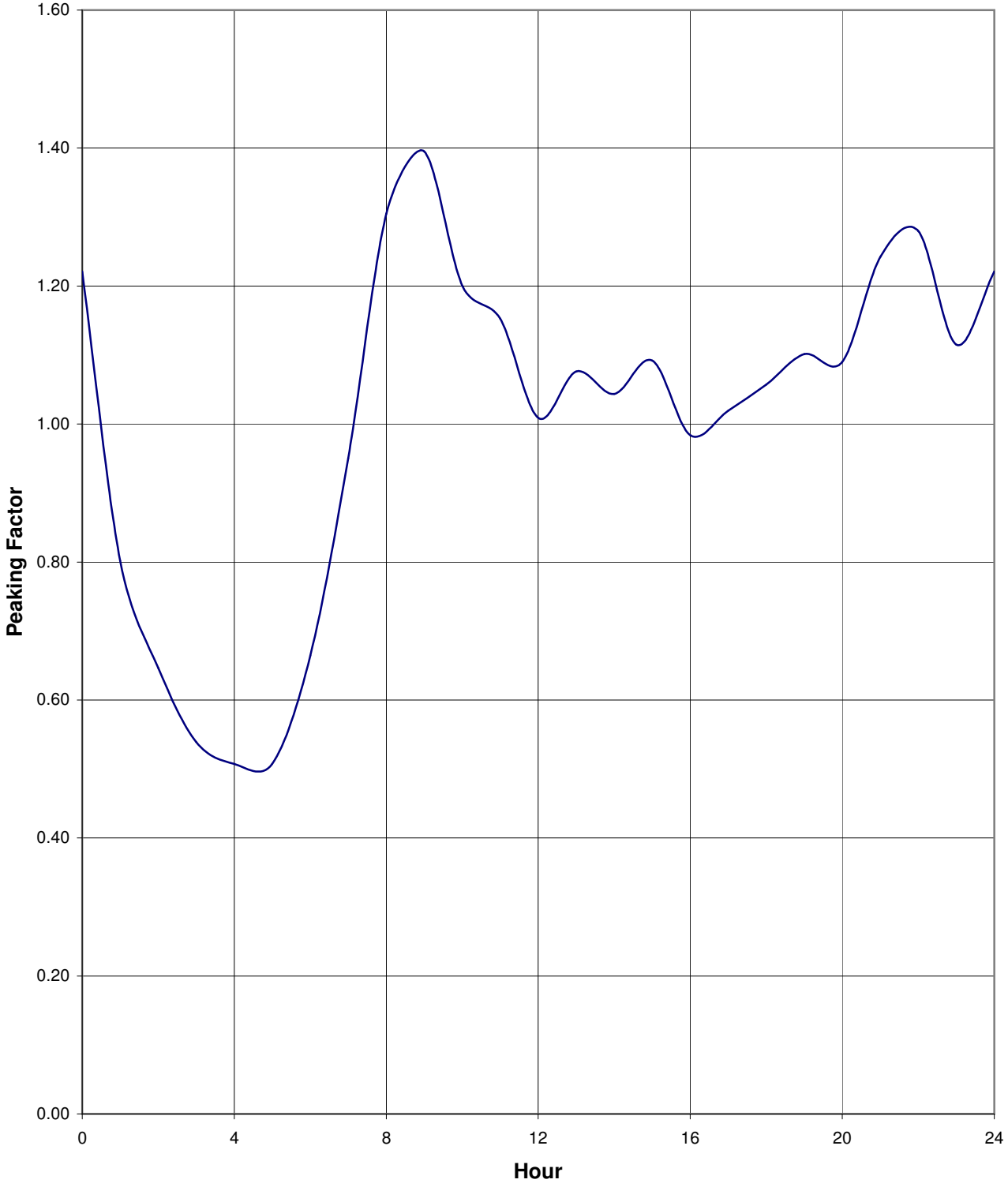


Figure 16

Representative Diurnal Curve for Downtown Area, Meter Location 4

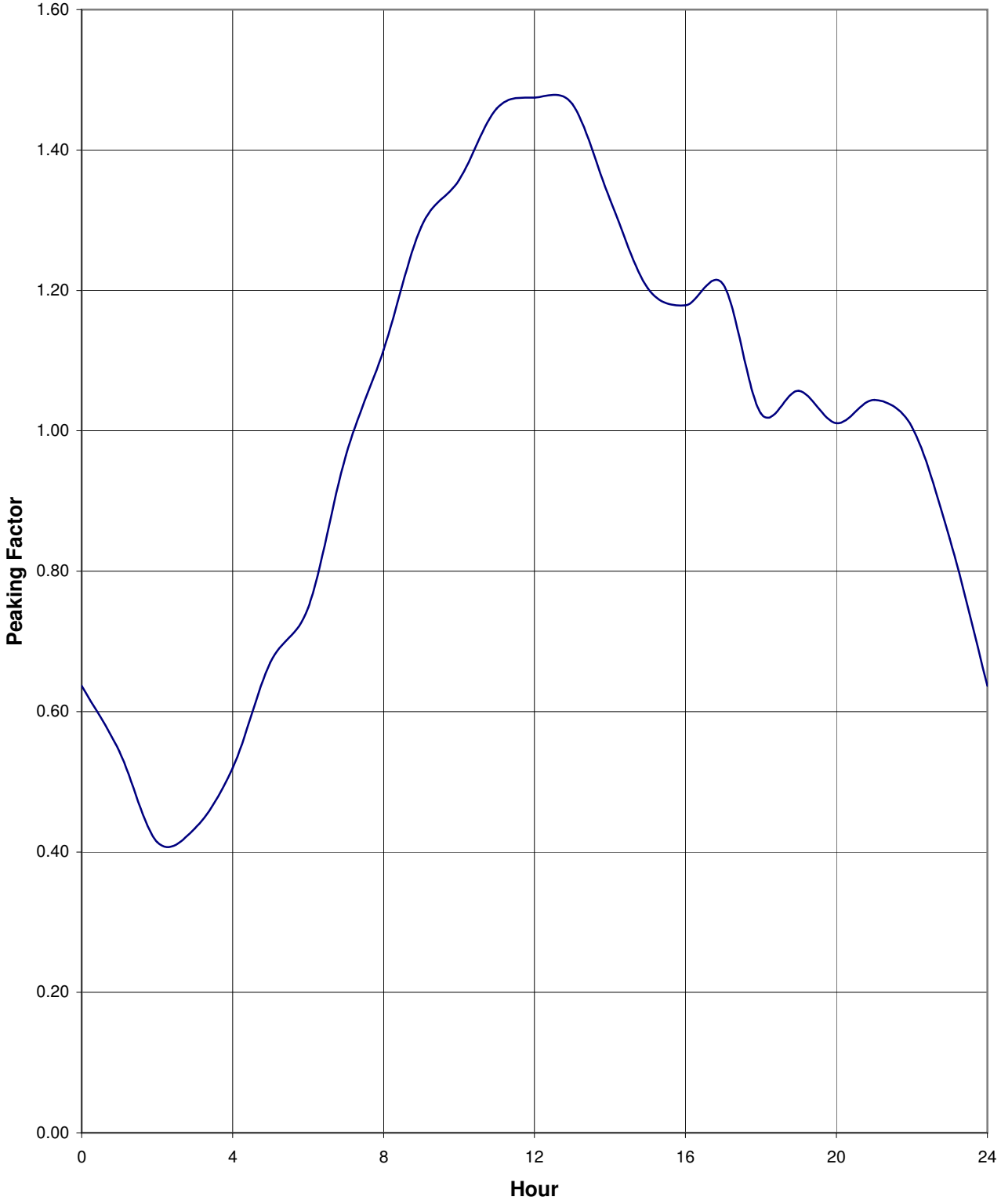
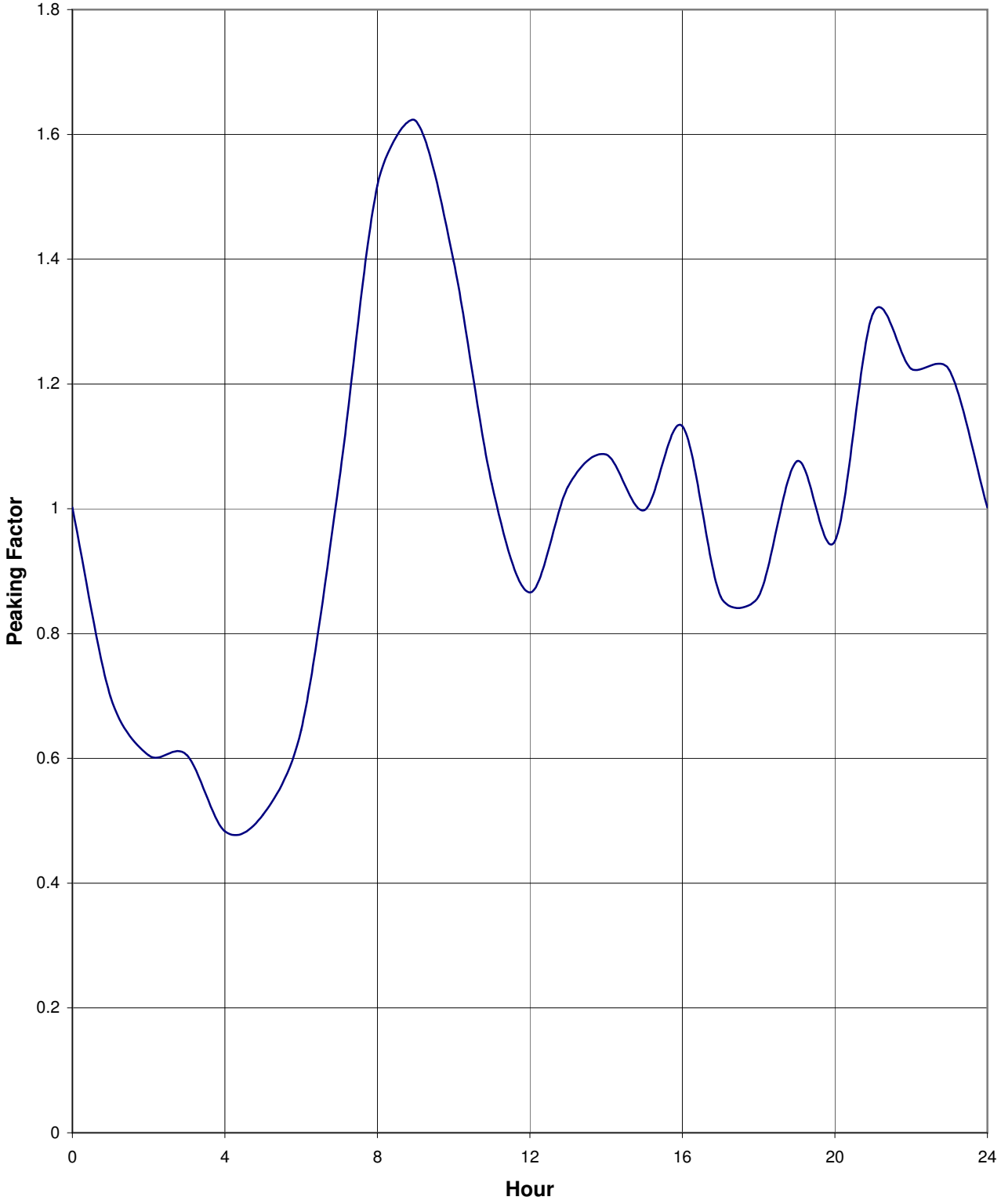


Figure 17

Representative Diurnal Curve for Single Family Residential (SFR)



Note:
This diurnal curve was originally developed from the Spruce Street Sewer Study dated June 2002.

6.0 COMPUTER MODEL SIMULATION ANALYSIS

6.1 Methodology

Capacity analysis involved evaluation of the available capacity in the existing collection system under present and future development conditions. Based on results of the analysis, phased facility improvements were identified to allow for projected growth within the service area.

This Section describes the analytical methodology and hydraulic model development, and summarizes the results of the analyses.

The principal tool utilized in the capacity analysis was a hydraulic model that simulates flow conditions using demand and piping characteristic input data. With this input information, the model is able to output sewage depth of flow, rate of flow, and velocity of flow, within selected pipes and manholes during different times of the day. The model selected for use in this study is XP-SWMM (XP Software, Version 2000); this modeling software belongs to a class of software referred to as “dynamic wave models”. These types of models provide an accurate simulation of hydraulic flow conditions over an extended period of time.

Data required to create the model include information describing the physical wastewater collection system, such as pipe diameters and reach lengths, manhole invert elevations, and estimated pipe roughness coefficients. Additionally, data describing the sewage loading at selected manholes, expressed as a varying flow rate over time (i.e. a diurnal curve), must be provided. Model output consists of a variety of hydraulic parameters, most importantly peak flow velocity and discharge rates.

Calibration of the model consisted of simulating existing sewer flow conditions and comparing the modeled and recorded flows at the meter locations. The assumed diurnal curves that serve as input to the model were iteratively adjusted until the simulated and recorded sewage flow hydrographs achieved reasonable agreement.

Simulations of future sewage flow conditions were performed by developing input data sets that included sewage generation projections for the assumed ultimate conditions. Pipe reaches in which simulated peak flows exceeded a specified trigger criteria were identified as potential improvement reaches. Improvements required to provide adequate capacity for projected flows are then determined through an iterative modeling process. The process consists of simulating flow conditions after increasing the diameter

of downstream portions of the identified reaches. In subsequent iterations, additional lengths of pipe are increased in diameter until the projected peak flow can be conveyed through the reach without exceeding the specified design flow criteria.

6.2 Limitations of Modeling

The hydraulic model, which was utilized as the primary planning tool for the sewer capacity analysis, provides an accurate simulation of actual flow conditions within a sanitary sewer system in response to existing and future sewage loading. The accuracy of the simulation, however, is directly related to the accuracy of the model input data, including physical parameters and sewage loading projections. For example, in a case where roots had entered the pipeline, thereby causing a restriction of flow, the model would be unable to predict the reduction in flow through this obstruction. Consequently, a general understanding of the data sources is critical in interpreting the modeling results.

The physical parameters of the model, including pipe diameter, slope, and roughness coefficients were based principally on City database information. Where this data appeared to be inaccurate, construction drawings were reviewed and the input data corrected. Network connectivity refers to the flow path followed by sewage within the sewer system. The connectivity is a function of the relative slope of each sewer pipe and the relative invert elevations of the incoming and outgoing sewer pipes at manholes. For example, a manhole may have two or more sewer pipes, which could convey flow away from the manhole. If the invert (bottom) of one of these pipes is lower than the other, the downstream flow path at this manhole would follow the lower pipe.

Sewage loading projections were based on calibrated flow rates. As previously described, flow rates used for calibration were based on actual monitored flows at key points in the trunk system over a 2-week period in July-August 2003. This period included the two weekends.

Since a degree of uncertainty exists in both the physical data and the sewage loading projections used as model inputs, reaches identified by model simulations as near or at capacity should be subject to additional engineering evaluation prior to improvement. Such evaluation may include field inspection, video monitoring and flow metering.

The results of model run for existing and ultimate conditions are summarized in Tables 7-1-A and 7-1-B respectively.

Table 7-1-A
Sewer Analysis Results (Existing Conditions)

Name	Diameter, ft	Slope (ft/ft)	Theoretical "Full" Flow (cfs)	Existing Modeled Peak Flow (cfs)	Existing % Full
P01	2.25	0.008	27.98	19.66	70%
P02	2.25	0.008	28.40	19.66	69%
P03	2.25	0.009	29.83	19.66	66%
P04	2.25	0.010	30.82	19.66	64%
P05	2.25	0.009	29.68	19.66	66%
P06	2.25	0.007	25.66	19.66	77%
P07	2.25	0.007	26.50	19.66	74%
P08	2.25	0.007	25.30	19.66	78%
P09	2.25	0.007	26.37	18.66	71%
P10	2.50	0.004	27.35	18.66	68%
P11	2.50	0.004	26.72	18.66	70%
P12	2.25	0.008	28.40	18.66	66%
P13	2.25	0.010	30.77	18.66	61%
P14	2.00	0.013	25.84	18.66	72%
P15	1.75	0.005	11.04	17.56	159%
P16	1.75	0.006	12.38	17.56	142%
P17	1.75	0.006	12.42	17.56	141%
P18	2.00	0.002	11.00	17.56	160%
P19	1.25	0.007	11.01	13.21	120%
P20	2.25	0.003	15.66	13.22	84%
P21	2.25	0.003	17.84	13.22	74%
P22	2.25	0.004	18.41	13.23	72%
P23	2.25	0.003	17.92	13.23	74%
P24	2.00	0.009	21.72	13.23	61%
P25	2.25	0.002	13.16	13.23	101%
P26	2.25	0.003	18.04	13.23	73%
P27	2.25	0.006	23.23	12.17	52%
P28	2.25	0.003	18.06	12.17	67%
P29	2.25	0.003	18.03	12.17	67%
P30	2.25	0.003	17.97	12.17	68%
P31	2.25	0.003	17.63	12.17	69%
P32	2.25	0.003	17.27	12.17	70%
P33	2.25	0.004	19.90	12.17	61%
P34	2.25	0.003	17.80	12.17	68%
P35	2.25	0.003	17.37	12.17	70%
P36	2.25	0.004	20.56	12.16	59%
P37	2.25	0.004	20.57	12.18	59%
P38	2.00	0.008	20.25	12.16	60%
P39	2.25	0.004	20.45	12.16	59%
P40	2.25	0.004	20.23	12.16	60%
P41	2.25	0.006	23.07	12.16	53%
P42	2.25	0.017	40.24	12.16	30%
P43	2.00	0.007	19.19	12.16	63%
P44	2.00	0.008	20.45	12.16	59%
P45	2.00	0.007	19.14	12.16	64%
P46	2.00	0.007	18.88	12.16	64%
P47	2.00	0.028	37.94	12.16	32%
P48	2.00	0.214	104.45	12.16	12%
P49	2.00	0.004	14.74	12.16	83%

Table 7-1-A
Sewer Analysis Results (Existing Conditions)

Name	Diameter, ft	Slope (ft/ft)	Theoretical "Full" Flow (cfs)	Existing Modeled Peak Flow (cfs)	Existing % Full
P50	1.50	0.002	4.73	12.16	257%
P51	2.00	0.012	24.35	12.16	50%
P52	2.25	0.003	15.91	11.95	75%
P53	2.25	0.002	13.29	11.95	90%
P54	2.25	0.002	13.21	11.95	90%
P55	2.25	0.002	13.28	11.95	90%
P56	2.00	0.004	13.75	11.96	87%
P57	2.00	0.003	12.90	11.98	93%
P58	2.00	0.003	12.77	11.99	94%
P59	2.00	0.003	12.80	12.03	94%
P60	1.75	0.006	12.23	12.06	99%
P61	1.75	0.006	12.35	12.05	98%
P62	1.75	0.006	12.34	12.06	98%
P63	1.75	0.006	12.34	12.06	98%
P64	1.75	0.006	12.38	12.06	97%
P65	1.75	0.006	12.36	12.07	98%
P66	1.75	0.006	12.30	12.07	98%
P67	2.00	0.004	15.06	12.07	80%
P68	1.75	0.009	15.35	10.72	70%
P69	1.75	0.007	13.30	10.72	81%
P70	1.75	0.008	13.85	10.72	77%
P71	1.75	0.007	13.36	10.72	80%
P72	1.75	0.008	13.80	10.72	78%
P73	1.75	0.006	12.71	10.72	84%
P74	1.75	0.006	12.64	10.72	85%
P75	1.75	0.007	13.42	10.72	80%
P76	1.75	0.008	13.78	10.72	78%
P77	1.75	0.010	15.81	10.72	68%
P78	1.75	0.010	15.81	10.72	68%
P79	1.75	0.010	15.81	10.72	68%
P80	1.75	0.010	15.57	10.72	69%
P81	1.50	0.012	11.31	10.72	95%
P82	1.50	0.012	11.34	10.72	95%
P83	1.50	0.012	11.34	10.72	95%
P84	1.50	0.012	11.41	10.72	94%
P85	1.50	0.012	11.34	10.72	95%
P86	1.50	0.012	11.60	10.72	92%
P87	1.50	0.012	11.34	3.35	30%
P88	1.50	0.014	12.22	2.68	22%
P89	1.50	0.013	11.85	2.68	23%
P90	1.50	0.012	11.29	2.68	24%
P91	1.50	0.012	11.28	2.68	24%
P92	1.75	0.011	16.47	0.90	5%
P93	1.75	0.014	18.76	0.90	5%
P94	1.75	0.014	18.67	0.90	5%
P95	1.25	0.301	35.31	0.90	3%
P96	2.25	0.002	13.75	0.90	7%
P97	2.25	0.002	13.83	0.90	6%
P98	2.25	0.002	13.95	0.90	6%

Table 7-1-A
Sewer Analysis Results (Existing Conditions)

Name	Diameter, ft	Slope (ft/ft)	Theoretical "Full" Flow (cfs)	Existing Modeled Peak Flow (cfs)	Existing % Full
P99	2.25	0.002	13.77	0.90	7%
P100	2.25	0.002	13.91	0.90	6%
P101	2.25	0.002	13.83	0.90	6%
P102	2.25	0.002	13.65	0.90	7%
P103	2.25	0.002	13.89	0.90	6%
P104	2.25	0.002	13.90	0.90	6%
P105	2.25	0.002	14.97	0.44	3%
P106	2.25	0.002	13.66	0.47	3%
P107	2.25	0.002	13.80	0.49	4%
P108	2.25	0.002	13.95	0.49	4%
P109	2.25	0.002	13.83	0.45	3%
P110	2.25	0.002	13.79	0.48	3%
P111	2.25	0.002	13.69	0.44	3%
P112	2.25	0.002	13.92	0.45	3%
P113	2.25	0.002	13.83	0.45	3%
P114	2.25	0.002	13.83	0.44	3%
P115	2.25	0.002	13.87	0.44	3%
P116	2.25	0.002	13.89	0.44	3%
P117	2.25	0.002	13.93	0.44	3%
P118	2.25	0.002	13.79	0.44	3%
P119	2.00	0.002	10.17	0.44	4%
P120	2.00	0.002	10.51	0.44	4%
P121	0.83	0.055	5.13	0.00	0%
P130	2.00	0.028	37.51	8.02	21%
P131	2.00	0.030	39.33	8.02	20%
P132	2.00	0.030	39.37	8.02	20%
P133	2.00	0.030	39.37	8.02	20%
P134	2.00	0.068	58.80	8.02	14%
P135	2.75	0.033	96.62	7.86	8%
P136	1.75	0.069	41.49	7.86	19%
P137	1.75	0.048	34.64	7.86	23%
P138	2.00	0.026	36.73	7.86	21%
P139	1.75	0.059	38.35	7.86	21%
P140	1.75	0.060	38.62	7.86	20%
P141	1.75	0.060	38.61	7.86	20%
P142	1.75	0.034	29.12	7.86	27%
P143	1.75	0.051	35.63	7.86	22%
P144	1.75	0.041	31.88	7.86	25%
P145	1.75	0.036	30.00	7.86	26%
P146	1.75	0.044	32.99	7.86	24%
P147	1.75	0.046	33.95	7.86	23%
P148	1.75	0.051	35.63	7.86	22%
P149	1.75	0.046	33.92	7.87	23%
P150	1.75	0.037	30.31	7.86	26%
P151	2.25	0.009	29.01	7.86	27%
P152	2.25	0.016	39.05	7.87	20%
P153	2.25	0.016	39.09	7.87	20%
P154	2.25	0.009	29.02	7.87	27%
P155	2.25	0.021	44.95	7.87	17%

Table 7-1-A
Sewer Analysis Results (Existing Conditions)

Name	Diameter, ft	Slope (ft/ft)	Theoretical "Full" Flow (cfs)	Existing Modeled Peak Flow (cfs)	Existing % Full
P156	2.25	0.021	44.71	7.87	18%
P157	3.50	0.001	30.77	7.87	26%
P158	3.50	0.001	27.58	7.12	26%
P159	3.50	0.001	28.61	7.12	25%
P160	3.50	0.001	28.39	7.13	25%
P161	3.50	0.001	28.47	7.13	25%
P162	3.50	0.001	28.47	7.13	25%
P163	3.50	0.001	28.47	7.14	25%
P164	3.50	0.001	28.47	6.63	23%
P165	3.50	0.001	28.47	6.64	23%
P166	3.50	0.001	28.47	6.64	23%
P167	3.50	0.001	28.47	6.65	23%
P168	3.50	0.001	28.47	6.65	23%
P169	3.50	0.001	28.47	6.65	23%
P170	3.50	0.001	28.19	6.66	24%
P171	3.50	0.001	38.23	5.85	15%
P172	1.67	0.012	30.38	5.85	19%
P173	3.50	0.001	28.44	5.85	21%
P174	2.50	0.001	13.50	5.59	41%
P175	2.50	0.001	13.52	5.59	41%
P176	2.50	0.001	13.44	5.59	42%
P177	2.50	0.001	13.18	5.59	42%
P178	2.50	0.001	13.68	5.60	41%
P179	2.50	0.001	13.44	5.60	42%
P180	2.50	0.001	13.48	5.60	42%
P181	2.50	0.001	13.48	5.61	42%
P182	2.00	0.002	10.10	5.29	52%
P183	2.00	0.002	10.11	5.29	52%
P184	2.00	0.002	10.04	5.29	53%
P185	2.00	0.002	10.10	5.30	52%
P186	2.00	0.002	10.10	5.30	52%
P187	2.00	0.054	52.29	5.30	10%
P188	2.00	0.002	9.81	5.30	54%
P189	1.50	0.010	10.43	3.89	37%
P190	1.50	0.010	10.48	3.89	37%
P191	1.50	0.010	10.48	3.89	37%
P192	1.50	0.012	11.37	3.78	33%
P193	1.50	0.014	12.47	3.78	30%
P194	1.50	0.019	14.57	3.78	26%
P195	1.50	0.020	14.91	3.78	25%
P196	1.50	0.020	14.82	4.07	27%
P197	1.50	0.020	14.82	3.78	26%
P198	1.50	0.010	10.49	3.78	36%
P199	1.50	0.020	14.82	3.78	26%
P200	1.50	0.009	10.05	3.78	38%
P201	1.50	0.009	10.05	3.79	38%
P202	1.50	0.010	10.47	3.79	36%
P203	1.50	0.010	10.48	3.79	36%
P204	1.50	0.011	11.21	3.79	34%

Table 7-1-A
Sewer Analysis Results (Existing Conditions)

Name	Diameter, ft	Slope (ft/ft)	Theoretical "Full" Flow (cfs)	Existing Modeled Peak Flow (cfs)	Existing % Full
P205	1.33	Force Main			
P206	1.75	0.004	10.54	4.54	43%
P207	1.50	0.002	5.20	2.51	48%
P208	1.50	0.002	5.12	2.51	49%
P209	1.50	0.002	5.17	1.94	37%
P210	1.50	0.002	5.12	1.94	38%
P211	1.50	0.002	5.11	1.94	38%
P212	1.50	0.003	5.92	1.94	33%
P213	1.50	0.073	28.27	1.94	7%
P214	1.50	0.002	5.08	1.94	38%
P215	1.50	0.002	5.15	1.94	38%
P216	1.50	0.032	18.74	1.94	10%
P217	1.50	0.032	18.74	1.94	10%
P218	1.50	0.002	5.14	1.84	36%
P219	1.00	0.083	10.20	1.46	14%
P220	1.00	0.013	3.98	1.46	37%
P221	1.00	0.009	3.44	1.46	42%
P222	1.00	0.009	3.44	1.46	42%
P223	1.00	0.009	3.44	1.46	42%
P224	1.00	0.009	3.44	1.46	42%
P225	1.00	0.015	4.34	1.46	34%
P226	1.00	0.015	4.36	1.46	33%
P227	1.00	0.015	4.35	1.46	33%
P228	1.00	0.006	2.74	1.46	53%
P229	1.00	0.006	2.75	1.46	53%
P230	1.00	0.006	2.75	1.46	53%
P231	1.00	0.006	2.75	1.46	53%
P232	0.67	0.018	1.63	0.77	47%
P233	0.67	0.049	2.65	0.08	3%
P234	0.67	0.042	2.44	0.08	3%
P235	0.83	0.010	2.16	0.69	32%
P236	0.83	0.010	2.16	0.69	32%
P237	0.83	0.010	2.16	0.69	32%
P238	1.50	0.017	13.81	2.03	15%
P239	1.50	0.017	13.74	2.03	15%
P240	1.50	0.017	13.72	2.03	15%
P241	1.00	0.004	2.24	0.60	27%
P242	1.00	0.004	2.24	0.60	27%
P243	1.00	0.032	6.39	0.60	9%
P244	1.00	0.032	6.39	0.60	9%
P245	1.00	0.032	6.39	0.60	9%
P246	1.00	0.032	6.40	0.60	9%
P247	1.00	0.026	5.72	0.60	10%
P248	1.00	0.002	1.74	0.60	34%
P249	1.00	0.002	1.74	0.60	34%
P250	1.00	0.002	1.74	0.60	34%
P251	1.00	0.008	3.22	0.60	19%
P252	1.00	0.002	1.73	0.60	35%
P253	1.25	0.026	10.36	1.43	14%

Table 7-1-A
Sewer Analysis Results (Existing Conditions)

Name	Diameter, ft	Slope (ft/ft)	Theoretical "Full" Flow (cfs)	Existing Modeled Peak Flow (cfs)	Existing % Full
P254	1.25	0.011	6.68	1.43	21%
P255	1.00	0.023	5.41	0.73	13%
P256	1.00	0.009	3.33	0.73	22%
P257	1.00	0.044	7.44	0.73	10%
P258	1.00	0.018	4.76	0.73	15%
P259	1.00	0.012	3.89	0.73	19%
P260	1.00	0.008	3.17	0.73	23%
P261	1.00	0.007	2.89	0.73	25%
P262	1.00	0.007	2.88	0.73	25%
P263	0.83	0.032	3.90	0.73	19%
P264	0.83	0.023	3.33	0.73	22%
P265	0.83	0.034	4.04	0.73	18%
P266	0.83	0.020	3.08	0.73	24%
P267	0.83	0.025	3.46	0.73	21%
P268	0.83	0.027	3.57	0.73	20%
P269	0.83	0.019	3.03	0.73	24%
P270	0.83	0.007	1.88	0.73	39%
P271	0.67	0.013	1.38	0.73	53%
P272	0.67	0.009	1.16	0.73	63%
P273	0.67	0.010	1.17	0.73	62%
P274	0.67	0.010	1.17	0.73	62%
P275	0.67	0.009	1.16	0.73	63%
P276	0.67	0.004	0.76	0.73	96%
P277	1.25	0.014	7.75	0.32	4%
P278	1.25	0.008	5.83	0.32	5%
P279	1.25	0.008	5.91	0.32	5%
P280	1.25	0.004	4.18	0.32	8%
P281	1.25	0.007	5.53	0.32	6%
P282	1.25	0.023	9.83	0.32	3%
P283	1.25	0.005	4.74	0.32	7%
P284	1.00	0.002	1.51	1.00	66%
P285	1.00	0.002	1.50	1.00	67%
P286	1.00	0.002	1.50	1.00	67%
P287	1.00	0.002	1.51	1.01	67%
P288	0.83	0.002	0.97	1.01	104%
P290	2.75	0.008	46.66	8.01	17%
P291	2.75	0.008	47.45	8.01	17%
P292	2.75	0.008	47.06	8.01	17%
P293	2.75	0.016	67.47	8.01	12%
P294	2.75	0.009	51.38	8.01	16%
P295	2.25	0.028	52.07	8.01	15%
P296	2.00	0.025	35.68	8.01	22%
P297	2.00	0.036	42.92	8.01	19%
P298	2.00	0.058	54.35	8.01	15%
P299	2.00	0.058	54.41	8.01	15%
P300	2.00	0.028	37.57	8.01	21%
P301	2.00	0.041	45.46	8.02	18%
P302	2.00	0.046	48.23	8.02	17%
P303	2.00	0.009	21.22	8.02	38%

Table 7-1-A
Sewer Analysis Results (Existing Conditions)

Name	Diameter, ft	Slope (ft/ft)	Theoretical "Full" Flow (cfs)	Existing Modeled Peak Flow (cfs)	Existing % Full
P304	2.00	0.028	37.49	8.02	21%
P305	2.00	0.012	24.83	8.02	32%
P306	2.00	0.009	21.44	8.02	37%
P307	2.00	0.014	26.82	8.02	30%
P307A	2.00	0.015	27.45	8.02	29%
P308	1.25	0.009	6.01	5.33	100%[1]
P309	1.25	0.009	6.16	5.33	100%[1]
P310	1.25	0.010	6.28	5.33	100%[1]
P311	1.25	0.013	7.45	2.99	100%[1]
P311A	1.25	0.012	7.16	2.51	100%[1]
P311B	1.25	0.012	7.01	2.46	100%[1]
P311C	1.25	0.022	9.52	2.46	26%
P311D	1.25	0.009	6.26	2.46	39%
P312	1.00	0.011	3.71	2.17	100%[1]
P313	1.00	0.026	5.68	2.13	100%[1]
P314	0.83	0.025	3.43	2.13	100%[1]
P315	1.75	0.006	12.63	4.51	36%
P316	1.75	0.006	12.59	4.51	36%
P317	1.75	0.005	11.57	4.51	39%
P318A	1.75	0.005	11.26	4.51	40%
P319	1.00	0.016	4.50	2.93	65%
P319A	1.00	0.022	5.31	1.58	30%
P320	0.83	0.018	2.93	2.93	100%[1]
P321	0.83	0.020	3.09	2.93	100%[1]
P322	1.00	0.037	6.80	1.58	23%
P323	1.00	0.042	7.24	4.51	62%
P324	1.00	0.042	7.30	4.51	62%
P325	1.25	0.024	10.06	1.58	16%
P326	1.25	0.015	7.83	1.58	20%
P327	0.83	0.021	3.15	1.58	50%
P327A	1.00	0.018	4.70	2.93	62%
P328	1.00	0.018	4.81	2.87	60%
P329	1.17	0.004	3.46	2.03	100%[1]
P329A	1.00	0.003	1.98	1.29	100%[1]
P330	1.25	0.003	3.77	2.03	100%[1]
P331	1.25	0.003	3.59	2.03	100%[1]
P332	1.00	0.003	1.88	1.86	100%[1]
P333	1.00	0.003	1.88	1.85	100%[1]
P334	1.00	0.003	1.89	1.85	100%[1]
P335	1.00	0.003	1.92	1.59	100%[1]
P336	1.00	0.003	1.93	1.59	100%[1]
P337	1.00	0.003	1.94	1.59	100%[1]
P338	1.00	0.003	2.03	1.17	100%[1]
P339	0.83	0.003	1.18	1.17	100%[1]
P340	0.83	0.002	1.02	0.64	100%[1]
P341	0.83	0.003	1.15	0.64	100%[1]

Table 7-1-A
Sewer Analysis Results (Existing Conditions)

Name	Diameter, ft	Slope (ft/ft)	Theoretical "Full" Flow (cfs)	Existing Modeled Peak Flow (cfs)	Existing % Full
P342	0.83	0.002	1.05	0.64	100%[1]
P343	0.83	0.003	1.25	0.64	100%[1]
P344	1.25	0.003	3.64	1.26	34.51%
P345	1.25	0.003	3.62	1.02	28.24%
P346	1.25	0.003	3.63	1.02	28.20%
P347	1.25	0.003	3.56	1.02	28.75%
P348	1.50	0.002	4.80	1.02	21.33%
P349	1.50	0.003	5.41	1.02	18.94%
P350	1.50	0.002	4.76	1.02	21.49%
P351	1.25	0.002	2.94	0.79	26.93%
P352	1.25	0.011	6.62	0.79	11.96%
P353	1.25	0.012	6.96	0.79	11.38%
P354	1.25	0.008	5.84	0.79	13.57%
P355	1.25	0.010	6.44	0.79	12.31%
P356	0.67	0.011	1.26	0.29	100%[1]
P357	0.67	0.011	1.23	0.29	100%[1]
P358	0.67	0.011	1.23	0.25	20.50%
P359	0.67	0.010	1.23	0.26	21.27%
P360	0.67	0.011	1.23	0.25	20.49%
P361	0.67	0.010	1.20	0.09	7.57%
P362	0.67	0.011	1.27	0.09	7.16%
P363	0.67	0.011	1.27	0.09	7.13%
P364	0.67	0.010	1.17	0.09	7.77%
P365	0.67	0.003	0.65	0.52	100%[1]
P366	0.67	0.006	0.97	0.60	100%[1]
P367	0.67	0.022	1.78	0.52	29.06%
P368	0.67	0.007	1.00	0.26	25.77%
P369	0.67	0.012	1.32	0.26	19.56%
P370	0.67	0.012	1.34	0.26	19.35%
P371	0.67	0.013	1.37	0.26	18.94%
P372	0.67	0.005	0.81	0.52	100%[1]
P373	0.67	0.005	0.82	0.52	62.56%
P374	0.67	0.004	0.74	0.52	70.02%
P375	0.67	0.004	0.80	0.52	64.60%
P376	0.67	0.008	1.08	0.26	23.84%
P377	0.67	0.008	1.04	0.26	24.78%
P378	0.67	0.017	1.57	0.26	16.42%
P379	0.67	0.014	1.44	0.26	17.91%
P380	0.67	0.012	1.29	0.26	20.04%
P381	0.67	0.010	1.20	0.26	21.44%
P382	0.67	0.010	1.21	0.26	21.41%
P383	0.67	0.010	1.22	0.26	21.17%
P384	0.67	0.010	1.20	0.26	21.55%
P385	0.67	0.010	1.22	0.26	21.23%

Table 7-1-A
Sewer Analysis Results (Existing Conditions)

Name	Diameter, ft	Slope (ft/ft)	Theoretical "Full" Flow (cfs)	Existing Modeled Peak Flow (cfs)	Existing % Full
P386	0.67	0.010	1.18	0.26	21.78%
P387	0.67	0.010	1.21	0.26	21.40%
P388	0.67	0.009	1.15	0.26	22.45%
P389	1.50	0.013	12.03	0.44	3.63%
P390	1.25	0.020	9.11	0.44	4.80%
P391	1.25	0.019	8.85	0.44	4.94%
P392	1.25	0.018	8.62	0.44	5.07%
P393	1.50	0.007	8.86	0.44	4.93%
P394	1.50	0.007	8.72	0.44	5.01%
P395	1.50	0.001	2.63	0.44	16.62%
P396	1.00	0.033	6.45	0.44	6.78%
P397	1.00	0.247	17.64	0.22	1.24%
P398	1.25	0.010	6.56	0.22	3.34%
P399	1.25	0.010	6.51	0.22	3.37%
P400	1.25	0.010	6.58	0.22	3.33%
P401	1.25	0.028	10.69	0.22	2.05%
P402	1.25	0.014	7.73	0.22	2.84%
P403	1.25	0.033	11.78	0.22	1.86%
P404	1.25	0.022	9.51	0.22	2.31%
P405	1.25	0.335	37.25	0.22	0.59%
P406	1.25	0.209	29.45	0.22	0.75%
P407	1.25	0.040	12.93	0.22	1.70%
P408	0.83	0.034	4.04	1.80	44.56%
P409	0.83	0.190	9.49	1.80	18.95%
P410	0.67	0.066	3.07	1.80	58.54%
P411	0.67	0.074	3.26	1.80	55.19%
P412	0.67	0.077	3.33	1.80	54.12%

1. Due to back-up in sewer system.

Table 7-1-B
Sewer Analysis Results (Ultimate Conditions)

Name	Diameter, ft	Slope (%)	Theoretical "Full" Flow (cfs)	Future Modeled Peak Flow (cfs)	Future % Full
P01	2.25	0.008	27.98	33.43	119%
P02	2.25	0.008	28.40	33.43	118%
P03	2.25	0.009	29.83	33.43	112%
P04	2.25	0.010	30.82	33.43	108%
P05	2.25	0.009	29.68	33.43	113%
P06	2.25	0.007	25.66	33.43	130%
P07	2.25	0.007	26.50	33.43	126%
P08	2.25	0.007	25.30	33.43	132%
P09	2.25	0.007	26.37	32.42	123%
P10	2.50	0.004	27.35	32.42	119%
P11	2.50	0.004	26.72	32.42	121%
P12	2.25	0.008	28.40	32.42	114%
P13	2.25	0.010	30.77	32.42	105%
P14	2.00	0.013	25.84	32.42	125%
P15	1.75	0.005	11.04	31.36	284%
P16	1.75	0.006	12.38	31.37	253%
P17	1.75	0.006	12.42	31.37	253%
P18	2.00	0.002	11.00	31.37	285%
P19	1.25	0.007	11.01	25.82	235%
P20	2.25	0.003	15.66	25.82	165%
P21	2.25	0.003	17.84	25.83	145%
P22	2.25	0.004	18.41	25.83	140%
P23	2.25	0.003	17.92	25.83	144%
P24	2.00	0.009	21.72	25.83	119%
P25	2.25	0.002	13.16	25.83	196%
P26	2.25	0.003	18.04	25.83	143%
P27	2.25	0.006	23.23	24.72	106%
P28	2.25	0.003	18.06	24.72	137%
P29	2.25	0.003	18.03	24.72	137%
P30	2.25	0.003	17.97	24.71	138%
P31	2.25	0.003	17.63	24.72	140%
P32	2.25	0.003	17.27	24.72	143%
P33	2.25	0.004	19.90	24.72	124%
P34	2.25	0.003	17.80	24.72	139%
P35	2.25	0.003	17.37	24.71	142%
P36	2.25	0.004	20.56	24.71	120%
P37	2.25	0.004	20.57	24.71	120%
P38	2.00	0.008	20.25	24.72	122%
P39	2.25	0.004	20.45	24.71	121%
P40	2.25	0.004	20.23	24.72	122%
P41	2.25	0.006	23.07	24.72	107%
P42	2.25	0.017	40.24	24.72	61%
P43	2.00	0.007	19.19	24.72	129%
P44	2.00	0.008	20.45	24.71	121%
P45	2.00	0.007	19.14	24.72	129%
P46	2.00	0.007	18.88	24.72	131%
P47	2.00	0.028	37.94	24.72	65%
P48	2.00	0.214	104.45	24.72	24%
P49	2.00	0.004	14.74	24.72	168%
P50	1.50	0.002	4.73	24.71	522%

Table 7-1-B
Sewer Analysis Results (Ultimate Conditions)

Name	Diameter, ft	Slope (%)	Theoretical "Full" Flow (cfs)	Future Modeled Peak Flow (cfs)	Future % Full
P51	2.00	0.012	24.35	24.72	101%
P52	2.25	0.003	15.91	24.50	154%
P53	2.25	0.002	13.29	24.51	184%
P54	2.25	0.002	13.21	24.55	186%
P55	2.25	0.002	13.28	24.57	185%
P56	2.00	0.004	13.75	24.58	179%
P57	2.00	0.003	12.90	24.58	191%
P58	2.00	0.003	12.77	24.58	192%
P59	2.00	0.003	12.80	24.58	192%
P60	1.75	0.006	12.23	24.58	201%
P61	1.75	0.006	12.35	24.58	199%
P62	1.75	0.006	12.34	24.58	199%
P63	1.75	0.006	12.34	24.58	199%
P64	1.75	0.006	12.38	24.58	199%
P65	1.75	0.006	12.36	24.58	199%
P66	1.75	0.006	12.30	24.58	200%
P67	2.00	0.004	15.06	24.58	163%
P68	1.75	0.009	15.35	22.22	145%
P69	1.75	0.007	13.30	22.22	167%
P70	1.75	0.008	13.85	22.22	160%
P71	1.75	0.007	13.36	22.22	166%
P72	1.75	0.008	13.80	22.22	161%
P73	1.75	0.006	12.71	22.22	175%
P74	1.75	0.006	12.64	22.22	176%
P75	1.75	0.007	13.42	22.22	166%
P76	1.75	0.008	13.78	22.22	161%
P77	1.75	0.010	15.81	22.22	141%
P78	1.75	0.010	15.81	22.22	141%
P79	1.75	0.010	15.81	22.22	141%
P80	1.75	0.010	15.57	22.22	143%
P81	1.50	0.012	11.31	22.22	197%
P82	1.50	0.012	11.34	22.22	196%
P83	1.50	0.012	11.34	22.22	196%
P84	1.50	0.012	11.41	22.22	195%
P85	1.50	0.012	11.34	22.22	196%
P86	1.50	0.012	11.60	22.22	192%
P87	1.50	0.012	11.34	3.41	30%
P88	1.50	0.014	12.22	2.74	22%
P89	1.50	0.013	11.85	2.74	23%
P90	1.50	0.012	11.29	2.74	24%
P91	1.50	0.012	11.28	2.74	24%
P92	1.75	0.011	16.47	0.90	5%
P93	1.75	0.014	18.76	0.90	5%
P94	1.75	0.014	18.67	0.90	5%
P95	1.25	0.301	35.31	0.90	3%
P96	2.25	0.002	13.75	0.90	7%
P97	2.25	0.002	13.83	0.90	6%
P98	2.25	0.002	13.95	0.90	6%
P99	2.25	0.002	13.77	0.90	7%
P100	2.25	0.002	13.91	0.90	6%

Table 7-1-B
Sewer Analysis Results (Ultimate Conditions)

Name	Diameter, ft	Slope (%)	Theoretical "Full" Flow (cfs)	Future Modeled Peak Flow (cfs)	Future % Full
P101	2.25	0.002	13.83	0.90	6%
P102	2.25	0.002	13.65	0.90	7%
P103	2.25	0.002	13.89	0.90	6%
P104	2.25	0.002	13.90	0.90	6%
P105	2.25	0.002	14.97	0.44	3%
P106	2.25	0.002	13.66	0.47	3%
P107	2.25	0.002	13.80	0.49	4%
P108	2.25	0.002	13.95	0.49	4%
P109	2.25	0.002	13.83	0.45	3%
P110	2.25	0.002	13.79	0.48	3%
P111	2.25	0.002	13.69	0.44	3%
P112	2.25	0.002	13.92	0.45	3%
P113	2.25	0.002	13.83	0.46	3%
P114	2.25	0.002	13.83	0.44	3%
P115	2.25	0.002	13.87	0.44	3%
P116	2.25	0.002	13.89	0.44	3%
P117	2.25	0.002	13.93	0.44	3%
P118	2.25	0.002	13.79	0.44	3%
P119	2.00	0.002	10.17	0.44	4%
P120	2.00	0.002	10.51	0.44	4%
P121	0.83	0.055	5.13	0.00	0%
P130	2.00	0.028	37.51	19.01	51%
P131	2.00	0.030	39.33	19.01	48%
P132	2.00	0.030	39.37	19.01	48%
P133	2.00	0.030	39.37	19.01	48%
P134	2.00	0.068	58.80	19.01	32%
P135	2.75	0.033	96.62	18.48	19%
P136	1.75	0.069	41.49	18.48	45%
P137	1.75	0.048	34.64	18.49	53%
P138	2.00	0.026	36.73	18.49	50%
P139	1.75	0.059	38.35	18.49	48%
P140	1.75	0.060	38.62	18.48	48%
P141	1.75	0.060	38.61	18.49	48%
P142	1.75	0.034	29.12	18.49	63%
P143	1.75	0.051	35.63	18.49	52%
P144	1.75	0.041	31.88	18.49	58%
P145	1.75	0.036	30.00	18.49	62%
P146	1.75	0.044	32.99	18.49	56%
P147	1.75	0.046	33.95	18.49	54%
P148	1.75	0.051	35.63	18.49	52%
P149	1.75	0.046	33.92	18.51	55%
P150	1.75	0.037	30.31	18.98	63%
P151	2.25	0.009	29.01	18.57	64%
P152	2.25	0.016	39.05	18.57	48%
P153	2.25	0.016	39.09	18.57	48%
P154	2.25	0.009	29.02	18.57	64%
P155	2.25	0.021	44.95	18.57	41%
P156	2.25	0.021	44.71	18.57	42%
P157	3.50	0.001	30.77	18.57	60%
P158	3.50	0.001	27.58	17.61	64%

Table 7-1-B
Sewer Analysis Results (Ultimate Conditions)

Name	Diameter, ft	Slope (%)	Theoretical "Full" Flow (cfs)	Future Modeled Peak Flow (cfs)	Future % Full
P159	3.50	0.001	28.61	17.61	62%
P160	3.50	0.001	28.39	17.61	62%
P161	3.50	0.001	28.47	17.61	62%
P162	3.50	0.001	28.47	13.75	48%
P163	3.50	0.001	28.47	13.74	48%
P164	3.50	0.001	28.47	13.75	48%
P165	3.50	0.001	28.47	13.76	48%
P166	3.50	0.001	28.47	13.77	48%
P167	3.50	0.001	28.47	13.78	48%
P168	3.50	0.001	28.47	13.79	48%
P169	3.50	0.001	28.47	13.79	48%
P170	3.50	0.001	28.19	13.80	49%
P171	3.50	0.001	38.23	12.27	32%
P172	1.67	0.012	30.38	12.28	40%
P173	3.50	0.001	28.44	12.28	43%
P174	2.50	0.001	13.50	9.87	73%
P175	2.50	0.001	13.52	9.87	73%
P176	2.50	0.001	13.44	9.88	73%
P177	2.50	0.001	13.18	9.88	75%
P178	2.50	0.001	13.68	9.88	72%
P179	2.50	0.001	13.44	9.89	74%
P180	2.50	0.001	13.48	9.89	73%
P181	2.50	0.001	13.48	9.90	73%
P182	2.00	0.002	10.10	7.47	74%
P183	2.00	0.002	10.11	7.48	74%
P184	2.00	0.002	10.04	7.48	74%
P185	2.00	0.002	10.10	7.48	74%
P186	2.00	0.002	10.10	7.49	74%
P187	2.00	0.054	52.29	7.49	14%
P188	2.00	0.002	9.81	7.49	76%
P189	1.50	0.010	10.43	5.76	55%
P190	1.50	0.010	10.48	5.76	55%
P191	1.50	0.010	10.48	5.76	55%
P192	1.50	0.012	11.37	5.29	47%
P193	1.50	0.014	12.47	5.29	42%
P194	1.50	0.019	14.57	5.64	39%
P195	1.50	0.020	14.91	5.29	36%
P196	1.50	0.020	14.82	5.29	36%
P197	1.50	0.020	14.82	5.30	36%
P198	1.50	0.010	10.49	5.29	50%
P199	1.50	0.020	14.82	5.30	36%
P200	1.50	0.009	10.05	5.30	53%
P201	1.50	0.009	10.05	5.30	53%
P202	1.50	0.010	10.47	5.31	51%
P203	1.50	0.010	10.48	5.31	51%
P204	1.50	0.011	11.21	5.31	47%
P205	1.33	Force Main			
P206	1.75	0.004	10.54	6.34	60%
P207	1.50	0.002	5.20	3.32	64%
P208	1.50	0.002	5.12	3.32	65%

Table 7-1-B
Sewer Analysis Results (Ultimate Conditions)

Name	Diameter, ft	Slope (%)	Theoretical "Full" Flow (cfs)	Future Modeled Peak Flow (cfs)	Future % Full
P209	1.50	0.002	5.17	2.66	51%
P210	1.50	0.002	5.12	2.66	52%
P211	1.50	0.002	5.11	2.66	52%
P212	1.50	0.003	5.92	2.66	45%
P213	1.50	0.073	28.27	2.66	9%
P214	1.50	0.002	5.08	2.66	52%
P215	1.50	0.002	5.15	2.66	52%
P216	1.50	0.032	18.74	2.66	14%
P217	1.50	0.032	18.74	2.66	14%
P218	1.50	0.002	5.14	2.57	50%
P219	1.00	0.083	10.20	2.18	21%
P220	1.00	0.013	3.98	2.18	55%
P221	1.00	0.009	3.44	2.29	67%
P222	1.00	0.009	3.44	2.29	67%
P223	1.00	0.009	3.44	2.25	65%
P224	1.00	0.009	3.44	2.21	64%
P225	1.00	0.015	4.34	2.19	50%
P226	1.00	0.015	4.36	2.19	50%
P227	1.00	0.015	4.35	2.19	50%
P228	1.00	0.006	2.74	2.19	80%
P229	1.00	0.006	2.75	2.19	80%
P230	1.00	0.006	2.75	2.19	80%
P231	1.00	0.006	2.75	2.19	80%
P232	0.67	0.018	1.63	1.47	91%
P233	0.67	0.049	2.65	0.75	28%
P234	0.67	0.042	2.44	0.75	31%
P235	0.83	0.010	2.16	0.72	33%
P236	0.83	0.010	2.16	0.72	33%
P237	0.83	0.010	2.16	0.72	33%
P238	1.50	0.017	13.81	3.02	22%
P239	1.50	0.017	13.74	3.02	22%
P240	1.50	0.017	13.72	3.02	22%
P241	1.00	0.004	2.24	0.68	30%
P242	1.00	0.004	2.24	0.68	30%
P243	1.00	0.032	6.39	0.68	11%
P244	1.00	0.032	6.39	0.68	11%
P245	1.00	0.032	6.39	0.68	11%
P246	1.00	0.032	6.40	0.68	11%
P247	1.00	0.026	5.72	0.68	12%
P248	1.00	0.002	1.74	0.68	39%
P249	1.00	0.002	1.74	0.69	39%
P250	1.00	0.002	1.74	0.69	39%
P251	1.00	0.008	3.22	0.69	21%
P252	1.00	0.002	1.73	0.69	40%
P253	1.25	0.026	10.36	2.35	23%
P254	1.25	0.011	6.68	2.35	35%
P255	1.00	0.023	5.41	1.18	22%
P256	1.00	0.009	3.33	1.18	36%
P257	1.00	0.044	7.44	1.18	16%
P258	1.00	0.018	4.76	1.18	25%

Table 7-1-B
Sewer Analysis Results (Ultimate Conditions)

Name	Diameter, ft	Slope (%)	Theoretical "Full" Flow (cfs)	Future Modeled Peak Flow (cfs)	Future % Full
P259	1.00	0.012	3.89	1.18	30%
P260	1.00	0.008	3.17	1.18	37%
P261	1.00	0.007	2.89	1.18	41%
P262	1.00	0.007	2.88	1.18	41%
P263	0.83	0.032	3.90	1.18	30%
P264	0.83	0.023	3.33	1.18	36%
P265	0.83	0.034	4.04	1.18	29%
P266	0.83	0.020	3.08	1.18	38%
P267	0.83	0.025	3.46	1.18	34%
P268	0.83	0.027	3.57	1.18	33%
P269	0.83	0.019	3.03	1.19	39%
P270	0.83	0.007	1.88	1.19	63%
P271	0.67	0.013	1.38	1.19	86%
P272	0.67	0.009	1.16	1.19	102%
P273	0.67	0.010	1.17	1.19	101%
P274	0.67	0.010	1.17	1.19	101%
P275	0.67	0.009	1.16	1.20	103%
P276	0.67	0.004	0.76	1.20	159%
P277	1.25	0.014	7.75	2.64	34%
P278	1.25	0.008	5.83	2.64	45%
P279	1.25	0.008	5.91	2.64	45%
P280	1.25	0.004	4.18	2.64	63%
P281	1.25	0.007	5.53	2.64	48%
P282	1.25	0.023	9.83	2.65	27%
P283	1.25	0.005	4.74	2.65	56%
P284	1.00	0.002	1.51	1.68	111%
P285	1.00	0.002	1.50	1.68	112%
P286	1.00	0.002	1.50	1.68	112%
P287	1.00	0.002	1.51	1.68	112%
P288	0.83	0.002	0.97	1.68	173%
P290	2.75	0.008	46.66	19.01	41%
P291	2.75	0.008	47.45	19.01	40%
P292	2.75	0.008	47.06	19.01	40%
P293	2.75	0.016	67.47	19.01	28%
P294	2.75	0.009	51.38	19.01	37%
P295	2.25	0.028	52.07	19.01	37%
P296	2.00	0.025	35.68	19.01	53%
P297	2.00	0.036	42.92	19.01	44%
P298	2.00	0.058	54.35	19.01	35%
P299	2.00	0.058	54.41	19.01	35%
P300	2.00	0.028	37.57	19.01	51%
P301	2.00	0.041	45.46	19.01	42%
P302	2.00	0.046	48.23	19.01	39%
P303	2.00	0.009	21.22	19.01	90%
P304	2.00	0.028	37.49	19.01	51%
P305	2.00	0.012	24.83	19.01	77%
P306	2.00	0.009	21.44	19.01	89%
P307	2.00	0.014	26.82	19.01	71%
P307A	2.00	0.015	27.45	19.01	69%
P308	1.25	0.009	6.01	5.70	100%[1]

Table 7-1-B
Sewer Analysis Results (Ultimate Conditions)

Name	Diameter, ft	Slope (%)	Theoretical "Full" Flow (cfs)	Future Modeled Peak Flow (cfs)	Future % Full
P309	1.25	0.009	6.16	5.70	100%[1]
P310	1.25	0.010	6.28	5.70	100%[1]
P311	1.25	0.013	7.45	3.09	100%[1]
P311A	1.25	0.012	7.16	2.61	100%[1]
P311B	1.25	0.012	7.01	2.61	100%[1]
P311C	1.25	0.022	9.52	2.61	27%
P311D	1.25	0.009	6.26	2.61	42%
P312	1.00	0.011	3.71	2.26	100%[1]
P313	1.00	0.026	5.68	2.26	100%[1]
P314	0.83	0.025	3.43	2.26	100%[1]
P315	1.75	0.006	12.63	4.86	39%
P316	1.75	0.006	12.59	4.86	39%
P317	1.75	0.005	11.57	4.86	42%
P318A	1.75	0.005	11.26	4.86	43%
P319	1.00	0.016	4.50	4.74	105%
P319A	1.00	0.022	5.31	0.12	2%
P320	0.83	0.018	2.93	4.74	162%
P321	0.83	0.020	3.09	4.74	153%
P322	1.00	0.037	6.80	0.12	2%
P323	1.00	0.042	7.24	4.87	67%
P324	1.00	0.042	7.30	4.86	67%
P325	1.25	0.024	10.06	1.71	17%
P326	1.25	0.015	7.83	1.71	22%
P327	0.83	0.021	3.15	1.71	54%
P327A	1.00	0.018	4.70	3.15	67%
P328	1.00	0.018	4.81	3.23	67%
P329	1.17	0.004	3.46	2.31	100%[1]
P329A	1.00	0.003	1.98	1.28	100%[1]
P330	1.25	0.003	3.77	2.31	100%[1]
P331	1.25	0.003	3.59	2.30	100%[1]
P332	1.00	0.003	1.88	1.89	101%
P333	1.00	0.003	1.88	1.89	100%
P334	1.00	0.003	1.89	1.89	100%
P335	1.00	0.003	1.92	1.62	100%[1]
P336	1.00	0.003	1.93	1.61	100%[1]
P337	1.00	0.003	1.94	1.59	100%[1]
P338	1.00	0.003	2.03	1.17	100%[1]
P339	0.83	0.003	1.23	1.17	100%[1]
P340	0.83	0.002	1.02	0.64	100%[1]
P341	0.83	0.003	1.15	0.64	100%[1]
P342	0.83	0.002	1.05	0.64	100%[1]
P343	0.83	0.003	1.25	0.64	100%[1]
P344	1.25	0.003	3.64	1.66	46%
P345	1.25	0.003	3.62	1.36	38%
P346	1.25	0.003	3.63	1.37	38%
P347	1.25	0.003	3.56	1.37	38%
P348	1.50	0.002	4.80	1.37	28%
P349	1.50	0.003	5.41	1.37	25%

Table 7-1-B
Sewer Analysis Results (Ultimate Conditions)

Name	Diameter, ft	Slope (%)	Theoretical "Full" Flow (cfs)	Future Modeled Peak Flow (cfs)	Future % Full
P350	1.50	0.002	4.76	1.37	29%
P351	1.25	0.002	2.94	1.06	36%
P352	1.25	0.011	6.62	1.06	16%
P353	1.25	0.012	6.96	1.06	15%
P354	1.25	0.008	5.84	1.06	18%
P355	1.25	0.010	6.44	1.06	16%
P356	0.67	0.011	1.26	0.25	100%[1]
P357	0.67	0.011	1.23	0.25	100%[1]
P358	0.67	0.011	1.23	0.25	20%
P359	0.67	0.010	1.23	0.25	21%
P360	0.67	0.011	1.23	0.25	20%
P361	0.67	0.010	1.20	0.09	8%
P362	0.67	0.011	1.27	0.09	7%
P363	0.67	0.011	1.27	0.09	7%
P364	0.67	0.010	1.17	0.09	8%
P365	0.67	0.003	0.65	0.58	100%[1]
P366	0.67	0.006	0.97	0.52	100%[1]
P367	0.67	0.022	1.78	0.52	29%
P368	0.67	0.007	1.00	0.26	26%
P369	0.67	0.012	1.32	0.26	20%
P370	0.67	0.012	1.34	0.26	19%
P371	0.67	0.013	1.37	0.26	19%
P372	0.67	0.005	0.81	0.51	100%[1]
P373	0.67	0.005	0.82	0.51	62%
P374	0.67	0.004	0.74	0.51	70%
P375	0.67	0.004	0.80	0.51	64%
P376	0.67	0.008	1.08	0.26	24%
P377	0.67	0.008	1.04	0.26	25%
P378	0.67	0.017	1.57	0.26	16%
P379	0.67	0.014	1.44	0.26	18%
P380	0.67	0.012	1.29	0.26	20%
P381	0.67	0.010	1.20	0.26	21%
P382	0.67	0.010	1.21	0.26	21%
P383	0.67	0.010	1.22	0.26	21%
P384	0.67	0.010	1.20	0.26	21%
P385	0.67	0.010	1.22	0.26	21%
P386	0.67	0.010	1.18	0.26	22%
P387	0.67	0.010	1.21	0.26	21%
P388	0.67	0.009	1.15	0.26	22%
P389	1.50	0.013	12.03	0.44	4%
P390	1.25	0.020	9.11	0.44	5%
P391	1.25	0.019	8.85	0.44	5%
P392	1.25	0.018	8.62	0.44	5%
P393	1.50	0.007	8.86	0.44	5%
P394	1.50	0.007	8.72	0.44	5%
P395	1.50	0.001	2.63	0.44	17%
P396	1.00	0.033	6.45	0.44	7%
P397	1.00	0.247	17.64	0.22	1%
P398	1.25	0.010	6.56	0.22	3%
P399	1.25	0.010	6.51	0.22	3%

Table 7-1-B
Sewer Analysis Results (Ultimate Conditions)

Name	Diameter, ft	Slope (%)	Theoretical "Full" Flow (cfs)	Future Modeled Peak Flow (cfs)	Future % Full
P400	1.25	0.010	6.58	0.22	3%
P401	1.25	0.028	10.69	0.22	2%
P402	1.25	0.014	7.73	0.22	3%
P403	1.25	0.033	11.78	0.22	2%
P404	1.25	0.022	9.51	0.22	2%
P405	1.25	0.335	37.25	0.22	1%
P406	1.25	0.209	29.45	0.22	1%
P407	1.25	0.040	12.93	0.22	2%
P408	0.83	0.034	4.04	1.86	46%
P409	0.83	0.190	9.49	1.86	20%
P410	0.67	0.066	3.07	1.86	60%
P411	0.67	0.074	3.26	1.86	57%
P412	0.67	0.077	3.33	1.86	56%

1. Due to back-up in sewer system.

7.0 DEFICIENCIES AND SOLUTIONS

7.1 Deficient and Marginally Deficient Pipes

The City's design criteria for sewer lines allows pipes to flow at a ratio of 75% of "full" hydraulic capacity. Assuming that "full" capacity is the maximum hydraulic capacity of a pipe flowing under gravity (non-pressure) conditions, Mannings equation shows that maximum flow occurs when a pipe reaches a flow depth ratio of about 95% d/D.

Pipe reaches which fail the "75% full" criteria for both existing and future flow conditions are shown in Table 7-2 and Figures 18 and 20. It is seen that portions of the modeled trunk system are already flowing at greater than "75% full", and several reaches are computed to be over 100% full (surcharge conditions). At ultimate conditions, numerous additional reaches are shown to surcharge or exceed the "75% full" criteria.

The pipes that are currently deficient are shown in Figure 18 whereas the pipes that are currently deficient in velocity are shown in Figure 19. The pipes that would be deficient in flow in the future are shown in Figure 20.

7.2 Project Prioritization Methodology

The 75% full criteria is useful for analyzing deficient pipes and as a basis for sizing new facilities. However, the criteria is not necessarily the trigger point for replacement or augmentation of an existing sewer line.

In most cases, a sewer entity would not implement a relief project until capacity problems are actually observed or known to be imminent.

A recommended system of project prioritization is the categorization of deficient sewer lines in different priorities, where the "A" priority projects are imminently needed and the "B" and "C" projects require further considerations for replacement. Priority classifications are described as follows:

Priority "A" – The pipes listed within this priority are currently deficient and are flowing more than 90% full under maximum flow condition. These pipes need replacement / re-habilitation in near future (year 2004-2007).

Table 7-2
Proposed Construction Prioritization and Schedule

Pipe Name	Length (ft)	Existing Pipe Size (inch)	Existing % Full	Future % Full	Proposed Pipe Size (inch)	New % Full for Future Flow	Priority	Approximate Replacement Period
P01	62	27	72%	120%	36	56%	B	2008-2013
P02	219	27	71%	119%	36	55%	B	2008-2013
P03	296	27	68%	113%	36	52%	B	2008-2013
P04	225	27	65%	109%	36	50%	B	2008-2013
P05	457	27	68%	113%	36	52%	B	2008-2013
P06	387	27	79%	131%	36	61%	B	2008-2013
P07	207	27	76%	127%	36	59%	B	2008-2013
P08	94	27	80%	133%	36	61%	B	2008-2013
P09	138	27	73%	124%	36	57%	B	2008-2013
P10	38	30	70%	119%	36	73%	B	2008-2013
P11	40	30	72%	122%	42	50%	B	2008-2013
P12	85	27	68%	115%	42	35%	B	2008-2013
P13	257	27	62%	106%	42	32%	B	2008-2013
P14	16	24	74%	126%	42	28%	B	2008-2013
P15	450	21	157%	276%	42	43%	A	2004-2007
P16	180	21	140%	246%	42	39%	A	2004-2007
P17	24	21	139%	246%	42	38%	A	2004-2007
P18	198	24	157%	277%	42	62%	A	2004-2007
P19(Siphon)	97	2-15	120%	236%	2-18	144%	C	2014-2018
P20	144	27	84%	165%	42	51%	A	2004-2007
P21	571	27	74%	145%	42	44%	B	2008-2013
P22	133	27	72%	141%	42	43%	B	2008-2013
P23	414	27	74%	145%	42	44%	B	2008-2013
P24	200	24	61%	119%	42	27%	B	2008-2013
P25	50	27	100%	197%	42	60%	A	2004-2007
P26	200	27	73%	144%	42	44%	B	2008-2013
P27	39	27	52%	107%	42	33%	B	2008-2013
P28	111	27	67%	137%	42	42%	B	2008-2013
P29	177	27	67%	138%	42	42%	B	2008-2013
P30	281	27	67%	138%	42	42%	B	2008-2013
P31	105	27	69%	141%	42	43%	B	2008-2013
P32	39	27	70%	144%	42	44%	B	2008-2013
P33	15	27	61%	125%	42	38%	B	2008-2013
P34	163	27	68%	139%	42	43%	B	2008-2013
P35	44	27	70%	143%	42	44%	B	2008-2013
P36	265	27	59%	121%	42	37%	B	2008-2013
P37	638	27	59%	121%	42	37%	B	2008-2013
P38	151	24	60%	123%	42	27%	B	2008-2013
P39	190	27	59%	121%	42	37%	B	2008-2013
P40	145	27	60%	123%	42	38%	B	2008-2013
P41	370	27	53%	107%	42	33%	B	2008-2013
P42	27	27	30%	62%				
P43	184	24	63%	129%	42	29%	B	2008-2013
P44	7	24	59%	121%	42	27%	B	2008-2013
P45	290	24	64%	130%	42	29%	B	2008-2013
P46	309	24	64%	131%	42	29%	B	2008-2013
P47	152	24	32%	65%				
P48	28	24	12%	24%				
P49	157	24	83%	168%	42	38%	B	2008-2013
P50(Siphon)	358	1-18	257%	524%	2-18	261%	A	2008-2013[2]
P51	227	24	50%	102%	42	23%	B	2008-2013
P52	15	27	75%	155%	42	47%	B	2008-2013
P53	249	27	90%	185%	42	57%	A	2004-2007
P54	280	27	90%	186%	42	57%	A	2004-2007
P55	195	27	90%	185%	42	57%	A	2004-2007
P56	246	24	87%	179%	36	61%	B	2004-2007[1]
P57	236	24	93%	191%	36	65%	A	2004-2007
P58	166	24	94%	192%	36	65%	A	2004-2007
P59	259	24	94%	192%	36	65%	A	2004-2007
P60	312	21	99%	201%	36	48%	A	2004-2007
P61	190	21	98%	199%	36	47%	A	2004-2007
P62	225	21	98%	199%	36	47%	A	2004-2007
P63	217	21	98%	199%	36	47%	A	2004-2007
P64	211	21	97%	199%	36	47%	A	2004-2007
P65	174	21	98%	199%	36	47%	A	2004-2007
P66	274	21	98%	200%	36	47%	A	2004-2007
P67	106	24	80%	163%	36	55%	B	2008-2013
P68	458	21	70%	145%	36	34%	B	2008-2013
P69	260	21	81%	167%	33	50%	B	2008-2013
P70	304	21	77%	160%	33	48%	B	2008-2013
P71	380	21	80%	166%	33	50%	B	2008-2013
P72	179	21	78%	161%	33	48%	B	2008-2013
P73	144	21	84%	175%	33	52%	B	2008-2013
P74	610	21	85%	176%	33	53%	B	2008-2013
P75	650	21	80%	166%	33	50%	B	2008-2013

Table 7-2
Proposed Construction Prioritization and Schedule

Pipe Name	Length (ft)	Existing Pipe Size (inch)	Existing % Full	Future % Full	Proposed Pipe Size (inch)	New % Full for Future Flow	Priority	Approximate Replacement Period
P76	344	21	78%	161%	33	48%	B	2008-2013
P77	578	21	68%	141%	33	42%	B	2008-2013
P78	628	21	68%	141%	33	42%	B	2008-2013
P79	600	21	68%	141%	33	42%	B	2008-2013
P80	500	21	69%	143%	33	43%	B	2008-2013
P81	453	18	95%	197%	33	39%	A	2004-2007
P82	73	18	95%	196%	33	39%	A	2004-2007
P83	118	18	95%	196%	33	39%	A	2004-2007
P84	48	18	94%	195%	33	39%	A	2004-2007
P85	177	18	95%	196%	33	39%	A	2004-2007
P86	9	18	92%	192%	33	38%	A	2004-2007
P87	203	18	30%	30%				
P88	525	18	22%	22%				
P89	525	18	23%	23%				
P90	675	18	24%	24%				
P91	720	18	24%	24%				
P92	177	21	5%	5%				
P93	287	21	5%	5%				
P94	246	21	5%	5%				
P95	201	15	3%	3%				
P96	81	27	7%	7%				
P97	75	27	6%	6%				
P98	133	27	6%	6%				
P99	313	27	7%	7%				
P100	178	27	6%	6%				
P101	90	27	6%	6%				
P102	252	27	7%	7%				
P103	243	27	6%	6%				
P104	193	27	6%	6%				
P105	209	27	3%	3%				
P106	97	27	3%	3%				
P107	181	27	4%	4%				
P108	197	27	4%	4%				
P109	175	27	3%	3%				
P110	247	27	3%	3%				
P111	97	27	3%	3%				
P112	281	27	3%	3%				
P113	350	27	3%	3%				
P114	150	27	3%	3%				
P115	204	27	3%	3%				
P116	303	27	3%	3%				
P117	389	27	3%	3%				
P118	342	27	3%	3%				
P119	257	24	4%	4%				
P120	245	24	4%	4%				
P121	134	10	0%	0%				
P130	471	24	21%	51%				
P131	465	24	20%	48%				
P132	495	24	20%	48%				
P133	496	24	20%	48%				
P134	63	24	14%	32%				
P135	172	33	8%	19%				
P136	400	21	19%	45%				
P137	500	21	23%	53%				
P138	500	24	21%	50%				
P139	500	21	21%	48%				
P140	173	21	20%	48%				
P141	327	21	20%	48%				
P142	500	21	27%	63%				
P143	500	21	22%	52%				
P144	525	21	25%	58%				
P145	95	21	26%	62%				
P146	480	21	24%	56%				
P147	500	21	23%	54%				
P148	500	21	22%	52%				
P149	500	21	23%	55%				
P150	370	21	26%	63%				
P151	505	27	27%	64%				
P152	244	27	20%	48%				

Table 7-2
Proposed Construction Prioritization and Schedule

Pipe Name	Length (ft)	Existing Pipe Size (inch)	Existing % Full	Future % Full	Proposed Pipe Size (inch)	New % Full for Future Flow	Priority	Approximate Replacement Period
P153	248	27	20%	48%				
P154	283	27	27%	64%				
P155	492	27	17%	41%				
P156	450	27	18%	42%				
P157	107	42	26%	60%				
P158	293	42	26%	64%				
P159	173	42	25%	62%				
P160	327	42	25%	62%				
P161	500	42	25%	62%				
P162	500	42	25%	48%				
P163	1000	42	25%	48%				
P164	400	42	23%	48%				
P165	500	42	23%	48%				
P166	500	42	23%	48%				
P167	500	42	23%	48%				
P168	500	42	23%	48%				
P169	475	42	23%	48%				
P170	446	42	24%	49%				
P-171	14	42	15%	32%				
P172	100	20	19%	40%				
P173	426	42	21%	43%				
P174	212	30	41%	73%				
P175	377	30	41%	73%				
P176	400	30	42%	73%				
P177	193	30	42%	75%	36	46%	C	2014-2018[7]
P178	207	30	41%	72%				
P179	400	30	42%	74%				
P180	425	30	42%	73%				
P181	407	30	42%	73%				
P182	430	24	52%	74%				
P183	504	24	52%	74%				
P184	506	24	53%	74%				
P185	500	24	52%	74%				
P186	450	24	52%	74%				
P187	350	24	10%	14%				
P188	520	24	54%	76%	30	42%	C	2014-2018[7]
P189	454	18	37%	55%				
P190	450	18	37%	55%				
P191	450	18	37%	55%				
P192	450	18	33%	47%				
P193	441	18	30%	42%				
P194	30	18	26%	39%				
P195	400	18	25%	36%				
P196	450	18	27%	36%				
P197	450	18	26%	36%				
P198	411	18	36%	50%				
P199	439	18	26%	36%				
P200	450	18	38%	53%				
P201	450	18	38%	53%				
P202	450	18	36%	51%				
P203	450	18	36%	51%				
P204	435	18	34%	47%				
P205	8178	16						Force Main
P206	56	21	43%	61%				
P207	65	18	48%	64%				
P208	176	18	49%	65%				
P209	25	18	37%	51%				
P210	465	18	38%	52%				
P211	462	18	38%	52%				
P212	13	18	33%	45%				
P213	174	18	7%	9%				
P214	174	18	38%	52%				
P215	228	18	38%	52%				
P216	106	18	10%	14%				
P217	344	18	10%	14%				
P218	424	18	36%	50%				

Table 7-2
Proposed Construction Prioritization and Schedule

Pipe Name	Length (ft)	Existing Pipe Size (inch)	Existing % Full	Future % Full	Proposed Pipe Size (inch)	New % Full for Future Flow	Priority	Approximate Replacement Period
P219	86	12	14%	21%				
P220	401	12	37%	55%				
P221	450	12	42%	67%				
P222	450	12	42%	67%				
P223	450	12	42%	65%				
P224	450	12	42%	64%				
P225	316	12	34%	50%				
P226	131	12	33%	50%				
P227	203	12	33%	50%				
P228	450	12	53%	80%	15	44%	C	2014-2018
P229	450	12	53%	80%	15	44%	C	2014-2018
P230	450	12	53%	80%	15	44%	C	2014-2018
P231	429	12	53%	80%	15	44%	C	2014-2018
P232	149	8	47%	91%	15	17%	B	2014-2018[4]
P233	260	8	3%	28%				
P234	294	8	3%	31%				
P235	450	10	32%	33%				
P236	210	10	32%	33%				
P237	146	10	32%	33%				
P238	225	18	15%	22%				
P239	270	18	15%	22%				
P240	70	18	15%	22%				
P241	310	12	27%	30%				
P242	300	12	27%	30%				
P243	172	12	9%	11%				
P244	203	12	9%	11%				
P245	285	12	9%	11%				
P246	90	12	9%	11%				
P247	350	12	10%	12%				
P248	400	12	34%	39%				
P249	391	12	34%	39%				
P250	442	12	34%	39%				
P251	437	12	19%	21%				
P252	156	12	35%	40%				
P253	352	15	14%	23%				
P254	338	15	21%	36%				
P255	337	12	13%	22%				
P256	300	12	22%	36%				
P257	400	12	10%	16%				
P258	380	12	15%	25%				
P259	320	12	19%	31%				
P260	350	12	23%	38%				
P261	201	12	25%	42%				
P262	99	12	25%	42%				
P263	350	10	19%	31%				
P264	274	10	22%	36%				
P265	277	10	18%	30%				
P266	301	10	24%	39%				
P267	302	10	21%	35%				
P268	351	10	20%	34%				
P269	350	10	24%	40%				
P270	348	10	39%	64%				
P271	352	8	53%	88%	10	48%	C	2008-2013[6]
P272	277	8	63%	104%	10	57%	B	2008-2013
P273	23	8	62%	103%	10	56%	B	2008-2013
P274	300	8	62%	103%	10	56%	B	2008-2013
P275	299	8	63%	104%	10	57%	B	2008-2013
P276	299	8	96%	161%	12	60%	A	2008-2013[2]
P277	435	15	4%	34%				
P278	440	15	5%	45%				
P279	428	15	5%	45%				
P280	574	15	8%	63%				
P281	710	15	6%	48%				
P282	123	15	3%	27%				
P283	24	15	7%	56%				
P284	339	12	66%	111%	18	46%	B	2008-2013
P285	343	12	67%	112%	18	47%	B	2008-2013
P286	337	12	67%	112%	18	47%	B	2008-2013
P287	338	12	67%	112%	18	46%	B	2008-2013
P288	380	10	104%	173%	18	44%	A	2004-2007
P290	12	33	17%	41%				
P291	190	33	17%	40%				
P292	521	33	17%	40%				

Table 7-2
Proposed Construction Prioritization and Schedule

Pipe Name	Length (ft)	Existing Pipe Size (inch)	Existing % Full	Future % Full	Proposed Pipe Size (inch)	New % Full for Future Flow	Priority	Approximate Replacement Period
P293	507	33	12%	28%				
P294	507	33	16%	37%				
P295	507	27	15%	37%				
P296	246	24	22%	53%				
P297	450	24	19%	44%				
P298	450	24	15%	35%				
P299	450	24	15%	35%				
P300	450	24	21%	51%				
P301	450	24	18%	42%				
P302	450	24	17%	39%				
P303	450	24	38%	90%	30	49.38%	B	2014-2018[5]
P304	450	24	21%	51%				
P305	450	24	32%	77%	30	42.18%	C	2014-2018[5]
P306	446	24	37%	89%	30	48.85%	C	2014-2018[5]
P307	454	24	30%	71%				
P307A	254	24	29%	69%				
P308	46	15	100%[8]	77%	18	58.43%	C	2014-2018
P309	400	15	100%[8]	75%	18	56.95%	C	2014-2018
P310	100	15	100%[8]	73%				See Appendix "C"
P311	23	15	100%[8]	35%				See Appendix "C"
P311A	227	15	100%[8]	28%				See Appendix "C"
P311B	324	15	100%[8]	29%				See Appendix "C"
P311C	54	15	26%	21%				
P311D	32	15	39%	32%				
P312	569	12	100%[8]	48%				See Appendix "C"
P313	27	12	100%[8]	32%				See Appendix "C"
P314	34	10	100%[8]	52%				See Appendix "C"
P315	348	21	36%	30%				
P316	377	21	36%	30%				
P317	28	21	39%	33%				
P318A	8	21	40%	34%				
P319	21	12	65%	84%	15	52.05%	C	2004-2007[3]
P319A	361	12	30%	30%				
P320	396	10	100%[8]	130%	15	49.11%	A	2004-2007
P321	20	10	100%[8]	123%	15	46.48%	A	2004-2007
P322	15	12	23%	23%				
P323	178	12	62%	52%				
P324	132	12	62%	52%				
P325	13	15	16%	13%				
P326	68	15	20%	17%				
P327	10	10	50%	42%				
P327A	87	12	62%	53%				
P328	397	12	60%	48%				
P329	33	14	100%[8]	34%				See Appendix "C"
P329A	397	12	100%[8]	58%				See Appendix "C"
P330	355	15	100%[8]	31%				See Appendix "C"
P331	10	15	100%[8]	32%				See Appendix "C"
P332	395	12	100%[8]	37%				See Appendix "C"
P333	118	12	100%[8]	37%				See Appendix "C"
P334	282	12	100%[8]	37%				See Appendix "C"
P335	164	12	100%[8]	22%				See Appendix "C"
P336	250	12	100%[8]	22%				See Appendix "C"
P337	429	12	100%[8]	22%				See Appendix "C"
P338	412	12	100%[8]	3%				See Appendix "C"
P339	399	10	100%[8]	52%				Abandon in place
P340	206	10	100%[8]	63%				See Appendix "C"
P341	18	10	100%[8]	56%				See Appendix "C"
P342	172	10	100%[8]	61%				See Appendix "C"
P343	395	10	100%[8]	134%				See Appendix "C"
P344	545	15	35%	37%				
P345	303	15	28%	38%				
P346	242	15	28%	38%				
P347	294	15	29%	38%				
P348	72	18	21%	28%				
P349	109	18	19%	25%				
P350	68	18	21%	22%				

Table 7-2
Proposed Construction Prioritization and Schedule

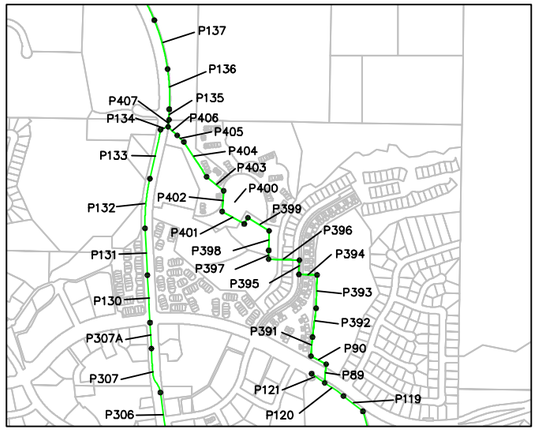
Pipe Name	Length (ft)	Existing Pipe Size (inch)	Existing % Full	Future % Full	Proposed Pipe Size (inch)	New % Full for Future Flow	Priority	Approximate Replacement Period
P351	24	15	27%	36%				
P352	315	15	12%	16%				
P353	267	15	11%	15%				
P354	38	15	14%	18%				
P355	157	15	12%	4%				
P356	115	8	100%[8]	20%				See Appendix "C"
P357	100	8	100%[8]	20%				See Appendix "C"
P358	423	8	20%	20%				
P359	205	8	21%	21%				
P360	395	8	20%	7%				
P361	201	8	8%	8%				
P362	197	8	7%	7%				
P363	398	8	7%	7%				
P364	378	8	8%	44%				
P365	651	8	100%[8]	80%	10	44%	A	2004-2007[3]
P366	401	8	100%[8]	54%				See Appendix "C"
P367	195	8	29%	15%				
P368	399	8	26%	26%				
P369	197	8	20%	20%				
P370	201	8	19%	19%				
P371	400	8	19%	38%				
P372	219	8	100%[8]	64%				See Appendix "C"
P373	211	8	63%	62%				
P374	212	8	70%	70%				
P375	203	8	65%	32%				
P376	184	8	24%	24%				
P377	13	8	25%	25%				
P378	198	8	16%	16%				
P379	132	8	18%	18%				
P380	69	8	20%	20%				
P381	199	8	21%	21%				
P382	181	8	21%	21%				
P383	16	8	21%	21%				
P384	201	8	22%	21%				
P385	117	8	21%	21%				
P386	21	8	22%	22%				
P387	255	8	21%	21%				
P388	11	8	22%	22%				
P389	166	18	4%	4%				
P390	170	15	5%	5%				
P391	189	15	5%	5%				
P392	288	15	5%	5%				
P393	330	18	5%	5%				
P394	181	18	5%	5%				
P395	143	18	17%	17%				
P396	304	12	7%	7%				
P397	81	12	1%	1%				
P398	194	15	3%	3%				
P399	246	15	3%	3%				
P400	72	15	3%	3%				
P401	250	15	2%	2%				
P402	206	15	3%	3%				
P403	217	15	2%	2%				
P404	413	15	2%	2%				
P405	93	15	1%	1%				
P406	130	15	1%	1%				
P407	71	15	2%	2%				
P408	433	10	45%	46%				
P409	113	10	19%	20%				
P410	379	8	59%	60%				
P411	311	8	55%	57%				
P412	311	8	56%	56%				

Table 7-2
Proposed Construction Prioritization and Schedule

Pipe Name	Length (ft)	Existing Pipe Size (inch)	Existing % Full	Future % Full	Proposed Pipe Size (inch)	New % Full for Future Flow	Priority	Approximate Replacement Period
New Pipelines:								
L440	414				12		A	2004-2007
L441	393				12		A	2004-2007
L442	396				12		A	2004-2007
L443	398				12		A	2004-2007
P1000	730				27		C	2014-2018
P1001	735				27		C	2014-2018
P1002	1160				27		C	2014-2018
P1003	560				27		C	2014-2018
P1004	1900				27		C	2014-2018
P1005	5260				27		C	2014-2018
P1005A	2650				27		C	2014-2018
P1006	650				27		C	2014-2018
P1013	2070				30		C	2014-2018
P1013A	250				30		C	2014-2018
P1014	1470				30		C	2014-2018
P1015	2060				30		C	2014-2018
P1016	360				30		C	2014-2018
P1017	195				30		C	2014-2018
P1018	195				30		C	2014-2018
P1019	350				30		C	2014-2018
P1020	570				30		C	2014-2018

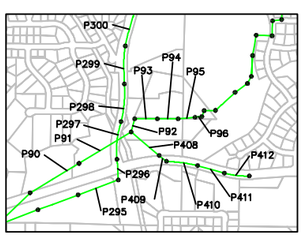
Notes:

1. Although this pipeline is under priority "B" it is proposed to be replaced in the period 2004-2007 to maintain continuity.
2. This segment of pipeline is a Siphon and would require replacement / re-habilitation in the period 2008-2013.
3. This segment is part of proposed improvement of Market Street so it is proposed to be replaced in the period 2004-2007.
4. Although this pipeline is under priority "B" it is proposed to be replaced in the period 2014-2018 to maintain continuity.
5. Although this pipeline is under priority "C" this segment would not be replaced due to proposed diversion of flow along Cyn Crest.
6. Although this pipeline is under priority "C" it is proposed to be replaced in the period 2008-2013 to maintain continuity.
7. Although this pipeline is under priority "C" (approx. 75% full), it may not have capacity problem in future due to larger diameter.
8. Surcharging conditions due to back-up in sewer system.

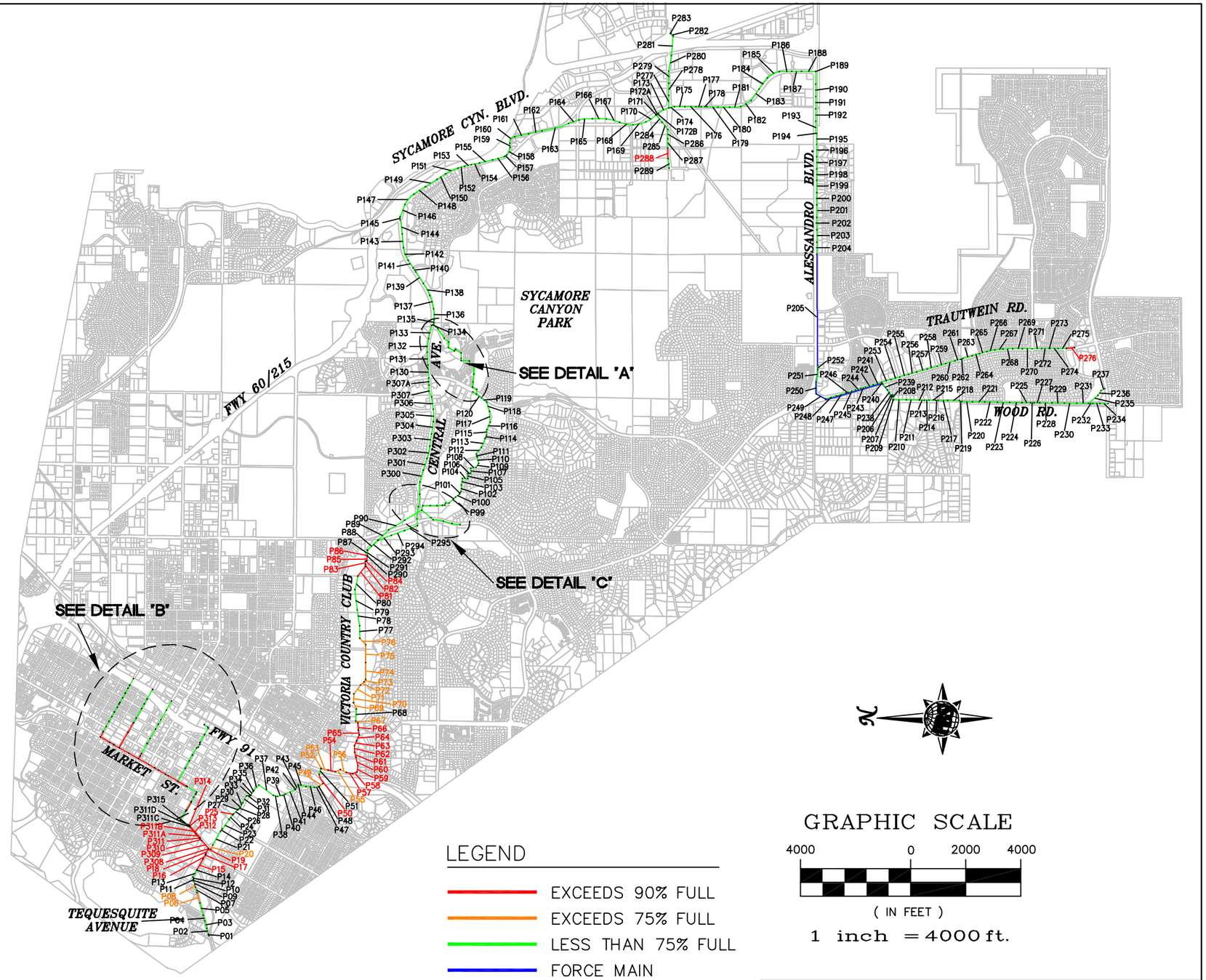


DETAIL "A"
NOT TO SCALE

DETAIL "B"
NOT TO SCALE



DETAIL "C"
NOT TO SCALE



LEGEND

- EXCEEDS 90% FULL
- EXCEEDS 75% FULL
- LESS THAN 75% FULL
- FORCE MAIN

GRAPHIC SCALE

4000 0 2000 4000

(IN FEET)

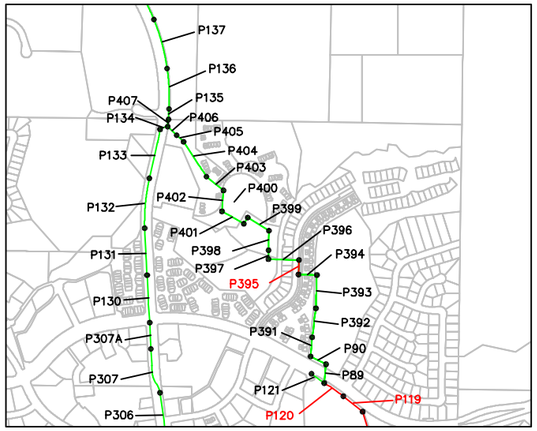
1 inch = 4000 ft.

Engineering
Planning
Surveying
Construction Services

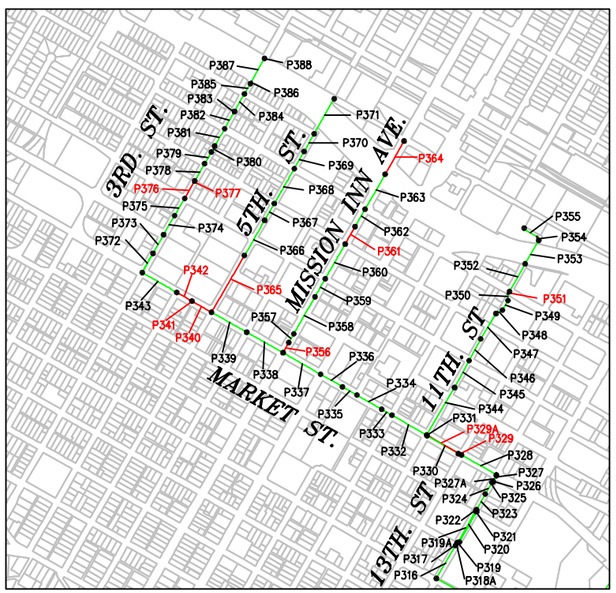
PBSJ

3610 Central Avenue
Suite 500
Riverside, CA 92506
Tel:(909) 341-6380
Fax:(909) 341-6389

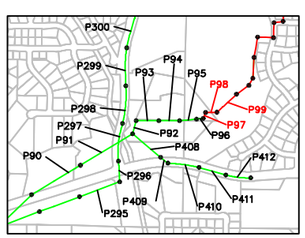
CITY OF RIVERSIDE TEQUESQUITE SEWER STUDY	FIGURE 18
EXISTING FLOW CONDITIONS	



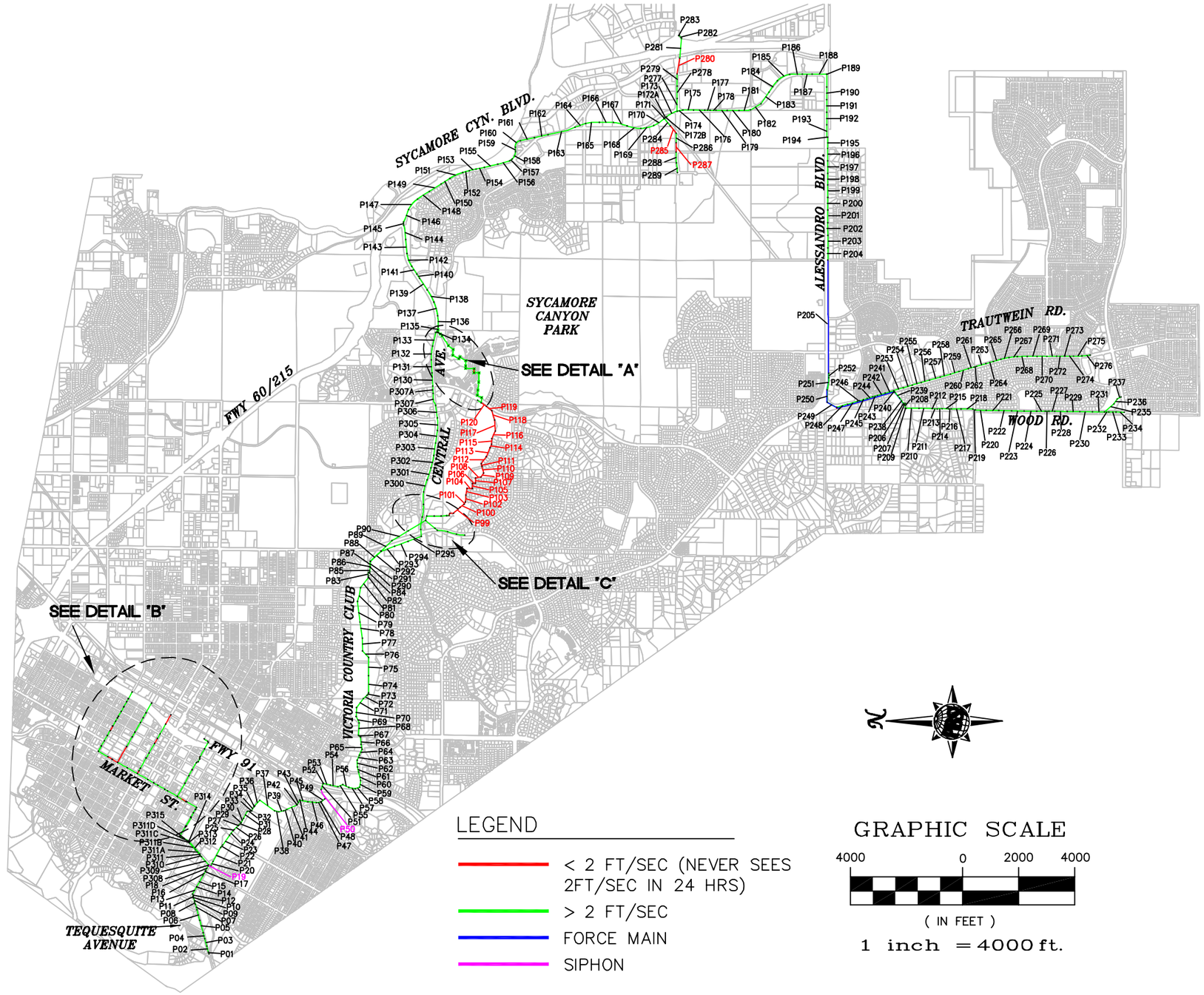
DETAIL "A"
NOT TO SCALE



DETAIL "B"
NOT TO SCALE



DETAIL "C"
NOT TO SCALE



LEGEND

- < 2 FT/SEC (NEVER SEES 2FT/SEC IN 24 HRS)
- > 2 FT/SEC
- FORCE MAIN
- SIPHON

N

GRAPHIC SCALE

4000 0 2000 4000

(IN FEET)

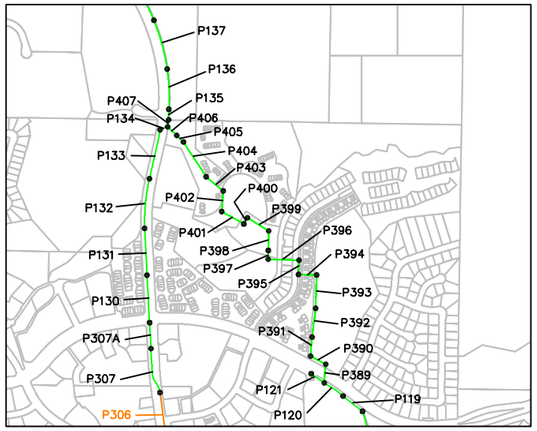
1 inch = 4000 ft.

Engineering
Planning
Surveying
Construction Services

PBSJ

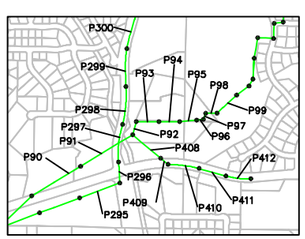
3610 Central Avenue
Suite 500
Riverside, CA 92506
Tel:(909) 341-6380
Fax:(909) 341-6389

CITY OF RIVERSIDE TEQUESQUITE SEWER STUDY	FIGURE 19
EXISTING SYSTEM DEFICIENCIES (VELOCITY)	

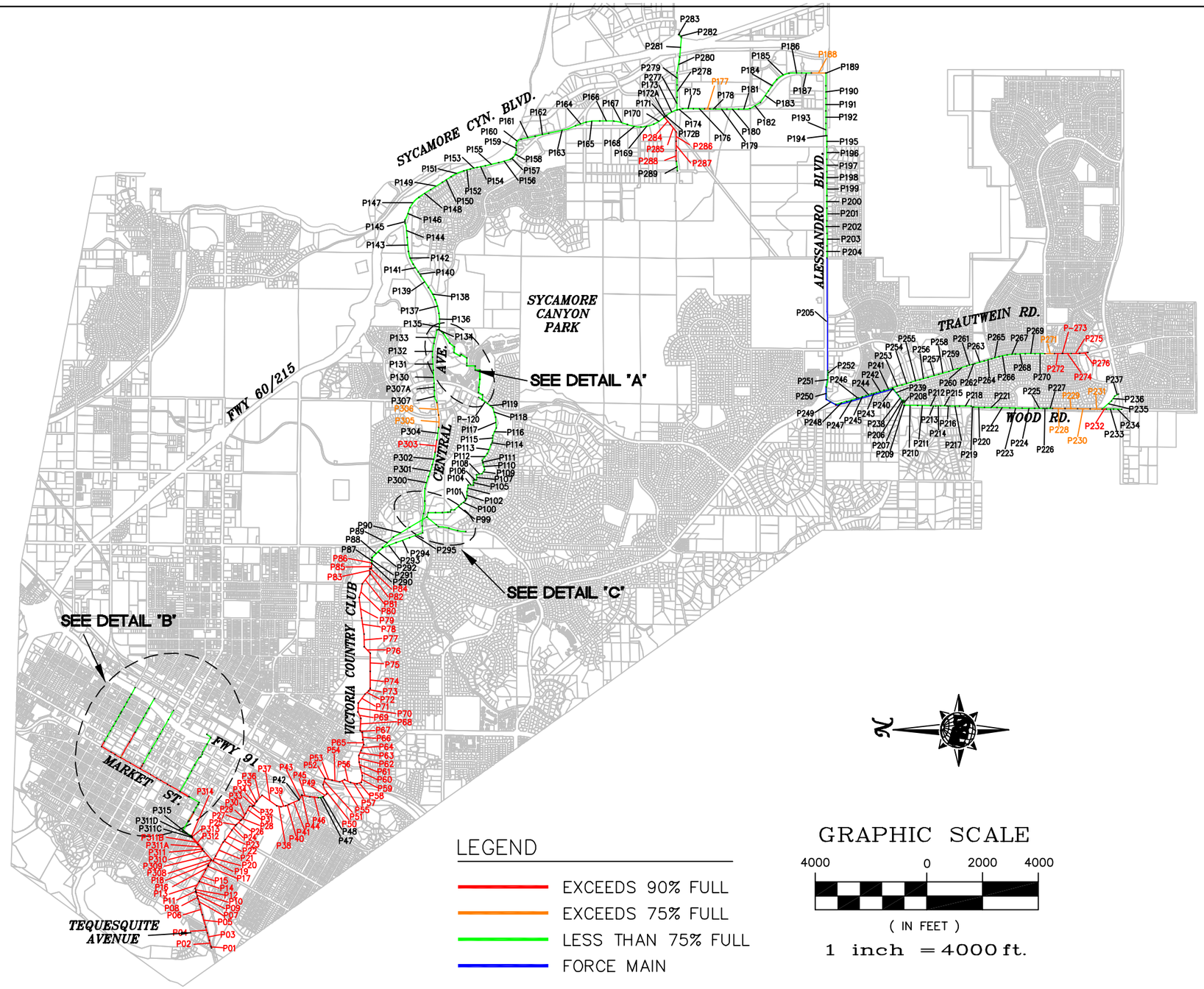


DETAIL "A"
NOT TO SCALE

DETAIL "B"
NOT TO SCALE



DETAIL "C"
NOT TO SCALE



LEGEND

- EXCEEDS 90% FULL
- EXCEEDS 75% FULL
- LESS THAN 75% FULL
- FORCE MAIN

GRAPHIC SCALE

4000 0 2000 4000

(IN FEET)

1 inch = 4000 ft.

Engineering
Planning
Surveying
Construction Services

PBS&J

3610 Central Avenue
Suite 500
Riverside, CA 92506
Tel:(909) 341-6380
Fax:(909) 341-6389

CITY OF RIVERSIDE
TEQUESQUITE SEWER STUDY

FIGURE 20

ULTIMATE FLOW CONDITIONS

Priority "B" – The pipes listed in this priority would be flowing more than 90% full in the future under maximum flow condition. A linear interpolation was done for anticipation of mid term flow in pipes between current year (2003) and ultimate year (2018). These pipes need evaluation as new development takes place in the tributary area. The flow monitoring within the study area should be considered for actual flow measurements. The pipes under this priority are grouped for replacement / re-habilitation in the period (2008-2013).

Priority "C" – The existing trunk sewer system would not be capable to handle anticipated ultimate flow without excess construction activities for replacement or re-habilitation of sewer system in the Victoria Country Club area. Also, an alternative sewer system would be required for the proposed expansion of UCR in Chicago Ave. - MLK Blvd. area. An alternative relief trunk sewer system (described separately) would intercept sewage flow from the existing sewer system at the intersection of Canyon Crest Dr. and Central Avenue to relieve the existing sewer system. This proposed new sewer system and pipelines in the existing sewer system that would flow more than 75% full under future flow conditions be listed under priority "C". An evaluation of the existing system would be required before undertaking this priority.

7.3 Recommended Improvements

Table 7.3 lists project priority, project location, problem, solution and approximate cost for problem reaches. This table identifies immediate and future problems in the sewer lines and suggested solutions for that. The project cost is based on year 2003 prices.

7.4 Grouping of Projects

Proposed improvements under different priorities have been combined or grouped into projects to improve deficient and marginally deficient pipes based on following criteria:

- Pipes identified as either deficient (Priority "A") or marginally deficient (Priority "B"), located geographically close to one another and requiring improvements in future (2004-2013) are grouped to reduce improvement costs.
- Some pipe reaches identified as marginally deficient (Priority "B") and marginally deficient in future (Priority "C") are grouped together for the same reason as mentioned above. However, improvements of these reaches would not be required until year 2014.
- Pipes identified in Priority "A" and Priority "C" in Market Street area are grouped together because the City is proposing improvements of Market Street in near future.

Table 7-3
Summary of Improvement Plans for Problem Areas

Priority	Location	Pipes	Problem	Solution	Approx. Cost (2003 $'s)
"A" (See Figure 21 and Table 7-7-A for details of pipes)	Tequesquite Avenue	Pipes P15 to P18, Pipe P20 and Pipe P25	Immediate Capacity Problem in the reach M25 to M14 due to flat slopes. Surcharging conditions.	Replace pipes with larger size pipes maintaining the same slope	$568,000
	Hwy 91 / Victoria Country Club	Pipes P53 to P66 and P81 to P86	Immediate Capacity Problem in the reach M67 to M53 and reach M87 to M81 due to flat slopes. Surcharging conditions.	Replace pipes with larger size pipes maintaining the same slope	$1,512,000
	Eastridge Avenue	Pipe P288	Immediate Capacity Problem in the reach M289 to M288 due to flat slope and smaller pipe size. Surcharging conditions.	Replace pipe with larger size pipe maintaining the same slope	$102,000
	13th Street	Pipes P319, P320 and P321	Immediate Capacity Problem in the reach M320 to M318 due to flat slopes, old pipes and smaller pipe sizes. Surcharging conditions.	Replace pipes with larger size pipes maintaining the same slope	$112,000
	5th Street[1]	Pipe365	Immediate Capacity Problem in the reach M366 to M340 due to flat slopes, old pipes and smaller pipe sizes. Surcharging conditions.	Replace pipe with larger size pipe maintaining the same slope	$123,000
	5th Street (New Pipeline)[1]	Pipes L440, L441, L442 and L443	Immediate Capacity Problems in the reach M340 to M328 due to flat slopes and smaller pipe sizes. Surcharging conditions.	Divert part of flow along Market Street at Manhole M340 along a proposed pipeline along 5th Street east of M340.	$340,000
				Total Cost for Priority "A" Projects (2004-2007 Replacement / Rehabilitation)	**$2,757,000**

Table 7-3
Summary of Improvement Plans for Problem Areas

Priority	Location	Pipes	Problem	Solution	Approx. Cost (2003 $'s)
"B" (See Figure 22 and Table 7-7-B for details of pipes)	Tequesquite Avenue	Pipes P01 to P14 and pipes Pipe P21 to P24	Future Capacity Problem due to increased flow in the system. The main contributor will be proposed Industrial Business Park (IBP) near Fwy 215 and Sycamore Canyon Boulevard.	Replace pipes with larger size pipes maintaining the same slope	$1,868,000
	Riverside Community College (R.C.C.)	Pipes P26 to P46, Pipe P50(Siphon)	Future Capacity Problem due to increased flow in the system. The main contributor will be proposed Industrial Business Park (IBP) near Fwy 215 and Sycamore Canyon Boulevard.	Replace pipes with larger size pipes maintaining the same slope	$2,675,000
	Hwy 91 / Victoria Country Club	Pipes P51, P52 and pipes P67 to P80	Future Capacity Problem due to increased flow in the system. The main contributor will be proposed Industrial Business Park (IBP) near Fwy 215 and Sycamore Canyon Boulevard.	Replace pipes with larger size pipes maintaining the same slope	$1,534,000
	Eastridge Avenue	Pipe P284 to P287	Future Capacity Problem in the reach M284 to M288 due to the proposed IBP development and smaller pipe sizes.	Replace pipe with larger size pipe maintaining the same slope	$347,000
	Trautwein Road	Pipes P271 to P276	Future Capacity Problems in the reach M277 to M270 due to proposed development in the area, smaller pipe sizes.	Replace pipes with larger size pipes maintaining the same slope	$310,000
				Total Cost for Priority "B" Projects (2008-2013 Replacement / Rehabilitation)	**$6,734,000**

Table 7-3
Summary of Improvement Plans for Problem Areas

Priority	Location	Pipes	Problem	Solution	Approx. Cost (2003 $'s)
"C" (See Figure 23 and Table 7-7-C for details of pipes)	Tequesquite Avenue	Pipe P19(Siphon)	Future Capacity Problem due to increased flow in the system. The main contributor will be proposed Industrial Business Park (IBP) near Fwy 215 and Sycamore Canyon Boulevard.	Replace siphon pipes with larger size pipes maintaining the same slope	$147,000
	Wood Road	Pipe P228 to P232	Future Capacity problem due to proposed new developments and smaller pipe sizes.	Replace pipes with larger size pipes maintaining the same slope	$407,000
	Brockton Avenue	Pipes P308, P309	Future Capacity Problem in the reach due to smaller pipe sizes.	Replace pipes with larger size pipes maintaining the same slope	$123,000
	NEW PIPELINES:				
	Cridge Avenue	New pipes Pipe P1015 to P1020	Future capacity problem.The existing sewer system would not be capable to handle anticipated future flow coming into the system primarily from the proposed IBP development without excessive construction activities in the Victoria Country Club area. This would necessitate exploring other alternatives for diversion of flow.	New pipeline for diversion of flow. Pipe size based on anticipated flow.	$1,915,000
	Victoria Avenue	New pipes Pipe P1014 and P1013A	Same as above	Same as above	$594,000
	Pennsylvania Avenue	New Pipe P1013	Same as above	Same as above	$718,000
	Martin Luther King Boulevard	New Pipe P1005, P1005A and P1006	Same as above	Same as above	$2,847,000
	Canyon Crest Drive	New Pipe P1000 to P1004	Same as above	Same as above	$1,649,000
				Total Cost for Priority "C" Projects (2014-2018 Replacement / Rehabilitation)	**$8,400,000**

1. See Appendix "C"

7.5 Construction Schedule

A summary of proposed construction prioritization and recommended scheduling is shown in Table 7-2. This table lists construction priorities and the year in which these activities are proposed. The pipes falling under priority "A" need near term replacement (2004-2007) whereas priority "B" and "C" pipes would need re-evaluation before their replacement.

7.6 Alternative

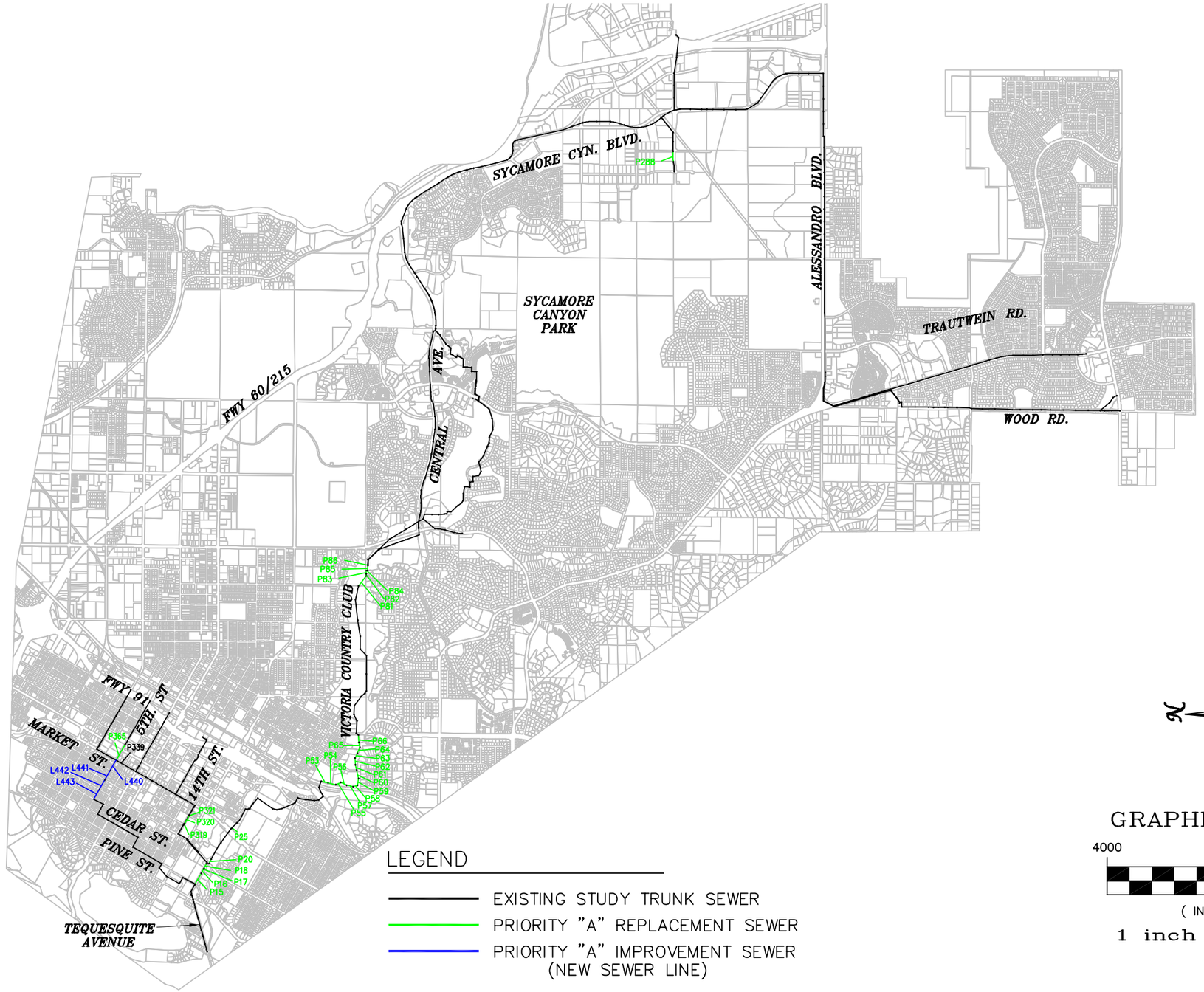
The study area involves a wide range of flow conditions contributing to the system; thus atypical flow patterns. A future addition of approximately 10 cfs maximum flow coming out of proposed IBP development near Fwy 215 and Sycamore Canyon Boulevard necessitates exploring of other alternative alignments of trunk sewer system to relieve the existing sewer system. The improvement of the existing sewer system for an additional 10 cfs maximum flow would require major construction activities in the Victoria Country Club Area. So, an alternative that would relieve the existing sewer system from additional flow and collect sewage flow from the proposed residential expansion of UCR was considered the best. This alternative trunk sewer line would begin at the Central Avenue – Canyon Crest Drive intersection and move westwards on Canyon Crest Drive to Martin Luther King Blvd. Beyond this intersection it would move southwards to Pennsylvania Avenue. Beyond this intersection the sewer line would continue along Pennsylvania Avenue till Victoria Avenue, then along Victoria Avenue till Cridge Street. From Cridge Street and Vine Street intersection it would move southwards towards Date Street and cross Hwy 91 near College Drive and Olivewood intersection. At this location it would join the existing study sewer system. The details of alternatives can be seen on Figure 23. The alternative for diversion of Market Street Wastewater Flow has been separately discussed in Appendix "C".

7.7 Cost Estimate

Unit costs of pipes are based on rates obtained from the contractors over telephone, bid prices for similar projects and from web site www.get-a-quote.net. The cost of construction includes labor, materials, excavation, backfill and all other items associated with pipe laying. To estimate total cost, cost of mobilization /

demobilization (7%), traffic control (7%), bond (1%), contractor's profit (15%) and construction contingency (20%) is added to the cost of construction. For priorities "B" and "C", the cost estimate is based on current year prices and no escalation has been added to estimate future cost. Following is the summary of cost for the various priorities:

- Priority "A" - $2,757,000 (See Figure 21 and Table 7-7-A for details)
- Priority "B" - $6,734,000 (See Figure 22 and Table 7-7-B for details)
- Priority "C" - $ 8,400,000 (See Figure 23 and Table 7-7-C for details)

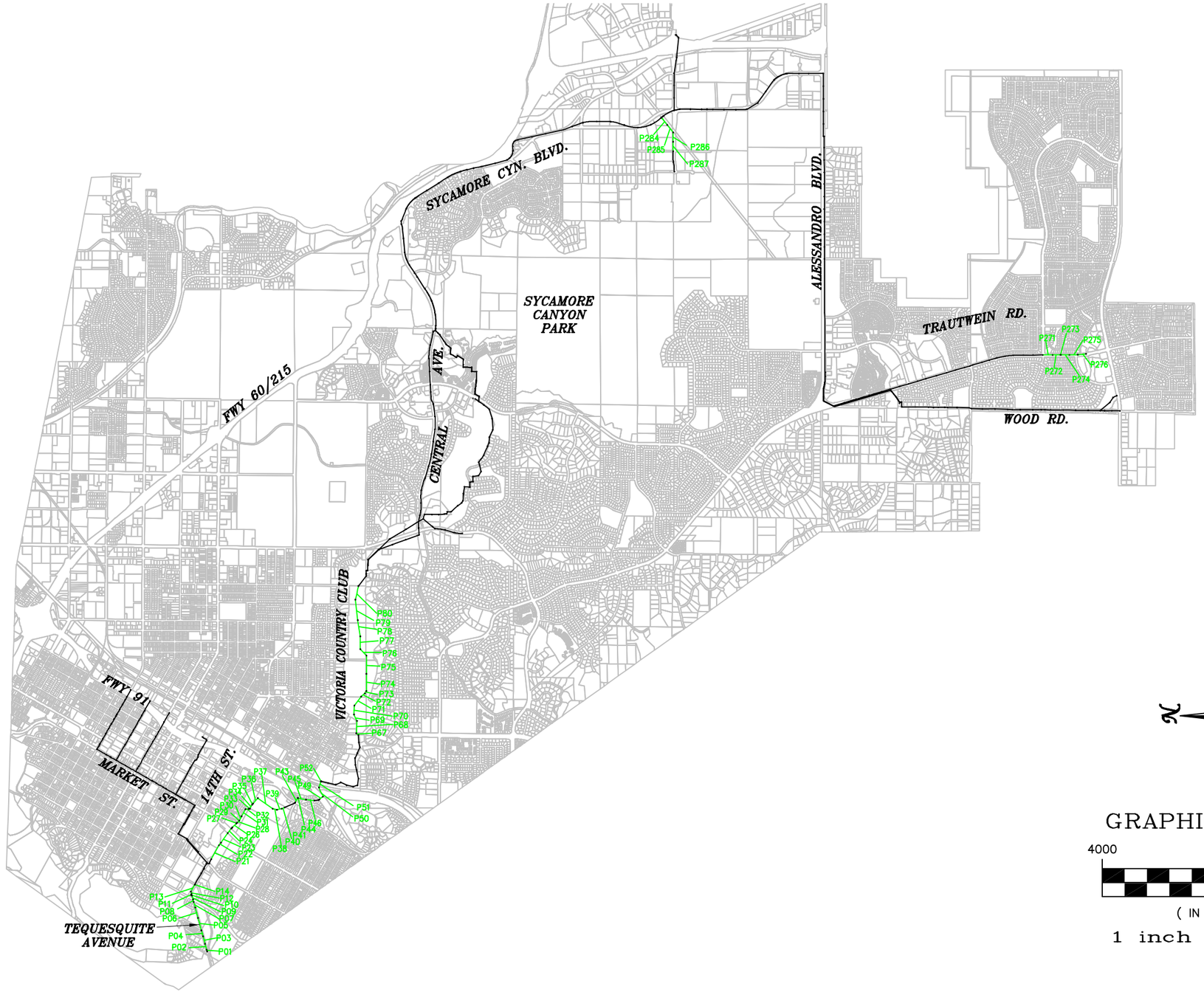


Engineering
Planning
Surveying
Construction Services
PBSJ
3610 Central Avenue
Suite 500
Riverside, CA 92506
Tel:(909) 341-6380
Fax:(909) 341-6389

CITY OF RIVERSIDE
TEQUESQUITE SEWER STUDY

FIGURE 21

PRIORITY "A"



GRAPHIC SCALE

4000 0 2000 4000

(IN FEET)

1 inch = 4000 ft.

LEGEND

EXISTING STUDY TRUNK SEWER

PRIORITY "B" REPLACEMENT SEWER

Engineering
Planning
Surveying
Construction Services

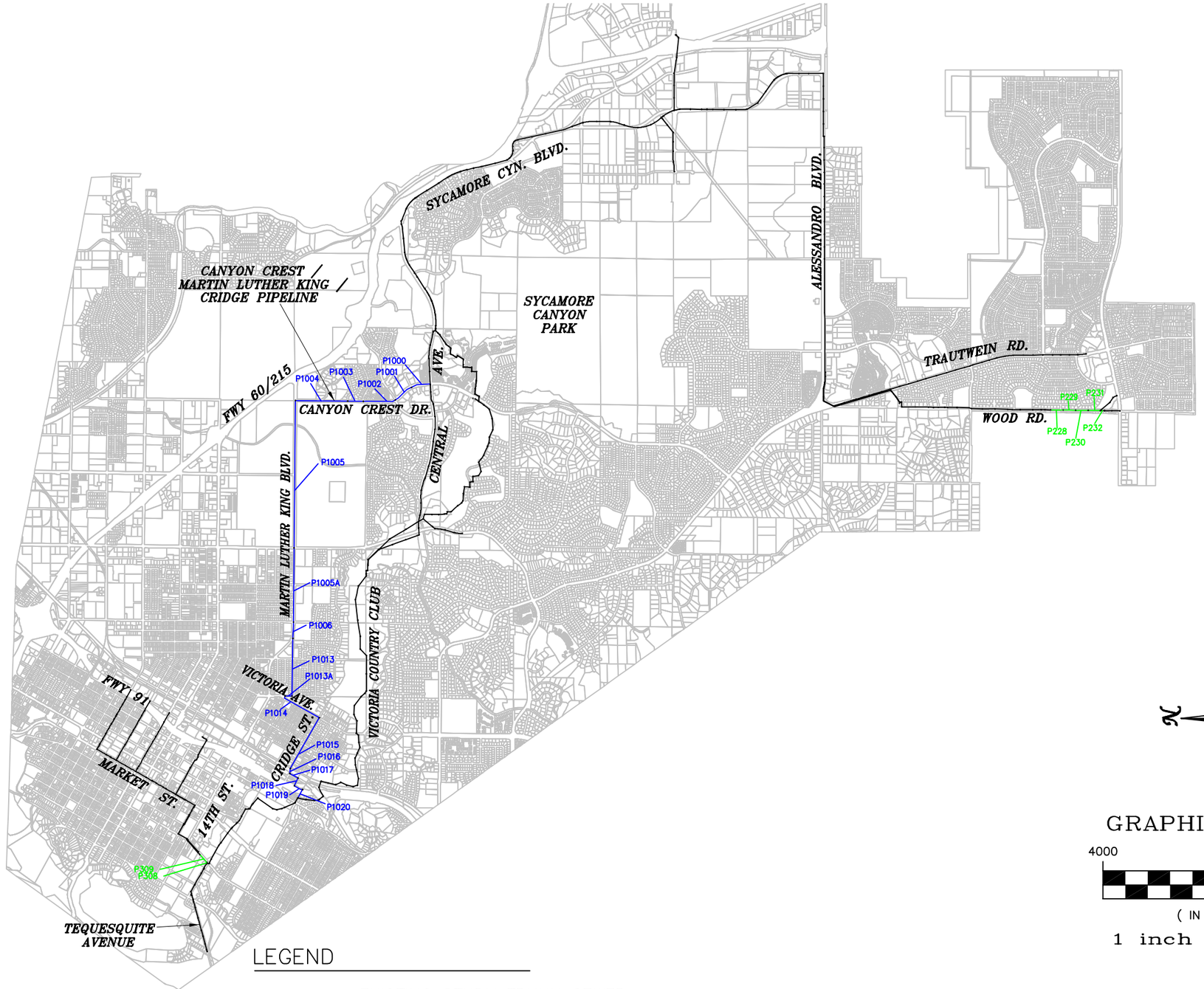
PBS&J

3610 Central Avenue
Suite 500
Riverside, CA 92506
Tel:(909) 341-6380
Fax:(909) 341-6389

CITY OF RIVERSIDE
TEQUESQUITE SEWER STUDY

FIGURE 22

PRIORITY "B"



N

GRAPHIC SCALE

4000 0 2000 4000

(IN FEET)

1 inch = 4000 ft.

LEGEND

- EXISTING STUDY TRUNK SEWER
- PRIORITY "C" REPLACEMENT SEWER
- PRIORITY "C" IMPROVEMENT SEWER (NEW SEWER LINE)

Engineering
Planning
Surveying
Construction Services
PBSJ
3610 Central Avenue
Suite 500
Riverside, CA 92506
Tel:(909) 341-6380
Fax:(909) 341-6389

CITY OF RIVERSIDE
TEQUESQUITE SEWER STUDY

FIGURE 23

PRIORITY "C"

Table 7-7-A
Cost Estimate For Priority "A" Projects, (2004-2007 Replacement / Rehabilitation)

Location	Description	Existing Diameter (inch)	New Diameter (inch)	Unit	Quantity	Unit Cost	Approx Total Cost(2003 $'s)
Tequesquiite Avenue	Replace Pipe P15	21	42	LF	450	$300	$135,000
	Replace Pipe P16	21	42	LF	180	$300	$54,000
	Replace Pipe P17	21	42	LF	24	$300	$7,200
	Replace Pipe P18	21	42	LF	198	$300	$59,400
	Replace Pipe P20	27	42	LF	144	$300	$43,200
	Replace Pipe P25	27	42	LF	50	$300	$15,000
	Rehab / Replace Manhole			EA	7	$5,000	$35,000
	Reconnect Sewer Laterals			EA	10	$1,500	$15,000
						Total:	$363,800
Mobilization / Demobilization (7%)							$25,466
Traffic Control (7%)							$25,466
Bond (1%)							$3,638
Contractor's Profit(15%)							$54,570
Subtotal:							$472,940
Construction Contingency(20%)							$94,588
Total Cost (Tequesquite Avenue Sewer)							**$568,000**
Hwy 91/Victoria Country Club	Replace Pipe P53	27	36	LF	249	$250	$62,335
	Replace Pipe P54	27	36	LF	280	$250	$69,888
	Replace Pipe P55	27	36	LF	195	$250	$48,825
	Replace Pipe P56	24	36	LF	246	$250	$61,425
	Replace Pipe P57	24	36	LF	236	$250	$59,018
	Replace Pipe P58	24	36	LF	166	$250	$41,453
	Replace Pipe P59	24	36	LF	259	$195	$50,427
	Replace Pipe P60	21	36	LF	312	$195	$60,916
	Replace Pipe P61	21	36	LF	190	$195	$37,089
	Replace Pipe P62	21	36	LF	225	$195	$43,904
	Replace Pipe P63	21	36	LF	217	$195	$42,237
	Replace Pipe P64	21	36	LF	211	$195	$41,048
	Replace Pipe P65	21	36	LF	174	$195	$33,833
	Replace Pipe P66	21	36	LF	274	$195	$53,469
	Replace Pipe P81	18	24	LF	453	$110	$49,864

Table 7-7-A
Cost Estimate For Priority "A" Projects, (2004-2007 Replacement / Rehabilitation)

Location	Description	Existing Diameter (inch)	New Diameter (inch)	Unit	Quantity	Unit Cost	Approx Total Cost(2003 $'s)
	Replace Pipe P82	18	24	LF	73	$110	$8,078
	Replace Pipe P83	18	24	LF	118	$110	$12,965
	Replace Pipe P84	18	24	LF	48	$110	$5,292
	Replace Pipe P85	18	24	LF	177	$110	$19,444
	Replace Pipe P86	18	24	LF	9	$110	$988
	Rehab / Replace Manhole			EA	21	$5,000	$105,000
	Reconnect Sewer Laterals			EA	41	$1,500	$61,500
						Total:	$968,995
Mobilization / Demobilization (7%)							$67,830
Traffic Control (7%)							$67,830
Bond (1%)							$9,690
Contractor's Profit(15%)							$145,349
Subtotal:							$1,259,694
Construction Contingency(20%)							$251,939
Total Cost (Hwy 91 / Victoria Country Club Sewer)							**$1,512,000**
Eastridge Avenue	Replace Pipe P288	10	18	LF	381	$130	$49,530
	Rehab / Replace Manhole			EA	2	$5,000	$10,000
	Reconnect Sewer Laterals			EA	4	$1,500	$6,000
						Total:	$65,530
Mobilization / Demobilization (7%)							$4,587
Traffic Control (7%)							$4,587
Bond (1%)							$655
Contractor's Profit(15%)							$9,830
Subtotal:							$85,189
Construction Contingency(20%)							$17,038
Total Cost (Eastridge Avenue Sewer)							**$102,000**

Table 7-7-A
Cost Estimate For Priority "A" Projects, (2004-2007 Replacement / Rehabilitation)

Location	Description	Existing Diameter (inch)	New Diameter (inch)	Unit	Quantity	Unit Cost	Approx Total Cost(2003 $'s)
13th Street	Replace Pipe P319	12	15	LF	21	$105	$2,205
	Replace Pipe P320	10	15	LF	396	$105	$41,580
	Replace Pipe P321	10	15	LF	20	$105	$2,100
	Rehab / Replace Manhole			EA	4	$5,000	$20,000
	Reconnect Sewer Laterals			EA	4	$1,500	$6,000
						Total:	$71,885
Mobilization / Demobilization (7%)							$5,032
Traffic Control (7%)							$5,032
Bond (1%)							$719
Contractor's Profit(15%)							$10,783
Subtotal:							$93,451
Construction Contingency(20%)							$18,690
Total Cost (13th Street Sewer)							**$112,000**
5th Street	Replace Pipe P365	8	10	LF	651	$90	$58,590
	Rehab / Replace Manhole			EA	2	$5,000	$10,000
	Reconnect Sewer Laterals			EA	7	$1,500	$10,500
						Total:	$79,090
Mobilization / Demobilization (7%)							$5,536
Traffic Control (7%)							$5,536
Bond (1%)							$791
Contractor's Profit(15%)							$11,864
Subtotal:							$102,817
Construction Contingency(20%)							$20,563
Total Cost (5th Street Sewer)							**$123,000**

Table 7-7-A
Cost Estimate For Priority "A" Projects, (2004-2007 Replacement / Rehabilitation)

Location	Description	Existing Diameter (inch)	New Diameter (inch)	Unit	Quantity	Unit Cost	Approx Total Cost(2003 $'s)
NEW PIPELINE:							
5th Street	New Pipe L440		12	LF	414	$100	$41,400
	New Pipe L441		12	LF	393	$100	$39,300
	New Pipe L442		12	LF	396	$100	$39,600
	New Pipe L443		12	LF	398	$100	$39,800
	Rehab / Replace Manhole			EA	5	$5,000	$25,000
	Reconnect Sewer Laterals			EA	20	$1,500	$30,000
	Abandon in place Pipe P339			LS	1	$3,000	$3,000
						Total =	$218,100
Mobilization / Demobilization (7%)							$15,267
Traffic Control (7%)							$15,267
Bond (1%)							$2,181
Contractor's Profit(15%)							$32,715
Subtotal:							$283,530
Construction Contingency(20%)							$56,706
Total Cost (5th Street New Sewer)							**$340,000**
TOTAL COST FOR PRIORITY "A" PROJECTS							**$2,757,000**

Table 7-7-B
Cost Estimate For Priority "B" Projects, (2008- 2013 Replacement / Rehabilitation)

Location	Description	Existing Diameter (inch)	New Diameter (inch)	Unit	Quantity	Unit Cost	Approx Total Cost(2003 $'s)
Tequesquiite Avenue	Replace Pipe P01	27	36	LF	62	$250	$15,585
	Replace Pipe P02	27	36	LF	219	$250	$54,868
	Replace Pipe P03	27	36	LF	296	$250	$73,950
	Replace Pipe P04	27	36	LF	225	$250	$56,178
	Replace Pipe P05	27	36	LF	457	$250	$114,335
	Replace Pipe P06	27	36	LF	387	$250	$96,663
	Replace Pipe P07	27	36	LF	207	$250	$51,770
	Replace Pipe P08	27	36	LF	94	$250	$23,545
	Replace Pipe P09	27	36	LF	138	$250	$34,393
	Replace Pipe P10	30	36	LF	38	$250	$9,540
	Replace Pipe P11	30	42	LF	40	$300	$12,000
	Replace Pipe P12	27	42	LF	85	$300	$25,620
	Replace Pipe P13	27	42	LF	257	$300	$77,010
	Replace Pipe P14	24	42	LF	16	$300	$4,812
	Replace Pipe P21	27	42	LF	571	$300	$171,348
	Replace Pipe P22	27	42	LF	133	$300	$39,789
	Replace Pipe P23	27	42	LF	414	$300	$124,200
	Replace Pipe P24	24	42	LF	200	$300	$60,000
	Rehab / Replace Manhole			EA	19	$5,000	$95,000
	Reconnect Sewer Laterals			EA	38	$1,500	$57,000
						Total:	$1,197,604
Mobilization / Demobilization (7%)							$83,832
Traffic Control (7%)							$83,832
Bond (1%)							$11,976
Contractor's Profit(15%)							$179,641
Subtotal:							$1,556,885
Construction Contingency(20%)							$311,377
Total Cost (Tequesquite Avenue Sewer)							**$1,868,000**
R.C.C	Replace Pipe P26	27	42	LF	200	$300	$59,964
	Replace Pipe P27	27	42	LF	39	$300	$11,700
	Replace Pipe P28	27	42	LF	111	$300	$33,432
	Replace Pipe P29	27	42	LF	177	$300	$52,974

Table 7-7-B
Cost Estimate For Priority "B" Projects, (2008- 2013 Replacement / Rehabilitation)

Location	Description	Existing Diameter (inch)	New Diameter (inch)	Unit	Quantity	Unit Cost	Approx Total Cost(2003 $'s)
	Replace Pipe P30	27	42	LF	281	$300	$84,420
	Replace Pipe P31	27	42	LF	105	$300	$31,416
	Replace Pipe P32	27	42	LF	39	$300	$11,550
	Replace Pipe P33	27	42	LF	15	$300	$4,350
	Replace Pipe P34	27	42	LF	163	$300	$48,954
	Replace Pipe P35	27	42	LF	44	$300	$13,326
	Replace Pipe P36	27	42	LF	265	$300	$79,422
	Replace Pipe P37	27	42	LF	638	$300	$191,325
	Replace Pipe P38	24	42	LF	151	$300	$45,183
	Replace Pipe P39	27	42	LF	190	$300	$57,000
	Replace Pipe P40	27	42	LF	145	$300	$43,500
	Replace Pipe P41	27	42	LF	370	$300	$111,102
	Replace Pipe P43	24	30	LF	184	$195	$35,933
	Replace Pipe P44	24	30	LF	7	$195	$1,427
	Replace Pipe P45	24	30	LF	290	$195	$56,458
	Replace Pipe P46	24	30	LF	309	$105	$32,461
	Replace Pipe P49	24	30	LF	157	$195	$30,615
	Replace Pipe P50 (Siphon)-DIP	18	2-18	LF	358	$280	$100,240
	Rehab / Replace Manhole			EA	23	$5,000	$115,000
	Reconnect Sewer Laterals			EA	42	$1,500	$63,000
	Jack and Bore Under Freeway and Railroad			LF	800	$500	$400,000
						Total:	$1,714,752
Mobilization / Demobilization (7%)							$120,033
Traffic Control (7%)							$120,033
Bond (1%)							$17,148
Contractor's Profit(15%)							$257,213
Subtotal:							$2,229,178
Construction Contingency(20%)							$445,836
Total Cost (R.C.C. Sewer)							**$2,675,000**

Table 7-7-B
Cost Estimate For Priority "B" Projects, (2008- 2013 Replacement / Rehabilitation)

Location	Description	Existing Diameter (inch)	New Diameter (inch)	Unit	Quantity	Unit Cost	Approx Total Cost(2003 $'s)
Victoria Country Club	Replace Pipe P51	24	36	LF	227	$250	$56,750
	Replace Pipe P52	24	36	LF	15	$250	$3,750
	Replace Pipe P67	24	30	LF	106	$145	$15,370
	Replace Pipe P68	21	27	LF	458	$130	$59,540
	Replace Pipe P69	21	27	LF	260	$130	$33,800
	Replace Pipe P70	21	27	LF	304	$130	$39,520
	Replace Pipe P71	21	27	LF	380	$130	$49,400
	Replace Pipe P72	21	27	LF	179	$130	$23,270
	Replace Pipe P73	21	27	LF	144	$130	$18,720
	Replace Pipe P74	21	27	LF	610	$130	$79,300
	Replace Pipe P75	21	27	LF	650	$130	$84,500
	Replace Pipe P76	21	27	LF	344	$130	$44,720
	Replace Pipe P77	21	27	LF	578	$130	$75,140
	Replace Pipe P78	21	27	LF	628	$130	$81,640
	Replace Pipe P79	21	27	LF	600	$130	$78,000
	Replace Pipe P80	21	27	LF	500	$130	$65,000
	Rehab / Replace Manhole			EA	17	$5,000	$85,000
	Reconnect Sewer Laterals			EA	60	$1,500	$90,000
						Total:	$983,420
Mobilization / Demobilization (7%)							$68,839
Traffic Control (7%)							$68,839
Bond (1%)							$9,834
Contractor's Profit(15%)							$147,513
Subtotal:							$1,278,446
Construction Contingency(20%)							$255,689
Total Cost (Victoria Country Club Sewer)							**$1,534,000**
Trautwein Road	Replace Pipe P271	8	10	LF	352	$90	$31,680
	Replace Pipe P272	8	10	LF	277	$90	$24,930
	Replace Pipe P273	8	10	LF	23	$90	$2,070
	Replace Pipe P274	8	10	LF	300	$90	$27,000
	Replace Pipe P275	8	10	LF	299	$90	$26,910
	Replace Pipe P276	8	10	LF	299	$90	$26,910
	Rehab / Replace Manhole			EA	7	$5,000	$35,000

Table 7-7-B
Cost Estimate For Priority "B" Projects, (2008- 2013 Replacement / Rehabilitation)

Location	Description	Existing Diameter (inch)	New Diameter (inch)	Unit	Quantity	Unit Cost	Approx Total Cost(2003 $'s)
	Reconnect Sewer Laterals			EA	16	$1,500	$24,000
						Total:	$198,500
Mobilization / Demobilization (7%)							$13,895
Traffic Control (7%)							$13,895
Bond (1%)							$1,985
Contractor's Profit(15%)							$29,775
Subtotal:							$258,050
Construction Contingency(20%)							$51,610
Total Cost (Trautwein Road Sewer)							**$310,000**
Eastridge Avenue	Replace Pipe P284	12	18	LF	339	$130	$44,044
	Replace Pipe P285	12	18	LF	343	$130	$44,647
	Replace Pipe P286	12	18	LF	337	$130	$43,759
	Replace Pipe P287	12	18	LF	338	$130	$43,953
	Rehab / Replace Manhole			EA	5	$5,000	$25,000
	Reconnect Sewer Laterals			EA	14	$1,500	$21,000
						Total:	$222,404
Mobilization / Demobilization (7%)							$15,568
Traffic Control (7%)							$15,568
Bond (1%)							$2,224
Contractor's Profit(15%)							$33,361
Subtotal:							$289,125
Construction Contingency(20%)							$57,825
Total Cost (Eastridge Avenue Sewer)							**$347,000**
TOTAL COST FOR PRIORITY "B" PROJECTS							**$6,734,000**

Table 7-7-C
Cost Estimate For Priority "C" Projects, (2014-2018 Replacement / Rehabilitation)

Location	Description	Existing Diameter (inch)	New Diameter (inch)	Unit	Quantity	Unit Cost	Approx Total Cost(2003 $'s)
Tequesquiite Avenue	Replace Pipe P19 (Siphon)-DIP	2-15	2-18	LF	194	$280	$54,320
	Rehab / Replace Manhole			EA	2	$5,000	$10,000
	Extra for Siphon Replacement			LS			$30,000
						Total:	$94,320
Mobilization / Demobilization (7%)							$6,602
Traffic Control (7%)							$6,602
Bond (1%)							$943
Contractor's Profit(15%)							$14,148
Subtotal:							$122,616
Construction Contingency(20%)							$24,523
Total Cost (Tequesquite Avenue Sewer)							**$147,000**
Wood Road	Replace Pipe P228	12	15	LF	450	$105	$47,250
	Replace Pipe P229	12	15	LF	450	$105	$47,250
	Replace Pipe P230	12	15	LF	450	$105	$47,250
	Replace Pipe P231	12	15	LF	429	$105	$45,090
	Replace Pipe P232	8	15	LF	149	$105	$15,649
	Rehab / Replace Manhole			EA	6	$5,000	$30,000
	Reconnect Sewer Laterals			EA	19	$1,500	$28,500
						Total:	$260,989
Mobilization / Demobilization (7%)							$18,269
Traffic Control (7%)							$18,269
Bond (1%)							$2,610
Contractor's Profit(15%)							$39,148
Subtotal:							$339,286
Construction Contingency(20%)							$67,857
Total Cost (Wood Road Sewer)							**$407,000**
Brockton Ave.	Replace Pipe P308	15	18	LF	46	$130	$5,980
	Replace Pipe P309	15	18	LF	400	$130	$52,000
	Rehab / Replace Manhole			EA	3	$5,000	$15,000
	Reconnect Sewer Laterals			EA	4	$1,500	$6,000

Table 7-7-C
Cost Estimate For Priority "C" Projects, (2014-2018 Replacement / Rehabilitation)

Location	Description	Existing Diameter (inch)	New Diameter (inch)	Unit	Quantity	Unit Cost	Approx Total Cost(2003 $'s)
						Total:	$78,980
Mobilization / Demobilization (7%)							$5,529
Traffic Control (7%)							$5,529
Bond (1%)							$790
Contractor's Profit(15%)							$11,847
Subtotal:							$102,674
Construction Contingency(20%)							$20,535
Total Cost (Brockton AvenueSewer)							**$123,000**
NEW PIPELINE:							
Cridge Avenue	New Pipe P1020		30	LF	570	$195	$111,150
	New Pipe P1019		30	LF	350	$195	$68,250
	New Pipe P1018		30	LF	195	$195	$38,025
	New Pipe P1017		30	LF	195	$195	$38,025
	New Pipe P1016		30	LF	360	$195	$70,200
	New Pipe P1015		30	LF	2060	$195	$401,700
	Rehab / Replace Manhole			EA	9	$5,000	$45,000
	Reconnect Sewer Laterals			EA	37	$1,500	$55,500
	Jack and Bore Under Freeway and Railroad			LF	800	$500	$400,000
						Total:	$1,227,850
Mobilization / Demobilization (7%)							$85,950
Traffic Control (7%)							$85,950
Bond (1%)							$12,279
Contractor's Profit(15%)							$184,178
Subtotal:							$1,596,205
Construction Contingency(20%)							$319,241
Total Cost (Cridge AvenueSewer)							**$1,915,000**
Victoria Avenue	New Pipe P1014		30	LF	1470	$195	$286,650
	New Pipe P1013A		30	LF	250	$195	$48,750
	Rehab / Replace Manhole			EA	4	$5,000	$20,000
	Reconnect Sewer Laterals			EA	17	$1,500	$25,500

Table 7-7-C
Cost Estimate For Priority "C" Projects, (2014-2018 Replacement / Rehabilitation)

Location	Description	Existing Diameter (inch)	New Diameter (inch)	Unit	Quantity	Unit Cost	Approx Total Cost(2003 $'s)
						Total:	$380,900
Mobilization / Demobilization (7%)							$26,663
Traffic Control (7%)							$26,663
Bond (1%)							$3,809
Contractor's Profit(15%)							$57,135
Subtotal:							$495,170
Construction Contingency(20%)							$99,034
Total Cost (Victoria Avenue Sewer)							**$594,000**
Pennsylvania Avenue	New Pipe P1013		30	LF	2070	$195	$403,650
	Rehab / Replace Manhole			EA	5	$5,000	$25,000
	Reconnect Sewer Laterals			EA	21	$1,500	$31,500
						Total:	$460,150
Mobilization / Demobilization (7%)							$32,211
Traffic Control (7%)							$32,211
Bond (1%)							$4,602
Contractor's Profit(15%)							$69,023
Subtotal:							$598,195
Construction Contingency(20%)							$119,639
Total Cost (Pennsylvania Avenue Sewer)							**$718,000**

Table 7-7-C
Cost Estimate For Priority "C" Projects, (2014-2018 Replacement / Rehabilitation)

Location	Description	Existing Diameter (inch)	New Diameter (inch)	Unit	Quantity	Unit Cost	Approx Total Cost(2003 $'s)
MLK Blvd.	New Pipe P1006		27	LF	650	$180	$117,000
	New Pipe P1005A		27	LF	2650	$180	$477,000
	New Pipe P1005		27	LF	5260	$180	$946,800
	Rehab / Replace Manhole			EA	21	$5,000	$105,000
	Reconnect Sewer Laterals			EA	86	$1,500	$129,000
	Jack and Bore under Gage Canal			LF	100	$500	$50,000
						Total:	$1,824,800
Mobilization / Demobilization (7%)							$127,736
Traffic Control (7%)							$127,736
Bond (1%)							$18,248
Contractor's Profit(15%)							$273,720
Subtotal:							$2,372,240
Construction Contingency(20%)							$474,448
Total Cost (MLK Blvd. Sewer)							**$2,847,000**
Canyon Crest Dr.	New Pipe P1004		27	LF	1900	$180	$342,000
	New Pipe P1003		27	LF	560	$180	$100,800
	New Pipe P1002		27	LF	1160	$180	$208,800
	New Pipe P1001		27	LF	735	$180	$132,300
	New Pipe P1000		27	LF	730	$180	$131,400
	Rehab / Replace Manhole			EA	13	$5,000	$65,000
	Reconnect Sewer Laterals			EA	51	$1,500	$76,500
						Total =	$1,056,800
Mobilization / Demobilization (7%)							$73,976
Traffic Control (7%)							$73,976
Bond (1%)							$10,568
Contractor's Profit(15%)							$158,520
Subtotal:							$1,373,840
Construction Contingency(20%)							$274,768
Total Cost (Canyon Crest Drive Sewer)							**$1,649,000**
TOTAL COST FOR PRIORITY "C" PROJECTS							**$8,400,000**

Appendix C
ARLANZA TRUNK SEWER STUDY

City of Riverside
Arlanza Trunk Sewer Study

590110.10

Prepared By:

10370 Hemet Street, Suite 200
Riverside, CA 92503
(951) 358-1433

August, 2006

ARLANZA TRUNK SEWER STUDY

City of Riverside

Client Representative L.F.(Sandy) Caldwell, P.E.

PBS&J

Project Director Gary H. Eikermann

Project Engineer Barmeshwar Rai, P.E.

Technical Support Charlene Drake
Cristina Chavez

J.N. 590110.10

August, 2006

10370 Hemet Street, Suite 200, Riverside, CA 92503 Ph: (951)-358-1433

TABLE OF CONTENTS

Page Number

Executive Summary

ES.1 *Introduction* *Ex-1*

ES.2 Existing Sewer System *Ex-1*

ES.3 Methodology *Ex-1*

ES.4 Project Priorities and Cost *Ex-2*

Table Ex-1 Summary of Prioritized Improvement Projects *Ex-3*

1.0 Introduction 1

1.1 Background 1

1.2 Study Area 1

1.3 Objective 2

1.4 Scope and Study Approach 2

2.0 Land Use 5

2.1 Existing Land Use 5

2.2 Proposed Land use 5

3.0 Existing Sewer System 6

3.1 System Overview 6

3.2 Collection System 6

3.3 System Description 7

3.4 Tributary Areas 19

4.0 Determination of Sewer Flows ……. ..... ….. 21

4.1 Flow Monitoring 21

4.2 Results of Flow Monitoring 22

5.0 Estimated Ultimate Flow 25

5.1 Methodology 25

5.2 Flow Coefficients 25

5.3 Representative Diurnal Hydrographs 26

6.0 Computer Model Simulation Analysis 28

6.1 Methodology 28

6.2 Limitations of Modeling 29

7.0 *Deficiencies and Solutions*……. 30

7.1 Deficient and Marginally Deficient Pipes ……. 30

7.2 Project Prioritization Methodology ……..... 31

7.3 Recommended Improvements 32

7.4 Grouping of Projects ……..... 32

7.5 Construction Schedule ……... 32

7.7 Cost Estimate ……..... 32

LIST OF TABLES

Page Follows/On

2-1	Land Use That Would Produce Wastewater Flow	5
3-1	Developed Tributary Areas and Current Wastewater Land Use	20
7-1	Sewer Analysis Results (Existing and Ultimate Conditions)	29
7-2	Proposed Construction Prioritization	33
7-3	Summary of Improvement Plans for Problem Areas……	33
7-6-A	Preliminary Construction Cost Estimate for Priority "A" Projects	33
7-6-B	Preliminary Construction Cost Estimate for Priority "B" Projects ..... ……	33
7-6-C	Preliminary Construction Cost Estimate for Priority "C" Projects	33

LIST OF FIGURES

Follows Page

1	Vicinity Map	1
2	Study Area	1
3A	Land Use Plan	5
3B	Land Use – Vacant	5
4	Tributary Areas	6
5	Flow Monitoring Locations.....	6
6A	Sewer System and Pipe Diameters – Part 1.....	18

6B Sewer System and Pipe Diameters – Part 2 18

7A Existing Manholes – Part 1 18

7B Existing Manholes – Part 2 18

7C Existing Manholes – Part 3 18

8A Existing Pipes – Part 1 18

8B Existing Pipes – Part 2 18

8C Existing Pipes – Part 3 18

9 to 16 Adjusted Flows at Meters 27

17 to 24 Representative Diurnal Hydrographs 27

25A Existing Volume Deficiencies – Part 1 30

25B Existing Volume Deficiencies – Part 2 30

25C Existing Volume Deficiencies – Part 3 30

26A Existing Velocity Deficiencies – Part 1 30

26B Existing Velocity Deficiencies – Part 2 30

26C Existing Velocity Deficiencies – Part 3 30

27A Ultimate Volume Deficiencies – Part 1 30

27B Ultimate Volume Deficiencies – Part 2 30

27C Ultimate Volume Deficiencies – Part 3 30

28A Priority “A” – Part 1 33

28B Priority “A” – Part 2 33

28C Priority “A” – Part 3 33

29A Priority “B” – Part 1 33

29B Priority “B” – Part 2 33

29C Priority “B” – Part 3 33

30A Priority “C” – Part 1 33

30B Priority “C” – Part 2 33

30C Priority “C” – Part 3 33

APPENDICES

Appendix A – Flow Data at Meter Locations

Appendix B – City of Riverside, Sewer Design Guidelines

Appendix C – Study Sewer Lines

Executive Summary

ES.1 Introduction

This report presents the results of the Arlanza Trunk Sewer System Capacity Study prepared by PBS&J for the City of Riverside. The report contains recommendations regarding system deficiencies as identified by hydraulic model XP-SWMM (XP Software, Version 9.1).

The City of Riverside is located in the County of Riverside at the intersection of three major freeways; Route 91, Route 60 and Route 215. The study area encompasses approximately 20,650 acres of mixed land use development and is generally bounded by Santa Ana River to the North, the City of Norco to the West, Home Gardens neighborhood of the County of Riverside to the South and Jefferson Street to the East. The study area is essentially a fully developed community, comprised of single family residential, multi family residential, commercial and light industrial areas with some vacant lands to be developed in the future. The portion of study area southeast of Victoria Avenue and designated as "residential semi-rural" would be one of the major contributors of sewage flow to the system. The study area can be divided into two distinct study basins: the area west of Tyler Street served by a lift station at Pierce Street and the area on east served by a gravity system.

ES.2 Existing Sewer System

The existing trunk sewer system within the study area is comprised of approximately 38 miles of gravity sewer mains, ranging in size from 8-inch to 51-inch in diameter, and 691 manholes. These sewer lines are essentially VCP and the manholes are typically brick lined. The sewer system also includes a lift station and 5.6 miles of force mains. The City of Riverside owns, maintains and operates the sewer system.

ES.3 Methodology

For determination of current wastewater flows, flow monitoring was performed at eight (8) strategic locations. These meter locations were chosen to observe actual flow characteristics for various sub areas with a distinct land use pattern within the study area. The flow monitoring was accomplished over a three-week period. The flow results were carefully evaluated for accuracy and some adjustments were made based on depth of flow at meter locations.

A theoretical estimate of wastewater flow from vacant areas was done based on factors from the City of Riverside "Criteria for Sewer Facility Design". Residential wastewater flow was estimated by using future projected population, whereas commercial and industrial flow was estimated based on acreage and City assumed unit flow coefficients.

The Computer Model Simulation Analysis involved evaluation of available capacity in the existing collection system under present and future development conditions. System deficiencies were identified from the results of model runs and a prioritized capital improvement plan was developed to allow for the projected growth within the study area.

ES.4 Project Priorities and Cost

Deficient and marginally deficient pipes were identified from the results of model runs and were prioritized for replacement/re-habilitation purpose. The pipes that are currently flowing more than 90% full under modeled existing maximum flow conditions and needing near term (2005-2010) replacement/re-habilitation are grouped under priority "A". The pipes that would flow more than 90% full in year 2015 under anticipated maximum future flow condition are classified as priority "B". The pipelines that are not included in priorities "A" and "B" and, are anticipated to flow more than 75% full under future flow conditions are categorized as priority "C". Some adjustment of priorities and combining of improvements was done for continuity and efficiency of effecting improvements.

The time phased improvements for various priorities are listed in Table 7-2. The approximate cost of recommended improvements is summarized in Tables 7-6-A, 7-6-B and 7-6-C.

Under existing flow conditions, a total of approximately 2,000 linear feet of priority "A" deficiencies were identified, requiring near term (2005-2010) attention. Additional deficiencies predicted under ultimate flow conditions (Priority "B") include an additional 9,000 linear feet of inadequate sewer lines. The estimated capital cost to remedy these identified deficiencies (in year 2005 $ s) is approximately $748,000 for Priority "A" and approximately $3,324,000 for Priority "B". The total length of pipelines under Priority "C" would be approximately 28,000 feet and the cost of Priority "C" projects would be approximately $10,000,000. However, it may be that not all of the Priority "B", and a fraction of Priority "C" improvements will need to be actually implemented. Only those projects where surcharging (within manholes) and other problems are deemed imminent should be considered for improvement. Periodic flow monitoring is recommended to verify anticipated deficiencies and the actual need for improvements. It is recommended that field observations of all pipes should be done where modeled results indicate surcharging conditions. The priorities are summarized in the Table Ex-1.

Table Ex-1
Summary of Prioritized Improvement Projects

Priority	Approximate Pipeline Length (feet)	Location	Replacement Year	Total Project Cost (year 2005 $ s)
"A"	2,000	Collett Avenue, Fillmore Street, Golden Avenue, RWQCP	2005-2010	$748,000
"B"	9,000	Monticello Avenue, Van Buren Boulevard	2011-2015	$3,324,000
"C"	28,000	Acorn Street, Arizona Avenue, Collett Avenue, Fillmore Street, Golden Avenue, Harrison Street, Hole Avenue, Jackson Street, Jones Avenue, La Sierra Channel, Magnolia Avenue, Monroe Street, RWQCP, Van Buren Boulevard	2016-2020	$10,000,000

1.0 INTRODUCTION

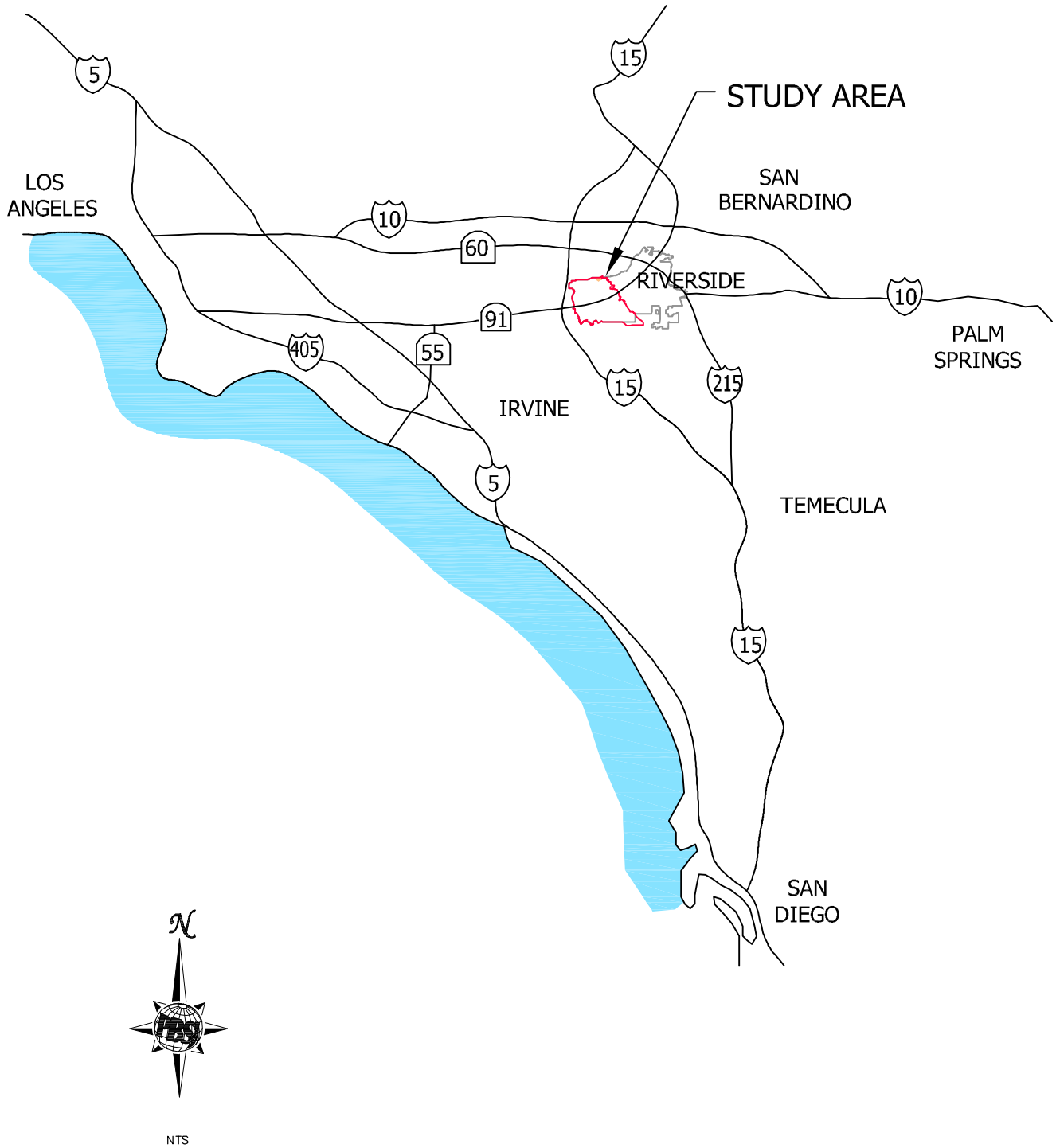
1.1 Background

The City of Riverside (City) retained PBS&J to prepare a Trunk Sewer System Study for the westerly portion of the City. The Sewer System has been designated as Arlanza Trunk Sewer System. The study is necessitated by the fact that the City desires to evaluate the capacity of the existing trunk sewer system.

1.2 Study Area

The City of Riverside is located in the northwest corner of the County of Riverside at the intersection of three major freeways; Route 91, Route 60 and Route 215. Founded in 1870, the City is known for its citrus industry, world famous Mission Inn and other historical monuments. Figure 1 is a Vicinity Map depicting the City's location and its accessibility. Figure 2 shows the study area. The study area shown in Figure 2 encompasses approximately 20,650 acres and is generally bounded by Santa Ana River to the North, the City of Norco to the West, Home Gardens neighborhood of the County of Riverside to the South and Jefferson Street to the East. For purposes of this study, the study area has been divided into 34 tributary sub-areas, where downstream sub-areas intercept sewage flow from upstream sub-areas. To obtain actual observed flow information for this study, sewage flow meters were placed at eight (8) strategic locations to monitor cumulative flows contributed from the tributary sub-areas.

The Arlanza Study Area can be divided into two distinct study basins: the area west of Tyler Street is served by a gravity – force main system with a lift station at Pierce Street and the area east of Tyler Street is served by the gravity system. The study area is considered to be a mature community comprised of single family residential, multi-family residential, commercial and light industrial uses. The portion of study area along both sides of Hwy 91 is primarily commercial development. Future development would take place in the eastern and south eastern portion of the study area which has been designated rural and light residential land use categories.



DATE: 12/21/05	DWN BY: CD

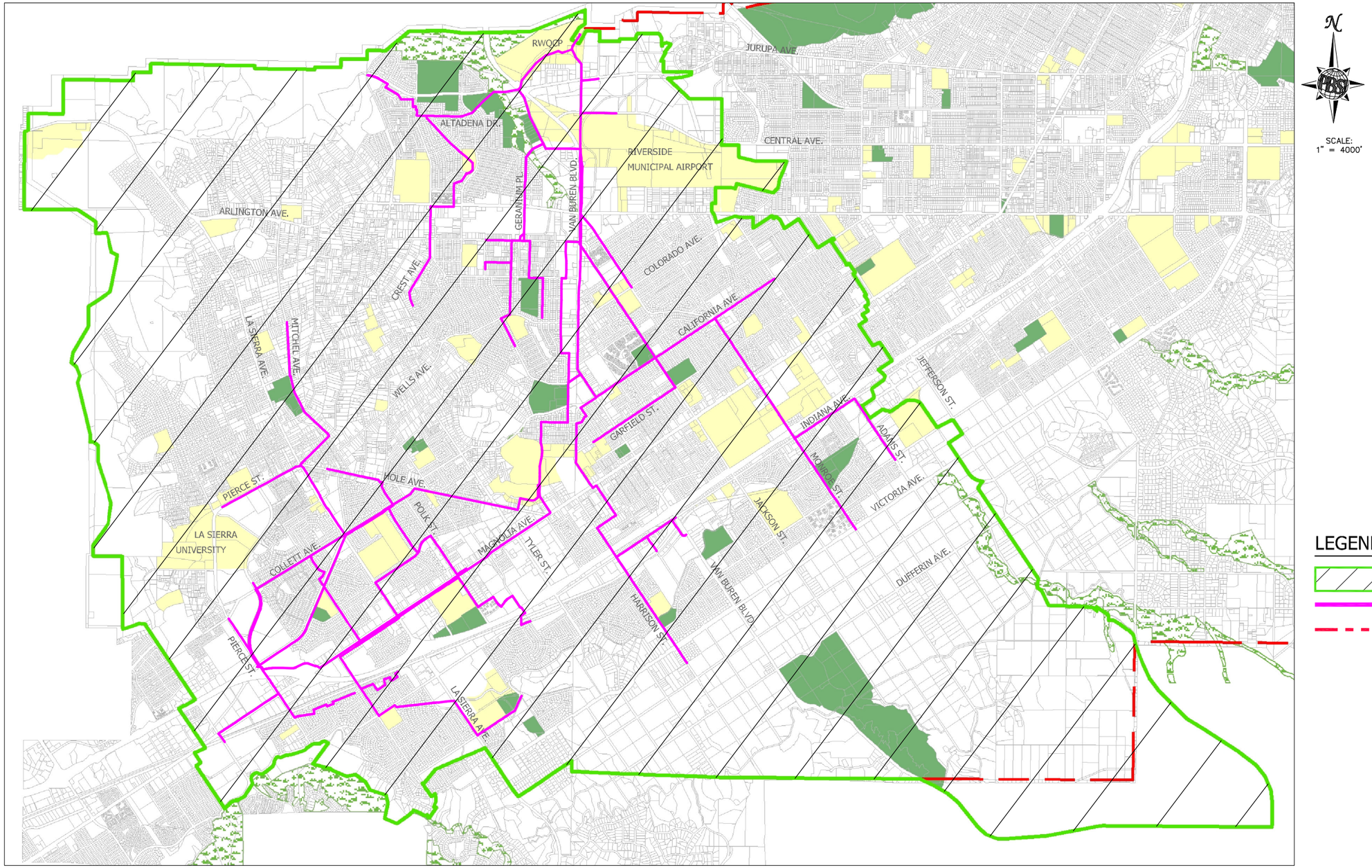
Engineering
Planning
Surveying
Construction Services
PBSJ
10370 Hemet Street
Suite 200
Riverside, CA 92503
Tel:(951) 358-1433
Fax:(951) 358-1434

CITY OF RIVERSIDE
ARLANZA SEWER STUDY

FIGURE 1

VICINITY MAP

Y:\City of Riverside\Arlanza\DWG\Exhibits\AZ-Vicinity.dwg, 9/28/2006 10:45:34 AM



N

SCALE:
1" = 4000'

LEGEND

- STUDY AREA BOUNDARY
- STUDY SEWER
- CITY LIMITS

DATE: 12/21/05	DWN BY: CD
CITY OF RIVERSIDE ARLANZA SEWER STUDY	FIGURE 2
STUDY AREA	

Engineering
Planning
Surveying
Construction Services
PBS&J
10370 Hemet Street
Suite 200
Riverside, CA 92503
Tel:(951) 358-1433
Fax:(951) 358-1434

Y:\City of Riverside\Arlanza\DWG\Exhibits\AZ-StudyArea.dwg, 9/28/2006 10:33:00 AM

1.3 Objective

The objective of this Sewer System Capacity Study is to provide a comprehensive evaluation of the capacity of the sewer system within the study area, identify deficiencies in the current system, and evaluate alternatives to enhance the conveyance capacity to accommodate ultimate wastewater flows anticipated to be generated in the study area.

1.4 Scope and Study Approach

Specific work tasks undertaken for this study are summarized as follows:

- Kickoff Meeting

  An initial meeting was held between PBS&J and the City to discuss the project scope, communication protocol, explanation of methodology and scheduling of flow monitoring. Field data and other digital files to be provided by the City were also discussed.

- Progress Meetings

  Informal Project Progress Meetings were held to discuss on-going issues and the progress of the study.

- Flow Monitoring and Hydrograph Development

  Downstream Services Inc, installed, maintained, and collected flow data from eight (8) monitoring stations within the study area. They submitted the collected raw data in an electronic/hard copy format to PBS&J. PBS&J then processed and reviewed this information and created a hydraulic database. The City provided a copy of City's General Plan for estimation of current and future flows. Other information such as as-built plans of wastewater facilities were provided by the City when requested by PBS&J.

- Model Development

  Model development included input data collection, conversion of data and calibration. The City's GIS staff made available data pertaining to roads, sewers, land use, buildings and other utilities in ArcView format on a CD. As-built plans for study sewer lines were reviewed. Data available from GIS system and as-built plans were placed in a database system (MS Excel) as a pre-processor for XP-SWMM model development.

Calibration of model was done after construction of the model and additional data input.

- Draft Report

  Based on the calibrated model and City's criteria for Sewer Facility Design, a Draft Report was prepared that summarized the existing and future capacity situations. Where deficiencies were identified, alternatives were developed for needed sewer improvements, along with probable costs. The draft report was prepared for submittal/review by the City.

- Final Report

  Draft Report review comments from the City were incorporated into the Final Report along with any additional information or research in order to reflect a final level of study completion. The Final Report will include data and information assembled, system deficiencies identified, alternatives evaluated, capital improvement recommendations to remediate anticipated deficiencies, prioritization of improvements, and approximate costs.

The comprehensive evaluation of the sewage collection system to accomplish the above-summarized scope entailed the following multi-step approach:

- Review of as built plans provided by the City to determine system configuration, inverts, pipe sizes and slopes
- Use of detailed database provided by the City in Arcview format
- Creation of computer hydraulic model using existing sewer system to study project area
- Identification of flow monitoring station locations
- Identification of tributary areas contributing sewage flow to meter locations or combinations
- Installation of flow meters and monitoring of flows at the selected locations on continuous basis for two-week period
- Review of current land use in study area per GIS information from the City and determination of existing land use, population and vacant land
- Assessment of ultimate land use and projected population
- Review and evaluation of metered data from flow monitoring stations
- Development of flow coefficients and representative diurnal flow patterns based on typical curves for various land uses and observed flows from monitored sub areas which are dominated by a specific land use

- Modeling of sewer system, deficiency identification, and model simulation of remedial alternatives using above-mentioned information as input data
- Evaluation of alternatives, optimization, cost comparison
- Prioritization of recommended improvements, including identification of critical pipelines which need immediate attention
- Draft Report and recommendations including phased improvements and costs
- Review of Draft Report by the City, comments and discussion
- Final Report

2.0 LAND USE

2.1 Existing Land Use

Land use is the basis for estimating sewage flow from the majority of the study area. The land use pattern for this study was developed from the GIS information provided by the City. Figure 3A shows land use within the study area based on the City's "Land Use" GIS layer. The vacant areas within various land use categories are shown in Figure 3B. For the purpose of this study, land uses in the study area have been broadly classified into four categories: Single Family Residential (SFR), Multi Family Residential (MFR), Commercial and Industrial. Table 2-1 summarizes the land use areas within the study area that would generate wastewater flow.

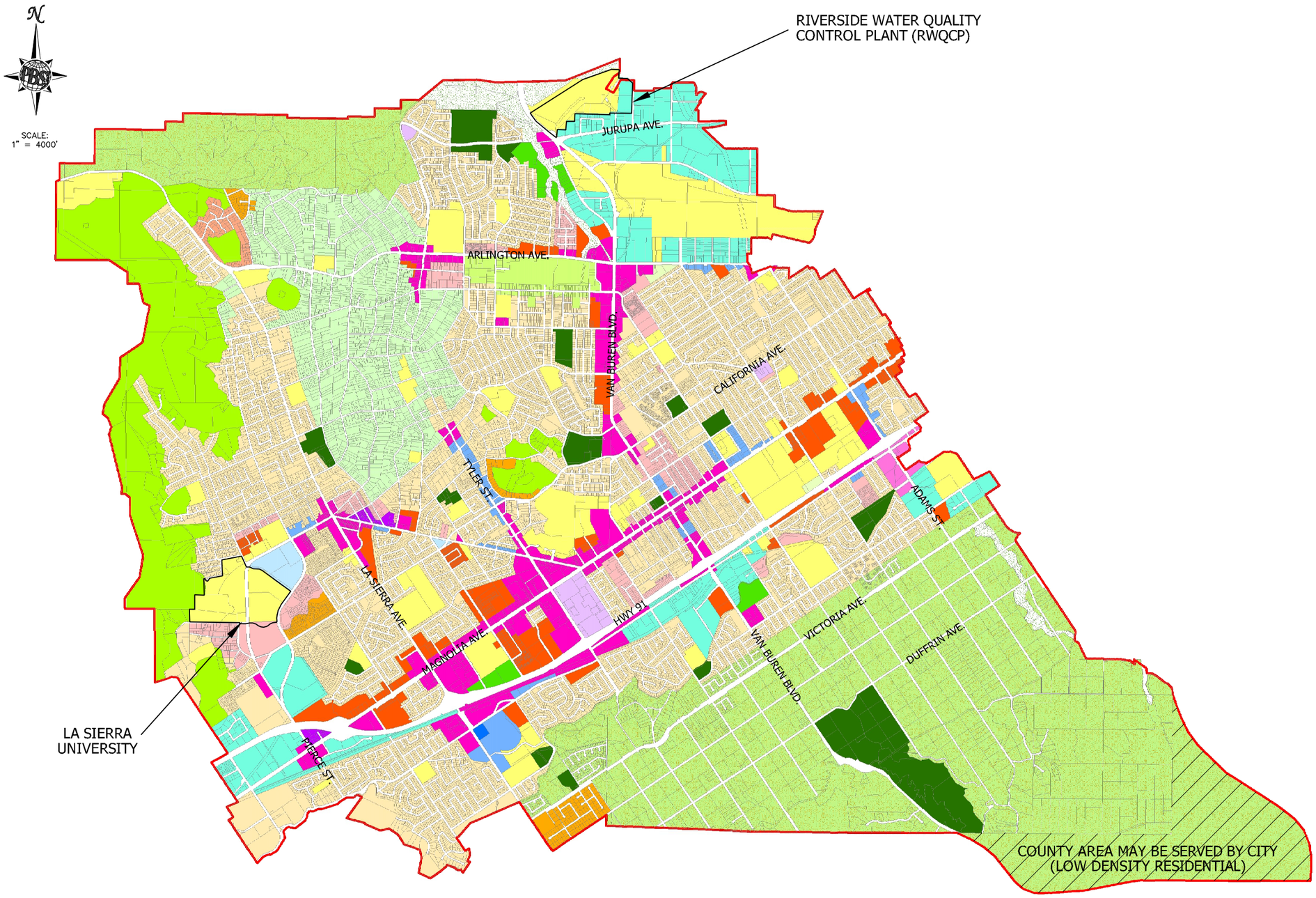
2.2 Proposed Land Use

The portion of study area northwest of Victoria Avenue is primarily a mature community. The portion of study area on southeast side of Victoria Avenue has vacant parcels that are designated as "residential - semi rural" and is expected to be developed in the future. This area is primarily designated to be developed as low density Single Family Residential (SFR). Another portion of the study area located at Riverside–Norco boundary may experience development in the future. It is assumed that the majority of vacant lots within the study area would be fully developed by year 2020.

Table 2-1
Land Use That Would Produce Wastewater Flow
(Acres)

Category	Existing (Year 2005)	Future (Year 2020)	Change
Single-Family Residential (SFR)	7,220	12,240	5,020 (70 %)
Multi-Family Residential (MFR)	880	960	80 (9 %)
Commercial / School	2,735	3,190	455 (17 %)
Industrial	190	215	25 (13 %)

The areas that are marked as open space or public facilities are not included in Table 2-1 because of zero sewage flow generation.



LEGEND

- Commercial – Business and Office
- Commercial – Center
- Commercial – Service
- Industrial – Business Park
- Industrial – General
- Industrial – Light
- Mixed Use – Office Emphasis
- Natural Open Space
- Office – Low Rise
- Office – Mid Rise
- Parks – Other Recreation
- Parks – Public
- Public Facilities and Open Space*
- Residential – Estate
- Residential – High Density
- Residential – Hillside
- Residential – Low Density
- Residential – Medium Density
- Residential – Medium–High Density
- Residential – Rural and Residential
- Residential – Semi–Rural
- County Area – May be Served by City**
- Sewer Basin Boundary

*Includes schools and other public use facilities
**Assumed to be Low Density Residential

DATE: 12/21/05	DWN BY: CD

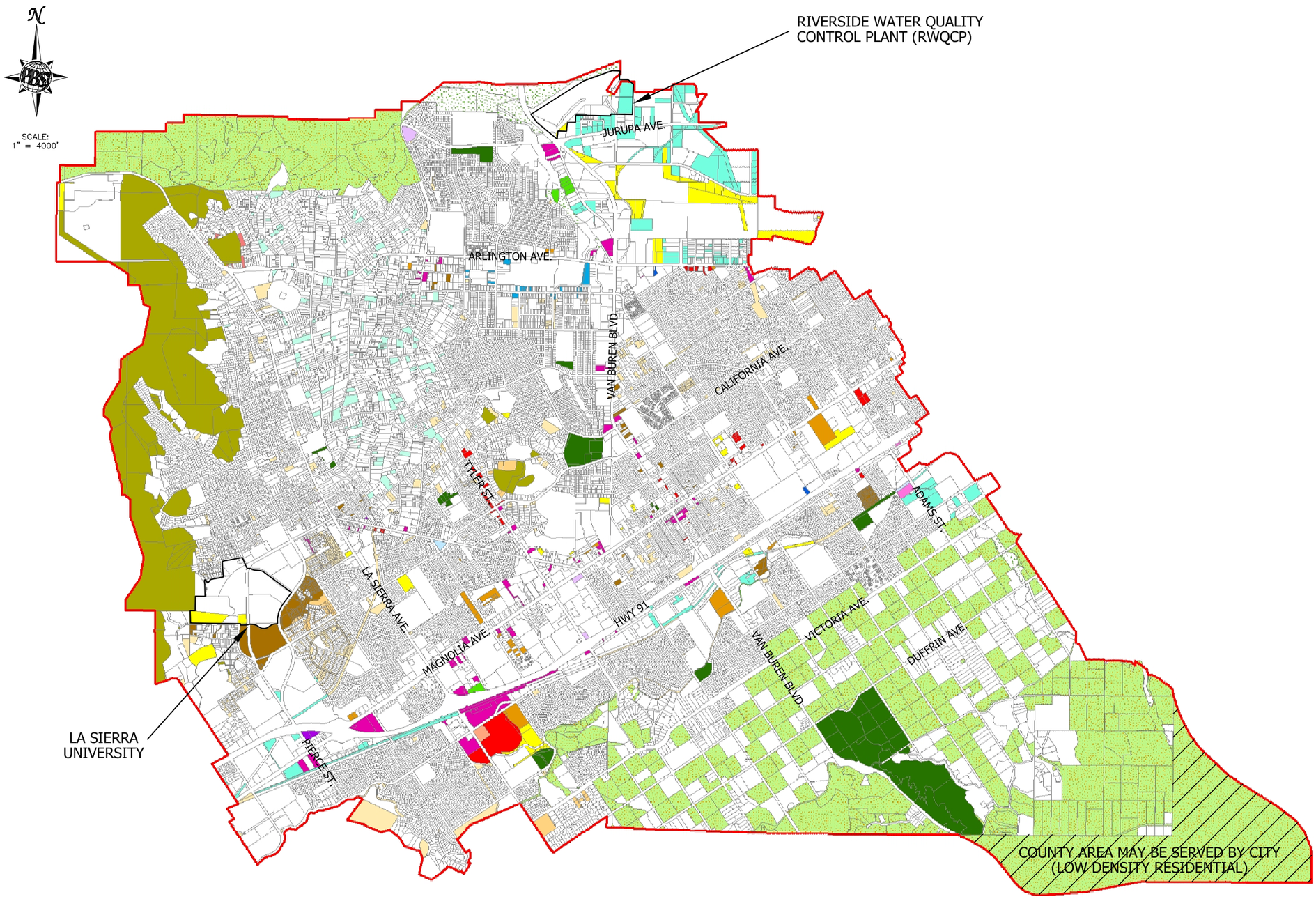
Engineering
Planning
Surveying
Construction Services
PBS&J
10370 Hemet Street
Suite 200
Riverside, CA 92503
Tel:(951) 358–1433
Fax:(951) 358–1434

CITY OF RIVERSIDE
ARLANZA SEWER STUDY

FIGURE 3A

ZONED LAND USE

Y:\City of Riverside\Arlanza\DWG\Exhibits\AZ-LandUse.dwg, 9/28/2006 9:53:48 AM



LEGEND

- Commercial – Automotive Park
- Commercial – Business and Office
- Commercial – Center
- Commercial – Service
- Industrial – Business Park
- Industrial – General
- Industrial – Light
- Mixed Use – Office Emphasis
- Natural Open Space
- Office – Low Rise
- Office – Mid Rise
- Parks – Other Recreation
- Parks – Public
- Public Facilities and Open Space*
- Residential – Estate
- Residential – High Density
- Residential – Hillside
- Residential – Low Density
- Residential – Medium Density
- Residential – Medium–High Density
- Residential – Rural and Residential
- Residential – Semi–Rural
- Occupied Parcels
- County Area – May be Served by City**
- Sewer Basin Boundary

*Includes schools and other public use facilities
**Assumed to be Low Density Residential

DATE: 12/21/05 | DWN BY: CD

Engineering
Planning
Surveying
Construction Services
PBS&J
10370 Hemet Street
Suite 200
Riverside, CA 92503
Tel:(951) 358–1433
Fax:(951) 358–1434

CITY OF RIVERSIDE
ARLANZA SEWER STUDY

FIGURE 3B

ZONED LAND USE (VACANT PARCELS)

3.0 EXISTING SEWER SYSTEM

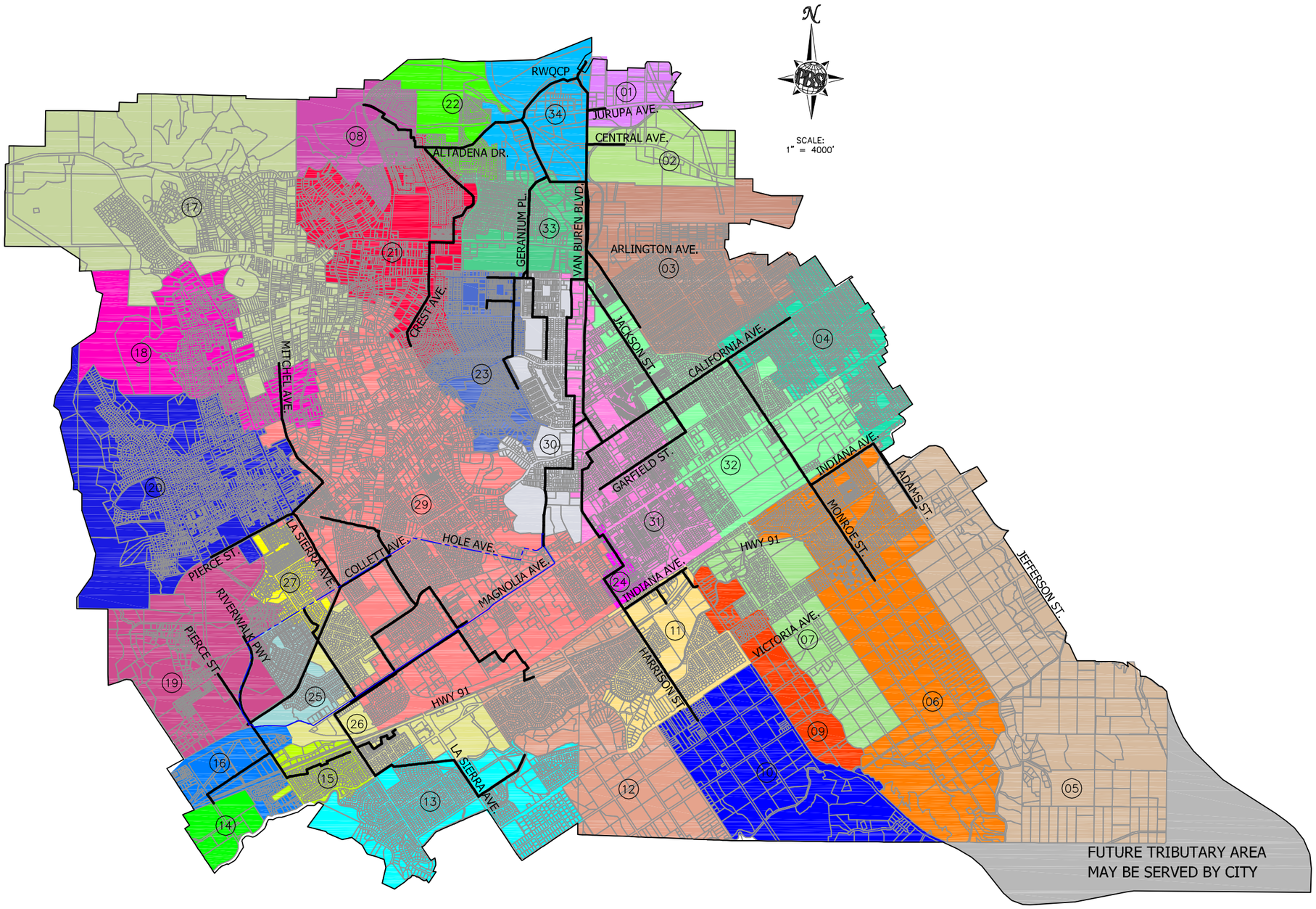
3.1 System Overview

As previously described, the Arlanza Trunk Sewer study area covers approximately 20,650 acres including the County of Riverside area that might be served by the City sewer system and have been divided into 34 tributary sub-areas (See Figure 4). The wastewater flow from a sub-area can be measured at a meter location or can be reasonably assessed based on land use plan of that sub-area. The location of meters can be seen on Figure 5. The modeled gravity conveyance system is approximately 202,000 linear feet (38 miles) of gravity sewer system, with pipe sizes varying from 8 inches to 51 inches in diameter (See Figures 6A and 6B). Most of the gravity sewer lines within the system are vitrified clay pipe (VCP). The sewer system also includes 29,400 linear feet (5.6 miles) of force main lines.

3.2 Collection System

The Arlanza Study Area can be divided into two distinct sub-areas. The western portion is served by a lift station at Pierce Street west of Hwy. 91 and the eastern portion is served by the gravity system. Generally, the wastewater flow generated from the area east of Tyler Street flows to the Lift Station in either southerly or easterly direction. The wastewater generated from the area west of Tyler Street generally flows in a northeasterly direction to the Regional Water Quality Control Plant (RWQCP).

The major trunk lines contributing to Pierce Street Lift Station are along La Sierra Avenue, Pierce Street, Hole Avenue, La Sierra Channel and Magnolia Avenue. The trunk lines contributing to the RWQCP are along Jurupa Avenue, California Avenue, Monroe Street, Jackson Street, Adams Street, Indiana Avenue and Van Buren Boulevard. The details of sewer system are explained in section 3.3 System Description. Pipe sizes, lengths, and number of manholes have been tabulated for major segments of the modeled trunk system (See Appendix “C”).



TRIBUTARY AREA LEGEND

- SUB AREA 01
- SUB AREA 02
- SUB AREA 03
- SUB AREA 04
- SUB AREA 05
- SUB AREA 06
- SUB AREA 07
- SUB AREA 08
- SUB AREA 09
- SUB AREA 10
- SUB AREA 11
- SUB AREA 12
- SUB AREA 13
- SUB AREA 14
- SUB AREA 15
- SUB AREA 16
- SUB AREA 17
- SUB AREA 18
- SUB AREA 19
- SUB AREA 20
- SUB AREA 21
- SUB AREA 22
- SUB AREA 23
- SUB AREA 24
- SUB AREA 25
- SUB AREA 26
- SUB AREA 27
- SUB AREA 29
- SUB AREA 30
- SUB AREA 31
- SUB AREA 32
- SUB AREA 34
- FUTURE TRIBUTARY AREA MAY BE SERVED BY CITY

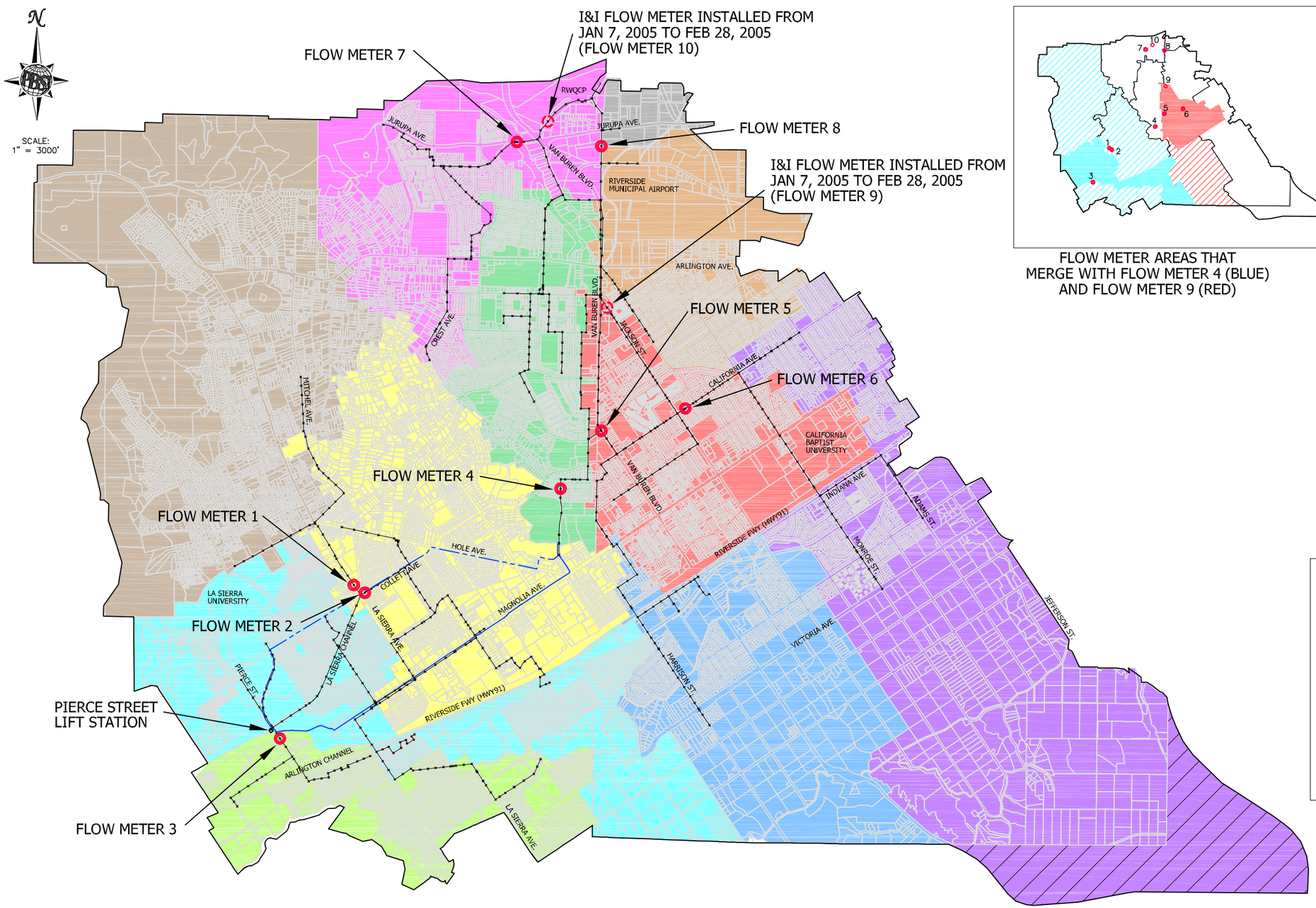
STUDY MAIN LEGEND

- GRAVITY MAIN
- MAGNOLIA FORCE MAIN
- LA SIERRA FORCE MAIN

Engineering
Planning
Surveying
Construction Services
PBS&J
10370 Hemet Street
Suite 200
Riverside, CA 92503
Tel:(951) 358-1433
Fax:(951) 358-1434

DATE: 12/21/05	DWN BY: CD
CITY OF RIVERSIDE ARLANZA SEWER STUDY	FIGURE 4
TRIBUTARY AREAS	

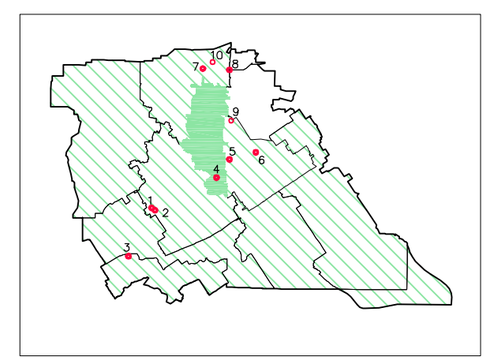
Y:\City of Riverside\Arlanza\DWG\Exhibits\AZ-TributaryAreas.dwg, 9/28/2006 10:33:42 AM



FLOW METER AREAS THAT
MERGE WITH FLOW METER 4 (BLUE)
AND FLOW METER 9 (RED)

LEGEND

- STUDY MAIN AND MANHOLES
- MAGNOLIA FORCE MAIN
- LA SIERRA FORCE MAIN
- SUB AREA 01
- FLOW METER 1
- FLOW METER 2
- FLOW METER 3
- FLOW METER 4
- FLOW METER 5
- FLOW METER 6
- FLOW METER 7
- FLOW METER 8
- FLOW METER 9
- FLOW METER 10
- COUNTY AREA MAY BE SERVED BY CITY (FLOWS TO METER 6)
- FLOW METER LOCATION
- INFLOW AND INFILTRATION STUDY FLOW METER LOCATION



FLOW METER AREAS THAT
MERGE WITH FLOW METER 10 AREA

DATE: 12/21/05	DWN BY: CD / ED
CITY OF RIVERSIDE ARLANZA SEWER STUDY	FIGURE 5
FLOW MONITORING LOCATIONS	

Engineering
Planning
Surveying
Construction Services
PBS&J
10370 Hemet Street
Suite 200
Riverside, CA 92503
Tel:(951) 358-1433
Fax:(951) 358-1434

Y:\City of Riverside\Arlanza\DWG\Exhibits\AZ-FlowMonitoring.dwg, 9/28/2006 9:49:32 AM

3.3 System Description

The existing trunk sewer system, which is the subject of this evaluation, is shown on Figures 6A and 6B. The sewer collection system was constructed over a period of time (possibly 50 plus years) to accommodate increasing sewage flow during the development within the City. As previously discussed in sections 1.2 and 3.2, the sewer system can be broadly divided into two distinct parts: the eastern part that consists of gravity sewers only and the western part that drains by gravity to a lift station at Pierce Street and then is pumped through force main sewer to the eastern gravity system. The GIS data and as-built plans provided by the City were studied to ascertain characteristics of the system. The existing sewer manholes and their numerical designations can be seen in Figures 7A, 7B and 7C. The existing pipelines and their numerical designations can be seen in Figures 8A, 8B and 8C. The pipelines in the system are prefixed with letter "P" (for pipe) and the manholes are prefixed with letter "M" (for manhole) to match with the Hydraulic Model. The description of sewer segments begins at the most upstream manhole and ends at the most downstream manhole. The sewer system is briefly described as follows:

- *Adams Street Sewer Line:* The trunk sewer line along Adams Street begins at manhole number M393 at the intersection of Adams Street and Lincoln Avenue with a 12-inch diameter line flowing northwest. At this location it picks up flow from residential developments on both sides of Adams Street. The size of the sewer line between manholes M393 and M390 is 12-inch. The size of sewer line between manhole M390 and M384 is 15-inch. The sewer line crosses Riverside Canal and Metrolink / BNSF Railroad near Auto Drive. At the manhole location M384 the sewer line joins the trunk sewer line along Indiana Avenue.

- *Indiana Avenue (1) Sewer Line*: The trunk sewer line in Indiana Avenue begins at manhole M384 located at Adams Street and Indiana Avenue intersection. The flow is in the southwesterly direction. The sewer line between manholes M384 and M349 is 15-inch. The sewer line collects wastewater flow from the commercial areas and office complexes located on both sides of Indiana Avenue. It joins the trunk sewer line along Monroe Street at M349.

- *Monroe Street Sewer Line*: The 12-inch trunk sewer line along Monroe Street begins at manhole M364 located at

the intersection of Monroe Street and Victoria Avenue. The flow is in the northwesterly direction. The sewer is 12-inch between manholes M364 and M344 and 15-inch between manholes M344 and M331. The sewer line crosses Riverside Canal near Lincoln Avenue and Metrolink Railroad near Don Derr Park. It also crosses Metropolitan Water District Aqueduct near Magnolia Avenue. It picks up wastewater flow from the residential development east of Hwy 91 and from California Baptist University on the western side of freeway. The sewer line joins California Avenue trunk sewer line at the manhole M331.

- *Garfield Street Sewer Line*: The trunk sewer line along Garfield Street begins at manhole M306 east of Van Buren Boulevard. A 12-inch sewer line collects wastewater flows from the residential development and flows in northeasterly direction to the trunk sewer line along Jackson Street. The sewer line between manholes M306 and M303 is 12-inch and, 14-inch between manholes M303 and M294. The sewer line joins the trunk line in Jackson Street at manhole M294 near Parkview Community Hospital Medical Center.

- *California Avenue (1) Sewer Lines:* The trunk sewer line along California Avenue (1) begins at manhole M375 located at the intersection of California Avenue and Adams Street. This trunk line picks up flow from Monroe Street sewer line at the manhole M331. The sewer line between manhole M375 and M331 is 15-inch and in the reach between manholes M331 and M290 is 21-inch. The sewer line crosses Metropolitan Water District Aqueduct between Adams Street and Monroe Street. The sewer line joins the trunk sewer line along Jackson Street at manhole M290.

- *California Avenue (2) Sewer Line:* The trunk sewer line along California Avenue (2) begins at manhole M127 located at the intersection of California Avenue and Van Buren Boulevard. At this location it picks up wastewater flow from Harrison Street sewer line. An 18-inch sewer line continues along California Avenue in the easterly direction up to manhole M290 located at the intersection of California Avenue and Jackson Street. This sewer line picks up part of flow from Harrison Street sewer line and residential development along this pipe segment.

- *Indiana Avenue (2) Sewer Line:* The trunk sewer line begins at manhole M431 located at the intersection of Indiana Avenue and Van Buren Boulevard. A 12-inch sewer line continues in the westerly direction to manhole M405. At this location it joins the trunk sewer line along

Harrison Street. The sewer line along Indiana Avenue (2) picks up wastewater flow generated from residential areas along Van Buren Boulevard and Meyers Street.

- *Harrison Street Sewer Line:* The sewer line along Harrison Street begins at manhole M422 located at Harrison Street south of Victoria Avenue. This sewer line consists of various pipe segments; sizes ranging from 12-inch to 24-inch. From manhole M422, a 12-inch sewer line continues in the northerly direction to manhole M410. At manhole M410, the pipe size changes to 15-inch to manhole M407. From there, a 12-inch line continues to manhole M405. The reach between manholes M405 and M137 is an 18-inch line. At this location the pipe size changes to 15-inch and continues to manhole M131. The size of pipeline between manhole M131 and M127 is 24-inch. The sewer line joins Van Buren Boulevard trunk sewer line at manhole M127. The sewer line crosses Riverside Canal near Victoria Avenue and Metrolink Railroad near Hwy. 91. This sewer line picks up wastewater flow from residential development between Victoria Avenue and Hwy. 91.

- *Jurupa Avenue Sewer Line:* The trunk sewer line in Jurupa Avenue comprises of a 12-inch sewer line beginning at node M253 at the intersection of Jurupa Avenue and Payton Avenue. This pipeline continues in a westerly direction and joins Acorn Street trunk sewer line at manhole M045. The sewer line collects wastewater flow generated from the commercial / light industrial development on north and south side of Jurupa Avenue.

- *Central Avenue Sewer Line:* This trunk sewer line comprises of a 12-inch sewer line that begins at manhole M257 at Central Avenue west of Wilderness Avenue. The pipeline joins Acorn Street trunk sewer line at manhole M047. The sewer line collects wastewater flow from the commercial area north of Riverside Municipal Airport.

- *Monticello Avenue Sewer Line:* The sewer line along Monticello Avenue begins at manhole M271 at the intersection of Monticello Avenue and Colorado Avenue. A 12-inch sewer line begins from this location and continues in a northwesterly direction and joins manhole M056 located at the intersection of Arlington Avenue and Van Buren Boulevard. The flow from this sewer line is discharged into the western trunk line along Van Buren Boulevard. This sewer line picks up wastewater flow from the residential area east of Monticello Avenue and commercial area south of Arlington Avenue.

- *Jackson Street Sewer Line:* The trunk sewer line along Jackson Street comprises of many sewer segments varying in size from 8-inch to 24-inch. The sewer begins at manhole M294 at the intersection of Jackson Street and Garfield Street. A 15-inch sewer line begins from this location and continues in northwesterly direction to manhole M290. Then a 24-inch line continues to manhole M059A. At this location it joins Van Buren trunk sewer line. A 20-inch sub-segment of sewer line runs parallel to the main sewer line between manholes M308 and M307. This sewer line picks up wastewater flow from California Avenue trunk sewer, the residential areas north of California Avenue and commercial areas at Van Buren Boulevard and Jackson Street intersection.

- *Van Buren Plaza Sewer Line:* This trunk sewer line, which runs parallel to Van Buren Boulevard trunk sewer line, begins at Megginson Lane north of Magnolia Avenue. It consists of many sewer segments varying in size from 24-inch to 36-inch. A 24-inch sewer begins at manhole M093 and continues in northerly direction to manhole M091. From manhole M091 to manhole M076 the size of sewer line is 33-inch. At this location the size changes to 36-inch up to manhole M059. This sewer picks up wastewater flow from 24-inch force main line at manhole M093. The sewer line joins Van Buren Boulevard trunk sewer at manhole M110 located at the intersection of Van Buren Boulevard and Cypress Avenue. Besides picking wastewater flow from force mains, this sewer line picks up flow from commercial areas west of Van Buren Boulevard.

- *Van Buren Boulevard Sewer Line:* This sewer line begins at manhole M127 at the intersection of Van Buren Boulevard and California Avenue. An 18-inch sewer line continues in northwesterly direction to manhole M124. Then a 24-inch line continues in northerly direction to manhole M110. The sewer line has two parallel segments between Cypress Avenue and Morris Street. The eastern line is 33-inch and the western line is 24-inch. From manhole M110, the 33-inch sewer line continues northwards to manhole M104. Then it turns westward to manhole M100. The sewer line between manhole M100 and M012 is 42-inch. The western portion of the sewer line (24-inch) begins at manhole M059A and continues northward to manhole M056. The sewer line between manhole M056 and M049 is 27-inch. The sewer line joins Riverside Water Quality Control Plant (RWQCP) trunk sewer line at manhole M012. This study sewer line picks up majority of flows generated from Arlanza study area. It picks up Harrison Street flow at manhole M127, Jackson Street flow at manhole M059A, Van Buren Plaza flow at

manhole M110 and Monticello Avenue flow at manhole M056.

- *Crest Avenue Sewer Line:* The trunk sewer line along Crest Avenue begins at manhole M250 at the intersection of Crest Avenue and Overton Avenue. A 12-inch sewer line begins from this location and continues in a northerly direction to manhole M247. Then a 15-inch line continues to manhole M246. The size changes to 12-inch between manholes M246 and M244, 15-inch between manholes M244 and M241B and 12-inch between manholes M241B and M241A. The sewer line between manhole M241A and M240 is 15-inch. From manhole M240, a 15-inch sewer line continues in northerly direction to manhole M237 where the size changes to 18-inch and continues to manhole M237. The sewer line between manhole M237 and M224 is 15-inch. From this location the sewer continues in a northwesterly direction. The sewer line between manhole M224 and manhole M027 is 27-inch. At manhole M027 the sewer line joins RWQCP trunk sewer line. This sewer line picks up wastewater flow generated from the residential and neighborhood commercial development between Van Buren Boulevard and Tyler Street south of Jurupa Avenue.

- *Trey Avenue Sewer Line:* The trunk sewer line along Trey Avenue begins at manhole M498 at Challen Avenue north of Philbin Avenue. At this location it picks up flow from residential developments south of Cypress Avenue. The sewer line between manholes M498 and M481 is 12-inch. At the manhole location M481 the sewer line joins the trunk sewer line along Picker Street.

- *Picker Street Sewer Line:* Picker Street trunk sewer line begins at manhole number M494 at the intersection of Challen Avenue and Orlando Drive. A 12-inch sewer line continues in a northerly direction to manhole M481. The sewer line is 15-inch from manhole M481 to manhole M476. The sewer line picks up flow from Trey Avenue sewer at manhole M481. It joins Cypress Avenue trunk sewer at manhole M476.

- *Cypress Avenue Sewer Line:* The trunk sewer line along Cypress Avenue begins at manhole M478 at the intersection of Cypress Avenue and Challen Avenue. A 12-inch sewer line continues in an easterly direction to manhole M476. The sewer line is 18-inch from manhole M476 to manhole M458. The sewer line picks up flow from Picker Street sewer at manhole M476. It joins Warren Street trunk sewer north of the siphon at manhole M476.

- *Warren Street Sewer Line:* The sewer line along Warren Street begins at manhole M472 at Crowin Lane north of Wells Avenue. A 12-inch sewer line begins from this location and continues in a northerly direction to manhole M464, where a 21-inch line continues to manhole M459. There is a 2-barrel siphon (size 12-inch) between manhole M459 and M458. The sewer line between manhole M458 and M453 is 21-inch. The size changes to 18-inch between manholes M453 and M100. The sewer line joins Van Buren trunk sewer line at manhole M100. A parallel 24-inch sewer continues from manhole M443 and joins Van Buren trunk sewer at M099. The sewer line picks up wastewater flow from Cypress Avenue sewer line at manhole M458. In addition, it picks up flow from residential areas between Picker Street and Van Buren Boulevard.

- *Acorn Street Sewer Line:* The trunk sewer line begins at manhole M049 north of Van Buren Boulevard and continues northward toward RWQCP sewer line. The sewer line between manhole M049 and M043 is 27-inch. From manhole M043 a 36-inch sewer line continues to manhole M002. This sewer line picks up wastewater flow from western trunk sewer line in Van Buren Boulevard. In addition, it picks up wastewater flow from the commercial development east of Van Buren Boulevard and north of Arlington Avenue.

- *RWQCP Sewer Line:* RWQCP trunk sewer line begins at manhole M042 at Jurupa Avenue west of Cobb Street. A 15-inch sewer line begins at this location and continues in an easterly direction to manhole M027. Then a 27-inch line continues to manhole M013. Beyond this manhole a 42-inch sewer line continues eastward to manhole M012. The size of sewer line between manhole M012 and M004 is 51-inch. This manhole is the entry point of to RWQCP.

- *Mitchell Avenue Sewer Line:* The study sewer line along Mitchell Avenue begins at manhole M749 at the intersection of Mitchell Avenue and Campbell Avenue. A 12-inch sewer line begins at this location and continues in a southerly direction to manhole M742. From there, a 15-inch line continues to manhole M738. The pipe segment between M738 and M737 is 8-inch. At manhole M737 the size changes to 12-inch and continues to manhole M735. The last segment of the pipeline is 15-inch. It joins Bushnell Avenue trunk sewer line at manhole M734. The sewer line picks up flow from the residential development in the northern portion of La Sierra Hills neighborhood.

- *Bushnell Avenue Sewer Line:* The trunk sewer line begins at manhole M734 located at the intersection of Bushnell Avenue and Mitchell Avenue and continues in a southwesterly direction. The sewer line between manhole M734 and M731 is 18-inch. At manhole M731 the size changes to 15-inch. The sewer line joins La Sierra Avenue (1) trunk sewer line at manhole M205. The sewer line crosses La Sierra Channel near Mitchell Avenue. This sewer line picks up wastewater flow from Mitchell Avenue sewer line and residential development along Bushnell Avenue.

- *Pierce Street (3) Sewer Line:* The trunk sewer line begins at manhole M214 located at Pierce Street east of Sierra Vista Avenue. A 15-inch sewer line continues from this location in an easterly direction to manhole M207. A 12-inch line continues to Manhole M205 at the intersection of Bushnell Avenue and La Sierra Avenue where it joins La Sierra Avenue (1) trunk sewer line. This sewer line picks up wastewater flow from residential development north of La Sierra University.

- *La Sierra Avenue (1) Sewer Line:* The trunk sewer line begins at manhole M205 located at La Sierra Avenue and Pierce Street intersection. A 21-inch sewer line continues from this location in a southeasterly direction to manhole M196. At this location, it joins the trunk sewer line along La Sierra Channel. The sewer line also crosses La Sierra Channel at this location. It picks up wastewater flow from Pierce Street sewer line and Bushnell Avenue sewer line at M205 in addition to flow from commercial development along La Sierra Avenue.

- *Hole Avenue Sewer Line:* Hole Avenue trunk sewer line is comprised of many sewer segments of varying sizes and begins at manhole M725 at the intersection of Hole Avenue and Doane Avenue. A 15-inch sewer line begins from this location and continues in a southeasterly direction to manhole M723. An 18-inch line continues to manhole M718. Beyond this manhole, a 12-inch sewer line continues southward to manhole M717. The sewer line joins Collett Avenue trunk sewer line at M188. The sewer line crosses La Sierra Channel north of Mitchell Avenue. This sewer line picks up wastewater flow from the residential development along Hole Avenue west of Collett Avenue. In addition, it picks up flow from commercial development near the Hole Avenue and California Avenue intersection.

- *Collett Avenue Sewer Line:* The trunk sewer line begins at manhole M188 located at the intersection of Collett Avenue and Jones Avenue. An 18-inch sewer line continues from this location in a southwesterly direction to manhole M196. This sewer line picks up wastewater flow from Hole Avenue and Jones Avenue sewer lines and also from residential and commercial development along Collett Avenue. It joins La Sierra Channel Trunk Sewer at manhole M196.

- *Arizona Avenue Sewer Line:* The trunk sewer line begins at manhole M622 located at the intersection of Arizona Avenue and Cross Street. An 18-inch sewer line continues from this location in a southwesterly direction to manhole M614. Then an 8-inch line continues to manhole M597. The size changes to 10-inch at this location and continues to manhole M594 where it joins Filmore Street trunk sewer. This sewer line picks up wastewater flow from residential development along La Sierra Avenue between Indiana Avenue and Victoria Avenue.

- *Polk Street (2) Sewer Line:* Polk Street (2) trunk sewer line begins at manhole M577 at the intersection of Indiana Avenue and Racine Drive and crisscrosses through many streets before joining Magnolia Avenue (1) sewer line at manhole M553. A 12-inch sewer line continues from manhole M577 in a southwesterly direction to manhole M573. From there, an 8-inch line continues to manhole M572. Beyond this manhole a 12-inch sewer line continues southwards to manhole M553. The sewer line joins Magnolia Avenue (1) trunk sewer line at M553. The sewer line crosses Metrolink Railroad and Hwy 91. It picks up wastewater flow from the residential development east of Hwy 91 and commercial developments between Hwy 91 and Magnolia Avenue.

- *Polk Street (1) Sewer Line:* The trunk sewer line begins at manhole M167B at the intersection of Magnolia Avenue and Polk Street. A 15-inch sewer line continues from this manhole in a northwesterly direction to manhole M177 and then continues southwesterly direction to manhole M180 at Jones Avenue. It picks up wastewater flow from commercial development along Polk Street west of Hwy 91.

- *Magnolia Avenue (1) Sewer Line:* Magnolia Avenue (1) trunk sewer line begins at manhole M553 at the intersection of Magnolia Avenue and Polk Street. An 8-inch sewer line continues from manhole M553 in

southwesterly direction to manhole M551. From there, a 21-inch line continues to manhole M548. Beyond this manhole a 24-inch sewer line continues to manhole M42. A parallel sewer line also continues from manhole M553 to M551. The sewer line joins La Sierra Avenue (2) trunk sewer line at M536. It picks up wastewater flow from Polk Street sewer line and commercial development between Hwy 91 and Magnolia Avenue.

- *Magnolia Avenue (2) Sewer Line:* The trunk sewer line has two parallel segments between La Sierra Avenue and Golden Avenue. A 12-inch segment begins at manhole M545 located at the intersection of Magnolia Avenue and Golden Avenue and continues in a northeasterly direction to manhole M538. At this location, the line changes to 15-inch and continues to manhole M536 located at the intersection of Magnolia Avenue and La Sierra Avenue. Another 24-inch segment of pipeline continues from manhole M536 in a southwesterly direction to manhole M582 located at the Magnolia Avenue and Golden Avenue intersection. Besides collecting flow from Polk Street (2) sewer, this sewer line picks up wastewater flow from the commercial development in the vicinity.

- *Magnolia Avenue (3) Sewer Line:* Magnolia Avenue (3) trunk sewer line begins at manhole M702 at Buchanan Avenue south of Magnolia Avenue. A 12-inch sewer line continues from manhole M702 in a westerly direction to manhole M701. Then an 8-inch line continues to manhole M700. Beyond this manhole a 15-inch sewer line continues to Pierce Street trunk sewer line at manhole M676. The sewer line crosses Arlington Channel and Metrolink Railroad east of Magnolia Avenue.

- *Queensborough Street Sewer Line:* The trunk sewer line begins at manhole M712 located at the intersection of Queensborough Street and Price Street. A 12-inch sewer line continues from manhole M712 in a southwesterly direction to manhole M591 at the intersection of Queensborough Street and Fillmore Street. It picks up wastewater flow from residential development south of La Sierra Avenue and east of Hwy.91.

- *Fillmore Street Sewer Line:* Fillmore Street trunk sewer line begins at manhole M594 at the intersection of Fillmore Street and Indiana Avenue. A 10-inch sewer line continues from manhole M594 in a northwesterly direction to manhole M587. Then, a 12-inch line continues to manhole M582. The sewer line joins Golden Avenue trunk sewer line at manhole M582. It crosses Arlington Channel,

Metrolink Railroad and Hwy 91 east of Magnolia Avenue. The sewer line picks up Arizona Avenue wastewater flow at M594, Queensborough Street flow at M591 and flow from residential development along Fillmore Street.

- *Riverwalk Parkway Sewer Line:* The trunk sewer line begins at manhole M668 located at the intersection of Riverwalk Parkway and Collett Avenue. A 12-inch sewer line continues from manhole M668 in a southeasterly direction to manhole M658 at the intersection of Riverwalk Parkway and Pierce Street. It picks up wastewater flow from La Sierra University (LSU) and residential development on eastern edge of LSU.

- *Pierce Street (1) Sewer Line:* Pierce Street (1) trunk sewer line begins at manhole M672 located at the intersection of Pierce Street and Collett Avenue. A 15-inch sewer line continues from this location in a southeasterly direction to manhole M671 where the size changes to 12-inch. The 12-inch line continues to manhole M657. The sewer line joins La Sierra Channel trunk sewer line at manhole M642. The sewer line picks up wastewater flow from Riverwalk Parkway sewer line and also from residential development west of Pierce Street.

- *Taylor Street Sewer Line:* The trunk sewer line begins at manhole M692 located at the intersection of Queensborough Street and Paines Street. A 15-inch sewer line continues from manhole M692 in a southwesterly direction to manhole M680 at the intersection of Taylor Street and Pierce Street. It picks up wastewater flow from residential development north of Pierce Street and west of Indiana Avenue.

- *Pierce Street (2) Sewer Line:* Pierce Street (2) trunk sewer line begins at manhole M680 located at the intersection of Pierce Street and Taylor Street. A 15-inch sewer line continues from this location in northwesterly direction to manhole M676, where the size changes to 21-inch. The 21-inch line continues to manhole M642 where it joins the La Sierra Channel trunk sewer line. The sewer line picks up wastewater flow from Magnolia Avenue (3) sewer at M676 and from Taylor Street sewer at M681.

- *Stonewall Drive Sewer Line:* The trunk sewer line begins at Collett Avenue north of Golden Avenue at manhole M656. A 12-inch sewer line continues from this location to manhole M651 where the size changes to 15-inch. The

sewer line joins La Sierra Channel trunk sewer line at manhole M650. It picks up wastewater flow from residential development west of La Sierra Channel and Collett Avenue.

- *Golden Avenue Sewer Line:* The sewer line begins at manhole M582 located at the intersection of Golden Avenue and Magnolia Avenue. A 12-inch sewer line continues from this location to manhole M631 where it joins La Sierra Channel trunk sewer line. It picks up wastewater flows from Fillmore Street and Magnolia Avenue (2) sewer lines. Also, it picks up wastewater flow from residential development along Golden Avenue between Magnolia Avenue and La Sierra Channel.

- *La Sierra Avenue (2) Sewer Line:* La Sierra Avenue (2) trunk sewer line begins at manhole M536 located at the intersection of La Sierra Avenue and Magnolia Avenue. It joins Cochran Avenue sewer line at manhole M531. The sewer line picks up wastewater flow from Magnolia Avenue (1) and Magnolia Avenue (2) sewer lines at manhole M536. Also, it picks up wastewater flow from commercial developments near La Sierra Avenue and Magnolia Avenue intersection.

- *Cochran Avenue Sewer Line:* The trunk sewer line begins at manhole M531 located at the intersection of Cochran Avenue and Jones Avenue. A 15-inch sewer line continues from this location to manhole M180 where it joins Jones Avenue trunk sewer line. It picks up wastewater flows from La Sierra Avenue (2) sewer line. Also, it picks up wastewater flow from residential development between La Sierra Avenue and Jones Avenue.

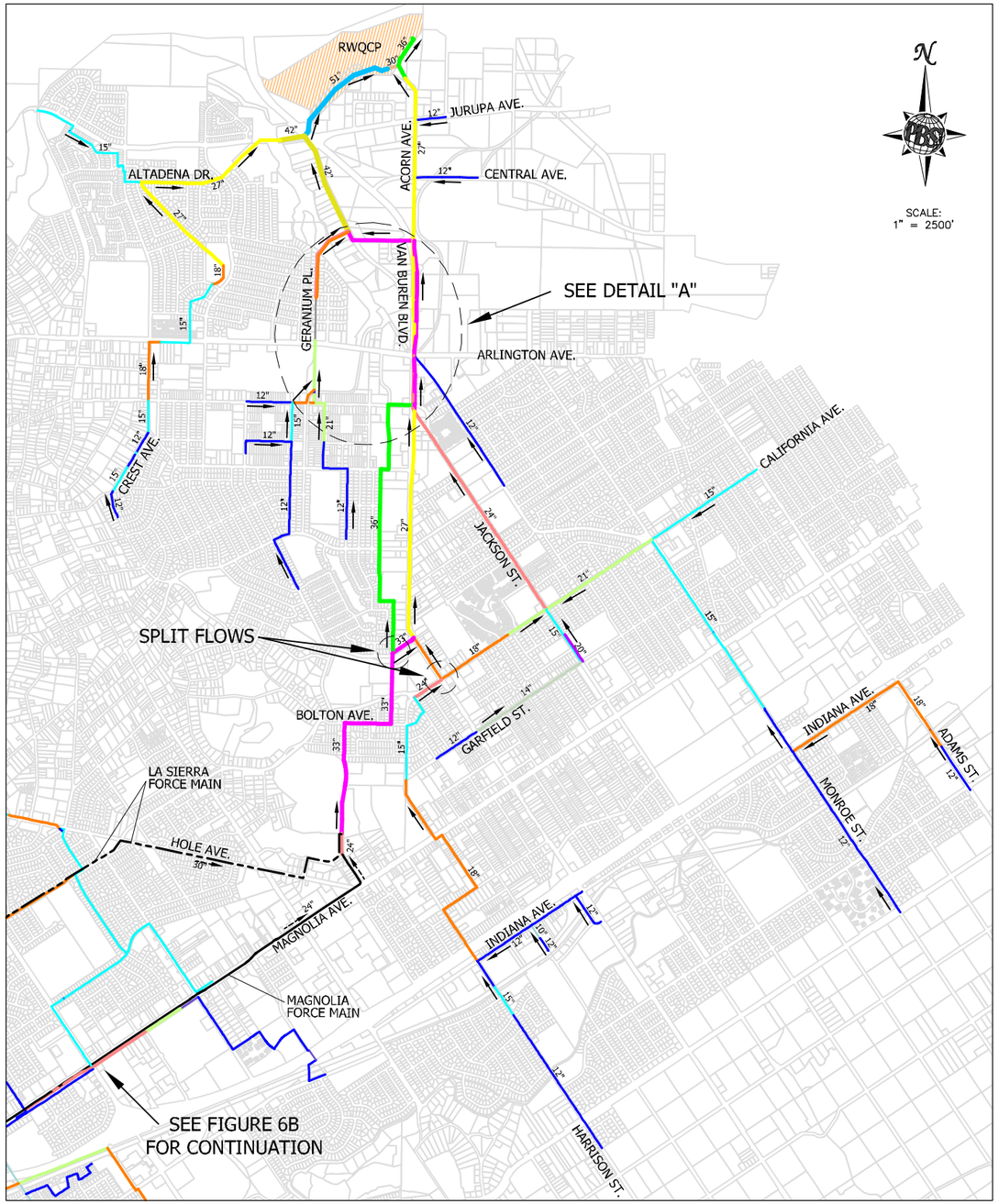
- *Jones Avenue Sewer Line:* The trunk sewer line begins at manhole M180 located at the intersection of Cochran Avenue and Jones Avenue. A 15-inch sewer line continues from this location to manhole M188, where it joins Collett Avenue trunk sewer line. It picks up wastewater flows from Polk Street (1) and Cochran Avenue sewer lines at manhole M180.

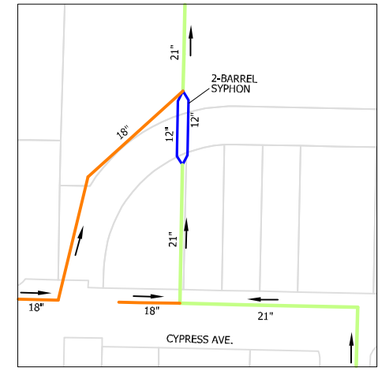
- *La Sierra Channel Sewer Line:* La Sierra Channel trunk sewer line picks up all wastewater flow from the western portion of the Arlanza Trunk Sewer Study Area that drains to Pierce Pump Station. The sewer line begins at manhole M196 located at the intersection of La Sierra Avenue and La Sierra Channel. A 27-inch sewer line continues from this location in a southeasterly direction to manhole M642.

From this location, a 30-inch sewer line continues to manhole M645, which is the location of the pump station.

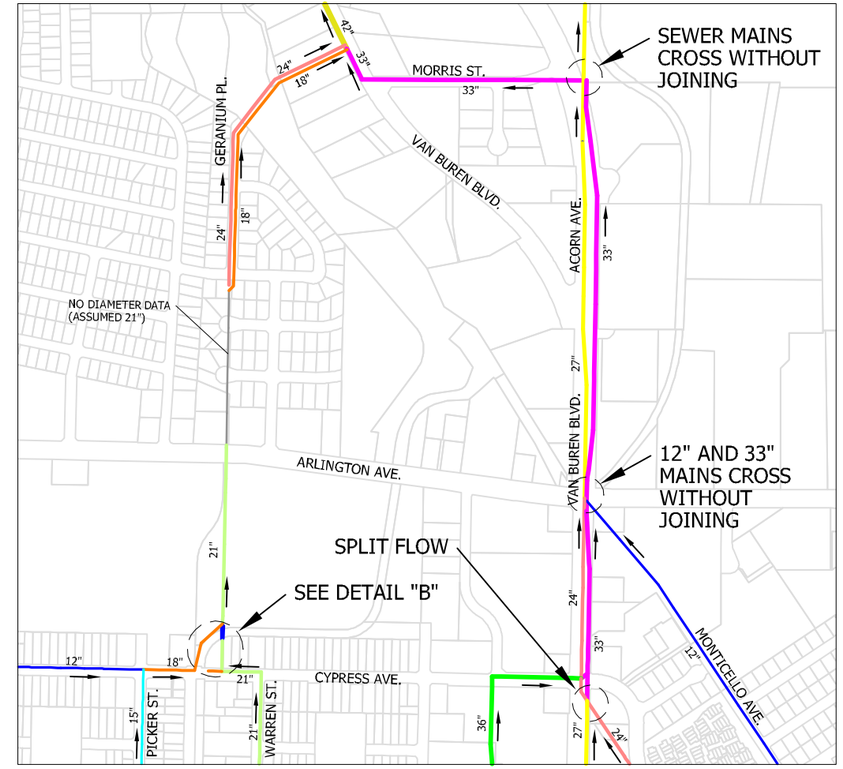
- *Magnolia Avenue Force Main:* Magnolia Avenue Force Main begins at Pierce Pump Station located near Pierce Street and Hwy.91. From this location, the line follows the alignment of Magnolia Avenue in northeasterly direction to manhole M093 where it joins the gravity sewer system at Megginson Lane north of Magnolia Avenue. It is a 24-inch Mortar Lined and Coated (ML&C) steel pipe in its entire reach.

- *La Sierra Area Force Main:* The force main begins at Pierce Pump Station located near Pierce Street and Hwy 91. From this location, the force main initially follows the alignment of Pierce Street in a northwesterly direction to Riverwalk Parkway and then along Riverwalk Parkway to Collett Avenue. From there, it follows Collett Avenue in a northeasterly direction to the intersection of Hole Avenue and Collett Avenue. It follows Hole Avenue to the intersection of Hole Avenue and Tyler Street. Thereafter, it continues through an easement to the gravity sewer line at manhole M092. The force main is a 30-inch ML&C steel pipeline.





DETAIL "B"
NTS



DETAIL "A"
NTS

LEGEND

- 8" DIAMETER PIPE
- 10" DIAMETER PIPE
- 12" DIAMETER PIPE
- 14" DIAMETER PIPE
- 15" DIAMETER PIPE
- 18" DIAMETER PIPE
- 20" DIAMETER PIPE
- 21" DIAMETER PIPE
- 24" DIAMETER PIPE
- 27" DIAMETER PIPE
- 30" DIAMETER PIPE
- 33" DIAMETER PIPE
- 36" DIAMETER PIPE
- 42" DIAMETER PIPE
- 51" DIAMETER PIPE
- NO DIAMETER DATA (ASSUMED 21")
- 24" MAGNOLIA FORCE MAIN
- 30" LA SIERRA FORCE MAIN
- GRAVITY MAIN FLOW DIRECTION
- FORCE MAIN FLOW DIRECTION

Engineering
Planning
Surveying
Construction Services
PBS&J
10370 Hemet Street
Suite 200
Riverside, CA 92503
Tel:(951) 358-1433
Fax:(951) 358-1434

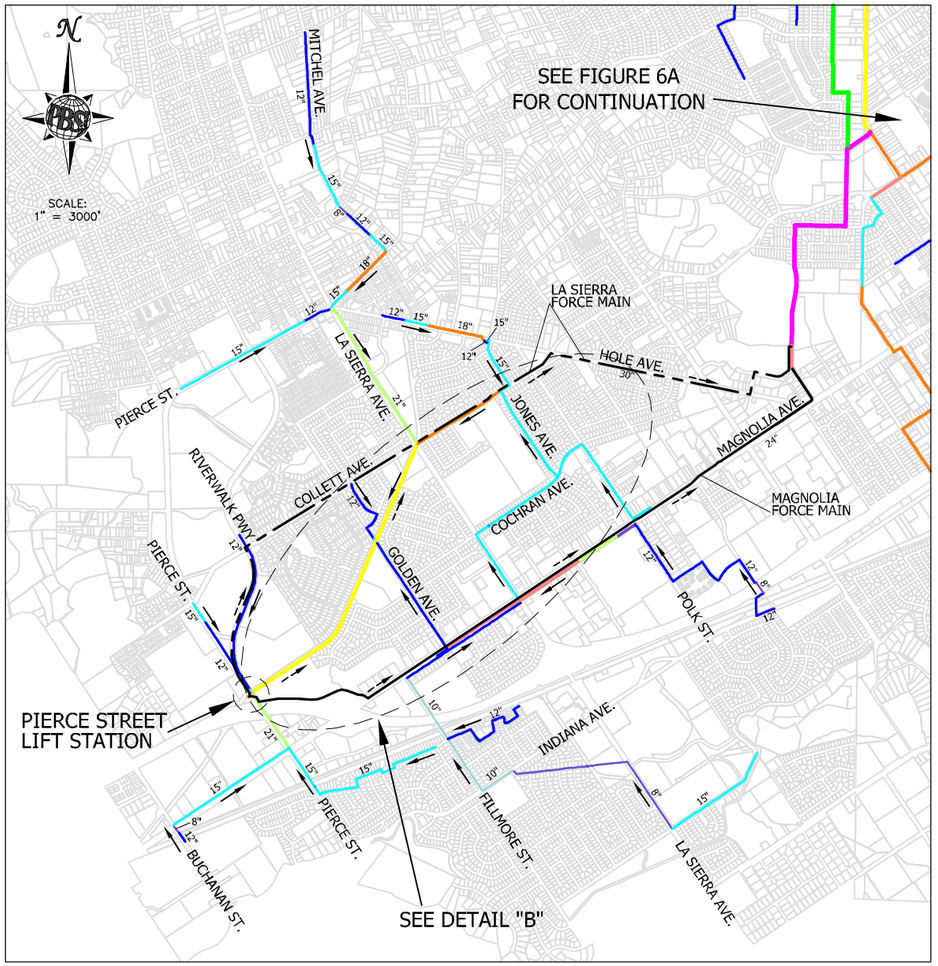
DATE: 12/21/05 | DWN BY: CD

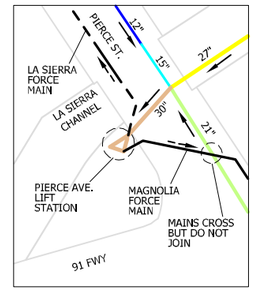
CITY OF RIVERSIDE
ARLANZA SEWER STUDY

FIGURE 6A

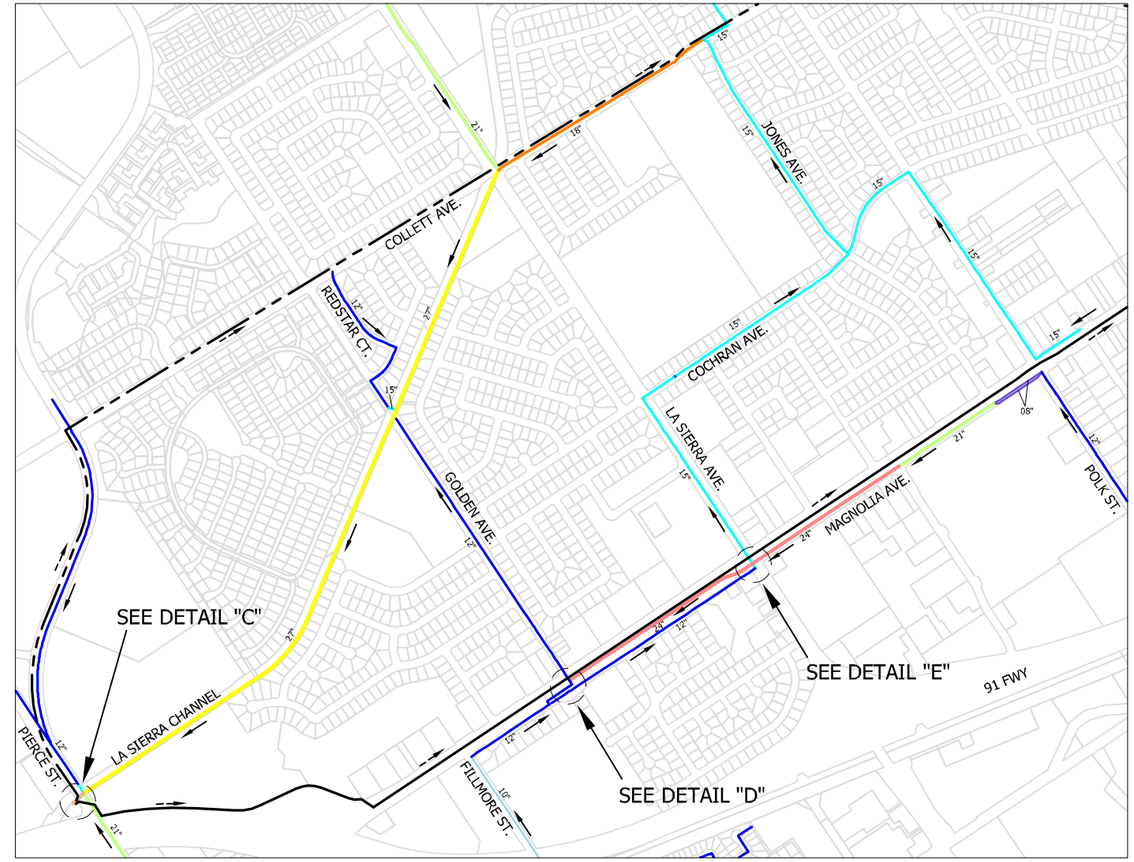
SYSTEM PIPE DIAMETERS - PART 1

Y:\City of Riverside\Arlanza\DWG\Exhibits\AZ-SewerSysAndDia.dwg, 9/28/2006 10:30:10 AM

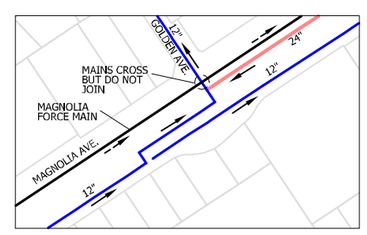




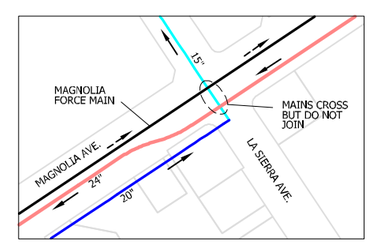
DETAIL "C"
NTS



DETAIL "B"
NTS



DETAIL "D"
NTS



DETAIL "E"
NTS

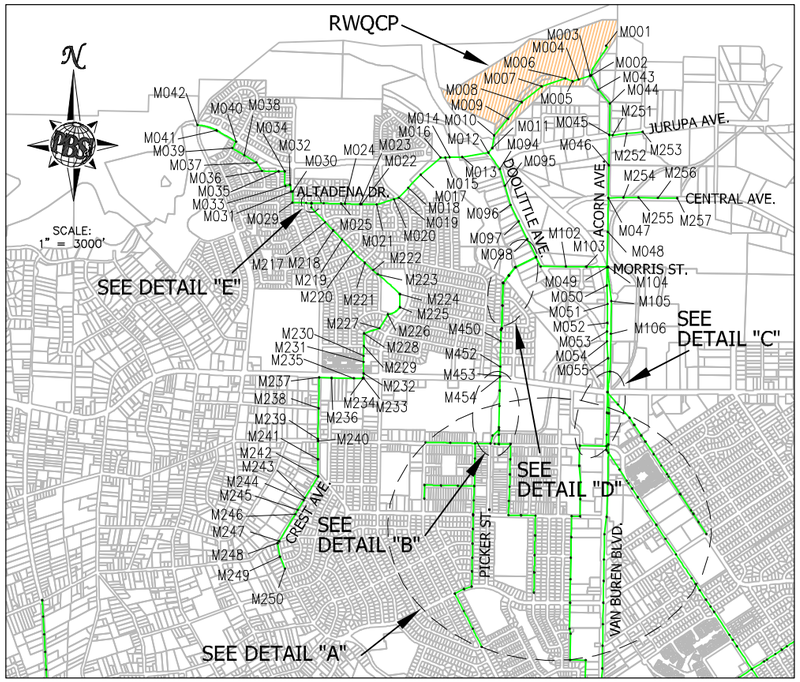
LEGEND

- 8" DIAMETER PIPE
- 10" DIAMETER PIPE
- 12" DIAMETER PIPE
- 14" DIAMETER PIPE
- 15" DIAMETER PIPE
- 18" DIAMETER PIPE
- 20" DIAMETER PIPE
- 21" DIAMETER PIPE
- 24" DIAMETER PIPE
- 27" DIAMETER PIPE
- 30" DIAMETER PIPE
- 33" DIAMETER PIPE
- 36" DIAMETER PIPE
- 42" DIAMETER PIPE
- 51" DIAMETER PIPE
- 24" MAGNOLIA FORCE MAIN
- 30" LA SIERRA FORCE MAIN
- FORCE MAIN FLOW DIRECTION
- GRAVITY MAIN FLOW DIRECTION

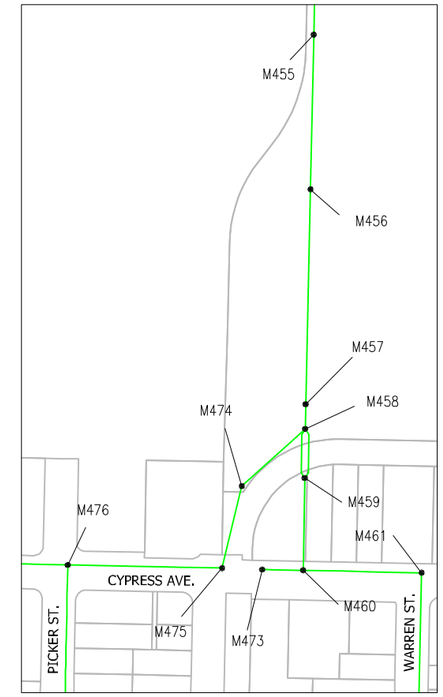
Engineering
Planning
Surveying
Construction Services
PBS&J
10370 Hemet Street
Suite 200
Riverside, CA 92503
Tel:(951) 358-1433
Fax:(951) 358-1434

DATE: 12/21/05	DWN BY: CD
CITY OF RIVERSIDE ARLANZA SEWER STUDY	FIGURE 6B
SYSTEM PIPE DIAMETERS - PART 2	

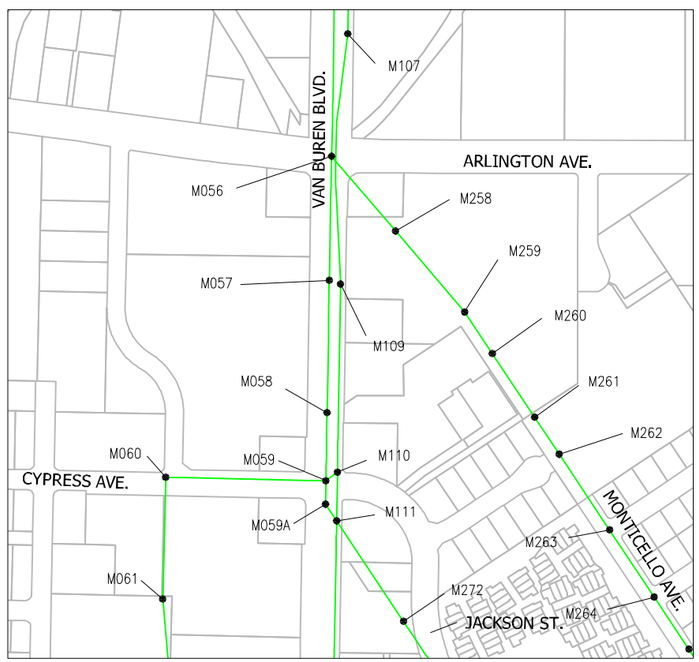
Y:\City of Riverside\Arlanza\DWG\Exhibits\AZ-SewerSysAndDia2.dwg, 9/28/2006 10:31:46 AM



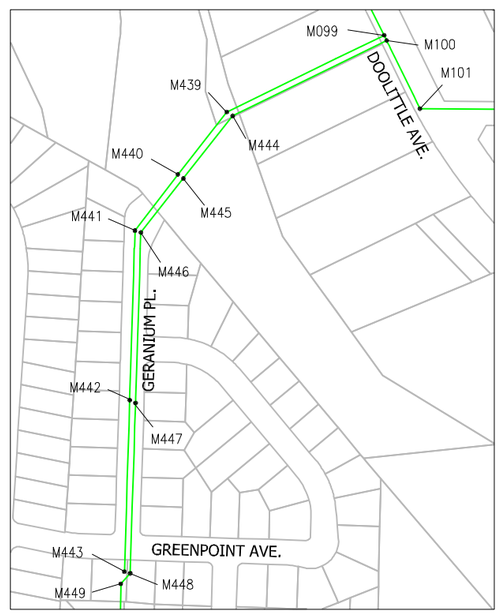
DETAIL "A"
NTS



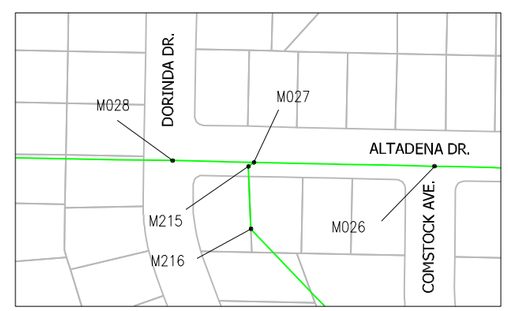
DETAIL "B"
NTS



DETAIL "C"
NTS



DETAIL "D"
NTS



DETAIL "E"
NTS

LEGEND

GRAVITY SEWER

M001 MANHOLE NUMBER

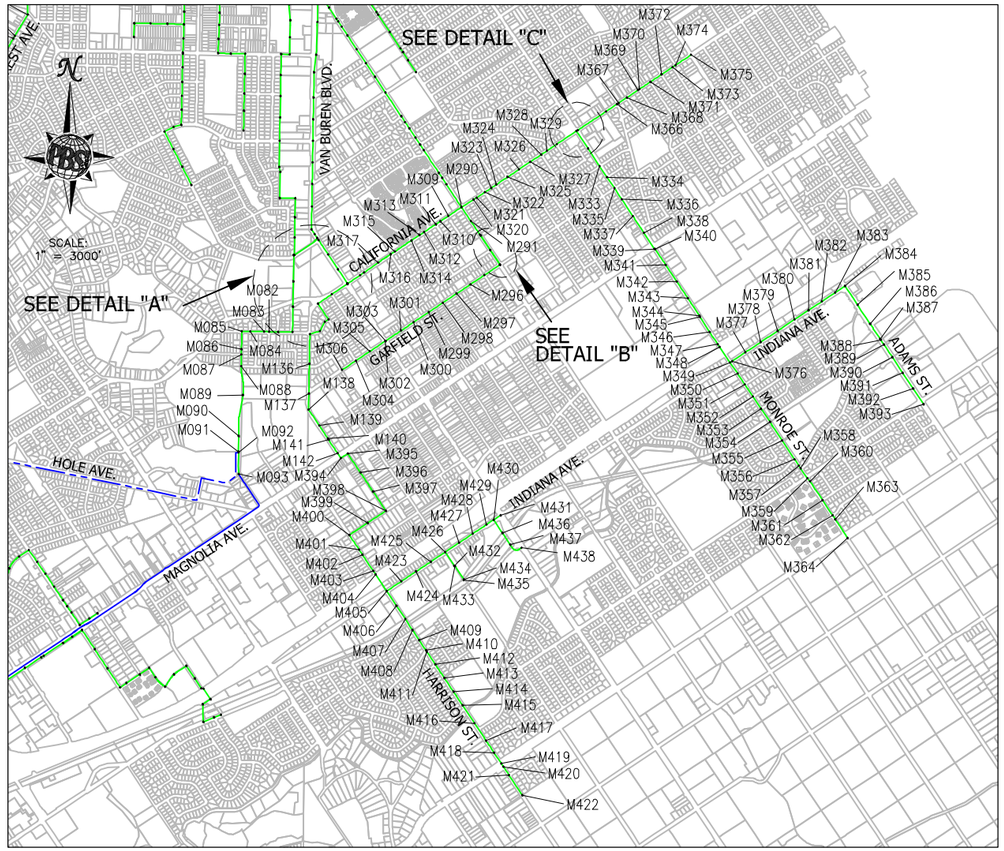
SEE FIGURES 7B AND 7C FOR CONTINUATION OF SEWER BASIN SYSTEM

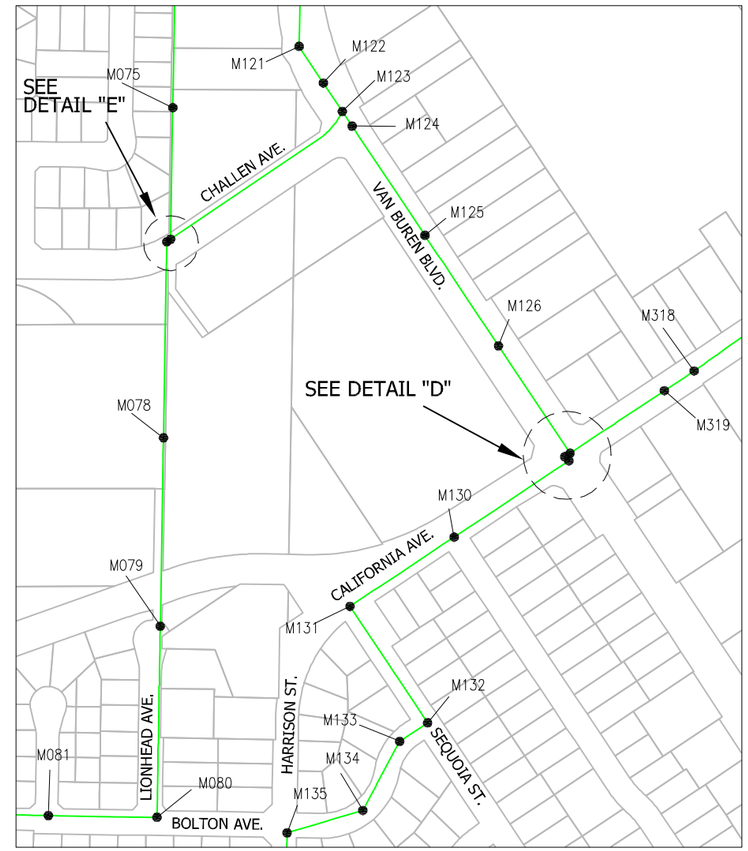
Engineering
Planning
Surveying
Construction Services
PBS&J
10370 Hemet Street
Suite 200
Riverside, CA 92503
Tel:(951) 358-1433
Fax:(951) 358-1434

DATE: 12/21/05	DWN BY: CD
CITY OF RIVERSIDE ARLANZA SEWER STUDY	FIGURE 7A

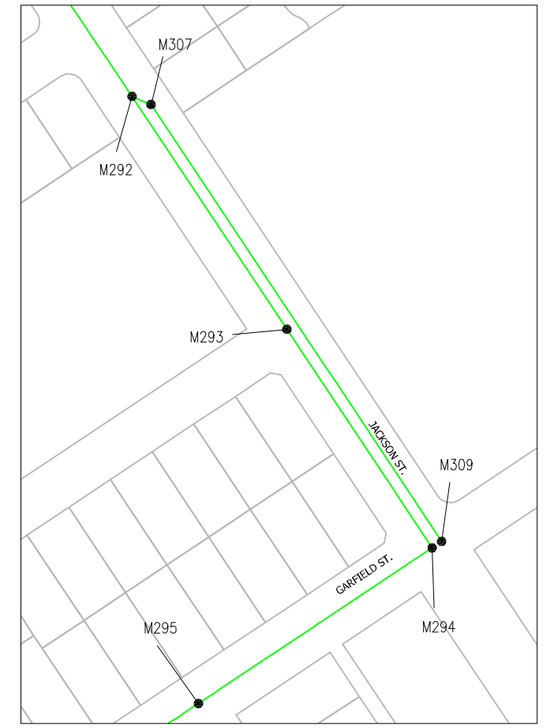
EXISTING MANHOLES - PART 1

Y:\City of Riverside\Arlanza\DWG\Exhibits\AZ-ManholestIDs.dwg, 9/28/2006 9:54:48 AM



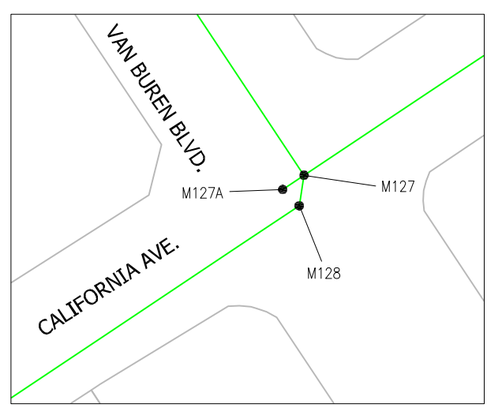


DETAIL "A"
NTS

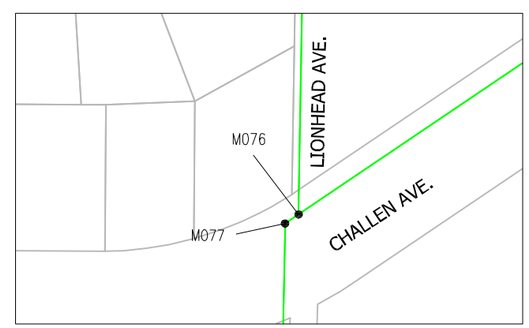


DETAIL "B"
NTS

DETAIL "C"
NTS



DETAIL "D"
NTS



DETAIL "E"
NTS

LEGEND

———	MAGNOLIA FORCE MAIN
— - - —	LA SIERRA FORCE MAIN
———	GRAVITY SEWER
M001	MANHOLE NUMBER

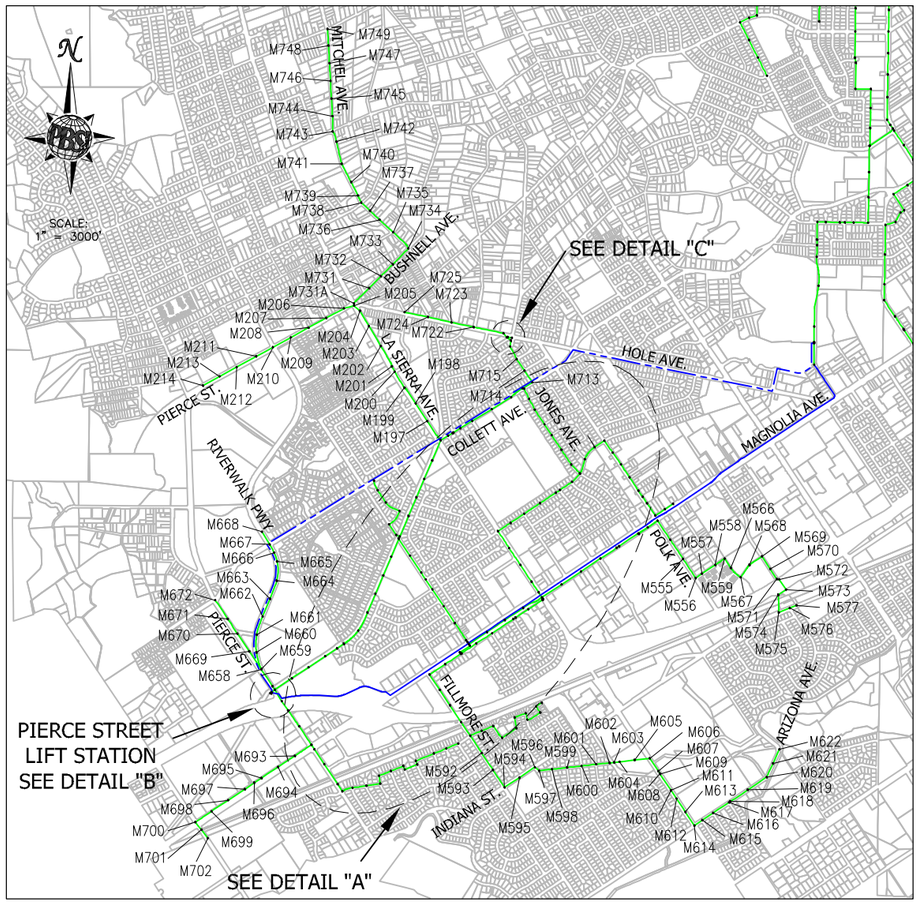
SEE FIGURES 7A AND 7C FOR CONTINUATION OF SEWER BASIN SYSTEM

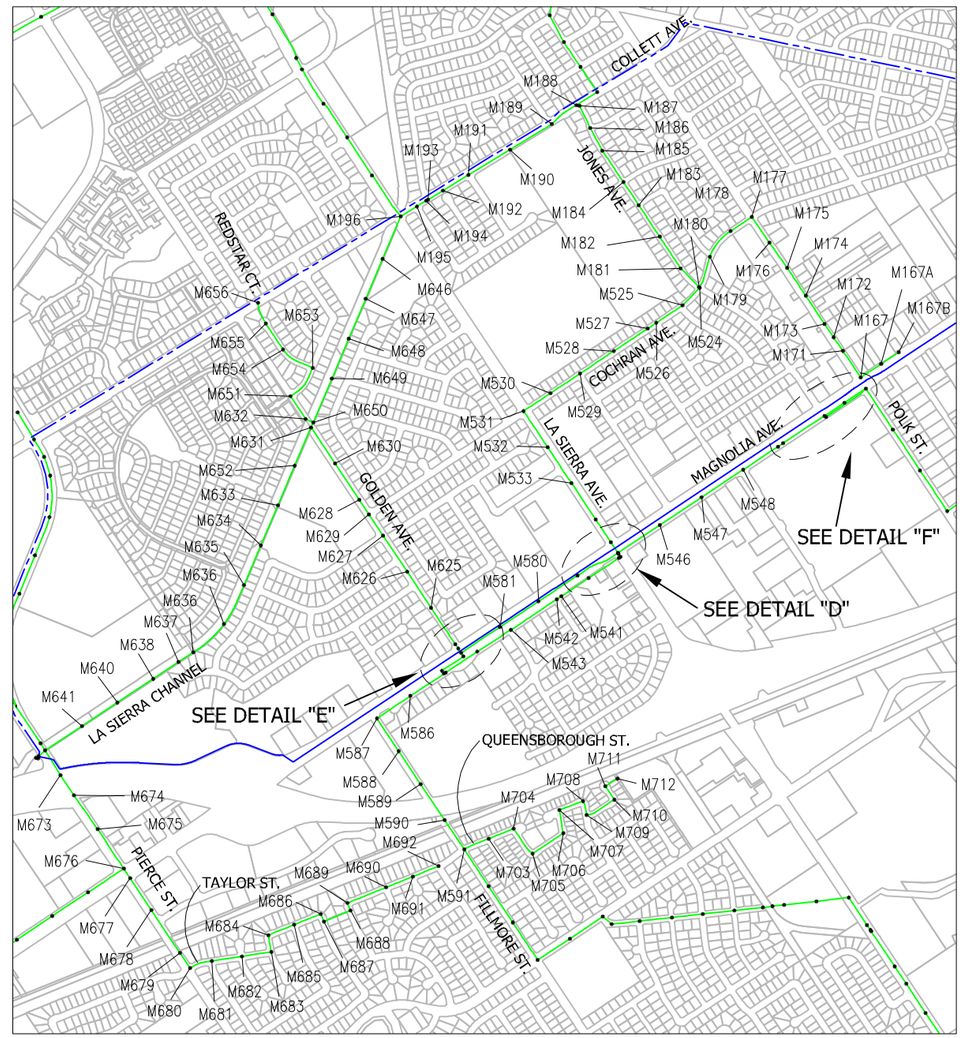
Engineering
Planning
Surveying
Construction Services
PBS&J
10370 Hemet Street
Suite 200
Riverside, CA 92503
Tel:(951) 358-1433
Fax:(951) 358-1434

DATE: 12/21/05	DWN BY: CD
CITY OF RIVERSIDE ARLANZA SEWER STUDY	FIGURE 7B

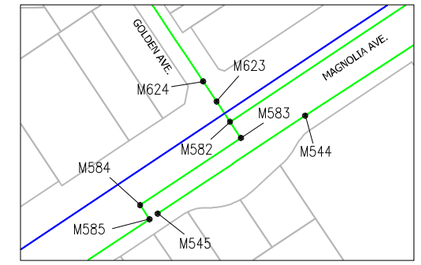
EXISTING MANHOLES - PART 2

Y:\City of Riverside\Arlanza\DWG\Exhibits\AZ-ManholesIDsB.dwg, 9/28/2006 9:58:33 AM

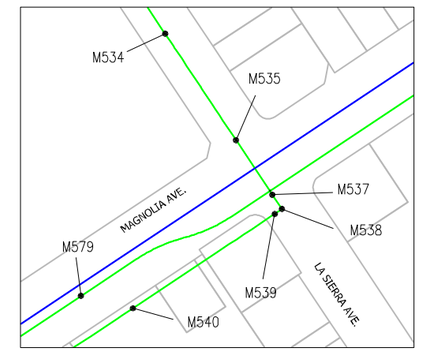




DETAIL "A"
NTS

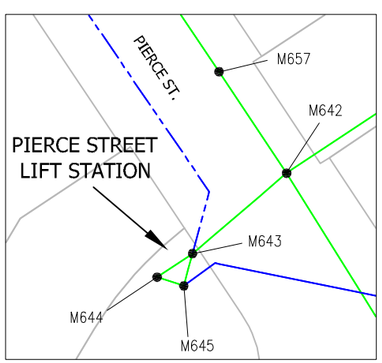


DETAIL "E"
NTS

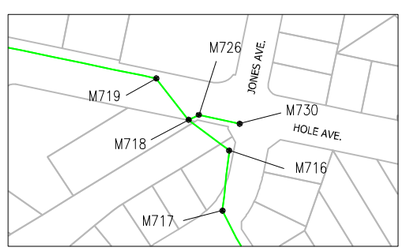


DETAIL "D"
NTS

DETAIL "F"
NTS



DETAIL "B"
NTS



DETAIL "C"
NTS

LEGEND

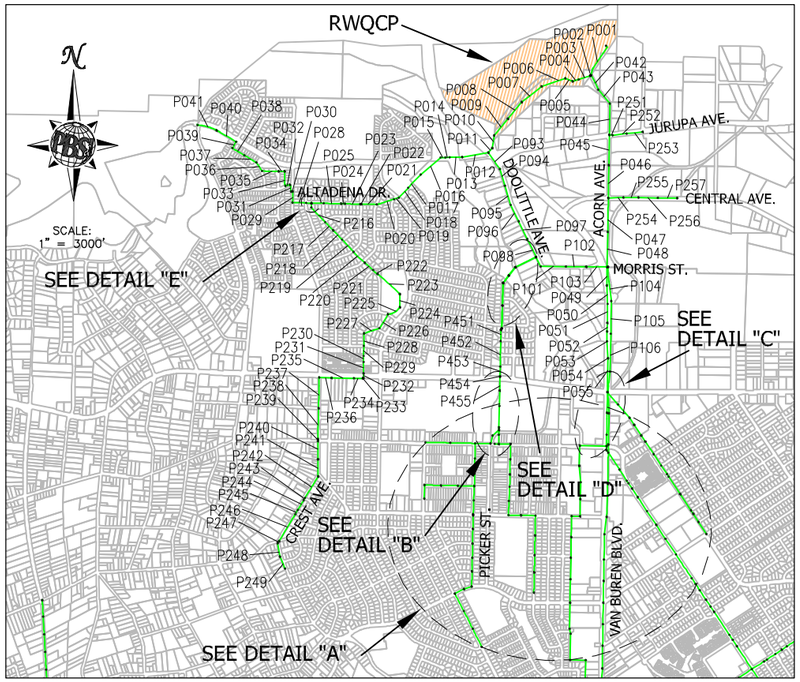
———	MAGNOLIA FORCE MAIN
— - — -	LA SIERRA FORCE MAIN
———	GRAVITY SEWER
M001	MANHOLE NUMBER

SEE FIGURES 7A AND 7B FOR CONTINUATION OF SEWER BASIN SYSTEM

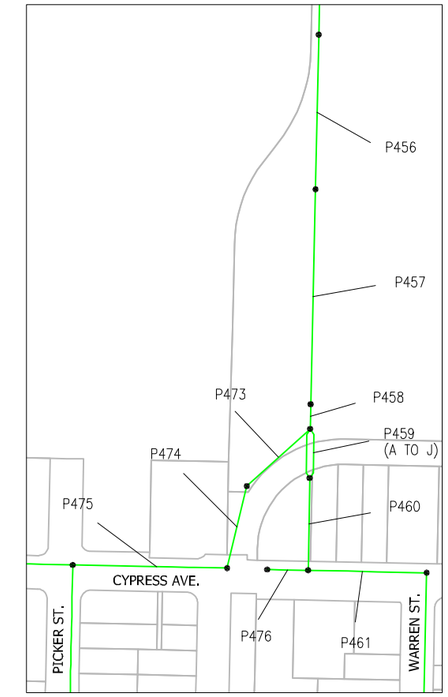
Engineering
Planning
Surveying
Construction Services
PBS&J
10370 Hemet Street
Suite 200
Riverside, CA 92503
Tel:(951) 358-1433
Fax:(951) 358-1434

DATE: 12/21/05	DWN BY: CD
CITY OF RIVERSIDE ARLANZA SEWER STUDY	FIGURE 7C
EXISTING MANHOLES - PART 3	

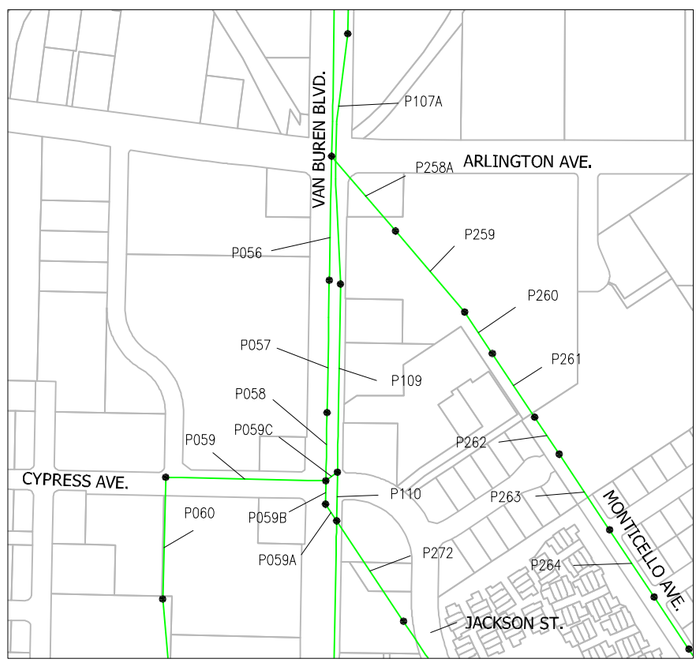
Y:\City of Riverside\Arlanza\DWG\Exhibits\AZ-Manholes\DsC.dwg, 9/28/2006 9:59:39 AM



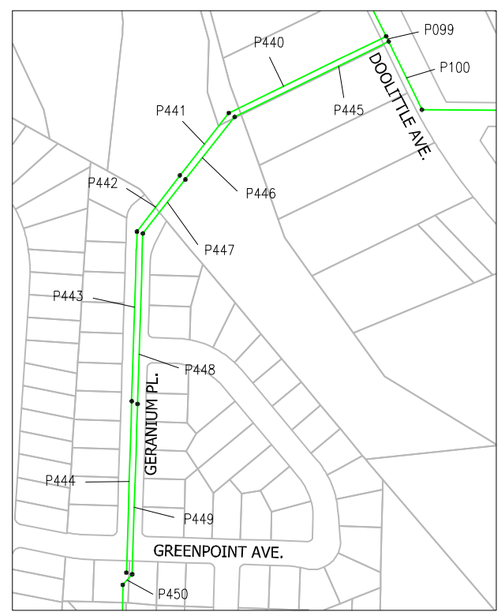
DETAIL "A"
NTS



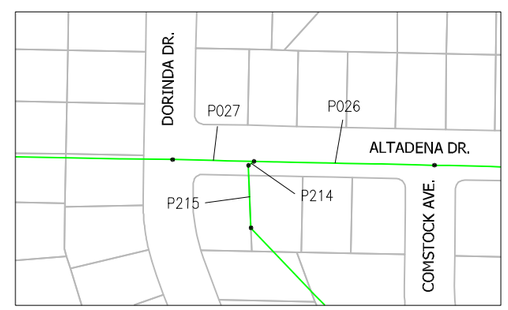
DETAIL "B"
NTS



DETAIL "C"
NTS



DETAIL "D"
NTS



DETAIL "E"
NTS

LEGEND

GRAVITY SEWER

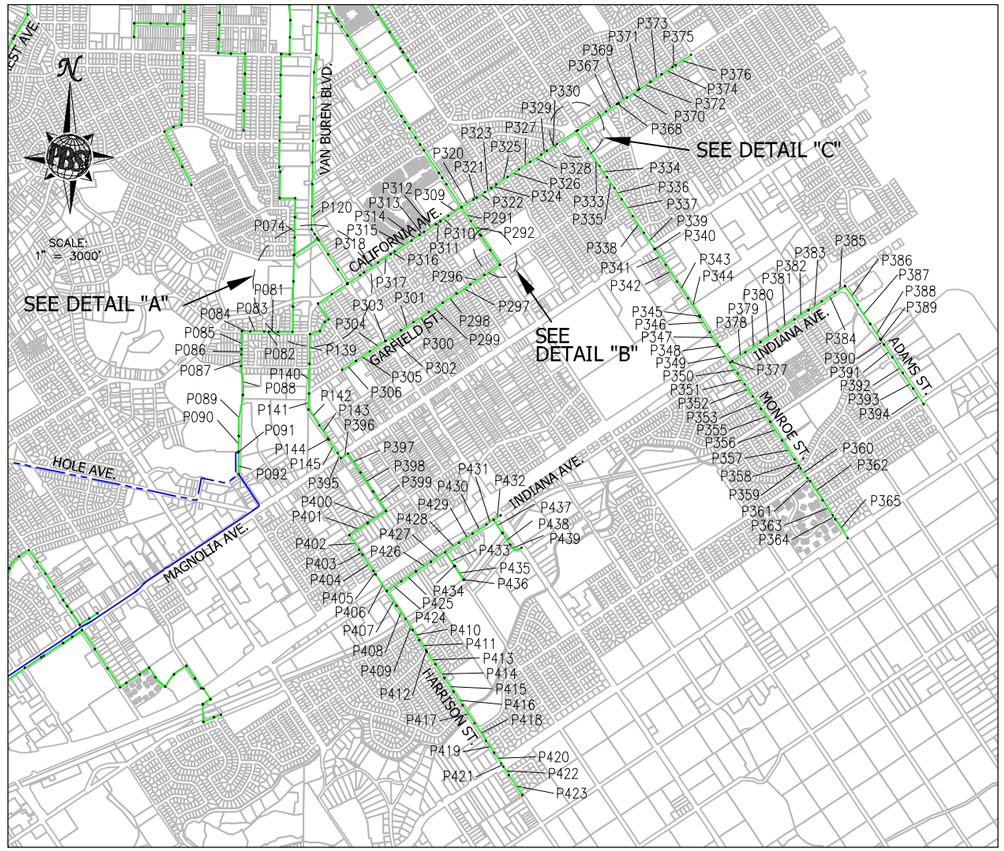
P001 PIPE SEGMENT NUMBER

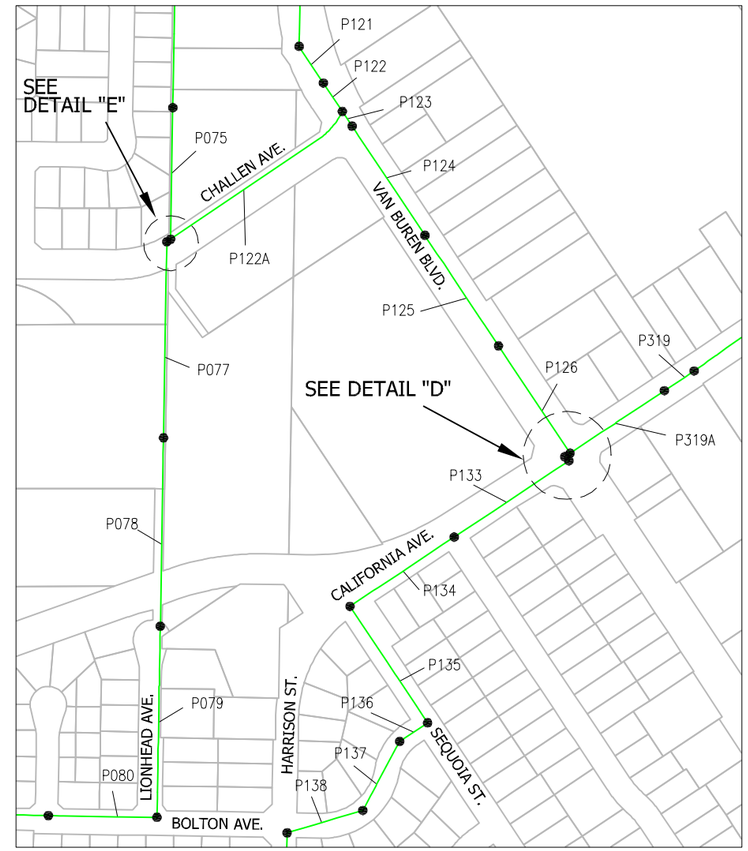
SEE FIGURES 8B AND 8C FOR CONTINUATION OF SEWER BASIN SYSTEM

Engineering
Planning
Surveying
Construction Services
PBS&J
10370 Hemet Street
Suite 200
Riverside, CA 92503
Tel:(951) 358-1433
Fax:(951) 358-1434

DATE: 12/21/05	DWN BY: CD
CITY OF RIVERSIDE ARLANZA SEWER STUDY	FIGURE 8A
EXISTING PIPES - PART 1	

Y:\City of Riverside\Arlanza\DWG\Exhibits\AZ-PipeIDs.dwg, 9/28/2006 10:01:41 AM

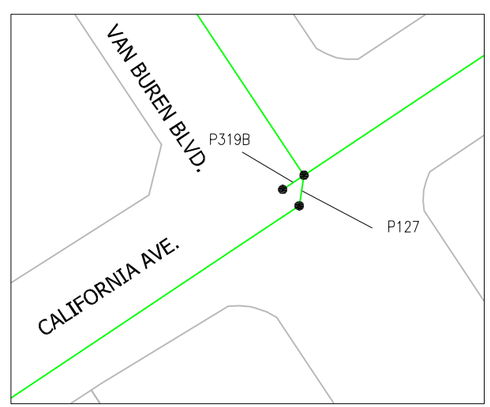




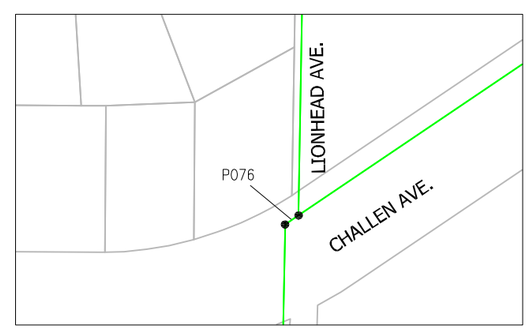
DETAIL "A"
NTS

DETAIL "B"
NTS

DETAIL "C"
NTS



DETAIL "D"
NTS



DETAIL "E"
NTS

LEGEND

———	MAGNOLIA FORCE MAIN
— - —	LA SIERRA FORCE MAIN
———	GRAVITY SEWER
P001	PIPE SEGMENT NUMBER

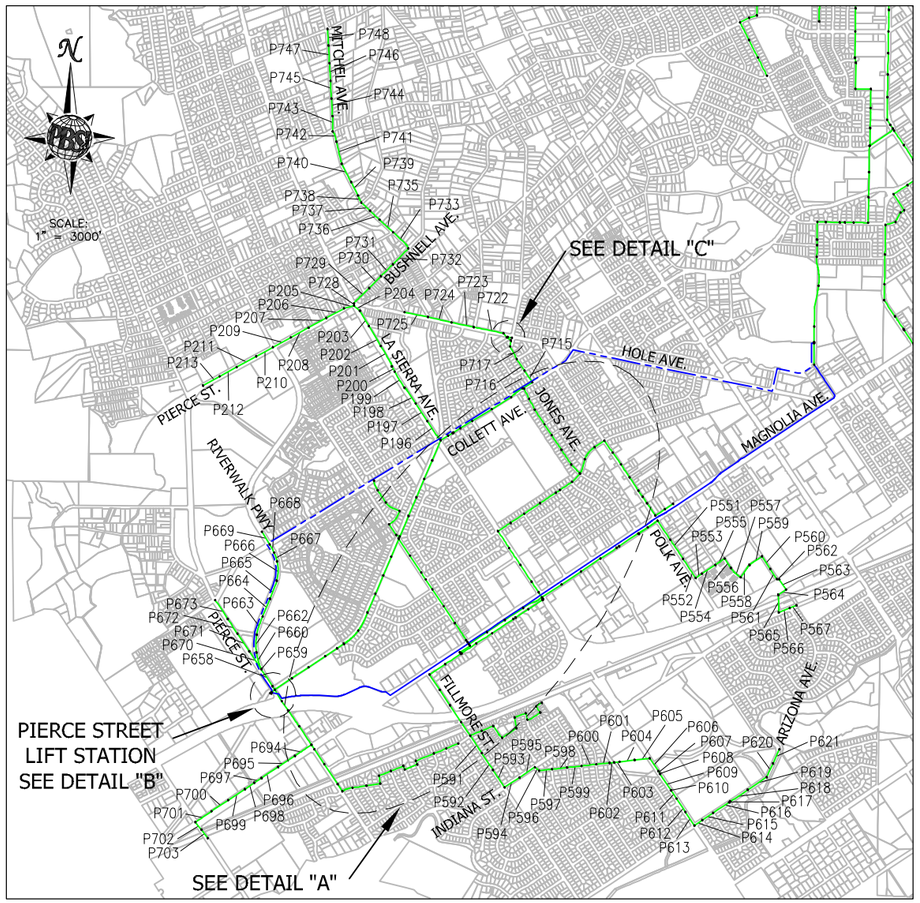
SEE FIGURES 8A AND 8C FOR CONTINUATION OF SEWER BASIN SYSTEM

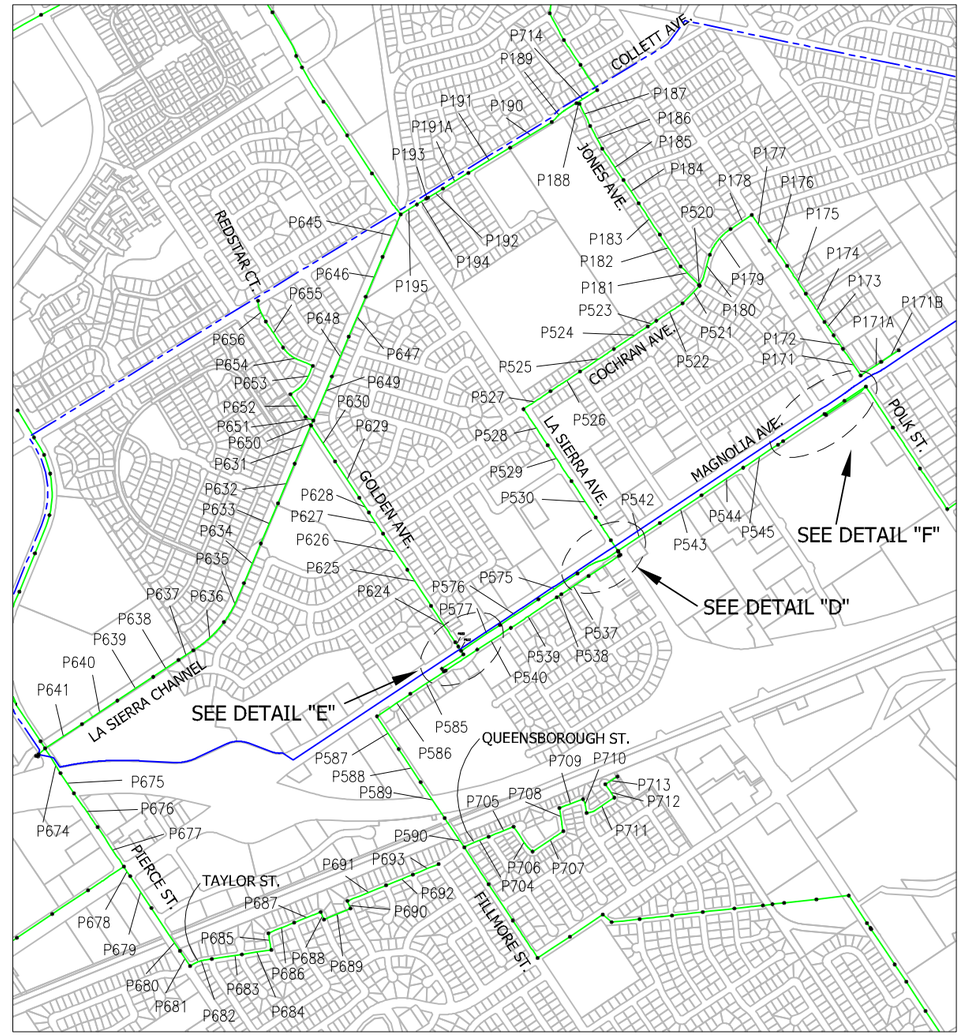
Engineering
Planning
Surveying
Construction Services
PBSJ
10370 Hemet Street
Suite 200
Riverside, CA 92503
Tel:(951) 358-1433
Fax:(951) 358-1434

DATE: 12/21/05	DWN BY: CD
CITY OF RIVERSIDE ARLANZA SEWER STUDY	FIGURE 8B

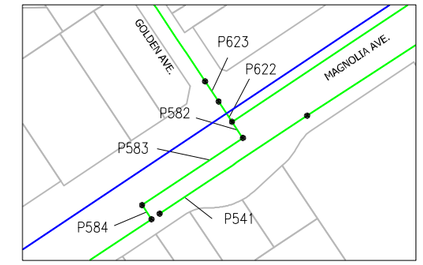
EXISTING PIPES - PART 2

Y:\City of Riverside\Arlanza\DWG\Exhibits\AZ-PipeIDs2.dwg, 9/28/2006 10:02:52 AM

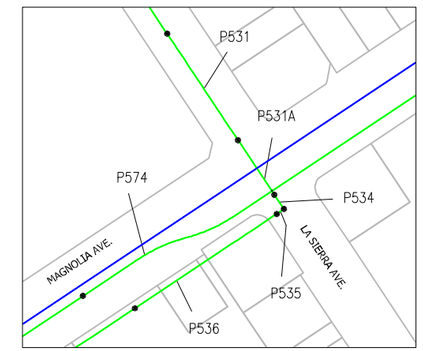




DETAIL "A"
NTS

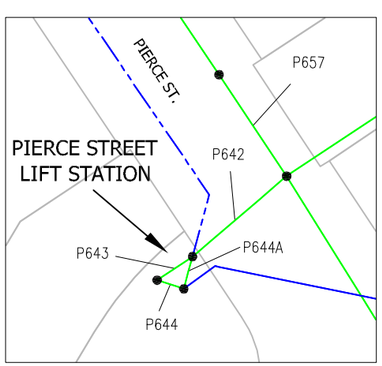


DETAIL "E"
NTS

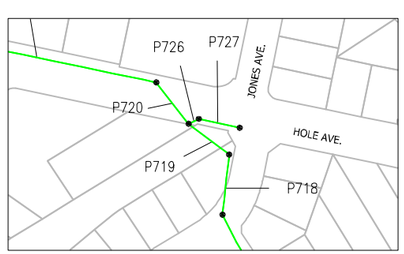


DETAIL "D"
NTS

DETAIL "F"
NTS



DETAIL "B"
NTS



DETAIL "C"
NTS

LEGEND

- MAGNOLIA FORCE MAIN
- LA SIERRA FORCE MAIN
- GRAVITY SEWER
- P001 PIPE SEGMENT NUMBER

SEE FIGURES 8A AND 8B FOR CONTINUATION OF SEWER BASIN SYSTEM

Engineering
Planning
Surveying
Construction Services
PBS&J
10370 Hemet Street
Suite 200
Riverside, CA 92503
Tel:(951) 358-1433
Fax:(951) 358-1434

DATE: 12/21/05	DWN BY: CD
CITY OF RIVERSIDE ARLANZA SEWER STUDY	FIGURE 8C
EXISTING PIPES - PART 3	

Y:\City of Riverside\Arlanza\DWG\Exhibits\AZ-PipeIDs3.dwg, 9/28/2006 10:04:01 AM

3.4 Tributary Areas

The study area is divided into 34 sub-areas, each having a land use or flow pattern distinctive from other. These sub-areas are tributary to a particular meter location either individually or collectively (See section 4.1 Flow Monitoring). Because of their strategic locations, meters upstream from a cumulative meter can be subtracted out to deduce the cumulative effect. See Figure 5 for meter locations and tributary areas, and Figure 4 for details of tributary sub-areas. Following is the listing of tributary sub-areas and their contribution to a particular meter location.

Meter No. 1: Sub-areas 17, 18 and 20 are tributary to meter No. 1, located on La Sierra Avenue, northwest of the La Sierra Avenue and Collett Avenue intersection.

Meter No. 2: Sub-areas 12 and 29 are tributary to meter No. 2 located on the Collett Avenue near Collett Avenue and Sunrose intersection.

Meter No. 3: Sub-areas 14, 15 and 16 are tributary to meter no. 3 located at Pierce Street near Pierce Street Lift Station.

Meter No. 4: Flow from Pierce Lift Station that includes sub-areas 12,13,14,15,16,18,19,20,25,16,27 and 29 are tributary to meter 4, located on Selma Avenue between the Tomilinson Avenue and Selma Avenue intersection.

Meter No. 5: Sub-areas 7, 9, 10, 11 and 24 are tributary to meter 5, located on Van Buren Boulevard at the Van Buren Boulevard and Challen Avenue intersection.

Meter No.6: Sub-areas 4, 5, 6 and 35 are tributary to meter 6, located on California Avenue between Nessel Street and Wheeler Street.

Meter No.7: Sub-areas 8, 21, 22 and 34 are tributary to meter 7, located on Jurupa Avenue west of the Van Buren Boulevard and Jurupa Avenue intersection.

Meter No. 8: Sub-areas 2 and 3 are tributary to meter 8, located on Acorn Street between Jurupa Avenue and Central Avenue. Also, flows from other upstream meters are intercepted at this location.

Within each sub-area there is generally a distinct mixture of land use, that generates a unique quantity and diurnal pattern of wastewater flows. For identification of land use patterns, data provided by the City of Riverside in GIS Arcview format was used. Table 3-2 summarizes the sub-areas and land uses within the

sub-areas that are currently contributing to the existing sewer system.

Table 3-1

Developed Tributary Areas and Current Wastewater Land Use

Sub Area	SFR (Acres)	MFR (Acres)	Commercial (Acres)	Industrial (Acres)	School (Acres)	Total (Acres)
1	0	0	82	0	0	82
2	0	0	151	0	0	151
3	265	14	305	12	9	605
4	299	40	19	0	7	365
5	401	8	94	0	0	503
6	526	21	22	0	0	569
7	113	5	27	0	50	195
8	95	0	0	0	0	95
9	42	0	26	0	0	68
10	212	0	0	0	0	212
11	190	0	83	0	11	284
12	314	16	55	0	0	385
13	354	0	7	0	38	399
14	9	93	0	0	0	102
15	60	0	31	0	4	95
16	42	27	77	0	0	146
17	727	0	0	0	27	754
18	317	0	0	0	0	317
19	176	81	155	33	103	548
20	479	23	18	10	82	612
21	382	38	86	24	10	540
22	63	0	0	0	0	63
23	241	0	4	17	31	293
24	25	9	3	0	0	37
25	83	38	0	0	0	121
26	118	36	20	0	10	184
27	67	3	5	0	0	75
29	903	200	397	0	80	1,580
30	177	12	31	11	31	262
31	207	80	127	2	24	440
32	260	80	67	5	216	628
33	73	58	42	79	10	262
34	0	0	52	0	0	52

SFR – Single Family Residential
MFR – Multi Family Residential

4.0 DETERMINATION OF SEWER FLOWS

4.1 Flow Monitoring

Flow Monitoring was conducted at eight (8) sites to measure flows at strategic locations. In addition, flow readings from the Inflow and Infiltration (I&I) Study meters that were installed between 01/07/05 and 02/28/05 were also used. (See Figure 5 for locations of Flow Monitoring Stations). The flow monitoring was designed to accomplish the following:

- Establish current flow levels (See Figures 9-16).
- Verify or adjust flow coefficients.
- Establish characteristic flow patterns (Diurnal Curves) for the model (See Figures 17-24).
- Confirm peak to average flow relationships.
- Help prioritize recommend improvements.

Meter locations were chosen to observe actual flow characteristics for the various sub-areas and to provide a continuous record of measured flows over a period of time (two weeks for this study). Meter locations were also chosen in such a manner that current flow quantities at the RWQCP could be quantitatively determined. The City measures inflow from Arlanza study area at RWQCP at one minute intervals. The flow records received from the City were used for flow comparison and determination of diurnal patterns. Following is an amplification of the logic for placement of each flow meter.

- Meter No. 1; location on La Sierra Avenue northwest of Collett Avenue – This location was chosen because it carries all the flow generated from the residential area north of Pierce Street. The flow pattern at this location would reflect a diurnal pattern for single family residential developments.

- Meter No. 2; location on Collett Avenue near Sunrose Drive – This location was chosen to observe flow generated from the mixed use land area west of Hwy 91. This meter will measure flow generated from a matured residential - commercial area. The flow pattern at this location reflects a diurnal pattern for mixed land use.

- Meter No. 3; location on Pierce Street northwest of Magnolia Avenue – This location was chosen to measure the flow from residential and commercial areas on both sides of Hwy 91. The flow pattern at this location reflects a mixed diurnal pattern for residential – commercial land use.

- Meter No. 4; location on Selma Avenue north of Tomlinson Avenue – This location was chosen to measure the flow from Pierce Street Lift Station. The meter measures approximately all wastewater flow from the study area west of Tyler Street. The flow pattern at this location also reflects a pattern for a lift station.

- Meter No. 5; location on Van Buren Boulevard south of Challen Avenue – This location was chosen to measure the flow from residential areas along Van Buren Boulevard. This portion of study area is typically low density residential.

- Meter No. 6; location on California Avenue between Nessel Street and Wheeler Street – This location was chosen to measure the flow from residential areas in the northeastern portion of study area. The residential land use in this portion of study area is typically low density. The diurnal flow pattern can be used to estimate and calibrate residential flow patterns.

- Meter No. 7; location on Jurupa Avenue (extended) west of Van Buren Boulevard – This location was chosen to measure the flow from residential areas near City's northern boundary. The residential land use is typically medium density.

- Meter No. 8; location on Acorn Street north of Central Avenue – This location was chosen to measure flow from the commercial areas east of Acorn Street. It also intercepts flows from upstream contributing areas.

In conjunction with flow measured at the above meters and the I&I meters, flow data from the City was also used.

4.2 Results of Flow Monitoring

Measurement of sewer flows is an imprecise science, as the in-line equipment is placed in a harsh environment and is subject to solids interference, turbulence and other problems, which can impede the accuracy. Installed equipment must be frequently inspected and maintained, and monitoring results interpreted, evaluated for reasonableness, and sometimes adjusted. In this particular application, metered flow information was generally good. However, some flows at specific meter locations did not display consistent values. Graphical results at each site were carefully reviewed for consistency and reasonableness, using the following general guidelines:

- Where the magnitude or daily pattern varies significantly from one non-holiday weekday to the next, the data is likely to be flawed.
- Where the base (low) flows are rising during the flow monitoring period, the data is suspect.
- Where the algebraic sum of flows from meters in series are significantly out of sync, the data from one or more meters may be faulty.
- Where the minimum (nighttime) flows are abnormally high or algebraically inconsistent, the data is suspect.
- Where the measured depth data and velocity data are inconsistent the data is suspect.

Metered flows displaying one or more of the above flaws were purged or adjusted based on reasonable assumptions.

At each meter location the flow-monitoring device measures depth of flow and velocity. Upon reviewing the report submitted by Downstream Services, and from discussions with their staff, it was determined the data (depth or velocity) that is more consistent should be used for determination of flow. By using depth of flow readings and inputting pipe characteristics from record drawings (slope, size and roughness "n" values), sewage flow can be calculated using Manning's equation. The raw flow data have been included in the Appendix "A".

The flow monitoring hydrographs at each meter site, adjusted based on the depth measurements, are shown in Figures 9 through 16. The following relevant observations were made from evaluation of the measured flows:

- At meter location 1 the velocity and depth of flow readings are consistent for the entire period. The flow during this monitoring period has been used for estimation of the maximum flow and calibration of the model for sub-areas 17, 18 and 20.

- Flow measured at meter location 2 are generally consistent for week days. Some inconsistency has been observed during weekends that can be explained by the mixed land use flow contribution. The flow measured at this meter location has been used for calibration of flow from sub-areas 12 and 29.

- At meter location 3 the velocity and depth of flow readings are generally consistent for the monitoring period. During the weekdays, small spikes have been observed. The flow during this monitoring period has been used for estimation

of the maximum flow and calibration of the model for sub-areas 14, 15 and 16.

- The flow from the Pierce Street Lift Station is measured at meter location 4. Data for depth, velocity and flow are consistent at this location. The maximum flow value observed at this location has been used for calibration of the model for sub-areas 13, 19, 25, 26 and 27.

- At meter location 5, the velocity and depth of flow readings are generally consistent for the monitoring period. It also shows some spikes in the flow during the rain event. The flow at this monitoring station has been used for calibration of the model for sub-areas 7, 9, 10, 11 and 24.

- At meter location 6 the flow readings are generally consistent for the monitoring period. At this location, primarily flow from residential land use is measured. It shows a typical residential diurnal pattern. The flow at this monitoring station has been used for calibration of the model for sub-areas 4, 5 and 6.

- Flow measured at meter location 7 is not consistent for the entire flow measurement period. Flow measured between Oct 11 and Oct 16 has been used for the calibration of the model. The flow and diurnal pattern of this meter location is used for flow calibration of sub-areas 8, 21 and 22.

- Flow measured at meter location 8 shows a minimum flow value during early hours and a high peaking factor. This phenomenon can be explained by the split flow situation upstream of this meter location. The flow and diurnal pattern at this meter location is used for flow calibration of sub-areas 2 and 3.

5.0 ESTIMATED ULTIMATE FLOW

5.1 Methodology

Future wastewater flows in the study area are estimated by applying unit (per acre or per capita) flow factors to the projected "ultimate" land use acreage or population in each sub area. As discussed in Section 2, ultimate land uses within the study area are estimated based on the City's current General Plan (which governs future development/redevelopment). The major contributor to the increased wastewater flow in the future would be undeveloped low density residential areas southeast of Victoria Avenue and areas at Riverside-Norco boundary. For purpose of this study it has been assumed that these areas would most likely be developed by the year 2020.

5.2 Flow Coefficients

A review of commonly used flow coefficients (or unit factors) was performed to arrive at preliminary criteria, which are considered to be an appropriate starting point for the study.

Flow coefficients are commonly expressed in terms of cubic feet per second (cfs) of average dry weather flow (ADWF) per acre of a specific land use type. For population based estimates, flows are expressed in gallons per capita per day (gpcd). Peak flow generation rates are estimated by applying peaking factors to the average flow, with factors often based on observed peak-to-average ratios from previous studies. However, peaking factors and diurnal flow patterns vary greatly from one setting to another. Peaks for various land uses differ not only in magnitude, but also in time of day. The diurnal patterns are a composite picture of inflows that are not simultaneous, but rather staggered throughout the day. Also, peaks are attenuated by lag times and in pipe storage as the flows move downstream. Notwithstanding the above, diurnal peaking factors are also estimated for each land use to estimate peak generation rates.

For preliminary estimation of wastewater flow, the document "Criteria for Sewer Facility Design, Public Works Department, City of Riverside" was used (See Appendix "B"). The document states the following general guideline for estimation of wastewater flows.

Flows from Residential Developments:

- Land use shown in the City's General Plan.
- No. of dwelling units per acre within a certain land use.

- Persons per living unit determined from the latest census data for the study area. However, it should not be less than an average of 2.75 persons per living unit.
- Average wastewater flow based on 65 gallons per capita per day.
- Peak to average flows to be determined from the graphs.

Flows from Non-residential Developments:

- Industrial Developments – Peak flow; 0.012 cfs per acre.
- Commercial Developments – Peak flow 0.01 cfs per acre.
- Offices – 30 gallons per capita (employee on site) per day peak flow.
- Schools – 0.01 cfs/acre peak flow.
- Laundromat – 580 gallons per machine per day peak flow.

5.3 Representative Diurnal Hydrographs

The study area is comprised of a variety of unique land uses. For the purpose of defining characteristic diurnal patterns, flow from each sub-basin was analyzed and percentage of flow contribution from each land use type was estimated. Although none of the tributary sub areas flowing to the meter locations are comprised of a single land use category, several are dominated by one or two categories, and are thus selected as being representative of the diurnal flow patterns for those land uses. The diurnal patterns were established for each meter location, and the model was calibrated for mixed land use patterns. The following diurnal patterns were used for the modeled peak flow evaluation.

- Flow at meter location 1: Mixed Land Use with SFR predominance.
- Flow at meter location 2: Mixed Land Use
- Flow at meter location 3: Mixed (Commercial and Residential)
- Flow at meter location 5: Mixed Land Use with residential predominance.
- Flow at meter location 6: Low density residential
- Flow at meter location 7: Medium density residential
- Flow at meter location 8: Commercial use

These representative diurnal hydrographs are shown in Figures 17-24. The flow patterns are used in the model to estimate the

percentage of Average Dry Weather Flow (ADWF) contributed at specific times throughout the day.

Figure 9

Flow at Meter 1
Location: La Sierra Ave. near Collett Ave.

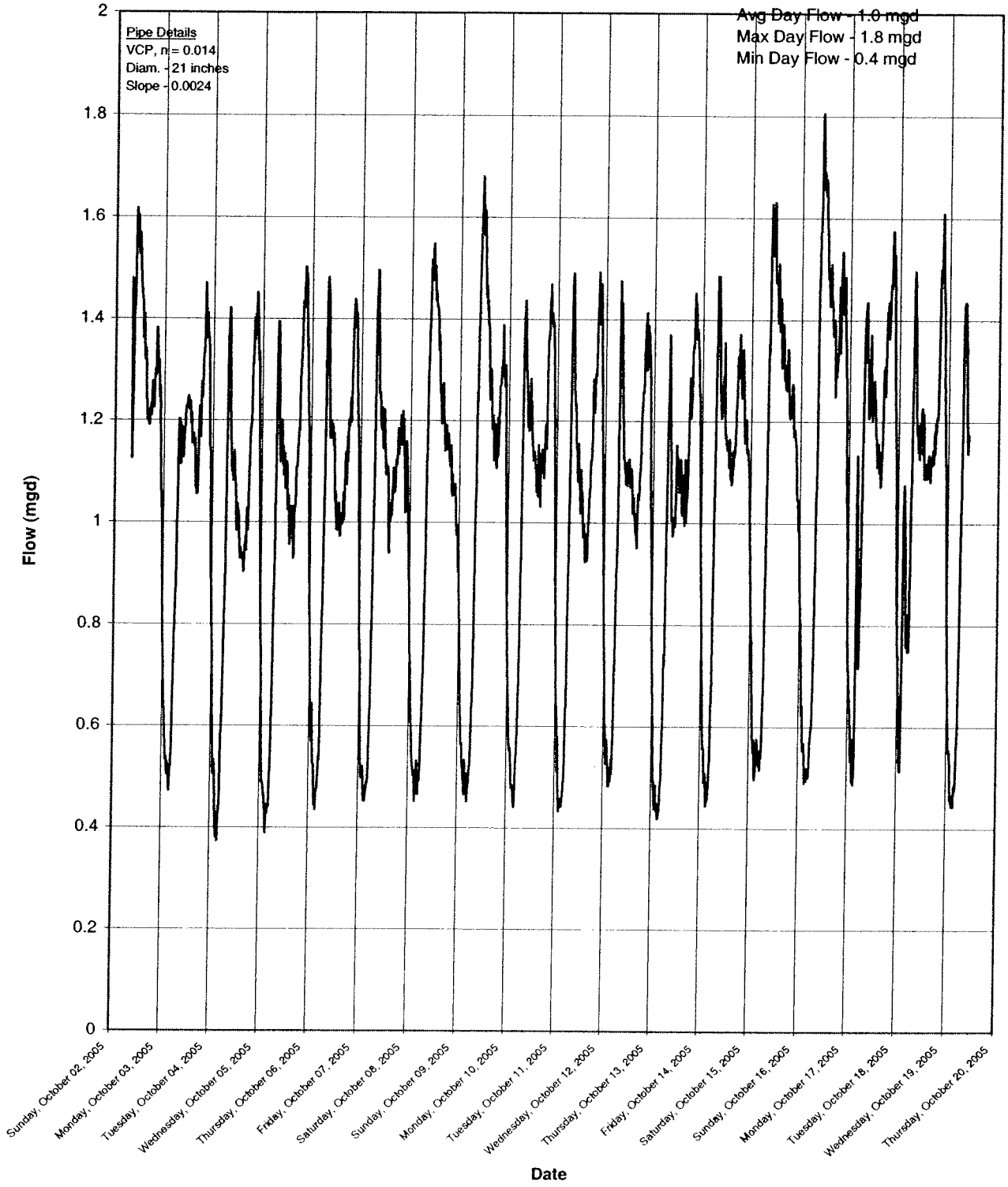


Figure 10

Flow at Meter 2
Location: Collett Ave. near La Sierra Ave.

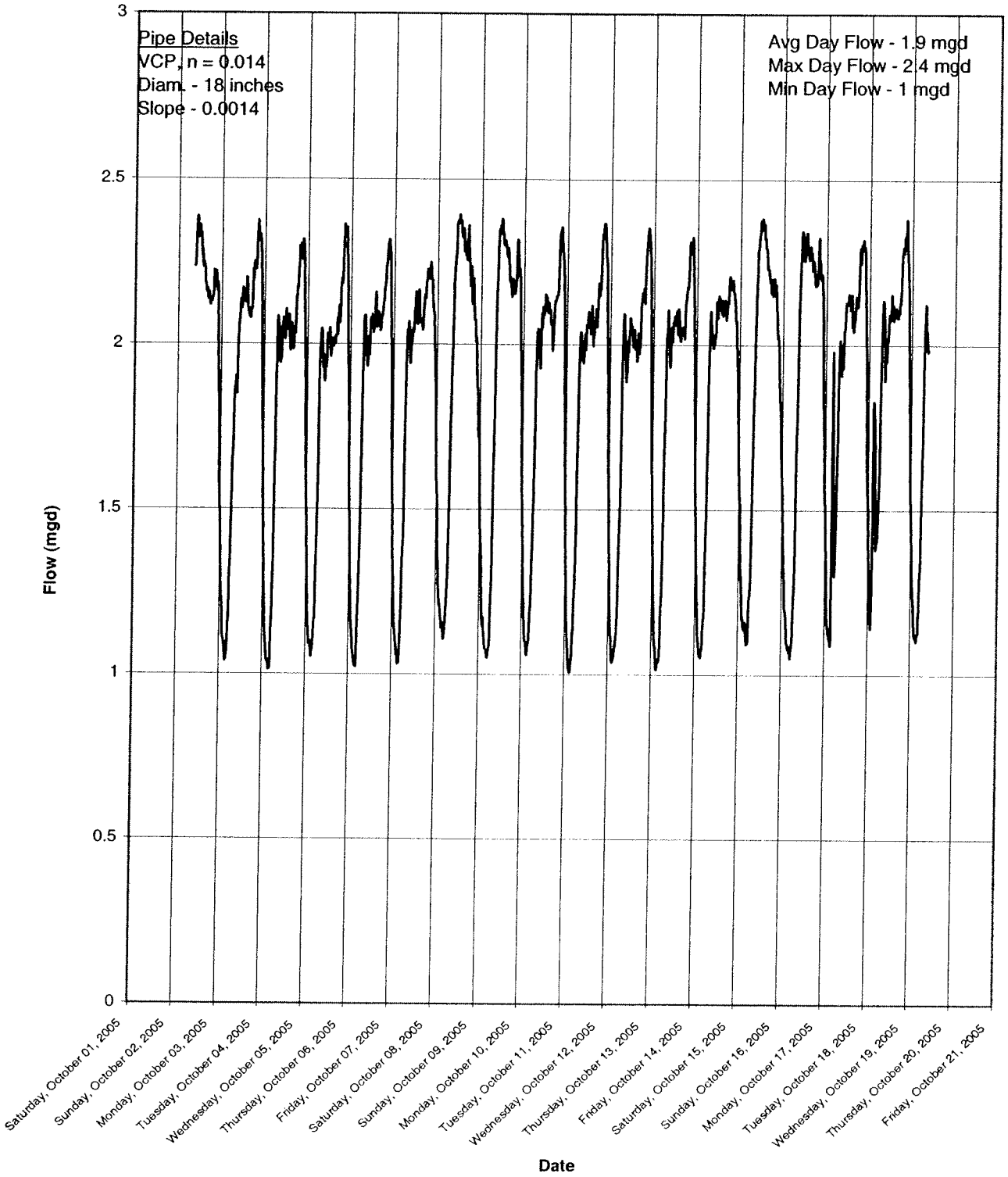


Figure 11

Flow at Meter 3
Location: Pierce St. near Pierce St. Pump Station

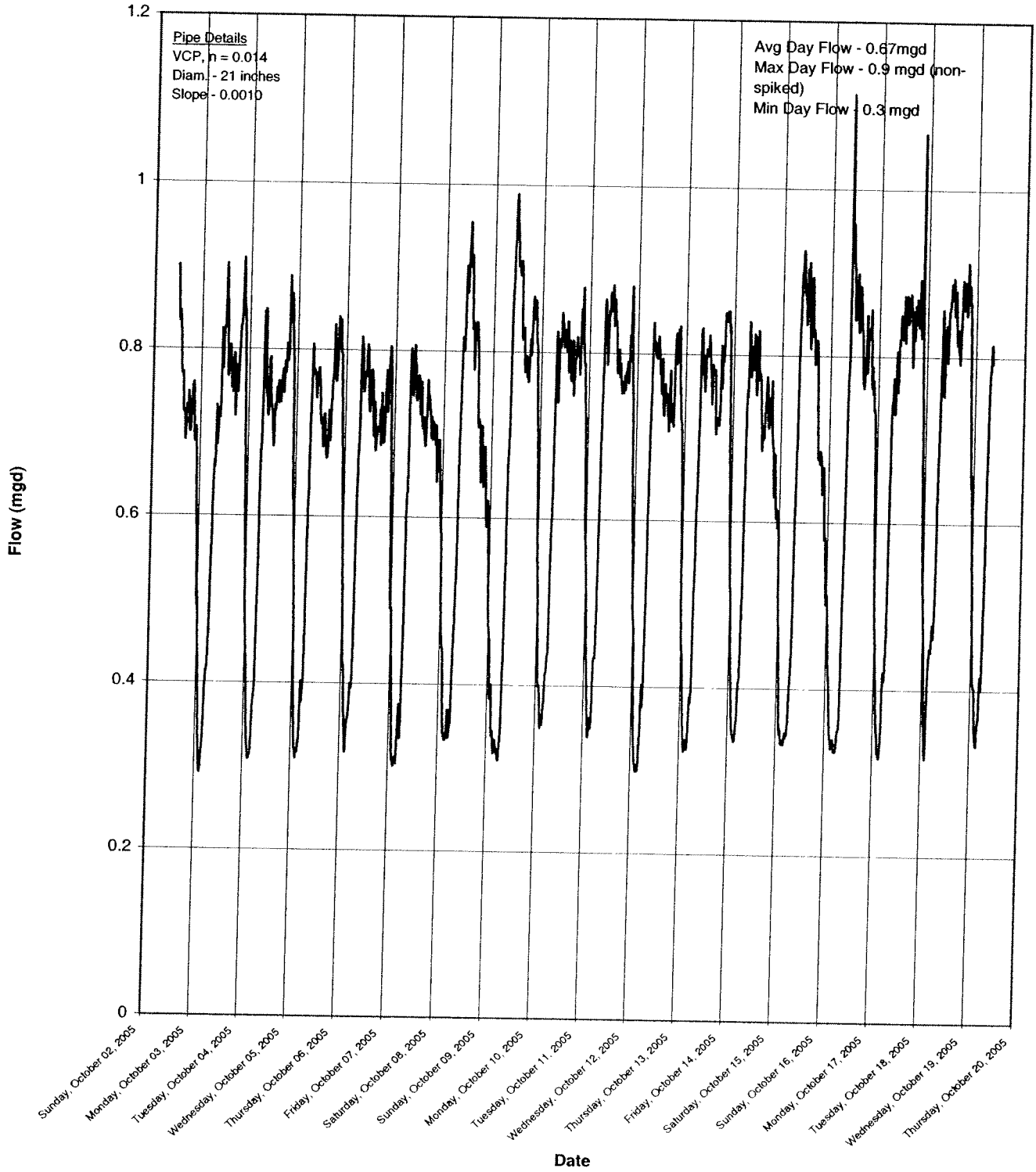


Figure 12

Flow at Meter 4
Location: Selma Ave. near Tomlinson Ave.

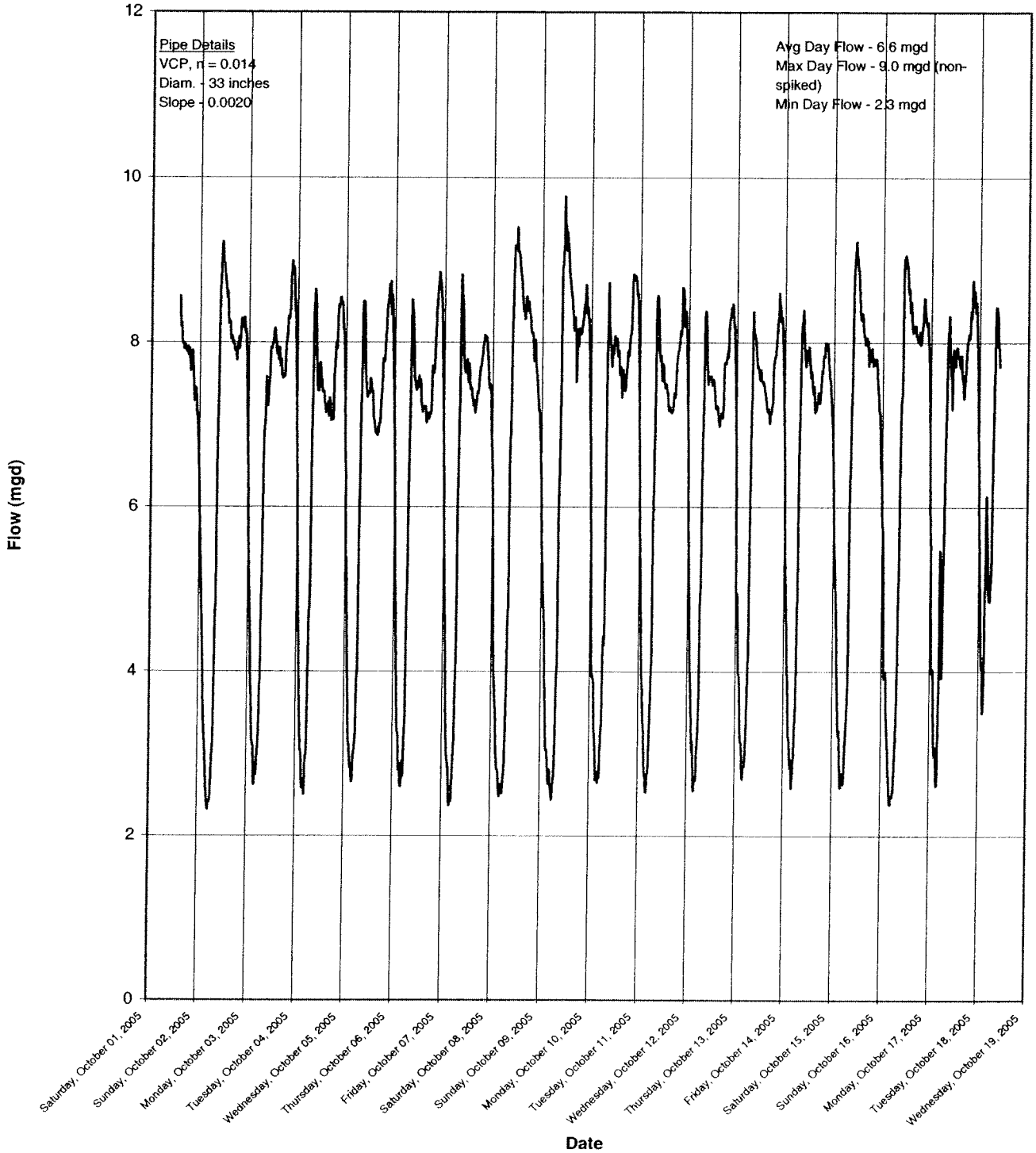


Figure 13

Flow at Meter 5
Location: Van Buren Blvd. near Challen Ave.

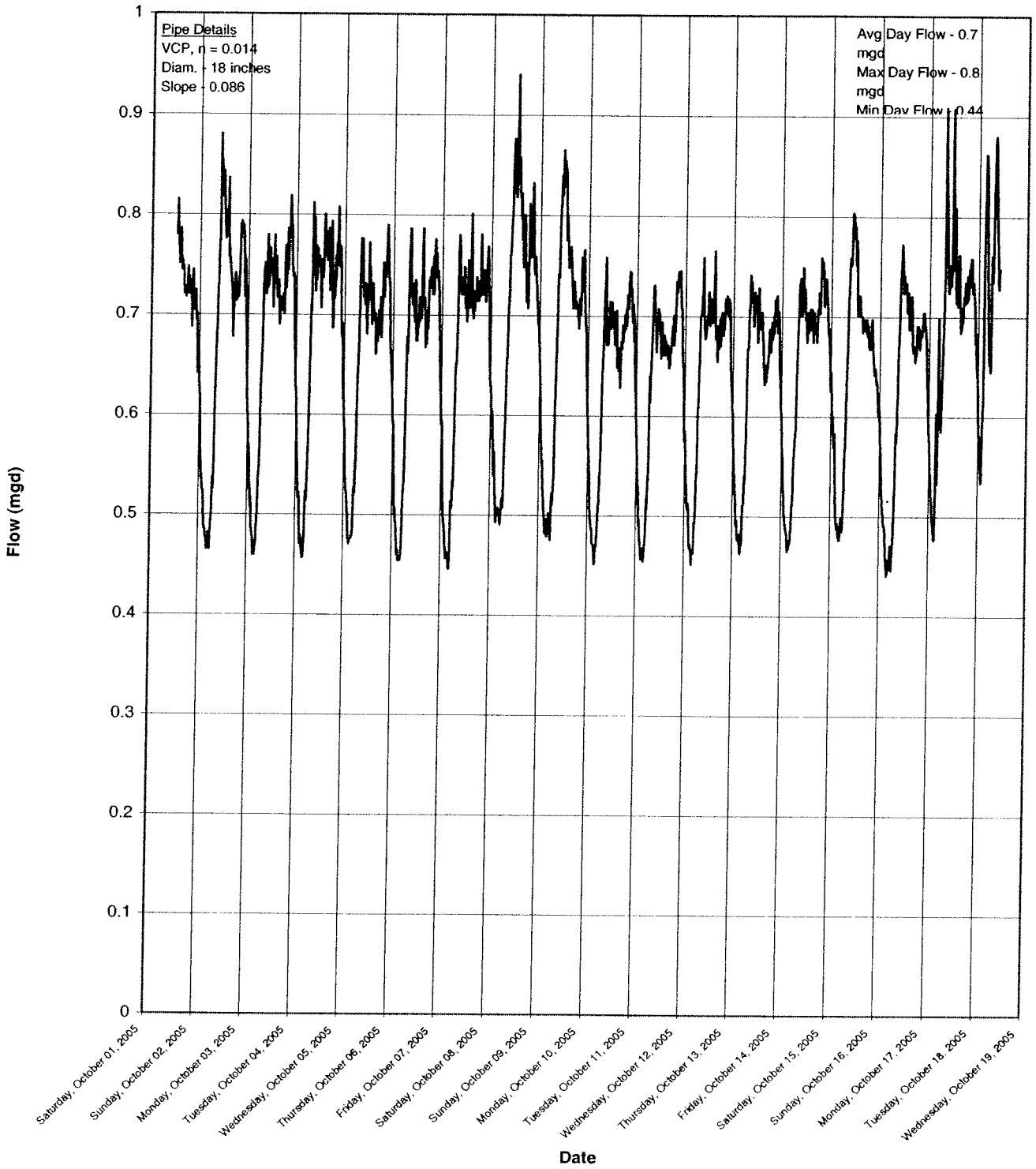


Figure 14

Flow at Meter 6
Location: California Ave. near Nessel St.

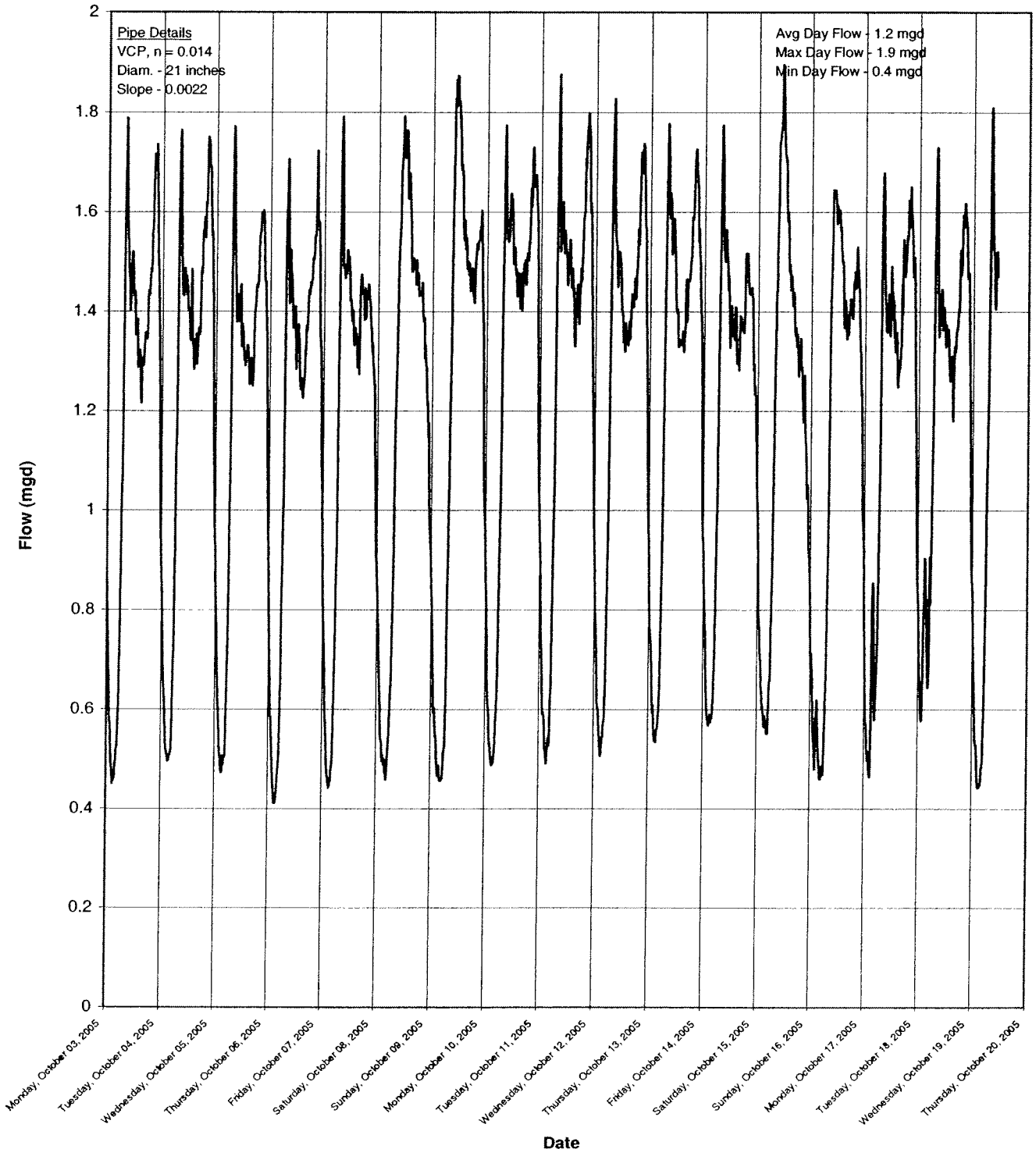


Figure 15

Flow at Meter 7
Location: Jurupa Ave. near Van Buren Blvd.

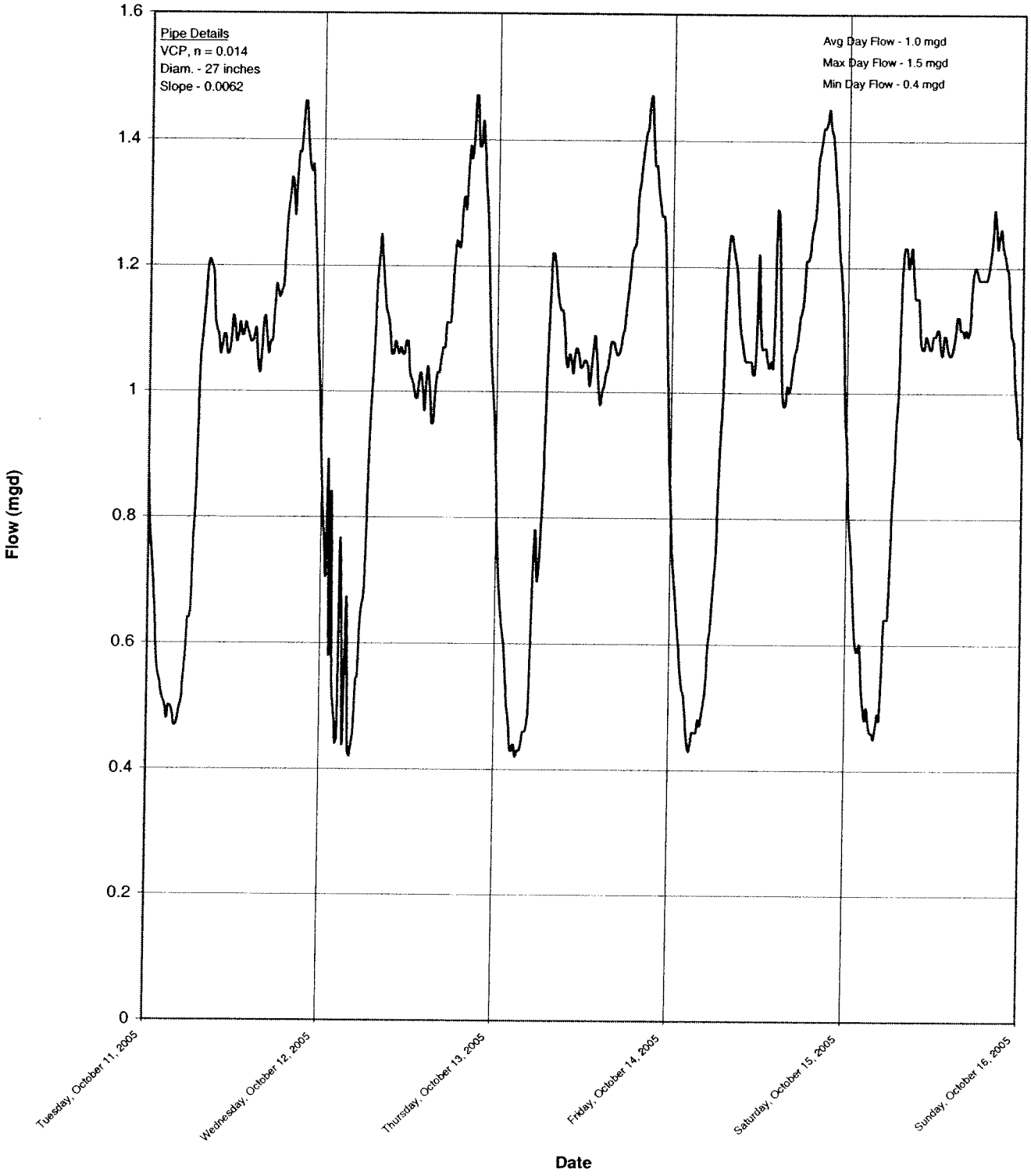


Figure 16

Flow at Meter 8
Location: Van Buren Blvd. near Central Ave.

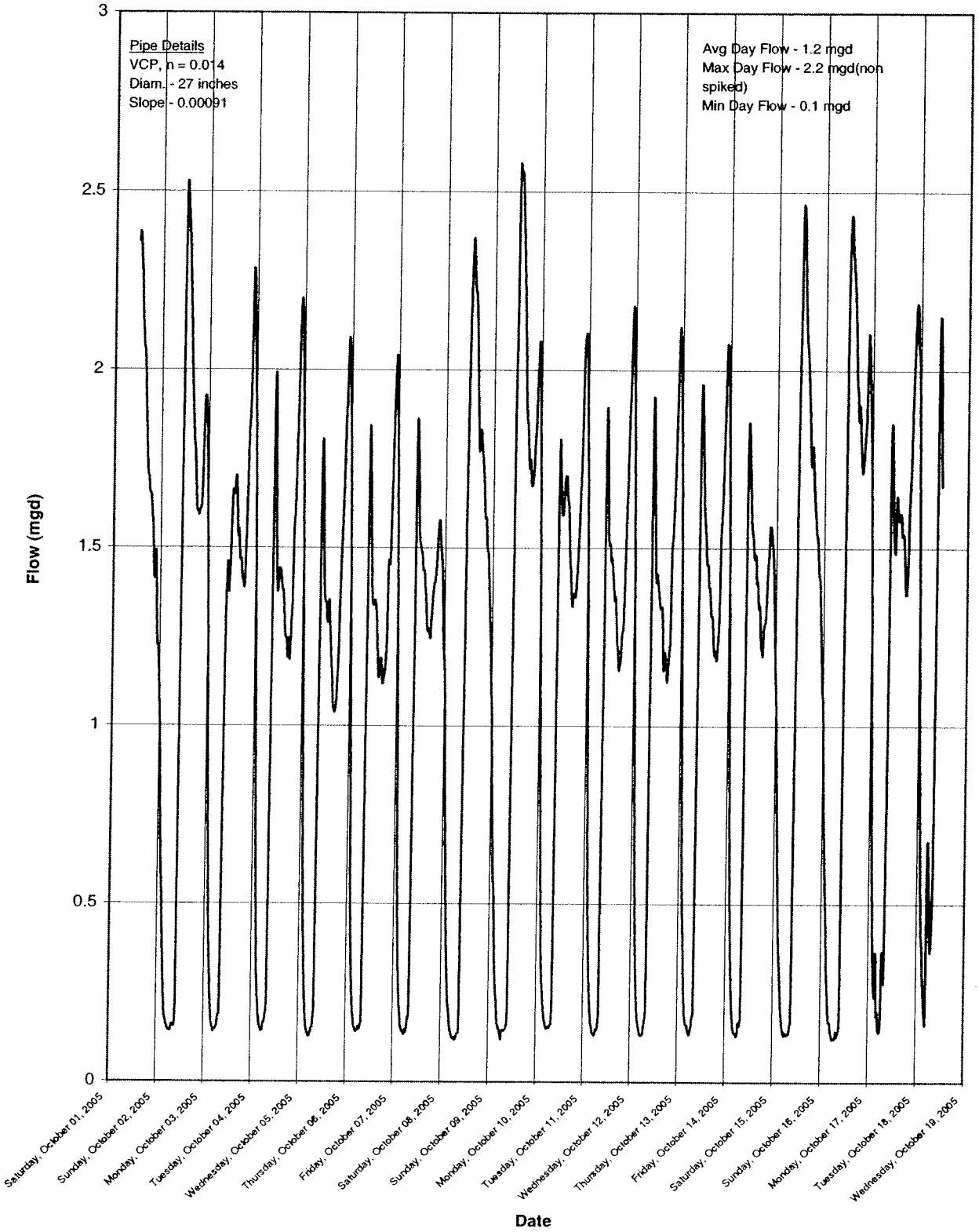


Figure 17

Representative Diurnal Pattern for Mixed Land Use
Meter Location - 1

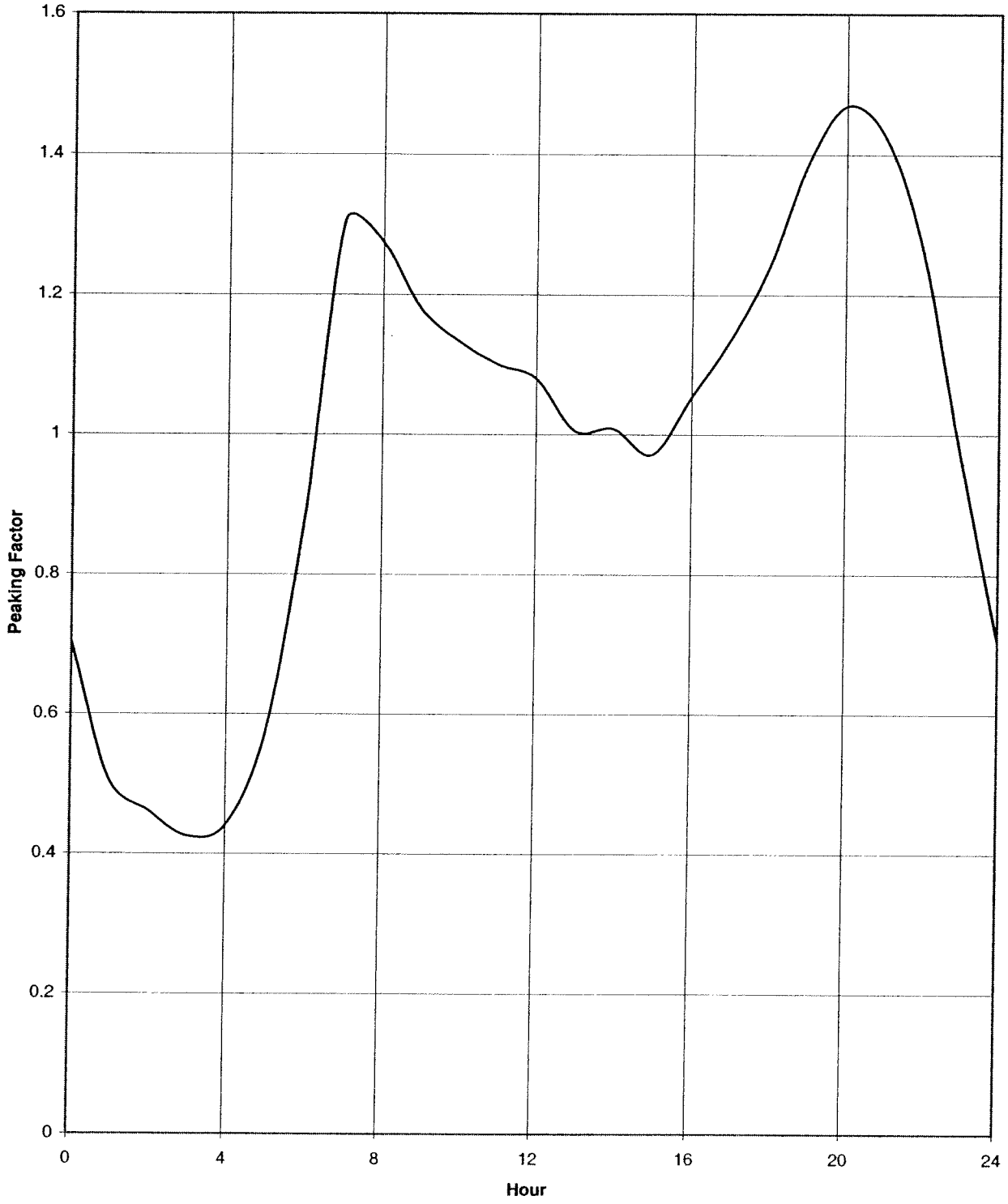


Figure 18

Representative Diurnal Pattern for Mixed Land Use
Meter Location - 2

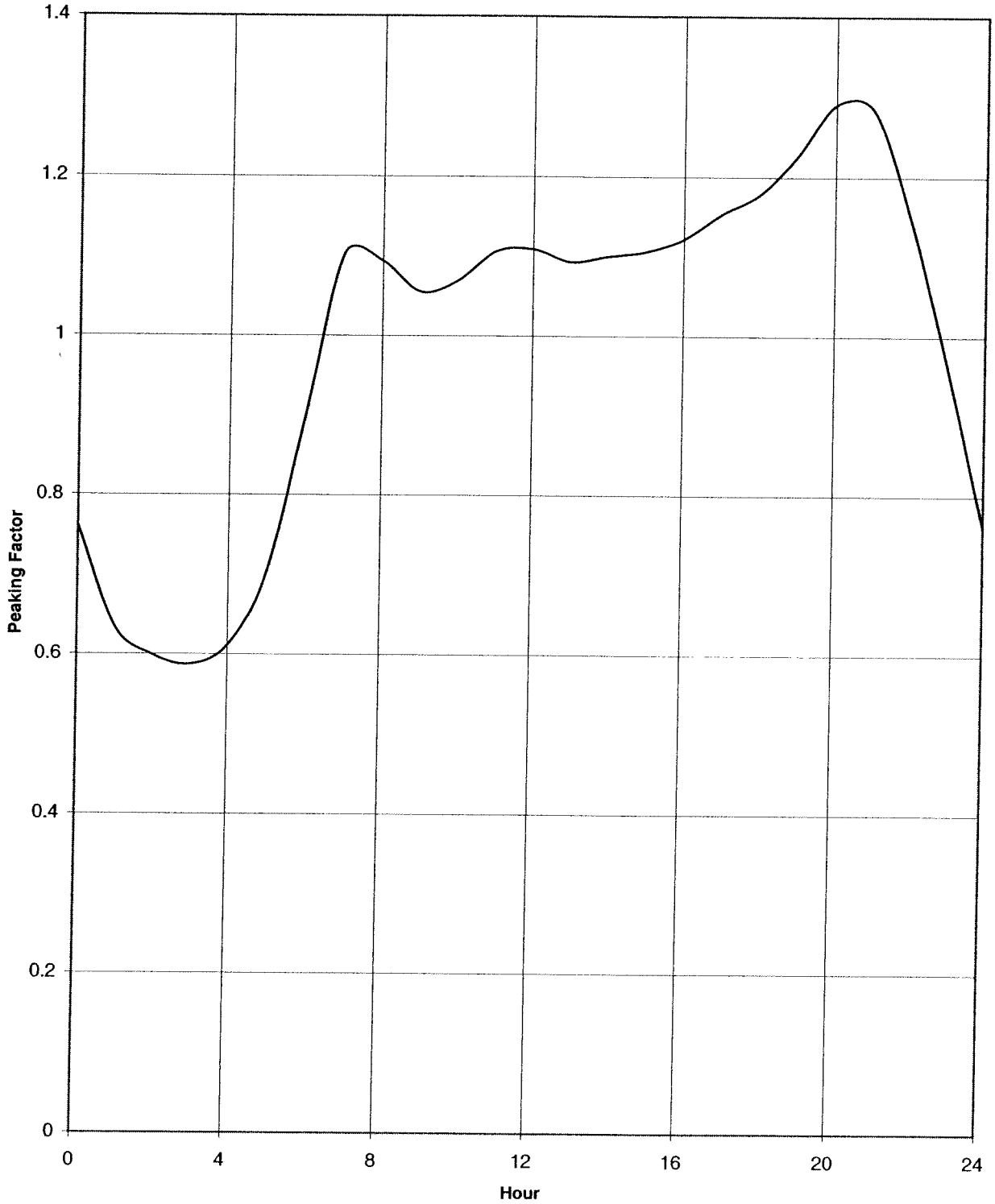


Figure 19

Representative Diurnal Pattern for Mixed Land Use
Meter Location - 3

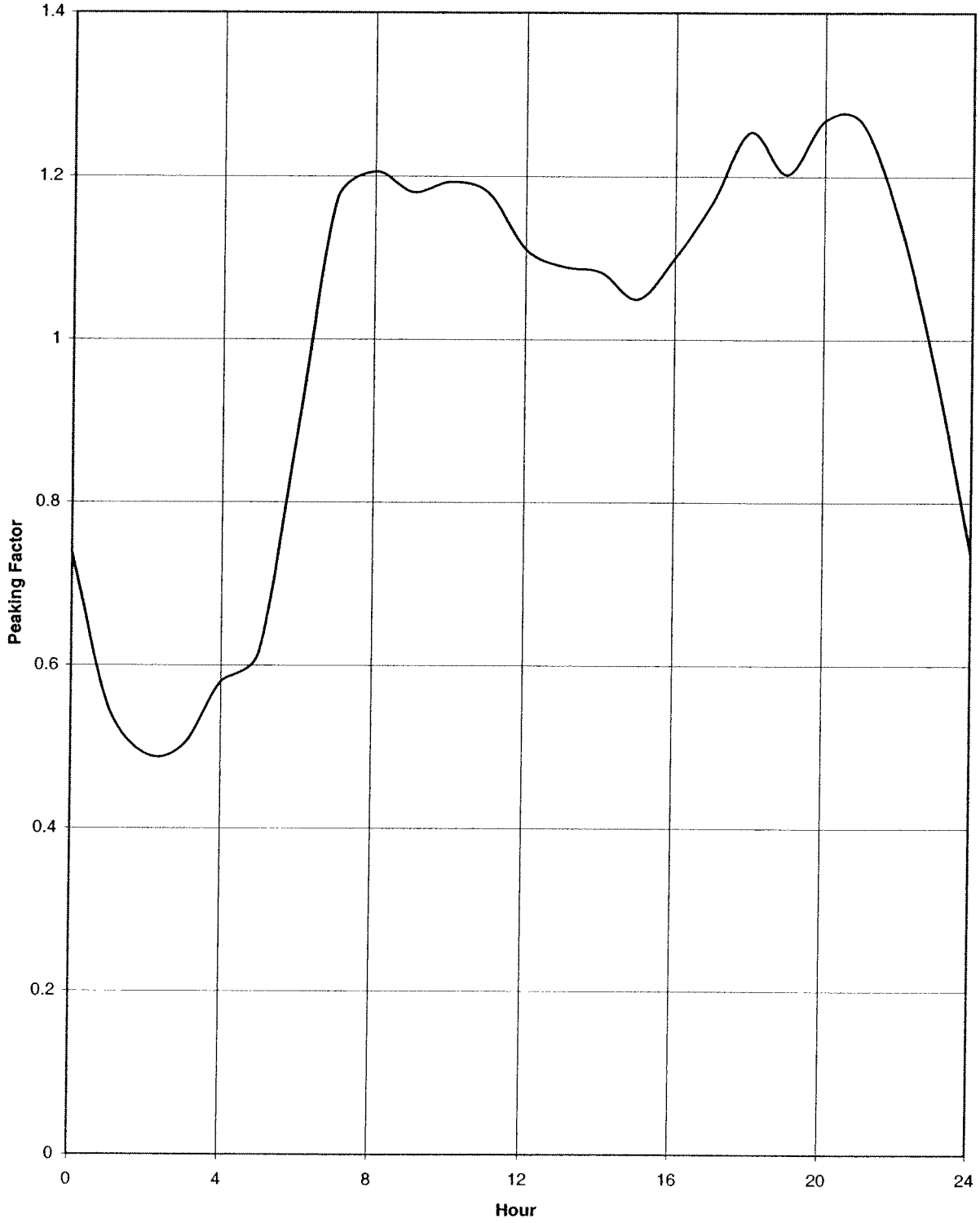


Figure 20

Representative Diurnal Pattern for Mixed Land Use
Meter Location - 4

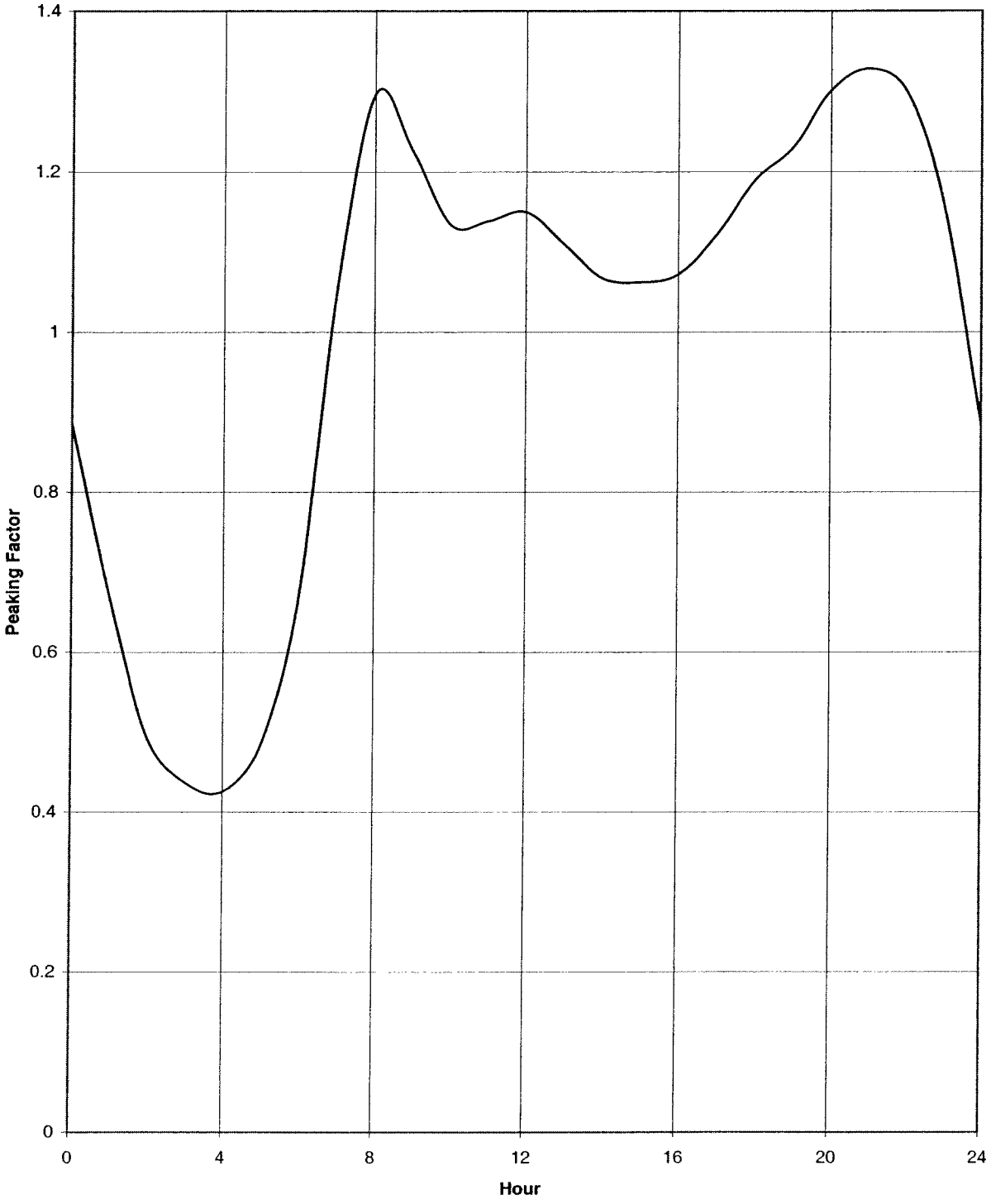


Figure 21

Representative Diurnal Pattern for Mixed Land Use
Meter Location - 5

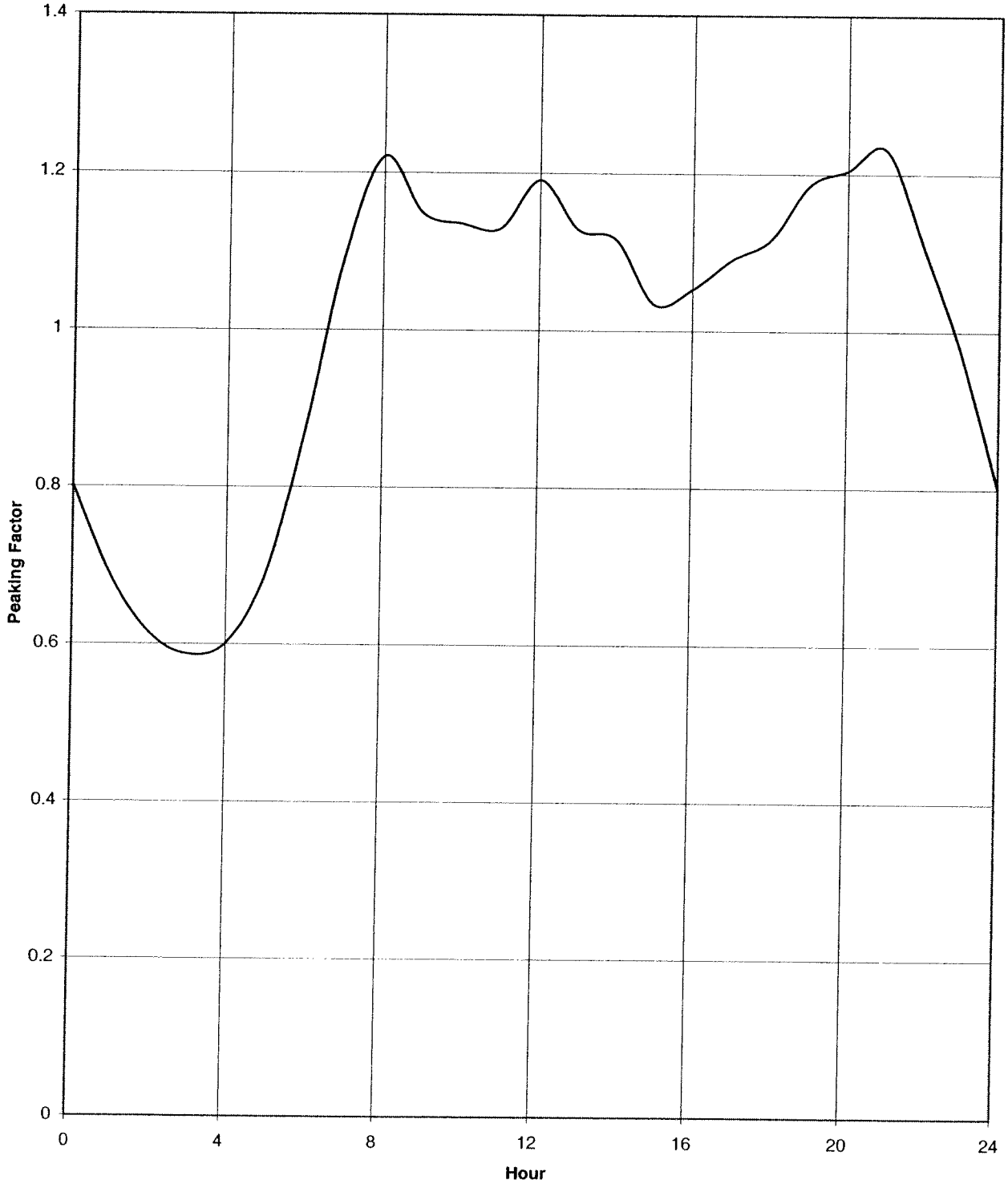


Figure 22

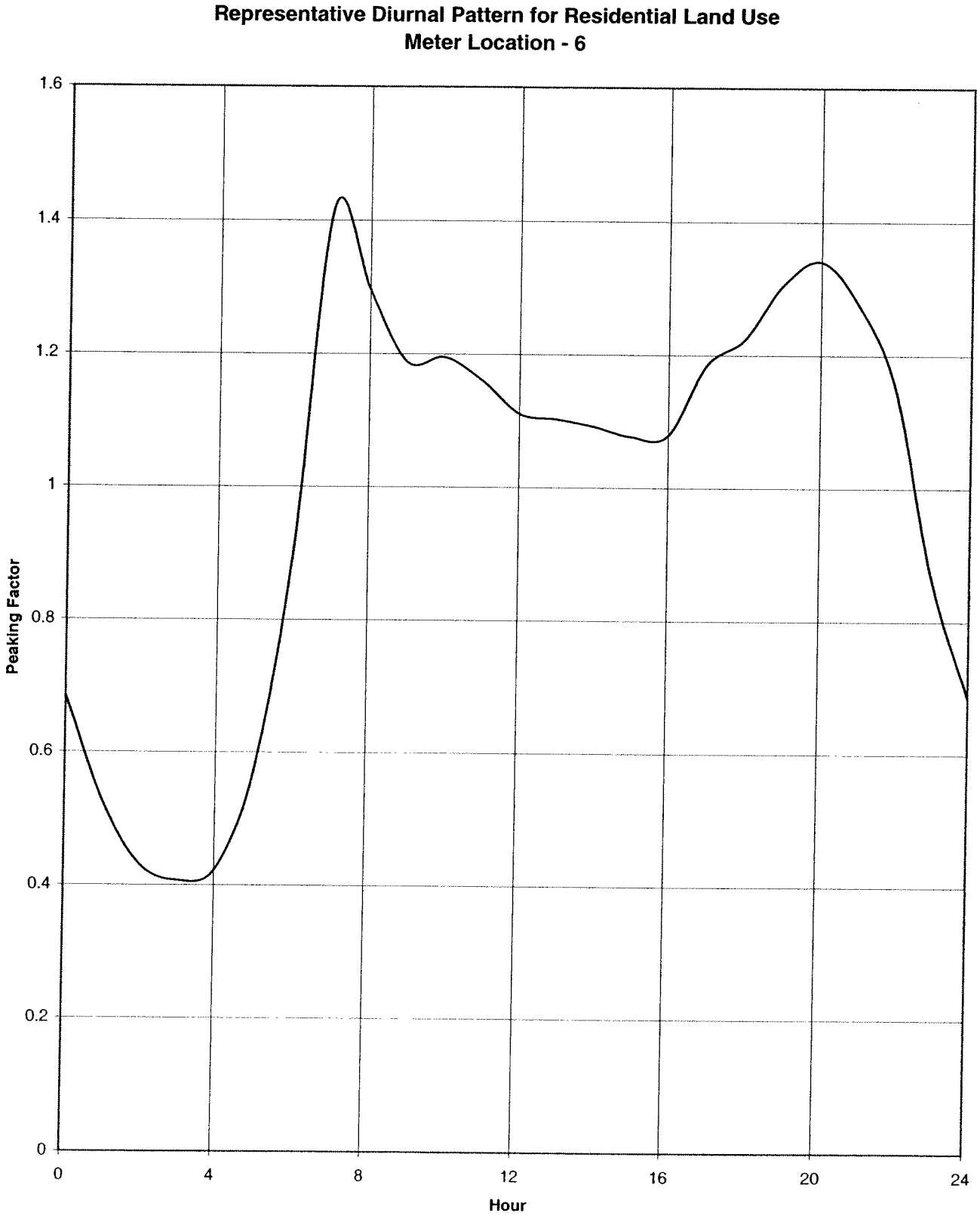

Representative Diurnal Pattern for Residential Land Use
Meter Location - 6
Peaking Factor
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0
4
8
12
16
20
24
Hour

Figure 23

Representative Diurnal Pattern for Mixed Land Use
Meter Location - 7

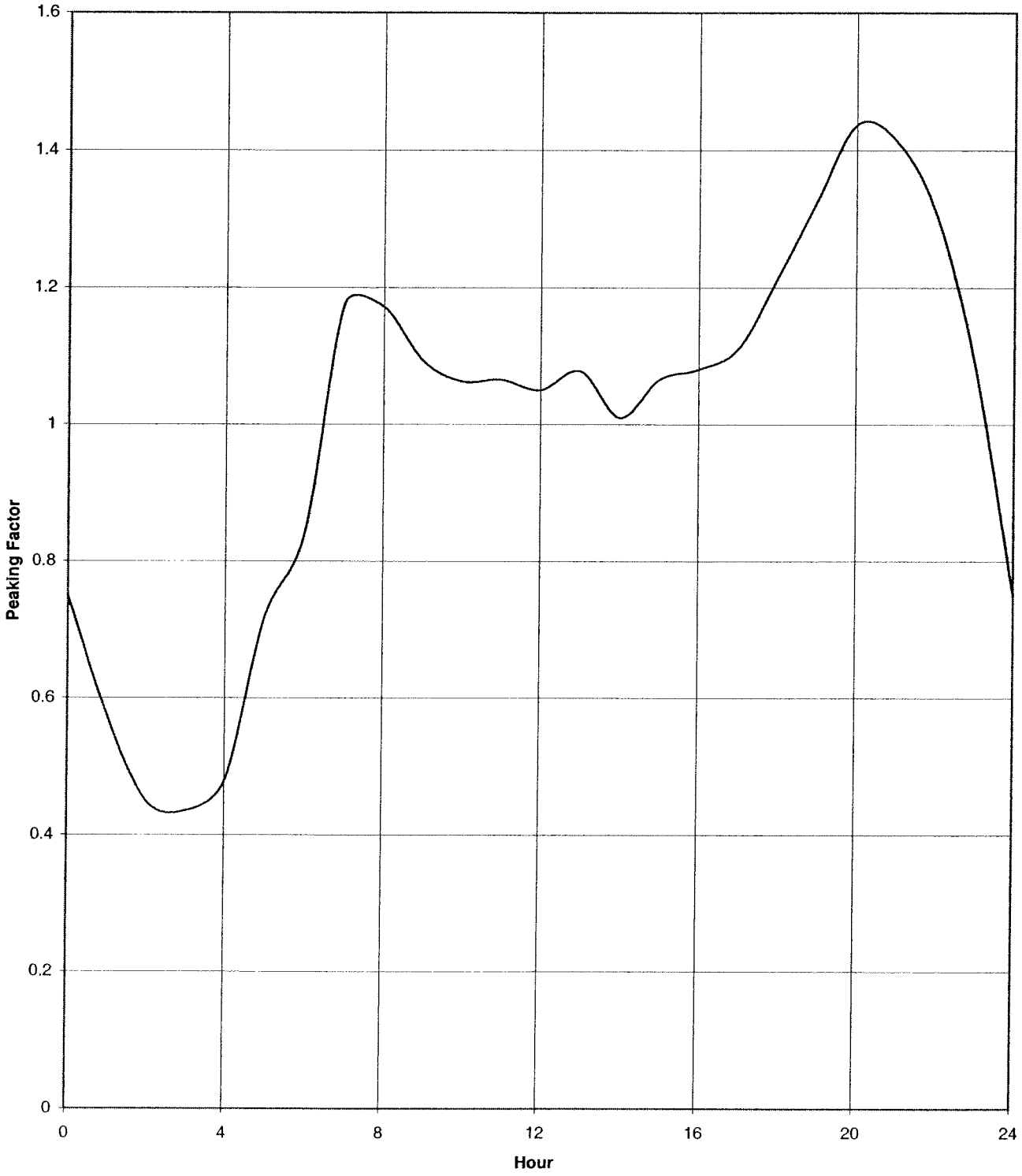
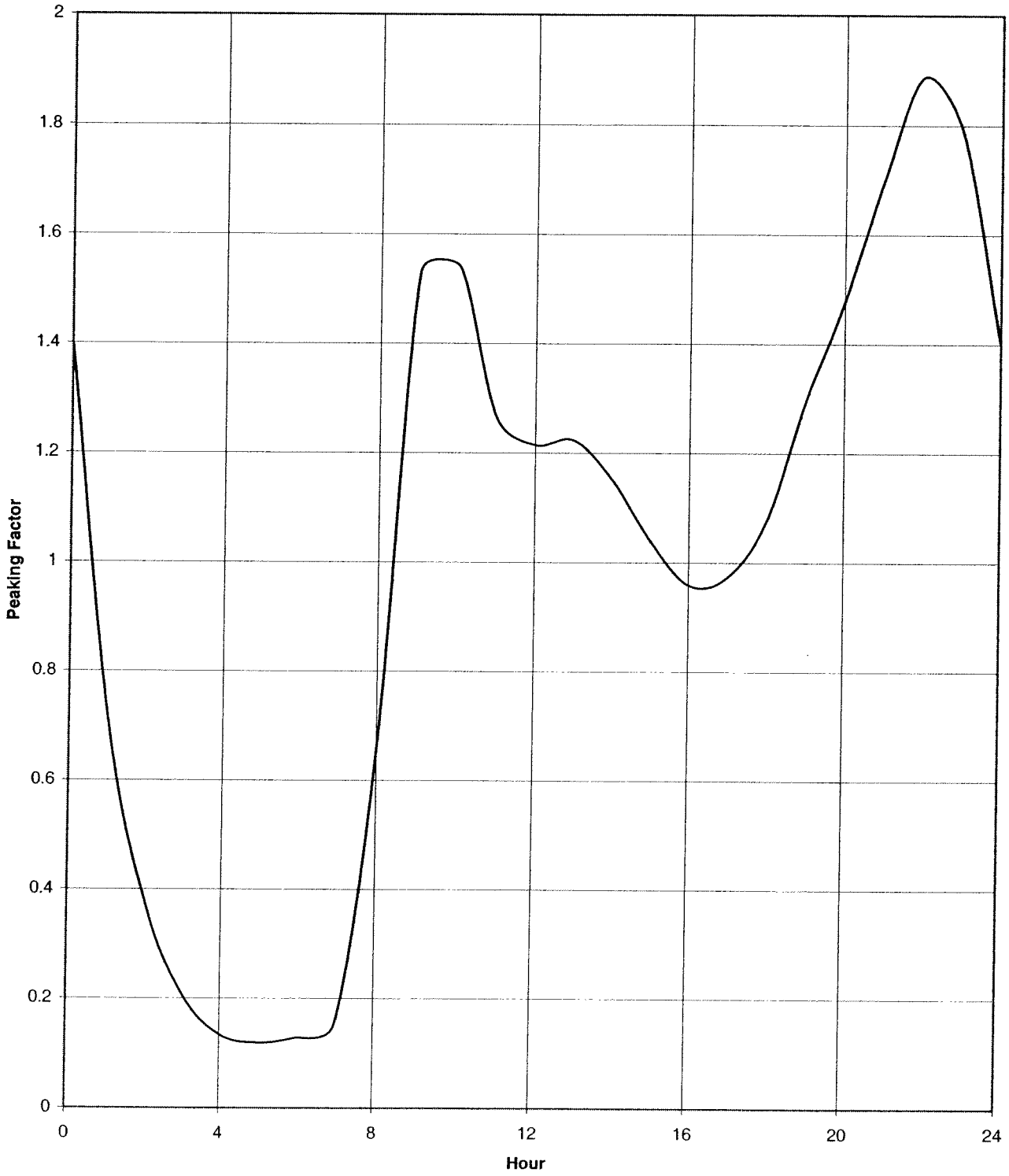


Figure 24

Representative Diurnal Pattern for Mixed Land Use
Meter Location - 8



6.0 COMPUTER MODEL SIMULATION ANALYSIS

6.1 Methodology

Capacity analysis involved the evaluation of the available capacity in the existing collection system under present and future development conditions. Based on results of the analysis, phased facility improvements were identified to allow for projected growth within the service area.

This section describes the analytical methodology and hydraulic model development and summarizes the results of the analyses.

The principal tool utilized in the capacity analysis was a hydraulic model that simulates flow conditions using inflow and sewer system characteristic input data. With this input information, the model is able to output sewage depth of flow, rate of flow, and velocity of flow, in selected pipes and manholes during different times of the day. The model selected for use in this study is XP-SWMM (XP Software, Version 9.10). This modeling software belongs to a class of software referred to as "dynamic wave models". These types of models provide an accurate simulation of hydraulic flow conditions over an extended period of time.

Data required to create the model include information describing the physical wastewater collection system, such as pipe diameters and reach lengths, manhole invert elevations, and estimated pipe roughness coefficients. Additionally, data describing the sewage loading at selected manholes expressed as a varying flow rate over time (i.e. a diurnal curve), must be provided. Model output consists of a variety of hydraulic parameters, most importantly peak flow velocity and discharge rates.

Calibration of the model consisted of simulating existing sewer flow conditions and comparing the modeled flows with the recorded flows at the meter locations. The assumed diurnal curves that serve as input to the model were iteratively adjusted until the recorded and recorded sewage flow hydrographs achieved reasonable agreement.

Simulations of future sewage flow conditions were performed by developing input data sets that included sewage generation projections for the assumed ultimate conditions. Pipe reaches, in which simulated peak flows exceeded a specified trigger criterion, were identified as potential improvement reaches. Improvements required to provide adequate capacity for projected flows were then determined through an iterative modeling process. The process consists of simulating flow conditions after increasing the diameter of downstream portions of the identified reaches. In

subsequent iterations, pipes were increased in diameter until the projected peak flow could be conveyed through the reach without exceeding the specified design flow criteria.

6.2 Limitations of Modeling

The hydraulic model, which was utilized as the primary planning tool for the sewer capacity analysis, provides an accurate simulation of flow conditions within a sanitary sewer system in response to existing and future sewage loading. The accuracy of the simulation, however, is directly related to the accuracy of the model input data, including physical parameters and sewage loading projections. For example, in a case where roots had entered the pipeline, thereby causing a restriction of flow, the model would be unable to predict the reduction in flow through this obstruction. Consequently, a general understanding of the data sources is critical in interpreting the modeling results.

The physical parameters of the model, including the pipe diameter, slope, and roughness coefficients were based principally on City's GIS database information. Where this data appeared to be inaccurate, construction drawings were reviewed and the input data corrected.

Network connectivity refers to the flow path followed by sewage within the sewer system. The connectivity is a function of the relative slope of each sewer pipe and the relative invert elevations of the incoming and outgoing sewer pipes at manholes. For example, a manhole may have two or more sewer pipes, which could convey flow away from the manhole. If the invert (bottom) of one of these pipes is lower than the other, the downstream flow path at this manhole would follow the lower pipe.

Sewage loading projections were based on calibrated flow rates. As previously described, flow rates used for calibration were based on actual monitored flows at key points in the trunk system measured in October 2005. This period included the weekends.

Since a degree of uncertainty exists in both the physical data and the sewage loading projections used as model inputs, reaches identified by model simulations as near or at capacity should be subject to additional engineering evaluation prior to improvement. Such evaluation may include field inspection, video monitoring and flow metering.

The results of model run evaluating the existing collection system for existing and ultimate flow conditions are summarized in Table 7-1.

Table 7-1
Sewer Analysis Results (Existing and Ultimate Conditions)

Name	Diameter, ft	Slope (%)	Theoretical "Full" Flow (cfs)	Existing Estimated Peak Flow (cfs)	Existing Estimated % Full	Future Estimated Peak Flow (cfs)	Future Estimated % Full
P001	3	0.4923	46.79	28.52	61%	36.70	78%
P002	2.5	0.0800	11.59	22.98	198%	27.69	239%
P003	2.5	0.0800	11.59	22.98	198%	27.69	239%
P004	4.25	0.0810	48.10	22.98	48%	27.69	58%
P005	4.25	0.1382	62.84	22.98	37%	27.69	44%
P006	4.25	0.0810	48.10	22.98	48%	27.70	58%
P007	4.25	0.0780	47.20	22.99	49%	27.71	59%
P008	4.25	0.0790	47.50	22.99	48%	27.72	58%
P009	4.25	0.0820	48.40	22.99	48%	27.73	57%
P010	4.25	0.0800	47.80	22.99	48%	27.74	58%
P011	4.25	0.0750	46.29	22.99	50%	27.75	60%
P012	3.5	0.0800	28.47	2.48	9%	3.05	11%
P013	2.25	0.6190	24.34	2.49	10%	3.07	13%
P014	2.25	0.6190	24.34	2.49	10%	3.07	13%
P015	2.25	0.6510	24.96	2.49	10%	3.07	12%
P016	2.25	0.7000	25.88	2.49	10%	3.07	12%
P017	2.25	0.6750	25.42	2.49	10%	3.07	12%
P018	2.25	0.5590	23.13	2.49	11%	3.07	13%
P019	2.25	0.5490	22.92	2.49	11%	3.07	13%
P020	2.25	0.8200	28.01	2.49	9%	3.07	11%
P021	2.25	0.6600	25.13	2.29	9%	2.86	11%
P022	2.25	0.7060	25.99	2.29	9%	2.86	11%
P023	2.25	0.6190	24.34	2.29	9%	2.86	12%
P024	2.25	0.5530	23.00	2.29	10%	2.86	12%
P025	2.25	0.6020	24.00	2.29	10%	2.86	12%
P026	2.25	0.6050	24.06	2.29	9%	2.86	12%
P027	1.25	0.1960	2.85	0.29	10%	0.73	26%
P028	1.25	0.1990	2.87	0.29	10%	0.73	25%
P029	1.25	0.2000	2.88	0.19	7%	0.49	17%
P030	1.25	0.5670	4.85	0.19	4%	0.49	10%
P031	1.25	0.2750	3.38	0.19	6%	0.49	14%
P032	1.25	0.3000	3.53	0.19	5%	0.49	14%
P033	1.25	0.1990	2.87	0.19	7%	0.49	17%
P034	1.25	0.2830	3.43	0.19	6%	0.49	14%
P035	1.25	0.1990	2.87	0.19	7%	0.49	17%
P036	1.25	0.1999	2.88	0.19	7%	0.49	17%
P037	1.25	0.1979	2.86	0.10	3%	0.24	9%
P038	1.25	0.3033	3.55	0.10	3%	0.24	7%
P039	1.25	0.2098	2.95	0.10	3%	0.24	8%
P040	1.25	0.2880	3.46	0.10	3%	0.24	7%
P041	1.25	0.2000	2.88	0.10	3%	0.24	9%
P042	3	1.5263	82.39	5.57	7%	9.02	11%
P043	2.25	1.6142	39.30	5.57	14%	9.02	23%
P044	2.25	0.0900	9.28	5.57	60%	9.02	97%
P045	2.25	0.0920	9.38	5.24	56%	8.19	87%
P046	2.25	0.0910	9.33	5.24	56%	8.19	88%
P047	2.25	0.0920	9.38	4.44	47%	6.34	68%
P048	2.25	0.0910	9.33	4.45	48%	6.35	68%

Table 7-1
Sewer Analysis Results (Existing and Ultimate Conditions)

Name	Diameter, ft	Slope (%)	Theoretical "Full" Flow (cfs)	Existing Estimated Peak Flow (cfs)	Existing Estimated % Full	Future Estimated Peak Flow (cfs)	Future Estimated % Full
P049	2.25	0.0890	9.23	4.45	48%	6.35	69%
P050	2.25	0.0900	9.28	4.45	48%	6.35	68%
P051	2.25	0.0320	5.53	4.45	80%	6.35	115%
P052	2.25	0.0400	6.19	4.45	72%	6.36	103%
P053	2.25	0.1500	11.98	4.45	37%	6.36	53%
P054	2.25	0.1500	11.98	4.45	37%	6.36	53%
P055	2.25	0.0910	9.33	4.45	48%	6.36	68%
P056	2	0.1660	9.20	3.18	35%	4.86	53%
P057	2	0.1630	9.12	3.19	35%	4.86	53%
P058	2	0.0935	6.91	3.19	46%	4.86	70%
P059	3	0.1192	23.02	6.03	26%	7.72	34%
P059B	2	0.1547	8.88	2.15	24%	3.50	39%
P059C	2.75	0.3256	30.16	4.99	17%	6.37	21%
P060	3	0.0970	20.77	6.02	29%	7.72	37%
P061	3	0.1020	21.30	6.02	28%	7.72	36%
P062	3	0.0980	20.88	6.02	29%	7.72	37%
P063	3	0.0970	20.77	6.02	29%	7.72	37%
P064	3	0.1560	26.34	6.02	23%	7.72	29%
P065	3	0.0990	20.98	6.02	29%	7.72	37%
P066	3	0.0970	20.77	6.02	29%	7.72	37%
P067	3	0.0990	20.98	6.02	29%	7.72	37%
P068	3	0.1000	21.09	6.02	29%	7.73	37%
P069	3	0.0990	20.98	6.02	29%	7.73	37%
P070	3	0.1080	21.91	6.02	27%	7.73	35%
P071	3	0.2410	32.74	6.02	18%	7.73	24%
P072	3	0.1010	21.19	6.02	28%	7.73	36%
P073	3	0.0980	20.88	6.02	29%	7.73	37%
P074	3	0.1050	21.61	6.02	28%	7.74	36%
P075	3	0.1015	21.24	6.02	28%	7.74	36%
P076	2.75	0.1665	21.57	12.22	57%	14.94	69%
P077	2.75	0.2221	24.91	12.22	49%	14.94	60%
P078	2.75	0.2010	23.70	12.22	52%	14.94	63%
P079	2.75	0.1980	23.52	12.22	52%	14.94	64%
P080	2.75	0.2000	23.64	12.22	52%	14.94	63%
P081	2.75	0.1890	22.98	12.22	53%	14.94	65%
P082	2.75	0.2180	24.68	12.22	50%	14.94	61%
P083	2.75	0.2280	25.24	12.22	48%	14.94	59%
P084	2.75	0.3370	30.69	12.22	40%	14.95	49%
P085	2.75	0.1990	23.58	12.22	52%	14.95	63%
P086	2.75	0.2040	23.88	12.22	51%	14.95	63%
P087	2.75	0.2038	23.86	12.22	51%	14.95	63%
P088	2.75	0.2035	23.85	12.22	51%	14.95	63%
P089	2.75	0.2030	23.82	12.22	51%	14.96	63%
P090	2.75	0.2010	23.70	12.22	52%	15.02	63%
P091	2.75	0.2000	23.64	0.02	0%	10.82	46%
P092	2	1.1250	23.96	12.22	51%	4.24	18%
P093	3.5	0.1010	31.98	20.44	64%	24.30	76%
P094	3.5	0.0990	31.67	20.43	65%	24.30	77%

Table 7-1
Sewer Analysis Results (Existing and Ultimate Conditions)

Name	Diameter, ft	Slope (%)	Theoretical "Full" Flow (cfs)	Existing Estimated Peak Flow (cfs)	Existing Estimated % Full	Future Estimated Peak Flow (cfs)	Future Estimated % Full
P095	3.5	0.0990	31.67	20.43	65%	24.30	77%
P096	3.5	0.0960	31.18	20.43	66%	24.31	78%
P097	3.5	0.0980	31.51	20.44	65%	24.31	77%
P098	3.5	0.1010	31.98	20.46	64%	24.33	76%
P099	3.5	6.6670	259.86	20.35	8%	24.22	9%
P100	2.75	0.2080	24.11	18.24	76%	21.85	91%
P101	2.75	0.2000	23.64	18.22	77%	21.84	92%
P102	2.75	0.2000	23.64	18.22	77%	21.84	92%
P103	2.75	0.1990	23.58	18.22	77%	21.84	93%
P104	2.75	0.2030	23.82	18.23	77%	21.84	92%
P105	2.75	0.2000	23.64	18.23	77%	21.84	92%
P106	2.75	0.2000	23.64	18.23	77%	21.84	92%
P107A	2.75	0.2271	25.19	16.97	67%	20.32	81%
P109	2.75	0.2289	25.29	16.97	67%	20.32	80%
P110	2.75	0.2400	25.90	12.04	46%	13.97	54%
P111	2.25	0.1200	10.72	8.58	80%	10.23	95%
P112	2.25	0.1200	10.72	8.58	80%	10.23	95%
P113	2.25	0.1200	10.72	8.58	80%	10.23	95%
P114	2.25	0.1200	10.72	8.58	80%	10.23	95%
P115	2.25	0.1200	10.72	8.58	80%	10.23	95%
P116	2.25	0.1200	10.72	8.58	80%	10.23	95%
P117	2.25	0.1200	10.72	8.58	80%	10.23	96%
P118	2.25	0.1170	10.58	8.58	81%	10.24	97%
P119	2.25	0.1170	10.58	8.58	81%	10.24	97%
P120	2.25	0.1170	10.58	8.58	81%	10.25	97%
P121	2.25	0.1170	10.58	8.58	81%	10.25	97%
P122	2.25	0.1170	10.58	8.58	81%	10.25	97%
P122A	2.75	0.1954	23.36	6.21	27%	7.19	31%
P123	2.25	0.3057	17.10	2.46	14%	3.07	18%
P124	1.5	0.8629	9.73	2.46	25%	3.07	32%
P125	1.5	0.9000	9.94	2.46	25%	3.07	31%
P126	1.5	0.8923	9.90	2.46	25%	3.07	31%
P127	2	0.4431	15.04	2.14	14%	2.79	19%
P133	2	0.3170	12.72	2.14	17%	2.79	22%
P134	2	0.3180	12.74	2.14	17%	2.79	22%
P135	1.25	0.4590	4.36	2.14	49%	2.79	64%
P136	1.25	0.6000	4.99	2.14	43%	2.79	56%
P137	1.25	0.6000	4.99	2.14	43%	2.79	56%
P138	1.25	0.6100	5.03	2.14	43%	2.79	55%
P139	1.25	0.4290	4.22	2.14	51%	2.79	66%
P140	1.25	0.7690	5.65	2.14	38%	2.79	49%
P141	1.5	0.1340	3.84	2.14	56%	2.79	73%
P142	1.5	0.1250	3.70	2.14	58%	2.79	75%
P143	1.5	0.1240	3.69	2.14	58%	2.79	76%
P144	1.5	0.1430	3.96	2.14	54%	2.79	70%
P145	1.5	0.1280	3.75	2.14	57%	2.79	74%
P171	1.25	0.3800	3.97	0.74	19%	0.93	24%
P171A	1.25	0.4150	4.15	0.74	18%	0.93	22%

Table 7-1
Sewer Analysis Results (Existing and Ultimate Conditions)

Name	Diameter, ft	Slope (%)	Theoretical "Full" Flow (cfs)	Existing Estimated Peak Flow (cfs)	Existing Estimated % Full	Future Estimated Peak Flow (cfs)	Future Estimated % Full
P171B	1.25	0.3210	3.65	0.74	20%	0.93	26%
P172	1.25	0.3820	3.98	0.74	19%	0.93	23%
P173	1.25	0.3790	3.96	0.74	19%	0.93	24%
P174	1.25	0.3870	4.01	0.74	19%	0.93	23%
P175	1.25	0.3920	4.03	0.74	18%	0.93	23%
P176	1.25	0.4040	4.09	0.74	18%	0.93	23%
P177	1.25	0.3920	4.03	0.74	18%	0.93	23%
P178	1.25	0.3880	4.01	0.74	18%	0.93	23%
P179	1.25	0.3820	3.98	0.74	19%	0.93	23%
P180	1.25	0.3870	4.01	0.74	19%	0.93	23%
P181	1.25	0.1240	2.27	1.48	65%	1.86	82%
P182	1.25	0.1200	2.23	1.48	66%	1.86	83%
P183	1.25	0.1200	2.23	1.48	66%	1.86	83%
P184	1.25	0.1220	2.25	1.48	66%	1.86	83%
P185	1.25	0.1480	2.48	1.48	60%	1.86	75%
P186	1.25	0.1180	2.21	1.48	67%	1.86	84%
P187	1.25	0.1240	2.27	1.48	65%	1.86	82%
P188	1.25	15.7425	25.55	1.48	6%	1.86	7%
P189	1.5	0.1400	3.92	2.95	75%	3.68	94%
P190	1.5	0.1400	3.92	2.95	75%	3.68	94%
P191	1.5	0.1400	3.92	2.95	75%	3.71	95%
P191A	1.5	0.1400	3.92	2.95	75%	3.72	95%
P192	1.5	0.1400	3.92	3.68	94%	4.57	116%
P193	1.5	0.1400	3.92	3.68	94%	4.57	116%
P194	1.5	0.1400	3.92	3.68	94%	4.57	116%
P195	1.5	0.1400	3.92	3.68	94%	4.57	116%
P196	1.75	0.1796	6.70	2.76	41%	3.39	51%
P197	1.75	0.2803	8.37	2.76	33%	3.39	40%
P198	1.75	0.2690	8.20	2.76	34%	3.39	41%
P199	1.75	0.3470	9.32	2.76	30%	3.39	36%
P200	1.75	0.3490	9.34	2.76	30%	3.39	36%
P201	1.75	0.3480	9.33	2.76	30%	3.39	36%
P202	1.75	0.4020	10.03	2.76	28%	3.39	34%
P203	1.75	0.6220	12.47	2.76	22%	3.39	27%
P204	1.75	0.4070	10.09	2.76	27%	3.39	34%
P205	1	1.5380	4.40	1.65	37%	1.82	41%
P206	1	1.5530	4.42	0.83	19%	0.91	21%
P207	1.25	0.4420	4.28	0.83	19%	0.91	21%
P208	1.25	0.4400	4.27	0.83	19%	0.91	21%
P209	1.25	0.4400	4.27	0.83	19%	0.91	21%
P210	1.25	0.4000	4.07	0.83	20%	0.91	22%
P211	1.25	0.4010	4.08	0.83	20%	0.91	22%
P212	1.25	0.3940	4.04	0.83	20%	0.92	23%
P213	1.25	0.6040	5.00	0.83	17%	0.92	18%
P214	2.25	0.1110	10.31	1.12	11%	1.19	12%
P215	2.25	0.0970	9.63	1.12	12%	1.19	12%
P216	2.25	0.1130	10.40	1.12	11%	1.18	11%
P217	2.25	0.1130	10.40	1.12	11%	1.18	11%

Table 7-1
Sewer Analysis Results (Existing and Ultimate Conditions)

Name	Diameter, ft	Slope (%)	Theoretical "Full" Flow (cfs)	Existing Estimated Peak Flow (cfs)	Existing Estimated % Full	Future Estimated Peak Flow (cfs)	Future Estimated % Full
P218	2.25	0.1150	10.49	1.12	11%	1.18	11%
P219	2.25	0.1120	10.35	1.12	11%	1.18	11%
P220	2.25	0.1140	10.44	1.12	11%	1.18	11%
P221	2.25	0.0650	7.89	1.12	14%	1.18	15%
P222	2.25	0.2000	13.83	1.12	8%	1.18	9%
P223	2.25	0.2000	13.83	1.12	8%	1.18	9%
P224	1.5	0.2000	4.69	1.12	24%	1.18	25%
P225	1.5	0.2010	4.70	1.12	24%	1.18	25%
P226	1.25	0.1800	2.73	1.12	41%	1.18	43%
P227	1.25	0.1000	2.04	1.12	55%	1.18	58%
P228	1.25	0.1019	2.06	1.12	54%	1.18	58%
P229	1.25	0.1110	2.15	1.12	52%	1.18	55%
P230	1.25	0.1170	2.20	1.12	51%	1.18	54%
P231	1.25	0.1170	2.20	1.12	51%	1.18	54%
P232	1.25	0.5130	4.61	1.12	24%	1.18	26%
P233	1.25	0.4160	4.15	1.12	27%	1.19	29%
P234	1.25	0.6570	5.22	1.12	21%	1.19	23%
P235	1.25	0.6630	5.24	1.12	21%	1.19	23%
P236	1.5	0.2000	4.69	1.12	24%	1.19	25%
P237	1.5	0.2200	4.91	1.12	23%	1.19	24%
P238	1.5	0.2340	5.07	1.12	22%	1.19	23%
P239	1.5	5.7040	25.02	1.12	4%	1.19	5%
P240	1.25	0.4290	4.22	1.12	26%	1.19	28%
P240A	1.25	0.4280	4.21	1.12	27%	1.20	28%
P240B	1	1.9420	4.95	1.12	23%	1.19	24%
P240C	1.25	2.6370	10.46	1.12	11%	1.19	11%
P244	1	1.8870	4.88	1.12	23%	1.19	24%
P245	1	2.2620	5.34	1.12	21%	1.19	22%
P246	1.25	0.7570	5.60	1.12	20%	1.19	21%
P247	1	0.7510	3.08	1.12	36%	1.19	39%
P248	1	2.0730	5.11	1.12	22%	1.19	23%
P249	1	1.8020	4.76	0.90	19%	0.97	20%
P251	1	30.7760	19.69	0.34	2%	0.86	4%
P252	1	0.5500	2.63	0.34	13%	0.86	33%
P253	1	0.5500	2.63	0.34	13%	0.87	33%
P254	1	1.0150	3.58	0.83	23%	1.91	53%
P255	1	1.0000	3.55	0.83	24%	1.91	54%
P256	1	1.1620	3.83	0.83	22%	1.91	50%
P257	1	1.0000	3.55	0.83	24%	1.91	54%
P258A	1	0.2000	1.59	1.27	80%	1.52	96%
P259	1	0.2000	1.59	1.27	80%	1.52	96%
P260	1	0.2000	1.59	1.27	80%	1.52	96%
P261	1	0.2000	1.59	1.27	80%	1.52	96%
P262	1	0.2000	1.59	1.27	80%	1.52	96%
P263	1	0.2000	1.59	1.27	80%	1.52	96%
P264	1	0.2000	1.59	1.27	80%	1.53	96%
P265	1	0.2000	1.59	1.27	80%	1.53	96%
P266	1	0.2000	1.59	1.28	80%	1.53	96%

Table 7-1
Sewer Analysis Results (Existing and Ultimate Conditions)

Name	Diameter, ft	Slope (%)	Theoretical "Full" Flow (cfs)	Existing Estimated Peak Flow (cfs)	Existing Estimated % Full	Future Estimated Peak Flow (cfs)	Future Estimated % Full
P267	1	0.2000	1.59	1.28	80%	1.53	96%
P268	1	0.2000	1.59	1.28	80%	1.53	97%
P269	1	0.2000	1.59	1.28	81%	1.53	97%
P270	1	0.2000	1.59	1.28	81%	1.54	97%
P271	1	0.2000	1.59	1.28	81%	1.54	97%
P272	2	0.2110	10.38	5.62	54%	7.24	70%
P273	2	0.2102	10.36	5.62	54%	7.24	70%
P274	2	0.2112	10.38	5.62	54%	7.24	70%
P275	2	0.2033	10.18	5.62	55%	7.24	71%
P276	2	0.2125	10.41	5.62	54%	7.24	70%
P277	2	0.3700	13.74	5.62	41%	7.24	53%
P278	2	0.3730	13.79	5.62	41%	7.24	53%
P279	2	0.3710	13.76	5.62	41%	7.24	53%
P280	2	0.3700	13.74	5.62	41%	7.24	53%
P281	2	0.1400	8.45	5.62	67%	7.24	86%
P282	2	0.1400	8.45	5.62	67%	7.24	86%
P283	2	0.1400	8.45	5.62	67%	7.24	86%
P284	2	0.1400	8.45	5.62	67%	7.24	86%
P285	2	0.2650	11.63	5.62	48%	7.25	62%
P286	2	0.2440	11.16	5.62	50%	7.25	65%
P287	2	0.1400	8.45	5.62	67%	7.25	86%
P288	2	0.1400	8.45	5.62	67%	7.25	86%
P289	2	0.1400	8.45	5.62	67%	7.25	86%
P290	2	0.1010	7.18	5.62	78%	7.25	101%
P291	1.25	0.4990	4.55	1.48	33%	1.79	39%
P292	1.25	0.4980	4.54	1.48	33%	1.79	39%
P293	1.25	0.5230	4.66	0.45	10%	0.53	11%
P294	1.25	0.3060	3.56	0.45	13%	0.53	15%
P295	1.17	0.0280	0.90	0.45	50%	0.53	59%
P296	1.17	0.0290	0.92	0.45	49%	0.53	58%
P297	1.17	0.0290	0.92	0.45	49%	0.53	58%
P298	1.17	0.0290	0.92	0.45	49%	0.54	58%
P299	1.17	0.2420	2.66	0.46	17%	0.54	20%
P300	1.17	0.1360	1.99	0.46	23%	0.54	27%
P301	1.17	0.1360	1.99	0.46	23%	0.54	27%
P302	1.17	0.1370	2.00	0.46	23%	0.54	27%
P303	1.17	0.1450	2.06	0.46	22%	0.55	27%
P304	1	0.1400	1.33	0.46	35%	0.55	41%
P305	1	0.1400	1.33	0.46	35%	0.55	41%
P306	1	0.1390	1.32	0.46	35%	0.55	42%
P307	0.67	14.5960	4.65	1.08	23%	1.31	28%
P308	1.67	0.2200	6.55	1.08	16%	1.31	20%
P309	1.75	0.1570	6.27	0.51	8%	0.68	11%
P310	1.75	0.1330	5.77	0.51	9%	0.69	12%
P311	1.75	0.1130	5.32	0.51	10%	0.69	13%
P312	1.75	0.0990	4.98	0.51	10%	0.69	14%
P313	1.75	0.0940	4.85	0.51	11%	0.70	14%
P314	1.5	0.2130	4.84	0.51	11%	0.70	14%

Table 7-1
Sewer Analysis Results (Existing and Ultimate Conditions)

Name	Diameter, ft	Slope (%)	Theoretical "Full" Flow (cfs)	Existing Estimated Peak Flow (cfs)	Existing Estimated % Full	Future Estimated Peak Flow (cfs)	Future Estimated % Full
P315	1.5	0.1730	4.36	0.51	12%	0.70	16%
P316	1.5	0.1930	4.60	0.51	11%	0.70	15%
P317	1.5	0.1850	4.51	0.51	11%	0.70	15%
P318	1.5	0.0380	2.04	0.51	25%	0.70	34%
P319	1.5	0.2670	5.41	0.51	9%	0.70	13%
P319A	1.5	0.2513	5.25	0.08	1%	0.18	3%
P319B	1.5	0.1447	3.99	0.47	12%	0.55	14%
P320	1.75	0.2860	8.46	2.84	34%	3.79	45%
P321	1.75	0.1714	6.55	2.84	43%	3.80	58%
P322	1.75	0.1673	6.47	2.84	44%	3.80	59%
P323	1.75	0.2020	7.11	2.84	40%	3.80	53%
P324	1.75	0.2010	7.09	2.84	40%	3.80	54%
P325	1.75	0.2120	7.28	2.84	39%	3.80	52%
P326	1.75	0.2160	7.35	2.84	39%	3.80	52%
P327	1.75	0.2160	7.35	2.84	39%	3.80	52%
P328	1.75	0.2120	7.28	2.84	39%	3.80	52%
P329	1.75	0.2380	7.71	2.84	37%	3.80	49%
P330	1.75	0.2000	7.07	2.84	40%	3.80	54%
P331	1.75	0.2000	7.07	2.85	40%	3.80	54%
P332	1.25	0.3500	3.81	1.64	43%	2.53	66%
P333	1.25	0.3500	3.81	1.64	43%	2.54	67%
P334	1.25	0.3500	3.81	1.64	43%	2.54	67%
P335	1.25	0.3500	3.81	1.64	43%	2.54	67%
P336	1.25	1.2360	7.16	1.64	23%	2.54	35%
P337	1.25	1.2290	7.14	1.64	23%	2.54	36%
P338	1.25	1.2290	7.14	1.64	23%	2.54	36%
P339	1.25	1.7020	8.40	1.64	20%	2.54	30%
P340	1.25	1.6830	8.35	1.64	20%	2.54	30%
P341	1.25	1.0110	6.48	1.64	25%	2.54	39%
P342	1.25	1.0100	6.47	1.64	25%	2.54	39%
P343	1.25	1.0350	6.55	1.64	25%	2.54	39%
P344	1.25	0.9600	6.31	1.64	26%	2.54	40%
P345	1	21.8900	16.60	1.64	10%	2.54	15%
P346	1	0.5300	2.58	1.64	64%	2.54	98%
P347	1	0.5300	2.58	1.64	64%	2.56	99%
P348	1	0.5300	2.58	1.64	64%	2.57	100%
P349	1	0.5300	2.58	1.64	64%	2.60	101%
P350	1	0.6070	2.77	0.94	34%	1.11	40%
P351	1	0.4710	2.44	0.94	39%	1.11	46%
P352	1	0.4870	2.48	0.94	38%	1.11	45%
P353	1	0.8530	3.28	0.94	29%	1.11	34%
P355	1	0.3890	2.21	0.94	43%	1.11	50%
P356	1	2.0500	5.08	0.47	9%	0.56	11%
P357	1	1.4000	4.20	0.47	11%	0.56	13%
P358	1	1.3620	4.14	0.47	11%	0.56	14%
P359	1	1.4860	4.33	0.47	11%	0.56	13%
P360	1	1.4050	4.21	0.47	11%	0.56	13%
P361	1	14.2770	13.41	0.47	4%	0.56	4%

Table 7-1
Sewer Analysis Results (Existing and Ultimate Conditions)

Name	Diameter, ft	Slope (%)	Theoretical "Full" Flow (cfs)	Existing Estimated Peak Flow (cfs)	Existing Estimated % Full	Future Estimated Peak Flow (cfs)	Future Estimated % Full
P362	1	1.3950	4.19	0.47	11%	0.56	13%
P363	1	1.7200	4.65	0.48	10%	0.56	12%
P364	1	1.7210	4.66	0.48	10%	0.56	12%
P365	1	1.7480	4.69	0.48	10%	0.56	12%
P366A	1.25	0.3440	3.78	1.24	33%	1.30	34%
P366B	1.25	0.3330	3.72	1.24	33%	1.30	35%
P367	1.25	0.3350	3.73	1.24	33%	1.30	35%
P368	1.25	0.1260	2.29	1.24	54%	1.30	57%
P369	1.25	0.1410	2.42	1.24	51%	1.30	54%
P370	1.25	0.1360	2.37	1.24	52%	1.30	55%
P371	1.25	0.1420	2.43	1.24	51%	1.30	54%
P372	1.25	0.1390	2.40	1.25	52%	1.30	54%
P373	1.25	0.1400	2.41	1.25	52%	1.31	54%
P374	1.25	0.1420	2.43	1.25	51%	1.31	54%
P375	1.25	0.1410	2.42	1.25	52%	1.31	54%
P376	1.25	0.1380	2.39	1.26	52%	1.31	55%
P377	1.5	0.7450	9.04	0.71	8%	1.49	16%
P378	1.5	2.1050	15.20	0.71	5%	1.49	10%
P379	1.5	1.1010	10.99	0.71	6%	1.49	14%
P380	1.5	0.7010	8.77	0.71	8%	1.49	17%
P381	1.5	0.7010	8.77	0.71	8%	1.49	17%
P382	1.5	0.7000	8.77	0.71	8%	1.49	17%
P383	1.5	1.0000	10.48	0.71	7%	1.49	14%
P384	1.5	1.0000	10.48	0.71	7%	1.49	14%
P385	1.5	1.4720	12.71	0.71	6%	1.49	12%
P386	1.5	1.2090	11.52	0.71	6%	1.49	13%
P387	1.5	0.9780	10.36	0.71	7%	1.50	14%
P388	1.5	0.9750	10.35	0.71	7%	1.49	14%
P389	1	0.9370	3.44	0.71	21%	1.49	44%
P390	1.5	1.8220	14.14	0.71	5%	1.49	11%
P391	1.5	1.6730	13.55	0.36	3%	0.81	6%
P392	1	1.3460	4.12	0.36	9%	0.81	20%
P393	1	1.3310	4.09	0.36	9%	0.81	20%
P394	1	1.3340	4.10	0.36	9%	0.69	17%
P395	1.5	0.1700	4.32	2.02	47%	2.66	62%
P396	1.5	0.1230	3.67	2.02	55%	2.66	72%
P397	1.5	0.1260	3.72	2.02	54%	2.66	72%
P398	1.5	0.1260	3.72	2.02	54%	2.66	72%
P399	1.5	0.1280	3.75	2.02	54%	2.66	71%
P400	1.5	0.1270	3.73	2.02	54%	2.66	71%
P401	1.5	0.1270	3.73	2.02	54%	2.67	71%
P402	1.5	0.1260	3.72	2.03	54%	2.67	72%
P403	1.5	0.1300	3.78	2.03	54%	2.67	71%
P404	1.5	0.1260	3.72	2.03	54%	2.67	72%
P405	1.5	0.1260	3.72	2.03	54%	2.67	72%
P406	1.5	0.1260	3.72	2.03	54%	2.67	72%
P407	1	1.4410	4.26	0.10	2%	0.28	7%
P408	1	1.9400	4.94	0.10	2%	0.28	6%

Table 7-1
Sewer Analysis Results (Existing and Ultimate Conditions)

Name	Diameter, ft	Slope (%)	Theoretical "Full" Flow (cfs)	Existing Estimated Peak Flow (cfs)	Existing Estimated % Full	Future Estimated Peak Flow (cfs)	Future Estimated % Full
P409	1.25	0.7700	5.65	0.10	2%	0.28	5%
P410	1.25	0.5580	4.81	0.10	2%	0.28	6%
P411	1.25	0.5680	4.85	0.10	2%	0.28	6%
P412	1	2.3650	5.46	0.10	2%	0.28	5%
P413	1	1.7840	4.74	0.10	2%	0.28	6%
P414	1	2.1600	5.22	0.10	2%	0.28	5%
P415	1	1.6800	4.60	0.10	2%	0.28	6%
P416	1	1.7060	4.64	0.10	2%	0.28	6%
P417	1	1.5500	4.42	0.10	2%	0.28	6%
P418	1	1.5000	4.35	0.10	2%	0.28	6%
P419	1	1.5010	4.35	0.10	2%	0.28	6%
P420	1	1.5000	4.35	0.10	2%	0.28	6%
P421	1	1.4970	4.34	0.10	2%	0.28	6%
P422	1	2.4400	5.54	0.10	2%	0.28	5%
P423	1	2.2840	5.36	0.10	2%	0.28	5%
P424	1	1.3890	4.18	1.43	34%	1.75	42%
P425	1	1.0000	3.55	1.43	40%	1.75	49%
P426	1	1.0000	3.55	1.43	40%	1.75	49%
P427	1	1.0010	3.55	1.43	40%	1.75	49%
P428	1	1.1770	3.85	0.94	24%	1.11	29%
P429	1	1.3020	4.05	0.94	23%	1.11	27%
P430	1	1.3020	4.05	0.94	23%	1.11	27%
P431	1	0.9610	3.48	0.94	27%	1.11	32%
P432	1	1.1770	3.85	0.72	19%	0.86	22%
P433	0.83	1.5470	2.68	0.49	18%	0.64	24%
P434	1	0.8030	3.18	0.49	16%	0.64	20%
P435	1	0.6000	2.75	0.49	18%	0.64	23%
P436	1	12.4740	12.53	0.49	4%	0.64	5%
P437	1	0.9150	3.39	0.21	6%	0.25	7%
P438	1	0.9150	3.39	0.21	6%	0.25	7%
P439	1	0.9170	3.40	0.21	6%	0.25	7%
P440	2	0.1000	7.14	0.36	5%	0.44	6%
P441	2	0.1010	7.18	0.36	5%	0.41	6%
P442	2	0.1030	7.25	0.36	5%	0.41	6%
P443	2	0.0850	6.59	0.36	6%	0.42	6%
P444	2	0.1150	7.66	0.36	5%	0.42	5%
P445	1.5	0.0990	3.30	1.55	47%	1.70	51%
P446	1.5	0.0990	3.30	1.55	47%	1.70	51%
P447	1.5	0.1040	3.38	1.55	46%	1.70	50%
P448	1.5	0.1000	3.31	1.55	47%	1.70	51%
P449	1.5	0.1000	3.31	1.55	47%	1.70	51%
P450	1.5	0.0880	3.11	1.55	50%	1.70	55%
P451	1.5	0.1040	3.38	1.55	46%	1.70	50%
P452	1.5	0.1080	3.44	1.55	45%	1.70	49%
P453	1.5	0.1060	3.41	1.55	45%	1.70	50%
P454	1.75	0.1250	5.59	1.55	28%	1.70	30%
P455	1.75	0.1090	5.22	1.55	30%	1.70	33%
P456	1.75	0.1080	5.20	1.55	30%	1.70	33%

Table 7-1
Sewer Analysis Results (Existing and Ultimate Conditions)

Name	Diameter, ft	Slope (%)	Theoretical "Full" Flow (cfs)	Existing Estimated Peak Flow (cfs)	Existing Estimated % Full	Future Estimated Peak Flow (cfs)	Future Estimated % Full
P457	1.75	0.1080	5.20	1.55	30%	1.70	33%
P458	1.75	0.1020	5.05	1.23	24%	1.33	26%
P459A	1	-4.6817	Siphon	0.32		0.33	Siphon
P459B	1	-15.1909	Siphon	0.32		0.33	Siphon
P459C	1	0.0000	Siphon	0.32		0.33	Siphon
P459D	1	15.1910	Siphon	0.32		0.33	Siphon
P459E	1	4.0115	Siphon	0.32		0.33	Siphon
P459F	1	4.0115	Siphon	0.32		0.33	Siphon
P459G	1	15.1910	Siphon	0.32		0.33	Siphon
P459H	1	0.0000	Siphon	0.32		0.33	Siphon
P459I	1	-15.1909	Siphon	0.32		0.33	Siphon
P459J	1	-4.6817	Siphon	0.32		0.33	Siphon
P460	1.75	0.1370	5.85	0.64	11%	0.67	11%
P461	1.75	0.1450	6.02	0.43	7%	0.45	7%
P462	1.75	0.1440	6.00	0.22	4%	0.23	4%
P463	1.75	0.1430	5.98	0.22	4%	0.23	4%
P464	1.75	0.1420	5.96	0.22	4%	0.23	4%
P465	1	0.2070	1.61	0.22	14%	0.23	14%
P466	1	0.2000	1.59	0.22	14%	0.23	14%
P467	1	0.2000	1.59	0.22	14%	0.23	14%
P468	1	0.2010	1.59	0.22	14%	0.23	14%
P469	1	0.2010	1.59	0.22	14%	0.23	14%
P470	1	0.2010	1.59	0.22	14%	0.23	15%
P471	1	0.2020	1.60	0.22	14%	0.23	14%
P472	1	0.2000	1.59	0.22	14%	0.23	15%
P473	1.5	0.1180	3.60	0.45	13%	0.51	14%
P474	1.5	0.1440	3.98	0.45	11%	0.51	13%
P475	1.5	0.3700	6.37	0.45	7%	0.51	8%
P476	1.5	0.1730	4.36	0.22	5%	0.23	5%
P477	1	0.3700	2.16	0.15	7%	0.17	8%
P478	1	0.3680	2.15	0.15	7%	0.17	8%
P479	1.25	0.1800	2.73	0.30	11%	0.34	12%
P480	1.25	0.1800	2.73	0.30	11%	0.34	12%
P481	1.25	0.1820	2.75	0.30	11%	0.34	12%
P482	1	0.1810	1.51	0.15	10%	0.17	11%
P483	1	0.1040	1.14	0.15	13%	0.17	15%
P484	1	1.8500	4.83	0.15	3%	0.17	4%
P485	1	0.2000	1.59	0.15	10%	0.17	11%
P486	1	0.2000	1.59	0.15	10%	0.17	11%
P487	1	0.1940	1.56	0.15	10%	0.17	11%
P488	1	0.2060	1.61	0.15	9%	0.17	11%
P489	1	0.2010	1.59	0.15	10%	0.17	11%
P490	1	0.1990	1.58	0.15	10%	0.17	11%
P491	1	0.2000	1.59	0.15	10%	0.17	11%
P492	1	0.2000	1.59	0.15	10%	0.17	11%
P493	1	0.2000	1.59	0.15	10%	0.17	11%
P494	1	0.1990	1.58	0.15	10%	0.17	11%
P495	1	0.3060	1.96	0.15	8%	0.17	9%

Table 7-1
Sewer Analysis Results (Existing and Ultimate Conditions)

Name	Diameter, ft	Slope (%)	Theoretical "Full" Flow (cfs)	Existing Estimated Peak Flow (cfs)	Existing Estimated % Full	Future Estimated Peak Flow (cfs)	Future Estimated % Full
P496	1	0.2670	1.83	0.15	8%	0.17	9%
P497	1	0.2650	1.83	0.15	8%	0.17	9%
P498	1	0.3830	2.20	0.15	7%	0.17	8%
P520	1.25	0.0830	1.86	0.74	40%	0.93	50%
P521	1.25	0.0790	1.81	0.74	41%	0.93	52%
P522	1.25	0.0970	2.01	0.74	37%	0.93	46%
P523	1.25	0.1020	2.06	0.74	36%	0.93	45%
P524	1.25	0.1010	2.05	0.74	36%	0.93	45%
P525	1.25	0.0990	2.03	0.74	37%	0.93	46%
P526	1.25	0.1010	2.05	0.74	36%	0.93	45%
P527	1.25	0.1010	2.05	0.74	36%	0.93	45%
P528	1.25	0.1000	2.04	0.74	36%	0.93	46%
P529	1.25	0.1000	2.04	0.74	36%	0.93	46%
P530	1.25	0.1000	2.04	0.74	36%	0.93	46%
P531	1.25	0.0910	1.94	0.74	38%	0.93	48%
P531A	1.25	0.1776	2.71	0.74	27%	0.93	34%
P534	1.25	0.6090	5.03	0.74	15%	0.93	19%
P535	1	0.1770	1.49	0.74	50%	0.93	62%
P536	1	0.1100	1.18	0.74	63%	0.93	79%
P537	1	0.1126	1.19	0.74	62%	0.93	78%
P538	1	0.1130	1.19	0.74	62%	0.93	78%
P539	1	0.1120	1.19	0.74	62%	0.93	78%
P540	1	0.1510	1.38	0.74	54%	0.93	68%
P541	1	0.1510	1.38	0.74	54%	0.93	68%
P542	2	0.2154	10.48	0.78	7%	0.96	9%
P543	2	0.0150	2.77	0.78	28%	0.95	34%
P544	2	0.1150	7.66	0.82	11%	0.99	13%
P545	1.75	0.1710	6.54	0.92	14%	1.11	17%
P546	1.75	1.1380	16.87	1.77	11%	2.06	12%
P547	1.75	0.1490	6.10	0.81	13%	0.97	16%
P548	1	11.3770	11.97	0.70	6%	0.81	7%
P548A	0.67	0.5770	0.93	0.08	8%	0.13	14%
P548B	0.67	0.5810	0.93	0.08	8%	0.13	14%
P549	1	0.4010	2.25	0.70	31%	0.81	36%
P550	1	0.4620	2.41	0.78	32%	0.94	39%
P551	1	0.4810	2.46	0.78	32%	0.94	38%
P552	1	0.7960	3.17	0.78	25%	0.94	30%
P553	1	0.3990	2.24	0.78	35%	0.94	42%
P554	1	0.4010	2.25	0.78	35%	0.94	42%
P555	1	0.5970	2.74	0.78	28%	0.94	34%
P556	1	0.5000	2.51	0.78	31%	0.94	38%
P557	1	0.5010	2.51	0.78	31%	0.94	37%
P558	1	0.7120	2.99	0.78	26%	0.94	31%
P559	1	0.7150	3.00	0.78	26%	0.94	31%
P560	1	0.7170	3.01	0.78	26%	0.94	31%
P561	1	0.7150	3.00	0.78	26%	0.94	31%
P562	1	1.3920	4.19	0.78	19%	0.94	22%
P563	0.67	1.1670	1.32	0.78	59%	0.94	72%

Table 7-1
Sewer Analysis Results (Existing and Ultimate Conditions)

Name	Diameter, ft	Slope (%)	Theoretical "Full" Flow (cfs)	Existing Estimated Peak Flow (cfs)	Existing Estimated % Full	Future Estimated Peak Flow (cfs)	Future Estimated % Full
P564	1	0.5980	2.74	0.78	28%	0.94	34%
P565	1	0.6030	2.76	0.78	28%	0.94	34%
P566	1	0.5420	2.61	0.78	30%	0.94	36%
P567	1	0.6960	2.96	0.78	26%	0.94	32%
P574	2	0.1140	7.63	0.78	10%	0.93	12%
P575	2	0.1150	7.66	0.78	10%	0.92	12%
P576	2	0.1150	7.66	0.78	10%	0.99	13%
P577	2	0.1110	7.53	0.78	10%	1.20	16%
P582	1	0.5449	2.62	1.14	44%	1.52	58%
P583	1	0.2801 0.32	1.88	1.15	61%	1.53	81%
P584 Flat	1	0.2990 - 0.32	1.94	1.15	59%	1.53	79%
P585	1	0.1000	1.12	1.15	102%	1.53	136%
P586	1	0.1000	1.12	1.15	102%	1.53	136%
P587	0.83	1.0020	2.16	1.15	53%	1.53	71%
P588	0.83	0.5000	1.53	1.15	75%	1.53	100%
P589	0.83	0.6700	1.77	1.15	65%	1.53	87%
P590	0.83	0.6710	1.77	1.15	65%	1.53	87%
P591	0.83	1.4610	2.61	0.81	31%	0.93	36%
P592	0.83	1.2520	2.41	0.81	34%	0.93	38%
P593	0.83	1.3160	2.48	0.81	33%	0.93	37%
P594	0.83	0.2180	1.01	0.81	81%	0.93	92%
P595	0.83	0.2180	1.01	0.81	81%	0.93	92%
P596	0.83	2.7580	3.58	0.81	23%	0.93	26%
P597	0.67	1.8270	1.65	0.81	49%	0.93	56%
P598	0.67	1.8270	1.65	0.81	49%	0.93	56%
P599	0.67	1.4910	1.49	0.81	55%	0.93	62%
P59A	2	0.2000	10.10	2.15	21%	3.50	35%
P600	0.67	1.1020	1.28	0.81	63%	0.93	73%
P601	0.67	1.0380	1.24	0.81	65%	0.93	75%
P602	0.67	1.3060	1.39	0.81	58%	0.93	67%
P603	0.67	1.3030	1.39	0.81	58%	0.93	67%
P604	0.67	1.2700	1.37	0.81	59%	0.93	68%
P605	0.67	1.2730	1.37	0.81	59%	0.93	67%
P606	0.67	1.0850	1.27	0.81	64%	0.93	73%
P607	0.67	1.1110	1.28	0.81	63%	0.93	72%
P608	0.67	1.0670	1.26	0.81	64%	0.93	74%
P609	0.67	1.0920	1.27	0.81	64%	0.93	73%
P610	0.67	1.1430	1.30	0.81	62%	0.93	71%
P611	0.67	1.0930	1.27	0.81	64%	0.93	73%
P612	0.67	0.9220	1.17	0.81	69%	0.93	79%
P613	0.67	0.8660	1.13	0.81	72%	0.93	82%
P614	1.25	0.3620	3.87	0.41	10%	0.46	12%
P615	1.25	0.3590	3.86	0.41	11%	0.46	12%
P616	1.25	0.2790	3.40	0.41	12%	0.46	14%
P617	1.25	1.4720	7.81	0.41	5%	0.46	6%
P618	1.25	0.3590	3.86	0.41	11%	0.46	12%
P619	1.25	1.2130	7.09	0.41	6%	0.46	7%
P620	1.25	0.7400	5.54	0.41	7%	0.46	8%

Table 7-1
Sewer Analysis Results (Existing and Ultimate Conditions)

Name	Diameter, ft	Slope (%)	Theoretical "Full" Flow (cfs)	Existing Estimated Peak Flow (cfs)	Existing Estimated % Full	Future Estimated Peak Flow (cfs)	Future Estimated % Full
P621	1.25	0.3550	3.84	0.41	11%	0.46	12%
P622	1	0.3600	2.13	1.92	90%	2.34	110%
P623	1	0.3600	2.13	1.92	90%	2.34	110%
P624	1	0.3600	2.13	1.92	90%	2.34	110%
P625	1	0.4400	2.35	1.92	81%	2.34	99%
P626	1	0.5400	2.61	1.92	73%	2.34	90%
P627	1	0.6400	2.84	1.92	67%	2.34	82%
P628	1	0.5750	2.69	1.92	71%	2.34	87%
P629	1	0.6380	2.83	1.92	68%	2.34	82%
P630	1	0.7950	3.16	1.92	61%	2.34	74%
P631	2.25	0.1950	13.66	9.05	66%	11.41	84%
P632	2.25	0.1930	13.59	9.05	67%	11.41	84%
P633	2.25	0.1920	13.55	9.05	67%	11.41	84%
P634	2.25	0.1900	13.48	9.05	67%	11.41	85%
P635	2.25	0.1910	13.52	9.05	67%	11.41	84%
P636	2.25	0.1910	13.52	9.05	67%	11.41	84%
P637	2.25	0.3870	19.24	9.05	47%	11.41	59%
P638	2.25	0.4320	20.33	9.52	47%	11.99	59%
P639	2.25	0.4210	20.07	9.51	47%	11.99	60%
P640	2.25	0.4200	20.05	9.42	47%	11.99	60%
P641	2.25	0.4110	19.83	9.21	46%	11.99	60%
P642	2.5	0.3554	24.43	12.26	50%	15.89	65%
P643	2.5	0.3570	24.49	5.36	22%	7.24	30%
P644	2.5	0.1080	13.47	5.36	40%	7.24	54%
P644A	2.5	0.5460	30.28	7.32	24%	8.65	29%
P645	2.25	0.3359	17.93	6.43	36%	7.93	44%
P646	2.25	0.1600	12.37	6.43	52%	7.93	64%
P647	2.25	0.1600	12.37	6.43	52%	7.93	64%
P648	2.25	0.1600	12.37	6.43	52%	7.93	64%
P649	2.25	0.1590	12.34	6.43	52%	7.93	64%
P650	2.25	0.1780	13.05	6.83	52%	8.52	65%
P651	1.25	0.3360	3.73	0.41	11%	0.59	16%
P652	1	0.2180	1.66	0.31	19%	0.39	24%
P653	1	0.2190	1.66	0.12	7%	0.21	13%
P654	1	0.2200	1.66	0.12	7%	0.21	13%
P655	1	0.2200	1.66	0.12	7%	0.21	13%
P656	1	0.2200	1.66	0.12	7%	0.21	13%
P657	1.25	0.2740	3.37	2.18	65%	2.31	68%
P658	1	1.1760	3.85	1.46	38%	1.54	40%
P659	1	0.2500	1.77	0.73	41%	0.77	43%
P660	1	0.3050	1.96	0.73	37%	0.77	39%
P662	1	0.3700	2.16	0.73	34%	0.77	36%
P663	1	0.2750	1.86	0.73	39%	0.77	41%
P664	1	0.1970	1.58	0.73	47%	0.77	49%
P665	1	0.2010	1.59	0.73	46%	0.77	48%
P666	1	0.1970	1.58	0.73	47%	0.77	49%
P667	1	0.1970	1.58	0.73	47%	0.77	49%
P668	1	0.2000	1.59	0.73	46%	0.77	48%

Table 7-1
Sewer Analysis Results (Existing and Ultimate Conditions)

Name	Diameter, ft	Slope (%)	Theoretical "Full" Flow (cfs)	Existing Estimated Peak Flow (cfs)	Existing Estimated % Full	Future Estimated Peak Flow (cfs)	Future Estimated % Full
P669	1	0.1970	1.58	0.73	47%	0.77	49%
P670	1	1.0470	3.63	0.73	20%	0.77	21%
P671	1	1.0000	3.55	0.73	21%	0.77	22%
P672	1	2.2060	5.27	0.73	14%	0.77	15%
P673	1.25	0.4560	4.35	0.73	17%	0.77	18%
P674	1.75	0.1010	5.03	2.12	42%	1.61	32%
P675	1.75	0.0990	4.98	2.03	41%	1.61	32%
P676	1.75	0.0990	4.98	1.91	38%	1.61	32%
P677	1.75	0.1000	5.00	1.74	35%	1.61	32%
P678	1.25	5.9420	15.70	0.27	2%	0.33	2%
P679	1.25	0.5980	4.98	0.27	6%	0.33	7%
P680	1.25	0.5940	4.96	0.27	6%	0.33	7%
P681	1.25	7.1190	17.18	0.27	2%	0.33	2%
P682	1.25	0.8000	5.76	0.14	2%	0.17	3%
P683	1.25	0.5430	4.75	0.14	3%	0.17	4%
P684	1.25	0.4000	4.07	0.14	3%	0.17	4%
P685	1.25	1.5790	8.09	0.14	2%	0.17	2%
P686	1.25	0.5110	4.60	0.14	3%	0.17	4%
P687	1.25	0.5000	4.55	0.14	3%	0.17	4%
P688	1.25	0.3970	4.06	0.14	3%	0.17	4%
P689	1.25	0.3980	4.06	0.14	3%	0.17	4%
P690	1.25	0.3980	4.06	0.14	3%	0.17	4%
P691	1.25	0.5760	4.89	0.14	3%	0.17	3%
P692	1.25	0.5000	4.55	0.14	3%	0.17	4%
P693	1.25	0.2360	3.13	0.14	4%	0.17	5%
P694	1.25	0.1010	2.05	1.39	68%	1.28	63%
P695	1.25	0.1010	2.05	1.27	62%	1.28	63%
P696	1.25	0.1010	2.05	1.16	57%	1.28	63%
P697	1.25	0.0930	1.96	1.12	57%	1.28	65%
P698	1.25	0.1070	2.11	1.12	53%	1.28	61%
P699	1.25	0.1260	2.29	1.12	49%	1.28	56%
P700	1.25	0.1010	2.05	1.12	55%	1.28	63%
P701	1.25	0.0940	1.97	1.12	57%	1.28	65%
P702	0.67	3.3869	2.24	1.12	50%	1.28	57%
P703	1	2.4720	5.58	0.57	10%	0.57	10%
P704	1	0.2960	1.93	0.34	18%	0.61	31%
P705	1	0.2940	1.92	0.34	18%	0.61	31%
P706	1	0.2960	1.93	0.34	18%	0.61	31%
P707	1	0.3050	1.96	0.34	17%	0.61	31%
P708	1	0.2950	1.93	0.34	18%	0.61	31%
P709	1	0.2950	1.93	0.34	18%	0.61	31%
P710	1	0.2920	1.92	0.34	18%	0.61	32%
P711	1	0.2940	1.92	0.34	18%	0.61	31%
P712	1	0.2930	1.92	0.34	18%	0.61	32%
P713	1	0.2980	1.94	0.34	18%	0.61	31%
P714	1.25	0.1412	2.42	1.48	61%	1.85	76%
P715	1.25	0.1360	2.37	1.48	62%	1.85	78%
P716	1.25	0.1450	2.45	1.48	60%	1.86	76%

Table 7-1
Sewer Analysis Results (Existing and Ultimate Conditions)

Name	Diameter, ft	Slope (%)	Theoretical "Full" Flow (cfs)	Existing Estimated Peak Flow (cfs)	Existing Estimated % Full	Future Estimated Peak Flow (cfs)	Future Estimated % Full
P717	1.25	0.1390	2.40	1.48	62%	1.86	78%
P718	1.25	0.1340	2.36	1.48	63%	1.86	79%
P719	1	0.9750	3.50	1.48	42%	1.86	53%
P720	1.5	0.1450	3.99	0.74	19%	0.93	23%
P722	1.5	0.1580	4.16	0.74	18%	0.93	22%
P723	1.5	0.0360	1.99	0.74	37%	0.93	47%
P724	1.25	0.3200	3.64	0.74	20%	0.93	26%
P725	1.25	1.3291	7.42	0.74	10%	0.93	13%
P726	0.67	2.2770	1.84	0.74	40%	0.93	51%
P727	1.25	0.2620	3.30	0.74	23%	0.93	28%
P728	1.25	0.7680	5.64	1.12	20%	1.58	28%
P729	1.25	0.4810	4.47	1.12	25%	1.58	35%
P730	1.5	0.1580	4.16	1.12	27%	1.57	38%
P731	1.5	0.1610	4.20	1.12	27%	1.57	37%
P732	1.5	0.1600	4.19	1.12	27%	1.57	38%
P733	1.25	0.5580	4.81	1.12	23%	1.57	33%
P735	1	1.5910	4.48	1.12	25%	1.57	35%
P736	1	1.6410	4.55	1.12	25%	1.57	35%
P737	1	0.5565	2.65	1.12	42%	1.57	59%
P738	1.25	0.5410	4.74	1.12	24%	1.57	33%
P739	1.25	0.5650	4.84	1.12	23%	1.57	33%
P740	1.25	0.5620	4.83	1.12	23%	1.58	33%
P741	1.25	0.5570	4.81	1.12	23%	1.58	33%
P742	1	1.6700	4.59	0.77	17%	1.11	24%
P743	1	0.6990	2.97	0.77	26%	1.11	38%
P744	1	0.7000	2.97	0.77	26%	1.12	38%
P745	1	0.7000	2.97	0.77	26%	1.12	38%
P746	1	0.7000	2.97	0.77	26%	1.12	38%
P747	1	0.7000	2.97	0.77	26%	1.12	38%
P748	1	0.6970	2.96	0.77	26%	1.12	38%

Note:

Deficient pipes in volume (flowing at > 90% capacity) are highlighted in dark color and marginally deficient pipes (flowing at >75% and < 90%) are highlighted in light color.

7.0 DEFICIENCIES AND SOLUTIONS

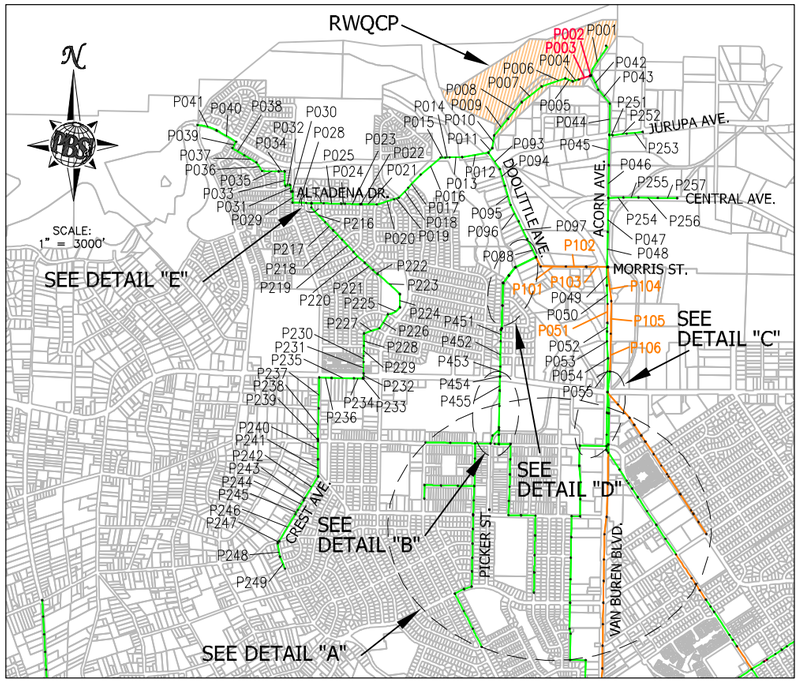
7.1 Deficient and Marginally Deficient Pipes

The Computer model simulations of the City's wastewater system have evaluated pipe reaches in terms of both volume and velocity criteria.

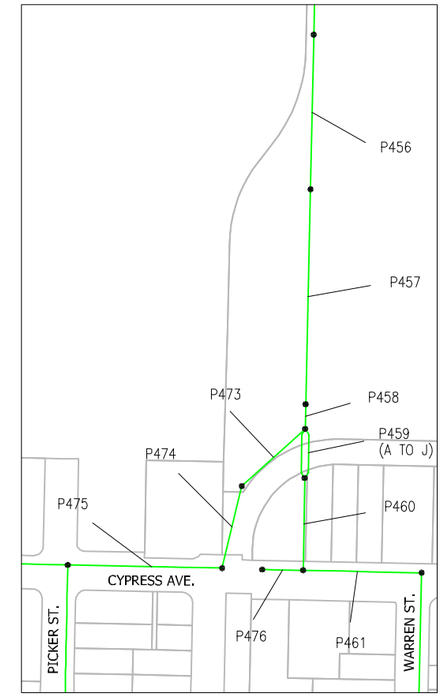
The City's design criterion for sewer lines allows pipes to flow at a ratio of 75% of "full" hydraulic capacity. Assuming that "full" capacity is the maximum hydraulic capacity of a pipe flowing under gravity (non-pressure) conditions, Manning's equation shows that maximum flow occurs when a pipe reaches a flow depth ratio of about 95% depth/diameter (d/D). For the purpose of this study, pipes flowing at 90% or greater capacity are considered "deficient", and pipes flowing at greater than 75% and less than 90% are considered "marginally deficient".

Pipe reaches which fail the "75% full" volume criterion for both existing and future flow conditions are shown in Table 7-2 and Figures 25A, 25B, 25C, 27A, 27B and 27C. It is seen that portions of the modeled trunk system are already flowing at greater than 75% full, and several reaches are computed to be over 100% full (surcharging) for existing and ultimate flow conditions. At ultimate conditions, numerous additional reaches are shown to surcharge or exceed the "75% full" criteria.

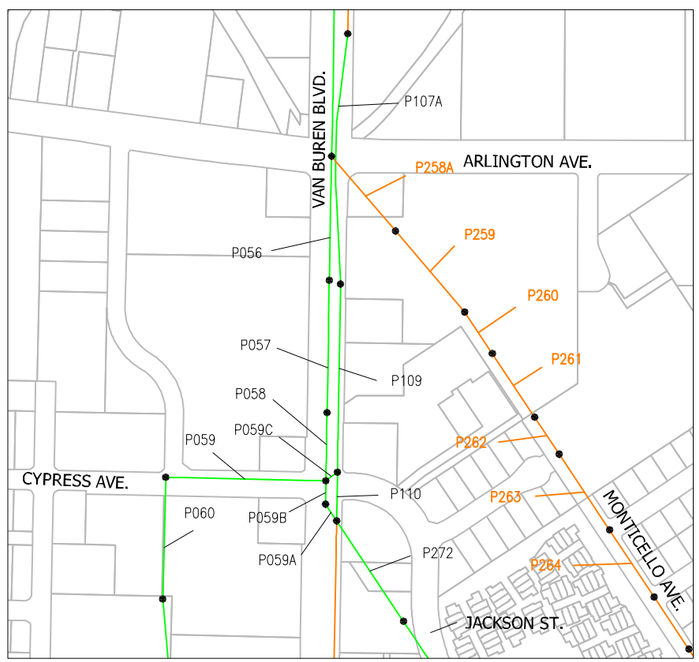
A velocity more than 10 feet per second is considered to be the threshold for scouring. The pipes having a maximum velocity of more than 10 feet per second are considered "deficient" in velocity, due to the potential erosion of the interiors of pipe walls over time. A velocity less than 2 feet per second is not considered self- cleansing and pipe reaches that have a maximum flow velocity less than 2 feet per second under existing flow conditions are also considered "deficient" in velocity. These pipes are shown in Figures 26A, 26B and 26C.



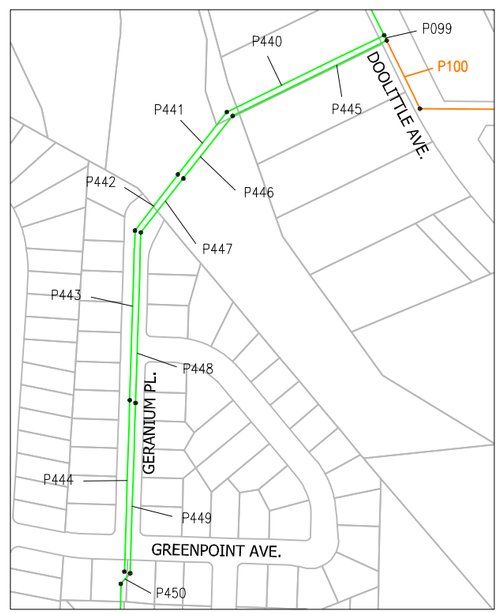
DETAIL "A"
NTS



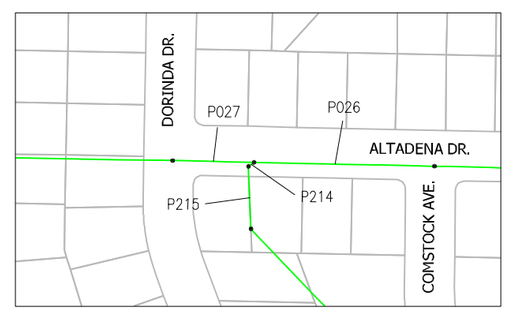
DETAIL "B"
NTS



DETAIL "C"
NTS



DETAIL "D"
NTS



DETAIL "E"
NTS

LEGEND

(green line)	VOLUME ≤ 75 % FULL
(orange line)	VOLUME > 75 < 90 % FULL
(red line)	VOLUME ≥ 90 % FULL
P001	PIPE SEGMENT NUMBER

SEE FIGURES 25B AND 25C FOR CONTINUATION OF SEWER BASIN SYSTEM

Engineering
Planning
Surveying
Construction Services

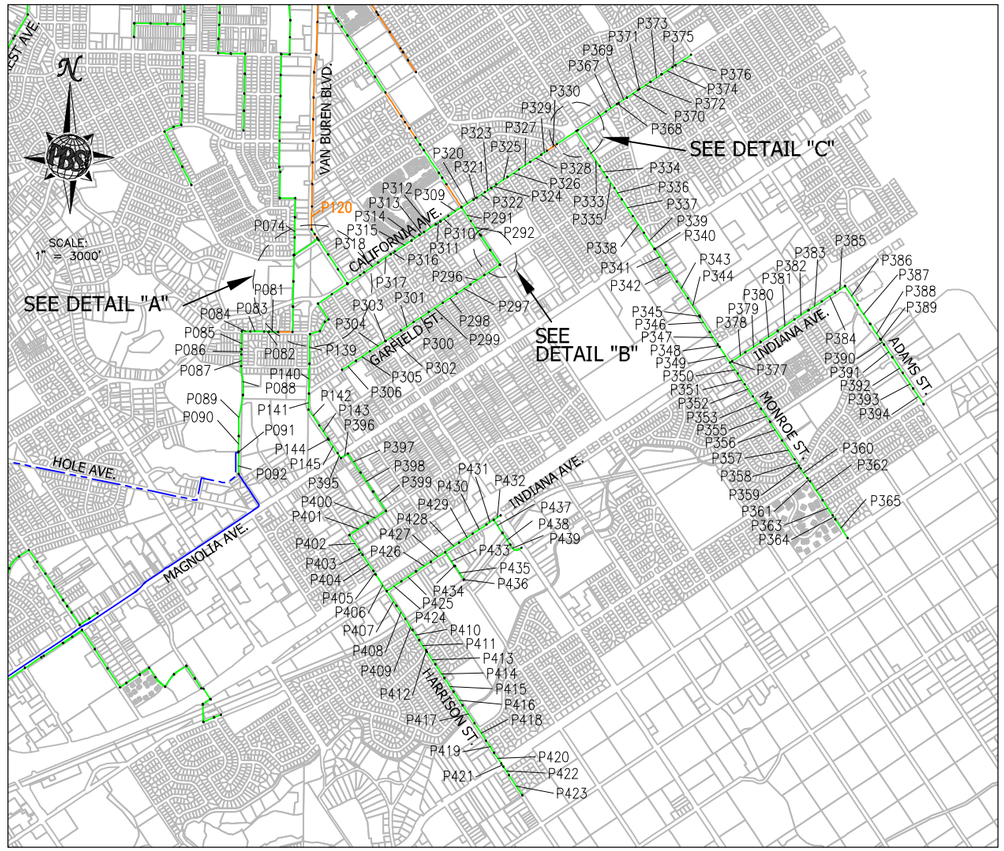
PBS&J

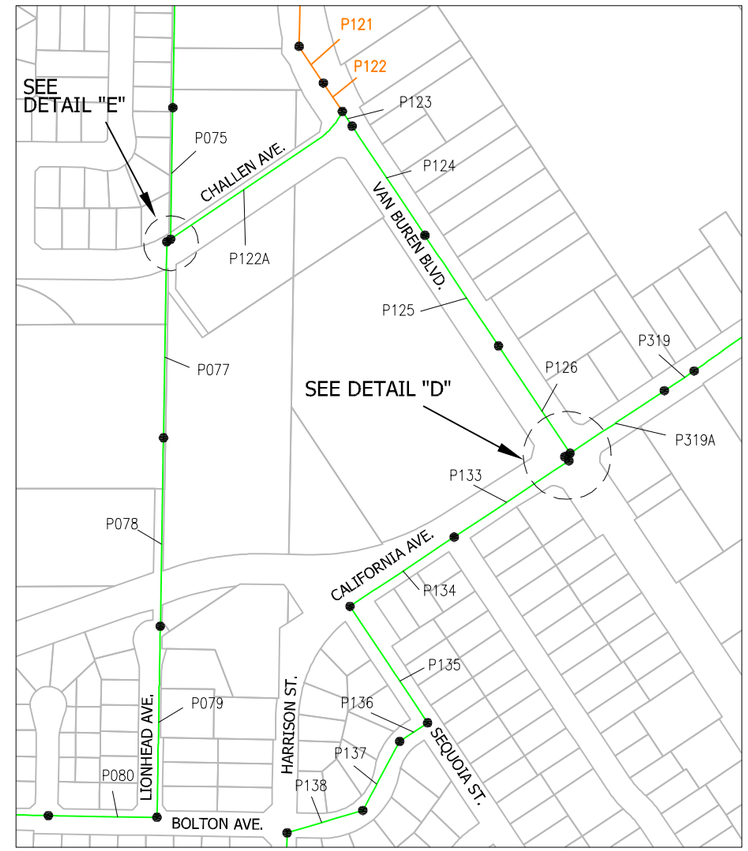
10370 Hemet Street
Suite 200
Riverside, CA 92503
Tel:(951) 358-1433
Fax:(951) 358-1434

DATE: 12/21/05	DWN BY: CD
CITY OF RIVERSIDE ARLANZA SEWER STUDY	FIGURE 25A

VOLUME DEFICIENCIES - PART 1

Y:\City of Riverside\Arlanza\DWG\Exhibits\AZ-VolumeDef.dwg, 9/28/2006 10:46:20 AM

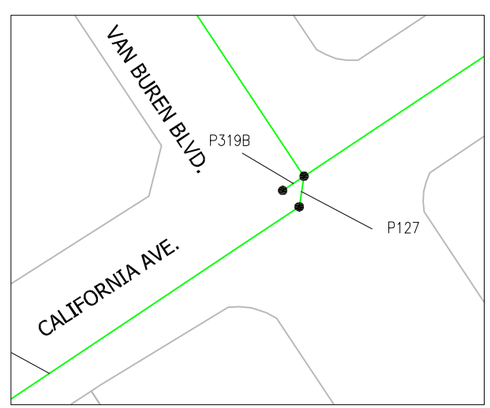




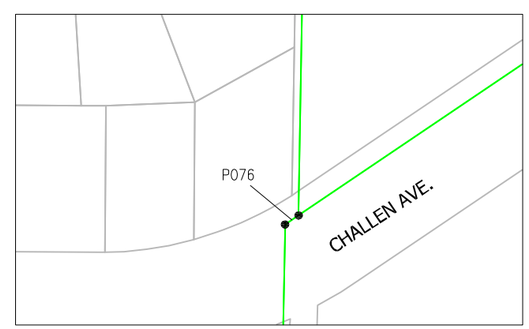
DETAIL "A"
NTS

DETAIL "B"
NTS

DETAIL "C"
NTS



DETAIL "D"
NTS



DETAIL "E"
NTS

LEGEND

———	MAGNOLIA FORCE MAIN
— - —	LA SIERRA FORCE MAIN
———	VOLUME ≤ 75 % FULL
———	VOLUME > 75 < 90 % FULL
———	VOLUME ≥ 90 % FULL
P001	PIPE SEGMENT NUMBER

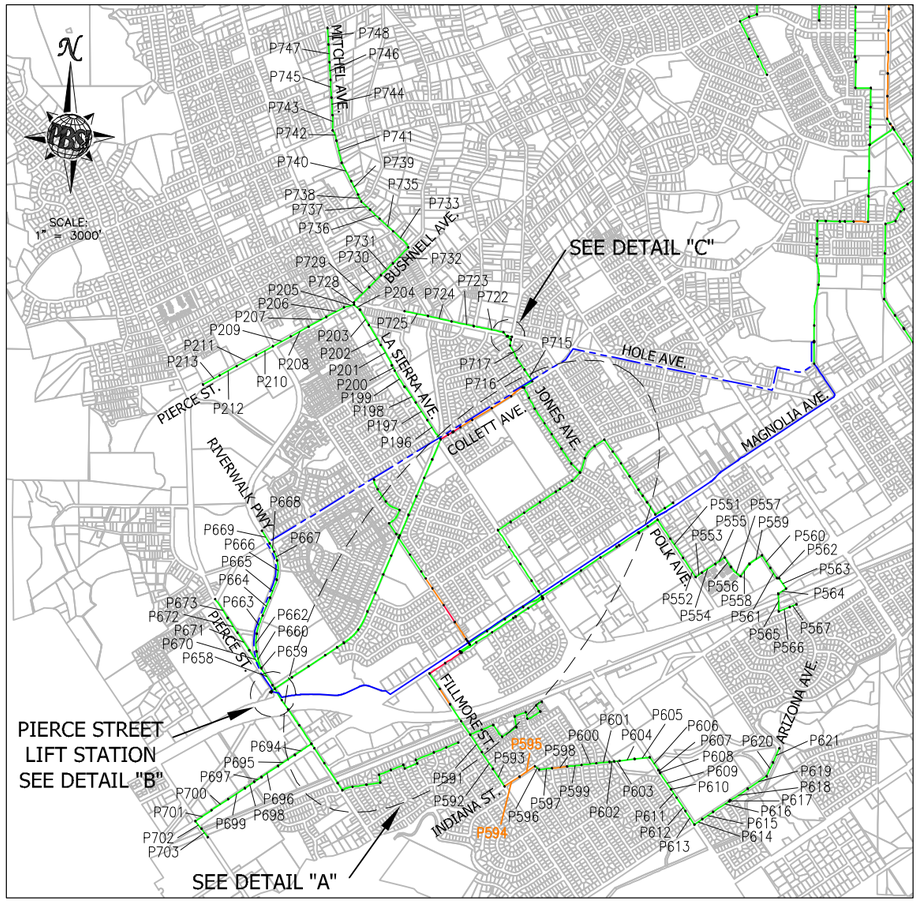
SEE FIGURES 25A AND 25C FOR CONTINUATION OF SEWER BASIN SYSTEM

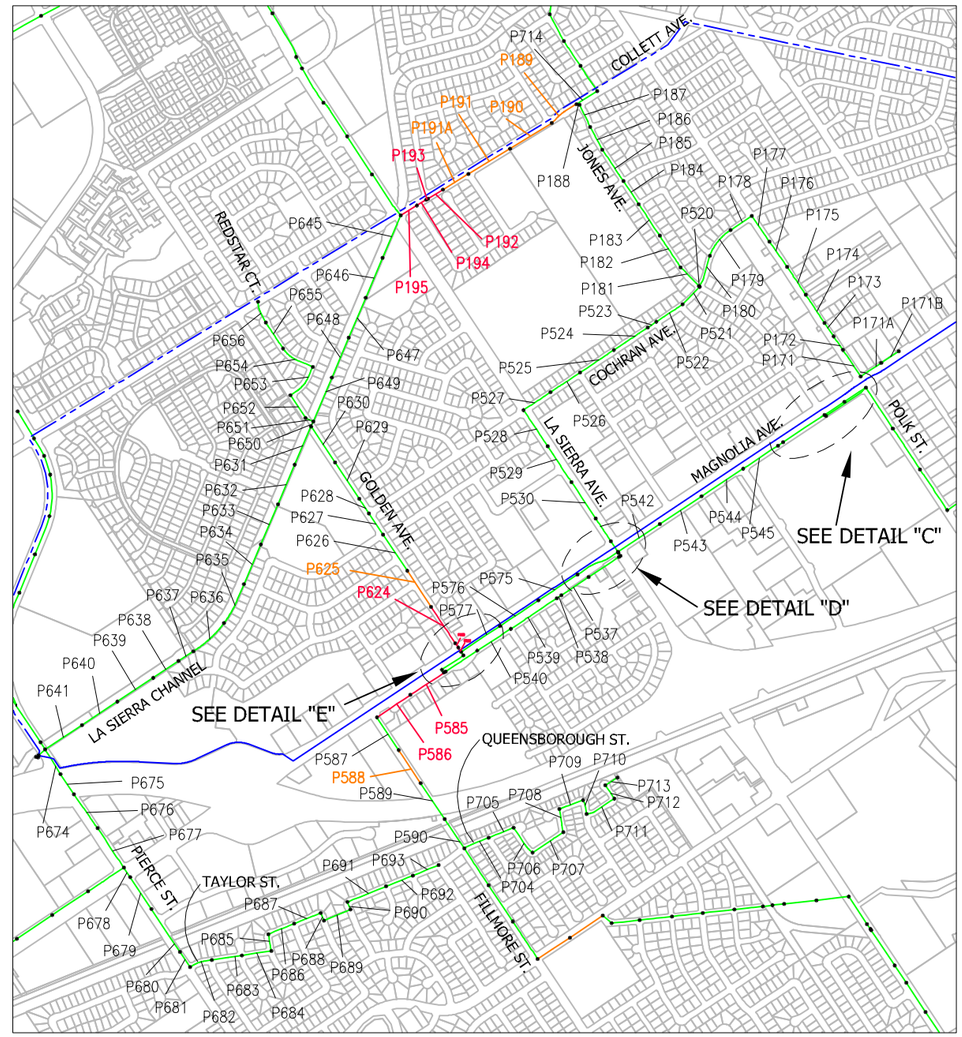
Engineering
Planning
Surveying
Construction Services
PBSJ
10370 Hemet Street
Suite 200
Riverside, CA 92503
Tel:(951) 358-1433
Fax:(951) 358-1434

DATE: 12/21/05	DWN BY: CD
CITY OF RIVERSIDE ARLANZA SEWER STUDY	FIGURE 25B

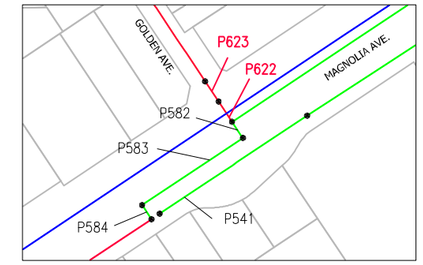
VOLUME DEFICIENCIES - PART 2

Y:\City of Riverside\Arlanza\DWG\Exhibits\AZ-VolumeDefB.dwg, 9/28/2006 10:47:22 AM

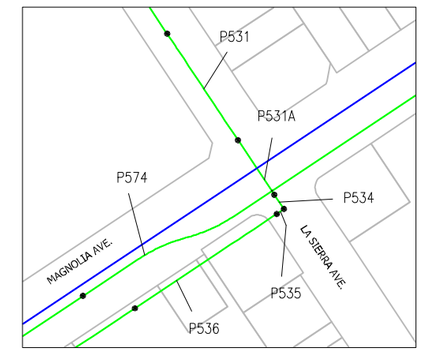




DETAIL "A"
NTS

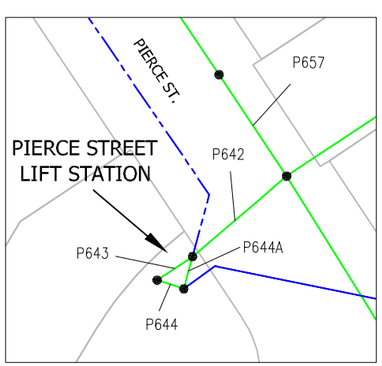


DETAIL "E"
NTS

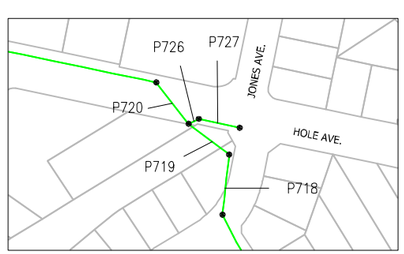


DETAIL "D"
NTS

DETAIL "F"
NTS



DETAIL "B"
NTS



DETAIL "C"
NTS

LEGEND

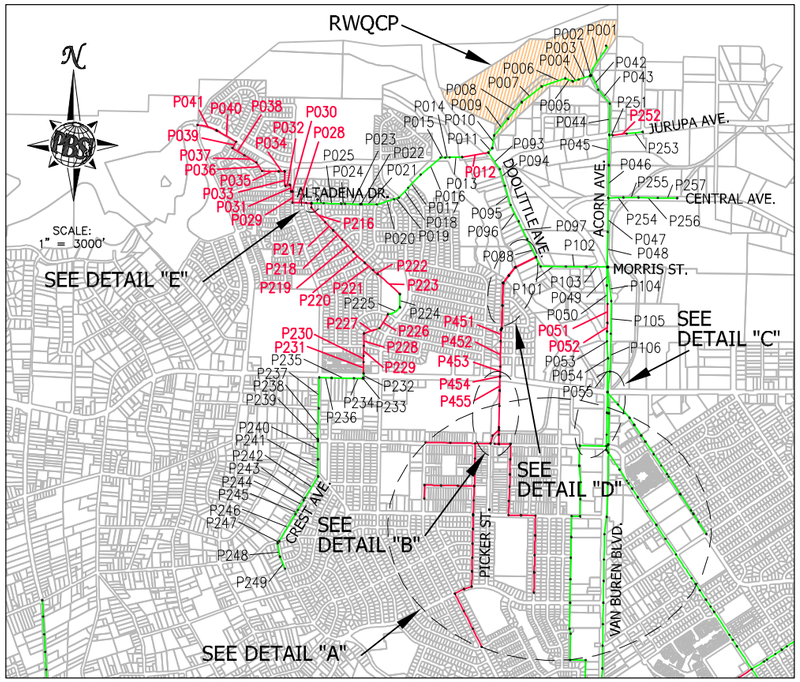
- MAGNOLIA FORCE MAIN
- LA SIERRA FORCE MAIN
- VOLUME ≤ 75 % FULL
- VOLUME > 75 < 90 % FULL
- VOLUME ≥ 90 % FULL
- P001 PIPE SEGMENT NUMBER

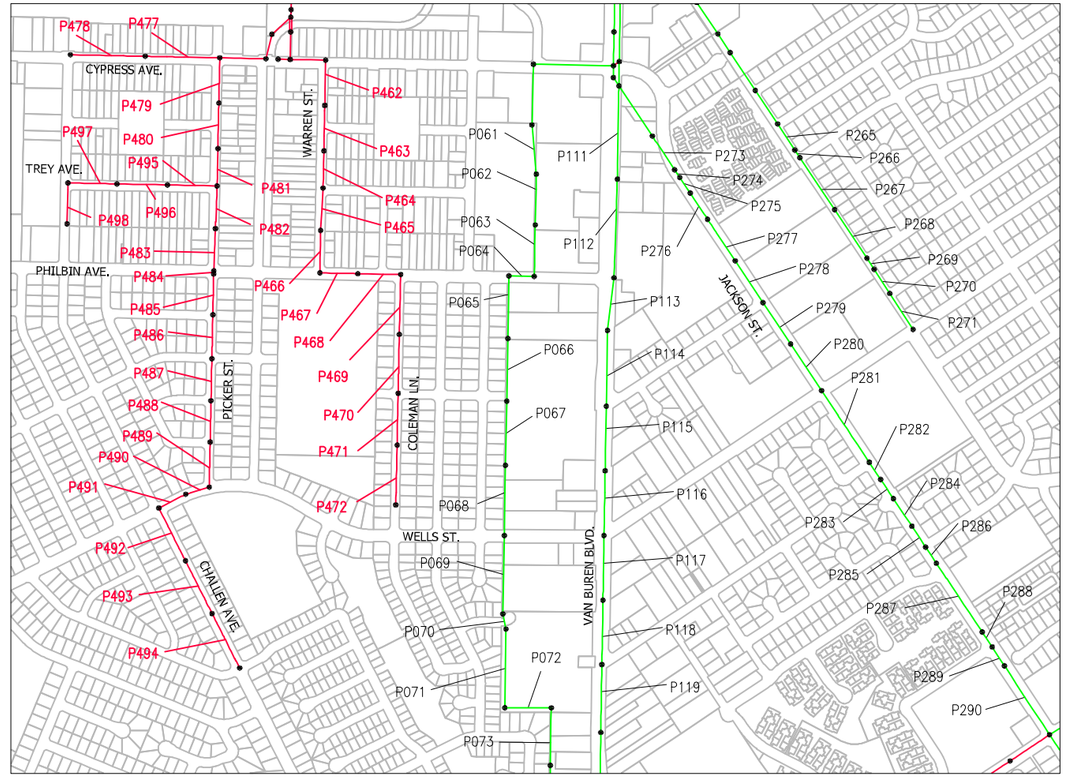
SEE FIGURES 25A AND 25B FOR CONTINUATION OF SEWER BASIN SYSTEM

Engineering
Planning
Surveying
Construction Services
PBSJ
10370 Hemet Street
Suite 200
Riverside, CA 92503
Tel:(951) 358-1433
Fax:(951) 358-1434

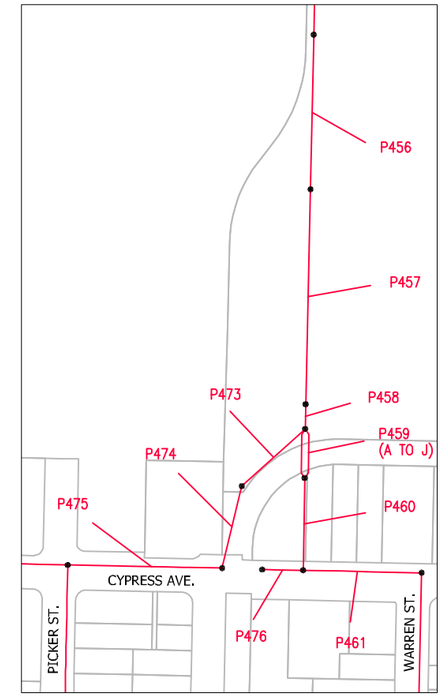
DATE: 12/21/05	DWN BY: CD
CITY OF RIVERSIDE ARLANZA SEWER STUDY	FIGURE 25C
VOLUME DEFICIENCIES - PART 3	

Y:\City of Riverside\Arlanza\DWG\Exhibits\AZ-VolumeDefC.dwg, 9/28/2006 10:48:25 AM

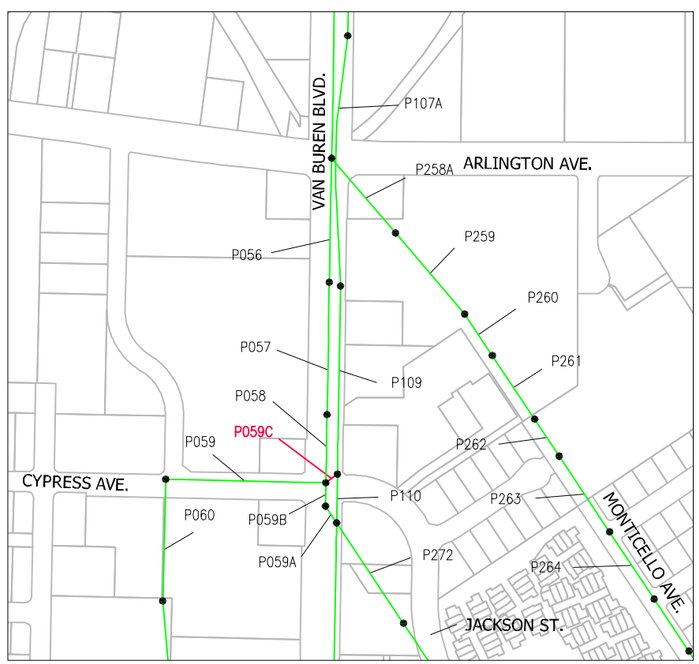




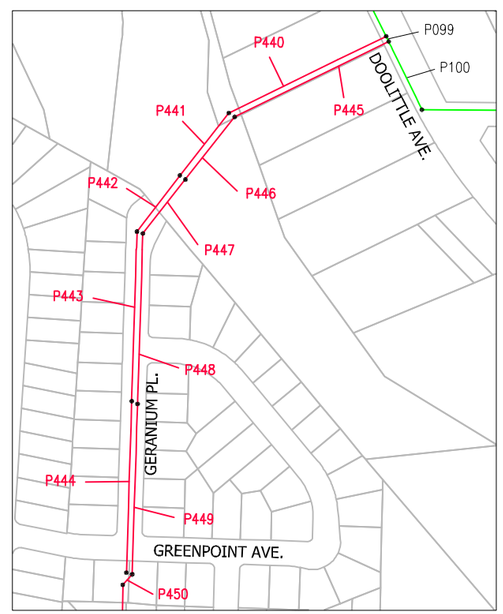
DETAIL "A"
NTS



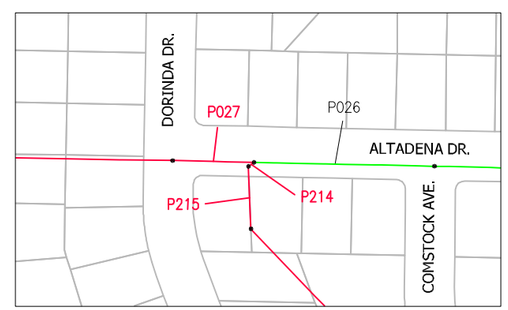
DETAIL "B"
NTS



DETAIL "C"
NTS



DETAIL "D"
NTS



DETAIL "E"
NTS

LEGEND

GRAVITY SEWER

VELOCITY < 2 FPS

P001 PIPE SEGMENT NUMBER

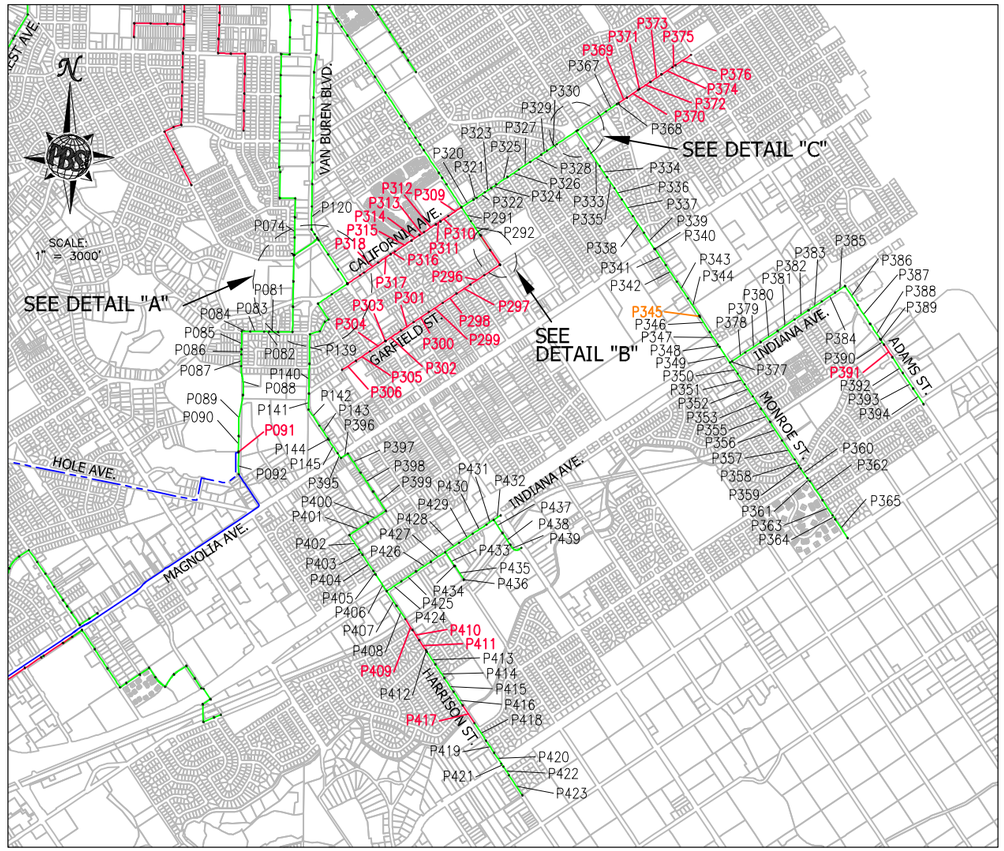
SEE FIGURES 26B AND 26C FOR CONTINUATION OF SEWER BASIN SYSTEM

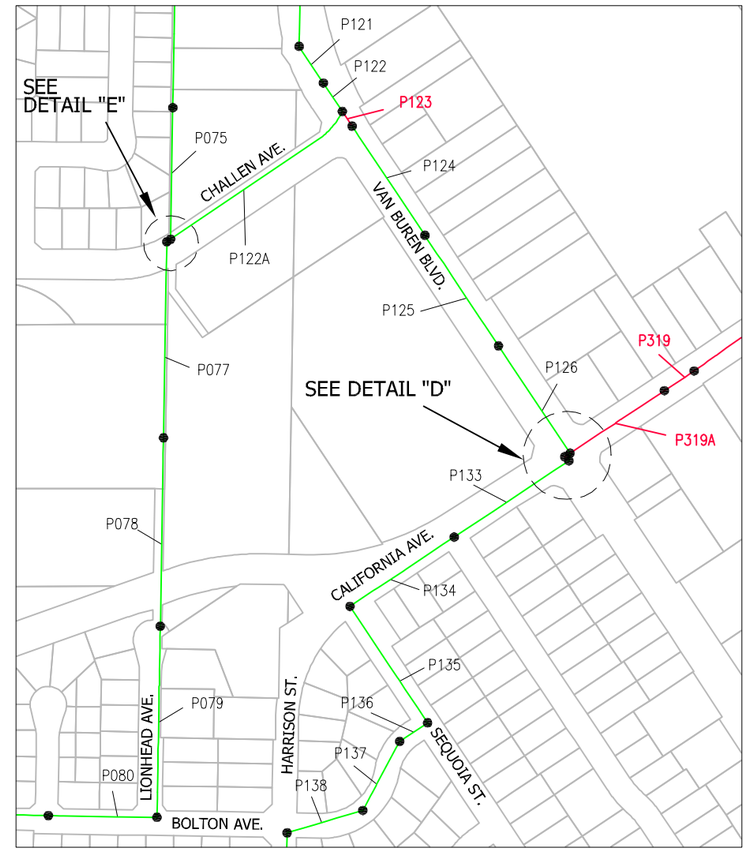
Engineering
Planning
Surveying
Construction Services
PBS&J
10370 Hemet Street
Suite 200
Riverside, CA 92503
Tel:(951) 358-1433
Fax:(951) 358-1434

DATE: 12/21/05	DWN BY: CD
CITY OF RIVERSIDE ARLANZA SEWER STUDY	FIGURE 26A

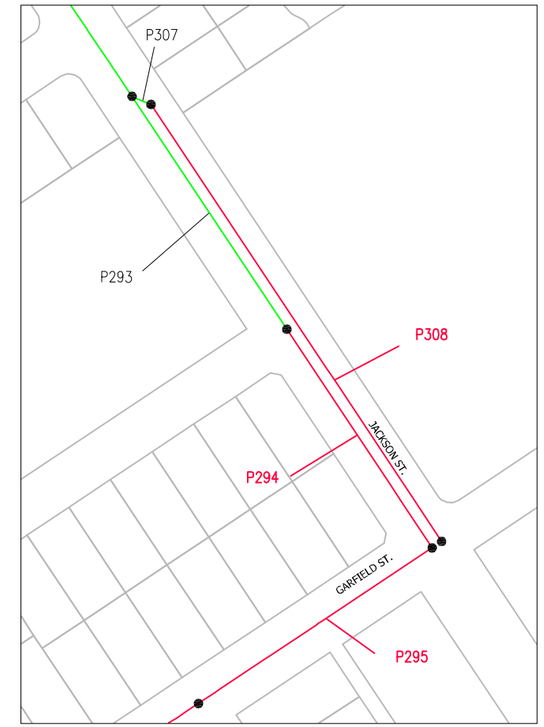
VELOCITY DEFICIENCIES - PART 1

Y:\City of Riverside\Arlanza\DWG\Exhibits\AZ-VelocityDef.dwg, 9/28/2006 10:40:24 AM



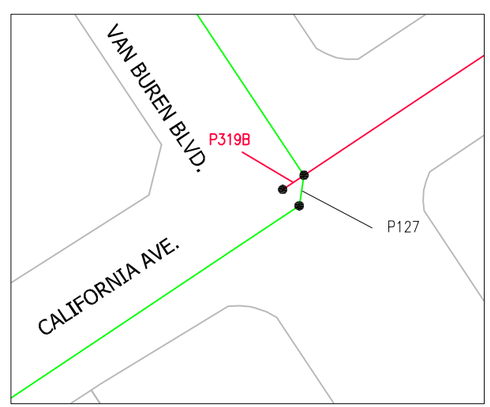


DETAIL "A"
NTS

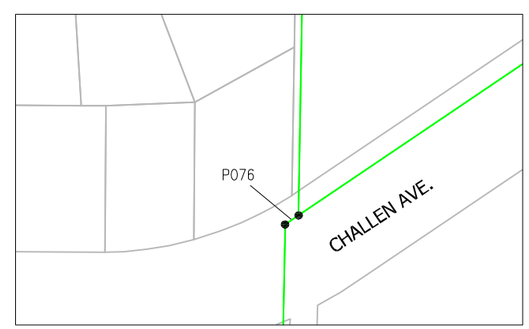


DETAIL "B"
NTS

DETAIL "C"
NTS



DETAIL "D"
NTS



DETAIL "E"
NTS

LEGEND

- MAGNOLIA FORCE MAIN
- LA SIERRA FORCE MAIN
- GRAVITY SEWER
- VELOCITY < 2 FPS
- VELOCITY > 10 FPS
- P001 PIPE SEGMENT NUMBER

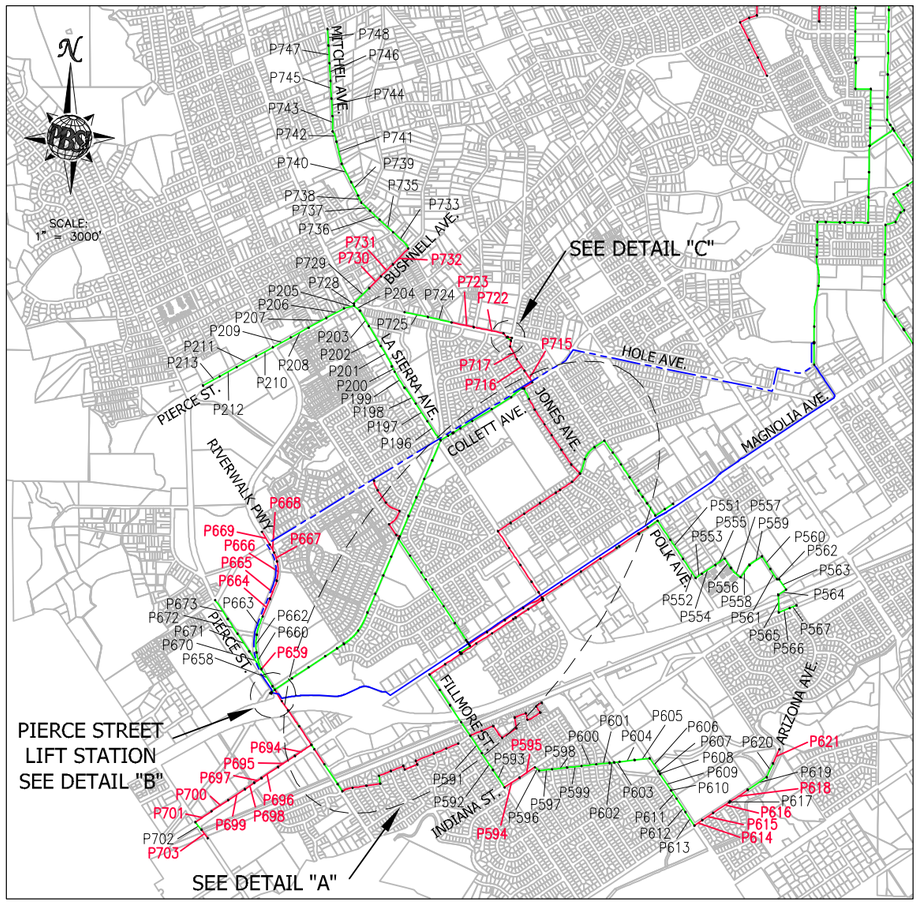
SEE FIGURES 26A AND 26C FOR CONTINUATION OF SEWER BASIN SYSTEM

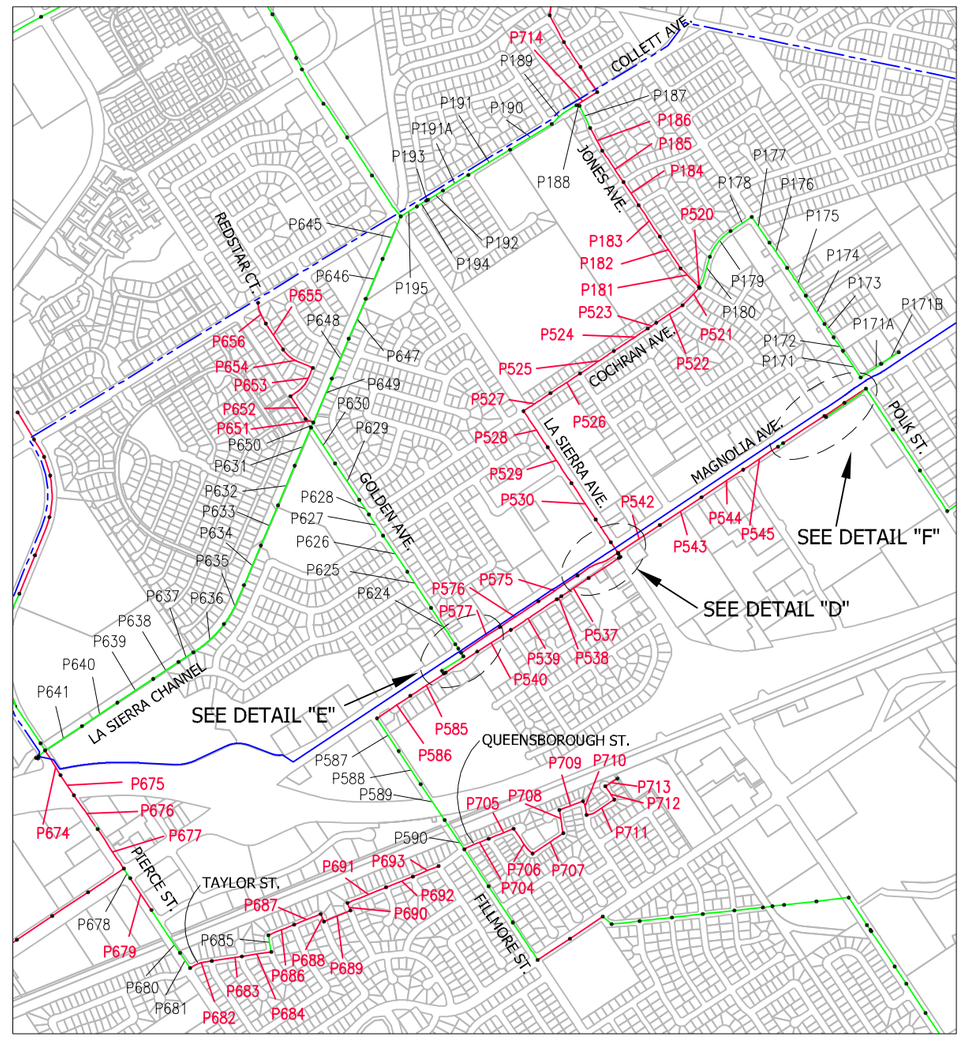
Engineering
Planning
Surveying
Construction Services
PBSJ
10370 Hemet Street
Suite 200
Riverside, CA 92503
Tel:(951) 358-1433
Fax:(951) 358-1434

DATE: 12/21/05	DWN BY: CD
CITY OF RIVERSIDE ARLANZA SEWER STUDY	FIGURE 26B

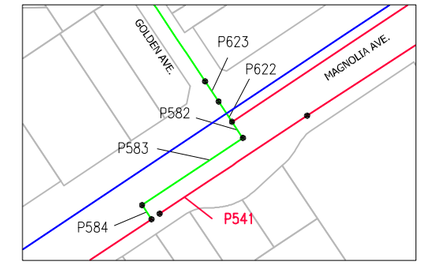
VELOCITY DEFICIENCIES - PART 2

Y:\City of Riverside\Arlanza\DWG\Exhibits\AZ-VelocityDefB.dwg, 9/28/2006 10:41:54 AM

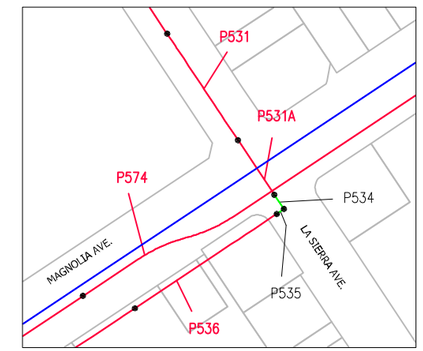




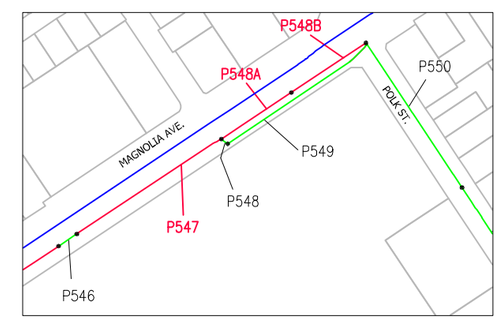
DETAIL "A"
NTS



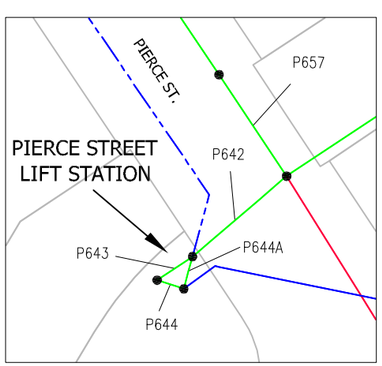
DETAIL "E"
NTS



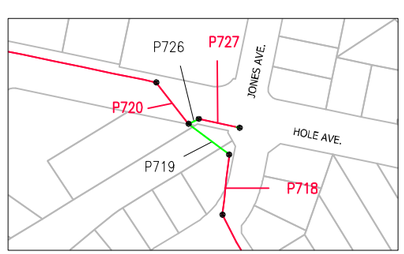
DETAIL "D"
NTS



DETAIL "F"
NTS



DETAIL "B"
NTS



DETAIL "C"
NTS

LEGEND

- MAGNOLIA FORCE MAIN
- LA SIERRA FORCE MAIN
- GRAVITY SEWER
- VELOCITY < 2 FPS
- P001 PIPE SEGMENT NUMBER

SEE FIGURES 26A AND 26B FOR CONTINUATION OF SEWER BASIN SYSTEM

Engineering
Planning
Surveying
Construction Services
PBSJ
10370 Hemet Street
Suite 200
Riverside, CA 92503
Tel:(951) 358-1433
Fax:(951) 358-1434

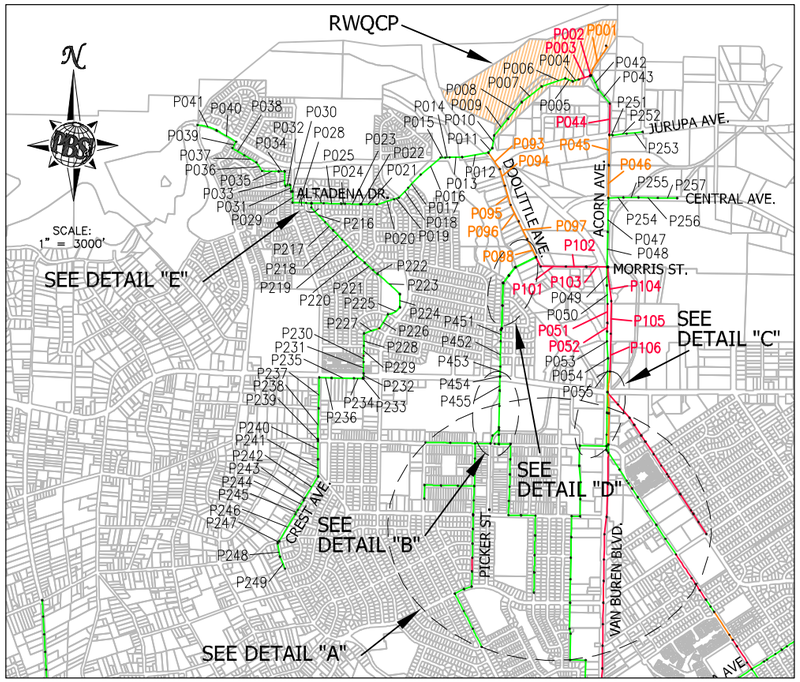
DATE: 12/21/05 | DWN BY: CD

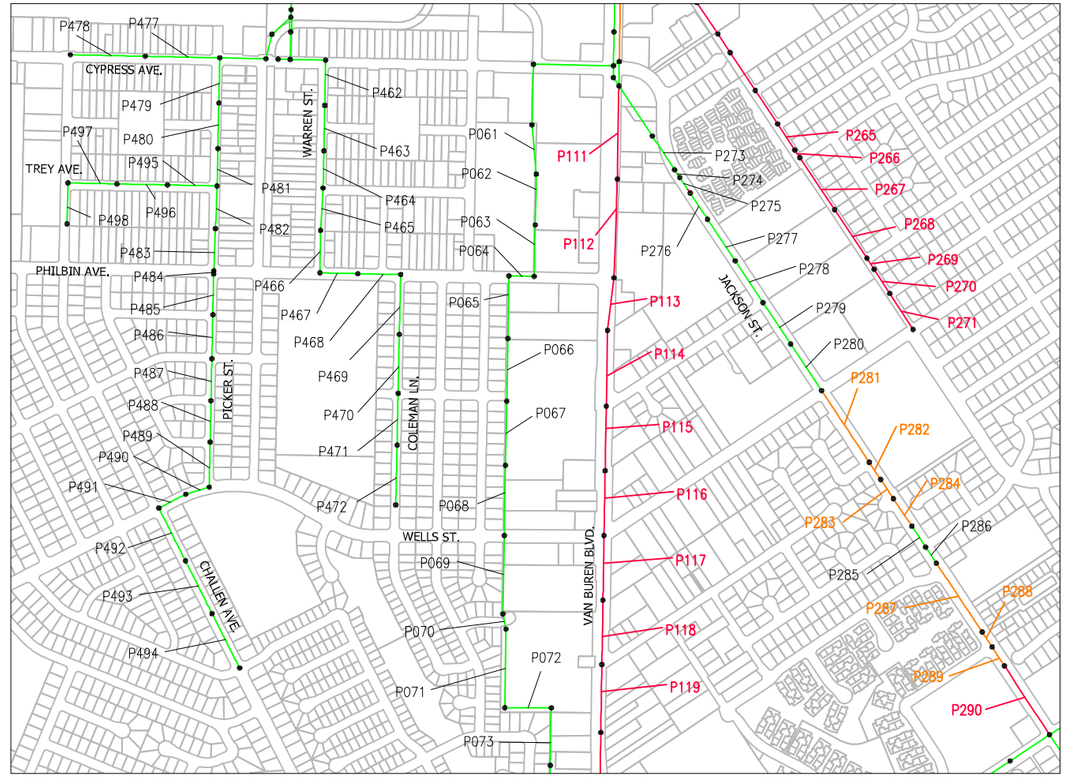
CITY OF RIVERSIDE
ARLANZA SEWER STUDY

FIGURE 26C

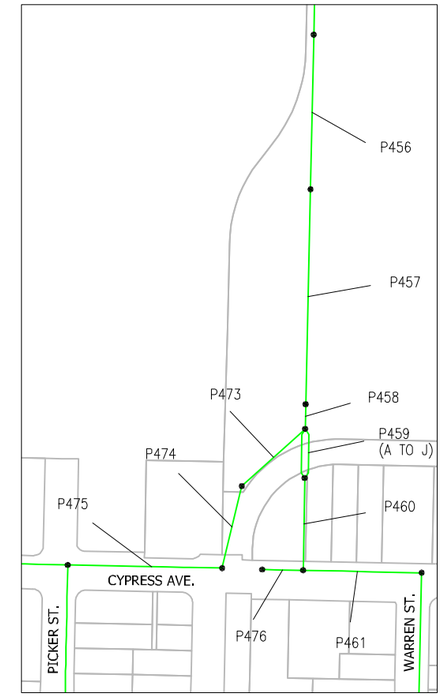
VELOCITY DEFICIENCIES - PART 3

Y:\City of Riverside\Arlanza\DWG\Exhibits\AZ-VelocityDefC.dwg, 9/28/2006 10:44:36 AM

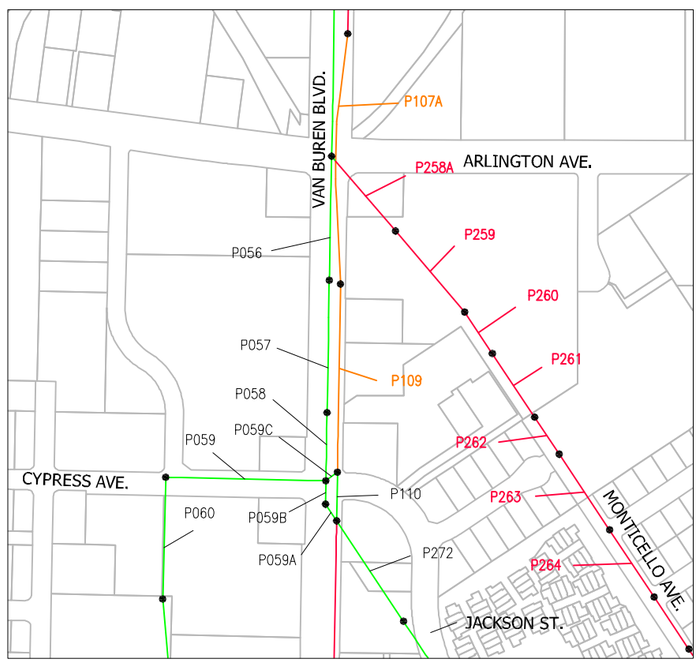




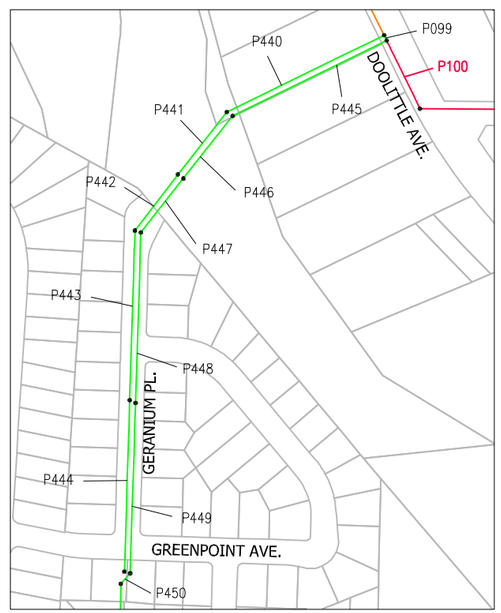
DETAIL "A"
NTS



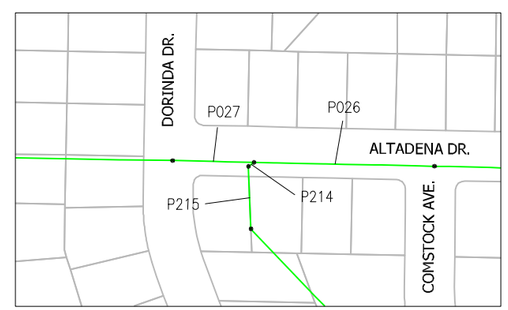
DETAIL "B"
NTS



DETAIL "C"
NTS



DETAIL "D"
NTS



DETAIL "E"
NTS

LEGEND

	VOLUME ≤ 75 % FULL
	VOLUME > 75 < 90 % FULL
	VOLUME ≥ 90 % FULL
P001	PIPE SEGMENT NUMBER

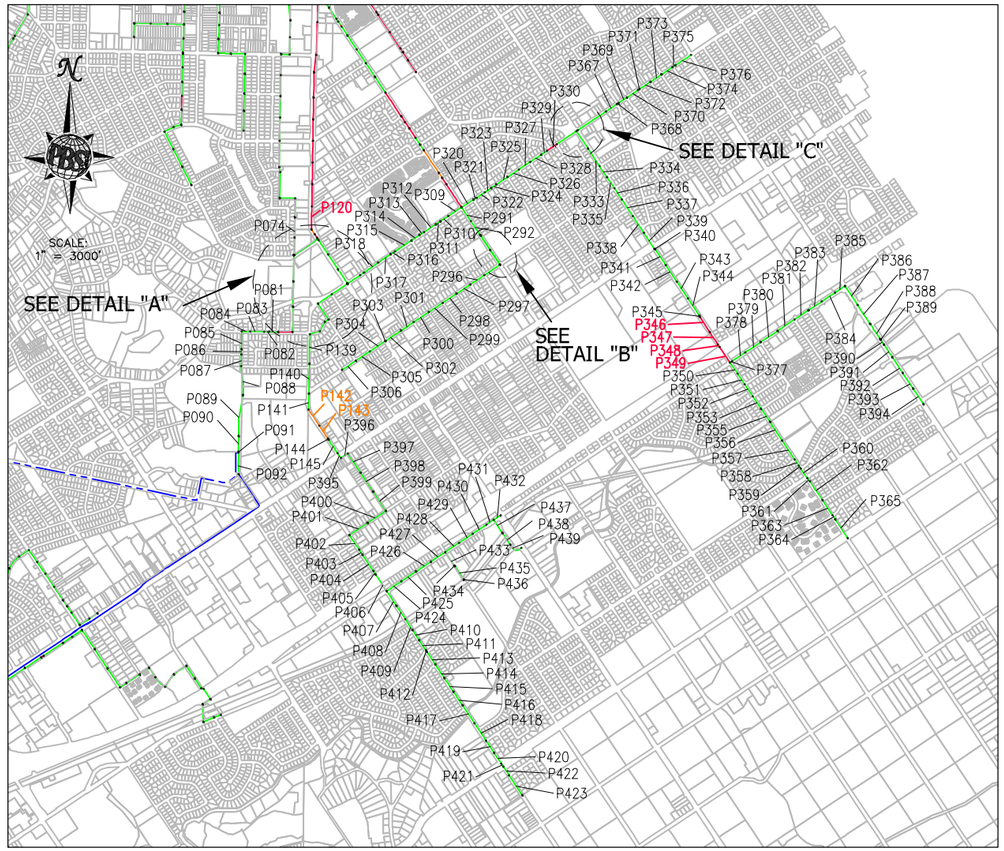
SEE FIGURES 27B AND 27C FOR CONTINUATION OF SEWER BASIN SYSTEM

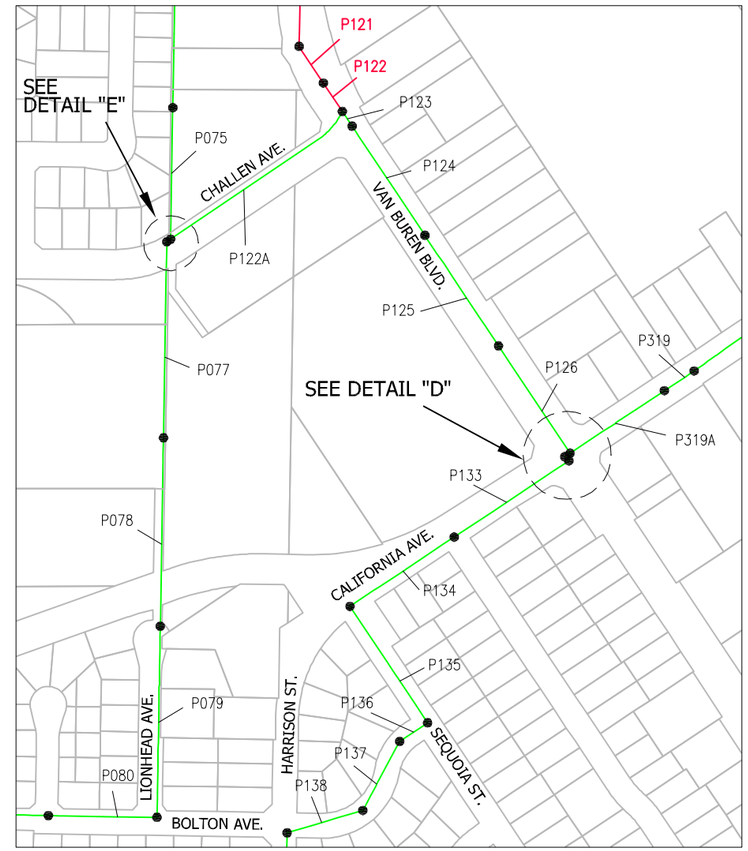
Engineering
Planning
Surveying
Construction Services
PBS&J
10370 Hemet Street
Suite 200
Riverside, CA 92503
Tel:(951) 358-1433
Fax:(951) 358-1434

DATE: 12/21/05	DWN BY: CD
CITY OF RIVERSIDE ARLANZA SEWER STUDY	FIGURE 27A

ULTIMATE VOLUME DEFICIENCIES - PART 1

Y:\City of Riverside\Arlanza\DWG\Exhibits\AZ-Ult\VolumeDef.dwg, 9/28/2006 10:34:40 AM

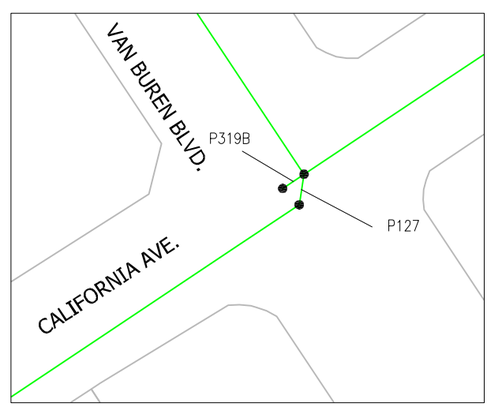




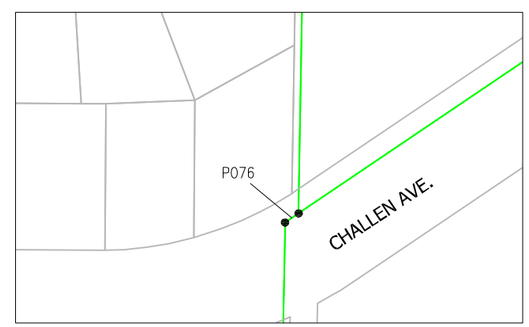
DETAIL "A"
NTS

DETAIL "B"
NTS

DETAIL "C"
NTS



DETAIL "D"
NTS



DETAIL "E"
NTS

LEGEND

- MAGNOLIA FORCE MAIN
- LA SIERRA FORCE MAIN
- VOLUME ≤ 75 % FULL
- VOLUME > 75 < 90 % FULL
- VOLUME ≥ 90 % FULL
- P001 PIPE SEGMENT NUMBER

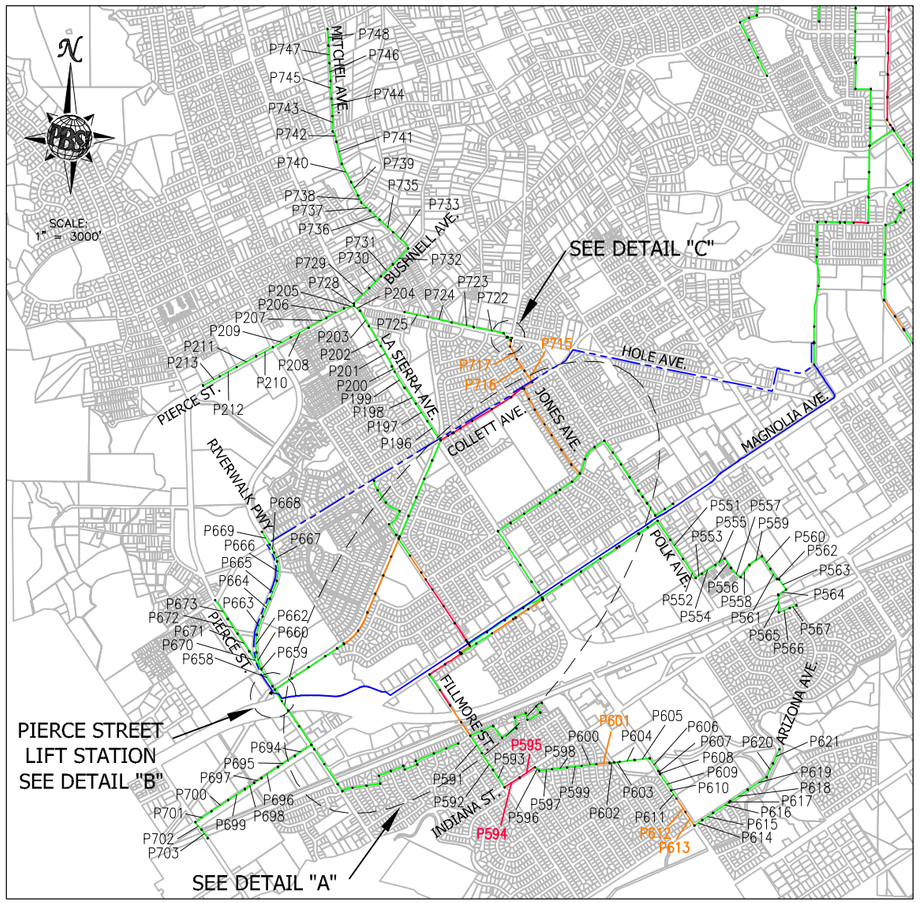
SEE FIGURES 27A AND 27C FOR CONTINUATION OF SEWER BASIN SYSTEM

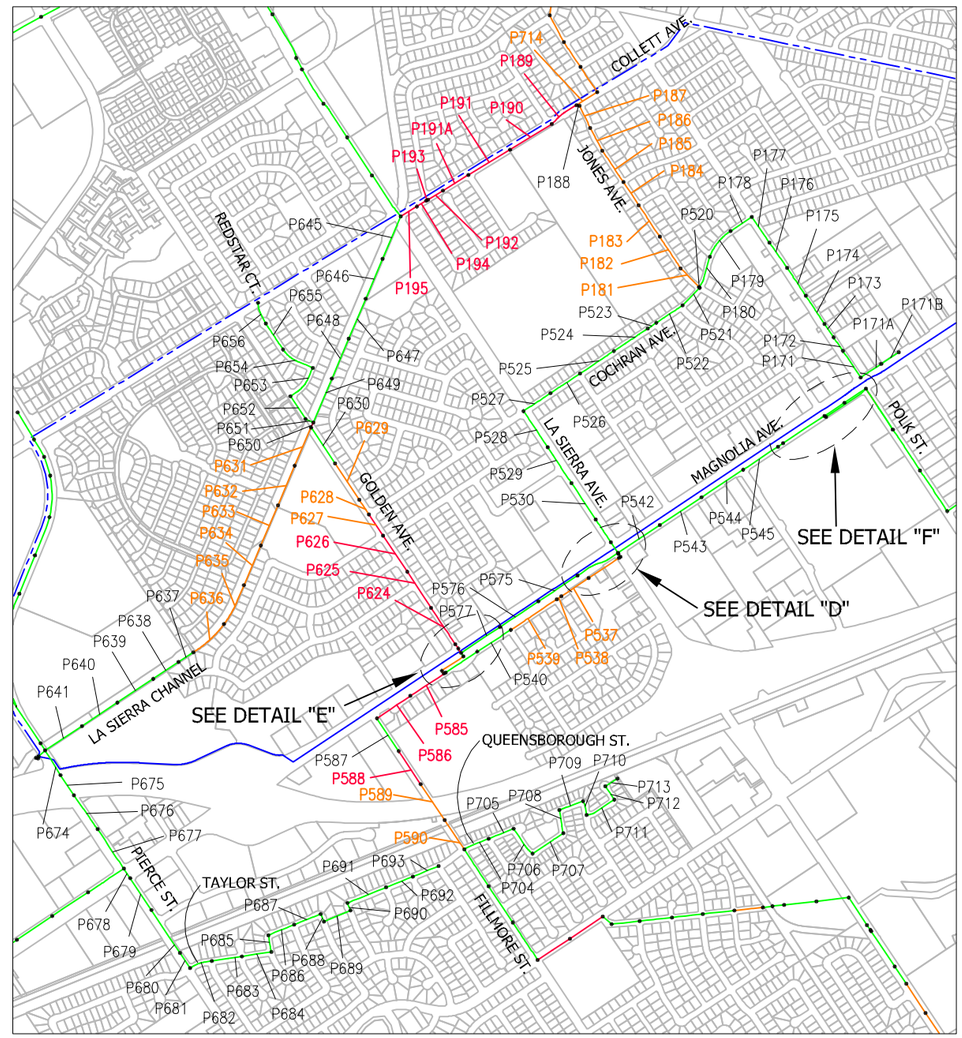
Engineering
Planning
Surveying
Construction Services
PBSJ
10370 Hemet Street
Suite 200
Riverside, CA 92503
Tel:(951) 358-1433
Fax:(951) 358-1434

DATE: 12/21/05	DWN BY: CD
CITY OF RIVERSIDE ARLANZA SEWER STUDY	FIGURE 27B

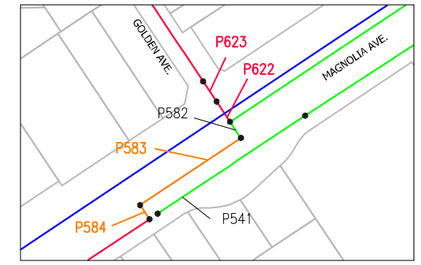
ULTIMATE VOLUME DEFICIENCIES - PART 2

Y:\City of Riverside\Arlanza\DWG\Exhibits\AZ-Ult\VolumeDef\B.dwg, 9/28/2006 10:36:02 AM

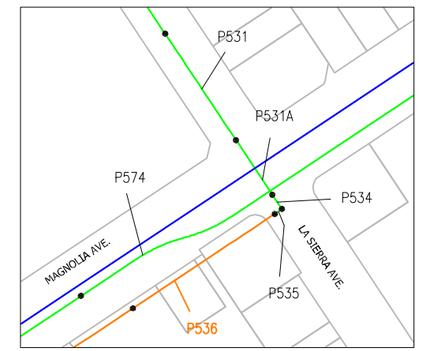




DETAIL "A"
NTS

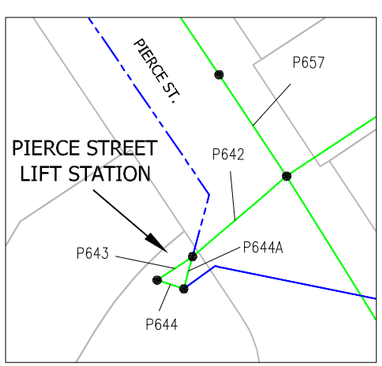


DETAIL "E"
NTS

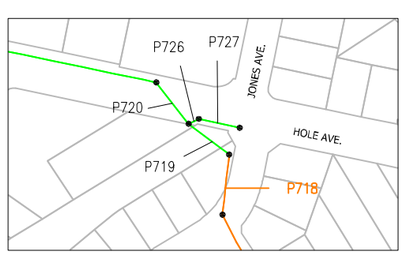


DETAIL "D"
NTS

DETAIL "F"
NTS



DETAIL "B"
NTS



DETAIL "C"
NTS

LEGEND

- MAGNOLIA FORCE MAIN
- LA SIERRA FORCE MAIN
- VOLUME ≤ 75 % FULL
- VOLUME > 75 < 90 % FULL
- VOLUME ≥ 90 % FULL
- P001 PIPE SEGMENT NUMBER

SEE FIGURES 27A AND 27B FOR CONTINUATION OF SEWER BASIN SYSTEM

Engineering
Planning
Surveying
Construction Services
PBS&J
10370 Hemet Street
Suite 200
Riverside, CA 92503
Tel:(951) 358-1433
Fax:(951) 358-1434

DATE: 12/21/05	DWN BY: CD
CITY OF RIVERSIDE ARLANZA SEWER STUDY	FIGURE 27C
ULTIMATE VOLUME DEFICIENCIES - PART 3	

Y:\City of Riverside\Arlanza\DWG\Exhibits\AZ-Ult\VolumeDefC.dwg, 9/28/2006 10:37:07 AM

7.2 Project Prioritization Methodology

The 75% full criterion is useful for analyzing deficient pipes and as a basis for sizing new facilities. However, the criterion is not necessarily the trigger point for replacement or augmentation of an existing sewer line. In most cases, a sewer entity would not implement a relief project until capacity problems are actually observed or known to be imminent. Velocity deficiencies are an indication of potential maintenance concerns, but are not ground for replacement.

A recommended system of project prioritization is the categorization of deficient sewer lines based on modeled % full results. The “A” priority projects are immediately needed and the “B” and “C” projects require further consideration for replacement. Priority classifications are described as follows:

Priority “A” – The pipes listed within this priority are currently flowing more than 90% full under maximum flow condition. These pipes are grouped for replacement/re-habilitation in the period (2005-2010); preferably as soon as practically possible.

Priority “B” – The pipes, listed in this priority are projected to be flowing more than 90% full in the future under estimated maximum flow conditions. A linear interpolation was done for anticipation of the mid-term flow in pipes between year 2005 and ultimate year (2020). The pipes that would be flowing more than 90% full in the year 2015 are placed under priority “B”. These pipes need evaluation as new development takes place in the tributary areas. Flow monitoring within the study area should be considered for observation of actual flows. The pipes under this priority are grouped for replacement/re-habilitation in the period (2011-2015).

Priority “C” – The pipes listed in this priority would be flowing more than 75% full in the future under maximum flow conditions. The pipes that are not part of priority “A” and “B” and will flow more than 75% full by the year 2020 are considered under priority “C”. These pipes need evaluation as new development takes place in the tributary areas. These may or may not be replaced or paralleled depending on actual observed flow conditions in the future. If tributary areas are at or near ultimate development and the metered flows are still below 90% of capacity, the pipes would not likely be replaced. Flow monitoring within the study area should be considered when significant development occurs. The pipes under this priority are grouped for replacement/re-habilitation in the period (2016-2020).

7.3 Recommended Improvements

Table 7-3 lists project priority, project location, problem, solution and approximate cost for problem reaches. This table identifies immediate and future problems in the sewer lines and suggested solutions. The project cost is based on year 2005 indices.

Note that the first order of priority is field observation of all pipes where model results indicate surcharging conditions to verify that the flows are indeed exceeding pipe capacity.

7.4 Grouping of Projects

Proposed improvements under different priorities have been combined or grouped into projects to improve deficient and marginally deficient pipes based on the following criteria:

Pipes identified as marginally deficient in near future (Priority "B"), and marginally deficient in more distant future (Priority "C") located geographically close to one another and requiring improvements in future are grouped to reduce improvement costs.

7.5 Construction Schedule

A summary of the proposed construction prioritization and recommended scheduling is shown in Table 7-2. This table lists construction priorities and the year in which these activities are proposed. Also, the pipes falling under priorities "B" and "C" will need re-evaluation before their replacement.

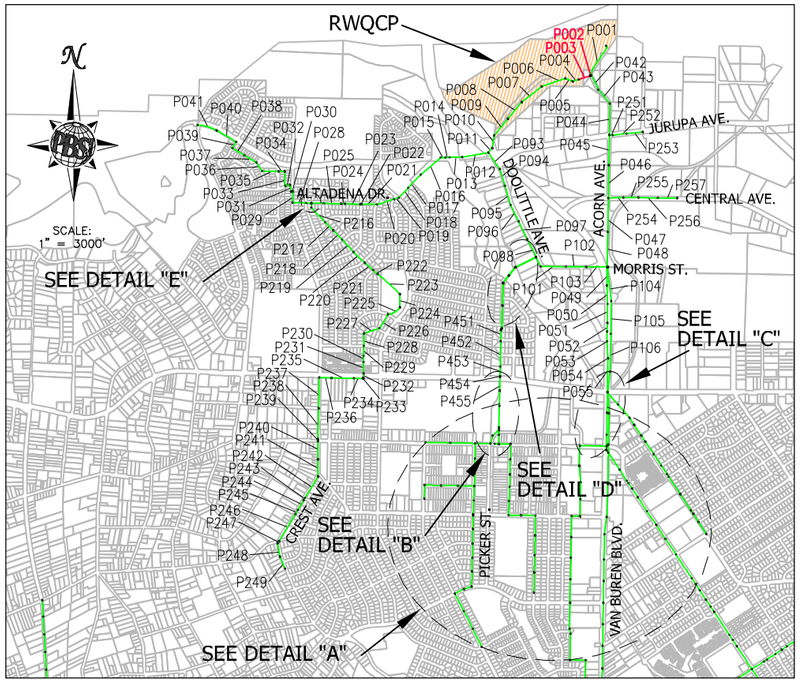
7.6 Cost Estimate

Unit costs of pipes are based on bid prices for similar projects and from the web site www.get-a-quote.net. The cost of construction includes labor, materials, excavation, backfill and all other items associated with pipe laying. To estimate total cost, cost of mobilization / demobilization (7%), traffic control (7%), bond (1%), contractor's profit (15%) and construction contingency (25%) is added to the cost of construction. The cost of engineering, right of way acquisition, permits, soil conditions remediation and by-pass pumping is not included in the construction cost. For priorities "B" and "C", the cost estimate is based on year 2005 prices and no escalation has been added to estimate future cost. Following is the summary of cost for the various priorities:

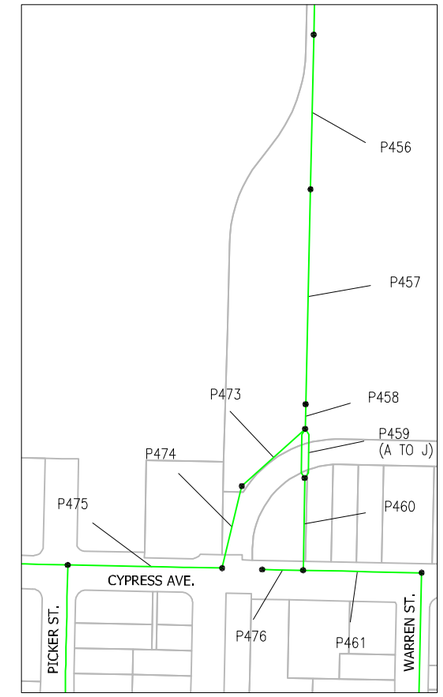
- Priority “A” - $0.75 Million (2005 $’s) (See Figures 28A, 28B, 28C and Table 7-6-A for details)

- Priority “B” - $3.32 Million (2005 $’s) (See Figures 28A, 28B, 28C and Table 7-6-B for details)

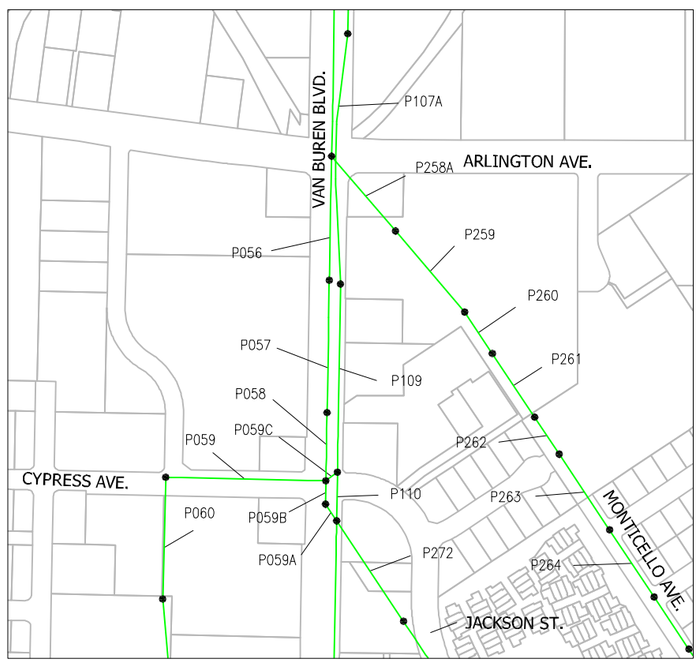
- Priority “C” - $ 10.13 Million (2005 $’s) (See Figures 28A, 28B, 28C and Table 7-6-C for details)



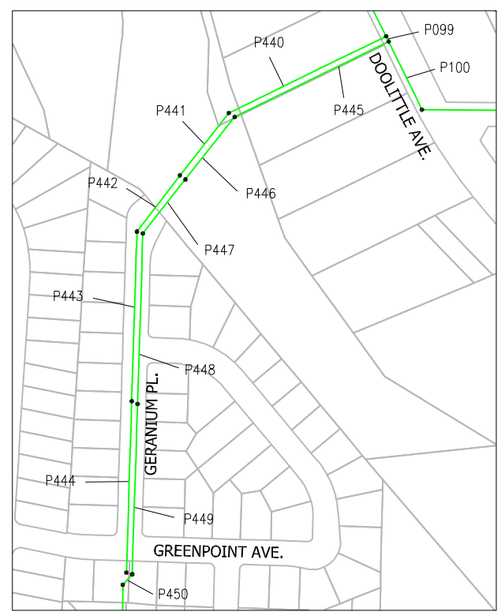
DETAIL "A"
NTS



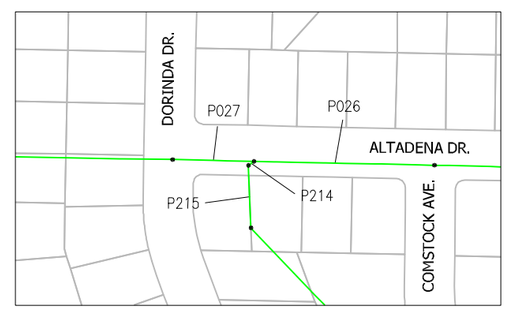
DETAIL "B"
NTS



DETAIL "C"
NTS



DETAIL "D"
NTS



DETAIL "E"
NTS

LEGEND

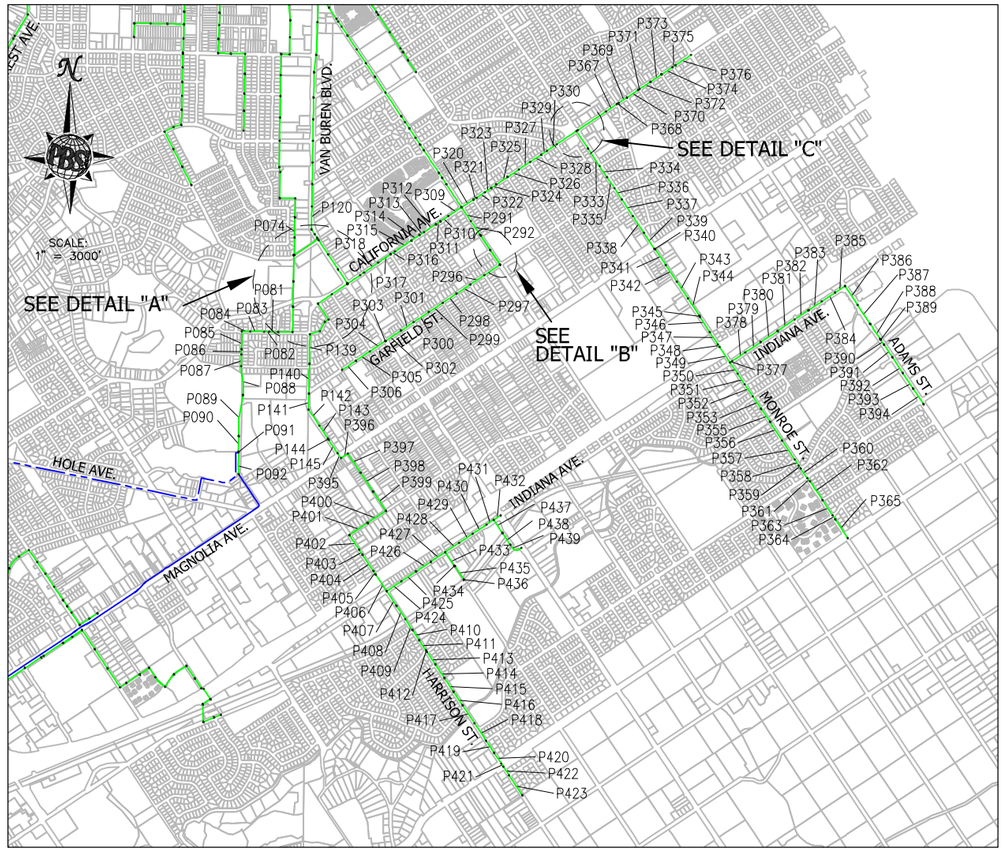
———	GRAVITY SEWER
———	IMPROVEMENT SEWER (2005 - 2010)
P001	PIPE SEGMENT NUMBER

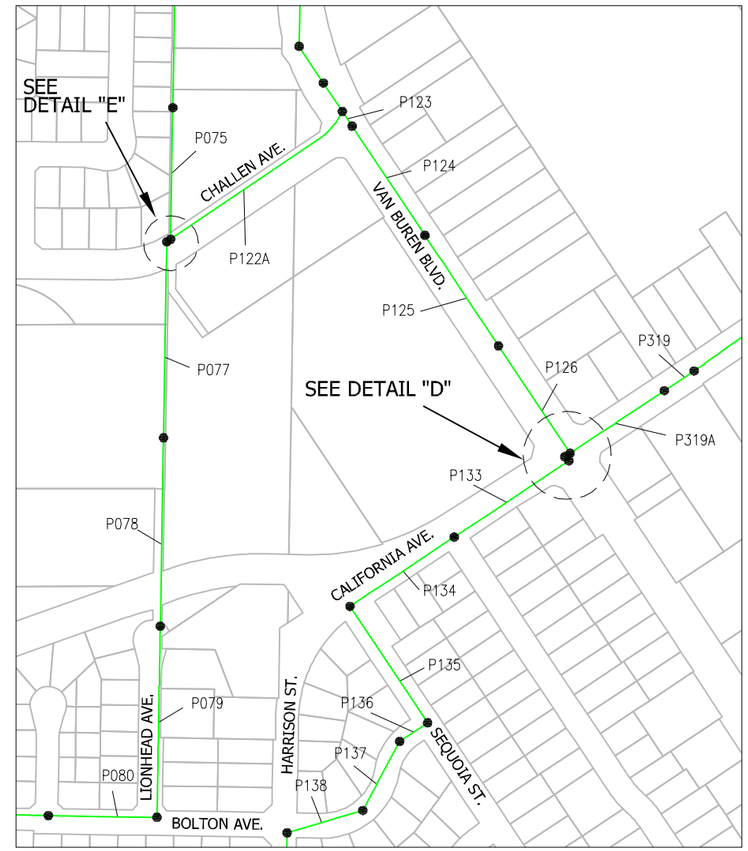
SEE FIGURES 28B AND 28C FOR CONTINUATION OF SEWER BASIN SYSTEM

Engineering
Planning
Surveying
Construction Services
PBS&J
10370 Hemet Street
Suite 200
Riverside, CA 92503
Tel:(951) 358-1433
Fax:(951) 358-1434

DATE: 12/21/05	DWN BY: CD
CITY OF RIVERSIDE ARLANZA SEWER STUDY	FIGURE 28A
PRIORITY A - PART 1	

Y:\City of Riverside\Arlanza\DWG\Exhibits\AZ-PriorityA.dwg, 9/28/2006 10:06:21 AM

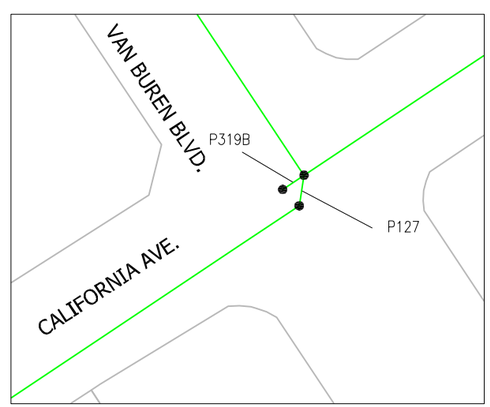




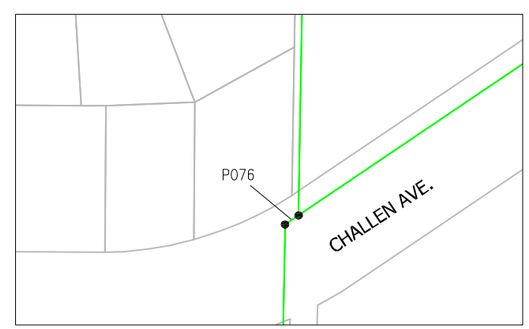
DETAIL "A"
NTS

DETAIL "B"
NTS

DETAIL "C"
NTS



DETAIL "D"
NTS



DETAIL "E"
NTS

LEGEND

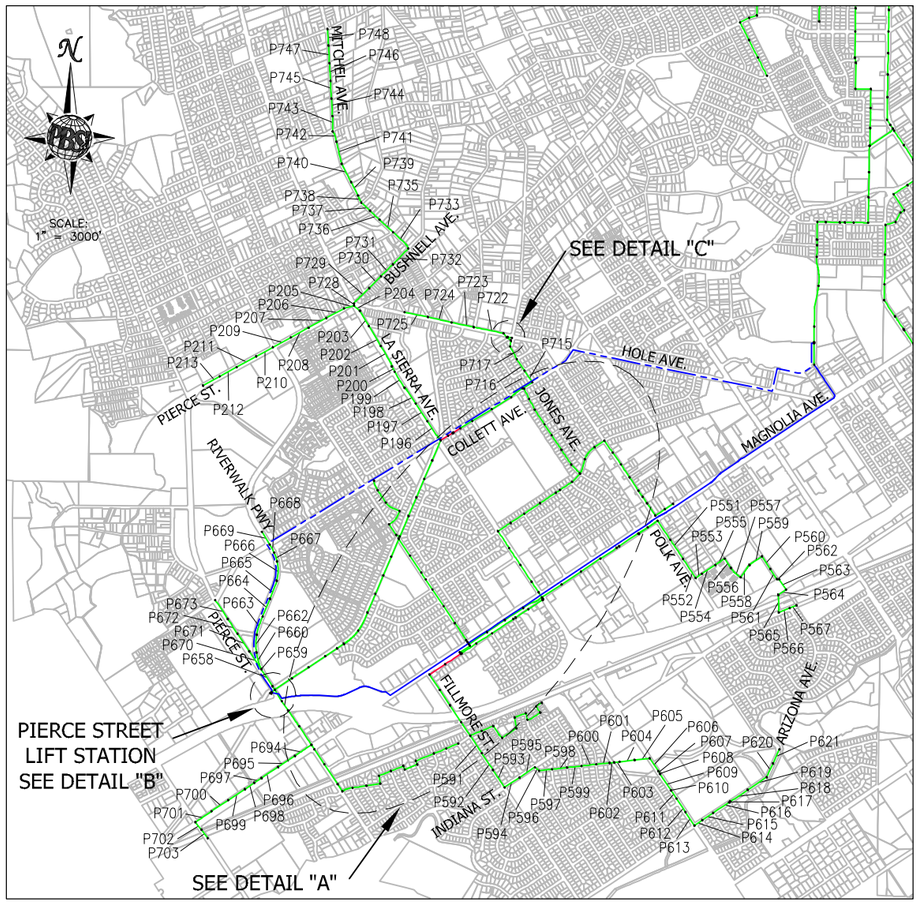
- MAGNOLIA FORCE MAIN
- LA SIERRA FORCE MAIN
- GRAVITY SEWER
- IMPROVEMENT SEWER (2005 - 2010)
- P001 PIPE SEGMENT NUMBER

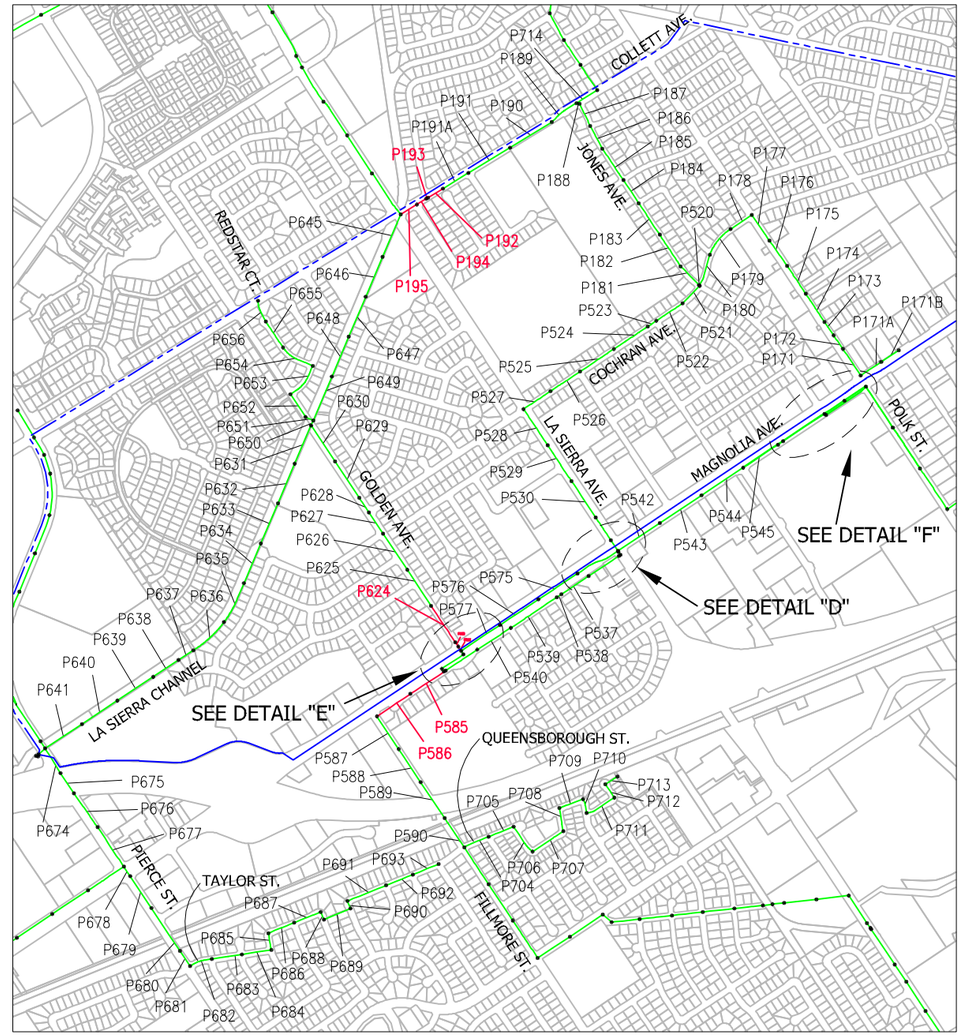
SEE FIGURES 28A AND 28C FOR CONTINUATION OF SEWER BASIN SYSTEM

Engineering
Planning
Surveying
Construction Services
PBSJ
10370 Hemet Street
Suite 200
Riverside, CA 92503
Tel:(951) 358-1433
Fax:(951) 358-1434

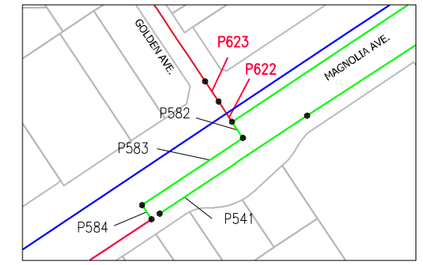
DATE: 12/21/05	DWN BY: CD
CITY OF RIVERSIDE ARLANZA SEWER STUDY	FIGURE 28B
PRIORITY A - PART 2	

Y:\City of Riverside\Arlanza\DWG\Exhibits\AZ-PriorityA-B.dwg, 9/28/2006 10:08:41 AM

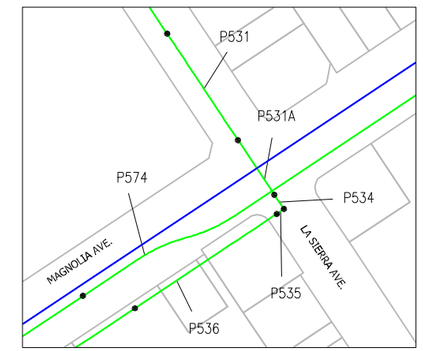




DETAIL "A"
NTS

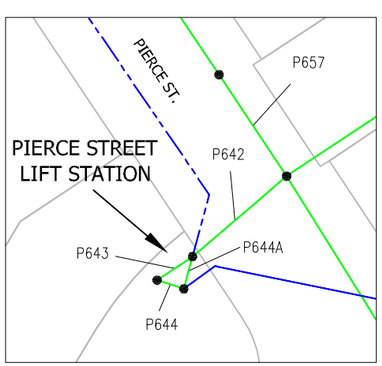


DETAIL "E"
NTS

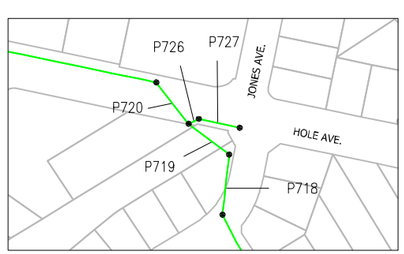


DETAIL "D"
NTS

DETAIL "F"
NTS



DETAIL "B"
NTS



DETAIL "C"
NTS

LEGEND

———	MAGNOLIA FORCE MAIN
— - — -	LA SIERRA FORCE MAIN
———	GRAVITY SEWER
———	IMPROVEMENT SEWER (2005 - 2010)
P001	PIPE SEGMENT NUMBER

SEE FIGURES 28A AND 28B FOR CONTINUATION OF SEWER BASIN SYSTEM

Engineering
Planning
Surveying
Construction Services
PBS&J
10370 Hemet Street
Suite 200
Riverside, CA 92503
Tel:(951) 358-1433
Fax:(951) 358-1434

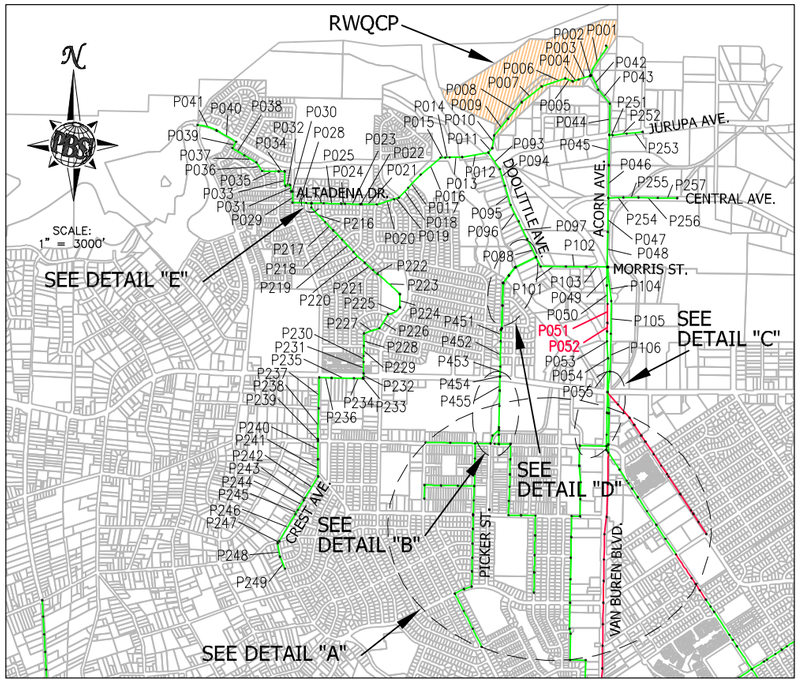
DATE: 12/21/05 | DWN BY: CD

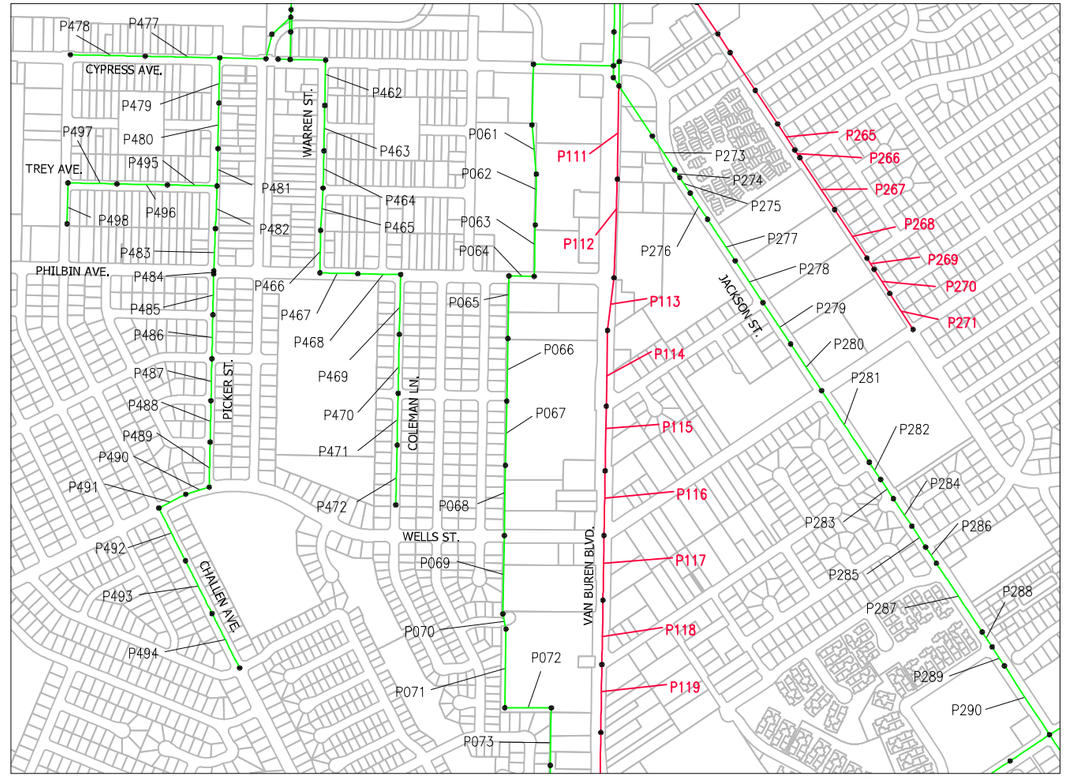
CITY OF RIVERSIDE
ARLANZA SEWER STUDY

FIGURE 28C

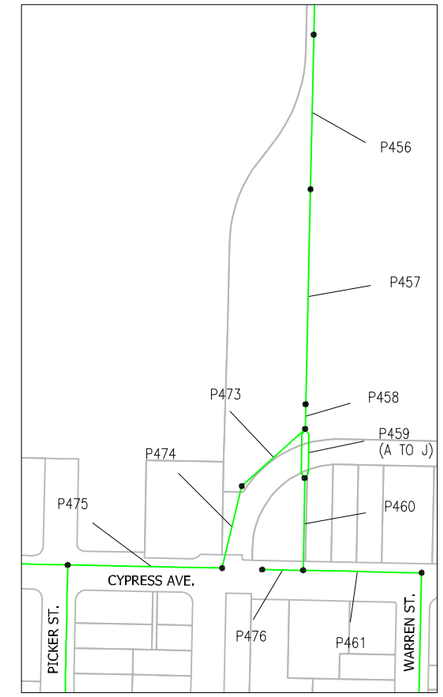
PRIORITY A - PART 3

Y:\City of Riverside\Arlanza\DWG\Exhibits\AZ-PriorityA-C.dwg, 9/28/2006 10:10:00 AM

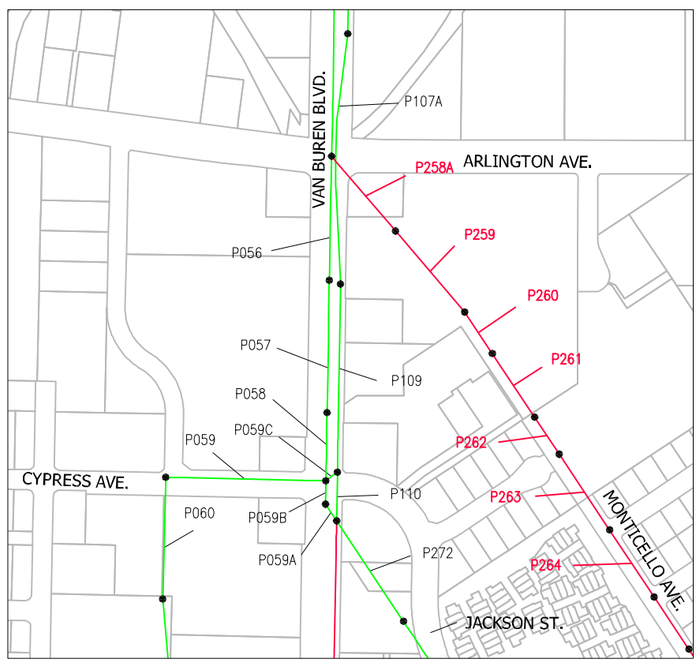




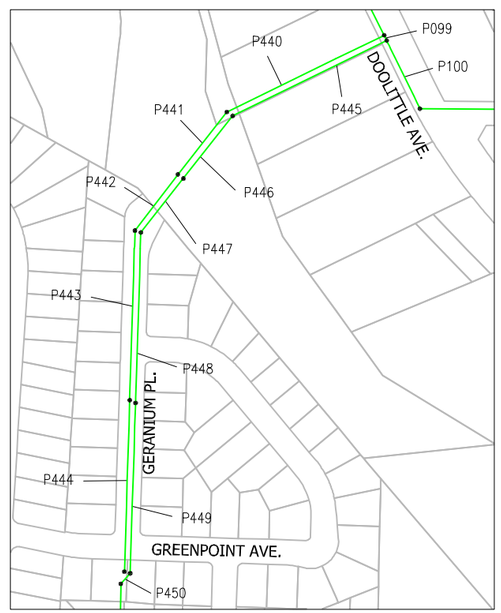
DETAIL "A"
NTS



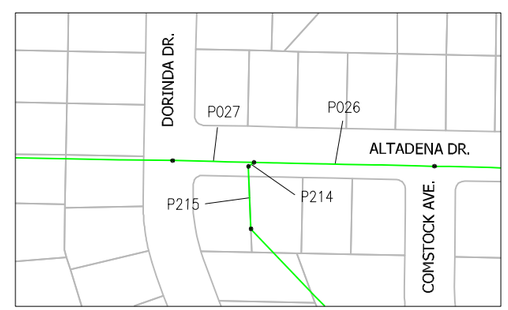
DETAIL "B"
NTS



DETAIL "C"
NTS



DETAIL "D"
NTS



DETAIL "E"
NTS

LEGEND

GRAVITY SEWER

IMPROVEMENT SEWER (2011 - 2015)

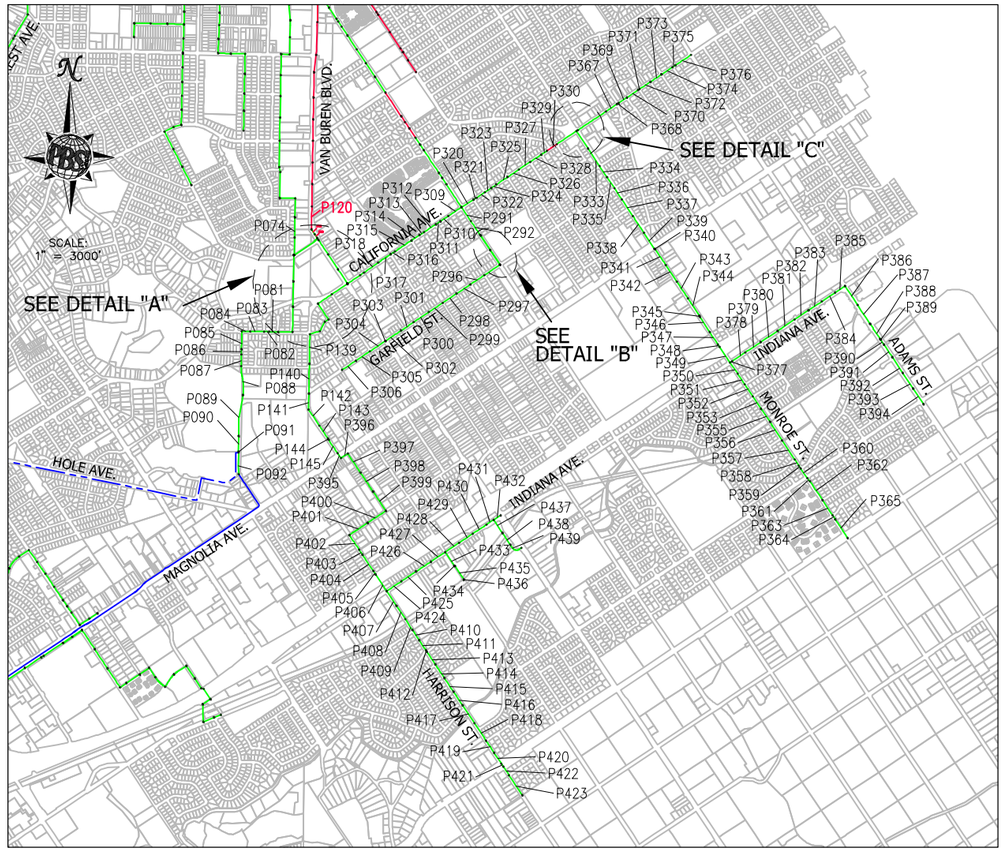
P001 PIPE SEGMENT NUMBER

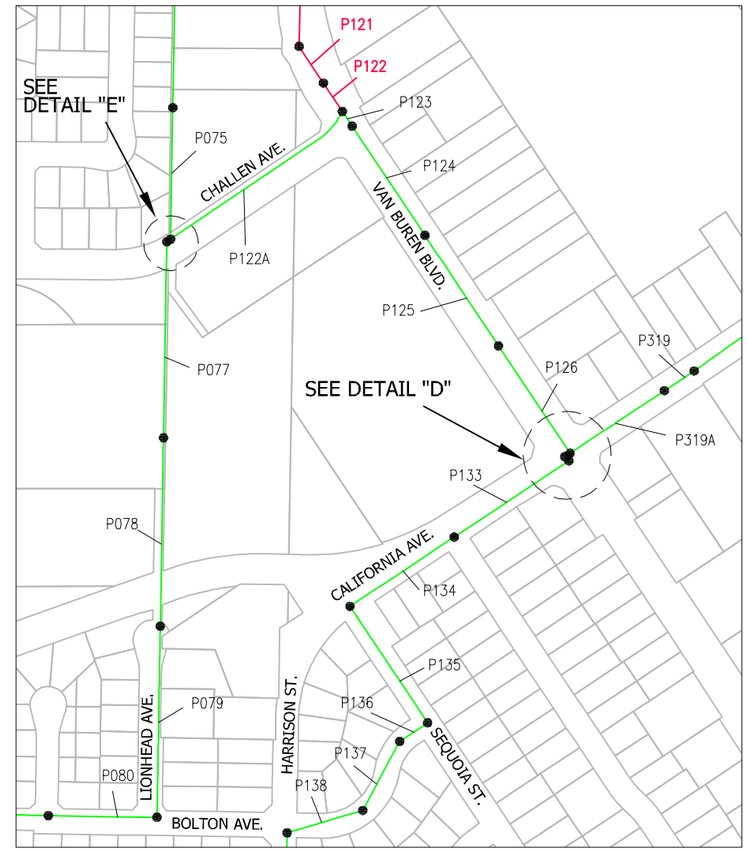
SEE FIGURES 29B AND 29C FOR CONTINUATION OF SEWER BASIN SYSTEM

Engineering
Planning
Surveying
Construction Services
PBS&J
10370 Hemet Street
Suite 200
Riverside, CA 92503
Tel:(951) 358-1433
Fax:(951) 358-1434

DATE: 12/21/05	DWN BY: CD
CITY OF RIVERSIDE ARLANZA SEWER STUDY	FIGURE 29A
PRIORITY B - PART 1	

Y:\City of Riverside\Arlanza\DWG\Exhibits\AZ-PriorityB.dwg, 9/28/2006 10:19:33 AM

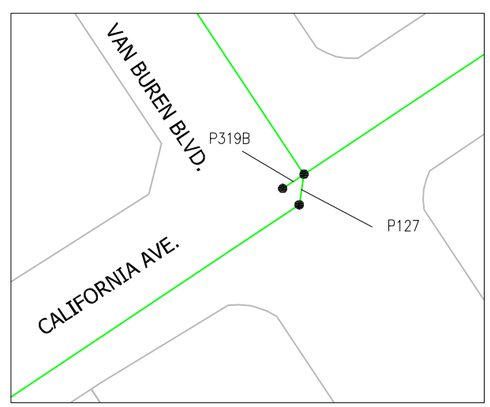




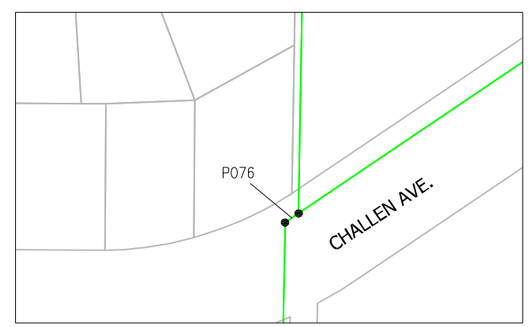
DETAIL "A"
NTS

DETAIL "B"
NTS

DETAIL "C"
NTS



DETAIL "D"
NTS



DETAIL "E"
NTS

LEGEND

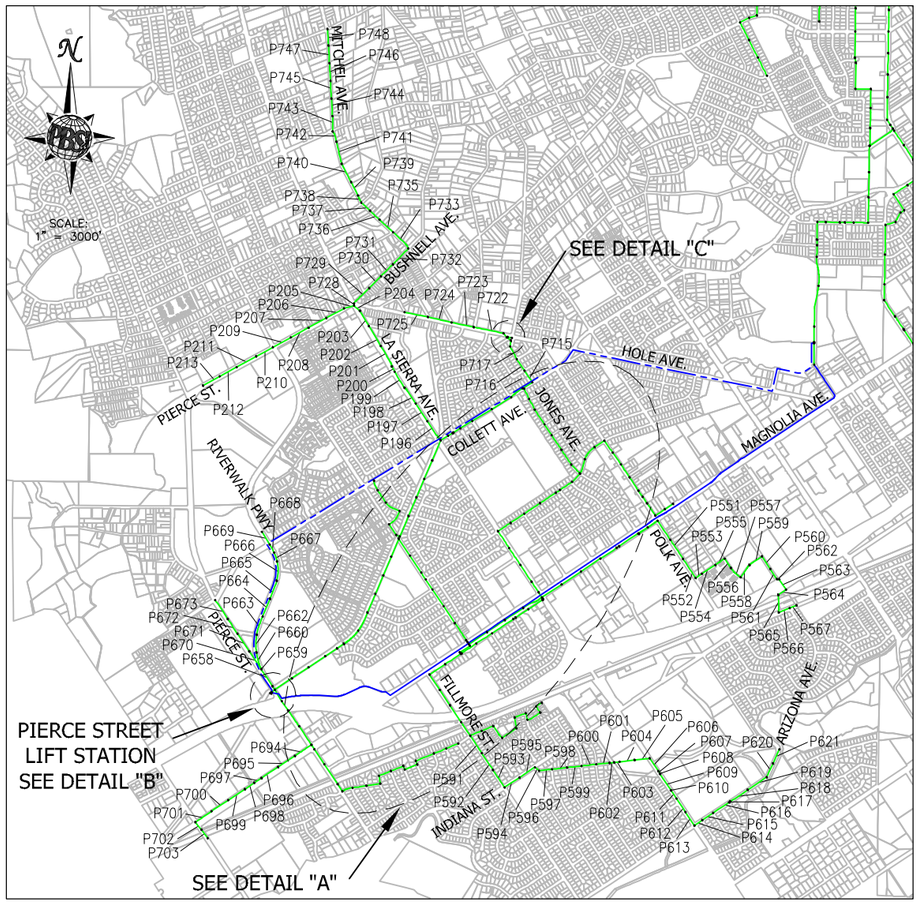
- MAGNOLIA FORCE MAIN
- LA SIERRA FORCE MAIN
- GRAVITY SEWER
- IMPROVEMENT SEWER (2011 - 2015)
- P001 PIPE SEGMENT NUMBER

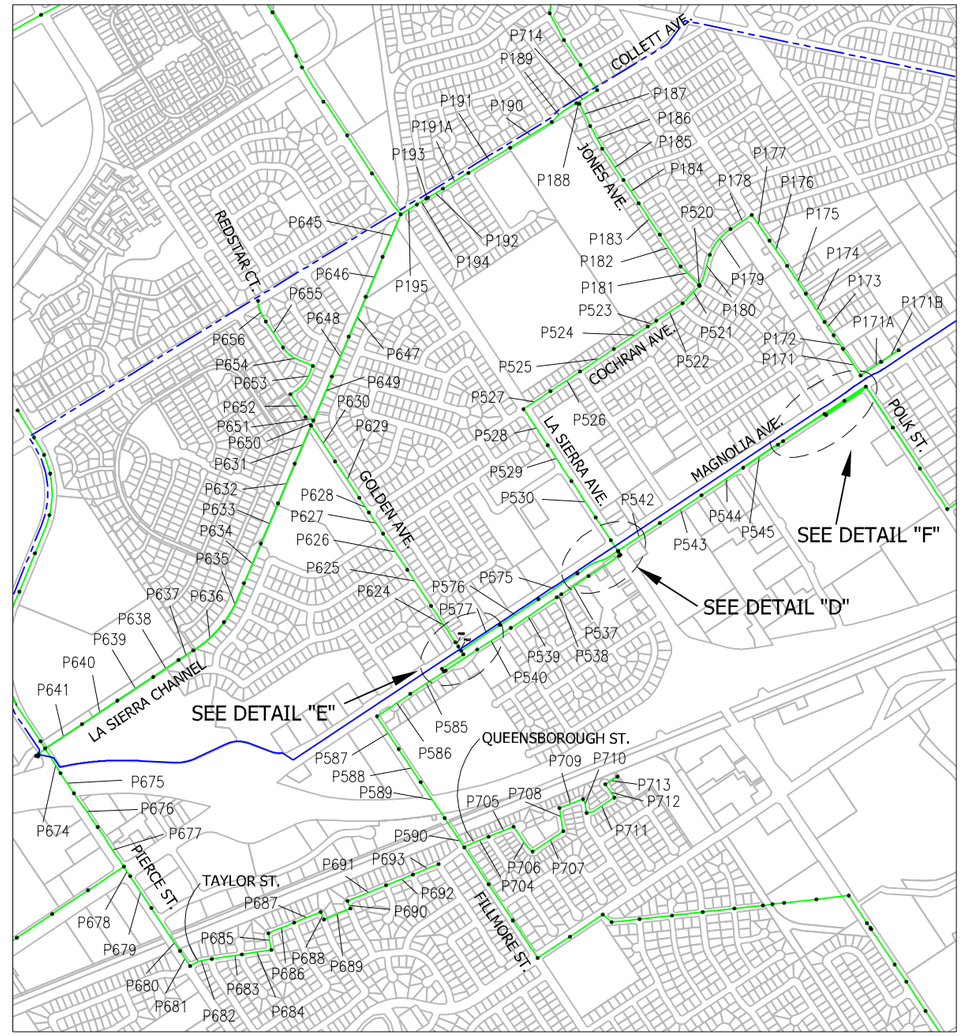
SEE FIGURES 29A AND 29C FOR CONTINUATION OF SEWER BASIN SYSTEM

Engineering
Planning
Surveying
Construction Services
PBSJ
10370 Hemet Street
Suite 200
Riverside, CA 92503
Tel:(951) 358-1433
Fax:(951) 358-1434

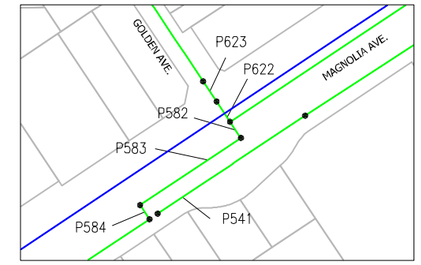
DATE: 12/21/05	DWN BY: CD
CITY OF RIVERSIDE ARLANZA SEWER STUDY	FIGURE 29B
PRIORITY B - PART 2	

Y:\City of Riverside\Arlanza\DWG\Exhibits\AZ-PriorityB-B.dwg, 9/28/2006 10:21:03 AM

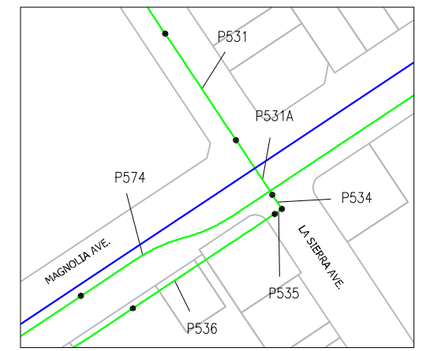




DETAIL "A"
NTS

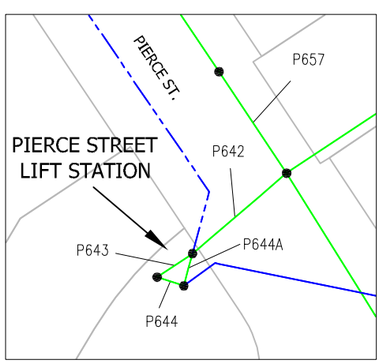


DETAIL "E"
NTS

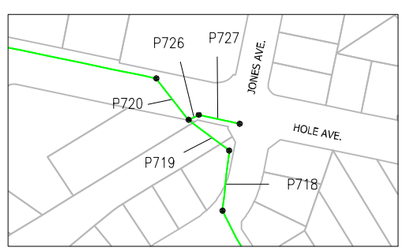


DETAIL "D"
NTS

DETAIL "F"
NTS



DETAIL "B"
NTS



DETAIL "C"
NTS

LEGEND

———	MAGNOLIA FORCE MAIN
— - —	LA SIERRA FORCE MAIN
———	GRAVITY SEWER
———	IMPROVEMENT SEWER (2011 - 2015)
P001	PIPE SEGMENT NUMBER

SEE FIGURES 29A AND 29B FOR CONTINUATION OF SEWER BASIN SYSTEM

Engineering
Planning
Surveying
Construction Services
PBS&J
10370 Hemet Street
Suite 200
Riverside, CA 92503
Tel:(951) 358-1433
Fax:(951) 358-1434

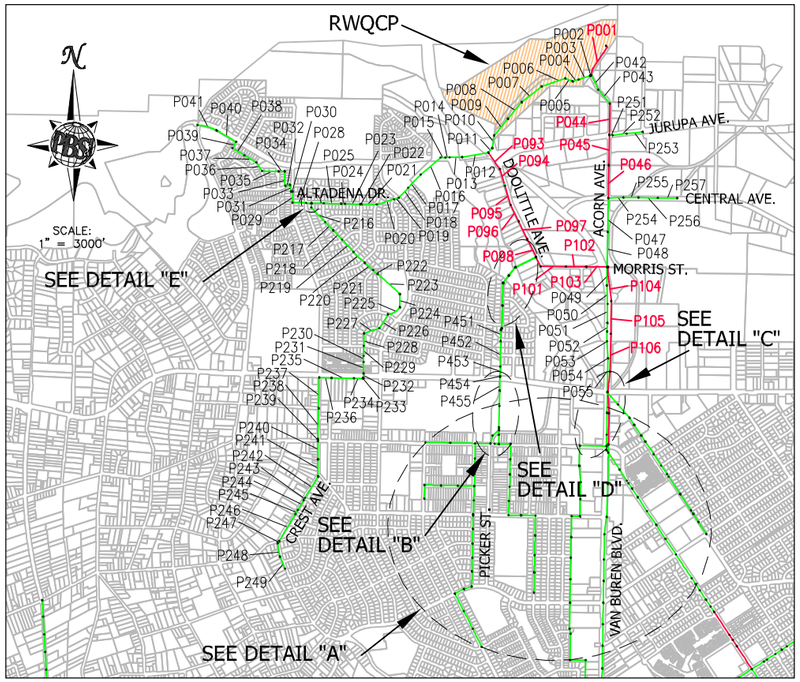
DATE: 12/21/05 | DWN BY: CD

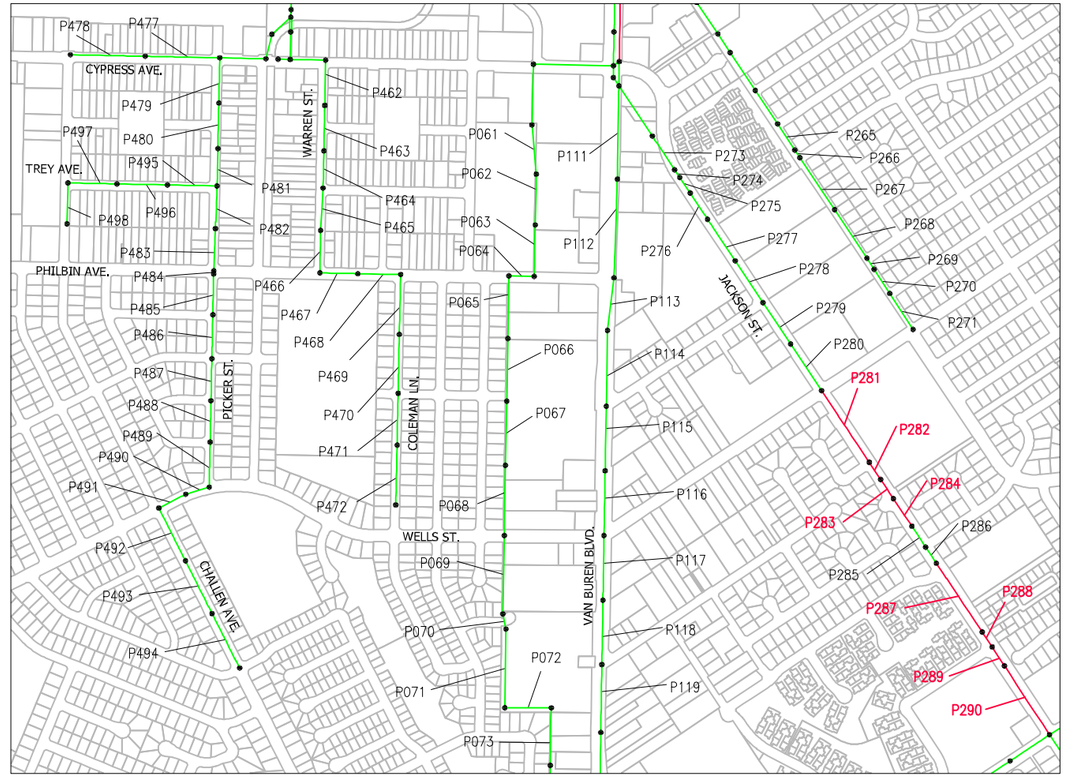
CITY OF RIVERSIDE
ARLANZA SEWER STUDY

FIGURE 29C

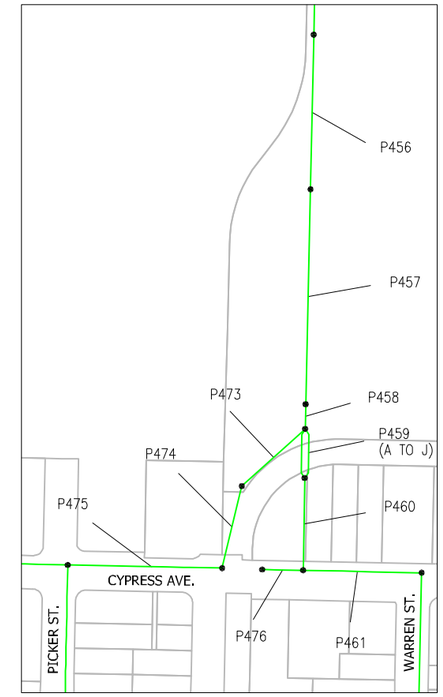
PRIORITY B - PART 3

Y:\City of Riverside\Arlanza\DWG\Exhibits\AZ-PriorityB-C.dwg, 9/28/2006 10:24:45 AM

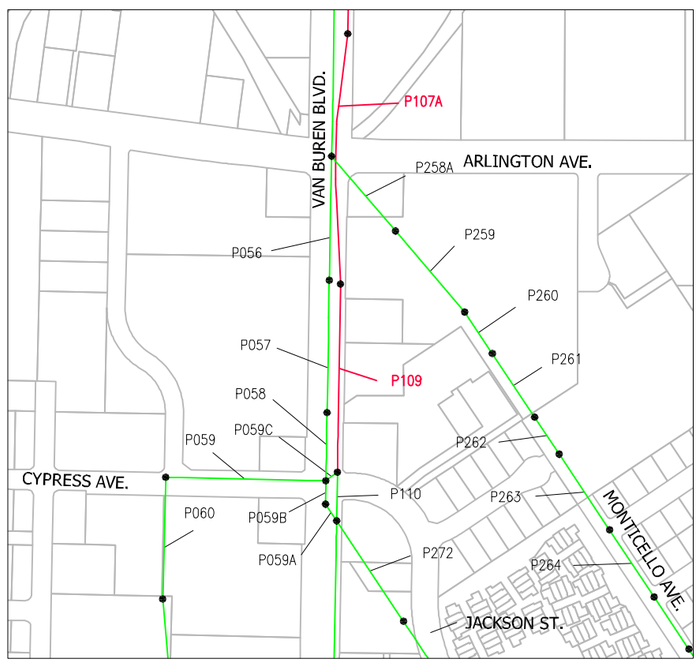




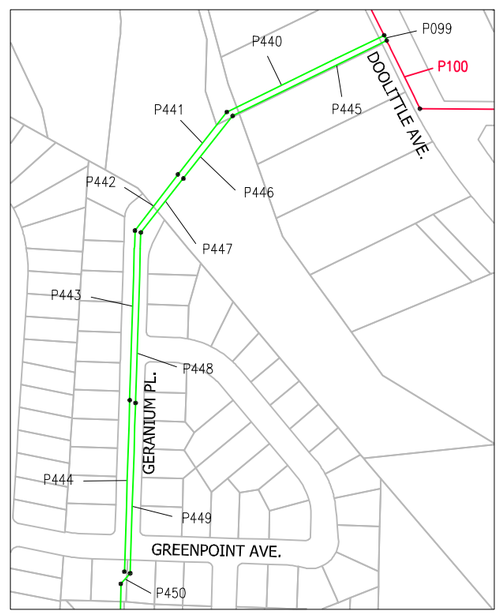
DETAIL "A"
NTS



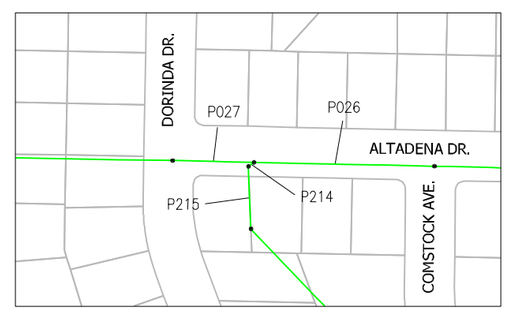
DETAIL "B"
NTS



DETAIL "C"
NTS



DETAIL "D"
NTS



DETAIL "E"
NTS

LEGEND

GRAVITY SEWER

IMPROVEMENT SEWER (2016 - 2020)

P001 PIPE SEGMENT NUMBER

SEE FIGURES 30B AND 30C FOR CONTINUATION OF SEWER BASIN SYSTEM

Engineering
Planning
Surveying
Construction Services

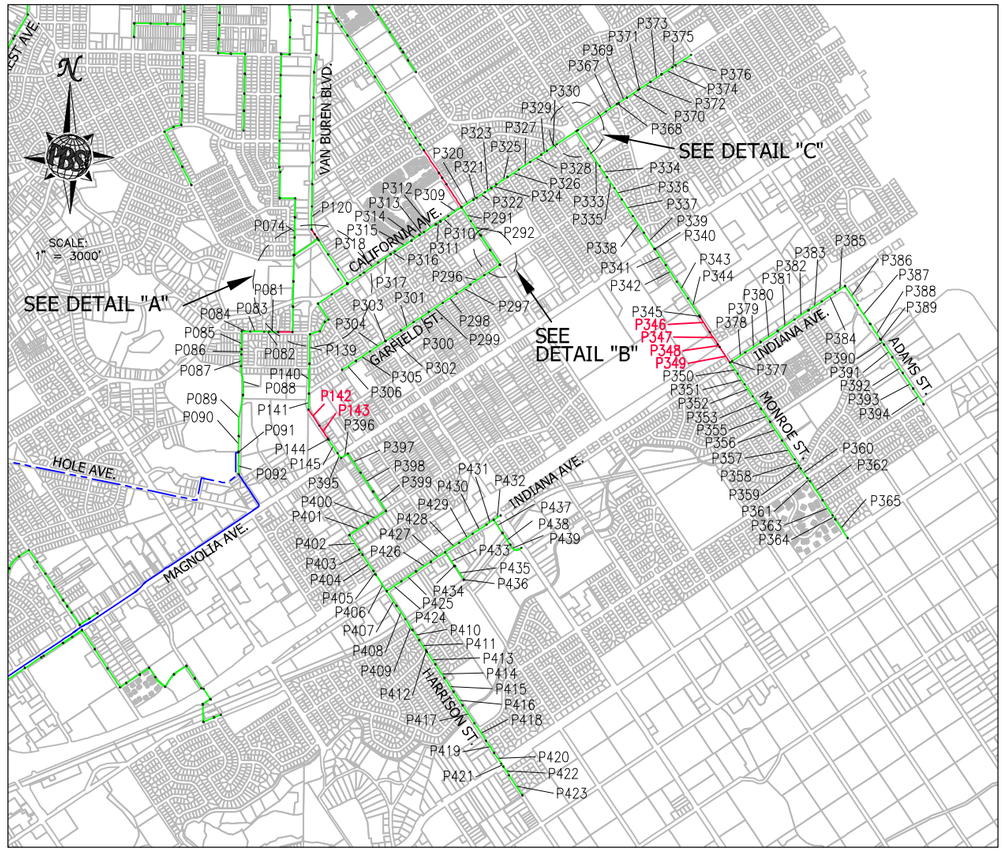
PBS&J

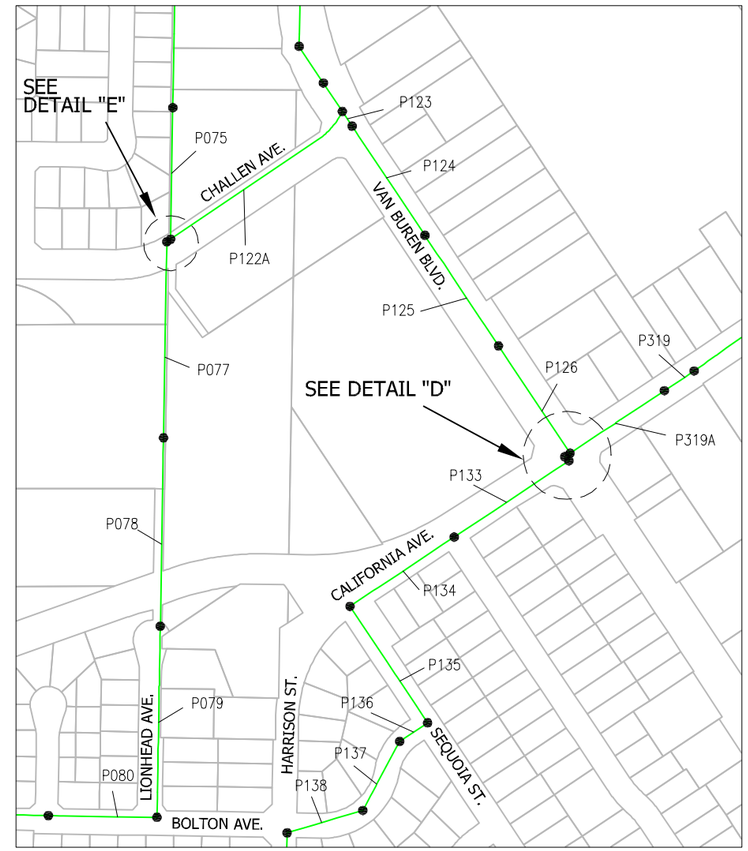
10370 Hemet Street
Suite 200
Riverside, CA 92503
Tel:(951) 358-1433
Fax:(951) 358-1434

DATE: 12/21/05	DWN BY: CD
CITY OF RIVERSIDE ARLANZA SEWER STUDY	FIGURE 30A
PRIORITY C - PART 1	

Y:\City of Riverside\Arlanza\DWG\Exhibits\AZ-PriorityC.dwg, 9/28/2006 10:26:07 AM

H:\Client\Riversid_SAOW\7472A00\Rpt\Volume 03\Appendices\Ch01-AppxC-ArlanzaFinal.pdf

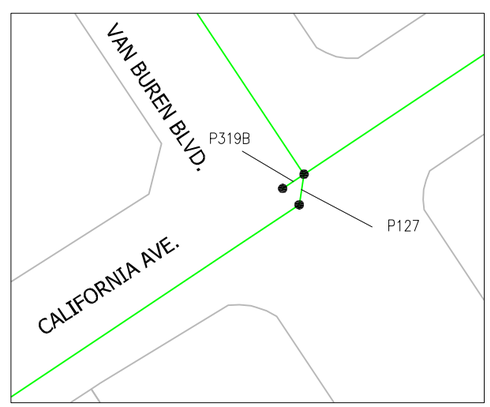




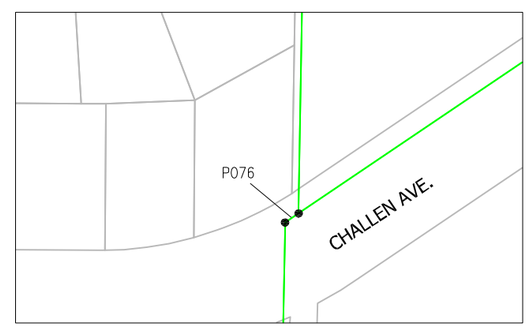
DETAIL "A"
NTS

DETAIL "B"
NTS

DETAIL "C"
NTS



DETAIL "D"
NTS



DETAIL "E"
NTS

LEGEND

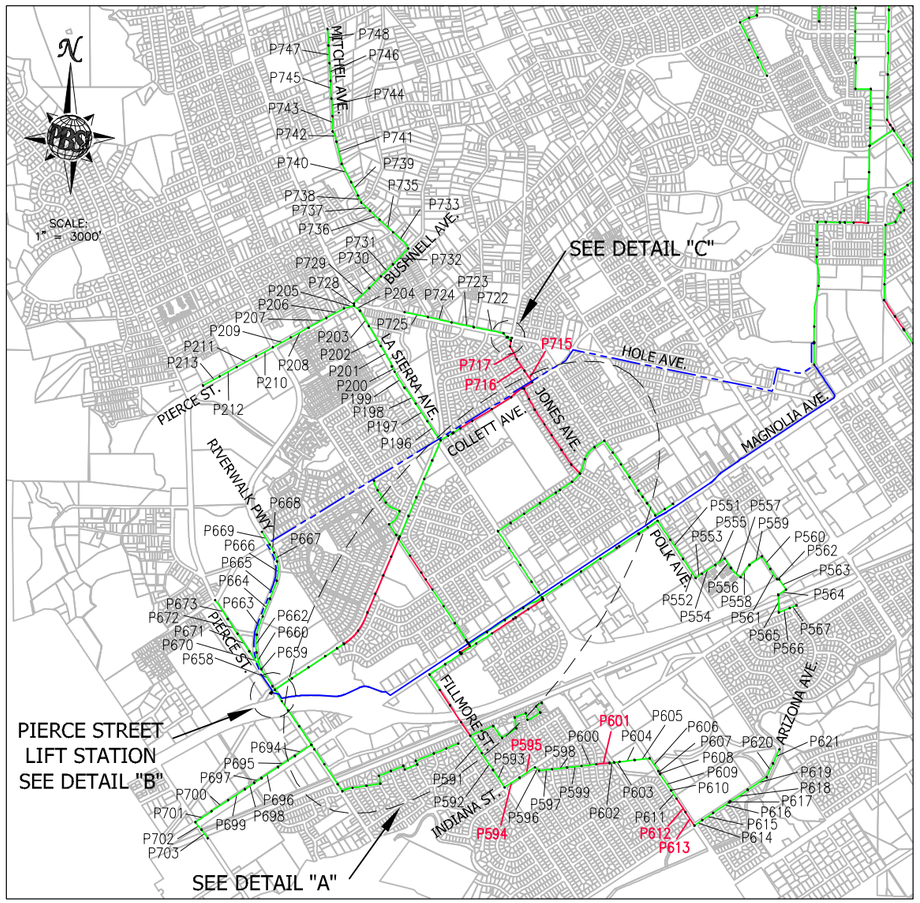
- MAGNOLIA FORCE MAIN
- LA SIERRA FORCE MAIN
- GRAVITY SEWER
- IMPROVEMENT SEWER (2016 - 2020)
- P001 PIPE SEGMENT NUMBER

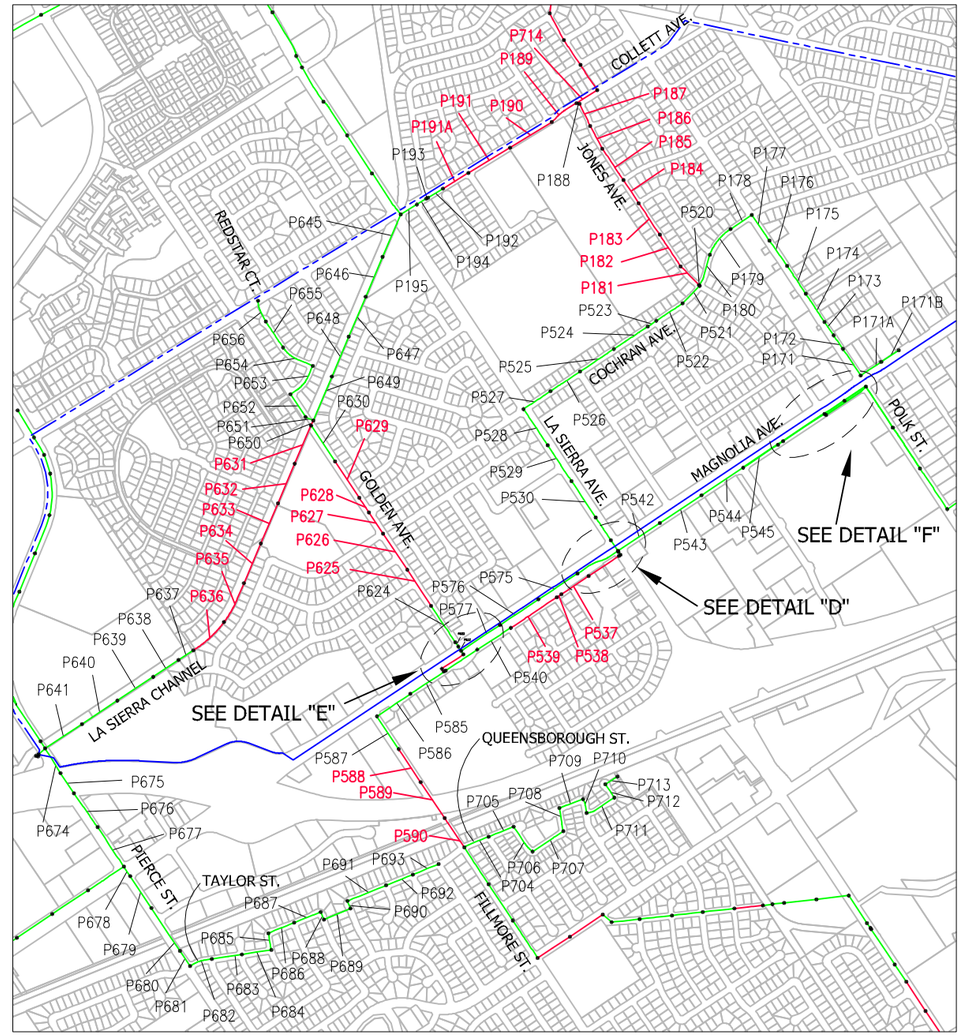
SEE FIGURES 30A AND 30C FOR CONTINUATION OF SEWER BASIN SYSTEM

Engineering
Planning
Surveying
Construction Services
PBSJ
10370 Hemet Street
Suite 200
Riverside, CA 92503
Tel:(951) 358-1433
Fax:(951) 358-1434

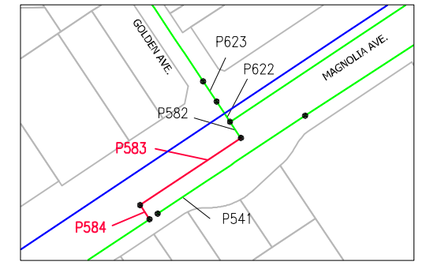
DATE: 12/21/05	DWN BY: CD
CITY OF RIVERSIDE ARLANZA SEWER STUDY	FIGURE 30B
PRIORITY C - PART 2	

Y:\City of Riverside\Arlanza\DWG\Exhibits\AZ-PriorityC-B.dwg, 9/28/2006 10:27:11 AM

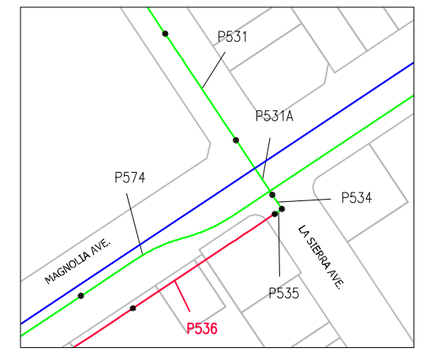




DETAIL "A"
NTS

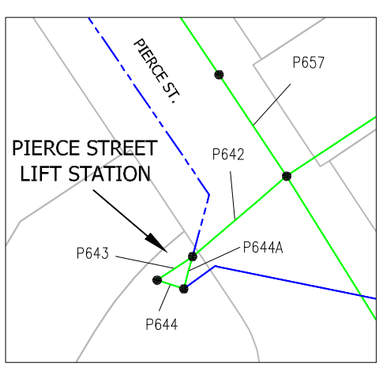


DETAIL "E"
NTS

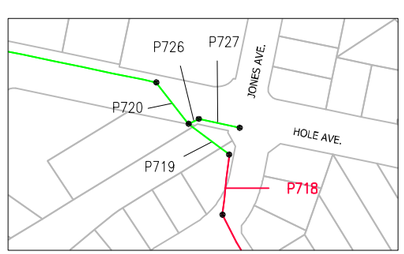


DETAIL "D"
NTS

DETAIL "F"
NTS



DETAIL "B"
NTS



DETAIL "C"
NTS

LEGEND

- MAGNOLIA FORCE MAIN
- LA SIERRA FORCE MAIN
- GRAVITY SEWER
- IMPROVEMENT SEWER (2016 - 2020)
- P001 PIPE SEGMENT NUMBER

SEE FIGURES 30A AND 30B FOR CONTINUATION OF SEWER BASIN SYSTEM

Engineering
Planning
Surveying
Construction Services
PBS&J
10370 Hemet Street
Suite 200
Riverside, CA 92503
Tel:(951) 358-1433
Fax:(951) 358-1434

DATE: 12/21/05 | DWN BY: CD

CITY OF RIVERSIDE
ARLANZA SEWER STUDY

FIGURE 30C

PRIORITY C - PART 3

Y:\City of Riverside\Arlanza\DWG\Exhibits\AZ-PriorityC-C.dwg, 9/28/2006 10:28:15 AM

Table 7-2
Proposed Construction Prioritization and Schedule

Name	Pipe Length (ft)	Existing Pipe Size (inch)	Existing Estimated % Full (Year 2005)	Year 2015 Estimated % Full	Future Estimated % Full (Year 2020)	Priority	New Diameter (inch)	New % Full (Year 2020)	Approximate Replacement Period
P001	697	36	61%	73%	78%	C	39	63%	2016-2020
P002	19	30	198%	225%	239%		48	68%	2005-2010
P003	240	30	198%	225%	239%		48	68%	2005-2010
P004	124	51	48%	54%	58%				
P005	159	51	37%	42%	44%				
P006	495	51	48%	54%	58%				
P007	502	51	49%	55%	59%				
P008	428	51	48%	55%	58%				
P009	429	51	48%	54%	57%				
P010	250	51	48%	55%	58%				
P011	121	51	50%	57%	60%				
P012	523	42	9%	10%	11%				
P013	251	27	10%	12%	13%				
P014	84	27	10%	12%	13%				
P015	95	27	10%	12%	12%				
P016	521	27	10%	11%	12%				
P017	357	27	10%	11%	12%				
P018	274	27	11%	12%	13%				
P019	97	27	11%	13%	13%				
P020	359	27	9%	10%	11%				
P021	303	27	9%	11%	11%				
P022	24	27	9%	10%	11%				
P023	301	27	9%	11%	12%				
P024	72	27	10%	12%	12%				
P025	350	27	10%	11%	12%				
P026	238	27	9%	11%	12%				
P027	107	15	10%	20%	26%				
P028	271	15	10%	20%	25%				
P029	220	15	7%	14%	17%				
P030	30	15	4%	8%	10%				
P031	131	15	6%	12%	14%				
P032	97	15	5%	11%	14%				
P033	291	15	7%	14%	17%				
P034	120	15	6%	11%	14%				
P035	332	15	7%	14%	17%				
P036	200	15	7%	14%	17%				
P037	278	15	3%	7%	9%				
P038	277	15	3%	5%	7%				
P039	143	15	3%	7%	8%				
P040	312	15	3%	6%	7%				
P041	394	15	3%	7%	9%				
P042	317	36	7%	10%	11%				
P043	356	27	14%	20%	23%				
P044	624	27	60%	85%	97%	C	33	57%	2016-2020
P045	600	27	56%	77%	87%	C	30	66%	2016-2020
P046	650	27	56%	77%	88%	C	30	66%	2016-2020
P047	666	27	47%	61%	68%				
P048	703	27	48%	61%	68%				
P049	359	27	48%	62%	69%				
P050	366	27	48%	62%	68%				
P051	372	27	80%	103%	115%	B	33	67%	2011-2015
P052	173	27	72%	92%	103%	B	33	60%	2011-2015
P053	194	27	37%	48%	53%				
P054	333	27	37%	48%	53%				
P055	671	27	48%	61%	68%				
P056	409	24	35%	47%	53%				
P057	436	24	35%	47%	53%				
P058	225	24	46%	62%	70%				
P059	529	36	26%	31%	34%				
P059B	78	24	24%	34%	39%				
P059C	43	33	17%	20%	21%				
P060	402	36	29%	34%	37%				
P061	325	36	28%	34%	36%				
P062	336	36	29%	34%	37%				
P063	339	36	29%	34%	37%				
P064	167	36	23%	27%	29%				
P065	412	36	29%	34%	37%				
P066	414	36	29%	34%	37%				

Table 7-2
Proposed Construction Prioritization and Schedule

Name	Pipe Length (ft)	Existing Pipe Size (inch)	Existing Estimated % Full (Year 2005)	Year 2015 Estimated % Full	Future Estimated % Full (Year 2020)	Priority	New Diameter (inch)	New % Full (Year 2020)	Approximate Replacement Period
P067	424	36	29%	34%	37%				
P068	462	36	29%	34%	37%				
P069	514	36	29%	34%	37%				
P070	102	36	27%	33%	35%				
P071	519	36	18%	22%	24%				
P072	307	36	28%	34%	36%				
P073	378	36	29%	34%	37%				
P074	382	36	28%	33%	36%				
P075	335	36	28%	34%	36%				
P076	12	33	57%	65%	69%				
P077	518	33	49%	56%	60%				
P078	497	33	52%	59%	63%				
P079	504	33	52%	60%	64%				
P080	286	33	52%	59%	63%				
P081	175	33	53%	61%	65%				
P082	101	33	50%	57%	61%				
P083	276	33	48%	56%	59%				
P084	166	33	40%	46%	49%				
P085	351	33	52%	60%	63%				
P086	108	33	51%	59%	63%				
P087	231	33	51%	59%	63%				
P088	113	33	51%	59%	63%				
P089	814	33	51%	59%	63%				
P090	309	33	52%	59%	63%				
P091	20	33	0%	31%	46%				
P092	448	24	51%	29%	18%				
P093	397	42	64%	72%	76%	C	45	63%	2016-2020
P094	345	42	65%	73%	77%	C	45	64%	2016-2020
P095	395	42	65%	73%	77%	C	45	64%	2016-2020
P096	363	42	66%	74%	78%	C	45	65%	2016-2020
P097	388	42	65%	73%	77%	C	45	64%	2016-2020
P098	395	42	64%	72%	76%	C	45	63%	2016-2020
P099	6	42	8%	9%	9%				
P100	204	33	76%	86%	91%	C	39	58%	2016-2020
P101	500	33	77%	87%	92%	C	39	59%	2016-2020
P102	400	33	77%	87%	92%	C	39	59%	2016-2020
P103	433	33	77%	88%	93%	C	39	59%	2016-2020
P104	688	33	77%	87%	92%	C	39	59%	2016-2020
P105	643	33	77%	87%	92%	C	39	59%	2016-2020
P106	748	33	77%	87%	92%	C	39	59%	2016-2020
P107A	727	33	67%	76%	81%	C	36	64%	2016-2020
P109	620	33	67%	76%	80%	C	36	64%	2016-2020
P110	161	33	46%	51%	54%		33	54%	2016-2020
P111	615	27	80%	90%	95%	B	33	56%	2011-2015
P112	651	27	80%	90%	95%	B	33	56%	2011-2015
P113	349	27	80%	90%	95%	B	33	56%	2011-2015
P114	501	27	80%	90%	95%	B	33	56%	2011-2015
P115	425	27	80%	90%	95%	B	33	56%	2011-2015
P116	427	27	80%	90%	95%	B	33	56%	2011-2015
P117	425	27	80%	90%	96%	B	33	56%	2011-2015
P118	424	27	81%	92%	97%	B	33	57%	2011-2015
P119	447	27	81%	92%	97%	B	33	57%	2011-2015
P120	452	27	81%	92%	97%	B	33	57%	2011-2015
P121	116	27	81%	92%	97%	B	33	57%	2011-2015
P122	90	27	81%	92%	97%	B	33	57%	2011-2015
P122A	568	33	27%	29%	31%				
P123	252	27	14%	17%	18%				
P124	347	18	25%	29%	32%				
P125	350	18	25%	29%	31%				
P126	341	18	25%	29%	31%				
P127	7	24	14%	17%	19%				
P133	372	24	17%	20%	22%				
P134	330	24	17%	20%	22%				
P135	379	15	49%	59%	64%				
P136	88	15	43%	52%	56%				
P137	207	15	43%	52%	56%				
P138	208	15	43%	51%	55%				
P139	586	15	51%	61%	66%				

Table 7-2
Proposed Construction Prioritization and Schedule

Name	Pipe Length (ft)	Existing Pipe Size (inch)	Existing Estimated % Full (Year 2005)	Year 2015 Estimated % Full	Future Estimated % Full (Year 2020)	Priority	New Diameter (inch)	New % Full (Year 2020)	Approximate Replacement Period
P140	590	15	38%	46%	49%				
P141	315	18	56%	67%	73%				
P142	383	18	58%	69%	75%	C	21	50%	2016-2020
P143	307	18	58%	70%	76%	C	21	50%	2016-2020
P144	28	18	54%	65%	70%				
P145	319	18	57%	69%	74%				
P171	295	15	19%	22%	24%				
P171A	229	15	18%	21%	22%				
P171B	193	15	20%	24%	26%				
P172	152	15	19%	22%	23%				
P173	148	15	19%	22%	24%				
P174	315	15	19%	22%	23%				
P175	309	15	18%	22%	23%				
P176	285	15	18%	21%	23%				
P177	288	15	18%	22%	23%				
P178	232	15	18%	22%	23%				
P179	311	15	19%	22%	23%				
P180	300	15	19%	22%	23%				
P181	242	15	65%	76%	82%	C	18	50%	2016-2020
P182	350	15	66%	78%	83%	C	18	51%	2016-2020
P183	350	15	66%	78%	83%	C	18	51%	2016-2020
P184	255	15	66%	77%	83%	C	18	51%	2016-2020
P185	285	15	60%	70%	75%	C	18	46%	2016-2020
P186	238	15	67%	78%	84%	C	18	52%	2016-2020
P187	226	15	65%	76%	82%	C	18	50%	2016-2020
P188	31	15	6%	7%	7%				
P189	283	18	75%	88%	94%	C	21	62%	2016-2020
P190	448	18	75%	88%	94%	C	21	62%	2016-2020
P191	446	18	75%	88%	95%	C	21	63%	2016-2020
P191A	276	18	75%	88%	95%	C	21	63%	2016-2020
P192	160	18	94%	109%	116%		24	54%	2005-2010
P193	21	18	94%	109%	116%		24	54%	2005-2010
P194	103	18	94%	109%	116%		24	54%	2005-2010
P195	173	18	94%	109%	116%		24	54%	2005-2010
P196	462	21	41%	47%	51%				
P197	421	21	33%	38%	40%				
P198	383	21	34%	39%	41%				
P199	374	21	30%	34%	36%				
P200	118	21	30%	34%	36%				
P201	463	21	30%	34%	36%				
P202	458	21	28%	32%	34%				
P203	222	21	22%	25%	27%				
P204	155	21	27%	32%	34%				
P205	207	12	37%	40%	41%				
P206	400	12	19%	20%	21%				
P207	400	15	19%	21%	21%				
P208	400	15	19%	21%	21%				
P209	405	15	19%	21%	21%				
P210	375	15	20%	22%	22%				
P211	441	15	20%	22%	22%				
P212	381	15	20%	22%	23%				
P213	379	15	17%	18%	18%				
P214	9	27	11%	11%	12%				
P215	82	27	12%	12%	12%				
P216	399	27	11%	11%	11%				
P217	230	27	11%	11%	11%				
P218	252	27	11%	11%	11%				
P219	329	27	11%	11%	11%				
P220	315	27	11%	11%	11%				
P221	215	27	14%	15%	15%				
P222	120	27	8%	8%	9%				
P223	591	27	8%	8%	9%				
P224	260	18	24%	25%	25%				
P225	288	18	24%	25%	25%				
P226	321	15	41%	43%	43%				
P227	321	15	55%	57%	58%				
P228	245	15	54%	57%	58%				
P229	199	15	52%	54%	55%				

Table 7-2
Proposed Construction Prioritization and Schedule

Name	Pipe Length (ft)	Existing Pipe Size (inch)	Existing Estimated % Full (Year 2005)	Year 2015 Estimated % Full	Future Estimated % Full (Year 2020)	Priority	New Diameter (inch)	New % Full (Year 2020)	Approximate Replacement Period
P230	120	15	51%	53%	54%				
P231	223	15	51%	53%	54%				
P232	94	15	24%	25%	26%				
P233	17	15	27%	28%	29%				
P234	175	15	21%	22%	23%				
P235	442	15	21%	22%	23%				
P236	245	18	24%	25%	25%				
P237	605	18	23%	24%	24%				
P238	611	18	22%	23%	23%				
P239	40	18	4%	5%	5%				
P240	361	15	26%	28%	28%				
P240A	339	15	27%	28%	28%				
P240B	499	12	23%	24%	24%				
P240C	55	15	11%	11%	11%				
P244	222	12	23%	24%	24%				
P245	96	12	21%	22%	22%				
P246	621	15	20%	21%	21%				
P247	52	12	36%	38%	39%				
P248	274	12	22%	23%	23%				
P249	251	12	19%	20%	20%				
P251	61	12	2%	4%	4%				
P252	278	12	13%	26%	33%				
P253	322	12	13%	26%	33%				
P254	296	12	23%	43%	53%				
P255	300	12	24%	44%	54%				
P256	382	12	22%	41%	50%				
P257	382	12	24%	44%	54%				
P258A	324	12	80%	91%	96%	B	15	53%	2011-2015
P259	351	12	80%	91%	96%	B	15	53%	2011-2015
P260	164	12	80%	91%	96%	B	15	53%	2011-2015
P261	253	12	80%	91%	96%	B	15	53%	2011-2015
P262	146	12	80%	91%	96%	B	15	53%	2011-2015
P263	300	12	80%	91%	96%	B	15	53%	2011-2015
P264	266	12	80%	91%	96%	B	15	53%	2011-2015
P265	206	12	80%	91%	96%	B	15	53%	2011-2015
P266	60	12	80%	91%	96%	B*	15	53%	2011-2015
P267	412	12	80%	91%	96%	B	15	53%	2011-2015
P268	385	12	80%	91%	97%	B	15	53%	2011-2015
P269	87	12	81%	91%	97%	B	15	53%	2011-2015
P270	190	12	81%	91%	97%	B	15	53%	2011-2015
P271	284	12	81%	92%	97%	B	15	53%	2011-2015
P272	398	24	54%	65%	70%				
P273	266	24	54%	65%	70%				
P274	62	24	54%	65%	70%				
P275	123	24	55%	66%	71%				
P276	207	24	54%	64%	70%				
P277	330	24	41%	49%	53%				
P278	330	24	41%	49%	53%				
P279	329	24	41%	49%	53%				
P280	370	24	41%	49%	53%				
P281	567	24	67%	79%	86%	C	27	63%	2016-2020
P282	135	24	67%	79%	86%	C	27	63%	2016-2020
P283	153	24	67%	79%	86%	C	27	63%	2016-2020
P284	218	24	67%	79%	86%	C	27	63%	2016-2020
P285	166	24	48%	58%	62%				
P286	127	24	50%	60%	65%				
P287	545	24	67%	79%	86%	C	27	63%	2016-2020
P288	118	24	67%	79%	86%	C	27	63%	2016-2020
P289	148	24	67%	79%	86%	C	27	63%	2016-2020
P290	544	24	78%	93%	101%	C*	30	56%	2016-2020
P291	327	15	33%	37%	39%				
P292	325	15	33%	37%	39%				
P293	369	15	10%	11%	11%				
P294	346	15	13%	14%	15%				
P295	371	14	50%	56%	59%				
P296	331	14	49%	55%	58%				
P297	330	14	49%	55%	58%				
P298	330	14	49%	55%	58%				

Table 7-2
Proposed Construction Prioritization and Schedule

Name	Pipe Length (ft)	Existing Pipe Size (inch)	Existing Estimated % Full (Year 2005)	Year 2015 Estimated % Full	Future Estimated % Full (Year 2020)	Priority	New Diameter (inch)	New % Full (Year 2020)	Approximate Replacement Period
P299	330	14	17%	19%	20%				
P300	361	14	23%	26%	27%				
P301	301	14	23%	26%	27%				
P302	365	14	23%	26%	27%				
P303	7	14	22%	25%	27%				
P304	370	12	35%	39%	41%				
P305	330	12	35%	39%	41%				
P306	330	12	35%	39%	42%				
P307	24	8	23%	26%	28%				
P308	692	20	16%	19%	20%				
P309	313	21	8%	10%	11%				
P310	188	21	9%	11%	12%				
P311	106	21	10%	12%	13%				
P312	282	21	10%	13%	14%				
P313	106	21	11%	13%	14%				
P314	192	18	11%	13%	14%				
P315	393	18	12%	15%	16%				
P316	99	18	11%	14%	15%				
P317	298	18	11%	14%	15%				
P318	343	18	25%	31%	34%				
P319	94	18	9%	12%	13%				
P319A	299	18	1%	3%	3%				
P319B	7	18	12%	13%	14%				
P320	283	21	34%	41%	45%				
P321	70	21	43%	53%	58%				
P322	197	21	44%	54%	59%				
P323	154	21	40%	49%	53%				
P324	119	21	40%	49%	54%				
P325	269	21	39%	48%	52%				
P326	269	21	39%	47%	52%				
P327	269	21	39%	47%	52%				
P328	264	21	39%	48%	52%				
P329	134	21	37%	45%	49%				
P330	234	21	40%	49%	54%				
P331	467	21	40%	49%	54%				
P332	417	15	43%	59%	66%				
P333	414	15	43%	59%	67%				
P334	263	15	43%	59%	67%				
P335	263	15	43%	59%	67%				
P336	263	15	23%	31%	35%				
P337	398	15	23%	31%	36%				
P338	398	15	23%	31%	36%				
P339	376	15	20%	27%	30%				
P340	18	15	20%	27%	30%				
P341	377	15	25%	35%	39%				
P342	396	15	25%	35%	39%				
P343	396	15	25%	34%	39%				
P344	411	15	26%	36%	40%				
P345	24	12	10%	13%	15%				
P346	362	12	64%	87%	98%	C	15	54%	2016-2020
P347	290	12	64%	87%	98%	C	15	55%	2016-2020
P348	61	12	64%	88%	100%	C	15	55%	2016-2020
P349	373	12	64%	88%	101%	C	15	56%	2016-2020
P350	262	12	34%	38%	40%				
P351	255	12	39%	43%	46%				
P352	288	12	38%	43%	45%				
P353	291	12	29%	32%	34%				
P355	321	12	43%	48%	50%				
P356	436	12	9%	10%	11%				
P357	450	12	11%	13%	13%				
P358	145	12	11%	13%	14%				
P359	67	12	11%	12%	13%				
P360	237	12	11%	13%	13%				
P361	79	12	4%	4%	4%				
P362	452	12	11%	13%	13%				
P363	354	12	10%	11%	12%				
P364	96	12	10%	11%	12%				
P365	445	12	10%	11%	12%				

Table 7-2
Proposed Construction Prioritization and Schedule

Name	Pipe Length (ft)	Existing Pipe Size (inch)	Existing Estimated % Full (Year 2005)	Year 2015 Estimated % Full	Future Estimated % Full (Year 2020)	Priority	New Diameter (inch)	New % Full (Year 2020)	Approximate Replacement Period
P366A	32	15	33%	34%	34%				
P366B	670	15	33%	34%	35%				
P367	260	15	33%	34%	35%				
P368	40	15	54%	56%	57%				
P369	199	15	51%	53%	54%				
P370	265	15	52%	54%	55%				
P371	35	15	51%	53%	54%				
P372	260	15	52%	54%	54%				
P373	264	15	52%	53%	54%				
P374	260	15	51%	53%	54%				
P375	71	15	52%	53%	54%				
P376	371	15	52%	54%	55%				
P377	47	18	8%	14%	16%				
P378	315	18	5%	8%	10%				
P379	365	18	6%	11%	14%				
P380	404	18	8%	14%	17%				
P381	404	18	8%	14%	17%				
P382	330	18	8%	14%	17%				
P383	316	18	7%	12%	14%				
P384	316	18	7%	12%	14%				
P385	232	18	6%	10%	12%				
P386	450	18	6%	11%	13%				
P387	450	18	7%	12%	14%				
P388	361	18	7%	12%	14%				
P389	19	12	21%	36%	44%				
P390	110	18	5%	9%	11%				
P391	300	18	3%	5%	6%				
P392	373	12	9%	16%	20%				
P393	375	12	9%	16%	20%				
P394	373	12	9%	14%	17%				
P395	118	18	47%	57%	62%				
P396	162	18	55%	67%	72%				
P397	454	18	54%	66%	72%				
P398	453	18	54%	66%	72%				
P399	453	18	54%	65%	71%				
P400	433	18	54%	66%	71%				
P401	433	18	54%	66%	71%				
P402	350	18	54%	66%	72%				
P403	116	18	54%	65%	71%				
P404	390	18	54%	66%	72%				
P405	79	18	54%	66%	72%				
P406	397	18	54%	66%	72%				
P407	347	12	2%	5%	7%				
P408	315	12	2%	4%	6%				
P409	257	15	2%	4%	5%				
P410	242	15	2%	5%	6%				
P411	241	15	2%	5%	6%				
P412	32	12	2%	4%	5%				
P413	304	12	2%	5%	6%				
P414	325	12	2%	4%	5%				
P415	325	12	2%	5%	6%				
P416	324	12	2%	5%	6%				
P417	422	12	2%	5%	6%				
P418	410	12	2%	5%	6%				
P419	290	12	2%	5%	6%				
P420	257	12	2%	5%	6%				
P421	76	12	2%	5%	6%				
P422	200	12	2%	4%	5%				
P423	469	12	2%	4%	5%				
P424	252	12	34%	39%	42%				
P425	350	12	40%	46%	49%				
P426	350	12	40%	46%	49%				
P427	342	12	40%	46%	49%				
P428	331	12	24%	27%	29%				
P429	325	12	23%	26%	27%				
P430	325	12	23%	26%	27%				
P431	171	12	27%	30%	32%				
P432	166	12	19%	21%	22%				

Table 7-2
Proposed Construction Prioritization and Schedule

Name	Pipe Length (ft)	Existing Pipe Size (inch)	Existing Estimated % Full (Year 2005)	Year 2015 Estimated % Full	Future Estimated % Full (Year 2020)	Priority	New Diameter (inch)	New % Full (Year 2020)	Approximate Replacement Period
P433	325	10	18%	22%	24%				
P434	12	12	16%	19%	20%				
P435	315	12	18%	22%	23%				
P436	15	12	4%	5%	5%				
P437	317	12	6%	7%	7%				
P438	270	12	6%	7%	7%				
P439	286	12	6%	7%	7%				
P440	460	24	5%	6%	6%				
P441	208	24	5%	6%	6%				
P442	185	24	5%	5%	6%				
P443	446	24	6%	6%	6%				
P444	452	24	5%	5%	5%				
P445	453	18	47%	50%	51%				
P446	211	18	47%	50%	51%				
P447	183	18	46%	49%	50%				
P448	451	18	47%	50%	51%				
P449	450	18	47%	50%	51%				
P450	34	18	50%	53%	55%				
P451	221	18	46%	49%	50%				
P452	508	18	45%	48%	49%				
P453	188	18	45%	48%	50%				
P454	16	21	28%	29%	30%				
P455	267	21	30%	32%	33%				
P456	306	21	30%	32%	33%				
P457	425	21	30%	32%	33%				
P458	49	21	24%	26%	26%				
P459A	11	12							
P459B	23	12							
P459C	26	12							
P459D	23	12							
P459E	14	12							
P459F	14	12							
P459G	23	12							
P459H	26	12							
P459I	23	12							
P459J	11	12							
P460	183	21	11%	11%	11%				
P461	234	21	7%	7%	7%				
P462	298	21	4%	4%	4%				
P463	300	21	4%	4%	4%				
P464	246	21	4%	4%	4%				
P465	271	12	14%	14%	14%				
P466	280	12	14%	14%	14%				
P467	250	12	14%	14%	14%				
P468	283	12	14%	14%	14%				
P469	394	12	14%	14%	14%				
P470	389	12	14%	14%	15%				
P471	342	12	14%	14%	14%				
P472	395	12	14%	15%	15%				
P473	169	18	13%	14%	14%				
P474	167	18	11%	12%	13%				
P475	305	18	7%	8%	8%				
P476	81	18	5%	5%	5%				
P477	492	12	7%	8%	8%				
P478	494	12	7%	8%	8%				
P479	298	15	11%	12%	12%				
P480	300	15	11%	12%	12%				
P481	247	15	11%	12%	12%				
P482	282	12	10%	11%	11%				
P483	278	12	13%	14%	15%				
P484	20	12	3%	3%	4%				
P485	270	12	10%	10%	11%				
P486	290	12	10%	10%	11%				
P487	278	12	10%	10%	11%				
P488	272	12	9%	10%	11%				
P489	298	12	10%	10%	11%				
P490	161	12	10%	10%	11%				
P491	200	12	10%	10%	11%				

Table 7-2
Proposed Construction Prioritization and Schedule

Name	Pipe Length (ft)	Existing Pipe Size (inch)	Existing Estimated % Full (Year 2005)	Year 2015 Estimated % Full	Future Estimated % Full (Year 2020)	Priority	New Diameter (inch)	New % Full (Year 2020)	Approximate Replacement Period
P492	390	12	10%	10%	11%				
P493	390	12	10%	10%	11%				
P494	403	12	10%	10%	11%				
P495	327	12	8%	8%	9%				
P496	333	12	8%	9%	9%				
P497	324	12	8%	9%	9%				
P498	227	12	7%	7%	8%				
P520	12	15	40%	47%	50%				
P521	229	15	41%	48%	52%				
P522	288	15	37%	43%	46%				
P523	98	15	36%	42%	45%				
P524	375	15	36%	42%	45%				
P525	375	15	37%	43%	46%				
P526	328	15	36%	42%	45%				
P527	298	15	36%	42%	45%				
P528	400	15	36%	43%	46%				
P529	400	15	36%	43%	46%				
P530	400	15	36%	43%	46%				
P531	253	15	38%	45%	48%				
P531A	130	15	27%	32%	34%				
P534	35	15	15%	17%	19%				
P535	17	12	50%	58%	62%				
P536	337	12	63%	74%	79%	C	15	44%	2016-2020
P537	302	12	62%	73%	78%	C	15	43%	2016-2020
P538	53	12	62%	73%	78%	C	15	43%	2016-2020
P539	508	12	62%	73%	78%	C	15	43%	2016-2020
P540	370	12	54%	63%	68%				
P541	350	12	54%	63%	68%				
P542	464	24	7%	9%	9%				
P543	462	24	28%	32%	34%				
P544	462	24	11%	12%	13%				
P545	385	21	14%	16%	17%				
P546	58	21	11%	12%	12%				
P547	456	21	13%	15%	16%				
P548	8	12	6%	6%	7%				
P548A	222	8	8%	12%	14%				
P548B	236	8	8%	12%	14%				
P549	451	12	31%	34%	36%				
P550	450	12	32%	37%	39%				
P551	455	12	32%	36%	38%				
P552	451	12	25%	28%	30%				
P553	150	12	35%	40%	42%				
P554	317	12	35%	39%	42%				
P555	224	12	28%	32%	34%				
P556	220	12	31%	35%	38%				
P557	272	12	31%	35%	37%				
P558	300	12	26%	30%	31%				
P559	299	12	26%	30%	31%				
P560	300	12	26%	30%	31%				
P561	236	12	26%	30%	31%				
P562	47	12	19%	21%	22%				
P563	245	8	59%	67%	72%				
P564	184	12	28%	32%	34%				
P565	348	12	28%	32%	34%				
P566	232	12	30%	34%	36%				
P567	144	12	26%	30%	32%				
P574	430	24	10%	12%	12%				
P575	434	24	10%	11%	12%				
P576	426	24	10%	12%	13%				
P577	431	24	10%	14%	16%				
P582	39	12	44%	53%	58%				
P583	239	12	61%	74%	81%	C	15	45%	2016-2020
P584	34	12	59%	72%	79%	C	15	43%	2016-2020
P585	370	12	102%	125%	136%		18	46%	2005-2010
P586	372	12	102%	125%	136%		18	46%	2005-2010
P587	364	10	53%	65%	71%				
P588	365	10	75%	92%	100%	C*	12	61%	2016-2020
P589	400	10	65%	79%	87%	C	12	53%	2016-2020

Table 7-2
Proposed Construction Prioritization and Schedule

Name	Pipe Length (ft)	Existing Pipe Size (inch)	Existing Estimated % Full (Year 2005)	Year 2015 Estimated % Full	Future Estimated % Full (Year 2020)	Priority	New Diameter (inch)	New % Full (Year 2020)	Approximate Replacement Period
P590	325	10	65%	79%	87%	C	12	53%	2016-2020
P591	411	10	31%	34%	36%				
P592	399	10	34%	37%	38%				
P593	418	10	33%	36%	37%				
P594	355	10	81%	88%	92%	C	12	56%	2016-2020
P595	367	10	81%	88%	92%	C	12	56%	2016-2020
P596	107	10	23%	25%	26%				
P597	260	8	49%	54%	56%				
P598	300	8	49%	54%	56%				
P599	285	8	55%	60%	62%				
P59A	66	24	21%	30%	35%				
P600	295	8	63%	69%	73%				
P601	265	8	65%	72%	75%	C	10	42%	2016-2020
P602	84	8	58%	64%	67%				
P603	109	8	58%	64%	67%				
P604	300	8	59%	65%	68%				
P605	300	8	59%	65%	67%				
P606	305	8	64%	70%	73%				
P607	54	8	63%	69%	72%				
P608	15	8	64%	71%	74%				
P609	382	8	64%	70%	73%				
P610	7	8	62%	68%	71%				
P611	194	8	64%	70%	73%				
P612	321	8	69%	76%	79%	C	10	45%	2016-2020
P613	321	8	72%	78%	82%	C	10	46%	2016-2020
P614	188	15	10%	11%	12%				
P615	257	15	11%	12%	12%				
P616	380	15	12%	13%	14%				
P617	30	15	5%	6%	6%				
P618	415	15	11%	12%	12%				
P619	451	15	6%	6%	7%				
P620	301	15	7%	8%	8%				
P621	304	15	11%	12%	12%				
P622	49	12	90%	103%	110%		15	60%	2005-2010
P623	48	12	90%	103%	110%		15	60%	2005-2010
P624	405	12	90%	103%	110%		15	60%	2005-2010
P625	400	12	81%	93%	99%	C*	15	55%	2016-2020
P626	400	12	73%	84%	90%	C	15	49%	2016-2020
P627	237	12	67%	77%	82%	C	15	45%	2016-2020
P628	163	12	71%	82%	87%	C	15	48%	2016-2020
P629	401	12	68%	77%	82%	C	15	45%	2016-2020
P630	400	12	61%	69%	74%				
P631	384	27	66%	78%	84%	C	30	63%	2016-2020
P632	400	27	67%	78%	84%	C	30	63%	2016-2020
P633	401	27	67%	78%	84%	C	30	64%	2016-2020
P634	400	27	67%	79%	85%	C	30	64%	2016-2020
P635	403	27	67%	79%	84%	C	30	64%	2016-2020
P636	388	27	67%	79%	84%	C	30	64%	2016-2020
P637	163	27	47%	55%	59%				
P638	280	27	47%	55%	59%				
P639	397	27	47%	56%	60%				
P640	395	27	47%	56%	60%				
P641	406	27	46%	56%	60%				
P642	82	30	50%	60%	65%				
P643	28	30	22%	27%	30%				
P644	18	30	40%	49%	54%				
P644A	22	30	24%	27%	29%				
P645	429	27	36%	41%	44%				
P646	400	27	52%	60%	64%				
P647	399	27	52%	60%	64%				
P648	401	27	52%	60%	64%				
P649	439	27	52%	60%	64%				
P650	51	27	52%	61%	65%				
P651	72	15	11%	14%	16%				
P652	252	12	19%	22%	24%				
P653	343	12	7%	11%	13%				
P654	327	12	7%	11%	13%				
P655	291	12	7%	11%	13%				

Table 7-2
Proposed Construction Prioritization and Schedule

Name	Pipe Length (ft)	Existing Pipe Size (inch)	Existing Estimated % Full (Year 2005)	Year 2015 Estimated % Full	Future Estimated % Full (Year 2020)	Priority	New Diameter (inch)	New % Full (Year 2020)	Approximate Replacement Period
P656	205	12	7%	11%	13%				
P657	80	15	65%	67%	68%				
P658	403	12	38%	39%	40%				
P659	8	12	41%	43%	43%				
P660	342	12	37%	39%	39%				
P662	351	12	34%	35%	36%				
P663	382	12	39%	41%	41%				
P664	381	12	47%	48%	49%				
P665	379	12	46%	48%	48%				
P666	386	12	47%	48%	49%				
P667	183	12	47%	48%	49%				
P668	185	12	46%	48%	48%				
P669	294	12	47%	48%	49%				
P670	425	12	20%	21%	21%				
P671	425	12	21%	21%	22%				
P672	349	12	14%	14%	15%				
P673	447	15	17%	17%	18%				
P674	267	21	42%	35%	32%				
P675	223	21	41%	35%	32%				
P676	382	21	38%	34%	32%				
P677	438	21	35%	33%	32%				
P678	104	15	2%	2%	2%				
P679	353	15	6%	6%	7%				
P680	475	15	6%	6%	7%				
P681	168	15	2%	2%	2%				
P682	215	15	2%	3%	3%				
P683	280	15	3%	3%	4%				
P684	275	15	3%	4%	4%				
P685	158	15	2%	2%	2%				
P686	255	15	3%	3%	4%				
P687	266	15	3%	3%	4%				
P688	76	15	3%	4%	4%				
P689	266	15	3%	4%	4%				
P690	75	15	3%	4%	4%				
P691	387	15	3%	3%	3%				
P692	264	15	3%	3%	4%				
P693	258	15	4%	5%	5%				
P694	395	15	68%	64%	63%				
P695	398	15	62%	62%	63%				
P696	395	15	57%	61%	63%				
P697	171	15	57%	62%	65%				
P698	224	15	53%	58%	61%				
P699	397	15	49%	54%	56%				
P700	396	15	55%	60%	63%				
P701	384	15	57%	62%	65%				
P702	205	8	50%	55%	57%				
P703	212	12	10%	10%	10%				
P704	247	12	18%	27%	31%				
P705	248	12	18%	27%	31%				
P706	291	12	18%	27%	31%				
P707	341	12	17%	26%	31%				
P708	217	12	18%	27%	31%				
P709	234	12	18%	27%	31%				
P710	134	12	18%	27%	32%				
P711	296	12	18%	27%	31%				
P712	147	12	18%	27%	32%				
P713	121	12	18%	27%	31%				
P714	227	15	61%	71%	76%	C	18	47%	2016-2020
P715	280	15	62%	73%	78%	C	18	48%	2016-2020
P716	276	15	60%	71%	76%	C	18	47%	2016-2020
P717	280	15	62%	72%	78%	C	18	48%	2016-2020
P718	120	15	63%	74%	79%	C	18	49%	2016-2020
P719	101	12	42%	50%	53%				
P720	104	18	19%	22%	23%				
P722	603	18	18%	21%	22%				
P723	448	18	37%	44%	47%				
P724	481	15	20%	24%	26%				
P725	471	15	10%	12%	13%				

Table 7-2
Proposed Construction Prioritization and Schedule

Name	Pipe Length (ft)	Existing Pipe Size (inch)	Existing Estimated % Full (Year 2005)	Year 2015 Estimated % Full	Future Estimated % Full (Year 2020)	Priority	New Diameter (inch)	New % Full (Year 2020)	Approximate Replacement Period
P726	22	8	40%	47%	51%				
P727	76	15	23%	26%	28%				
P728	43	15	20%	25%	28%				
P729	428	15	25%	32%	35%				
P730	330	18	27%	34%	38%				
P731	335	18	27%	34%	37%				
P732	438	18	27%	34%	38%				
P733	441	15	23%	30%	33%				
P735	367	12	25%	32%	35%				
P736	251	12	25%	31%	35%				
P737	235	12	42%	54%	59%				
P738	155	15	24%	30%	33%				
P739	297	15	23%	29%	33%				
P740	408	15	23%	29%	33%				
P741	451	15	23%	30%	33%				
P742	220	12	17%	22%	24%				
P743	300	12	26%	34%	38%				
P744	350	12	26%	34%	38%				
P745	350	12	26%	34%	38%				
P746	350	12	26%	34%	38%				
P747	350	12	26%	34%	38%				
P748	327	12	26%	34%	38%				

* Placed under different category due to geographical location.

Table 7-3
Summary of Improvement Plans for Problem Areas
Priority "A"

Priority	Location	Pipes	Problem	Solution	Approx. Cost (2005 $'s)
"A" (See Figures 28A, 28B, 28C and Table 7-2 for details of pipes)	Collett Avenue	Pipes P192 to P195	Immediate Capacity Problem in reach M192 to M195 due to flat slopes. Surcharging conditions.	Field verify surcharging conditions Replace pipe with larger size pipe maintaining the same slope	$207,000
	Fillmore Street	Pipes P585 to P586	Immediate Capacity Problem in reach M585 to M587 due to flat slopes. Surcharging conditions.	Field verify surcharging conditions Replace pipe with larger size pipe maintaining the same slope	$220,000
	Golden Avenue	Pipes P622 to P624	Immediate Capacity Problem in reach M623 to M625 due to flat slopes. Surcharging conditions.	Field verify surcharging conditions Replace pipe with larger size pipe maintaining the same slope	$143,000
	RWQCP Sewer	Pipes P002 to P003	Immediate Capacity Problem in reach M002 to M004 due to flat slope. Surcharging conditions.	Field verify surcharging conditions Replace pipe with larger size pipe maintaining the same slope	$178,000
				Total Construction Cost for Priority "A" Projects (2005-2010 Replacement / Rehabilitation)	**$748,000**

Table 7-3
Summary of Improvement Plans for Problem Areas
Priority "B"

Priority	Location	Pipes	Problem	Solution	Approx. Cost (2005 $'s)
"B" (See Figures 29A, 29B, 29C and Table 7-2 for details of pipes)	Monticello Avenue	Pipes P258A and P259 to P271	Future Capacity Problem in reaches M258 to M056 and M258 to M271 due to flat slopes and increased flow in the system.	Monitor flow in future to verify that it will exceed 90% criteria. Replace pipes with larger size pipes maintaining same slopes.	$866,000
	Van Buren Boulevard	Pipes P051 to P052 and P111 to P122	Future Capacity Problem in reaches M051 to M053 and M111 to M122 due to flat slopes and increased flow in the system.	Monitor flow in future to verify that it will exceed 90% criteria. Replace pipes with larger size pipes maintaining same slopes.	$2,458,000
				Total Construction Cost for Priority "B" Projects (2011-2015 Replacement / Rehabilitation)	**$3,324,000**

Table 7-3
Summary of Improvement Plans for Problem Areas
Priority "C"

Priority	Location	Pipes	Problem	Solution	Approx. Cost (2005 $'s)
"C" (See Figures 30A, 30B, 30C and Table 7-2 for details of pipes)	Acorn Street	Pipes 044 to P046	Future Capacity Problem in reach M044 to M047 due to flat slopes and increased flow in the system.	Monitor flow in future to verify that it will exceed 75% criteria. Replace pipes with larger size pipes maintaining same slopes if surcharging appears imminent or if part of another needed project.	$782,000
	Arizona Avenue	Pipes P594 to P595, P601, P612 to P613	Future Capacity Problem in reach M594 to M596, M601 to M602 and M612 to M614 due to flat slopes, smaller pipe sizes and increased flow in the system.	Monitor flow in future to verify that it will exceed 75% criteria. Replace pipes with larger size pipes maintaining same slopes if surcharging appears imminent or if part of another needed project.	$373,000
	Collett Avenue	Pipes P189 to P191A	Future Capacity Problem in reach M188 to M192 due to flat slopes and increased flow in the system.	Monitor flow in future to verify that it will exceed 75% criteria. Replace pipes with larger size pipes maintaining same slopes if surcharging appears imminent or if part of another needed project.	$486,000
	Fillmore Street	Pipes P583 to P584, P588 to P590	Future Capacity Problem in reaches M583 to M585 and M588 to M591 due to smaller pipe sizes, flat slopes and increased flow in the system.	Monitor flow in future to verify that it will exceed 75% criteria. Replace pipes with larger size pipes maintaining same slopes if surcharging appears imminent or if part of another needed project.	$337,000
	Golden Avenue	Pipes P625 to P629	Future Capacity Problem in reach M625 to M630 due to smaller pipe sizes, flat slopes and increased flow in the system.	Monitor flow in future to verify that it will exceed 75% criteria. Replace pipes with larger size pipes maintaining same slopes if surcharging appears imminent or if part of another needed project.	$396,000
	Harrison Street	Pipes P142 to P143	Future Capacity Problem in reach M138 to M140 due to flat slopes and increased flow in the system.	Monitor flow in future to verify that it will exceed 75% criteria. Replace pipes with larger size pipes maintaining same slopes if surcharging appears imminent or if part of another needed project.	$236,000
	Hole Avenue	Pipes P714 to P718	Future Capacity Problem in reaches M188 to M713 and M713 to M717 due to flat slopes and increased flow in the system.	Monitor flow in future to verify that it will exceed 75% criteria. Replace pipes with larger size pipes maintaining same slopes if surcharging appears imminent or if part of another needed project.	$365,000
	Jackson Street	Pipes P281 to P284, P287 to P290	Future Capacity Problem in the reach M280 to M284, M286 to M290 due to flat slopes and increased flow in the system.	Monitor flow in future to verify that it will exceed 75% criteria. Replace pipes with larger size pipes maintaining same slopes if surcharging appears imminent or if part of another needed project.	$967,000

Table 7-3
Summary of Improvement Plans for Problem Areas
Priority "C"

Priority	Location	Pipes	Problem	Solution	Approx. Cost (2005 $'s)
	Jones Avenue	Pipes P181 to P187	Future Capacity Problem in the reach M180 to M187 due to flat slopes and increased flow in the system.	Monitor flow in future to verify that it will exceed 75% criteria. Replace pipes with larger size pipes maintaining same slopes if surcharging appears imminent or if part of another needed project.	$581,000
	La Sierra Channel	Pipes P631 to P636	Future Capacity Problem in reach M631 to M637 due to flat slopes and increased flow in the system.	Monitor flow in future to verify that it will exceed 75% criteria. Replace pipes with larger size pipes maintaining same slopes if surcharging appears imminent or if part of another needed project.	$976,000
	Magnolia Avenue (2)	Pipes P536 to P539	Future Capacity Problem in reach M539 to M543 due to flat slopes, smaller pipe sizes and increased flow in the system.	Monitor flow in future to verify that it will exceed 75% criteria. Replace pipes with larger size pipes maintaining same slopes if surcharging appears imminent or if part of another needed project.	$301,000
	Monroe Street	Pipes P346 and P349	Future Capacity Problem in reach M345 to M349 due to flat slopes, smaller pipe sizes and increased flow in the system.	Monitor flow in future to verify that it will exceed 75% criteria. Replace pipes with larger size pipes maintaining same slopes if surcharging appears imminent or if part of another needed project.	$277,000
	RWQCP Sewer	Pipe P001	Future Capacity Problem in reach M001 to M002 due to flat slopes and increased flow in the system.	Monitor flow in future to verify that it will exceed 75% criteria. Replace pipes with larger size pipes maintaining same slopes if surcharging appears imminent or if part of another needed project.	$348,000
	Van Buren Boulevard	Pipes P093 to P098, P100 to P106 and P107A, P109	Future Capacity Problem in reaches M012 to M094, M094 to M099, M100 to M107, M107 to M110 due to flat slopes and increased flow in the system.	Monitor flow in future to verify that it will exceed 75% criteria. Replace pipes with larger size pipes maintaining same slopes if surcharging appears imminent or if part of another needed project.	$3,708,000
				Total Construction Cost for Priority "C" Projects (2016-2020 Replacement / Rehabilitation)	**$10,133,000**

Table 7-6-A
Preliminary Construction Cost Estimate For Priority "A" Projects
(2005- 2010 Replacement / Rehabilitation)

Location	Description	Existing Diameter (inch)	New Diameter (inch)	Unit	Quantity	Unit Cost	Approx Total Cost(2005 $'s)
Collett Avenue	Replace Pipes P192 to P195	18	24	LF	457	$200	$91,400
	Rehab / Replace Manhole			EA	5	$5,500	$27,500
	Reconnect Sewer Laterals			EA	5	$1,650	$8,250
						Total:	$127,150
Mobilization / Demobilization (7%)							$8,901
Traffic Control (7%)							$8,901
Bond (1%)							$1,272
Contractor's Profit(15%)							$19,073
Subtotal:							$165,295
Construction Contingency(25%)							$41,324
Total Construction Cost (Collett Avenue Sewer)							**$207,000**
Fillmore Street	Replace Pipes P585 and P586	12	18	LF	742	$145	$107,590
	Rehab / Replace Manhole			EA	3	$5,500	$16,500
	Reconnect Sewer Laterals			EA	7	$1,650	$11,550
						Total:	$135,640
Mobilization / Demobilization (7%)							$9,495
Traffic Control (7%)							$9,495
Bond (1%)							$1,356
Contractor's Profit(15%)							$20,346
Subtotal:							$176,332
Construction Contingency(25%)							$44,083
Total Construction Cost (Fillmore Street Sewer)							**$220,000**
Golden Avenue	Replace Pipes P622 to P624	12	15	LF	502	$115	$57,730
	Rehab / Replace Manhole			EA	4	$5,500	$22,000
	Reconnect Sewer Laterals			EA	5	$1,650	$8,250
						Total:	$87,980
Mobilization / Demobilization (7%)							$6,159
Traffic Control (7%)							$6,159
Bond (1%)							$880
Contractor's Profit(15%)							$13,197

Table 7-6-A
Preliminary Construction Cost Estimate For Priority "A" Projects
(2005- 2010 Replacement / Rehabilitation)

Location	Description	Existing Diameter (inch)	New Diameter (inch)	Unit	Quantity	Unit Cost	Approx Total Cost(2005 $'s)
Subtotal:							$114,374
Construction Contingency(25%)							$28,594
Total Construction Cost (Golden Avenue Sewer)							**$143,000**
RWQCP	Replace Pipe P002 and P003	30	48	LF	259	$340	$88,060
	Rehab / Replace Manhole			EA	3	$5,500	$16,500
	Reconnect Sewer Laterals			EA	3	$1,650	$4,950
						Total:	$109,510
Mobilization / Demobilization (7%)							$7,666
Traffic Control (7%)							$7,666
Bond (1%)							$1,095
Contractor's Profit(15%)							$16,427
Subtotal:							$142,363
Construction Contingency(25%)							$35,591
Total Construction Cost (RWQCP Sewer)							**$178,000**
TOTAL CONSTRUCTION COST FOR PRIORITY "A" PROJECTS							**$748,000**

Table 7-6-B
Preliminary Cost Estimate For Priority "B" Projects
(2011- 2015 Replacement / Rehabilitation)

Location	Description	Existing Diameter (Inch)	New Diameter (Inch)	Unit	Quantity	Unit Cost	Approx Total Cost(2005 $'s)
Monticello Avenue							
	Replace Pipe P258A, P259-P271	12	15	LF	3428	$115	$394,220
	Rehab / Replace Manhole			EA	15	$5,500	$82,500
	Reconnect Sewer Laterals			EA	34	$1,650	$56,100
						Total:	$532,820
Mobilization / Demobilization (7%)							$37,297
Traffic Control (7%)							$37,297
Bond (1%)							$5,328
Contractor's Profit(15%)							$79,923
Subtotal:							$692,666
Construction Contingency(25%)							$173,167
Total Construction Cost (Monticello Avenue Sewer)							**$866,000**
Van Buren Boulevard							
	Replace Pipe P051, P052	27	33	LF	545	$245	$133,525
	Replace Pipe P111-P122	27	33	LF	4922	$245	$1,205,890
	Rehab / Replace Manhole			EA	15	$5,500	$82,500
	Reconnect Sewer Laterals			EA	55	$1,650	$90,750
						Total:	$1,512,665
Mobilization / Demobilization (7%)							$105,887
Traffic Control (7%)							$105,887
Bond (1%)							$15,127
Contractor's Profit(15%)							$226,900
Subtotal:							$1,966,465
Construction Contingency(25%)							$491,616
Total Construction Cost (Van Buren Boulevard Sewer)							**$2,458,000**
TOTAL CONSTRUCTION COST FOR PRIORITY "B" PROJECTS							**$3,324,000**

Table 7-6-C
Preliminary Construction Cost Estimate For Priority "C" Projects
(2016- 2020 Replacement / Rehabilitation)

Location	Description	Existing Diameter (inch)	New Diameter (inch)	Unit	Quantity	Unit Cost	Approx Total Cost(2005 $'s)
Acorn Street	Replace Pipe P044	27	33	LF	624	$245	$152,880
	Replace Pipe P045, P046	27	30	LF	1,250	$220	$275,000
	Rehab / Replace Manhole			EA	4	$5,500	$22,000
	Reconnect Sewer Laterals			EA	19	$1,650	$31,350
						Total:	$481,230
Mobilization / Demobilization (7%)							$33,686
Traffic Control (7%)							$33,686
Bond (1%)							$4,812
Contractor's Profit(15%)							$72,185
Subtotal:							$625,599
Construction Contingency(25%)							$156,400
Total Construction Cost (Acorn Street Sewer)							**$782,000**
Arizona Avenue	Replace Pipes P594, P595	10	12	LF	722	$110	$79,420
	Replace Pipes P601, P612, P613	8	10	LF	907	$100	$90,700
	Rehab / Replace Manhole			EA	6	$5,500	$33,000
	Reconnect Sewer Laterals			EA	16	$1,650	$26,400
						Total:	$229,520
Mobilization / Demobilization (7%)							$16,066
Traffic Control (7%)							$16,066
Bond (1%)							$2,295
Contractor's Profit(15%)							$34,428
Subtotal:							$298,376
Construction Contingency(25%)							$74,594
Total Construction Cost (Arizona Avenue Sewer)							**$373,000**
Collett Avenue	Replace Pipe P189-P191, P191A	18	21	LF	1453	$170	$247,010
	Rehab / Replace Manhole			EA	5	$5,500	$27,500
	Reconnect Sewer Laterals			EA	15	$1,650	$24,750
						Total:	$299,260
Mobilization / Demobilization (7%)							$20,948
Traffic Control (7%)							$20,948
Bond (1%)							$2,993

Table 7-6-C
Preliminary Construction Cost Estimate For Priority "C" Projects
(2016- 2020 Replacement / Rehabilitation)

Location	Description	Existing Diameter (inch)	New Diameter (inch)	Unit	Quantity	Unit Cost	Approx Total Cost(2005 $'s)
Contractor's Profit(15%)							$44,889
Subtotal:							$389,038
Construction Contingency(25%)							$97,260
Total Construction Cost (Collett Avenue Sewer)							**$486,000**
Fillmore Street	Replace Pipe P583-P584	12	15	LF	273	$115	$31,395
	Replace Pipe P588-P590	10	12	LF	1,090	$110	$119,900
	Rehab / Replace Manhole			EA	6	$5,500	$33,000
	Reconnect Sewer Laterals			EA	14	$1,650	$23,100
						Total:	$207,395
Mobilization / Demobilization (7%)							$14,518
Traffic Control (7%)							$14,518
Bond (1%)							$2,074
Contractor's Profit(15%)							$31,109
Subtotal:							$269,614
Construction Contingency(25%)							$67,403
Total Construction Cost (Fillmore Street Sewer)							**$337,000**
Golden Avenue	Replace Pipe P625-P629	12	15	LF	1601	$115	$184,115
	Rehab / Replace Manhole			EA	6	$5,500	$33,000
	Reconnect Sewer Laterals			EA	16	$1,650	$26,400
						Total:	$243,515
Mobilization / Demobilization (7%)							$17,046
Traffic Control (7%)							$17,046
Bond (1%)							$2,435
Contractor's Profit(15%)							$36,527
Subtotal:							$316,570
Construction Contingency(25%)							$79,142
Total Construction Cost (Golden Avenue Sewer)							**$396,000**
Harrison Street	Replace Pipes P142, P143	18	21	LF	690	$170	$117,300
	Rehab / Replace Manhole			EA	3	$5,500	$16,500
	Reconnect Sewer Laterals			EA	7	$1,650	$11,550

Table 7-6-C
Preliminary Construction Cost Estimate For Priority "C" Projects
(2016- 2020 Replacement / Rehabilitation)

Location	Description	Existing Diameter (inch)	New Diameter (inch)	Unit	Quantity	Unit Cost	Approx Total Cost(2005 $'s)
						Total:	$145,350
Mobilization / Demobilization (7%)							$10,175
Traffic Control (7%)							$10,175
Bond (1%)							$1,454
Contractor's Profit(15%)							$21,803
Subtotal:							$188,955
Construction Contingency(25%)							$47,239
Total Construction Cost (Harrison Street Sewer)							**$236,000**
Hole Avenue	Replace Pipes P714-P718	15	18	LF	1,183	$145	$171,535
	Rehab / Replace Manhole			EA	6	$5,500	$33,000
	Reconnect Sewer Laterals			EA	12	$1,650	$19,800
						Total:	$224,335
Mobilization / Demobilization (7%)							$15,703
Traffic Control (7%)							$15,703
Bond (1%)							$2,243
Contractor's Profit(15%)							$33,650
Subtotal:							$291,636
Construction Contingency(25%)							$72,909
Total Construction Cost (Hole Avenue Sewer)							**$365,000**
Jackson Street	Replace Pipe P281 - P284	24	27	LF	1,073	$205	$219,965
	Replace Pipe P290	24	30	LF	544	$220	$119,680
	Replace Pipe P287-P289	24	27	LF	811	$205	$166,255
	Rehab / Replace Manhole			EA	9	$5,500	$49,500
	Reconnect Sewer Laterals			EA	24	$1,650	$39,600
						Total:	$595,000
Mobilization / Demobilization (7%)							$41,650
Traffic Control (7%)							$41,650
Bond (1%)							$5,950
Contractor's Profit(15%)							$89,250
Subtotal:							$773,500

Table 7-6-C
Preliminary Construction Cost Estimate For Priority "C" Projects
(2016- 2020 Replacement / Rehabilitation)

Location	Description	Existing Diameter (inch)	New Diameter (inch)	Unit	Quantity	Unit Cost	Approx Total Cost(2005 $'s)
Construction Contingency(25%)							$193,375
Total Construction Cost (Jackson Street Sewer)							**$967,000**
Jones Avenue	Replace Pipes P181-P187	15	18	LF	1,946	$145	$282,170
	Rehab / Replace Manhole			EA	8	$5,500	$44,000
	Reconnect Sewer Laterals			EA	19	$1,650	$31,350
						Total:	$357,520
Mobilization / Demobilization (7%)							$25,026
Traffic Control (7%)							$25,026
Bond (1%)							$3,575
Contractor's Profit(15%)							$53,628
Subtotal:							$464,776
Construction Contingency(25%)							$116,194
Total Construction Cost (Jones Avenue Sewer)							**$581,000**
La Sierra Channel	Replace Pipes P631-P636	27	30	LF	2,376	$220	$522,720
	Rehab / Replace Manhole			EA	7	$5,500	$38,500
	Reconnect Sewer Laterals			EA	24	$1,650	$39,600
						Total:	$600,820
Mobilization / Demobilization (7%)							$42,057
Traffic Control (7%)							$42,057
Bond (1%)							$6,008
Contractor's Profit(15%)							$90,123
Subtotal:							$781,066
Construction Contingency(25%)							$195,267
Total Construction Cost (La Sierra Channel Sewer)							**$976,000**
Magnolia Avenue (2)	Replace Pipes P536 - P539	12	15	LF	1,200	$115	$138,000
	Rehab / Replace Manhole			EA	5	$5,500	$27,500
	Reconnect Sewer Laterals			EA	12	$1,650	$19,800
						Total:	$185,300
Mobilization / Demobilization (7%)							$12,971
Traffic Control (7%)							$12,971

Table 7-6-C
Preliminary Construction Cost Estimate For Priority "C" Projects
(2016- 2020 Replacement / Rehabilitation)

Location	Description	Existing Diameter (inch)	New Diameter (inch)	Unit	Quantity	Unit Cost	Approx Total Cost(2005 $'s)
Bond (1%)							$1,853
Contractor's Profit(15%)							$27,795
Subtotal:							$240,890
Construction Contingency(25%)							$60,223
Total Construction Cost (Magnolia Avenue (2) Sewer)							**$301,000**
Monroe Street	Replace Pipes P346 - P349	12	15	LF	1086	$115	$124,890
	Rehab / Replace Manhole			EA	5	$5,500	$27,500
	Reconnect Sewer Laterals			EA	11	$1,650	$18,150
						Total:	$170,540
Mobilization / Demobilization (7%)							$11,938
Traffic Control (7%)							$11,938
Bond (1%)							$1,705
Contractor's Profit(15%)							$25,581
Subtotal:							$221,702
Construction Contingency(25%)							$55,426
Total Construction Cost (Monroe Street Sewer)							**$277,000**
RWQCP Sewer	Replace Pipe P001	36	39	LF	697	$275	$191,675
	Rehab / Replace Manhole			EA	2	$5,500	$11,000
	Reconnect Sewer Laterals			EA	7	$1,650	$11,550
						Total:	$214,225
Mobilization / Demobilization (7%)							$14,996
Traffic Control (7%)							$14,996
Bond (1%)							$2,142
Contractor's Profit(15%)							$32,134
Subtotal:							$278,493
Construction Contingency(25%)							$69,623
Total Construction Cost (RWQCP) Sewer)							**$348,000**
Van Buren Boulevard	Replace Pipes P093 - P098	42	45	LF	2283	$320	$730,560
	Replace Pipes P100-P106	33	39	LF	3616	$275	$994,400
	Replace Pipes P107A, P109	33	36	LF	1347	$260	$350,220

Table 7-6-C
Preliminary Construction Cost Estimate For Priority "C" Projects
(2016- 2020 Replacement / Rehabilitation)

Location	Description	Existing Diameter (Inch)	New Diameter (Inch)	Unit	Quantity	Unit Cost	Approx Total Cost(2005 $'s)
	Rehab / Replace Manhole			EA	16	$5,500	$88,000
	Reconnect Sewer Laterals			EA	72	$1,650	$118,800
						Total:	$2,281,980
Mobilization / Demobilization (7%)							$159,739
Traffic Control (7%)							$159,739
Bond (1%)							$22,820
Contractor's Profit(15%)							$342,297
Subtotal:							$2,966,574
Construction Contingency(25%)							$741,644
Total Construction Cost (Van Buren Boulevard Sewer)							**$3,708,000**
TOTAL CONSTRUCTION COST FOR PRIORITY "C" PROJECTS							**$10,133,000**

City of Riverside
Arlanza Trunk Sewer Study

Appendices

590110.10

Prepared By:

PBS&J
10370 Hemet Street, Suite 200
Riverside, CA 92503
(951) 358-1433

August, 2006

Appendix A

Flow Data at Meter Locations (On CD)

Appendix B

City of Riverside, Criteria for Sewer Facility Design

CITY OF RIVERSIDE
PUBLIC WORKS DEPARTMENT
ENGINEERING DIVISION

CRITERIA FOR SEWER FACILITY DESIGN
~~March 2000~~
Revised May 2004

Determination of Sewage Flows:

The sewer line shall be designed to flow 75% full during peak flows. Use a Manning's "n"=0.013.

Residential sewer flows are determined by using the following sources of information and criteria:

- Land use shown in the City's General Plan.
- Based on the Land Use determine the number of living units per acre.
- The capita per living unit can be determined from the latest census data for the study area. However, not less than an average 2.75 capita per living unit.
- Use 65 gallons per capita per day for average flows.
- Peak to average flow coefficient is to be determined from the attached graphs.

Peak flows for other types of development shall be determined using the following criteria:

- Industrial developments use: 0.012 cfs/acre
- Commercial developments use: 0.010 cfs/acre
- Offices: 30 gallons per capita per day (g/c/d)
- Schools: 30 g/c/d
- Laundromat: 580 gallons per machine per day

The Public Works Department must approve sewer flows for any other specific types of development.

Criteria for Sewage Pump Station Design:

Construction of a sewage pump station shall be considered the last resort for handling sewage flows from any development. An analysis of alternate gravity system alignments must be performed and submitted to the City for review. The analysis shall consider the economics of constructing and maintaining a pump station over a 20-year period versus obtaining right of way and constructing a gravity system.

If the analysis shows that a pump station is the most economical alternative the following criteria shall be used in its design.

Peak flows are determined by the criteria stated above in the Determination of Sewage Flows section.

Configuration of the components of the pump station shall be in such a way to permit easy access by maintenance equipment. Fencing shall be placed around the pump station components with gates provided at locations for access by maintenance personnel and equipment. The fencing is to be 6-feet in height and of materials and color permitted by the City's Planning Department. All metal parts are to be powder coated with the approved color.

All hatches and hardware shall be stainless steel.

The developer/contractor shall submit complete maintenance and spare parts information for all station components.

Force Main Design:

The force main shall be sized in such a way that the pumps will maintain a minimum flow velocity of 2 feet per second. The force main shall be no smaller than 4 inches in diameter and shall be made of ductile iron pipe. However, if the force main is small and located in a residential street, AWWA C900 PVC pipe may be used. The use of PVC pipe will require specific approval by the Public Works Department.

The force main shall have a continuous upward grade from the pump station to the outlet. No low or high points will be permitted between the pump station and outlet.

The force main shall outlet to a manhole connected to a gravity system. The outlet shall be at the flowline of the manhole and channeled as shown in City Standard Drawing No. 500. Within 30 feet of the manhole the force main shall have an elevation high enough to prevent sewage in the gravity system from flowing down the force main during the off cycle of the pumps.

The designer shall analyze bends in the force main for the need to use thrust blocks or restrained joints.

A force main cleaning station must be installed at approximately 500-foot intervals if the following conditions will exist in the completed system.

- Flows from the area served by the pump station are not enough to require the force main to be emptied every 4 hours.
- The force main is over 950 feet long.
- The difference in elevation between the force main at the valve vault and the outlet is greater than 25 feet.

Pump Design:

Pumps are to be sized to provide a minimum flow velocity of 2 feet per second in the force main.

Pumps shall be able to handle 4-inch solids.

Pump selection shall be based on the most efficient drive/pump/impeller combination for the force main system. The discharge flow velocity should be in the range of 10 to 14 feet per second. The designer shall graph the pipe system curve against the pump curve. If multiple pumps are used this graph shall show the curve for each pump. The minimum pump efficiency allowed is 60 percent.

Wet Well Design:

In stations that have 5 to 100 horsepower pumps the wet wells shall be sized to permit the pumps to cycle not less than 15 minutes between stops and starts. In addition the pumps must not run less than 10 minutes per cycle. Stations with pumps greater than 100 horsepower shall have a cycle time between pump stops and starts not be less than 20 minutes with a minimum run time of 15 minutes.

Pumps on and off elevations are to be shown on the plan. These elevations must be below the inlet elevation to the wet well. Flap gates on the wet well inlet are not permitted.

The wet well shall have a 6-foot minimum diameter and lined with PVC or City approved coating.

If the wet well is over 30 feet in depth there must be a "step off" landing designed in the well. The landing is a safety precaution to provide a location for maintenance personnel to step off the wet well access ladder.

All nuts, bolts, and washers shall be made of 304 or 316 stainless steel.

A wastewater recirculator or scum breaker shall be provided.

Valve Vault Design:

The vault shall be large enough to permit easy access by maintenance personnel. The bottom shall be a minimum 4-inch thick concrete slab. A 4-inch diameter PVC pipe shall be provided to drain the valve vault into the wet well.

All pipe and fittings from the pumps through the valve vault shall be made of ductile iron. Only flanged fittings shall be used. All nuts, bolts, and washers shall be made of 304 or 316 stainless steel.

Discharge and isolation valves shall be plug valves and not gate valves.

Controls and Electric Design:

A 480-volt three-phase power supply is required.

All conduits shall be schedule 80 PVC.

An emergency transfer switch shall be provided. Small stations will require a manual switch where large stations with emergency backup generators will require an automatic transfer switch. When a manual transfer switch is required a 100-amp plug and receptacle such as Killark 8581/21-407 and 8581/22-407 shall be provided. In addition, a minimum 30-foot long jumper cable shall be provided.

Lights shall be provided within the control panel to allow for night work.

The pump station shall have a communications link with the City's wastewater treatment plant. The equipment to provide this link shall be City approved.

An electric schematic diagram shall be provided on the pump station plans.

The wet well level measuring device shall be a Milltronics Hydroranger ultrasonic measuring device.

The station shall be controlled by a Modicon Quantum Programmable Logic Controller(PLC).

The station shall be equipped with a Motorola Moscad Radio Telemetry Unit(RTU).

This RTU shall be installed and completely functional prior to the acceptance by the City.

The Developer/contractor shall coordinate and pay for the integration of this RTU into the City's existing SCADA system.

Control system integration with the City's SCADA shall be performed by an integrator approved by the City.

Three phase 480 VAC power shall be the power source.

The power source for station controls shall be 120 VAC.

Two spare conduits shall be provided between the control panel and the wet well. This conduit shall same size of the largest conduit needed between the control panel and wet well.

One spare conduit shall be provided between the control panel and the valve vault. This conduit shall of the same size of the largest conduit needed between the control panel and valve vault.

The developer/contractor shall provide complete as built drawings of the electrical system. This shall include all wiring, general, and internal to the control panel

All wires must be individually tagged. They must be tagged at every termination and inside every junction box.

The developer/contractor shall provide a copy of the proposed PLC program for review prior to construction. A final fully annotated copy of the PLC program shall be provided, both in electronic format and in a hard copy printed format.

All panels shall be of the appropriate construction for the application. (minimum, NEMA 4X or 3R.

Pump Station Functional Requirements

Milltronics Hydroranger Ultrasonic Level Indicator/Controller

Shall provide analog level input to the Programmable Logic Controller (PLC)

Shall provide off & on starting of pumps in the event of PLC failure

Shall provide alternation of pumps in event of PLC failure

Shall provide ultrasonic failure Input to RTU

Float Switch

Shall provide an input to the RTU (high-high level)

Programmable Logic Controller (PLC)

Shall provide starting and stopping of the pumps in auto

Shall provide alternation of the pumps (after each cycle)

Recognize Milltronics failure and provide an input to the RTU

Shall recognize pump hand switch position and adjust the control logic

Shall provide all timing functions

Shall provide low level alarm output to RTU

Shall provide input to the RTU In event of seal failure of pumps (Each Pump)

Shall provide input to the RTU in event of Thermal overload

Shall call lag pump if required

Shall provide input to the RTU indicating pump failure and identifying the pump

Shall provide output to the RTU for high level alarm

A three-position selector switch shall interface with the PLC to provide for manual override of the automatic changing of lead and lag pumps, in case of pump failure (i.e.: P1-AUTO-P2)

Controls

A manual bypass shall be provided for water levels, PLC, Milltronics; etc. and shall directly energize the motor starters.

The auto function shall be controlled by the PLC or in the event of PLC failure, the Milltronics will start, stop, and alternate lead and lag pumps.

Radio Telemetry Unit (RTU)

Shall monitor only, not control

Transmit Dynamic Wet Well Level (Analog Output)

Indicate low level

Indicate high level

Indicate site entry

Indicate AC failure

Indicate individual pump failure

Indicate pump auto, pump not auto

Indicate pump run status

Indicate ultrasonic failure

Indicate Seal Failure

External Relays

(1) Intrinsically safe for the high, high level float

(2) For seal failure

(2) Motor starters

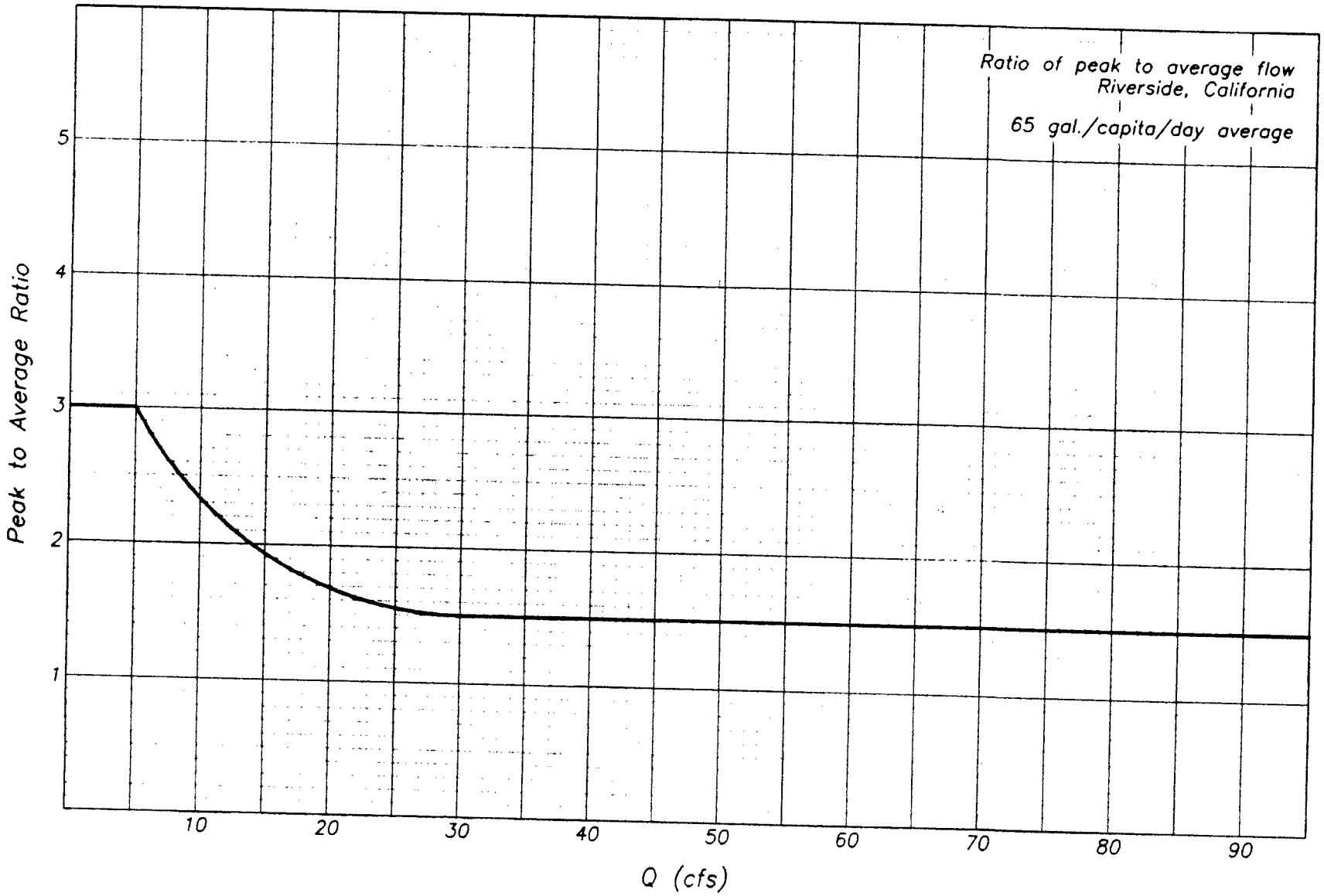
Criteria for Inverted Siphon Design:

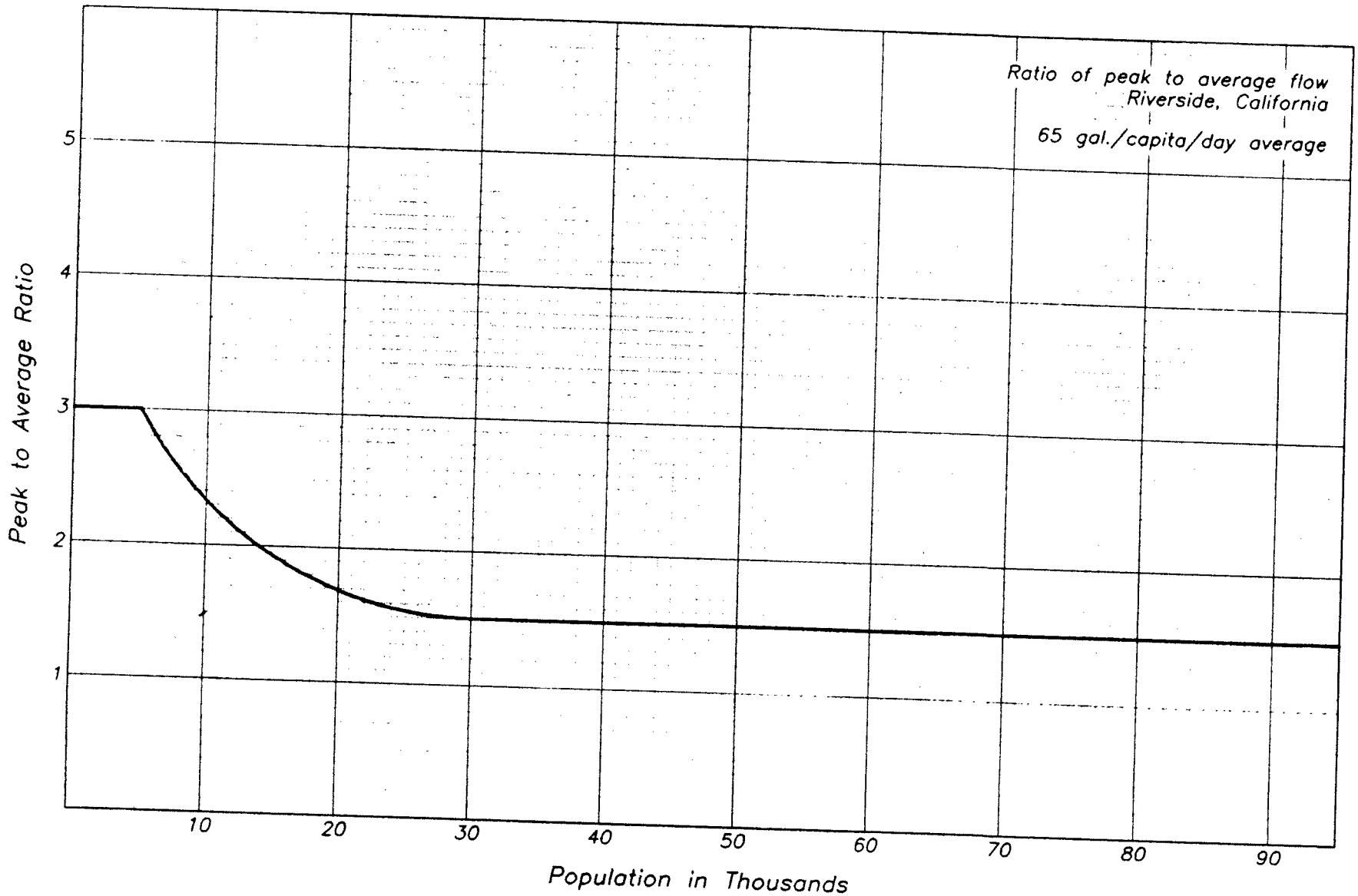
Minimum flow velocity of 3 feet per second and maximum velocity of 7 feet per second within the siphon pipe(s) is required. A multiple pipe design should be incorporated with the upstream manhole designed to direct the anticipated average daily flow into one pipe and the anticipated peak flow into all pipes of the siphon. If the siphon will serve future development it may be necessary to design the siphon with more than two pipes in order to maintain the minimum flow velocity until the future development is constructed. Weirs shall be cast into the base of the manholes.

Minimum pipe size to be used in the siphon is 6-inch. Either Vitrified Clay Pipe or Ductile Iron Cement Mortar Lined Pipe (DIP) shall be used in the siphon. Type V cement shall be used for the lining of the DIP. Internal pressure of the siphon shall be considered in material selection.

The siphon shall not exceed 350 feet in length with manholes installed at each end. Flow shall be directed straight through these manholes. No side connections to the manholes will be permitted. The manhole diameter shall be determined by the number, size, and spacing of the siphon pipes plus 3 feet. The shelf elevation shall be above the water level during ultimate peak flows.

During ultimate peak flow the water surface elevation at the first sewer lateral connection upstream of the siphon must be within the sewer main.


Ratio of peak to average flow
Riverside, California
65 gal./capita/day average
Peak to Average Ratio
5
4
3
2
1
10
20
30
40
50
60
70
80
90
Q (cfs)


Ratio of peak to average flow
Riverside, California
65 gal./capita/day average
Peak to Average Ratio
5
4
3
2
1
10
20
30
40
50
60
70
80
90
Population in Thousands

Appendix C
Study Sewer Lines

City of Riverside
Arlanza Trunk Sewer System: Study Sewer Lines

Location	Pipe Diameter	Length	Number of Manholes
	(inch)	(feet)	
Adams Street	12	1,121	4
	15	1,691	5
Indiana Avenue (1)	15	2,729	9
Monroe Street	12	5,286	20
	15	4,390	13
Garfield Street	12	1,030	3
	14	2,724	9
California Avenue (1)	15	2,725	12
	21	2,729	12
California Avenue (2)	18	1,723	8
	21	995	5
Indiana Avenue (2)	10	325	0
	12	3,826	16
Harrison Street	12	4,095	14
	15	2,798	9
	18	5,189	17
	24	709	3
Jurupa Avenue	12	660	3
Central Avenue	12	1,360	4
Monticello Avenue	12	3,428	14
Jackson Street	8	24	1
	15	1,367	4
	20	692	1
	24	5,203	20
Van Buren Plaza	24	448	1
	33	5,556	18
	36	6,358	17
Van Buren Boulevard	18	1,037	3
	24	1,148	4
	27	7,597	21
	33	4,964	9
	42	2,290	7

City of Riverside
Arlanza Trunk Sewer System: Study Sewer Lines

Location	Pipe Diameter	Length	Number of Manholes
Crest Avenue	12	1,394	6
	15	4,079	16
	18	1,501	4
	27	2,542	10
Trey Avenue	12	1,212	4
Picker Street	12	3,532	13
	15	845	3
Cypress Avenue	12	986	2
	18	641	3
Warren Street	12	2,798	9
	18	2,780	10
	21	2,323	10
	24	1,751	5
Acorn Street	27	3,598	6
	36	317	1
Riverside Water Quality Control Plant	15	3,204	15
	27	3,326	14
	30	262	2
	36	697	1
	42	523	1
	51	2,507	8
Mitchell Avenue	8	235	1
	12	2,866	9
	15	1,752	5
Bushnell Avenue	15	471	2
	18	1,103	3
Pierce Street	12	607	2
	15	2,781	7
La Sierra Avenue (1)	21	3,053	9
Hole Avenue	8	22	1
	12	101	1
	15	1,984	7
	18	1,154	3
Collett Avenue	18	1,921	8

City of Riverside
Arlanza Trunk Sewer System: Study Sewer Lines

Location	Pipe Diameter	Length	Number of Manholes
Arizona Avenue	8	3,790	16
	10	829	3
	15	2,326	8
Polk Street (1)	15	3,057	12
Polk Street (2)	8	245	1
	12	4,630	17
Magnolia Avenue (1)	8	917	4
	21	899	3
	24	1,721	3
Magnolia Avenue (2)	12	1,937	7
	15	43	2
	24	1,721	3
Magnolia Avenue (3)	8	192	1
	12	212	1
	15	2,760	8
Queensborugh Street	12	2,274	10
Filmore Street	10	2,682	7
	12	1,054	5
Riverwalk Parkway	12	2,891	10
Pierce Street (1)	12	1,602	4
	15	527	2
Pierce Street (2)	15	1,100	4
	21	1,310	4
Taylor Street	15	2,775	12
Stonewall Drive	12	1,418	5
	15	72	1
Golden Avenue	12	2,502	9
La Sierra Avenue (2)	15	1,574	5
Cochran Avenue	15	2,002	8
Jones Avenue	15	1,976	8

City of Riverside
Arlanza Trunk Sewer System: Study Sewer Lines

Location	Pipe Diameter	Length	Number of Manholes
La Sierra Channel	27	6,136	17
	30	150	4
Total of Gravity Study Sewer Lines		**202,409**	**691**
		(38.3 Miles)	

Magnolia Force Main	24	13,861	
La Sierra Force Main	30	15,512	

Total of Force Main Sewer Lines	**29,373**	
	(5.6 Miles)	

Appendix D
PHOENIX TRUNK SEWER STUDY

City of Riverside
Phoenix Trunk Sewer Study

590110.20

Prepared By:

10370 Hemet Street, Suite 200
Riverside, CA 92503
(951) 358-1433

August, 2006

PHOENIX TRUNK SEWER STUDY

City of Riverside

Client Representative L.F.(Sandy) Caldwell, P.E.

PBS&J

Project Director Gary H. Eikermann

Project Engineer Barmeshwar Rai, P.E.

Technical Support Charlene Drake
Cristina Chavez

J.N. 590110.20

August, 2006

10370 Hemet Street, Suite 200, Riverside, CA 92503

TABLE OF CONTENTS

Page Number

Executive Summary

ES.1 *Introduction* *Ex-1*

ES.2 Existing Sewer System *Ex-1*

ES.3 Methodology *Ex-1*

ES.4 Project Priorities and Cost *Ex-2*

Table Ex-1 Summary of Priorities..... *Ex-3*

1.0 *Introduction* 1

1.1 Background 1

1.2 Study Area 1

1.3 Objective 1

1.4 Scope and Study Approach 2

2.0 *Land Use* 4

2.1 Existing Land Use 4

2.2 Future Land use 4

3.0 *Existing Sewer System* 5

3.1 System Overview 5

3.2 Collection System 5

3.3 System Description 5

3.4 Tributary Areas 11

4.0 *Determination of Sewer Flows* ……. ..... ….. 13

4.1 Flow Monitoring 13

4.2 Results of Flow Monitoring 14

5.0 *Estimated Ultimate Flow* 16

5.1 Methodology 16

5.2 Flow Coefficients 16

5.3 Representative Diurnal Hydrographs 17

6.0 *Computer Model Simulation Analysis* 19

6.1 Methodology 19

6.2 Limitations of Modeling 20

7.0 *Deficiencies and Solutions*……. 21

7.1 Deficient and Marginally Deficient Pipes ……. 21

7.2 Project Prioritization Methodology ……..... 21

7.3 Recommended Improvements 22

7.4 Grouping of Projects ……..... 22

7.5 Construction Schedule ……... 23

7.7 Cost Estimate ……..... 23

LIST OF TABLES

Page Follows/On

2-1	Land Use that would produce wastewater flow within the Study Area	4
3-1	Development Tributary Areas and Current Wastewater Generating Land Use	14
7-1	Sewer Analysis Results (Existing and Future Conditions)	20
7-2	Proposed Construction Prioritization	21
7-3	Summary of Improvement Plans for Problem Areas	22
7-4	Cost Estimate for Priority "A" Projects	23
7-5	Cost Estimate for Priority "B" Projects	23
7-6	Cost Estimate for Priority "C" Projects	23

LIST OF FIGURES

Follows Page

1	Vicinity Map	1
2	Study Area	1
3A	Zoned Land Use Plan	4
3B	Zoned Land Use (Vacant Parcels)	4
4	Tributary Areas	5
5	Flow Meter Locations	5

6	System Pipe Diameters	5
7A	Existing Manholes – Part 1	10
7B	Existing Manholes – Part 2	10
8A	Existing Pipelines – Part 1	10
8B	Existing Pipelines – Part 2	10
9 to13	Adjusted Flows at Meters	18
14 to18	Representative Diurnal Hydrographs	18
19A	Existing Volume Deficiencies – Part 1	20
19B	Existing Volume Deficiencies – Part 2	20
20A	Existing Velocity Deficiencies – Part 1	20
20B	Existing Velocity Deficiencies – Part 2	20
21A	Ultimate Volume Deficiencies – Part 1	20
21B	Ultimate Volume Deficiencies – Part 2	20
22A	Priority “A” – Part 1	23
22B	Priority “A” – Part 2	23
23A	Priority “B” – Part 1	23
23B	Priority “B” – Part 2	23
24A	Priority “C” – Part 1	23
24B	Priority “C” – Part 2	23

APPENDICES

Appendix A – Flow Data at Meter Locations

Appendix B – City of Riverside, Sewer Design Guidelines

Appendix C – Study Sewer Lines

Executive Summary

ES.1 Introduction

This report presents the results of the Phoenix Trunk Sewer System Capacity Study prepared by PBS&J for the City of Riverside. The report contains recommendations regarding system deficiencies as identified by hydraulic model XP-SWMM (XP Software, Version 9.1).

The City of Riverside is located in the County of Riverside at the intersection of three major freeways; Route 91, Route 60 and Route 215. The study area encompasses approximately 11,000 acres of mixed land use development and is generally bounded by Santa Ana River to the North, Jefferson Street to the West, Van Buren Boulevard to the South and Alessandro Boulevard to the East. The study area is essentially a fully developed community, comprising single family residential, multi family residential, commercial and light industrial areas with some vacant lands to be developed in the future. The portion of study area southwest of Victoria Avenue and designated as "residential semi-rural" would be one of the major contributors of sewage flow to the system. The trunk sewer line along Santa Ana River also intercepts flows from upstream study areas (Spruce, Tequesquite and Northside) besides flows from Phoenix study area.

ES.2 Existing Sewer System

The existing trunk sewer system within the study area is comprised of approximately 23 miles of gravity sewer mains. The gravity sewer main lines range in sizes from 8-inch to 48-inch in diameter and there are 379 manholes. These sewer lines are essentially VCP and the manholes are typically brick lined. The City of Riverside owns, maintains and operates the sewer system.

ES.3 Methodology

For determination of current wastewater flows, flow monitoring was performed at five (5) strategic locations. These meter locations were chosen to observe actual flow characteristics for various sub areas with a distinct land use pattern within the study area. The flow monitoring was accomplished over a three-week period. The flow results were carefully evaluated for their accuracy and some adjustments were made based on depth of flow at meter locations. The readings of first week at meter no. 4 were discarded for inconsistencies.

A theoretical estimate of wastewater flow from vacant areas was estimated based on factors from the City of Riverside "Criteria for Sewer Facility Design". Residential wastewater flow was determined by using future projected population, whereas commercial and industrial flow was determined based on acreage and City estimated flow coefficients.

The Computer Model Simulation Analysis involved evaluation of available capacity in the existing collection system under present and future development conditions. Based on the results of model runs, system deficiencies were identified on a priority basis and a phased facility improvement plan was developed to accommodate for the projected growth within the study area.

ES.4 Project Priorities and Cost

Deficient and marginally deficient pipes were identified from the results of model runs and were prioritized for replacement/rehabilitation purposes. The pipes that are currently flowing more than 90% full under modeled existing maximum flow conditions and needing near term (2005-2010) replacement/rehabilitations are grouped under priority "A". The pipes that would flow more than 90% full in year 2015 under anticipated maximum future flow conditions are classified as priority "B". The pipelines that are not included in priorities "A" and "B" and are anticipated to flow more than 75% full under future flow conditions are categorized as priority "C". Some adjustment of priorities and combining of improvements was done for continuity and efficiency of improvements.

The time phased improvements for various priorities are listed in Table 7-2. The approximate cost of recommended improvements is summarized in Tables 7-4, 7-5 and 7-6.

Under existing flow conditions, a total of approximately 5,700 linear feet of priority "A" deficiencies were identified, requiring near term (2005-2010) attention. Additional deficiencies predicted under ultimate flow conditions (Priority "B") include an additional 900 linear feet of inadequate sewer lines. The estimated capital cost to remedy these identified deficiencies (in year 2005 $'s) is approximately $2,586,000 for Priority "A" and approximately $304,000 for Priority "B". The total length of pipelines under Priority "C" would be approximately 40,000 feet and the cost of Priority "C" projects would be approximately $19,438,000. However, it is probable that majority of Priority "C" improvements will not need to be actually implemented and also that some of Priority "B" improvements may not be needed. Only those where surcharging (within manhole) and other problems are deemed imminent should be considered for improvement. Periodic flow monitoring is also recommended to verify anticipated deficiencies and need for improvements. It is recommended that field observations of all pipes should be done where modeled results indicate surcharging conditions. The priorities are summarized in the table Ex-1:

Table Ex-1
Summary of Priorities

Priority	Approximate Pipeline Length (feet)	Location	Replacement Year	Total Project Cost (Year 2005$'s)
"A"	5,700	Central Avenue, Hillside Avenue, Phoenix Avenue and Santa Ana Trunk Line	2005-2010	$2,586,000
"B"	900	Madison Street	2011-2015	$304,000
"C"	40,000	Madison Street, Phoenix Avenue and Santa Ana Trunk Line	2016-2020	$19,438,000

1.0 INTRODUCTION

1.1 Background

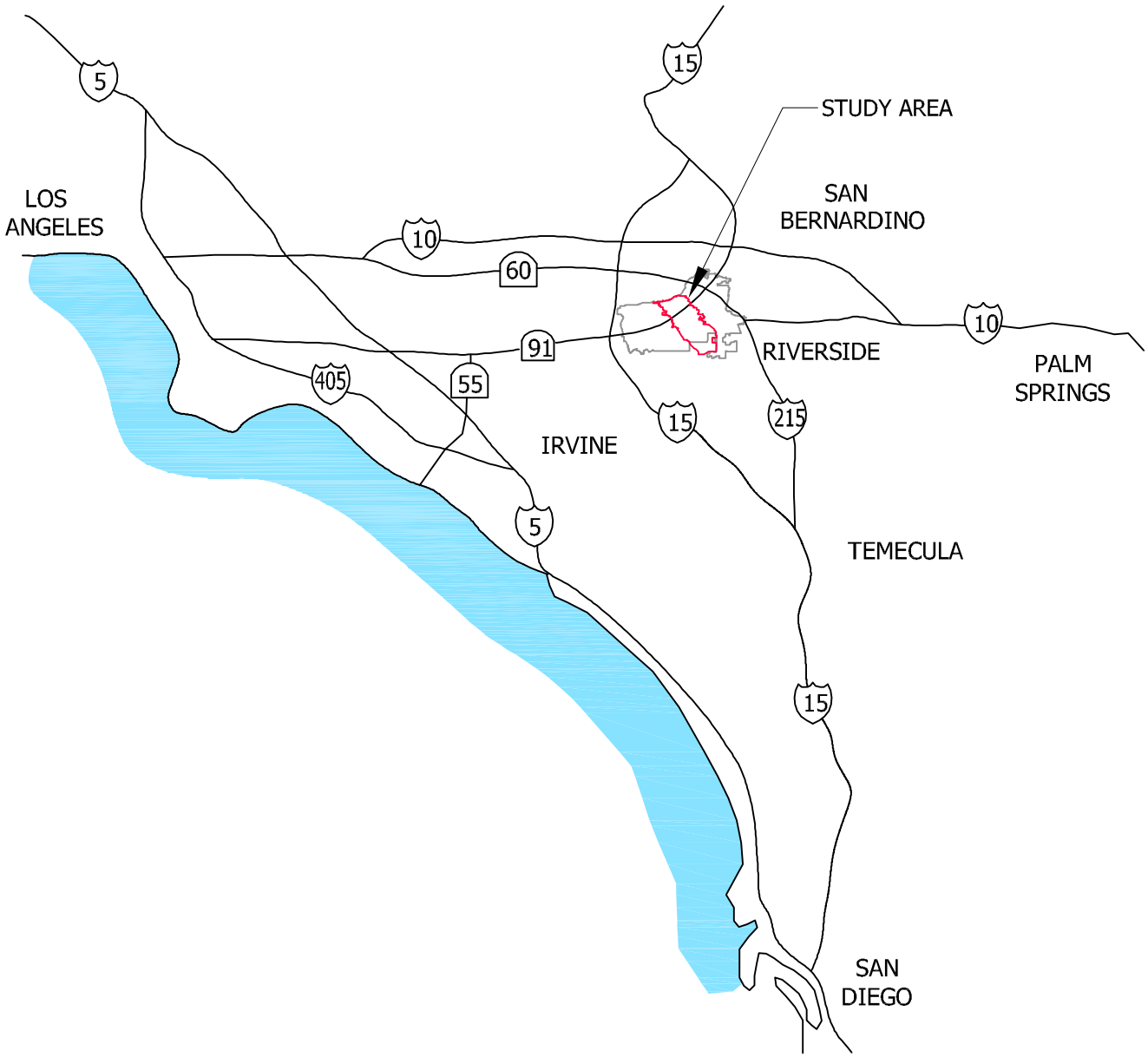
The City of Riverside (City) retained PBS&J to prepare a Trunk Sewer System Study for the central portion of the City. The Sewer System has been designated as Phoenix Trunk Sewer System. The study is necessitated by the fact that the City desires to evaluate the capacity of the existing sewer system and identify needed improvements.

1.2 Study Area

The City of Riverside is located in the northwest corner of the County of Riverside at the intersection of three major freeways; Route 91, Route 60 and Route 215. Founded in 1870, the City is known for its citrus industry, world famous Mission Inn and other historical monuments. Figure-1 is a Vicinity Map depicting the City's location and its accessibility. Figure 2 shows the study area. The study area shown in Figure 2 encompasses approximately 11,000 acres and is generally bounded by Santa Ana River to the North, Jefferson Street to the West, Van Buren Boulevard to the South and Alessandro Boulevard to the East. For purposes of this study, the study area has been divided into 21 tributary sub-areas, where downstream sub-areas intercept sewage flow from upstream sub-areas. To obtain actual observed flow information for this study, sewage flow meters were placed at five (5) strategic locations to monitor cumulative flows contributed from the tributary sub-areas.

1.3 Objective

The objective of this Sewer System Capacity Study is to provide a comprehensive evaluation of the capacity of the sewer system within the study area, identify deficiencies in the current system and evaluate alternatives to enhance the conveyance capacity to accommodate ultimate wastewater flows anticipated to be generated in the study area.



N

NTS

DATE: 11/09/05	DWN BY: CD

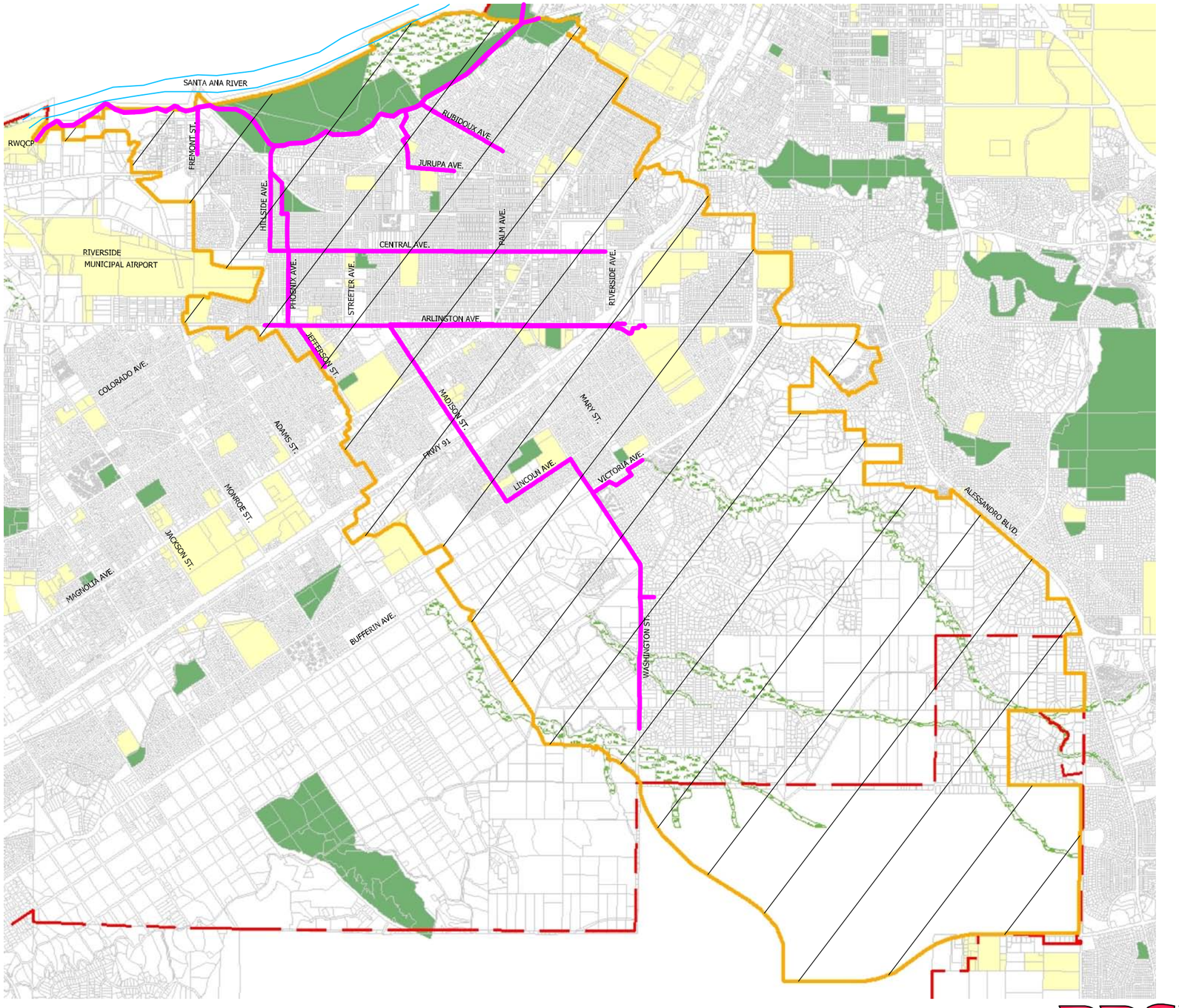
Engineering
Planning
Surveying
Construction Services
PBS&J
10370 Hemet Street
Suite 200
Riverside, CA 92503
Tel:(951) 358-1433
Fax:(951) 358-1434

CITY OF RIVERSIDE
PHOENIX SEWER STUDY

FIGURE 1

VICINITY MAP

Y:\City of Riverside\Phoenix\DWG\Exhibits\PH-Vicinity.dwg, 9/28/2006 11:21:14 AM



N

SCALE:
1" = 4000'

LEGEND

- STUDY AREA BOUNDARY
- STUDY SEWER
- CITY LIMITS

Engineering
Planning
Surveying
Construction Services
PBSJ
10370 Hemet Street
Suite 200
Riverside, CA 92503
Tel:(951) 358-1433
Fax:(951) 358-1434

DATE: 11/08/05	DWN BY: CD
CITY OF RIVERSIDE PHOENIX SEWER STUDY	FIGURE 2
STUDY AREA	

Y:\City of Riverside\Phoenix\DWG\Exhibits\PH-StudyArea.dwg, 9/28/2006 11:10:56 AM

1.4 Scope and Study Approach

Specific work tasks undertaken for this study are summarized as follows:

- Kickoff Meeting

  An initial meeting was held between PBS&J and the City to discuss the project scope, communication protocol, explanation of methodology and scheduling of flow monitoring. Field data and other digital files to be provided by the City were also discussed.

- Progress Meetings

  Informal Project Progress Meetings were held to discuss on-going issues and the progress of the study.

- Flow Monitoring and Hydrograph Development

  Downstream Services Inc. installed, maintained, and collected flow data from five (5) monitoring stations throughout the study area. They submitted the collected raw data in electronic/hard copy format to PBS&J. PBS&J then processed and reviewed this information and created a hydraulic database. The City provided a copy of City's General Plan for estimation of current and future flows. Other information including as-built plans of wastewater facilities were provided by the City as and when requested by PBS&J.

- Model Development

  Model development included input data collection, conversion of data and calibration. The City's GIS staff made available data pertaining to roads, sewers, land use, buildings and other utilities in ArcView format on a CD. As-built plans for study sewer lines were reviewed. Data available from GIS system and as-built plans were placed in a database system (MS Excel) as a pre-processor for XP-SWMM model development. Calibration of the model was done after construction of the model and additional data input.

- Draft Report

  Based on the model simulations and the City's criteria for Sewer Facility Design, a Draft Report was prepared that summarized the existing and future capacity situations. Where deficiencies were identified, alternatives were developed for

needed sewer improvements, along with probable costs. The draft report was prepared for submittal / review by the City.

- Final Report

  Draft Report review comments from the City were incorporated into the Final Report along with any additional information or research, in order to reflect a final level of study completion. The Final Report includes data and information assembled, system deficiencies identified, alternatives evaluated, capital improvement recommendations to remediate anticipated deficiencies, prioritization of improvements, and approximate costs.

The comprehensive evaluation of the sewage collection system to accomplish the above-summarized scope of work features the following multi-step approach:

- Review of as built plans provided by the City to determine system configuration, inverts, pipe sizes and slopes
- Use of detailed database provided by the City in Arcview format
- Creation of computer hydraulic model using existing sewer system to study project area
- Identification of flow monitoring station locations
- Identification of tributary areas contributing sewage flow to meter locations or combinations
- Installation of flow meters and monitoring of flows at the selected locations on continuous basis for two-week period
- Review of current land use in study area per GIS information from the City and determination of existing land use, population and vacant land
- Assessment of ultimate land use and projected population
- Review and evaluation of metered data from flow monitoring stations
- Development of flow coefficients and representative diurnal flow patterns based on typical curves for various land uses and observed flows from monitored sub areas which are dominated by a specific land use
- Modeling of sewer system, deficiency identification, and model simulation of remedial alternatives using above-mentioned information as input data
- Evaluation of alternatives, optimization, cost comparison
- Prioritization of recommended improvements, including identification of critical pipelines which need immediate attention
- Draft Report and recommendations including phased improvements and costs
- Review of Draft Report by the City, comments and discussion

- Final Report

2.0 LAND USE

2.1 Existing Land Use

Land use is the basis for estimating sewage flow from the majority of the study area. The land use pattern for this study was developed from the GIS information provided by the City. Figure 3A shows land use within the study area based on the City's "Land Use" GIS layer. For the purpose of this study, land uses in the study area have been broadly classified into four categories: Single Family Residential (SFR), Multi Family Residential (MFR), Commercial and Industrial. Table 2-1 summarizes the land use areas within the study area that would generate wastewater flow.

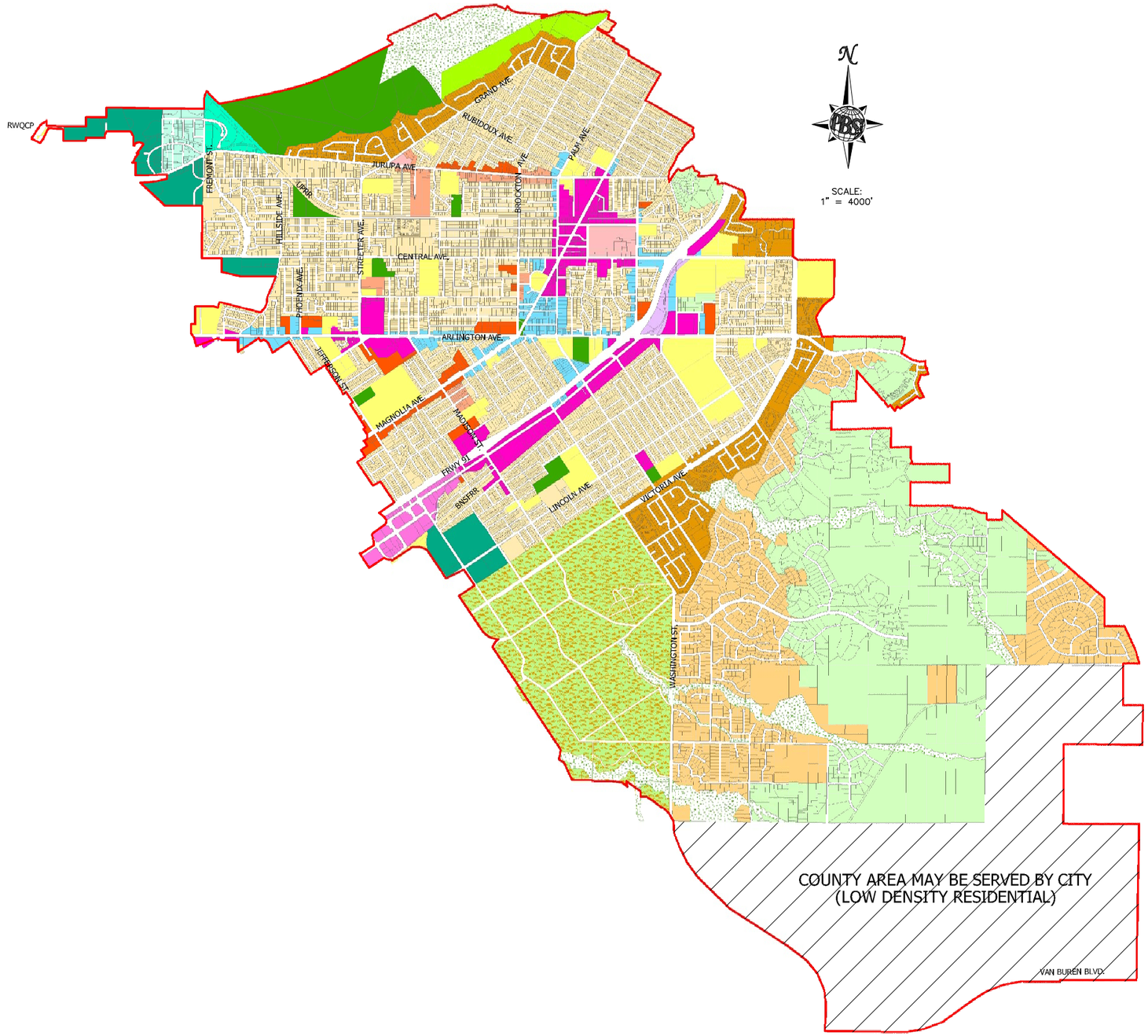
2.2 Future Land Use

The portion of study area on northwest of Victoria Avenue is primarily a mature community. The portion of study area on southeast side of Victoria Avenue has vacant parcels that are designated as "residential semi-rural" and is expected to be developed in the future. This area is primarily designated to be developed as low density Single Family Residential (SFR). The vacant parcels are shown in Figure 3B. It is assumed that the majority of vacant lots within the study area would be fully developed by year 2020.

Table 2-1
Land Use that would produce Wastewater Flow within the Study Area (Acres)

General Category	Existing (Year 2005)	Future (Year 2020)	Change
Single-Family Residential (SFR)	4,500	6,230	1,730 (38 %)
Multi-Family Residential (MFR)	76	78	2 (2.6 %)
Commercial / School	1,100	1,210	110 (10 %)
Industrial	190	215	25 (13 %)

The areas that are marked as open space or public facilities are not included in Table 2-1 because of zero wastewater flow generation.



N

SCALE:
1" = 4000'

LEGEND

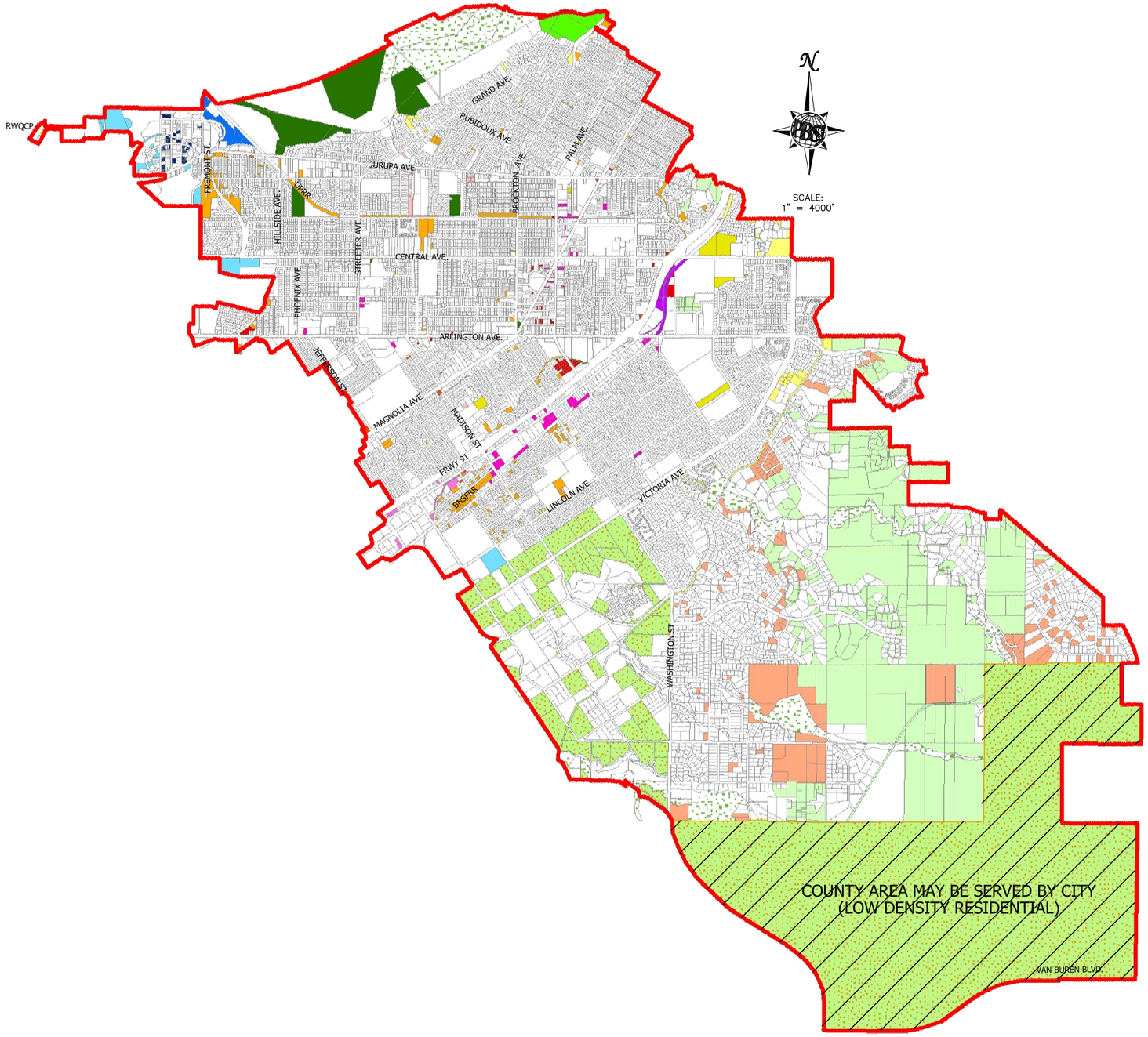
- Commercial - Automotive Park
- Commercial - Business and Office
- Commercial - Center
- Commercial - Service
- Industrial - Business Park
- Industrial - General
- Industrial - Light
- Natural Open Space
- Office - Low Rise
- Parks - Other Recreation
- Parks - Public
- Public Facilities and Open Space*
- Residential - Estate
- Residential - High Density
- Residential - Hillside
- Residential - Low Density
- Residential - Medium Density
- Residential - Medium-High Density
- Residential - Rural and Residential

*Includes schools and other public use facilities

Engineering
Planning
Surveying
Construction Services
PBSJ
10370 Hemet Street
Suite 200
Riverside, CA 92503
Tel:(951) 358-1433
Fax:(951) 358-1434

DATE: 12/15/05	DWN BY: CD
CITY OF RIVERSIDE PHOENIX SEWER STUDY	FIGURE 3A
ZONED LAND USE	

Y:\City of Riverside\Phoenix\DWG\Exhibits\PH-LandUse.dwg, 9/28/2006 10:51:05 AM



LEGEND

- Commercial - Automotive Park
- Commercial - Business and Office
- Commercial - Service
- Industrial - Business Park
- Industrial - General
- Industrial - Light
- Natural Open Space
- Office - Low Rise
- Parks - Other Recreation
- Parks - Public
- Public Facilities and Open Space*
- Residential - Estate
- Residential - High Density
- Residential - Hillside
- Residential - Low Density
- Residential - Medium Density
- Residential - Medium-High Density
- Residential - Rural and Residential
- Area May be Served by City**
- Occupied Parcels
- Sewer Basin Boundary

*Includes schools and other public use facilities
**Assumed to be Low Density Residential

Engineering
Planning
Surveying
Construction Services
PBS&J
10370 Hemet Street
Suite 200
Riverside, CA 92503
Tel:(951) 358-1433
Fax:(951) 358-1434

DATE: 12/15/05	DWN BY: CD
CITY OF RIVERSIDE PHOENIX SEWER STUDY	FIGURE 3B

ZONED LAND USE (VACANT PARCELS)

3.0 EXISTING SEWER SYSTEM

3.1 System Overview

As previously described, the Phoenix Trunk Sewer Study covers approximately 11,000 acres, which has been divided into 21 tributary sub-areas (See Figure 4). Each sub-area can be considered as a sewer sub-basin where wastewater flow from it is intercepted by a sewer trunk line. The wastewater flow generated from a sub-area can be measured at a meter location or can be reasonably assessed based on land use plan of that sub-area. The location of meters can be seen on Figure 5. The modeled gravity conveyance system is approximately 122,000 linear feet (23 miles) of gravity sewer system, with pipe sizes varying from 8 inches to 48 inches in diameter (See Figure 6). Most of the gravity sewer lines within the system are vitrified clay pipe (VCP) except for northern Santa Ana Trunk Line which is Reinforced Concrete Pipe (RCP).

3.2 Collection System

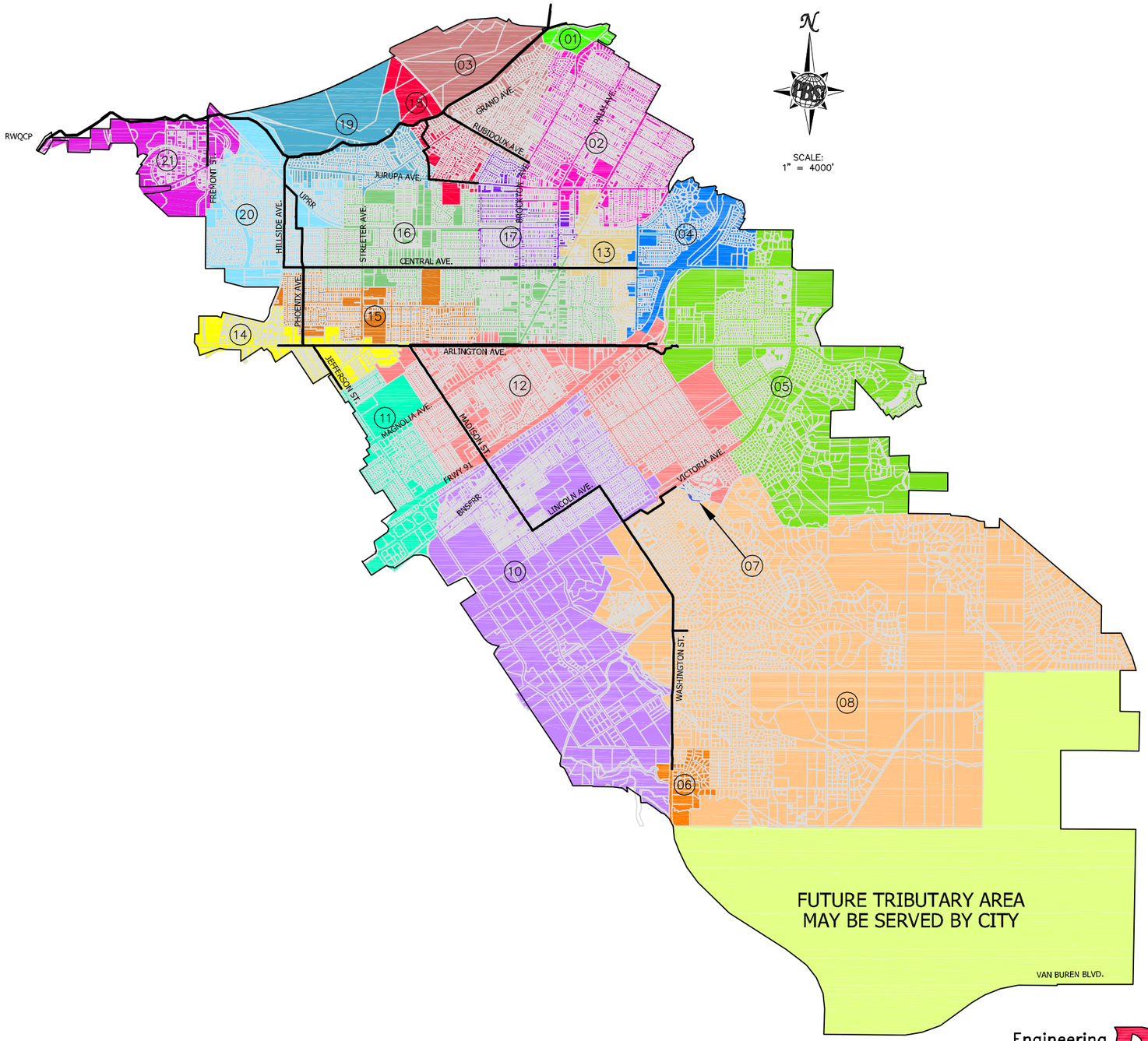
The Phoenix Study Area can be divided into two distinct sub-areas. The portion northwest of Victoria Avenue is a developed matured community and the area southeast of Victoria Avenue, has some vacant parcels that will be developed in the future. The wastewater generated from the study area generally flows in a northwesterly direction.

A major trunk line runs parallel to the Santa Ana River and it picks up wastewater flows from the trunk lines along Phoenix Avenue Rubidoux Avenue and Hillside Avenue. It also collects flows from the Northside, Spruce and Tequesquite Study Areas.

The details of the sewer system are explained in sub-section 3.3 System Description. Pipe sizes, lengths, and number of manholes have been tabulated for major segments of the modeled trunk system (See Appendix “C”).

3.3 System Description

The existing trunk sewer system, which is the subject of this evaluation, is shown on Figure 7A thru 8B. The sewer collection system was constructed over a period of time (50 plus years) to accommodate increasing sewage flow during the development within the City. The GIS data and as-built plans provided by the



LEGEND

- SUB AREA 01
- SUB AREA 02
- SUB AREA 03
- SUB AREA 04
- SUB AREA 05
- SUB AREA 06
- SUB AREA 07
- SUB AREA 08
- SUB AREA 10
- SUB AREA 11
- SUB AREA 12
- SUB AREA 13
- SUB AREA 14
- SUB AREA 15
- SUB AREA 16
- SUB AREA 17
- SUB AREA 18
- SUB AREA 19
- SUB AREA 20
- SUB AREA 21
- COUNTY AREA MAY BE SERVED BY CITY
- TRUNK SEWER STUDIED

Engineering
Planning
Surveying
Construction Services
PBSJ
10370 Hemet Street
Suite 200
Riverside, CA 92503
Tel:(951) 358-1433
Fax:(951) 358-1434

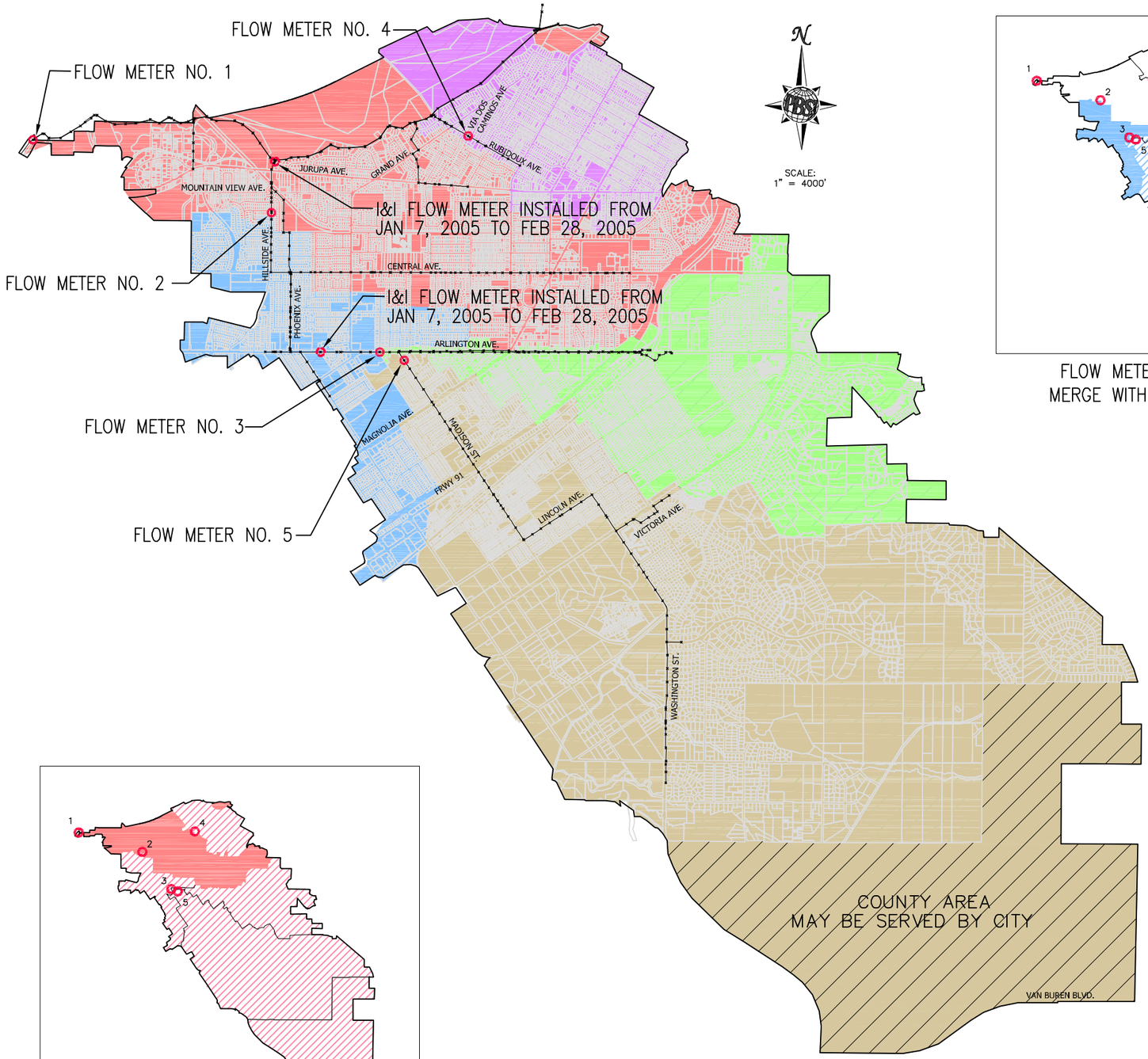
DATE: 12/15/05 | DWN BY: CD

CITY OF RIVERSIDE
PHOENIX SEWER STUDY

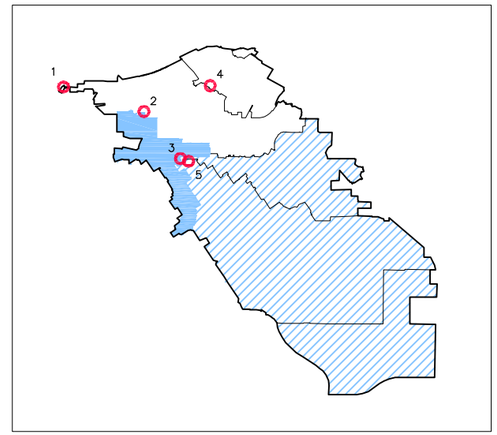
FIGURE 4

TRIBUTARY AREAS

Y:\City of Riverside\Phoenix\DWG\Exhibits\PH-TributaryAreas.dwg, 9/28/2006 11:11:38 AM



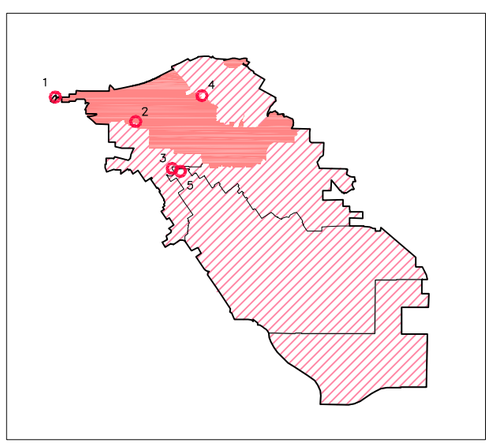
SCALE:
1" = 4000'



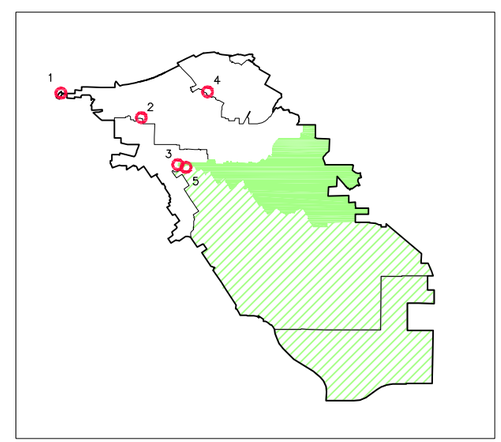
FLOW METER AREAS THAT
MERGE WITH FLOW METER 2

LEGEND

- STUDY MAIN AND MANHOLES
- FLOW METER LOCATION
- FLOW METER 1
- FLOW METER 2
- FLOW METER 3
- FLOW METER 4
- FLOW METER 5
- COUNTY AREA MAY BE SERVED BY CITY (FLOWS TO METER 5)



FLOW METER AREAS THAT
MERGE WITH FLOW METER 1

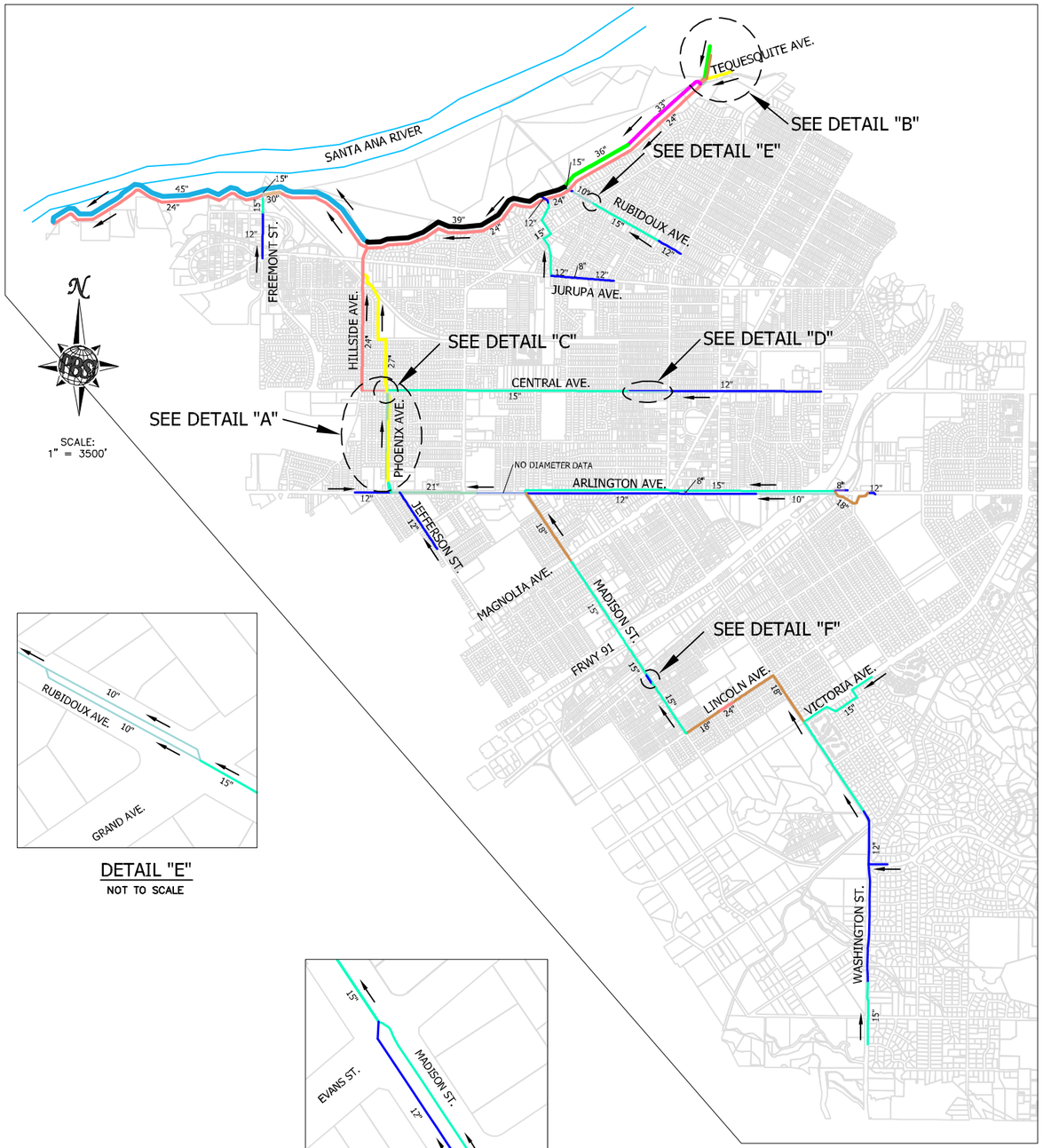


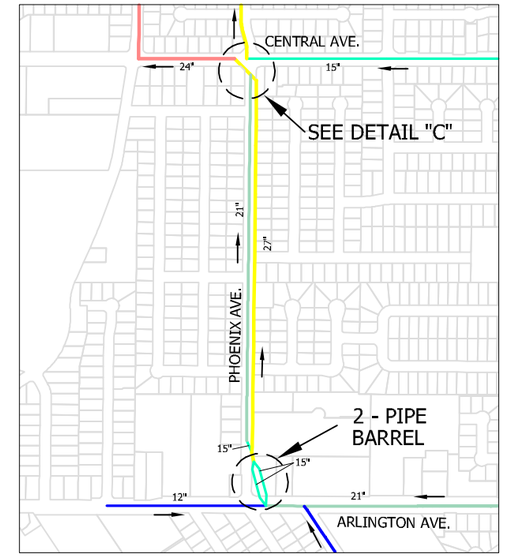
FLOW METER AREAS THAT
MERGE WITH FLOW METER 3

Engineering
Planning
Surveying
Construction Services
PBSJ
10370 Hemet Street
Suite 200
Riverside, CA 92503
Tel:(951) 358-1433
Fax:(951) 358-1434

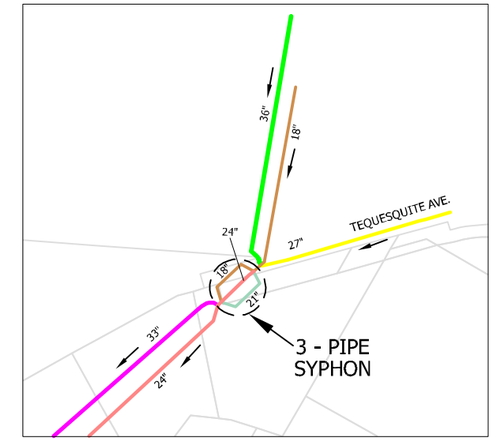
DATE: 12/15/05	DWN BY: CD
CITY OF RIVERSIDE PHOENIX SEWER STUDY	FIGURE 5
FLOW METER LOCATIONS	

Y:\City of Riverside\Phoenix\DWG\Exhibits\PH-FlowMonitoringCMC.dwg, 9/28/2006 10:49:45 AM



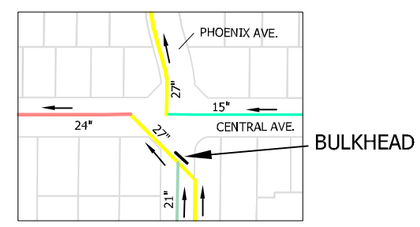


DETAIL "A"
NOT TO SCALE

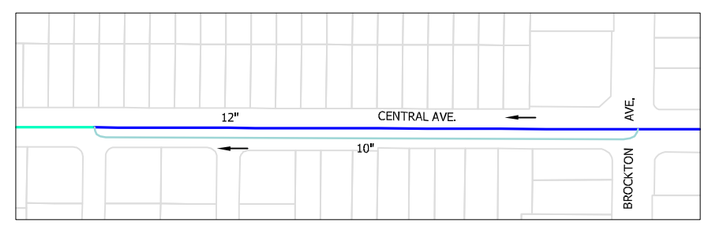


DETAIL "B"
NOT TO SCALE

DETAIL "E"
NOT TO SCALE



DETAIL "C"
NOT TO SCALE



DETAIL "D"
NOT TO SCALE

DETAIL "F"
NOT TO SCALE

LEGEND

- 8" DIAMETER PIPE
- 10" DIAMETER PIPE
- 12" DIAMETER PIPE
- 15" DIAMETER PIPE
- 18" DIAMETER PIPE
- 21" DIAMETER PIPE
- 24" DIAMETER PIPE
- 27" DIAMETER PIPE
- 30" DIAMETER PIPE
- 33" DIAMETER PIPE
- 36" DIAMETER PIPE
- 39" DIAMETER PIPE
- 45" DIAMETER PIPE
- NO DIAMETER DATA
- FLOW DIRECTION

Engineering
Planning
Surveying
Construction Services
PBSJ
10370 Hemet Street
Suite 200
Riverside, CA 92503
Tel:(951) 358-1433
Fax:(951) 358-1434

DATE: 12/15/05	DWN BY: CD
CITY OF RIVERSIDE PHOENIX SEWER STUDY	FIGURE 6

SYSTEM PIPE DIAMETERS

Y:\City of Riverside\Phoenix\DWG\Exhibits\PH-SewerSysAndDia.dwg, 9/28/2006 11:10:11 AM

City were studied to ascertain characteristics of the system. The existing sewer manholes can be seen in Figure 7A and 7B and the pipes can be seen on figures 8A and 8B. The pipelines in the system are prefixed with letter "P" (for pipe) and the manholes are prefixed with letter "M" (for manhole) to match the Hydraulic Model. The description of sewer segments begins at the most upstream manhole and ends at the most downstream manhole. The sewer system is briefly described as follows:

- *Santa Ana River Sewer Line:* The sewer line along the Santa Ana River picks up wastewater flows from the Tequesquite, Northside and Spruce Sewer Basins. Tequesquite flows are collected at manhole M428 and Northside and Spruce flows are collected at manholes M428 and M430. The sewer line between manholes M428 and M426 is 27-inch in diameter. The sewer line between M429 and M426 is 18-inch and between M430 and M426, 36-inch. At manhole M426, which is the upstream manhole of a 3-barrel siphon, wastewater flows from all upstream sewer basins converge. The diameters of barrels in the siphon are 24-inch, 21-inch and 18-inch. These three pipelines converge at manhole M424 and transition into two parallel lines; a 24-inch diameter line and the other a 33-inch diameter line. The 24-inch diameter line begins at manhole M424 and runs southwesterly along the Santa Ana River until it reaches manhole M055. The 33-inch diameter line also runs southwesterly along the Santa Ana River and ends at manhole M088. A 36-inch diameter line extends from manhole M088 to manhole M087. At this junction, a 15-inch diameter connector joins manhole M087 to manhole M094. At that junction, the line transitions into parallel 39-inch and 24-inch lines. The 24-inch line extends from manhole M055 to manhole M053. At that point, it crosses the Jurupa Avenue pipeline and continues as a 24-inch line from M053 to M052. From M052, the line continues as a 24-inch diameter line until it reaches to manhole M001. The 39-inch diameter line begins at manhole M087 and continues to manhole M080. At this junction, the 39-inch line becomes a 45-inch diameter line. This line continues until it terminates at manhole M002 and joins the parallel 24-inch line. This pipeline segment begins near Tequesquite Arroyo Park and crosses the Union Pacific Railroad. This pipeline ends at the Regional Water Quality Control Plant.

- *Overlook Parkway Sewer Line*: The study sewer line along Overlook Parkway begins at manhole M292, located at the intersection of Alton Way and Overlook Parkway. It is a single-segment 12-inch diameter line that flows in the westerly direction from manhole M292 to M291. The sewer line collects wastewater flow from the residential areas

located on both sides of Overlook Parkway. It joins the trunk sewer line along Washington Street at manhole M291.

- *Victoria Avenue Sewer Line*: The 15-inch gravity sewer line along Victoria Avenue begins at manhole M281 located at the intersection of Stonegate Drive and Victoria Avenue. It flows in the westerly direction and joins the Washington Street Pipeline at manhole M271. Washington Elementary School is located on Victoria Avenue and Washington Park is on the intersection of Mary Street and Victoria Avenue. It picks up wastewater flow from the residential developments east of Hwy 91 and along Victoria Avenue.

- *Washington Street Sewer Line*: The study sewer line along Washington Street begins at manhole M307 at the intersection of Highridge Street. This sewer line consists of three different pipe segments: 12-inch, 15-inch and an 18-inch diameter. The 15-inch sewer line collects wastewater flows from the residential development and flows in the northerly direction along Washington Street. The sewer line between manholes M307 and M302 is 15-inch, and it transitions into a 12-inch between manholes M302 and M288. There, it crosses the Overlook Parkway Sewer Line as well as the Gage Canal. The sewer line between M288 and M271 is 15-inch.The sewer line between manholes M271 and M267 is 18-inch. At manhole M267 it joins Lincoln Avenue trunk sewer line.

- *Lincoln Avenue Sewer Line:* The trunk sewer line along Lincoln Avenue begins at manhole M267 located at the intersection of Washington Street and Lincoln Avenue. This trunk line picks up flow from the Washington Street sewer line at this location. This sewer line consists of two different pipe segments: an 18-inch and a 24-inch diameter line. The sewer line between manhole M267 and M263 is 18-inch. There is a short 24-inch diameter segment between M263 and M262. It then returns to an 18-inch line from M262 to M259 where it terminates at the Madison Street sewer line.

- *Madison Street Sewer Line:* The trunk sewer line along Madison Street begins at the intersection of Madison Street and Victoria Avenue. At this location, it picks up wastewater flow from the Victoria Avenue sewer line. This sewer line consists of three different pipe segments (12-inch, 15-inch and an 18-inch). This pipeline begins as a 15-inch line at manhole M259 and continues along Madison Street in the northerly direction up to manhole

M252. At this location a 12-inch pipe segment runs parallel to the 15-inch line between manhole M252 and M249. From manhole M249, a single 15-inch line continues to manhole M238. Finally, an 18-inch diameter sewer line continues in the northerly direction to manhole M228, where it joins the trunk sewer line along Arlington Avenue.

- *Jefferson Street Sewer Line:* The sewer line begins at manhole M413, located at the intersection of Jefferson Street and Willow Avenue. This 12-inch sewer line continues in the northwesterly direction as one size until it reaches manhole M213. At this location, it joins the trunk sewer line along Arlington Avenue. Don Jones Park, adjacent to Sycamore Avenue, and Jefferson Elementary School, are situated on Jefferson Street. There is also a fire station on Streeter Avenue and Arlington Avenue.

- *Arlington Avenue Sewer Line:* The sewer line along Arlington Avenue begins at the intersection of Arlington Avenue and McMahon Street. This line consists of various pipe segments ranging from 8-inch to 21-inch in diameter. The first segment begins at manhole M367 as a 12-inch sewer line and continues to manhole M365. The second pipeline begins at manhole M359 as a 12-inch line and traverses parallel to the first line. At manhole M365, the pipe size changes to 18-inch and continues to manhole M356. From there, it transitions into a 10-inch diameter line until it reaches manhole M340. The parallel line consists of two 8-inch segments from M358 to M355. An 18-inch connector joins these two parallel lines between manholes M356 to M355. The sewer line continues as a 15-inch line from manhole M355 to manhole M315 where it becomes 12-inch until it reaches the end of the parallel segment at manhole M228. At the intersection of Arlington Avenue and the Hwy 91, a 12-inch pipe segment continues in the westerly direction to manhole M358. At this location, it transitions to 8-inch and continues to manhole M355 where it becomes a 15-inch line running westerly to manhole M315. At this location there is a small 12-inch diameter segment. Beyond M315 it continues to manhole M226 as a 15-inch line. At this location the parallel sewer lines join. An 18-inch line connects the parallel lines from manhole M356 to manhole M355. Beyond manhole M226 is a single 21-inch line, crossing the Jefferson Street trunk sewer line and the Phoenix Avenue trunk sewer line. At manhole M219, a 12-inch diameter line runs easterly on Arlington Avenue to manhole M212. The sewer line joins the Phoenix Avenue trunk sewer line at manhole M212.

  The line crosses the Metrolink Railroad near Hwy. 91. The California School for the Deaf on Arlington Avenue is one

of the major contributors of wastewater flow. This sewer line picks up wastewater flow from residential and commercial development all along Arlington Avenue.

- *Central Avenue Sewer Line:* The sewer line on Central Avenue is comprised of 12-inch, 15-inch and 24-inch segments. It begins at manhole M206 at the intersection of Central Avenue and Riverside Avenue as a 12-inch line. It continues from manhole M206 in the westerly direction until it reaches manhole M183, where it transitions to a 15-inch diameter sewer line and continues to manhole M135. From M135, a 24-inch sewer line continues to manhole M123. The line collects wastewater flow generated from the residential development on the north and south side of Central Avenue. It also picks up wastewater flow from Riverside Plaza. This sewer line joins Phoenix Avenue trunk sewer line near Riverside Municipal Airport.

- *Phoenix Avenue Sewer Line:* This sewer is comprised of 15-inch, 21-inch and 27-inch segments. It begins at manhole M212 and continues as a 15-inch line for a short length to manhole M211 at the intersection of Phoenix Avenue and Arlington Avenue. Between manhole M211 and M210, the size is 27-inch. The sewer line between manhole M210 and M209 is 15-inch. At this junction, the single line diverges into two parallel lines running northerly on Phoenix Avenue. The first line begins at manhole M210 and continues as a 27-inch until it reaches manhole M140. The second line begins at manhole M209 and continues as a 21-inch until it reaches manhole M139. At this location, the parallel lines transition into one line running northerly on Phoenix Avenue (27-inch sewer line) to manhole M110. The pipeline joins the Hillside Avenue trunk sewer line at manhole M110. The line collects wastewater flow from the commercial and residential area east of the Riverside Municipal Airport.

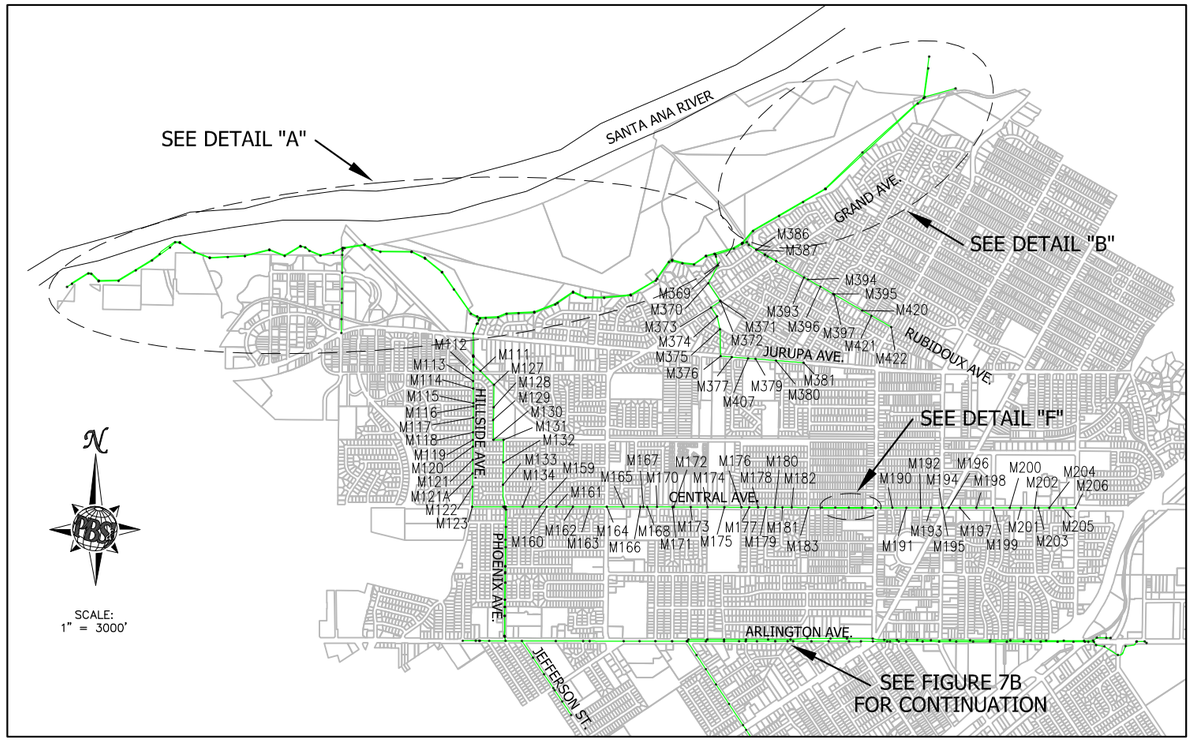
- *Hillside Avenue Sewer Line:* The initial reach of this sewer line is a 24-inch segment that begins at manhole M123 at the intersection of Central Avenue and Hillside Avenue. It continues north until it reaches manhole M107, where it becomes a short 27-inch diameter segment to manhole M106. At manhole M106, it continues as a 24-inch diameter line until it ends at manhole M081, where it crosses the Santa Ana River Pipeline and the Union Pacific Railroad. The pipeline joins the Santa Ana River trunk sewer line at manhole M081. The sewer line collects wastewater flow from the commercial and residential area east of the Riverside Municipal Airport.

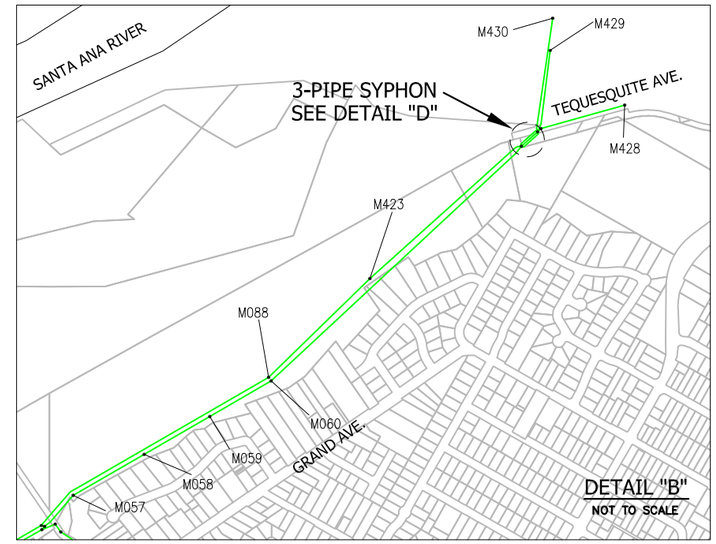
- *Rubidoux Avenue Sewer Line:* The sewer line along Rubidoux Avenue begins at manhole M422 at the intersection of Rubidoux Avenue and Brockton Avenue. It consists of three sewer segments (10-inch, 12-inch and 15-inch). The 12-inch sewer line begins at manhole M422 and continues in a westerly direction to manhole M420. There, it transitions into a 15-inch diameter sewer line until it reaches manhole M392, where it splits into two segments. These are each 10-inch diameter lines ending at manhole M388. The sewer line between M388 and M384 is 10-inch in size. Thereafter, it continues as a 12-inch line to manhole M055, where it joins the Santa Ana River Pipeline. It picks up wastewater flow from the residential area east of Rubidoux Avenue.

- *Jurupa Avenue Sewer Line:* The sewer line along Jurupa Avenue begins at the intersection of Tower Road and Jurupa Avenue. It consists of 8-inch, 12-inch and 15-inch segments. It begins at manhole M381 as a 12-inch diameter line and runs easterly along Jurupa Avenue until it reaches manhole M379. There, it transitions to an 8-inch diameter sewer line for a small segment of pipe between manhole M379 and M407. From manhole M407 to manhole M376, the size is 12-inch. At this location, it continues in a northerly direction as a 15-inch diameter line until it reaches manhole M368. The line from manhole M368 to M053 is 12-inch, where it joins the Santa Ana River trunk sewer line. This sewer line picks up wastewater flow from the residential areas north and south of Jurupa Avenue.

- *Freemont Street Sewer Line:* This study area sewer line begins at Jurupa Avenue. It consists of three sewer segments varying in sizes from 10-inch to 15-inch. A 12-inch diameter line begins at manhole M101 and continues in a northerly direction to manhole M097. From manhole M097 to manhole M096, the line is 15-inch diameter. At this location, the size changes to 10-inch diameter to manhole M076, where it joins the Santa Ana River Pipeline. This sewer line picks up wastewater flow from the commercial areas east and west of Freemont Street.

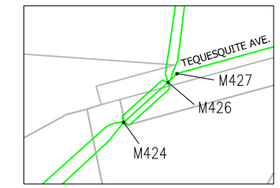
3.4 Tributary Areas



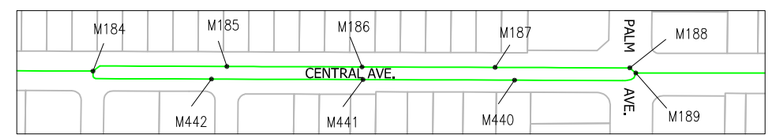


DETAIL "B"
NOT TO SCALE

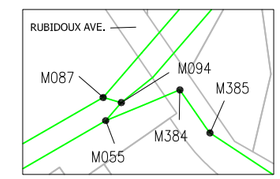
DETAIL "C"
NOT TO SCALE



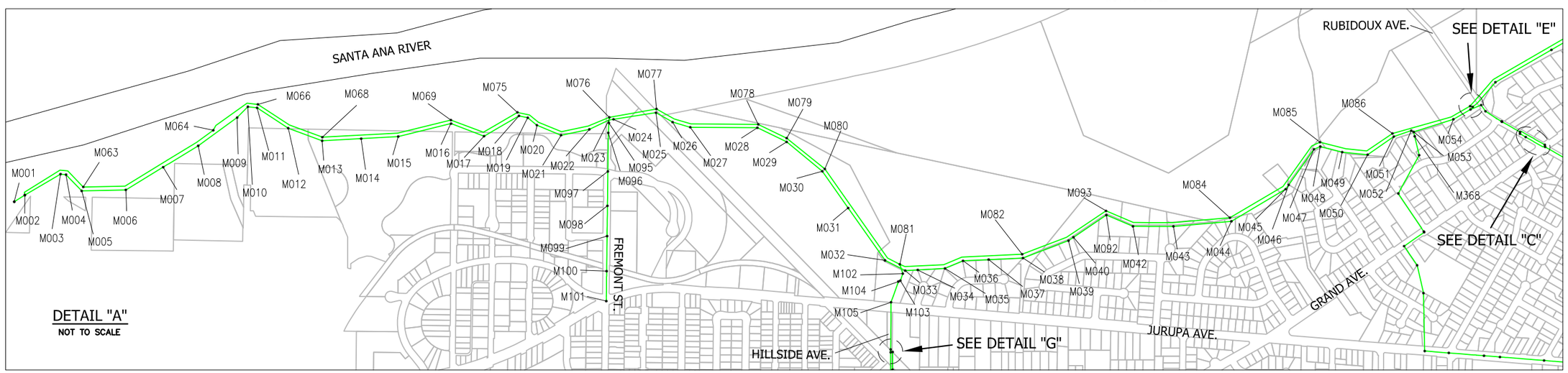
DETAIL "D"
NOT TO SCALE



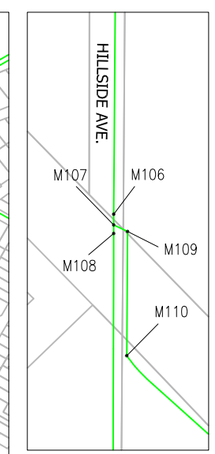
DETAIL "F"
NOT TO SCALE



DETAIL "E"
NOT TO SCALE



DETAIL "A"
NOT TO SCALE



DETAIL "G"
NOT TO SCALE

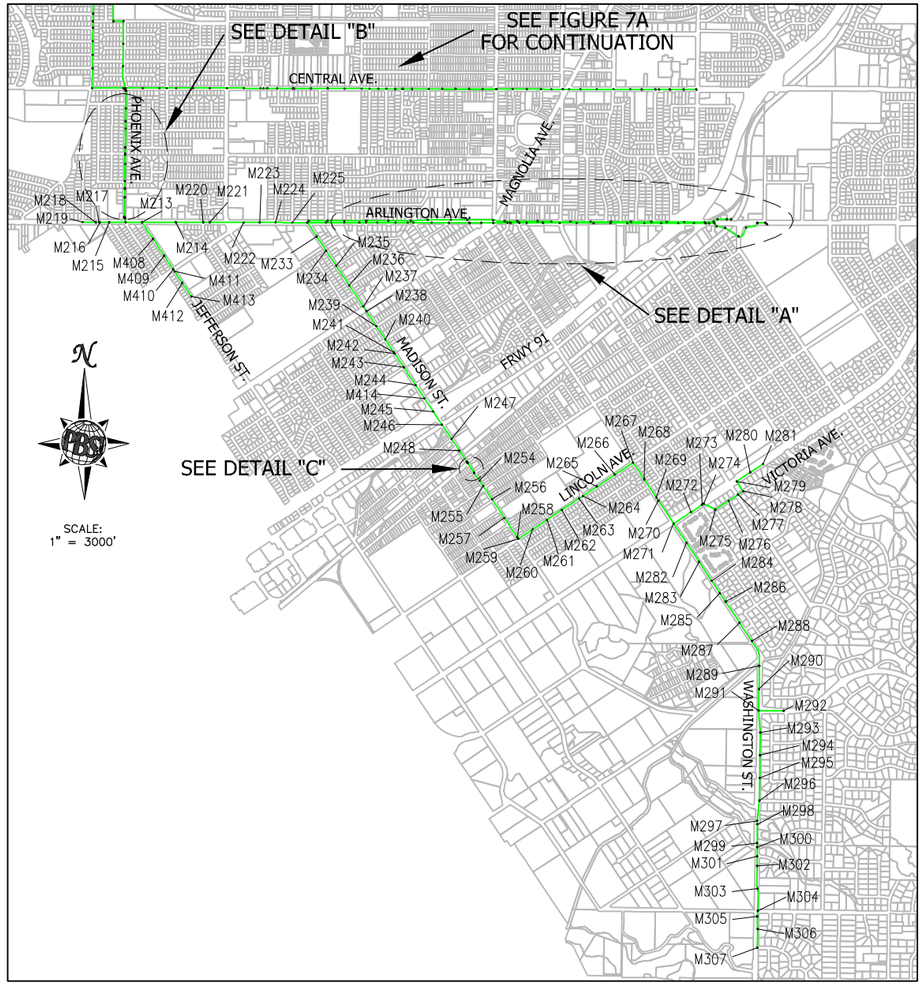
LEGEND

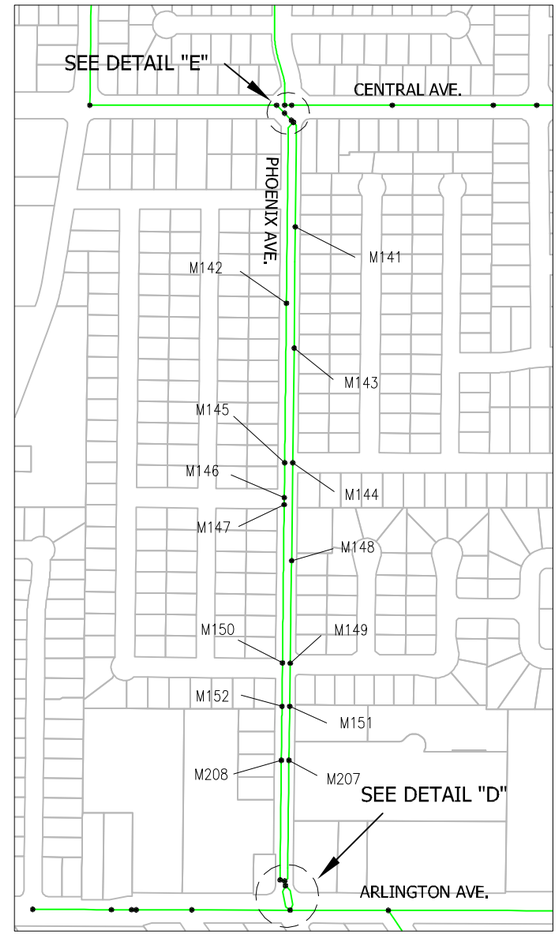
GRAVITY SEWER

M001 MANHOLE NUMBER

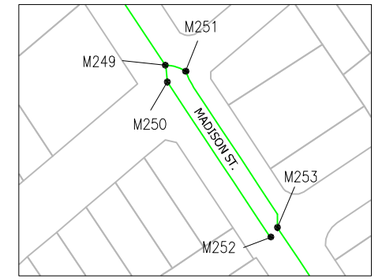
Engineering
Planning
Surveying
Construction Services
PBSJ
10370 Hemet Street
Suite 200
Riverside, CA 92503
Tel:(951) 358-1433
Fax:(951) 358-1434

DATE: 12/15/05	DWN BY: CD
CITY OF RIVERSIDE PHOENIX SEWER STUDY	FIGURE 7A
EXISTING MANHOLES - PART 1	

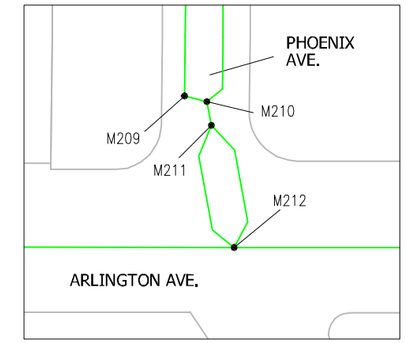




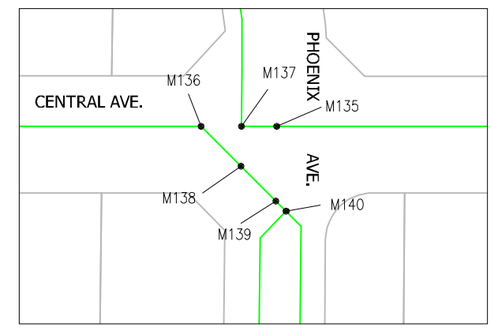
DETAIL "B"
NOT TO SCALE



DETAIL "C"
NOT TO SCALE



DETAIL "D"
NOT TO SCALE



DETAIL "E"
NOT TO SCALE

LEGEND

GRAVITY SEWER

M001 MANHOLE NUMBER

DETAIL "A"
NOT TO SCALE

DATE: 12/15/05	DWN BY: CD

Engineering
Planning
Surveying
Construction Services

PBS&J

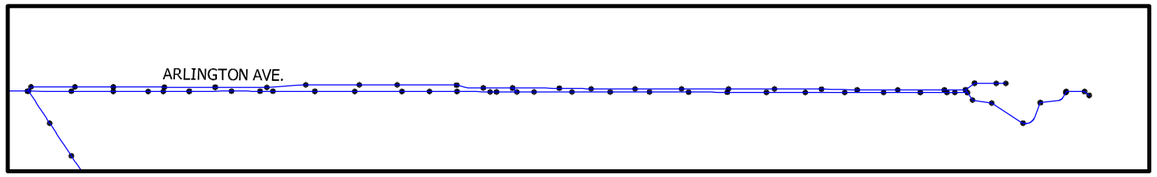
10370 Hemet Street
Suite 200
Riverside, CA 92503
Tel:(951) 358-1433
Fax:(951) 358-1434

CITY OF RIVERSIDE
PHOENIX SEWER STUDY

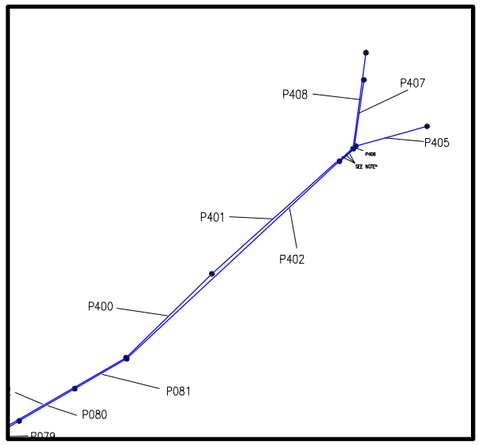
FIGURE 7B

EXISTING MANHOLES - PART 2

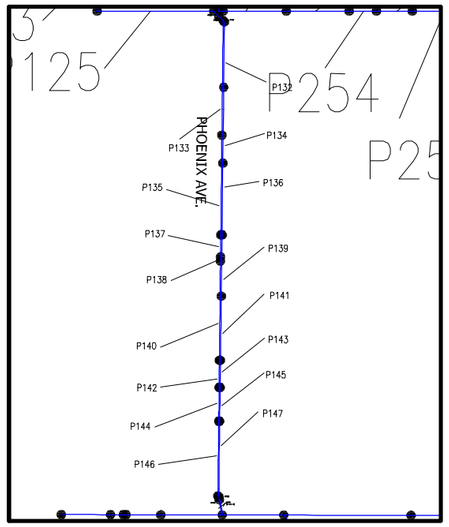
Y:\City of Riverside\Phoenix\DWG\Exhibits\PH-ManholeIDsB.dwg, 9/28/2006 10:52:46 AM



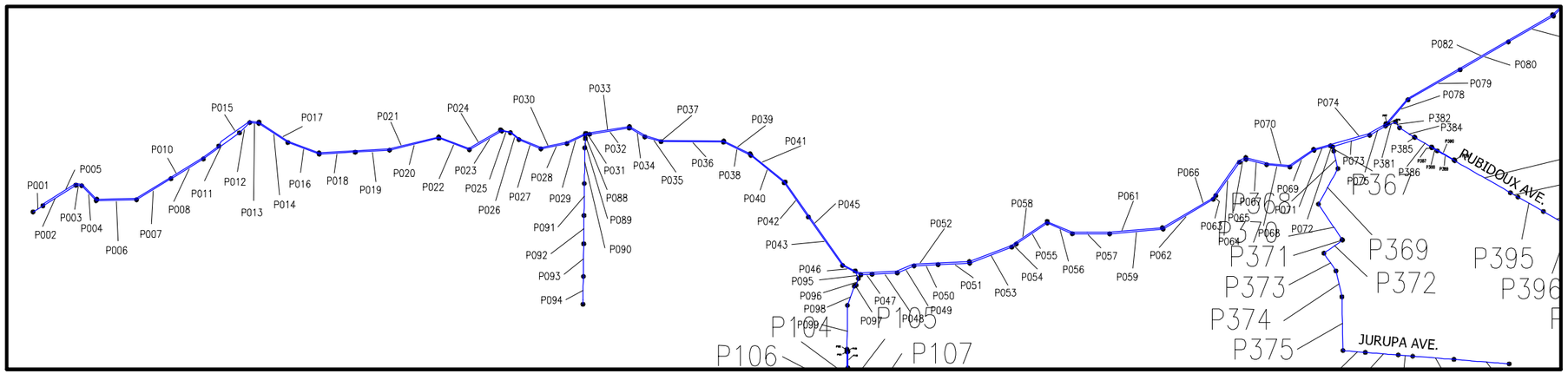
DETAIL "A"
NOT TO SCALE



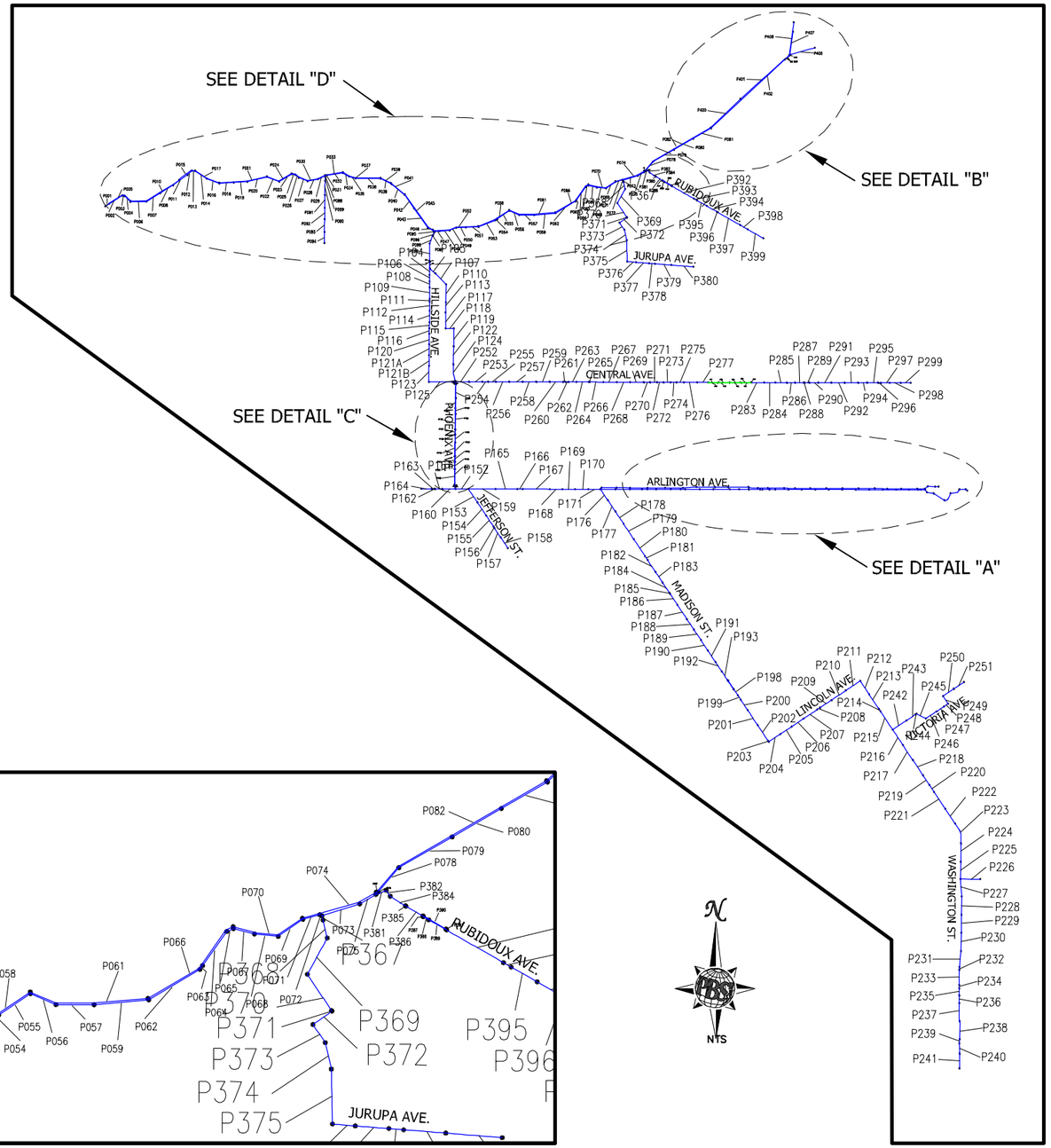
DETAIL "B"
NOT TO SCALE



DETAIL "C"
NOT TO SCALE



DETAIL "D"
NOT TO SCALE



LEGEND

GRAVITY SEWER

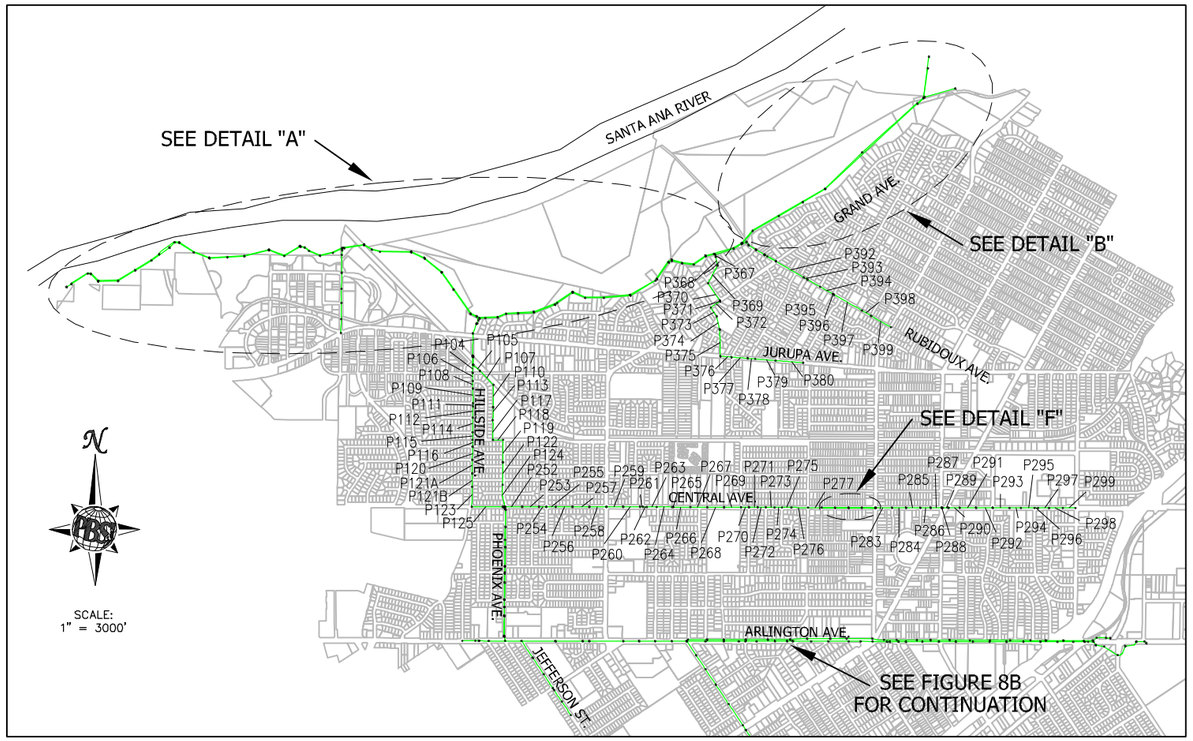
P001 PIPE SEGMENT NUMBER

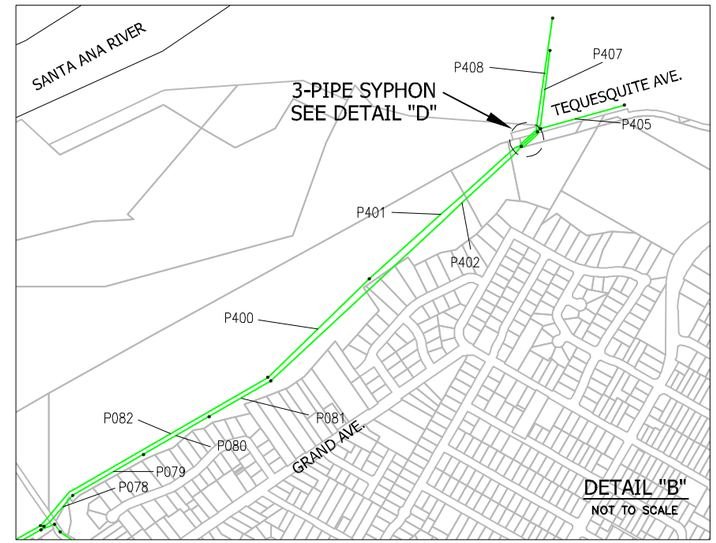
Engineering
Planning
Surveying
Construction Services
PBS&J
10370 Hemet Street
Suite 200
Riverside, CA 92503
Tel:(951) 358-1433
Fax:(951) 358-1434

CITY OF RIVERSIDE
PHOENIX SEWER STUDY

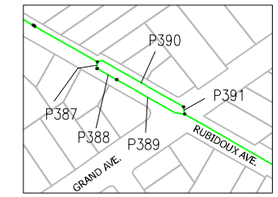
FIGURE 8

EXISTING PIPELINES

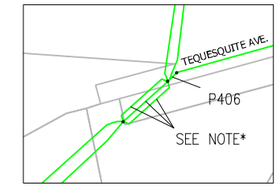




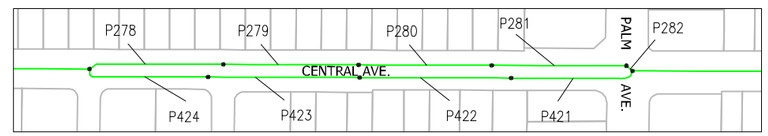
DETAIL "B"
NOT TO SCALE



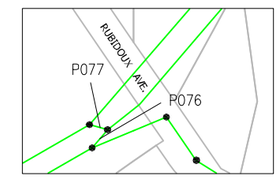
DETAIL "C"
NOT TO SCALE



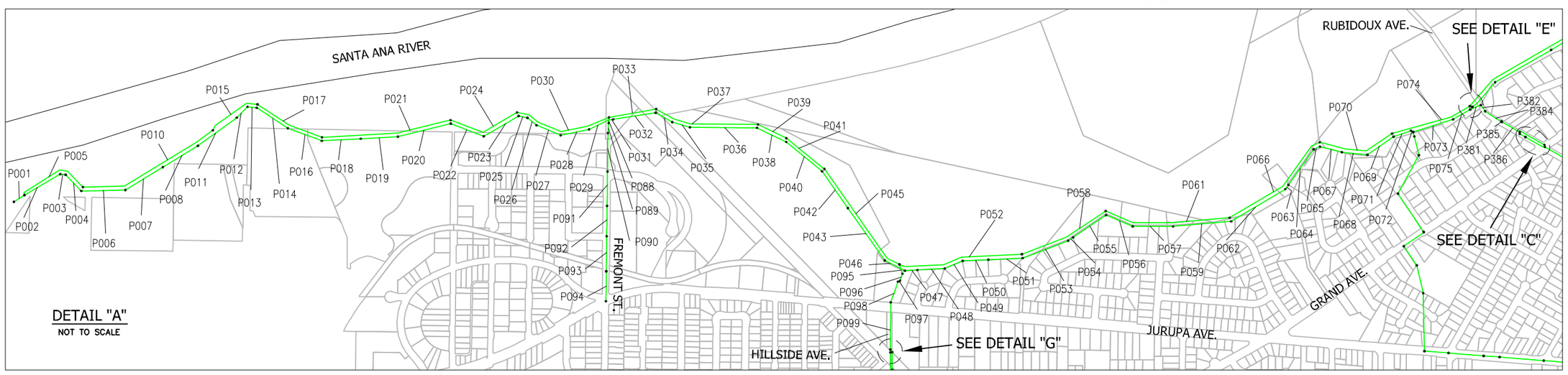
DETAIL "D"
NOT TO SCALE



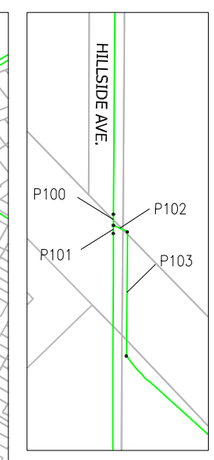
DETAIL "F"
NOT TO SCALE



DETAIL "E"
NOT TO SCALE



DETAIL "A"
NOT TO SCALE



DETAIL "G"
NOT TO SCALE

LEGEND

GRAVITY SEWER

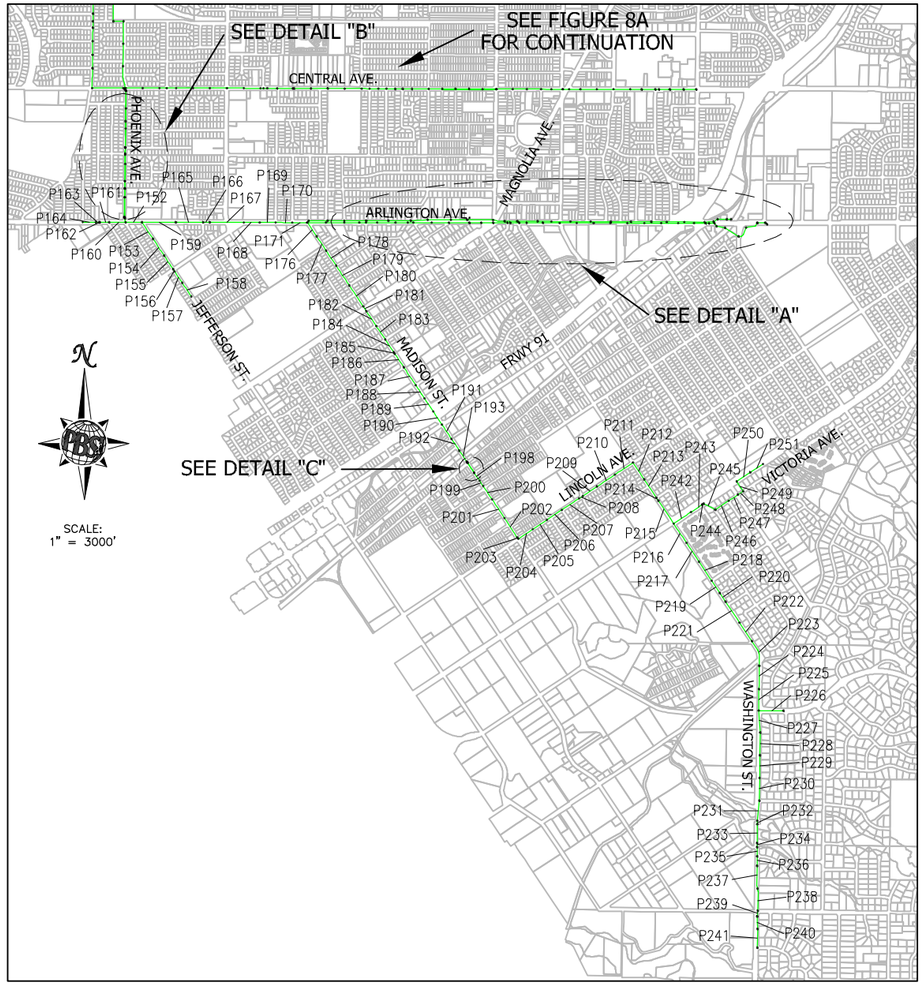
P001 PIPELINE NUMBER

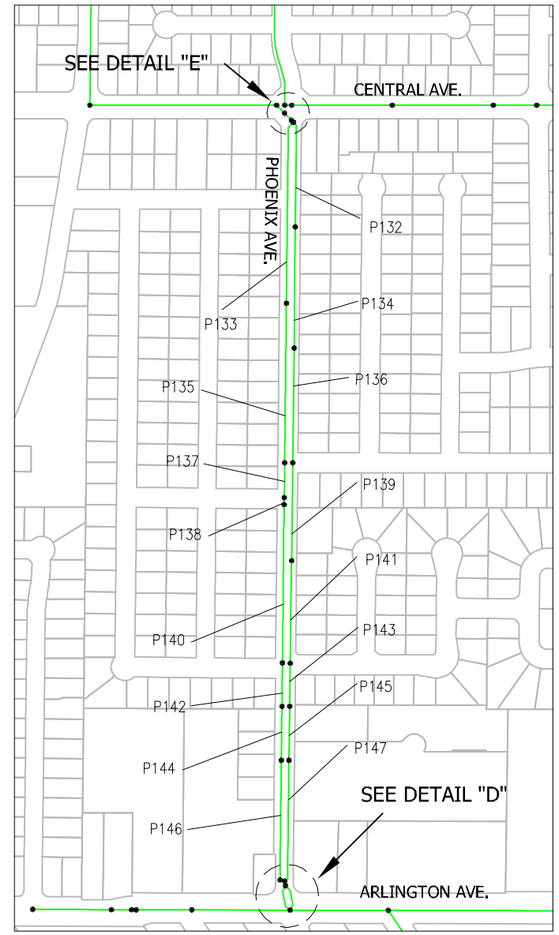
NOTE* THIS 3-PIPE SYPHON CONSISTS OF PIPELINE NUMBERS P409 THROUGH P420.

Engineering
Planning
Surveying
Construction Services
PBS&J
10370 Hemet Street
Suite 200
Riverside, CA 92503
Tel:(951) 358-1433
Fax:(951) 358-1434

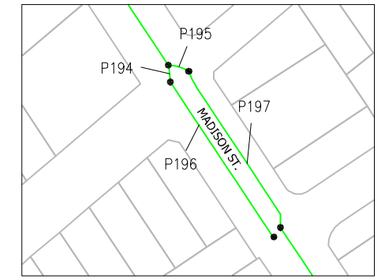
DATE: 12/15/05	DWN BY: CD
CITY OF RIVERSIDE PHOENIX SEWER STUDY	FIGURE 8A
EXISTING PIPELINES - PART 1	

Y:\City of Riverside\Phoenix\DWG\Exhibits\PH-PipelDsA.dwg, 9/28/2006 10:55:07 AM

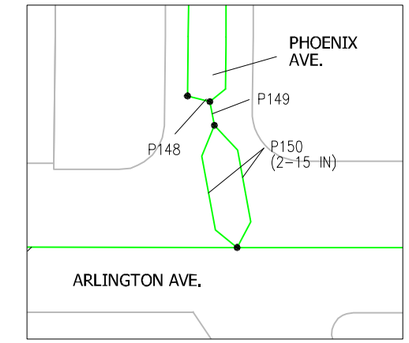




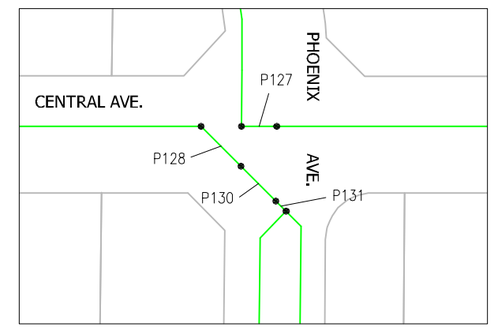
DETAIL "B"
NOT TO SCALE



DETAIL "C"
NOT TO SCALE



DETAIL "D"
NOT TO SCALE



DETAIL "E"
NOT TO SCALE

LEGEND

GRAVITY SEWER

P001 PIPELINE NUMBER

DETAIL "A"
NOT TO SCALE

DATE: 12/15/05	DWN BY: CD
CITY OF RIVERSIDE PHOENIX SEWER STUDY	FIGURE 8B
EXISTING PIPELINES - PART 2	

Engineering
Planning
Surveying
Construction Services
PBS&J
10370 Hemet Street
Suite 200
Riverside, CA 92503
Tel:(951) 358-1433
Fax:(951) 358-1434

Y:\City of Riverside\Phoenix\DWG\Exhibits\PH-PipelDsB.dwg, 9/28/2006 10:56:15 AM

The study area is divided into 21 sub-areas, each area having a land use or flow pattern distinctive from the other. These sub-areas are tributary to a particular meter location either individually or collectively. Because of their strategic locations, meters upstream to a cumulative meter can be subtracted out to reduce the cumulative effect. See Figure 4 for details of tributary sub-areas and Figure 5 for meter locations. The following is the listing of tributary sub-areas and their contribution to a particular meter location.

Meter No. 1: All sub-areas are tributary to meter No. 1, located at the entrance of the Regional Water Quality Control Plant.

Meter No. 2: Sub-areas 4, 14 (part), 16 (part) 17 and 20 are tributary to meter No. 2 located on Hillside Avenue near the Mountain View Avenue intersection.

Meter No. 3: Sub-areas 5, 13 (part), 14 (part) 15 and 16 (part) are tributary to meter no. 3, located on Arlington Avenue near Madison Street intersection.

Meter No. 4: Sub-areas 2 and 3 (part) are tributary to meter 4, located on Rubidoux Avenue at the Via Dos Caminos Avenue Intersection.

Meter No. 5: Sub-areas 6, 7, 8, 10 and12 are tributary to meter 5, located on Madison Street at the intersection of Magnolia Avenue.

Within each sub-area there is generally a distinct mixture of land use, that generates a unique quantity and diurnal pattern of wastewater flows. For identification of land use patterns, data provided by the City of Riverside in GIS Arcview format was used. The following table summarizes land uses within the particular sub-areas.

Table 3-1 summarizes the sub-areas and land uses within the sub-areas that are currently contributing to the existing sewer system.

Table 3-1

Developed Tributary Areas and Current Wastewater Generating Land Use

Sub Area	SFR (Acres)	MFR (Acres)	Commercial (Acres)	Industrial (Acres)	School (Acres)	Total (Acres)
1	2	0	0	0	0	2
2	361	9	39	0	8	417
3	142	0	0	0	0	142
4	118	0	30	0	6	154
5	509	0	24	0	78	611
6	36	0	0	0	0	36
7	5	0	0	0	0	5
8	1,126	0	0	0	0	1,126
10	577	0	160	0	0	737
11	104	7	52	0	54	217
12	434	9	112	0	90	645
13	21	0	89	0	0	110
14	61	7	76	0	10	154
15	159	6	25	0	19	209
16	363	22	62	0	12	459
17	117	7	12	0	0	136
18	55	3	15	0	0	73
19	103	7	4	0	12	126
20	203	0	13	0	0	216
21	2	0	97	55	0	154

SFR – Single Family Residential
MFR – Multi Family Residential

4.0 DETERMINATION OF SEWER FLOWS

4.1 Flow Monitoring

Flow Monitoring was conducted at five (5) sites in order to accomplish the following: (See Figure 5 for locations of Flow Monitoring Stations).

- Establish current flow levels.
- Verify or adjust flow coefficients.
- Establish characteristic flow patterns (Diurnal Curves) for the model (See Figures 14-18).
- Confirm peak to average flow relationships.
- Help prioritize recommended improvements.

Meter locations were chosen to observe actual flow characteristics for the various sub-areas and to provide a continuous record of measured flows over a period of time (three weeks for this study). Meter locations were also chosen in such a manner that current flow quantities at the RWQCP could be quantitatively determined. The City measures inflow from Santa Ana Trunk Sewer Line at RWQCP at one minute intervals. The flow records received from the City were used for flow comparison and determination of diurnal pattern at meter location No. 1. The following is an amplification of the logic for placement of each flow meter.

- Meter No. 1; location is at the entrance of the RWQCP where the 45-inch and 24-inch lines join – This location was chosen because it carries all the flow generated from all the residential, industrial and commercial areas in the Phoenix Sewer System and all upstream sewer basins (Tequesquite, Spruce and Northside). The flow pattern at this location reflects a diurnal pattern for mixed land use.

- Meter No. 2; location on Hillside Avenue near Mountain View Avenue – This location was chosen to observe flow generated from the mixed use along the west side of the study area. This meter intercepts flow generated from a matured residential / commercial area. The flow pattern at this location reflects a diurnal pattern for mixed land use. This meter also records majority of cumulative flows from meters 3 and 5.

- Meter No. 3; location on Arlington Avenue west of Madison Street – This location was chosen to measure the flow from residential and commercial areas on both sides of Route 91.

The flow pattern at this location reflects a mixed diurnal pattern for mixed residential-commercial land use. Meter 3 also picks up flows from meter 5.

- Meter No. 4; location on Rubidoux Avenue near the intersection of Via Los Caminos Avenue – Measures wastewater flow from the northerly end of study area mostly west of Magnolia Avenue. This area consists of primarily residential land use.

- Meter No. 5; location on Madison Street south of Arlington Avenue – This location was chosen to measure the flow from residential areas along Madison Street, Lincoln Avenue, Victoria Avenue and Washington Street. The residential land use in this portion of study ranges from low density to medium-high density. The diurnal flow pattern can be used to estimate and calibrate future flow patterns.

4.2 Results of Flow Monitoring

Measurement of sewer flows is an imprecise science, as the in-line equipment is placed in a harsh environment and is subject to solids interference, calibration, turbulence and other problems, which can impede the accuracy. Installed equipment must be frequently inspected and maintained, and monitoring results interpreted, evaluated for reasonableness, and sometimes adjusted. In this particular application, metered flow information was generally good. However, some flows at specific meter locations did not display consistent values. Graphical results at each site were carefully reviewed for consistency and reasonableness, using the following general guidelines.

- Where the magnitude or daily pattern varies significantly from one non-holiday weekday to the next, the data is likely to be flawed.
- Where the base (low) flows are rising during the flow monitoring period, the data is suspect.
- Where the algebraic sum of flows from meters in series are significantly out of sync, the data from one or more meters may be faulty.
- Where minimum (nighttime) flows are abnormally high or algebraically inconsistent, the data is suspect.
- Where the measured depth data and velocity data are inconsistent, the data is suspect.

Metered flows displaying one or more of the above flaws were purged or adjusted based on reasonable assumptions.

At each meter location, the flow-monitoring device measures depth of flow and velocity. Upon reviewing the report submitted by Downstream Services, and from discussions with their staff, it was determined the data (depth or velocity) that is more consistent should be used for determination of flow. By using depth of flow readings and inputting pipe characteristics from record drawings (slope, size and roughness "n" values), sewage flow can be calculated using Manning's equation. The raw flow data have been included in Appendix "A".

The flow data at each meter site, adjusted based on the depth measurement, are shown in Figures 9 through 13. The following relevant observations were made from evaluation of the measured flows:

- Flows measured at meter location 5 shows a low amount of flow although it covers a larger portion of study area. This may be attributed to the fact that most of the areas contributing to meter 5 are low density residential areas (2-3 dwelling units per acre).

- Flows measured at meter location 4 were not consistent for the period October 1 to October 9. Flow hydrographs for October 10 to October 20 were used for analysis.

- At meter location 2, the flows measured during week days are slightly higher than weekends. The land uses contributing to this meter include residential, commercial and institutional establishments. The closures of many commercial and institutional establishments could explain the lower measured flows during weekends

5.0 ESTIMATED ULTIMATE FLOW

5.1 Methodology

Future wastewater flows in the study area are estimated by applying unit (per acre or per capita) flow factors to the projected "ultimate" land use acreage or population in each sub area. As discussed in Section 2, ultimate land uses within the study area are estimated based on the City's current General Plan (which governs future development/redevelopment) and input from City staff. The major contributor to the projected increase in wastewater flow in the future is development of low density residential areas southeast of Victoria Avenue. For purposes of this study, it is assumed that these areas will be developed by the year 2020.

5.2 Flow Coefficients

A review of commonly used flow coefficients (or unit factors) was performed to arrive at preliminary criteria, which is an appropriate starting point for the study area.

Flow coefficients are commonly expressed in terms of cubic feet per second (cfs) of average dry weather flow (ADWF) per acre of a specific land use type. For population based estimates, flows are expressed in gallons per capita per day (gpcd). Peak flow generation rates can be estimated by applying peaking factors to the average flow, with factors often based on observed peak-to-average ratios from previous studies. However peaking factors and diurnal flow patterns vary greatly from one setting to another. Peaks for various uses differ not only in magnitude, but also in time of the day. The diurnal patterns are thus a composite picture of inflows that are not simultaneous, but rather staggered throughout the day. Also, peaks are attenuated by lag times and in-pipe storage as the flows move downstream. Notwithstanding the above, diurnal peaking factors are also estimated for each land use type to estimate peak generation rates.

For preliminary estimation of wastewater flow, the document "Criteria for Sewer Facility Design, Public Works Department, City of Riverside" was used. (See Appendix "B"). The document states the following general guidelines for estimation of wastewater flows.

Flows from Residential Developments:

- Land use shown in the City's General Plan.
- No. of dwelling units per acre within a certain land use.

- Persons per living unit determined from the latest census data for the study area. However, it should not be less than an average of 2.75 persons per living unit.
- Average wastewater flow based on 65 gallons per capita per day.
- Peak to average flows to be determined from the graphs.

Flows from non-residential developments:

- Industrial Developments – Peak flow; 0.012 cfs per acre.
- Commercial Developments – Peak flow 0.01 cfs per acre.
- Offices – 30 gallons per capita (employee on site) per day peak flow.
- Schools – 0.01 cfs/acre peak flow.
- Laundromat – 580 gallons per machine per day peak flow.

5.3 Representative Diurnal Hydrographs

The study area is comprised of a variety of unique land uses. For the purpose of defining characteristic diurnal patterns, flow from each sub-basin was analyzed and percentage of flow contribution from each land use type was estimated. Although only a few of the tributary sub areas flowing to the meter locations are comprised of a single land use category, several are dominated by one or two categories, and are thus selected as being representative of the diurnal flow patterns for those land uses. The diurnal patterns were established at each meter location, and the model was calibrated for mixed land use patterns. The following diurnal patterns were used for the modeled peak flow evaluation.

- Flow at meter location 1: Mixed Land Use Pattern (Residential, Commercial and Industrial). The diurnal pattern was derived from the flow data at meter location 1.

- Flow at meter location 2: Mixed Land Use (Residential and Commercial)

- Flow at meter location 3: Mixed Land Use (Residential and Commercial)

- Flow at meter location 4: Single Family Residential

- Flow at meter location 5: Mixed with residential predominance

These representative diurnal hydrographs are shown in Figures 14-18. The flow patterns are used in the model to estimate the

percentage of Average Dry Weather Flow (ADWF) contributed at specific times throughout the day.

Figure 9

Flows at Meter 1 (Adjusted)

Meter Location - at the entrance of the RWQCP on a 48-inch Sewer

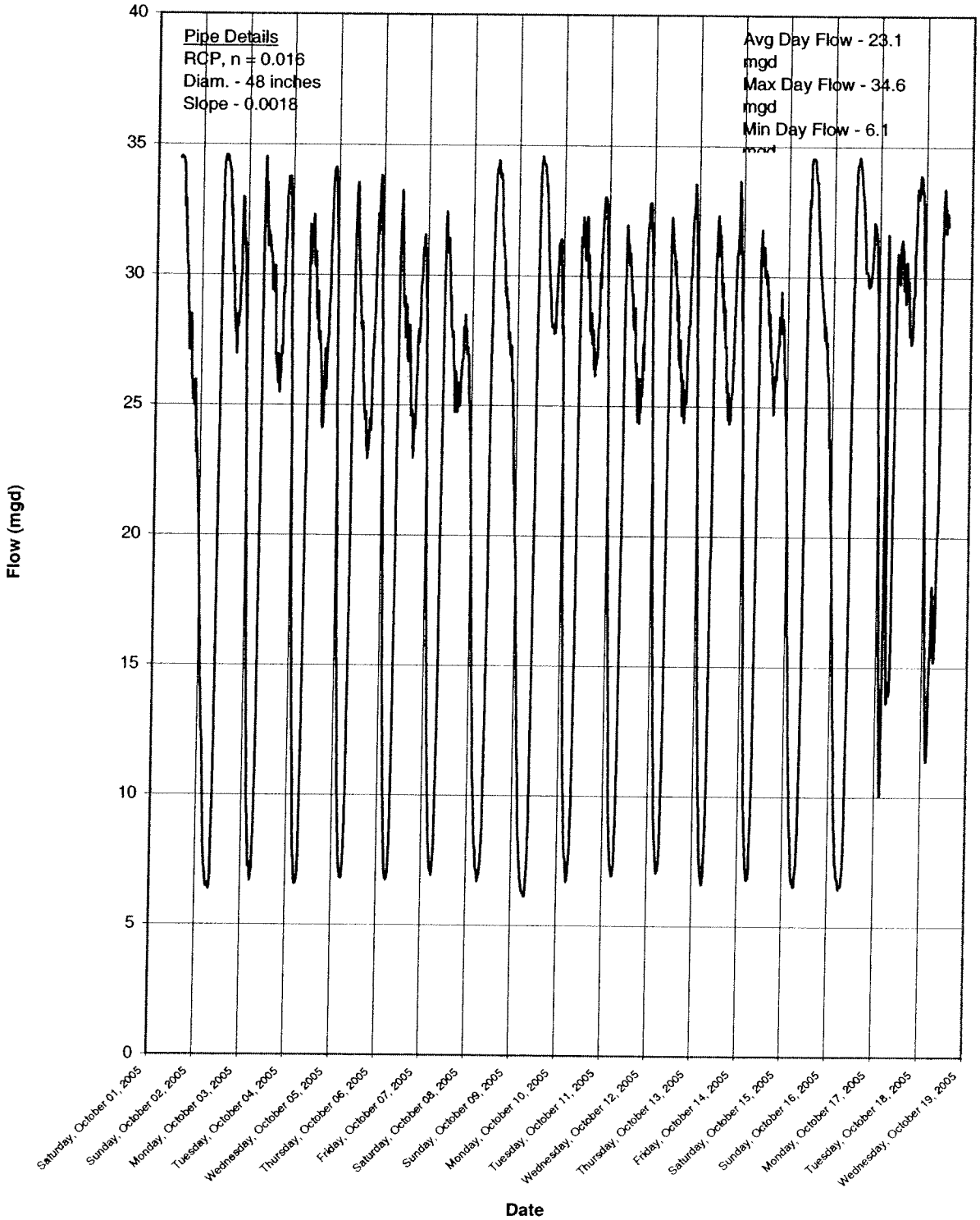


Figure 10

Flow at Meter 2 (Adjusted)

Meter Location - Hillside Ave. near Mountain View Ave. on a 24-inch Sewer

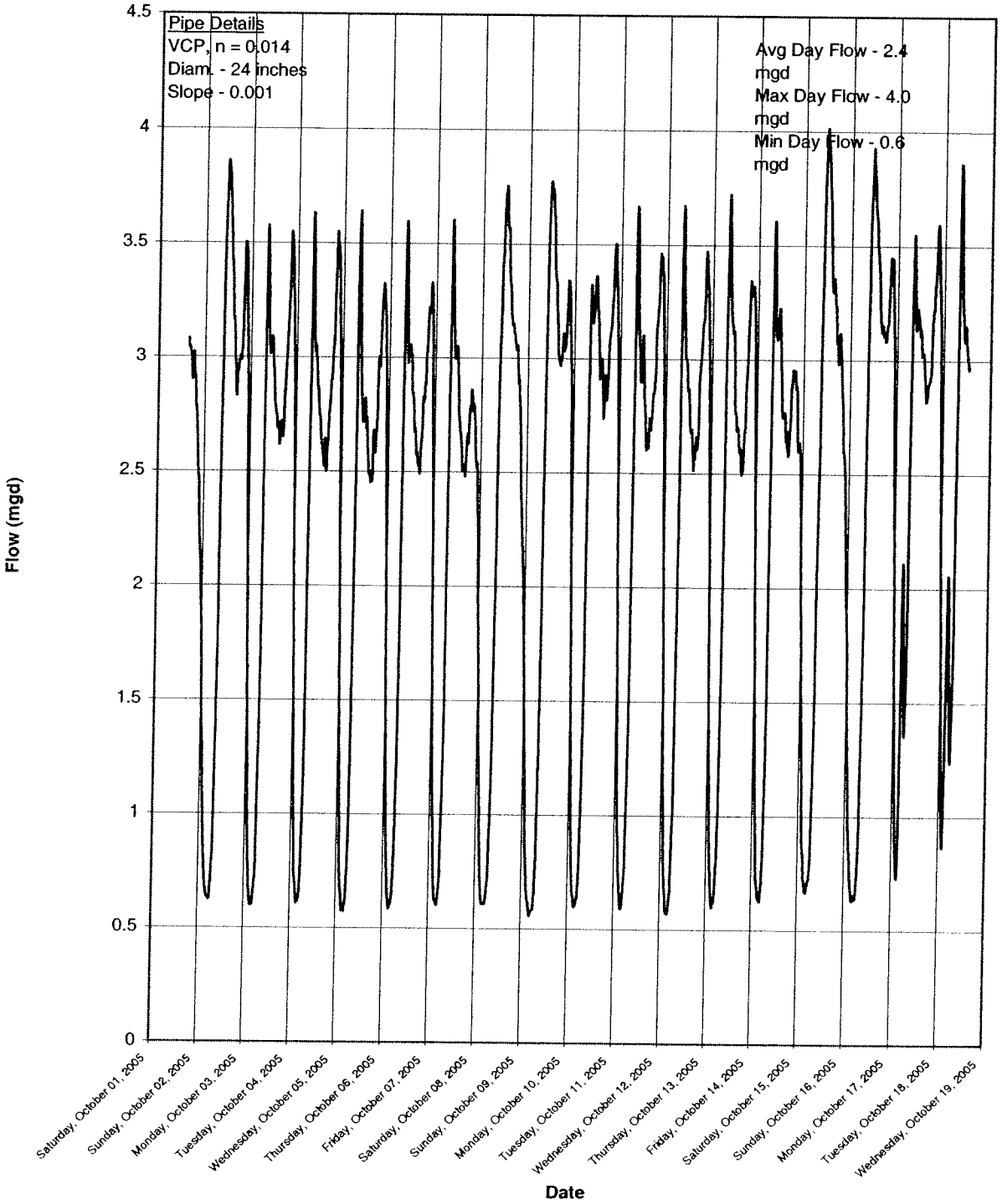


Figure 11

Flow at Meter 3 (Adjusted)

Meter Location - Arlington Ave. near Madison St. on a 21-inch Sewer

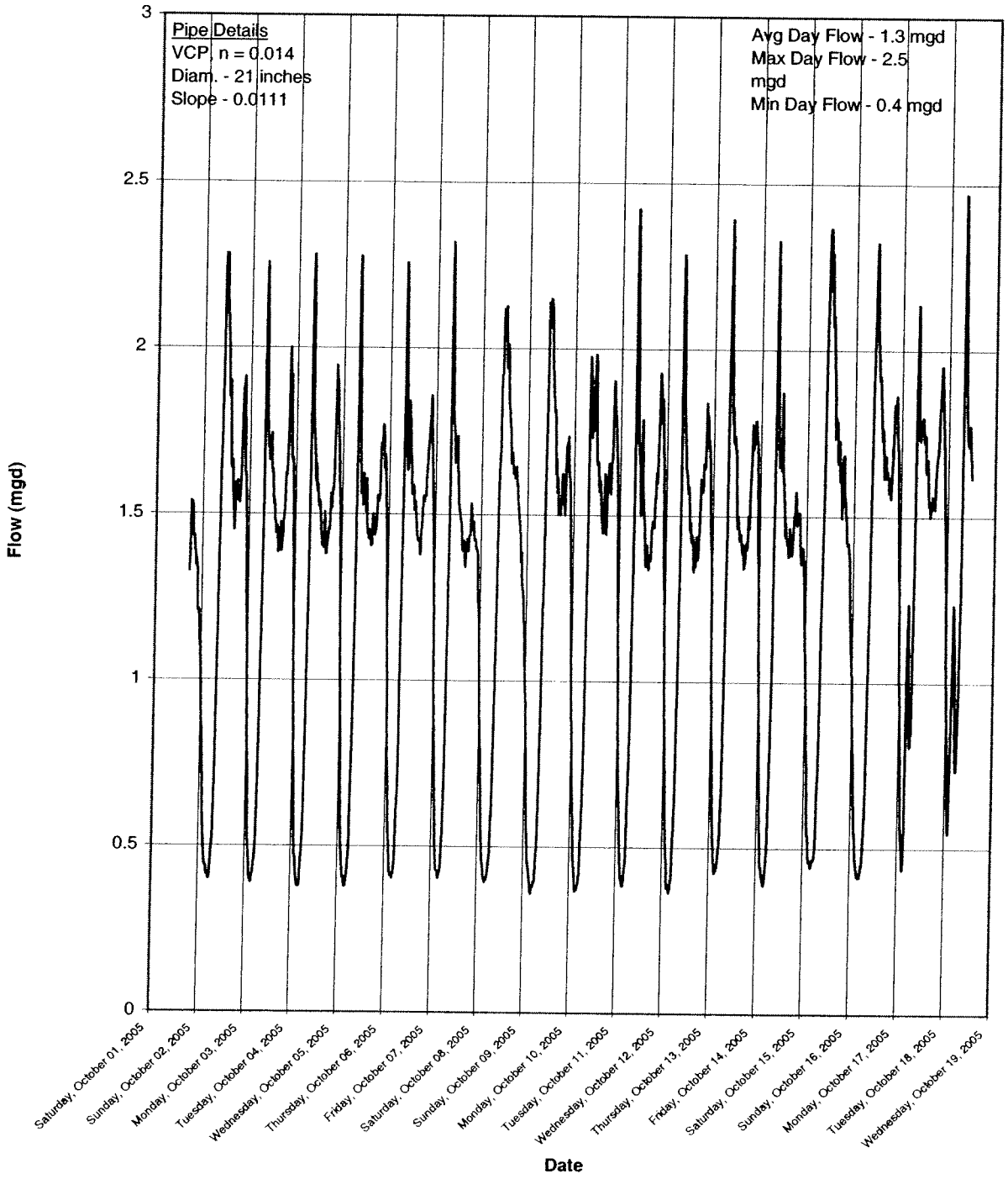


Figure 12

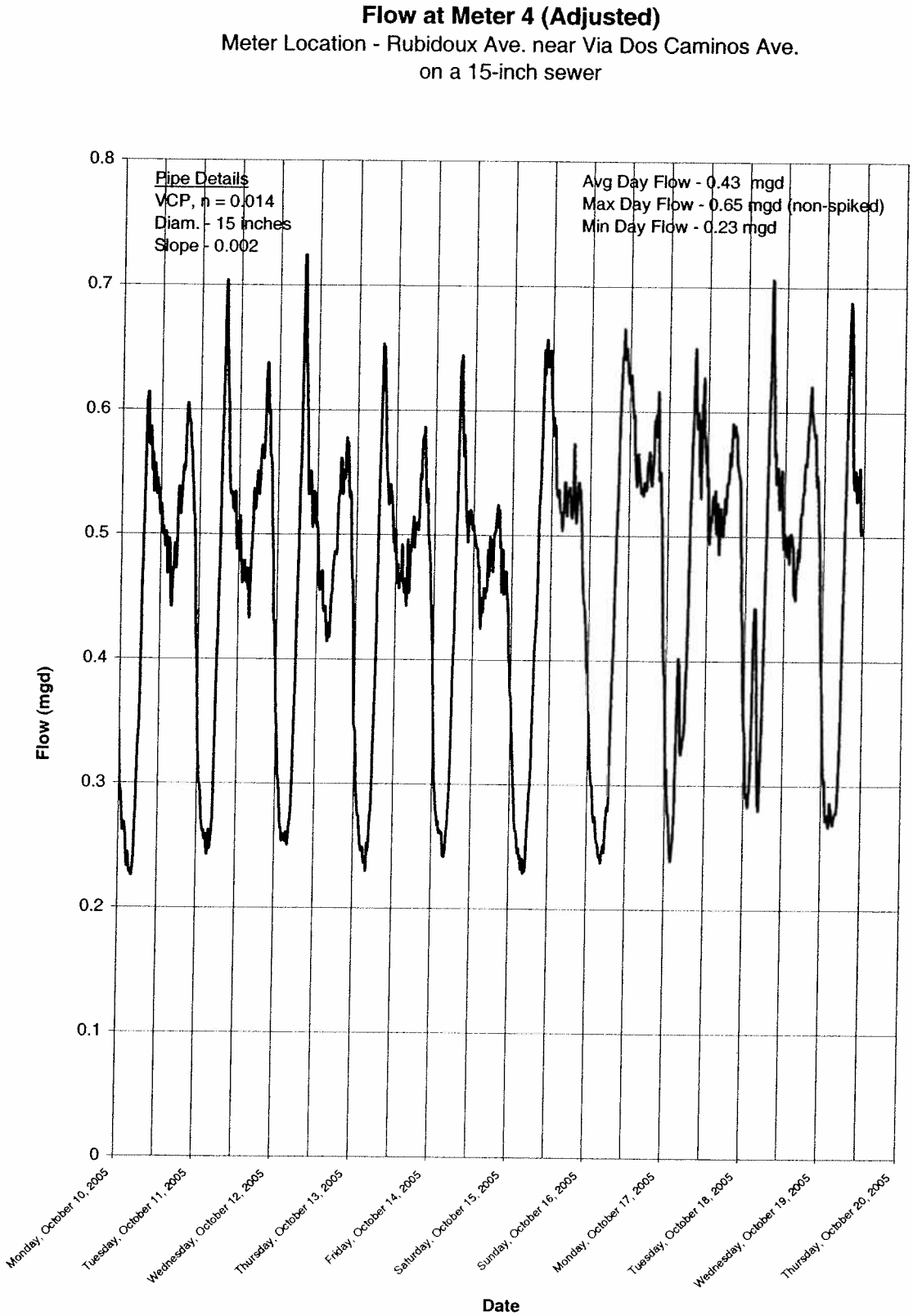

Flow at Meter 4 (Adjusted)
Meter Location - Rubidoux Ave. near Via Dos Caminos Ave.
on a 15-inch sewer
Pipe Details
VCP, n = 0.014
Diam. - 15 inches
Slope - 0.002
Avg Day Flow - 0.43 mgd
Max Day Flow - 0.65 mgd (non-spiked)
Min Day Flow - 0.23 mgd
Flow (mgd)
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
Monday, October 10, 2005
Tuesday, October 11, 2005
Wednesday, October 12, 2005
Thursday, October 13, 2005
Friday, October 14, 2005
Saturday, October 15, 2005
Sunday, October 16, 2005
Monday, October 17, 2005
Tuesday, October 18, 2005
Wednesday, October 19, 2005
Thursday, October 20, 2005
Date

Figure 13

Flow at Meter 5 (Adjusted)

Meter Location - Madison St. near Arlington Ave. on an 18-inch Sewer

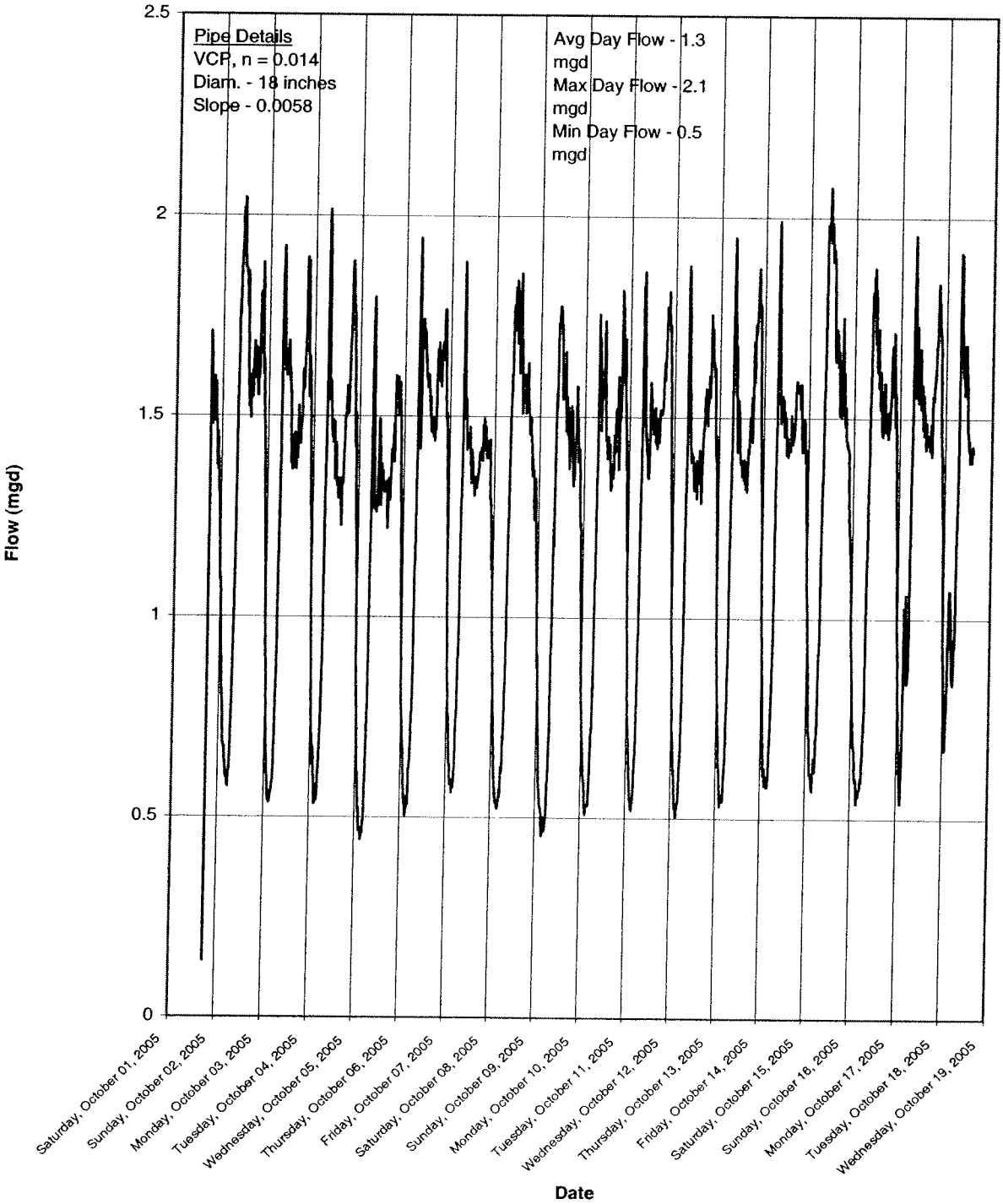


Figure 14

Representative Diurnal Pattern for Mixed Land Use
Meter Location - 1

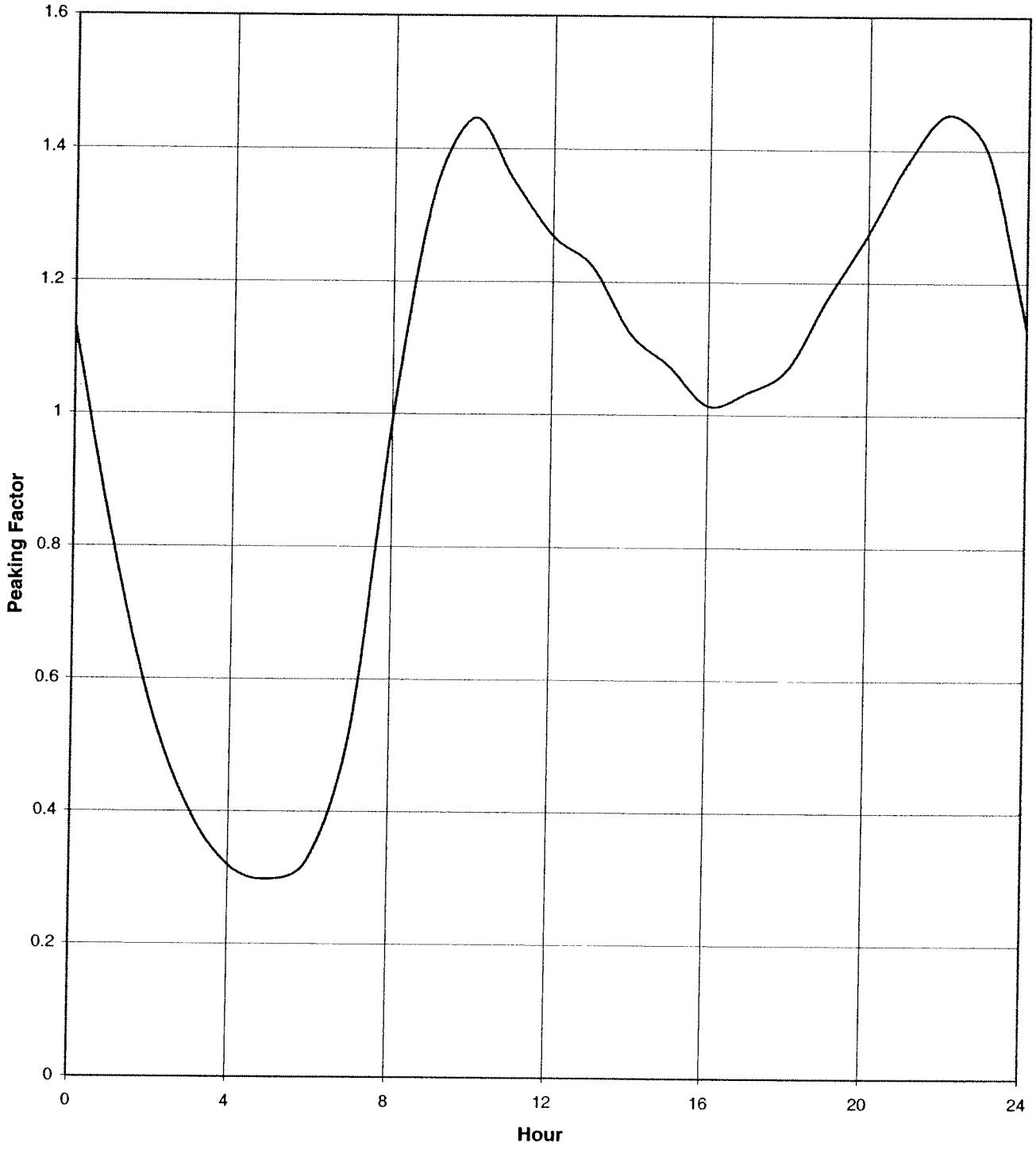


Figure 15

Representative Diurnal Pattern for Mixed Land Use
Wednesday Oct. 5, 2005
Meter Location - 2

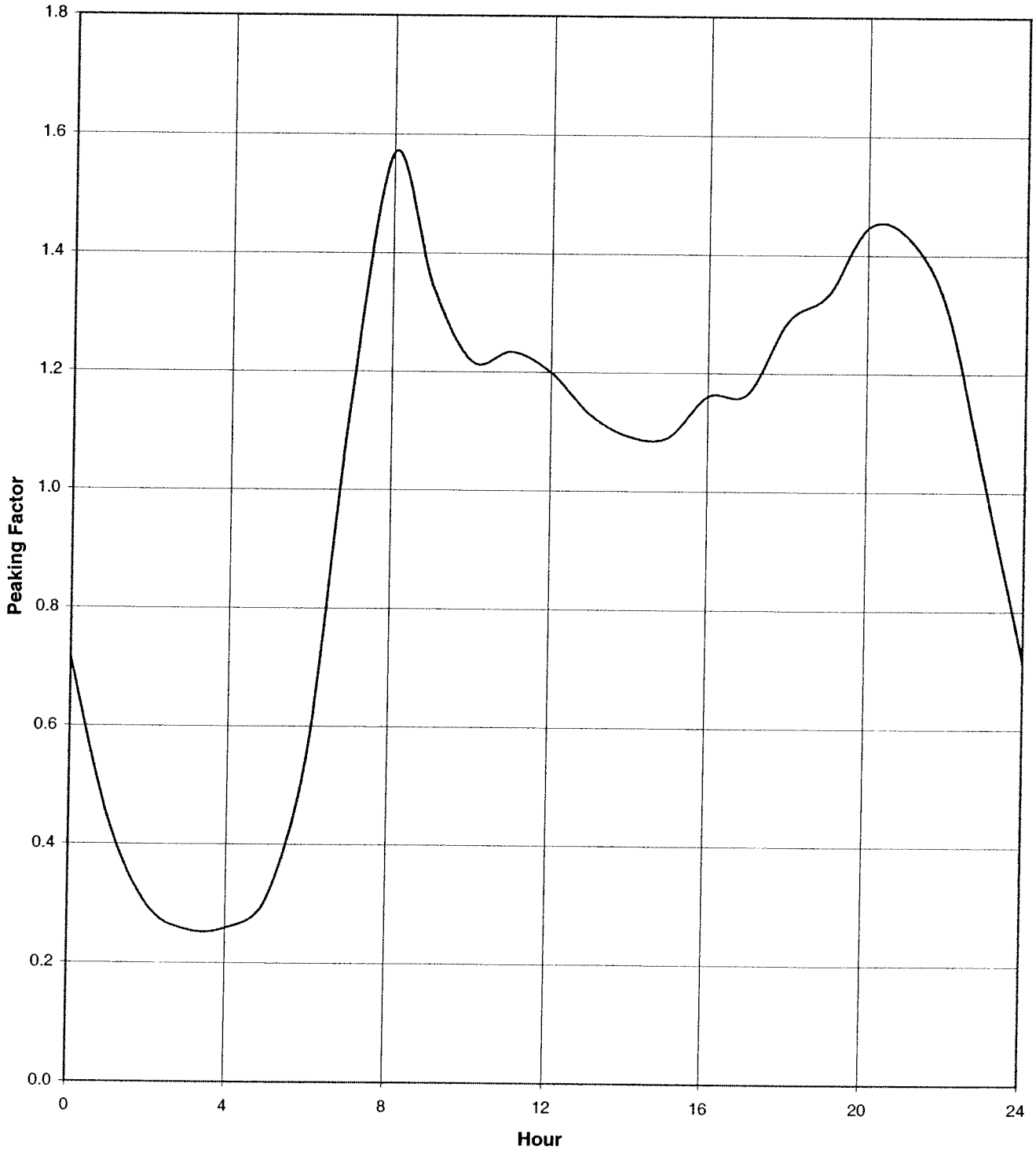


Figure 16

Representative Diurnal Pattern for Mixed Land Use
Wednesday Oct. 5, 2005
Meter Location - 3

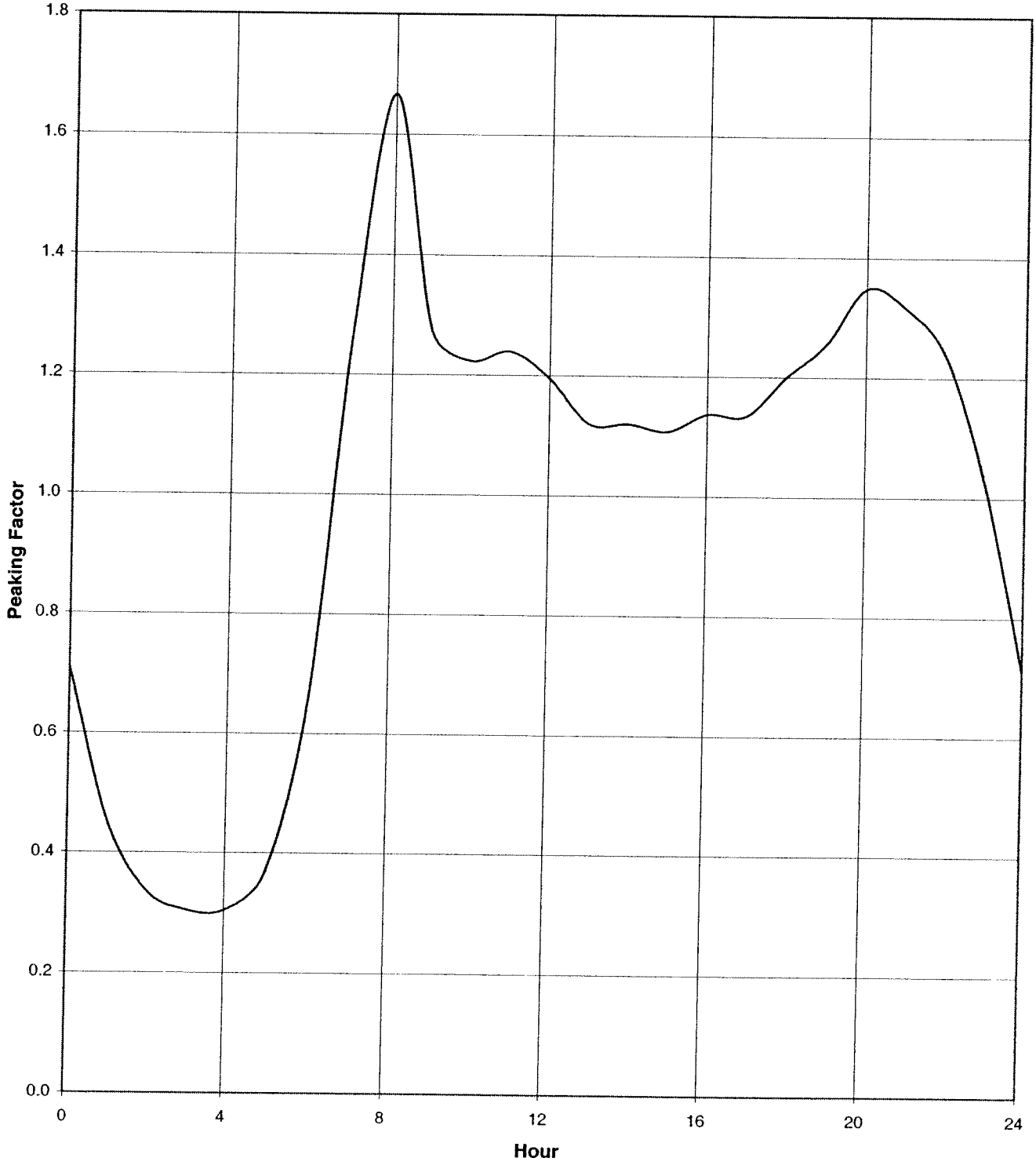


Figure 17

Representative Diurnal Pattern for Residential Land Use
Wednesday Oct. 5, 2005
Meter Location - 4

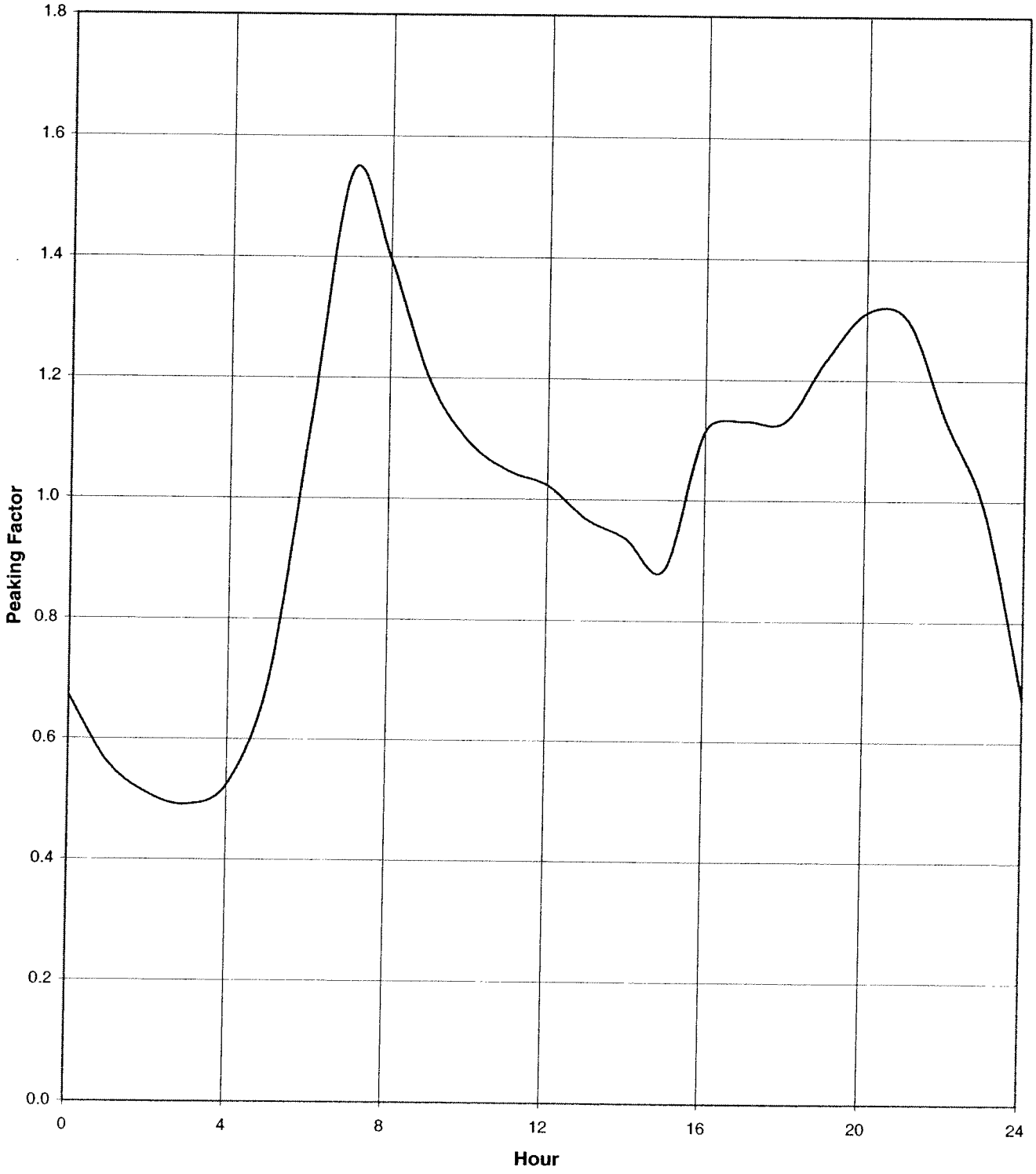
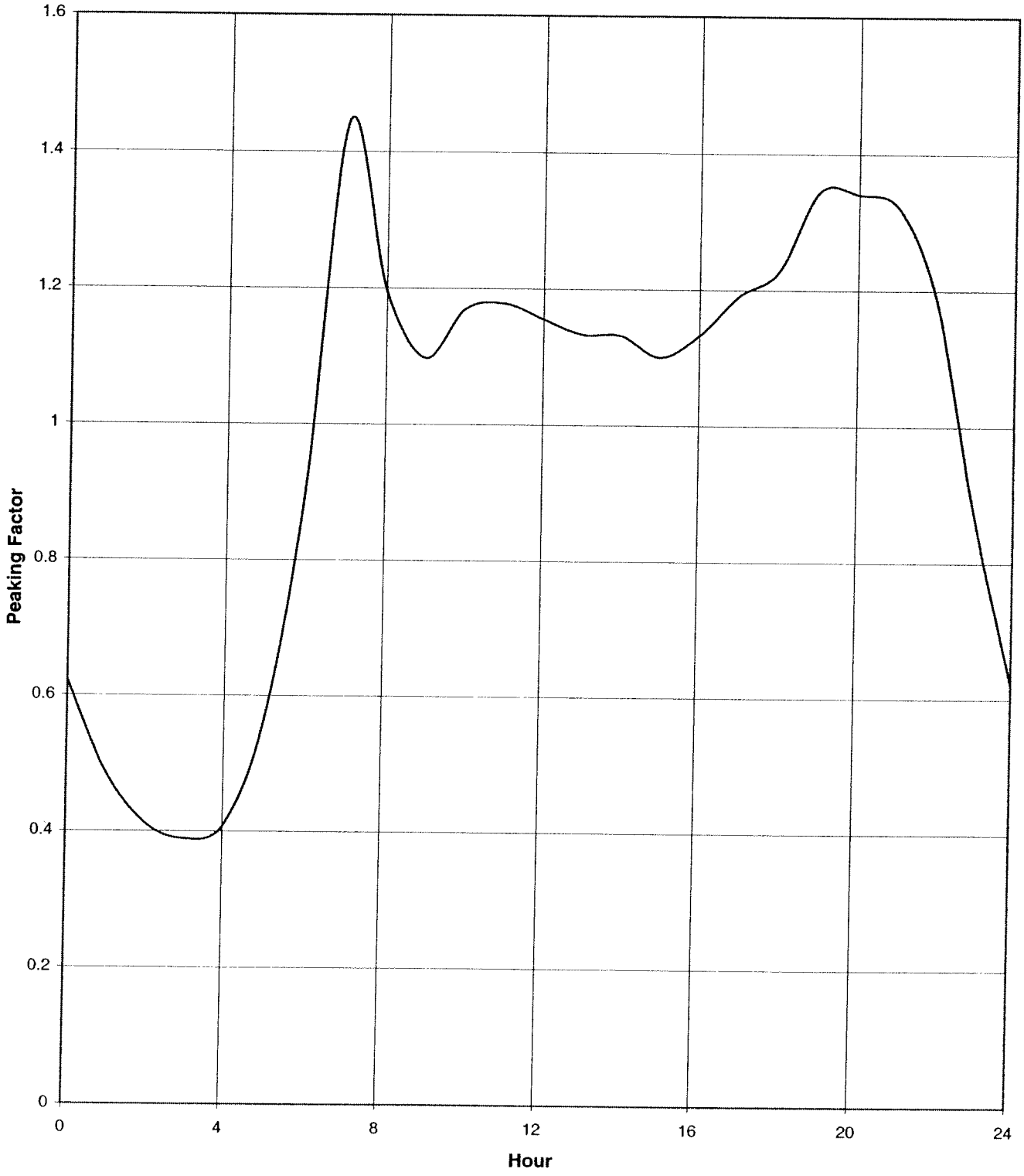


Figure 18

Representative Diurnal Pattern for Residential Land Use
Wednesday Oct. 5, 2005
Meter Location - 5



6.0 COMPUTER MODEL SIMULATION ANALYSIS

6.1 Methodology

Capacity analysis involved the evaluation of the available capacity in the existing collection system under present and future development conditions. Based on results of the analysis, phased facility improvements were identified to allow for projected growth within the service area.

This section describes the analytical methodology and hydraulic model development and summarizes the results of the analyses.

The principal tool utilized in the capacity analysis was a hydraulic model that simulates flow conditions using inflows and sewer system characteristic input data. With this input information, the model is able to compute and output depth of flow, rate of flow, and velocity of flow in selected pipes and manholes during different times of the day. The model selected for use in this study is XP-SWMM (XP Software, Version 9.12). This modeling software belongs to a class of software referred to as "dynamic wave models". These types of models are able to provide an accurate simulation of hydraulic flow conditions over an extended period of time.

Data required to create the model include information describing the physical wastewater collection system, such as pipe diameters and reach lengths, manhole invert elevations, and estimated pipe roughness coefficients. Additionally, data describing the sewage loading at selected manholes expressed as a varying flow rate over time (i.e. a diurnal curve), must be provided. Model output consists of a variety of hydraulic parameters, most importantly peak flow velocity and discharge rates.

Calibration of the model consisted of simulating existing sewer flow conditions and comparing the modeled flows with the recorded flows at the meter locations. The assumed diurnal curves that serve as input to the model were iteratively adjusted until the recorded and modeled hydrographs show reasonable agreement.

Simulations of future sewage flow conditions were performed by developing input data sets that included sewage generation projections for the assumed ultimate development conditions. Pipe reaches in which simulated peak flows exceeded a specified trigger criteria were identified as potential improvement reaches. Improvements required to provide adequate capacity for projected flows were then determined through an iterative modeling process. The process consists of simulating flow conditions after

increasing the diameter of downstream portions of the identified reaches. In subsequent iterations, additional lengths of pipe were increased in diameter until the projected peak flow could be conveyed through the reach without exceeding the specified design flow criteria.

6.2 Limitations of Modeling

The hydraulic model, which was utilized as the primary planning tool for the sewer capacity analysis, provides an accurate simulation of actual flow conditions within a sanitary sewer system in response to existing and future sewage loading. The accuracy of the simulation, however, is directly related to the accuracy of the model input data, including physical parameters and sewage loading projections. For example, in a case where roots had entered the pipeline, thereby causing a restriction of flow, the model would be unable to predict the reduction in flow through this obstruction. Consequently, a general understanding of the data sources is critical in interpreting the modeling results.

The physical parameters of the model, including the pipe diameter, slope, and roughness coefficients were based principally on City's GIS database information. Where this data appeared to be inaccurate, construction drawings were reviewed and the input data corrected.

Network connectivity refers to the flow path followed by sewage within the sewer system. The connectivity is a function of the relative slope of each sewer pipe and the relative invert elevations of the incoming and outgoing sewer pipes at manholes. For example, a manhole may have two or more sewer pipes, which could convey flow away from the manhole. If the invert (bottom) of one of these pipes is lower than the other, the downstream flow path at this manhole would follow the lower pipe.

Sewage loading projections were based on calibrated flow rates. As previously described, flow rates used for calibration were based on actual monitored flows at key points in the trunk system over a 2-week period in October 2005. This period included the two weekends.

Since a degree of uncertainty exists in both the physical data and the sewage loading projections used as model inputs, reaches identified by model simulations as near or at capacity should be subject to additional engineering evaluation prior to implementing improvements. Such evaluation may include field inspection, video monitoring and flow metering.

The results of model runs for existing and ultimate conditions are summarized in Table 7-1.

Table 7-1
Sewer Analysis Results (Existing and Future Conditions)

Name	Diameter, ft	Slope (%)	Theoretical "Full" Flow (cfs)	Existing Estimated Peak Flow (cfs)	Existing Estimated % Full	Future Estimated Peak Flow (cfs)	Future Estimated % Full
P001	4	0.2091	65.74	37.72	57.38%	54.24	82.50%
P002	2	0.2000	10.10	6.57	64.99%	10.06	99.56%
P003	2	0.2000	10.10	6.56	64.96%	10.05	99.48%
P004	2	0.2000	10.10	6.56	64.92%	10.04	99.42%
P005	3.75	0.1783	51.09	31.35	61.37%	44.38	86.88%
P006	2	0.2000	10.10	6.55	64.86%	10.03	99.29%
P007	2	0.2000	10.10	6.55	64.79%	10.02	99.15%
P008	2	0.2000	10.10	6.54	64.74%	10.00	99.03%
P010	3.75	0.1802	51.36	31.35	61.04%	44.38	86.42%
P011	2	0.2000	10.10	6.54	64.70%	9.99	98.91%
P012	2	0.2000	10.10	6.53	64.67%	9.98	98.82%
P013	2	0.2000	10.10	6.53	64.65%	9.98	98.78%
P014	2	0.2000	10.10	6.54	64.70%	9.97	98.67%
P015	3.75	0.1797	51.29	31.35	61.12%	44.39	86.53%
P016	2	0.2000	10.10	6.52	64.59%	9.95	98.52%
P017	3.75	0.1807	51.43	31.35	60.96%	44.39	86.30%
P018	2	0.2000	10.10	6.52	64.56%	9.94	98.36%
P019	2	0.2000	10.10	6.52	64.52%	9.92	98.20%
P020	2	0.2000	10.10	6.51	64.48%	9.90	98.04%
P021	3.75	0.1798	51.31	31.35	61.11%	44.39	86.52%
P022	2	0.2000	10.10	6.51	64.44%	9.91	98.07%
P023	2	0.2000	10.10	6.51	64.41%	9.94	98.35%
P024	3.75	0.2008	54.22	31.36	57.83%	44.40	81.89%
P025	2	0.2000	10.10	6.50	64.39%	9.95	98.47%
P026	2	0.2000	10.10	6.50	64.38%	9.95	98.52%
P027	2	0.2000	10.10	6.50	64.36%	9.96	98.59%
P028	2	0.2000	10.10	6.50	64.34%	9.97	98.67%
P029	2	0.2000	10.10	6.50	64.33%	9.97	98.73%
P030	3.75	0.1989	53.96	31.36	58.11%	44.41	82.29%
P031	2	0.2000	10.10	6.50	64.32%	9.98	98.76%
P032	2.5	0.2000	18.33	6.49	35.44%	9.99	54.48%
P033	3.75	0.2157	56.20	30.40	54.10%	43.00	76.52%
P034	2	0.2000	10.10	6.49	64.28%	9.99	98.91%
P035	2	0.2000	10.10	6.49	64.27%	9.99	98.91%
P036	2	0.2000	10.10	6.49	64.25%	9.99	98.91%
P037	3.75	0.2065	54.98	30.40	55.30%	43.01	78.22%
P038	2	0.2000	10.10	6.49	64.23%	9.99	98.92%
P039	3.75	0.1815	51.55	30.40	58.98%	43.01	83.43%
P040	2	0.2000	10.10	6.49	64.22%	9.99	98.92%
P041	3.75	0.1768	50.88	30.40	59.76%	43.01	84.54%
P042	2	0.2000	10.10	6.49	64.20%	9.99	98.92%
P043	2	0.2000	10.10	6.48	64.19%	9.99	98.92%
P045	3.75	0.2617	61.90	30.41	49.12%	43.01	69.49%
P046	2	0.2000	10.10	6.48	64.18%	9.99	98.92%
P047	2	0.2000	10.10	6.48	64.18%	9.99	98.93%
P048	2	0.2000	10.10	6.32	62.53%	9.83	97.27%
P049	2	0.2000	10.10	6.32	62.52%	9.83	97.27%
P050	2	0.2000	10.10	6.32	62.52%	9.83	97.27%
P051	2	0.2000	10.10	6.32	62.52%	9.83	97.27%
P052	3.25	0.2004	36.96	21.80	58.98%	31.39	84.92%
P053	2	0.2000	10.10	6.31	62.51%	9.83	97.27%
P054	2	0.2000	10.10	6.31	62.51%	9.83	97.28%
P055	2	0.2000	10.10	6.31	62.51%	9.83	97.35%
P056	2	0.2000	10.10	6.31	62.51%	9.84	97.38%
P057	2	0.2000	10.10	6.31	62.51%	9.85	97.54%
P058	3.25	0.2000	36.92	21.80	59.04%	31.38	84.99%
P059	2	0.2000	10.10	6.31	62.51%	9.91	98.08%
P061	3.25	0.2031	37.21	21.80	58.59%	31.38	84.33%
P062	2	0.2000	10.10	6.15	60.85%	9.82	97.25%

Table 7-1
Sewer Analysis Results (Existing and Future Conditions)

Name	Diameter, ft	Slope (%)	Theoretical "Full" Flow (cfs)	Existing Estimated Peak Flow (cfs)	Existing Estimated % Full	Future Estimated Peak Flow (cfs)	Future Estimated % Full
P063	2	0.2000	10.10	6.15	60.85%	9.87	97.74%
P064	2	0.2000	10.10	6.15	60.85%	9.92	98.18%
P065	2	0.2000	10.10	6.15	60.85%	9.95	98.54%
P066	3.25	0.2000	36.93	21.80	59.04%	31.38	84.98%
P067	2	0.2000	10.10	6.15	60.85%	9.97	98.73%
P068	2	0.2000	10.10	6.15	60.85%	10.01	99.05%
P069	2	0.2000	10.10	6.15	60.85%	10.04	99.44%
P070	3.25	0.2000	36.93	21.80	59.04%	31.38	84.98%
P071	2	0.2000	10.10	6.15	60.85%	10.08	99.76%
P072	2	0.2000	10.10	6.15	60.85%	10.09	99.88%
P073	2	0.2000	10.10	5.47	54.15%	9.35	92.55%
P074	3.25	0.1800	35.03	21.80	62.24%	31.38	89.58%
P075	2	0.2000	10.10	5.47	54.15%	9.38	92.86%
P076	2	0.2000	10.10	5.47	54.15%	9.39	92.97%
P077	1.25	0.6000	4.99	4.80	96.15%	6.96	139.59%
P078	2	0.2000	10.10	9.08	89.92%	12.45	123.27%
P079	2	0.2000	10.10	9.08	89.92%	12.46	123.39%
P080	2	0.2000	10.10	9.08	89.92%	12.46	123.39%
P081	2	0.2000	10.10	9.08	89.93%	12.47	123.40%
P082	3	0.2007	29.88	17.06	57.09%	26.98	90.31%
P088	0.833	56.9574	16.44	0.97	5.88%	1.42	8.63%
P089	0.833	16.6048	8.88	0.97	10.89%	1.42	15.98%
P090	1.25	1.2988	7.34	0.97	13.18%	1.42	19.33%
P091	1	1.5014	4.35	0.48	11.13%	0.71	16.31%
P092	1	1.3003	4.05	0.48	11.96%	0.71	17.53%
P093	1	0.1648	1.44	0.48	33.59%	0.71	49.25%
P094	1	1.1055	3.73	0.48	12.99%	0.71	19.05%
P095	2	10.6318	73.65	8.74	11.87%	11.66	15.83%
P096	2	8.5441	66.02	8.63	13.08%	11.45	17.34%
P097	2	5.8621	54.69	8.63	15.79%	11.45	20.93%
P098	2	1.8548	30.76	8.63	28.07%	11.45	37.21%
P099	2	1.8576	30.78	8.63	28.05%	11.45	37.18%
P100	2.25	0.1405	11.59	8.63	74.47%	11.45	98.73%
P101	2	0.0899	6.77	6.13	90.59%	8.83	130.42%
P102	2.25	0.0832	8.92	2.61	29.29%	2.78	31.15%
P103	2.25	0.0808	8.79	2.61	29.70%	2.78	31.59%
P104	2	0.0875	6.68	6.13	91.81%	8.83	132.17%
P105	2.25	0.0767	8.57	2.61	30.44%	2.77	32.37%
P106	2	0.0869	6.66	6.13	92.13%	8.83	132.63%
P107	2.25	0.0755	8.50	2.61	30.65%	2.77	32.58%
P108	2	0.0878	6.69	6.13	91.67%	8.83	131.97%
P109	2	0.0896	6.76	6.14	90.73%	8.83	130.61%
P110	2.25	0.0831	8.92	2.60	29.21%	2.77	31.03%
P111	2	0.0781	6.31	6.14	97.18%	8.83	139.90%
P112	2	0.0905	6.79	6.14	90.31%	8.83	130.01%
P113	2.25	0.0872	9.14	2.60	28.51%	2.77	30.28%
P114	2	0.0895	6.76	6.14	90.81%	8.83	130.73%
P115	2	0.0867	6.65	6.14	92.28%	8.83	132.83%
P116	2	0.0828	6.50	6.14	94.43%	8.83	135.93%
P117	2.25	0.0968	9.63	2.60	27.06%	2.77	28.74%
P118	2.25	0.1234	10.87	2.60	23.97%	2.77	25.46%
P119	2.25	0.0787	8.68	2.61	30.01%	2.77	31.88%
P120	2	0.0875	6.68	6.14	91.83%	8.83	132.19%
P121A	2	0.0875	6.68	6.14	91.84%	8.83	132.19%
P121B	2	0.0875	6.68	6.14	91.87%	8.83	132.22%
P122	2.25	0.0809	8.80	2.61	29.61%	2.77	31.45%
P123	2	0.0983	7.08	6.14	86.68%	8.83	124.73%
P124	2.25	0.0801	8.75	2.61	29.77%	2.77	31.62%
P125	2	0.0341	4.17	6.02	144.33%	8.61	206.33%

Table 7-1
Sewer Analysis Results (Existing and Future Conditions)

Name	Diameter, ft	Slope (%)	Theoretical "Full" Flow (cfs)	Existing Estimated Peak Flow (cfs)	Existing Estimated % Full	Future Estimated Peak Flow (cfs)	Future Estimated % Full
P127	2	1.3391	26.14	2.61	9.97%	2.77	10.59%
P128	2.25	0.2059	14.04	6.02	42.92%	8.61	61.35%
P130	2.25	0.2059	14.04	6.02	42.92%	8.61	61.35%
P131	2.25	0.1042	9.98	5.75	57.57%	6.78	67.92%
P132	2.25	0.0812	8.81	5.75	65.24%	6.84	77.57%
P133	1.75	0.1109	5.27	0.25	4.67%	2.86	54.26%
P134	2.25	0.0800	8.75	5.75	65.76%	6.99	79.90%
P135	1.75	0.1122	5.30	0.20	3.81%	2.86	53.95%
P136	2.25	0.0794	8.72	5.76	66.05%	7.15	82.06%
P137	1.75	0.1131	5.32	0.19	3.57%	2.86	53.76%
P138	1.75	0.1717	6.55	0.10	1.49%	2.76	42.17%
P139	2.25	0.0805	8.78	5.76	65.62%	7.28	82.94%
P140	1.75	0.0708	4.21	0.10	2.43%	2.76	65.67%
P141	2.25	0.0799	8.74	5.76	65.91%	7.38	84.43%
P142	1.75	0.0490	3.50	0.10	2.96%	2.76	78.98%
P143	2.25	0.0769	8.58	5.76	67.18%	7.44	86.71%
P144	1.75	0.0562	3.75	0.10	2.77%	2.76	73.69%
P145	2.25	0.0787	8.68	5.67	65.29%	7.37	84.86%
P146	1.75	0.2917	8.54	0.11	1.23%	2.76	32.36%
P147	2.25	0.0829	8.91	5.67	63.64%	7.42	83.28%
P148	1.25	4.9180	14.28	0.00	0.00%	2.67	18.68%
P149	2.25	0.1250	10.94	5.67	51.83%	8.36	76.45%
P150	1.25	0.2000	5.76	5.67	98.42%	8.36	145.22%
P152	1.75	0.8107	14.24	5.35	37.59%	8.03	56.39%
P153	1	0.2331	1.71	0.84	49.20%	0.89	51.94%
P154	1	0.3053	1.96	0.85	43.10%	0.89	45.56%
P155	1	0.2076	1.62	0.85	52.37%	0.90	55.38%
P156	1	0.5980	2.74	0.68	24.63%	0.71	25.97%
P157	1	0.6052	2.76	0.68	24.51%	0.71	25.85%
P158	1	0.5994	2.75	0.68	24.68%	0.72	26.02%
P159	1.75	0.3860	9.82	4.57	46.54%	7.15	72.75%
P160	1	0.1855	1.53	0.17	11.20%	0.33	21.74%
P161	1	0.2342	1.72	0.17	9.99%	0.29	16.62%
P162	1	0.1333	1.30	0.17	13.24%	0.25	19.25%
P163	1	0.1046	1.15	0.17	14.95%	0.23	19.69%
P164	1	0.2008	1.59	0.17	10.83%	0.18	11.59%
P165	1.75	0.3885	9.86	4.57	46.39%	7.17	72.74%
P166	1.75	0.4546	10.66	4.57	42.89%	7.17	67.26%
P167	1.75	1.1248	16.77	4.57	27.26%	7.17	42.76%
P168	1.75	1.1214	16.75	4.57	27.31%	7.17	42.83%
P169	1.75	1.0464	16.18	4.57	28.27%	7.17	44.33%
P170	1.75	1.1061	16.63	4.57	27.49%	7.17	43.12%
P171	1.75	1.2083	17.38	4.57	26.30%	7.17	41.26%
P172	1.75	1.3000	18.03	3.67	20.36%	5.63	31.21%
P173	1.25	1.0715	6.67	1.02	15.32%	1.80	26.99%
P174	1.25	1.0562	6.62	1.02	15.43%	1.80	27.19%
P175	1	1.1102	3.74	0.03	0.71%	0.05	1.24%
P176	1.5	0.5341	7.66	3.65	47.60%	5.59	72.94%
P177	1.5	0.5791	7.97	3.65	45.72%	5.59	70.05%
P178	1.5	0.5440	7.73	3.65	47.17%	5.59	72.28%
P179	1.5	0.3000	5.74	3.65	63.52%	5.59	97.33%
P180	1.5	0.3000	5.74	3.65	63.52%	5.59	97.33%
P181	1.5	0.3000	5.74	3.65	63.52%	5.59	97.33%
P182	1.25	0.7500	5.58	3.39	60.75%	5.25	94.19%
P183	1.25	1.0177	6.50	3.39	52.15%	5.25	80.86%
P184	1.25	1.0287	6.53	3.39	51.87%	5.25	80.42%
P185	1.25	1.0015	6.44	3.39	52.57%	5.25	81.51%
P186	1.25	2.0345	9.19	3.39	36.88%	5.25	57.19%
P187	1.25	1.6953	8.38	3.39	40.41%	5.25	62.65%

Table 7-1
Sewer Analysis Results (Existing and Future Conditions)

Name	Diameter, ft	Slope (%)	Theoretical "Full" Flow (cfs)	Existing Estimated Peak Flow (cfs)	Existing Estimated % Full	Future Estimated Peak Flow (cfs)	Future Estimated % Full
P188	1.25	1.2000	7.05	3.13	44.37%	4.92	69.73%
P189	1.25	1.8500	8.76	3.13	35.74%	4.92	56.16%
P190	1.25	1.8400	8.74	3.13	35.84%	4.92	56.31%
P191	1.25	0.3000	3.53	2.61	73.95%	4.14	117.45%
P192	1.25	0.3000	3.53	2.61	73.96%	4.14	117.46%
P193	1.25	0.3000	3.53	2.61	73.97%	4.14	117.47%
P194	1.25	1.0500	6.60	0.55	8.37%	0.82	12.44%
P195	1.25	1.3823	7.57	2.10	27.68%	3.38	44.69%
P196	1	1.9461	4.95	0.56	11.37%	0.84	16.99%
P197	1.25	1.0000	6.44	2.10	32.55%	3.38	52.51%
P198	1.25	1.0000	6.44	2.10	32.55%	3.38	52.52%
P199	1.25	4.7615	14.05	2.10	14.92%	3.38	24.07%
P200	1.25	1.0000	6.44	2.10	32.55%	3.38	52.51%
P201	1.25	2.0269	9.17	2.10	22.86%	3.38	36.89%
P202	1.25	1.0427	6.58	2.10	31.88%	3.38	51.43%
P203	1.25	1.6485	8.27	2.10	25.35%	3.38	40.91%
P204	1.5	0.2735	5.48	2.10	38.25%	3.38	61.72%
P205	1.5	0.2907	5.65	2.10	37.12%	3.38	59.89%
P206	1.5	0.2994	5.73	2.10	36.57%	3.38	59.01%
P207	2	0.2948	12.26	2.10	17.10%	3.38	27.59%
P208	1.5	1.1561	11.27	2.10	18.61%	3.38	30.04%
P209	1.5	1.1681	11.32	2.10	18.52%	3.38	29.88%
P210	1.5	1.1335	11.16	2.10	18.80%	3.38	30.34%
P211	1.5	1.1319	11.15	2.10	18.81%	3.38	30.36%
P212	1.5	1.1850	11.41	1.57	13.75%	2.60	22.78%
P213	1.5	1.1034	11.01	1.57	14.26%	2.60	23.62%
P214	1.5	1.1079	11.03	1.05	9.50%	1.83	16.56%
P215	1.5	1.1303	11.14	1.05	9.41%	1.83	16.39%
P216	1.25	2.1316	9.40	0.70	7.49%	1.35	14.41%
P217	1.25	2.1378	9.42	0.70	7.48%	1.35	14.39%
P218	1.25	1.9678	9.03	0.70	7.80%	1.35	15.00%
P219	1.25	2.5655	10.31	0.70	6.83%	1.36	13.14%
P220	1.25	2.7290	10.64	0.70	6.62%	1.36	12.74%
P221	1.25	1.4120	7.65	0.70	9.20%	1.36	17.71%
P222	1.25	1.5358	7.98	0.70	8.83%	1.36	16.99%
P223	1	4.7241	7.71	0.70	9.14%	1.36	17.58%
P224	1	2.6813	5.81	0.70	12.13%	1.36	23.34%
P225	1	2.3703	5.46	0.70	12.90%	1.36	24.83%
P226	1	2.1922	5.25	0.35	6.73%	0.49	9.37%
P227	1	2.6774	5.81	0.37	6.40%	0.89	15.33%
P228	1	2.3400	5.43	0.37	6.85%	0.89	16.40%
P229	1	1.2178	3.92	0.37	9.49%	0.89	22.74%
P230	1	0.2028	1.60	0.37	23.29%	0.89	55.77%
P231	1	0.2226	1.67	0.38	22.42%	0.90	53.61%
P232	1	1.2913	4.03	0.38	9.30%	0.90	22.24%
P233	1	6.7719	9.24	0.38	4.06%	0.90	9.71%
P234	1	2.5597	5.68	0.38	6.60%	0.90	15.80%
P235	1	2.6842	5.81	0.38	6.45%	0.90	15.43%
P236	1	2.6857	5.82	0.38	6.45%	0.90	15.42%
P237	1.25	0.2867	3.45	0.38	10.88%	0.90	26.02%
P238	1.25	0.2927	3.48	0.38	10.81%	0.90	25.95%
P239	1.25	0.2663	3.32	0.03	0.82%	0.41	12.43%
P240	1.25	0.2717	3.36	0.03	0.81%	0.41	12.31%
P241	1.25	0.2701	3.35	0.03	0.82%	0.03	1.03%
P242	1.25	3.4186	11.91	0.02	0.18%	0.02	0.18%
P243	1.25	1.5317	7.97	0.02	0.26%	0.02	0.27%
P244	1.25	1.5432	8.00	0.02	0.26%	0.02	0.26%
P245	1.25	1.0004	6.44	0.02	0.33%	0.02	0.33%
P246	1.25	0.3994	4.07	0.02	0.52%	0.02	0.52%

Table 7-1
Sewer Analysis Results (Existing and Future Conditions)

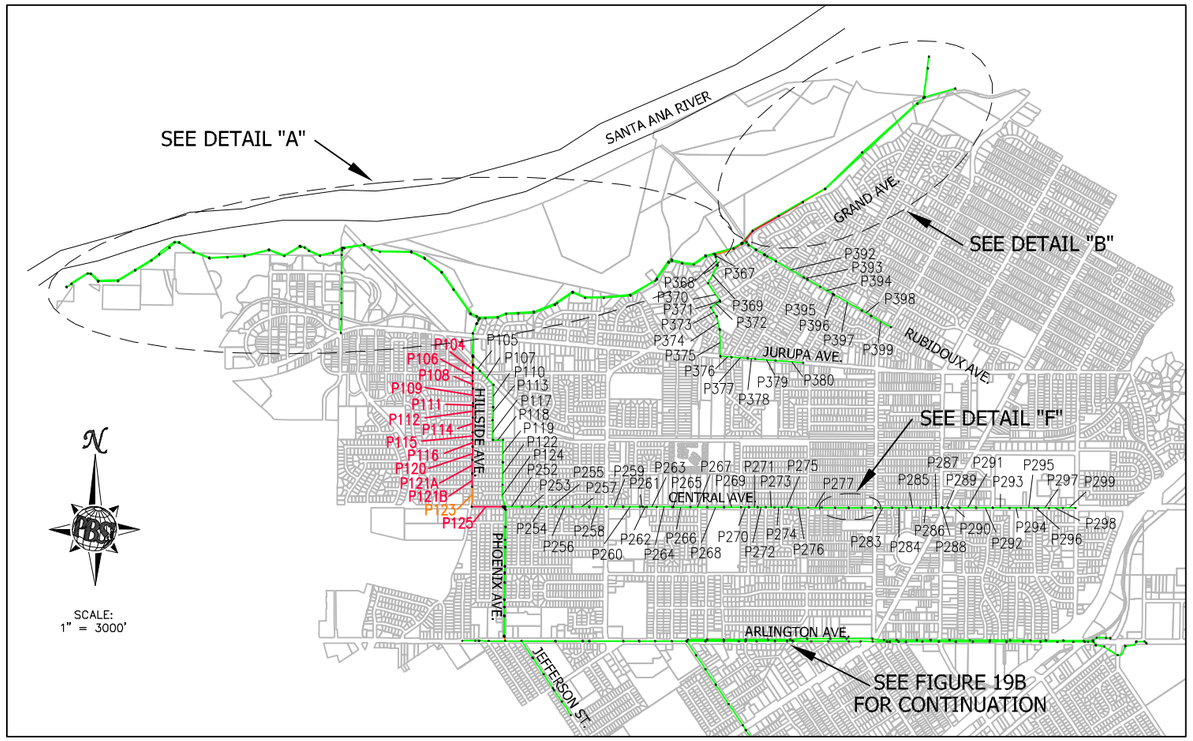
Name	Diameter, ft	Slope (%)	Theoretical "Full" Flow (cfs)	Existing Estimated Peak Flow (cfs)	Existing Estimated % Full	Future Estimated Peak Flow (cfs)	Future Estimated % Full
P247	1.25	0.3909	4.03	0.02	0.53%	0.02	0.53%
P248	1.25	0.3984	4.06	0.02	0.52%	0.02	0.53%
P249	1.25	0.4007	4.08	0.02	0.52%	0.02	0.52%
P250	1.25	0.4025	4.09	0.02	0.52%	0.02	0.52%
P251	1.25	0.3992	4.07	0.02	0.54%	0.02	0.54%
P252	1.25	1.3692	7.54	2.09	27.77%	2.23	29.65%
P253	1.25	1.3723	7.54	2.09	27.74%	2.23	29.62%
P254	1.25	0.3484	3.80	2.09	55.06%	2.23	58.79%
P255	1.25	0.3117	3.60	2.09	58.21%	2.23	62.16%
P256	1.25	0.3130	3.60	2.09	58.09%	2.23	62.03%
P257	1.25	0.3130	3.60	2.09	58.10%	2.23	62.03%
P258	1.25	0.3196	3.64	2.09	57.49%	2.23	61.39%
P259	1.25	0.2525	3.24	2.09	64.69%	2.24	69.07%
P260	1.25	0.2555	3.26	2.09	64.31%	2.24	68.67%
P261	1.25	0.2582	3.27	2.09	63.98%	2.24	68.31%
P262	1.25	0.2929	3.49	2.09	60.07%	2.24	64.13%
P263	1.25	0.4000	4.07	2.09	51.40%	2.24	54.88%
P264	1.25	0.3118	3.60	2.09	58.22%	2.24	62.17%
P265	1.25	1.3710	7.54	2.09	27.77%	2.24	29.65%
P266	1.25	0.5554	4.80	2.09	43.62%	2.24	46.58%
P267	1.25	1.0991	6.75	2.09	31.01%	2.24	33.11%
P268	1.25	1.1004	6.76	2.09	30.99%	2.24	33.09%
P269	1.25	0.7877	5.72	2.09	36.63%	2.24	39.11%
P270	1.25	0.8077	5.79	1.57	27.20%	1.70	29.29%
P271	1.25	0.7701	5.65	1.57	27.85%	1.70	30.00%
P272	1.25	0.4240	4.19	1.57	37.54%	1.70	40.43%
P273	1.25	0.5345	4.71	1.57	33.43%	1.70	36.01%
P274	1.25	0.3973	4.06	1.57	38.78%	1.70	41.77%
P275	1.25	0.5468	4.76	1.57	33.05%	1.70	35.60%
P276	1.25	0.4717	4.42	1.57	35.59%	1.70	38.33%
P277	1.25	0.7063	5.41	1.57	29.09%	1.70	31.33%
P278	1	0.3999	2.24	0.52	23.39%	0.57	25.28%
P279	1	0.3888	2.21	0.53	23.73%	0.57	25.64%
P280	1	1.1499	3.81	0.53	13.80%	0.57	14.91%
P281	1	1.5078	4.36	0.53	12.05%	0.57	13.02%
P282	1	0.4167	2.29	0.53	22.92%	0.57	24.77%
P283	1	0.4194	2.30	1.57	68.50%	1.70	73.78%
P284	1	0.4289	2.32	1.57	67.74%	1.70	72.96%
P285	1	0.4254	2.31	1.57	68.02%	1.70	73.26%
P286	1	0.4108	2.27	1.57	69.22%	1.70	74.56%
P287	1	0.3810	2.19	1.05	47.96%	1.15	52.56%
P288	1	0.9565	3.47	1.05	30.26%	1.15	33.17%
P289	1	0.3259	2.03	1.05	51.85%	1.15	56.82%
P290	1	0.4665	2.42	0.75	30.73%	0.85	34.89%
P291	1	0.4167	2.29	0.75	32.53%	0.85	36.93%
P292	1	0.4128	2.28	0.75	32.68%	0.85	37.11%
P293	1	0.4214	2.30	0.75	32.35%	0.85	36.73%
P294	1	0.4189	2.30	0.75	32.45%	0.85	36.85%
P295	1	0.4322	2.33	0.75	31.95%	0.85	36.27%
P296	1	0.4028	2.25	0.44	19.46%	0.54	23.94%
P297	1	0.4026	2.25	0.44	19.47%	0.54	23.95%
P298	1	0.4162	2.29	0.44	19.16%	0.54	23.56%
P299	1	0.3692	2.16	0.44	20.35%	0.54	25.03%
P300	1	1.1299	3.77	0.03	0.74%	0.05	1.25%
P301	1.25	0.8781	6.03	1.02	16.93%	1.80	29.83%
P302	1	1.1338	3.78	0.03	0.71%	0.05	1.24%
P303	1.25	1.0204	6.50	1.02	15.71%	1.80	27.67%
P304	1	1.1527	3.81	0.03	0.70%	0.05	1.23%
P305	1	1.1478	3.80	0.03	0.71%	0.05	1.23%

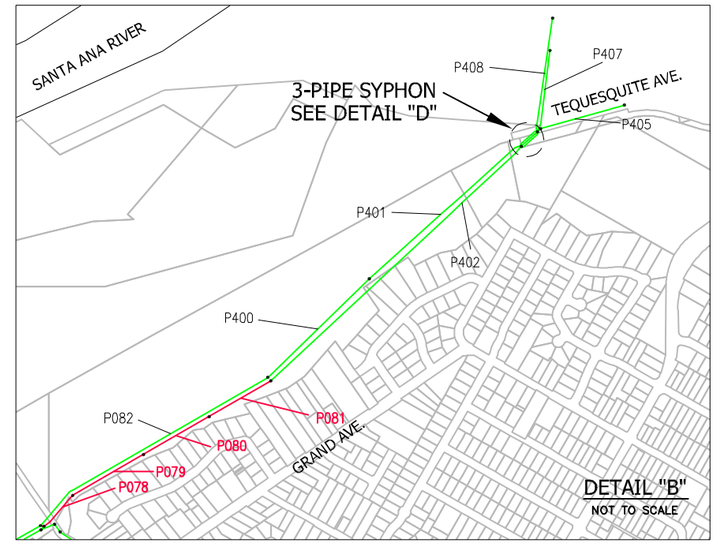
Table 7-1
Sewer Analysis Results (Existing and Future Conditions)

Name	Diameter, ft	Slope (%)	Theoretical "Full" Flow (cfs)	Existing Estimated Peak Flow (cfs)	Existing Estimated % Full	Future Estimated Peak Flow (cfs)	Future Estimated % Full
P306	1.25	1.0801	6.69	1.02	15.27%	1.80	26.91%
P307	1	1.1065	3.73	0.03	0.72%	0.05	1.26%
P308	1.25	0.9640	6.32	1.02	16.17%	1.80	28.49%
P309	1	1.1216	3.76	0.03	0.71%	0.05	1.25%
P310	1	1.1312	3.77	0.03	0.71%	0.05	1.24%
P311	1	0.3962	2.23	0.03	1.20%	0.05	2.10%
P312	1.25	1.0762	6.68	1.02	15.31%	1.80	26.96%
P313	1.25	0.5536	4.79	1.02	21.35%	1.80	37.61%
P314	1	0.4102	2.27	0.03	1.20%	0.05	2.08%
P315	1.25	0.5828	4.92	1.02	20.81%	1.80	36.66%
P316	1	0.3762	2.18	0.03	1.27%	0.05	2.19%
P317	1.25	0.4479	4.31	1.02	23.76%	1.80	41.84%
P318	1	0.4239	2.31	0.03	1.20%	0.05	2.06%
P319	1	0.4190	2.30	0.03	1.22%	0.05	2.08%
P322	1.25	1.5867	8.11	1.02	12.62%	1.80	22.23%
P324	0.666	4.3313	2.50	0.25	10.17%	0.33	13.08%
P325	1	0.8539	3.28	0.03	0.85%	0.05	1.46%
P326	1	0.9946	3.54	0.03	0.80%	0.05	1.36%
P327	1	0.8656	3.30	0.03	0.85%	0.05	1.45%
P328	1.25	0.7833	5.70	1.02	17.97%	1.80	31.64%
P329	1	0.9945	3.54	0.28	7.97%	0.37	10.57%
P330	1.25	0.1596	2.57	0.81	31.42%	1.52	59.12%
P331	1	0.1477	1.36	0.28	20.70%	0.37	27.46%
P332	1.25	0.3562	3.84	0.81	21.11%	1.53	39.69%
P333	1	0.1525	1.39	0.28	20.47%	0.38	27.09%
P334	1.25	0.3417	3.76	0.81	21.58%	1.53	40.57%
P335	1	0.1482	1.37	0.29	20.90%	0.38	27.59%
P336	1.25	0.3513	3.82	0.81	21.29%	1.53	40.02%
P337	1	0.1375	1.32	0.29	21.80%	0.38	28.69%
P338	1.25	0.3491	3.81	0.81	21.38%	1.53	40.19%
P339	1	0.1656	1.44	0.29	20.01%	0.38	26.24%
P340	1.25	0.6061	5.01	0.81	16.24%	1.53	30.52%
P341	0.833	0.8806	2.04	0.29	14.18%	0.38	18.57%
P342	1.25	0.5955	4.97	0.81	16.40%	1.53	30.81%
P343	0.833	0.8811	2.05	0.29	14.28%	0.38	18.62%
P344	1.25	0.5906	4.95	0.81	16.46%	1.53	30.94%
P345	0.833	0.8771	2.04	0.29	14.37%	0.38	18.68%
P346	1.25	0.6035	5.00	0.81	16.29%	1.53	30.61%
P347	0.833	0.8796	2.04	0.30	14.47%	0.38	18.77%
P348	1.25	0.6000	4.99	0.82	16.35%	1.53	30.72%
P349	0.833	0.9395	2.11	0.30	14.35%	0.39	18.52%
P350	0.833	0.4814	1.51	0.31	20.53%	0.39	26.01%
P351	0.833	0.3445	1.28	0.01	0.82%	0.01	1.10%
P352	1.25	1.9791	9.06	0.82	9.00%	1.53	16.91%
P353	0.833	1.0627	2.25	0.00	0.00%	0.00	0.00%
P354	0.666	1.9210	1.66	0.41	24.85%	0.77	46.60%
P355	0.666	1.9839	1.69	0.41	24.47%	0.77	45.87%
P356	1	1.8705	4.85	0.41	8.52%	0.78	15.97%
P357	1.5	0.1178	3.60	0.41	11.39%	0.77	21.39%
P358	1.5	10.1954	33.46	0.41	1.22%	0.77	2.30%
P359	1.5	0.4119	6.73	0.41	6.09%	0.77	11.44%
P361	1.5	0.4202	6.79	0.41	6.04%	0.77	11.33%
P362	1.5	0.3796	6.46	0.41	6.37%	0.77	11.95%
P363	1.5	0.5889	8.04	0.41	5.12%	0.77	9.61%
P364	1.5	1.1125	11.05	0.41	3.74%	0.77	7.01%
P365	1	0.8154	3.20	0.41	12.89%	0.77	24.16%
P366	1	0.8761	3.32	0.41	12.45%	0.78	23.35%
P367	1	4.4208	7.46	0.70	9.40%	0.79	10.58%
P368	1.25	4.4557	13.59	0.70	5.16%	0.79	5.81%

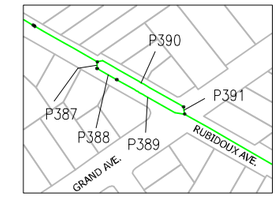
Table 7-1
Sewer Analysis Results (Existing and Future Conditions)

Name	Diameter, ft	Slope (%)	Theoretical "Full" Flow (cfs)	Existing Estimated Peak Flow (cfs)	Existing Estimated % Full	Future Estimated Peak Flow (cfs)	Future Estimated % Full
P369	1.25	4.4541	13.59	0.70	5.16%	0.79	5.81%
P370	1.25	4.4537	13.59	0.58	4.30%	0.65	4.75%
P371	1.25	0.1429	2.43	0.58	24.01%	0.65	26.50%
P372	1.25	0.1962	2.85	0.58	20.49%	0.65	22.62%
P373	1.25	0.1978	2.86	0.58	20.40%	0.65	22.53%
P374	1.25	0.1986	2.87	0.58	20.37%	0.65	22.49%
P375	1.25	0.1993	2.87	0.58	20.34%	0.65	22.46%
P376	1	0.1982	1.58	0.58	37.02%	0.65	40.87%
P377	1	0.1999	1.59	0.47	29.41%	0.50	31.49%
P378	1	0.1987	1.58	0.47	29.51%	0.50	31.60%
P379	1	0.4727	2.44	0.47	19.14%	0.50	20.49%
P380	1	0.4752	2.45	0.47	19.11%	0.50	20.46%
P381	1	120.2077	38.91	1.42	3.64%	1.45	3.73%
P382	0.833	12.6748	7.76	1.42	18.28%	1.45	18.69%
P384	0.833	8.8752	6.49	1.42	21.85%	1.45	22.34%
P385	0.833	21.7391	10.16	1.42	13.96%	1.45	14.27%
P386	0.833	2.6306	3.53	1.42	40.13%	1.45	41.03%
P387	0.833	19.6242	9.65	0.86	8.94%	0.88	9.14%
P388	0.833	4.3825	4.56	0.86	18.92%	0.88	19.34%
P389	0.833	2.6861	3.57	0.86	24.17%	0.88	24.70%
P390	0.833	3.7303	4.21	0.55	13.19%	0.57	13.50%
P391	0.833	2.5882	3.51	0.55	15.83%	0.57	16.20%
P392	1.25	0.1996	2.88	1.30	45.14%	1.33	46.24%
P393	1.25	0.3341	3.72	1.30	34.93%	1.33	35.78%
P394	1.25	0.4608	4.37	1.30	29.75%	1.33	30.48%
P395	1.25	0.2235	3.04	1.30	42.73%	1.33	43.77%
P396	1.25	0.5925	4.96	1.18	23.81%	1.21	24.45%
P397	1.25	0.1792	2.73	1.18	43.38%	1.21	44.55%
P398	1	0.6518	2.87	1.19	41.41%	1.22	42.52%
P399	1	0.6494	2.86	1.19	41.56%	1.22	42.68%
P400	2.75	0.3000	28.95	17.06	58.92%	27.31	94.33%
P401	2.75	0.3456	31.08	17.06	54.89%	27.58	88.74%
P402	2	0.3457	13.28	9.09	68.42%	12.62	95.07%
P405	2.25	0.7166	26.19	16.86	64.38%	26.15	99.85%
P406	2.25	1.0030	30.98	16.85	54.38%	26.15	84.39%
P407	1.5	0.4571	7.08	2.80	39.52%	3.53	49.83%
P408	3	0.2336	32.23	6.95	21.56%	15.57	48.31%
P409	1.75	1.0982	Siphon	8.55		13.00	
P410	1.5	0.2402	Siphon	5.62		8.68	
P411	2	0.2402	Siphon	11.99		18.47	
P412	1.75	20.4809	Siphon	8.55		12.96	
P413	2	21.0273	Siphon	11.99		18.43	
P414	1.5	21.0273	Siphon	5.61		8.65	
P415	1.75	0.0000	Siphon	8.55		12.93	
P416	2	0.0000	Siphon	11.99		18.41	
P417	1.5	0.0000	Siphon	5.60		8.62	
P418	1.75	-21.3376	Siphon	8.55		12.91	
P419	1.5	-21.3376	Siphon	5.60		8.59	
P420	2	-21.2627	Siphon	11.99		18.39	
P421	0.833	1.4932	2.66	1.05	39.41%	1.13	42.38%
P422	0.833	1.2400	2.43	1.05	43.25%	1.13	46.50%
P423	0.833	1.2400	2.43	1.05	43.25%	1.13	46.50%
P424	0.833	1.1956	2.38	1.05	44.04%	1.13	47.36%

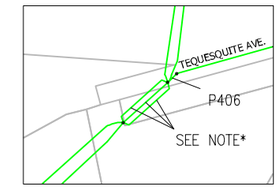




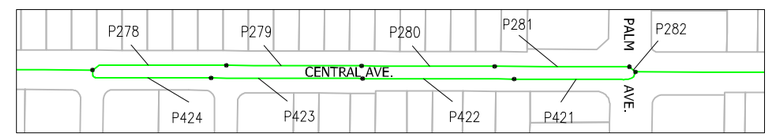
DETAIL "B"
NOT TO SCALE



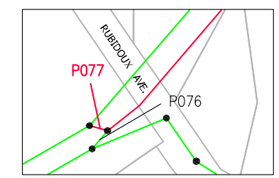
DETAIL "C"
NOT TO SCALE



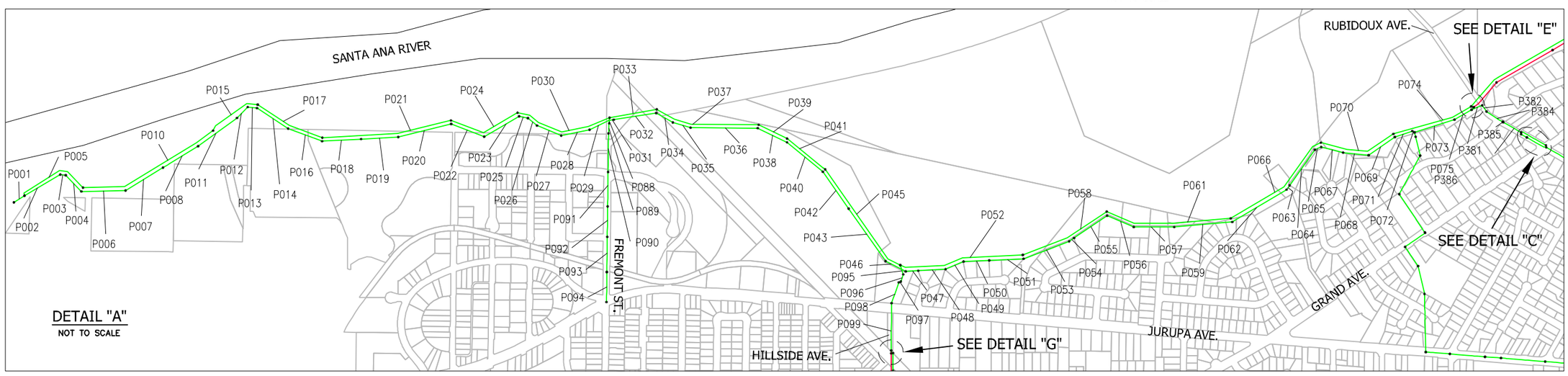
DETAIL "D"
NOT TO SCALE



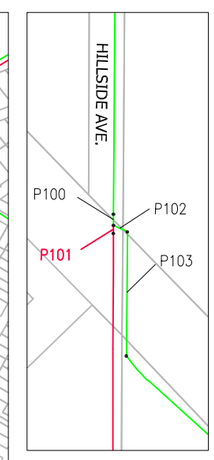
DETAIL "F"
NOT TO SCALE



DETAIL "E"
NOT TO SCALE



DETAIL "A"
NOT TO SCALE



DETAIL "G"
NOT TO SCALE

LEGEND

- EXCEEDS 90% FULL
- > 75% < 90% FULL
- LESS THAN 75% FULL
- P001 PIPELINE NUMBER

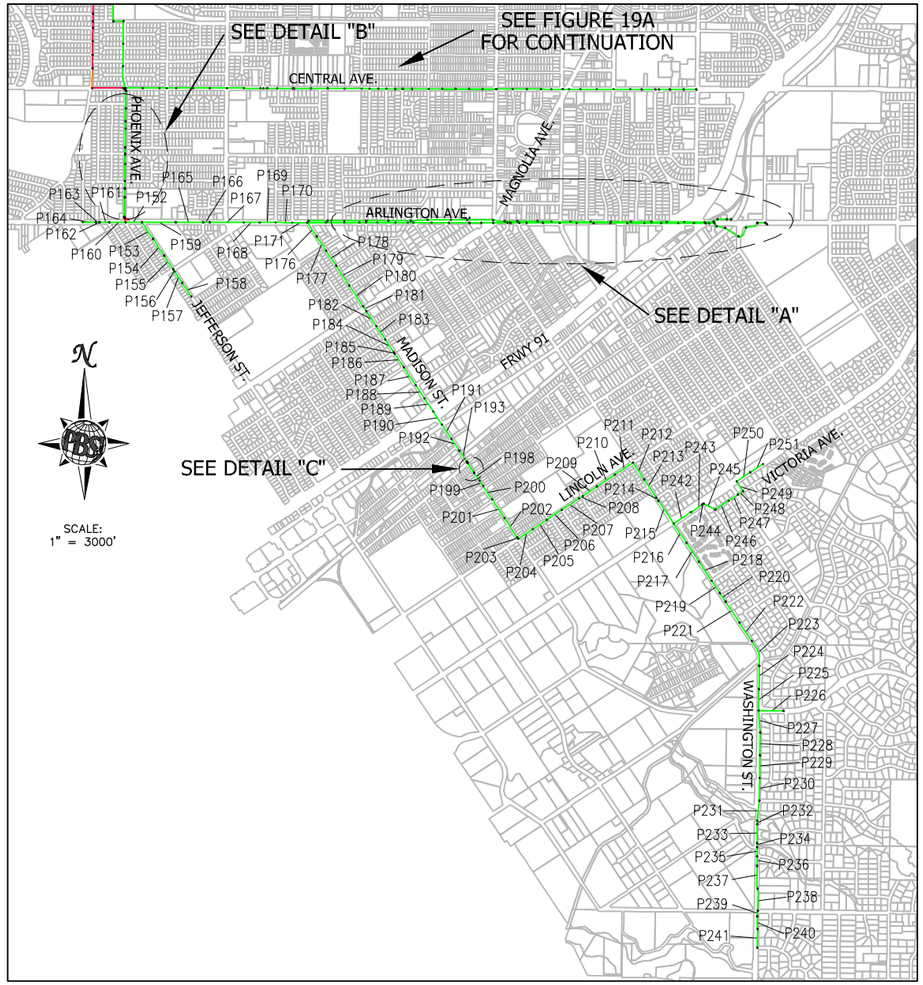
NOTE* THIS 3-PIPE SYPHON CONSISTS OF PIPELINE NUMBERS P409 THROUGH P420.

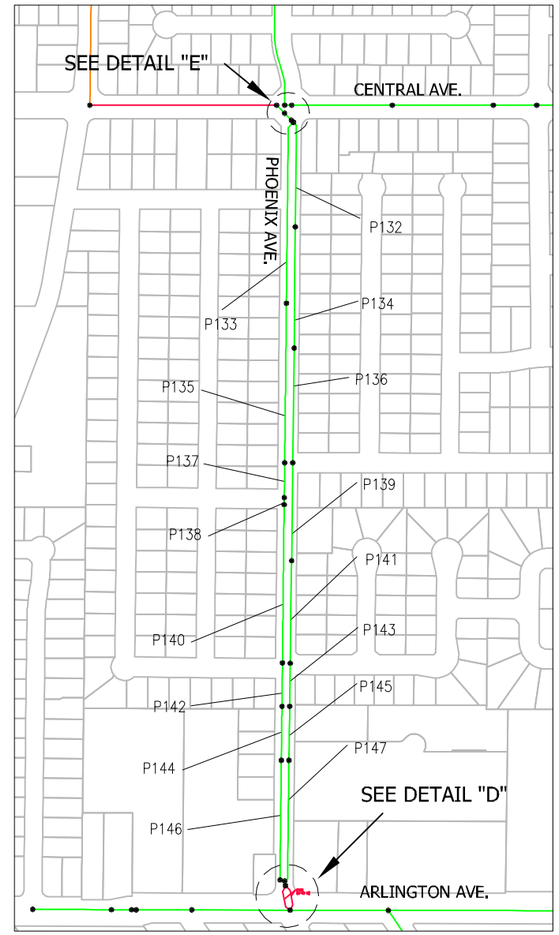
Engineering
Planning
Surveying
Construction Services
PBS&J
10370 Hemet Street
Suite 200
Riverside, CA 92503
Tel:(951) 358-1433
Fax:(951) 358-1434

DATE: 12/15/05	DWN BY: CD
CITY OF RIVERSIDE PHOENIX SEWER STUDY	FIGURE 19A

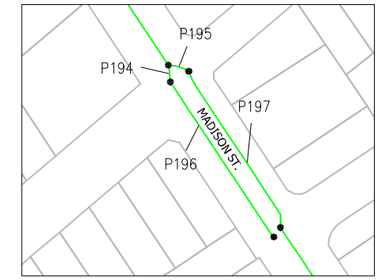
EXISTING VOLUME DEFICIENCIES - PART 1

Y:\City of Riverside\Phoenix\DWG\Exhibits\PH-VolumeDeficientA.dwg, 9/28/2006 11:21:58 AM
H:\Client\Riversid_SAOW\7472A00\Rpt\Volume 03\Appendices\Ch01-AppxD-Phoenix Final 02-26-07.pdf

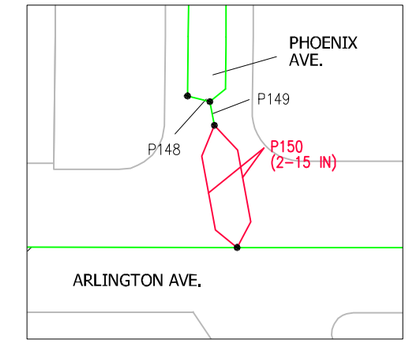




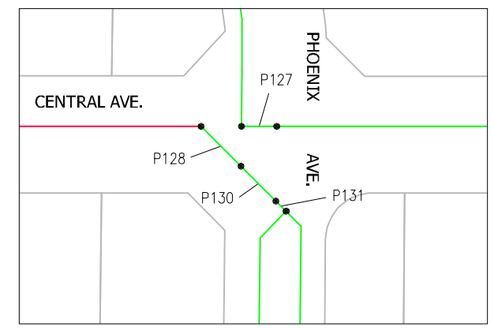
DETAIL "B"
NOT TO SCALE



DETAIL "C"
NOT TO SCALE



DETAIL "D"
NOT TO SCALE



DETAIL "E"
NOT TO SCALE

LEGEND

	EXCEEDS 90% FULL
	> 75% < 90% FULL
	LESS THAN 75% FULL
P001	PIPELINE NUMBER

DETAIL "A"
NOT TO SCALE

Engineering
Planning
Surveying
Construction Services
PBS&J
10370 Hemet Street
Suite 200
Riverside, CA 92503
Tel:(951) 358-1433
Fax:(951) 358-1434

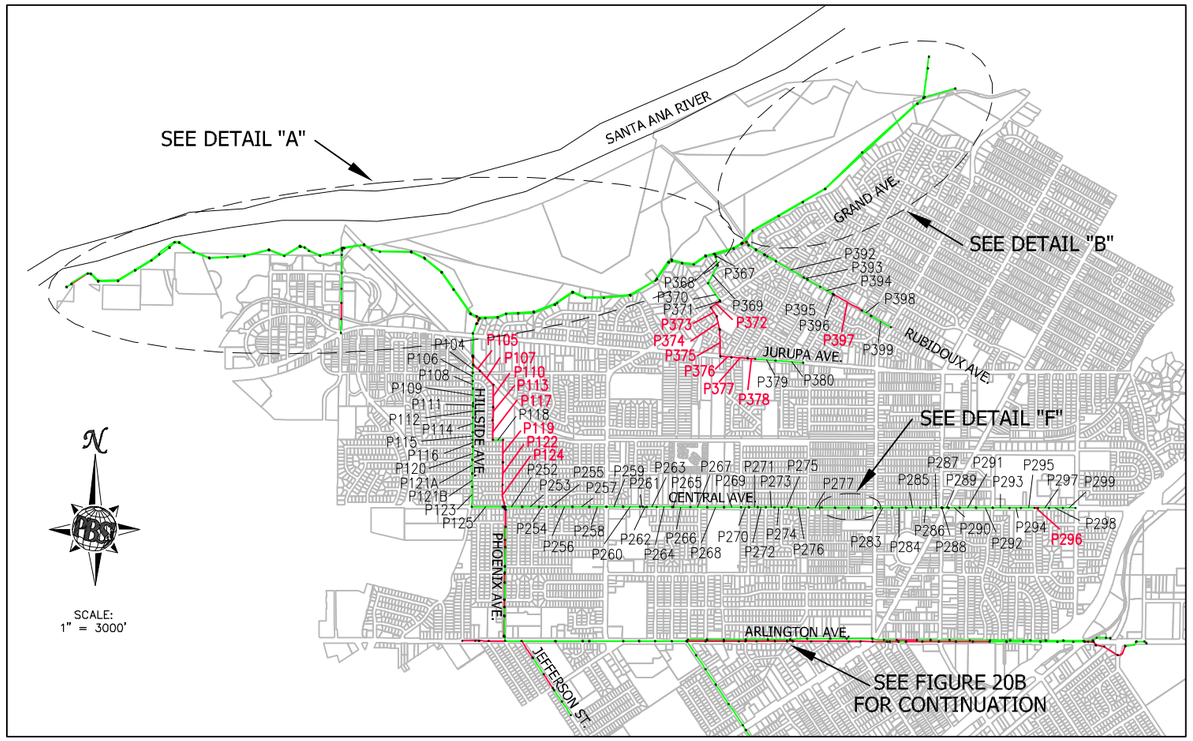
DATE: 12/15/05 | DWN BY: CD

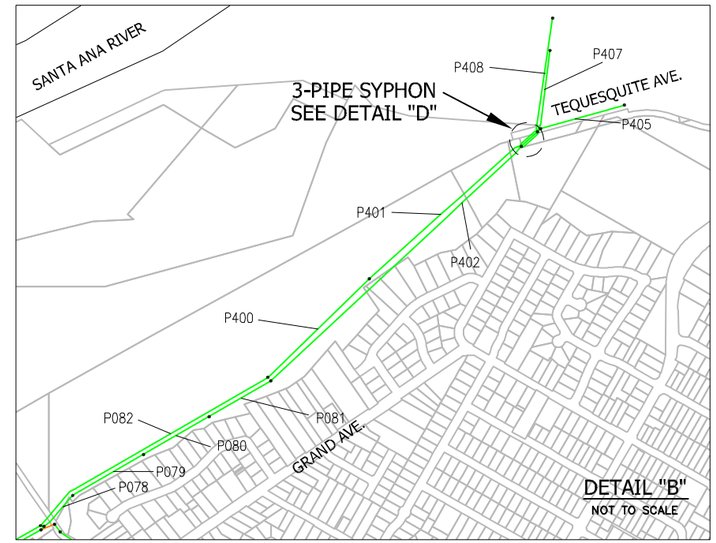
CITY OF RIVERSIDE
PHOENIX SEWER STUDY

FIGURE 19B

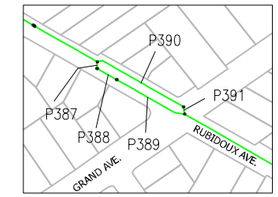
EXISTING VOLUME DEFICIENCIES - PART 2

Y:\City of Riverside\Phoenix\DWG\Exhibits\PH-VolumeDeficientB.dwg, 9/28/2006 11:23:16 AM

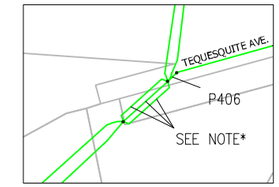




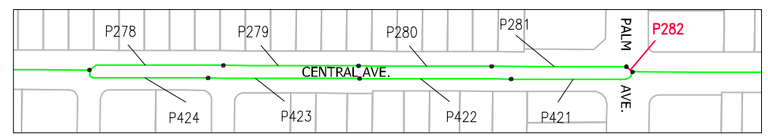
DETAIL "B"
NOT TO SCALE



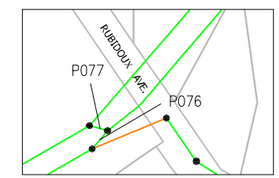
DETAIL "C"
NOT TO SCALE



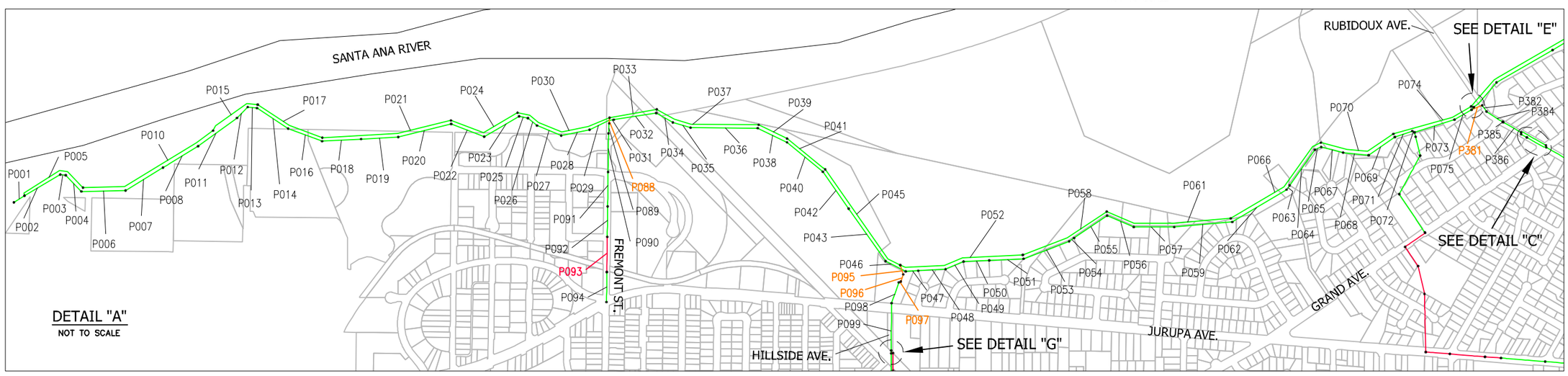
DETAIL "D"
NOT TO SCALE



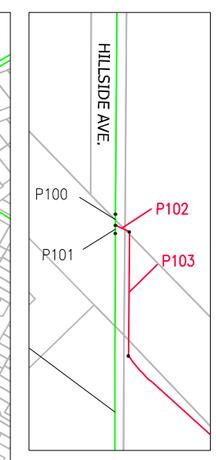
DETAIL "F"
NOT TO SCALE



DETAIL "E"
NOT TO SCALE



DETAIL "A"
NOT TO SCALE



DETAIL "G"
NOT TO SCALE

LEGEND

- LESS THAN 2 FPS
- EXCEEDS 2 FPS
- EXCEEDS 10 FPS
- P001 PIPELINE NUMBER

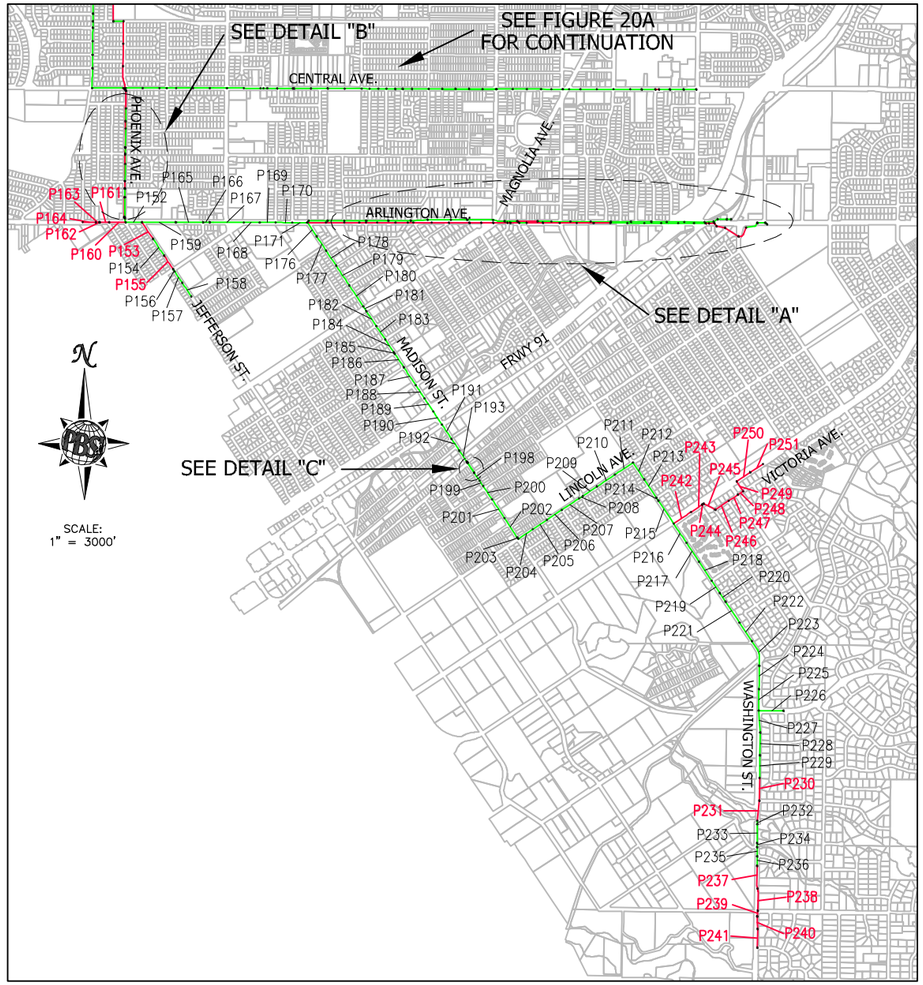
NOTE* THIS 3-PIPE SYPHON CONSISTS OF PIPELINE NUMBERS P409 THROUGH P420.

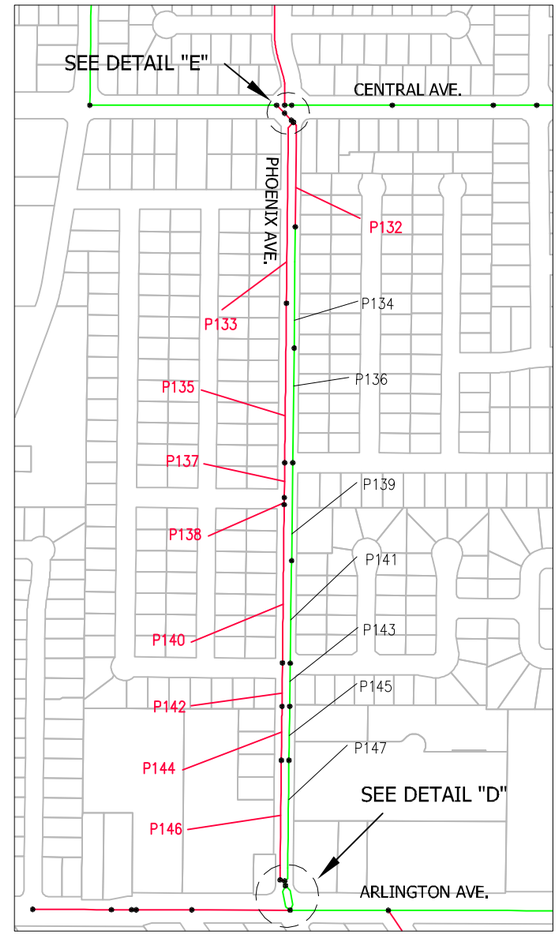
Engineering
Planning
Surveying
Construction Services
PBSJ
10370 Hemet Street
Suite 200
Riverside, CA 92503
Tel:(951) 358-1433
Fax:(951) 358-1434

DATE: 12/15/05	DWN BY: CD
CITY OF RIVERSIDE PHOENIX SEWER STUDY	FIGURE 20A

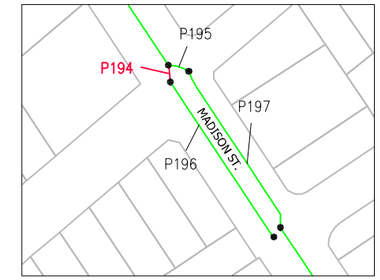
EXISTING VELOCITY DEFICIENCIES - PART 1

Y:\City of Riverside\Phoenix\DWG\Exhibits\PH-VelocityDeficientA.dwg, 9/28/2006 11:19:34 AM
H:\Client\Riversid_SAOW\7472A00\Rpt\Volume 03\Appendices\Ch01-AppxD-Phoenix Final 02-26-07.pdf

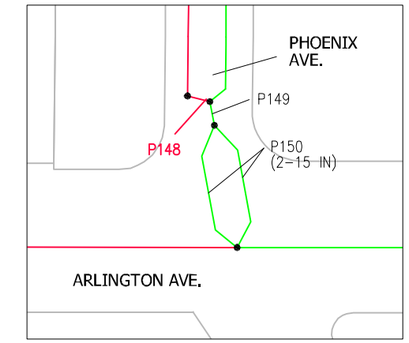




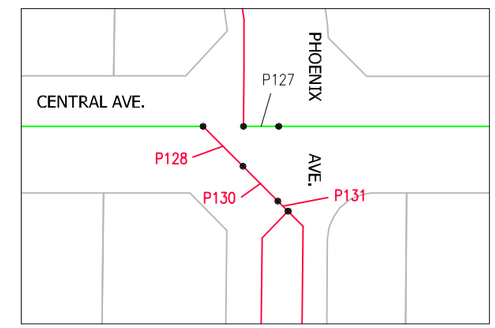
DETAIL "B"
NOT TO SCALE



DETAIL "C"
NOT TO SCALE



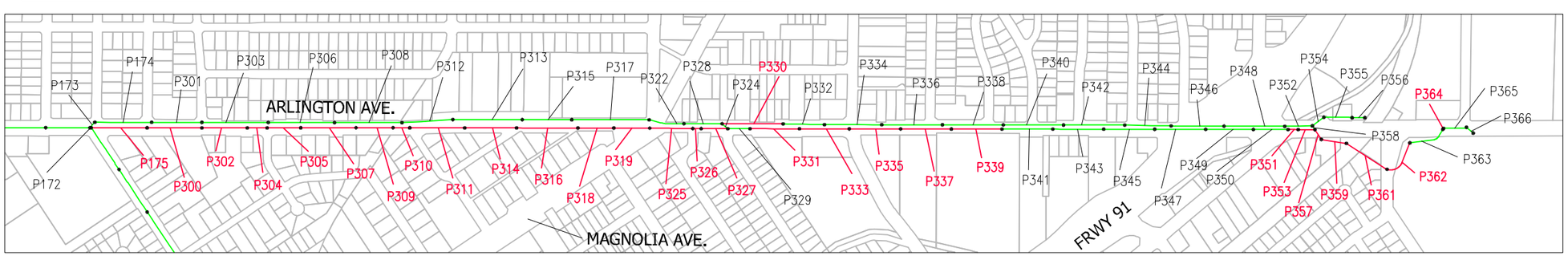
DETAIL "D"
NOT TO SCALE



DETAIL "E"
NOT TO SCALE

LEGEND

	LESS THAN 2 FPS
	EXCEEDS 2 FPS
P001	PIPELINE NUMBER

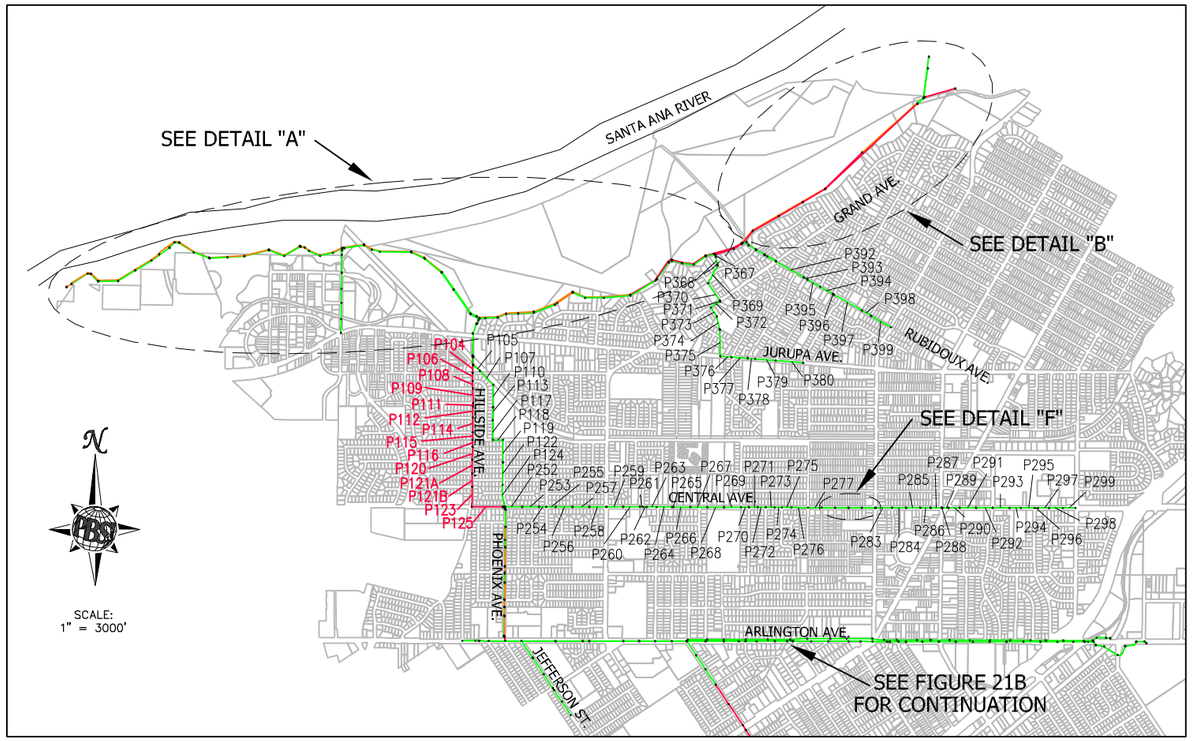


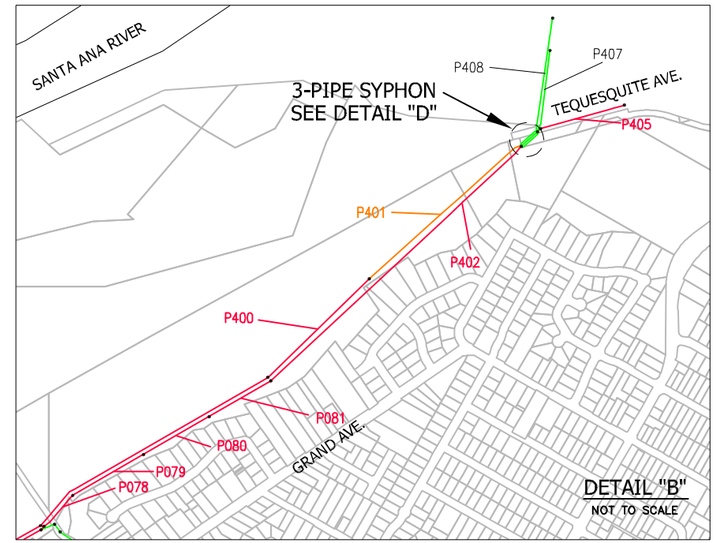
DETAIL "A"
NOT TO SCALE

DATE: 12/15/05	DWN BY: CD
CITY OF RIVERSIDE PHOENIX SEWER STUDY	FIGURE 20B
EXISTING VELOCITY DEFICIENCIES - PART 2	

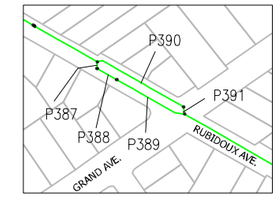
Engineering
Planning
Surveying
Construction Services
PBS&J
10370 Hemet Street
Suite 200
Riverside, CA 92503
Tel:(951) 358-1433
Fax:(951) 358-1434

Y:\City of Riverside\Phoenix\DWG\Exhibits\PH-VelocityDeficientB.dwg, 9/28/2006 11:20:31 AM

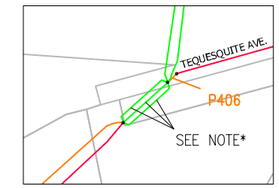




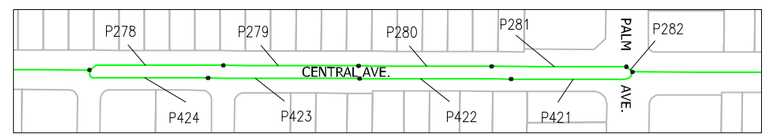
DETAIL "B"
NOT TO SCALE



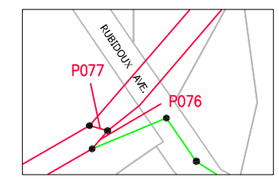
DETAIL "C"
NOT TO SCALE



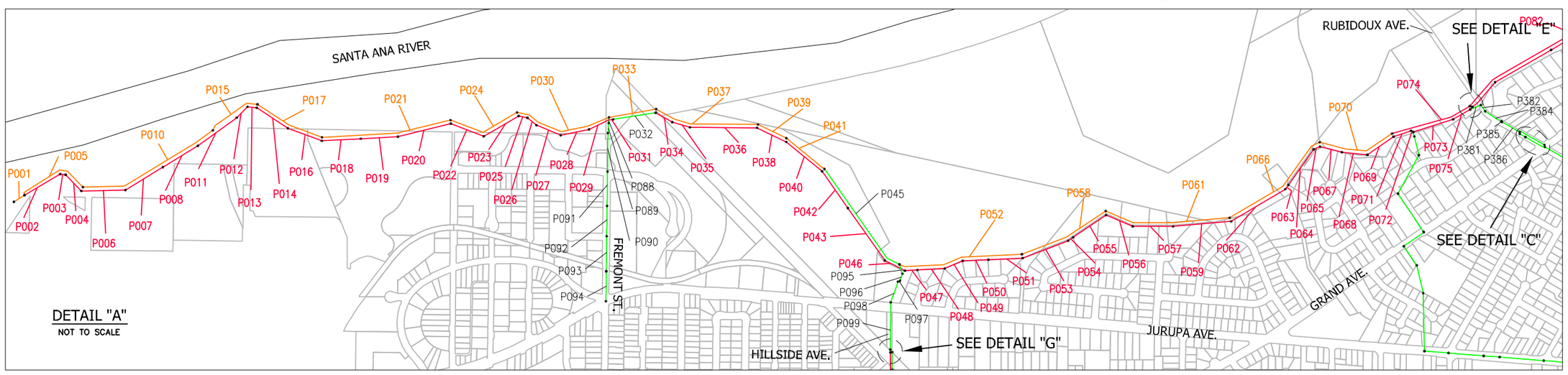
DETAIL "D"
NOT TO SCALE



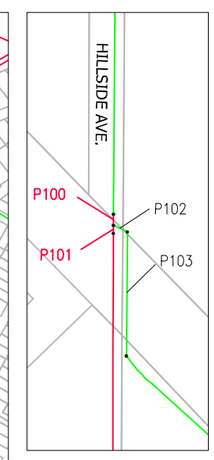
DETAIL "F"
NOT TO SCALE



DETAIL "E"
NOT TO SCALE



DETAIL "A"
NOT TO SCALE



DETAIL "G"
NOT TO SCALE

LEGEND

- EXCEEDS 90% FULL
- > 75% < 90% FULL
- LESS THAN 75% FULL
- P001 PIPELINE NUMBER

NOTE* THIS 3-PIPE SYPHON CONSISTS OF PIPELINE NUMBERS P409 THROUGH P420.

Engineering
Planning
Surveying
Construction Services
PBS&J
10370 Hemet Street
Suite 200
Riverside, CA 92503
Tel:(951) 358-1433
Fax:(951) 358-1434

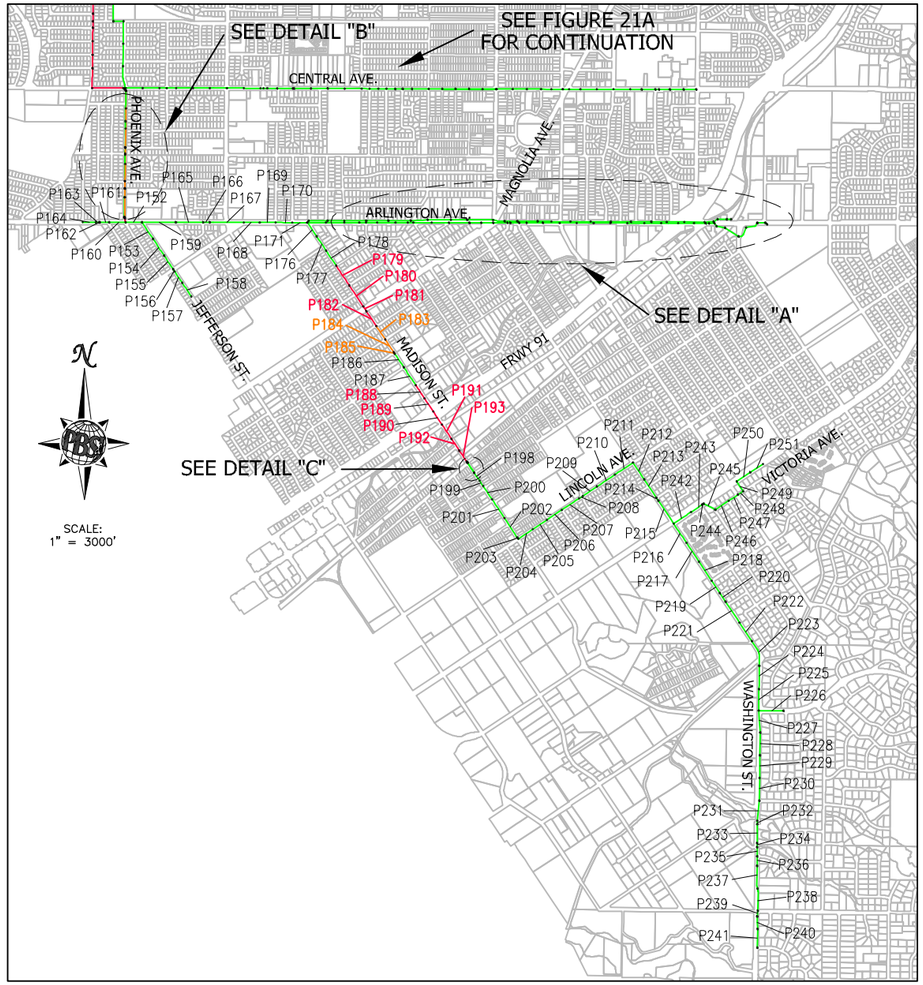
DATE: 12/15/05 | DWN BY: CD

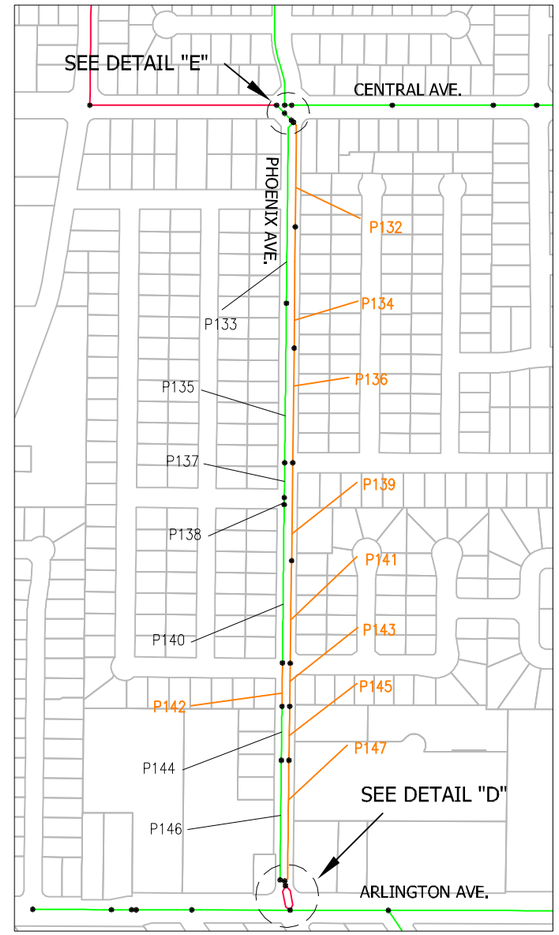
CITY OF RIVERSIDE
PHOENIX SEWER STUDY

FIGURE 21A

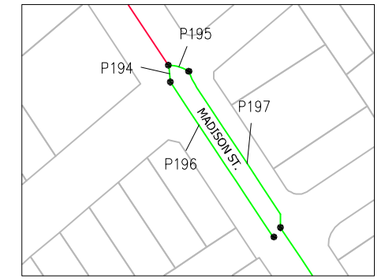
ULTIMATE VOLUME DEFICIENCIES - PART 1

Y:\City of Riverside\Phoenix\DWG\Exhibits\PH-UltVolumeDeficientA.dwg, 9/28/2006 11:12:49 AM

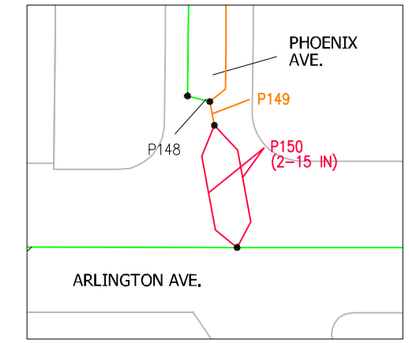




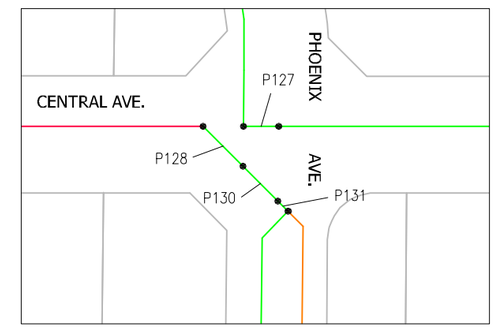
DETAIL "B"
NOT TO SCALE



DETAIL "C"
NOT TO SCALE



DETAIL "D"
NOT TO SCALE



DETAIL "E"
NOT TO SCALE

LEGEND

	EXCEEDS 90% FULL
	> 75% < 90% FULL
	LESS THAN 75% FULL
P001	PIPELINE NUMBER

DETAIL "A"
NOT TO SCALE

Engineering
Planning
Surveying
Construction Services
PBS&J
10370 Hemet Street
Suite 200
Riverside, CA 92503
Tel:(951) 358-1433
Fax:(951) 358-1434

DATE: 12/15/05 | DWN BY: CD

CITY OF RIVERSIDE
PHOENIX SEWER STUDY

FIGURE 21B

ULTIMATE VOLUME DEFICIENCIES - PART 2

Y:\City of Riverside\Phoenix\DWG\Exhibits\PH-UltVolumeDeficientB.dwg, 9/28/2006 11:17:21 AM

7.0 DEFICIENCIES AND SOLUTIONS

7.1 Deficient and Marginally Deficient Pipes

The City's design criterion for sewer lines allows pipes to flow at a ratio of 75% of "full" hydraulic capacity. Assuming that "full" capacity is the maximum hydraulic capacity of a pipe flowing under gravity (non-pressure) conditions, Manning's equation shows that maximum flow occurs when a pipe reaches a flow depth ratio of about 95% depth/diameter (d/D). For the purpose of this study, pipes flowing at greater than 90% capacity are considered "deficient", and pipes flowing at greater than 75% and less than 90% are considered "marginally deficient".

Pipe reaches which fail the "75% full" criterion for both existing and future flow conditions are shown in Table 7-2 and Figures 19A, 19B, 21A and 21B. It is seen that portions of the modeled trunk system are already flowing at greater than "75% full", and several reaches are computed to be over 100% full (surcharge conditions) in existing and future conditions. At ultimate conditions, numerous additional reaches are shown to surcharge or exceed the "75% full" criteria.

Pipe reaches that have flow velocity less than 2 feet per second and more than 10 feet per second under existing flow conditions are shown in Figures 20A and 20B.

7.2 Project Prioritization Methodology

The 75% full criterion is useful for analyzing deficient pipes and as a basis for sizing new facilities. However, the criterion is not necessarily the trigger point for replacement or augmentation of an existing sewer line. In most cases, a sewer entity would not implement a relief project until capacity problems are actually observed or known to be imminent.

A recommended system of project prioritization is the categorization of deficient sewer lines based on modeled % full results. The "A" priority projects are imminently needed and the "B" and "C" projects require further consideration for replacement. Priority classifications are described as follows:

Priority "A" – The pipes listed within this priority are currently flowing more than 90% full under maximum flow conditions. These pipes are grouped for replacement/rehabilitation in the period (2005-2010); preferably as soon as practically possible.

Table 7-2
Proposed Construction Prioritization and Schedule

Pipe Name	Pipe Length (ft)	Existing Pipe Size (inch)	Existing Estimated % Full (Year 2005)	Year 2015 Estimated % Full	Future Estimated % Full (Year 2020)	Priority	New Diameter (inch)	New % Full (Year 2020)	Approximate Replacement Period
P001	115	48	57.38%	74.13%	82.50%	C	54	60%	2016-2020
P002	384	24	64.99%	88.04%	99.56%	C	30	55%	2016-2020
P003	58	24	64.96%	87.97%	99.48%	C	30	55%	2016-2020
P004	206	24	64.92%	87.92%	99.42%	C	30	55%	2016-2020
P005	668	45	61.37%	78.37%	86.88%	C	51	62%	2016-2020
P006	398	24	64.86%	87.81%	99.29%	C	30	55%	2016-2020
P007	399	24	64.79%	87.69%	99.15%	C	30	55%	2016-2020
P008	376	24	64.74%	87.60%	99.03%	C	30	55%	2016-2020
P010	1354	45	61.04%	77.96%	86.42%	C	51	62%	2016-2020
P011	440	24	64.70%	87.51%	98.91%	C	30	55%	2016-2020
P012	144	24	64.67%	87.43%	98.82%	C	30	54%	2016-2020
P013	93	24	64.65%	87.40%	98.78%	C	30	54%	2016-2020
P014	342	24	64.70%	87.35%	98.67%	C	30	54%	2016-2020
P015	490	45	61.12%	78.06%	86.53%	C	51	62%	2016-2020
P016	329	24	64.59%	87.21%	98.52%	C	30	54%	2016-2020
P017	670	45	60.96%	77.85%	86.30%	C	51	62%	2016-2020
P018	356	24	64.56%	87.09%	98.36%	C	30	54%	2016-2020
P019	340	24	64.52%	86.97%	98.20%	C	30	54%	2016-2020
P020	502	24	64.48%	86.85%	98.04%	C	30	54%	2016-2020
P021	1196	45	61.11%	78.05%	86.52%	C	51	62%	2016-2020
P022	322	24	64.44%	86.86%	98.07%	C	30	54%	2016-2020
P023	370	24	64.41%	87.04%	98.35%	C	30	54%	2016-2020
P024	682	45	57.83%	73.87%	81.89%	C	51	59%	2016-2020
P025	88	24	64.39%	87.11%	98.47%	C	30	54%	2016-2020
P026	109	24	64.38%	87.14%	98.52%	C	30	54%	2016-2020
P027	236	24	64.36%	87.18%	98.59%	C	30	54%	2016-2020
P028	262	24	64.34%	87.22%	98.67%	C	30	54%	2016-2020
P029	199	24	64.33%	87.26%	98.73%	C	30	54%	2016-2020
P030	910	45	58.11%	74.23%	82.29%	C	51	59%	2016-2020
P031	44	24	64.32%	87.28%	98.76%	C	30	54%	2016-2020
P032	398	30	35.44%	48.13%	54.48%				
P033	436	45	54.10%	69.04%	76.52%	C	48	64%	2016-2020
P034	178	24	64.28%	87.37%	98.91%	C	30	55%	2016-2020
P035	166	24	64.27%	87.37%	98.91%	C	30	55%	2016-2020
P036	617	24	64.25%	87.36%	98.91%	C	30	55%	2016-2020
P037	964	45	55.30%	70.58%	78.22%	C	48	66%	2016-2020
P038	302	24	64.23%	87.35%	98.92%	C	30	55%	2016-2020
P039	287	45	58.98%	75.28%	83.43%	C	51	60%	2016-2020
P040	426	24	64.22%	87.35%	98.92%	C	30	55%	2016-2020
P041	447	45	59.76%	76.28%	84.54%	C	51	61%	2016-2020
P042	414	24	64.20%	87.34%	98.92%	C	30	55%	2016-2020
P043	586	24	64.19%	87.34%	98.92%	C	30	55%	2016-2020
P045	1131	45	49.12%	62.70%	69.49%				
P046	202	24	64.18%	87.34%	98.92%	C	30	55%	2016-2020
P047	113	24	64.18%	87.34%	98.93%	C	30	55%	2016-2020
P048	249	24	62.53%	85.69%	97.27%	C	30	54%	2016-2020
P049	180	24	62.52%	85.69%	97.27%	C	30	54%	2016-2020
P050	237	24	62.52%	85.68%	97.27%	C	30	54%	2016-2020
P051	313	24	62.52%	85.68%	97.27%	C	30	54%	2016-2020
P052	1148	39	58.98%	76.27%	84.92%	C	45	58%	2016-2020
P053	444	24	62.51%	85.68%	97.27%	C	30	54%	2016-2020
P054	54	24	62.51%	85.69%	97.28%	C	30	54%	2016-2020
P055	370	24	62.51%	85.73%	97.35%	C	33	42%	2016-2020
P056	268	24	62.51%	85.75%	97.38%	C	30	54%	2016-2020
P057	369	24	62.51%	85.86%	97.54%	C	30	54%	2016-2020
P058	870	39	59.04%	76.34%	84.99%	C	45	58%	2016-2020
P059	531	24	62.51%	86.22%	98.08%	C	30	54%	2016-2020
P061	1162	39	58.59%	75.75%	84.33%	C	45	58%	2016-2020
P062	575	24	60.85%	85.11%	97.25%	C	30	54%	2016-2020
P063	46	24	60.85%	85.44%	97.74%	C	30	54%	2016-2020
P064	403	24	60.85%	85.74%	98.18%	C	30	54%	2016-2020
P065	70	24	60.85%	85.97%	98.54%	C	30	54%	2016-2020
P066	1102	39	59.04%	76.33%	84.98%	C	45	58%	2016-2020
P067	210	24	60.85%	86.10%	98.73%	C	30	54%	2016-2020
P068	231	24	60.85%	86.31%	99.05%	C	30	55%	2016-2020
P069	290	24	60.85%	86.57%	99.44%	C	30	55%	2016-2020
P070	726	39	59.04%	76.33%	84.98%	C	45	58%	2016-2020
P071	170	24	60.85%	86.79%	99.76%	C	30	55%	2016-2020
P072	24	24	60.85%	86.87%	99.88%	C	30	55%	2016-2020
P073	383	24	54.15%	79.75%	92.55%	C	30	51%	2016-2020
P074	763	39	62.24%	80.46%	89.58%	C	48	51%	2016-2020
P075	181	24	54.15%	79.95%	92.86%	C	30	51%	2016-2020
P076	31	24	54.15%	80.02%	92.97%	C	30	51%	2016-2020
P077	15	15	96.15%	125.11%	139.59%	A	21	57%	2005-2010
P078	309	24	89.92%	112.15%	123.27%	A	33	53%	2005-2010

Table 7-2
Proposed Construction Prioritization and Schedule

Pipe Name	Pipe Length (ft)	Existing Pipe Size (inch)	Existing Estimated % Full (Year 2005)	Year 2015 Estimated % Full	Future Estimated % Full (Year 2020)	Priority	New Diameter (inch)	New % Full (Year 2020)	Approximate Replacement Period
P079	595	24	89.92%	112.23%	123.39%	A	30	68%	2005-2010
P080	550	24	89.92%	112.24%	123.39%	A	30	68%	2005-2010
P081	514	24	89.93%	112.24%	123.40%	A	30	68%	2005-2010
P082	1983	36	57.09%	79.23%	90.31%	C	42	60%	2016-2020
P088	52	10	5.88%	7.71%	8.63%				
P089	92	10	10.89%	14.28%	15.98%				
P090	353	15	13.18%	17.28%	19.33%				
P091	278	12	11.13%	14.58%	16.31%				
P092	278	12	11.96%	15.68%	17.53%				
P093	322	12	33.59%	44.03%	49.25%				
P094	275	12	12.99%	17.03%	19.05%				
P095	82	24	11.87%	14.51%	15.83%				
P096	68	24	13.08%	15.92%	17.34%				
P097	20	24	15.79%	19.21%	20.93%				
P098	201	24	28.07%	34.16%	37.21%				
P099	434	24	28.05%	34.13%	37.18%				
P100	14	27	74.47%	90.64%	98.73%	A*	33	58%	2005-2010
P101	11	24	[illegible]	117.14%	130.42%	A	33	56%	2005-2010
P102	12	27	29.29%	30.53%	31.15%				
P103	161	27	29.70%	30.96%	31.59%				
P104	320	24	91.81%	118.72%	132.17%	A	33	56%	2005-2010
P105	183	27	30.44%	31.73%	32.37%				
P106	161	24	92.13%	119.13%	132.63%	A	33	57%	2005-2010
P107	384	27	30.65%	31.94%	32.58%				
P108	148	24	91.67%	118.53%	131.97%	A	33	56%	2005-2010
P109	290	24	90.73%	117.32%	130.61%	A	33	56%	2005-2010
P110	445	27	29.21%	30.42%	31.03%				
P111	64	24	97.18%	125.66%	139.90%	A	33	60%	2005-2010
P112	221	24	90.31%	116.78%	130.01%	A	33	56%	2005-2010
P113	252	27	28.51%	29.69%	30.28%				
P114	279	24	90.81%	117.42%	130.73%	A	33	56%	2005-2010
P115	150	24	92.28%	119.31%	132.83%	A	33	57%	2005-2010
P116	133	24	94.43%	122.09%	135.93%	A	33	58%	2005-2010
P117	392	27	27.06%	28.18%	28.74%				
P118	203	27	23.97%	24.96%	25.46%				
P119	445	27	30.01%	31.26%	31.88%				
P120	263	24	91.83%	118.74%	132.19%	A	33	56%	2005-2010
P121A	263	24	91.84%	118.74%	132.19%	A	33	56%	2005-2010
P121B	263	24	91.87%	118.76%	132.22%	A	33	56%	2005-2010
P122	445	27	29.61%	30.84%	31.45%				
P123	397	24	86.68%	112.04%	124.73%	A*	30	69%	2005-2010
P124	437	27	29.77%	31.01%	31.62%				
P125	615	24	[illegible]	185.66%	206.33%	A	36	70%	2005-2010
P127	23	24	9.97%	10.38%	10.59%				
P128	34	27	42.92%	55.20%	61.35%				
P130	34	27	42.92%	55.21%	61.35%				
P131	10	27	57.57%	64.47%	67.92%				
P132	345	27	65.24%	73.46%	77.57%	C	30	59%	2016-2020
P133	604	21	4.67%	37.73%	54.26%				
P134	400	27	65.76%	75.19%	79.90%	C	30	60%	2016-2020
P135	526	21	3.81%	37.23%	53.95%				
P136	378	27	66.05%	76.72%	82.06%	C	30	62%	2016-2020
P137	115	21	3.57%	37.03%	53.76%				
P138	23	21	1.49%	28.61%	42.17%				
P139	323	27	65.62%	77.16%	82.94%	C	30	63%	2016-2020
P140	523	21	2.43%	44.58%	65.67%				
P141	338	27	65.91%	78.25%	84.43%	C	30	64%	2016-2020
P142	143	21	2.96%	53.63%	78.98%	C	24	55%	2016-2020
P143	143	27	67.18%	80.20%	86.71%	C	30	65%	2016-2020
P144	178	21	2.77%	50.05%	73.69%				
P145	178	27	65.29%	78.33%	84.86%	C	30	64%	2016-2020
P146	394	21	1.23%	21.99%	32.36%				
P147	398	27	63.64%	76.73%	83.28%	C	30	63%	2016-2020
P148	6	15	0.00%	12.45%	18.68%				
P149	16	27	51.83%	68.25%	76.45%	A*	30	58%	2005-2010
P150**	71	15	86.42%	129.62%	145.22%	A	2-18	71%	2005-2010
P152	324	21	37.59%	50.12%	56.39%				
P153	399	12	49.20%	51.03%	51.94%				
P154	393	12	43.10%	44.74%	45.56%				
P155	328	12	52.37%	54.38%	55.38%				
P156	50	12	24.63%	25.53%	25.97%				
P157	271	12	24.51%	25.40%	25.85%				
P158	322	12	24.68%	25.57%	26.02%				
P159	671	21	46.54%	64.01%	72.75%				
P160	324	12	11.20%	18.23%	21.74%				

Table 7-2
Proposed Construction Prioritization and Schedule

Pipe Name	Pipe Length (ft)	Existing Pipe Size (inch)	Existing Estimated % Full (Year 2005)	Year 2015 Estimated % Full	Future Estimated % Full (Year 2020)	Priority	New Diameter (inch)	New % Full (Year 2020)	Approximate Replacement Period
P161	184	12	9.99%	14.41%	16.62%				
P162	15	12	13.24%	17.24%	19.25%				
P163	67	12	14.95%	18.11%	19.69%				
P164	259	12	10.83%	11.34%	11.59%				
P165	541	21	46.39%	63.95%	72.74%				
P166	130	21	42.89%	59.13%	67.26%				
P167	673	21	27.26%	37.59%	42.76%				
P168	315	21	27.31%	37.65%	42.83%				
P169	314	21	28.27%	38.98%	44.33%				
P170	330	21	27.49%	37.91%	43.12%				
P171	291	21	26.30%	36.27%	41.26%				
P172	10	21	20.36%	27.59%	31.21%				
P173	49	15	15.32%	23.10%	26.99%				
P174	374	15	15.43%	23.27%	27.19%				
P175	367	12	0.71%	1.06%	1.24%				
P176	330	18	47.60%	64.49%	72.94%				
P177	335	18	45.72%	61.94%	70.05%				
P178	364	18	47.17%	63.91%	72.28%				
P179	462	18	63.52%	86.06%	97.33%	C	24	45%	2016-2020
P180	503	18	63.52%	86.06%	97.33%	C	24	45%	2016-2020
P181	114	18	63.52%	86.06%	97.33%	C	24	45%	2016-2020
P182	355	15	60.75%	83.04%	94.19%	C	18	58%	2016-2020
P183	316	15	52.15%	71.29%	80.86%	C	18	50%	2016-2020
P184	303	15	51.87%	70.91%	80.42%	C	18	49%	2016-2020
P185	34	15	52.57%	71.86%	81.51%	C	18	50%	2016-2020
P186	324	15	36.88%	50.42%	57.19%				
P187	425	15	40.41%	55.23%	62.65%				
P188	313	15	44.37%	61.28%	69.73%				
P189	313	15	35.74%	49.35%	56.16%				
P190	312	15	35.84%	49.49%	56.31%				
P191	338	15	73.95%	102.94%	117.45%	B	21	48%	2011-2015
P192	282	15	73.96%	102.95%	117.46%	B	21	48%	2011-2015
P193	263	15	73.97%	102.97%	117.47%	B	21	48%	2011-2015
P194	20	15	8.37%	11.08%	12.44%				
P195	21	15	27.68%	39.02%	44.69%				
P196	245	12	11.37%	15.12%	16.99%				
P197	241	15	32.55%	45.86%	52.51%				
P198	192	15	32.55%	45.86%	52.52%				
P199	130	15	14.92%	21.02%	24.07%				
P200	312	15	32.55%	45.86%	52.51%				
P201	446	15	22.86%	32.21%	36.89%				
P202	461	15	31.88%	44.91%	51.43%				
P203	34	15	25.35%	35.72%	40.91%				
P204	340	18	38.25%	53.90%	61.72%				
P205	337	18	37.12%	52.30%	59.89%				
P206	354	18	36.57%	51.53%	59.01%				
P207	411	24	17.10%	24.09%	27.59%				
P208	87	18	18.61%	26.23%	30.04%				
P209	337	18	18.52%	26.09%	29.88%				
P210	427	18	18.80%	26.49%	30.34%				
P211	429	18	18.81%	26.51%	30.36%				
P212	400	18	13.75%	19.77%	22.78%				
P213	431	18	14.26%	20.50%	23.62%				
P214	70	18	9.50%	14.20%	16.56%				
P215	545	18	9.41%	14.06%	16.39%				
P216	456	15	7.49%	12.10%	14.41%				
P217	450	15	7.48%	12.08%	14.39%				
P218	453	15	7.80%	12.60%	15.00%				
P219	290	15	6.83%	11.03%	13.14%				
P220	206	15	6.62%	10.70%	12.74%				
P221	500	15	9.20%	14.88%	17.71%				
P222	441	15	8.83%	14.27%	16.99%				
P223	529	12	9.14%	14.76%	17.58%				
P224	455	12	12.13%	19.60%	23.34%				
P225	428	12	12.90%	20.85%	24.83%				
P226	488	12	6.73%	8.49%	9.37%				
P227	434	12	6.40%	12.35%	15.33%				
P228	450	12	6.85%	13.22%	16.40%				
P229	450	12	9.49%	18.33%	22.74%				
P230	449	12	23.29%	44.94%	55.77%				
P231	400	12	22.42%	43.21%	53.61%				
P232	70	12	9.30%	17.93%	22.24%				
P233	70	12	4.06%	7.83%	9.71%				
P234	82	12	6.60%	12.73%	15.80%				
P235	175	12	6.45%	12.43%	15.43%				

Table 7-2
Proposed Construction Prioritization and Schedule

Pipe Name	Pipe Length (ft)	Existing Pipe Size (inch)	Existing Estimated % Full (Year 2005)	Year 2015 Estimated % Full	Future Estimated % Full (Year 2020)	Priority	New Diameter (inch)	New % Full (Year 2020)	Approximate Replacement Period
P236	193	12	6.45%	12.43%	15.42%				
P237	450	15	10.88%	20.97%	26.02%				
P238	444	15	10.81%	20.90%	25.95%				
P239	109	15	0.82%	8.56%	12.43%				
P240	250	15	0.81%	8.47%	12.31%				
P241	367	15	0.82%	0.96%	1.03%				
P242	227	15	0.18%	0.18%	0.18%				
P243	263	15	0.26%	0.26%	0.27%				
P244	39	15	0.26%	0.26%	0.26%				
P245	260	15	0.33%	0.33%	0.33%				
P246	318	15	0.52%	0.52%	0.52%				
P247	220	15	0.53%	0.53%	0.53%				
P248	123	15	0.52%	0.52%	0.53%				
P249	230	15	0.52%	0.52%	0.52%				
P250	323	15	0.52%	0.52%	0.52%				
P251	301	15	0.54%	0.54%	0.54%				
P252	332	15	27.77%	29.03%	29.65%				
P253	332	15	27.74%	29.00%	29.62%				
P254	144	15	55.06%	57.54%	58.79%				
P255	189	15	58.21%	60.84%	62.16%				
P256	332	15	58.09%	60.72%	62.03%				
P257	332	15	58.10%	60.72%	62.03%				
P258	338	15	57.49%	60.09%	61.39%				
P259	333	15	64.69%	67.61%	69.07%				
P260	333	15	64.31%	67.21%	68.67%				
P261	58	15	63.98%	66.87%	68.31%				
P262	75	15	60.07%	62.78%	64.13%				
P263	195	15	51.40%	53.72%	54.88%				
P264	308	15	58.22%	60.85%	62.17%				
P265	24	15	27.77%	29.02%	29.65%				
P266	337	15	43.62%	45.59%	46.58%				
P267	333	15	31.01%	32.41%	33.11%				
P268	333	15	30.99%	32.39%	33.09%				
P269	338	15	36.63%	38.29%	39.11%				
P270	156	15	27.20%	28.60%	29.29%				
P271	174	15	27.85%	29.28%	30.00%				
P272	158	15	37.54%	39.47%	40.43%				
P273	174	15	33.43%	35.15%	36.01%				
P274	149	15	38.78%	40.77%	41.77%				
P275	185	15	33.05%	34.75%	35.60%				
P276	331	15	35.59%	37.42%	38.33%				
P277	268	15	29.09%	30.58%	31.33%				
P278	265	12	23.39%	24.65%	25.28%				
P279	268	12	23.73%	25.00%	25.64%				
P280	264	12	13.80%	14.54%	14.91%				
P281	267	12	12.05%	12.70%	13.02%				
P282	12	12	22.92%	24.15%	24.77%				
P283	320	12	68.50%	72.02%	73.78%				
P284	277	12	67.74%	71.22%	72.96%				
P285	282	12	68.02%	71.52%	73.26%				
P286	205	12	69.22%	72.78%	74.56%				
P287	221	12	47.96%	51.02%	52.56%				
P288	12	12	30.26%	32.20%	33.17%				
P289	120	12	51.85%	55.17%	56.82%				
P290	223	12	30.73%	33.51%	34.89%				
P291	324	12	32.53%	35.46%	36.93%				
P292	330	12	32.68%	35.63%	37.11%				
P293	332	12	32.35%	35.27%	36.73%				
P294	224	12	32.45%	35.38%	36.85%				
P295	271	12	31.95%	34.83%	36.27%				
P296	72	12	19.46%	22.45%	23.94%				
P297	216	12	19.47%	22.46%	23.95%				
P298	272	12	19.16%	22.09%	23.56%				
P299	249	12	20.35%	23.47%	25.03%				
P300	360	12	0.74%	1.08%	1.25%				
P301	391	15	16.93%	25.53%	29.83%				
P302	299	12	0.71%	1.06%	1.24%				
P303	436	15	15.71%	23.68%	27.67%				
P304	131	12	0.70%	1.06%	1.23%				
P305	221	12	0.71%	1.06%	1.23%				
P306	437	15	15.27%	23.03%	26.91%				
P307	363	12	0.72%	1.08%	1.26%				
P308	444	15	16.17%	24.38%	28.49%				
P309	243	12	0.71%	1.07%	1.25%				
P310	111	12	0.71%	1.07%	1.24%				

Table 7-2
Proposed Construction Prioritization and Schedule

Pipe Name	Pipe Length (ft)	Existing Pipe Size (inch)	Existing Estimated % Full (Year 2005)	Year 2015 Estimated % Full	Future Estimated % Full (Year 2020)	Priority	New Diameter (inch)	New % Full (Year 2020)	Approximate Replacement Period
P311	361	12	1.20%	1.80%	2.10%				
P312	335	15	15.31%	23.08%	26.96%				
P313	457	15	21.35%	32.19%	37.61%				
P314	341	12	1.20%	1.79%	2.08%				
P315	326	15	20.81%	31.38%	36.66%				
P316	404	12	1.27%	1.88%	2.19%				
P317	509	15	23.76%	35.81%	41.84%				
P318	236	12	1.20%	1.78%	2.06%				
P319	236	12	1.22%	1.79%	2.08%				
P322	231	15	12.62%	19.03%	22.23%				
P324	50	8	10.17%	12.11%	13.08%				
P325	283	12	0.85%	1.25%	1.46%				
P326	55	12	0.80%	1.17%	1.36%				
P327	176	12	0.85%	1.25%	1.45%				
P328	252	15	17.97%	27.08%	31.64%				
P329	146	12	7.97%	9.71%	10.57%				
P330	401	15	31.42%	49.88%	59.12%				
P331	325	12	20.70%	25.20%	27.46%				
P332	272	15	21.11%	33.50%	39.69%				
P333	328	12	20.47%	24.88%	27.09%				
P334	378	15	21.58%	34.24%	40.57%				
P335	338	12	20.90%	25.36%	27.59%				
P336	399	15	21.29%	33.77%	40.02%				
P337	335	12	21.80%	26.39%	28.69%				
P338	401	15	21.38%	33.92%	40.19%				
P339	332	12	20.01%	24.17%	26.24%				
P340	396	15	16.24%	25.75%	30.52%				
P341	335	10	14.18%	17.11%	18.57%				
P342	403	15	16.40%	26.01%	30.81%				
P343	335	10	14.28%	17.18%	18.62%				
P344	305	15	16.46%	26.11%	30.94%				
P345	335	10	14.37%	17.24%	18.68%				
P346	348	15	16.29%	25.84%	30.61%				
P347	335	10	14.47%	17.34%	18.77%				
P348	400	15	16.35%	25.93%	30.72%				
P349	314	10	14.35%	17.13%	18.52%				
P350	229	10	20.53%	24.18%	26.01%				
P351	67	10	0.82%	1.01%	1.10%				
P352	182	15	9.00%	14.27%	16.91%				
P353	110	10	0.00%	0.00%	0.00%				
P354	94	8	24.85%	39.35%	46.60%				
P355	186	8	24.47%	38.74%	45.87%				
P356	83	12	8.52%	13.48%	15.97%				
P357	76	18	11.39%	18.06%	21.39%				
P358	31	18	1.22%	1.94%	2.30%				
P359	168	18	6.09%	9.66%	11.44%				
P361	317	18	6.04%	9.57%	11.33%				
P362	258	18	6.37%	10.09%	11.95%				
P363	253	18	5.12%	8.12%	9.61%				
P364	8	18	3.74%	5.92%	7.01%				
P365	158	12	12.89%	20.40%	24.16%				
P366	47	12	12.45%	19.71%	23.35%				
P367	42	12	9.40%	10.19%	10.58%				
P368	177	15	5.16%	5.60%	5.81%				
P369	401	15	5.16%	5.60%	5.81%				
P370	420	15	4.30%	4.60%	4.75%				
P371	7	15	24.01%	25.67%	26.50%				
P372	224	15	20.49%	21.91%	22.62%				
P373	212	15	20.40%	21.82%	22.53%				
P374	262	15	20.37%	21.78%	22.49%				
P375	532	15	20.34%	21.75%	22.46%				
P376	222	12	37.02%	39.59%	40.87%				
P377	325	12	29.41%	30.79%	31.49%				
P378	146	12	29.51%	30.90%	31.60%				
P379	406	12	19.14%	20.04%	20.49%				
P380	549	12	19.11%	20.01%	20.46%				
P381	11	12	3.64%	3.70%	3.73%				
P382	69	10	18.28%	18.55%	18.69%				
P384	175	10	21.85%	22.17%	22.34%				
P385	6	10	13.96%	14.17%	14.27%				
P386	189	10	40.13%	40.73%	41.03%				
P387	10	10	8.94%	9.07%	9.14%				
P388	60	10	18.92%	19.20%	19.34%				
P389	200	10	24.17%	24.52%	24.70%				
P390	256	10	13.19%	13.39%	13.50%				

Table 7-2
Proposed Construction Prioritization and Schedule

Pipe Name	Pipe Length (ft)	Existing Pipe Size (inch)	Existing Estimated % Full (Year 2005)	Year 2015 Estimated % Full	Future Estimated % Full (Year 2020)	Priority	New Diameter (inch)	New % Full (Year 2020)	Approximate Replacement Period
P391	13	10	15.83%	16.08%	16.20%				
P392	631	15	45.14%	45.87%	46.24%				
P393	87	15	34.93%	35.50%	35.78%				
P394	87	15	29.75%	30.23%	30.48%				
P395	286	15	42.73%	43.42%	43.77%				
P396	24	15	23.81%	24.23%	24.45%				
P397	798	15	43.38%	44.16%	44.55%				
P398	210	12	41.41%	42.15%	42.52%				
P399	451	12	41.56%	42.31%	42.68%				
P400	1028	33	58.92%	82.52%	94.33%	C	39	60%	2016-2020
P401	1273	33	54.89%	77.45%	88.74%	C	39	57%	2016-2020
P402	1906	24	68.42%	86.18%	95.07%	C	30	52%	2016-2020
P405	632	27	64.38%	88.02%	99.85%	C	33	58%	2016-2020
P406	33	27	54.38%	74.39%	84.39%	C	30	64%	2016-2020
P407	595	18	39.52%	46.39%	49.83%				
P408	831	36	21.56%	39.39%	48.31%				
P409	29	21							
P410	29	18							
P411	29	24							
P412	46	21							
P413	46	24							
P414	46	18							
P415	52	21							
P416	52	24							
P417	52	18							
P418	40	21							
P419	40	18							
P420	40	24							
P421	241	10	39.41%	41.39%	42.38%				
P422	300	10	43.25%	45.42%	46.50%				
P423	300	10	43.25%	45.42%	46.50%				
P424	237	10	44.04%	46.25%	47.36%				

* Placed under a different category due to geographical location.

** P150 is a two barrel pipe.

Priority "B" – The pipes listed in this priority are projected to be flowing more than 90% full in the future under estimated maximum flow conditions. A linear interpolation was done for anticipation of the mid-term flow in pipes between year 2005 and ultimate year (2020). The pipes that would be flowing more than 90% full in the year 2015 are placed under priority "B". These pipes need evaluation as new development takes place in the tributary areas. Flow monitoring within the study area should be considered for observation of actual flows. The pipes under this priority are grouped for replacement/re-habilitation in the period (2011-2015).

Priority "C" – The pipes listed in this priority would be flowing more than 75% full in the future under maximum flow conditions. The pipes that are not part of priority "A" and "B" and will flow more than 75% full by the year 2020 are considered as priority "C". These pipes need evaluation as new development takes place in the tributary areas. These may or may not be replaced or paralleled depending on actual observed flow conditions in the future. Flow monitoring within the study area should be considered when significant development occurs. The pipes under this priority are grouped for possible replacement/re-habilitation in the period (2016-2020).

7.3 Recommended Improvements

Table 7-3 lists project priority, project location, problem, solution and approximate cost for problem reaches. This table identifies immediate and future problems in the sewer lines and suggested solutions. The project cost is based on year 2005 indices.

Note that the first order of priority is field observation of all pipes where modeled results indicate surcharging conditions, to verify that flows are indeed exceeding pipe capacity.

7.4 Grouping of Projects

Proposed improvements under different priorities have been combined or grouped into projects to improve deficient and marginally deficient pipes based on the following criteria:

Pipes identified as marginally deficient in the near future (Priority "B"), and marginally deficient in the more distant future (Priority "C") located geographically close to one another and requiring improvements, are grouped to reduce improvement costs.

Table 7-3
Summary of Improvement Plans for Problem Areas
Priority "A"

Priority	Location	Pipes	Problem	Solution	Approx. Cost (2005 $'s)
"A" (See Figures 22A, 22B and Table 7-2 for details of pipes)	Central Avenue	Pipes P125	Immediate Capacity Problem in reach M123 to M136 due to flat slope and smaller pipe size. Surcharging conditions.	Field verify surcharging conditions. Replace pipes with larger sizes pipe maintaining the same slope	$294,000
	Hillside Avenue	Pipes P100 to P101, P104, P106, P108 to P109, P111 to P112, P114 to P116, P120, P121A to P121B and P123	Immediate Capacity Problem in reaches M106 to M107, M107 to M108, M108 to M112, M112 to M121, M121 to M121A, M121A to M122, M122 to M123 due to flat slopes and small pipe sizes. Surcharging conditions.	Field verify surcharging conditions. Replace pipes with larger sizes pipe maintaining the same slope	$1,393,000
	Phoenix Avenue	Pipes P149-P150	Immediate Capacity Problem in reach M210 to M212 due to flat slopes and small pipe sizes. Surcharging conditions.	Field verify surcharging conditions. Replace pipes with larger sizes pipe maintaining the same slope	$71,000
	Santa Ana River Pipeline	Pipes P077 to P082	Immediate Capacity Problem in reaches M094 to M087, M058 to M060, M088 to M087 and M087 to M086 due to flat slopes and small pipe sizes. Surcharging conditions.	Field verify surcharging conditions. Replace pipes with larger sizes pipe maintaining the same slope	$828,000
				Total Cost for Priority "A" Projects (2005-2010 Replacement / Rehabilitation)	**$2,586,000**

Table 7-3
Summary of Improvement Plans for Problem Areas
Priority "B"

Priority	Location	Pipes	Problem	Solution	Approx. Cost (2005 $'s)
"B" (See Figures 23A, 23B and Table 7-2 for details of pipes)	Madison Street	Pipes P191 to P193	Future Capacity Problem in reach M246 to M249 due to smaller pipe sizes, flat slopes and increased flow in the system.	Monitor flow in future to verify that it will exceed 90% criteria. Replace pipes with larger size pipes maintaining the same slope	$304,000
				Total Cost for Priority "B" Projects (2011-2015 Replacement / Rehabilitation)	**$304,000**

Table 7-3
Summary of Improvement Plans for Problem Areas
Priority "C"

Priority	Location	Pipes	Problem	Solution	Approx. Cost (2005 $'s)
"C" (See Figures 24A, 24B and Table 7-2 for details of pipes)	Madison Street	Pipes P179 to P185	Future Capacity Problem in reaches M235 to M242 due to flat slopes, smaller pipe sizes and increased flow in the system.	Monitor in future to verify that flows exceed 75% criteria. Replace with larger size pipes maintaining same slopes if surcharging appears imminent or if part of another needed project.	$716,000
	Phoenix Avenue	Pipes P132, P134, P136, P139, P141 to P143, P145, P147	Future Capacity Problem in reaches M140 to M141, M141 to M143, M143 to M144, M144 to M148, M148 to M149, M150 to M152, M149 to M151, M151 to M207, M207 to M210 due to flat slopes, smaller pipe sizes and increased flow in the system.	Monitor in future to verify that flows exceed 75% criteria. Replace with larger size pipes maintaining same slopes if surcharging appears imminent or if part of another needed project.	$1,100,000
	Santa Ana River Pipeline	Pipes P001 to P005, P006 to P008, P011 to P014, P016, P018 to P020, P022 to P023, P025 to P029, P031, P034 to P036, P038, P040, P042 to P043, P046 to P051, P053, P054, P055, P056 to P057, P059, P062, P063 to P065, P067 to P069, P071 to P073, P075, P076, P033, P037, P010, P015, P017, P021, P024, P030, P039, P041, P052, P058, P061, P070, P074, P082, P400 to P402, P405 to P406	Future Capacity Problem in the entire reach of two parallel pipelines along Santa Ana River between M001 to M426 due to flat slopes and increased flow in the system.	Monitor in future to verify that flows exceed 75% criteria. Replace with larger size pipes maintaining same slopes if surcharging appears imminent or if part of another needed project.	$17,622,000
				Total Cost for Priority "C" Projects (2016-2020 Replacement / Rehabilitation)	**$19,438,000**

7.5 Construction Schedule

A summary of proposed construction prioritization and recommended scheduling is shown in Table 7-2. This table lists construction priorities and the year in which these activities are proposed. Also, the pipes included in priorities “B” and “C” will need re-evaluation before their replacement.

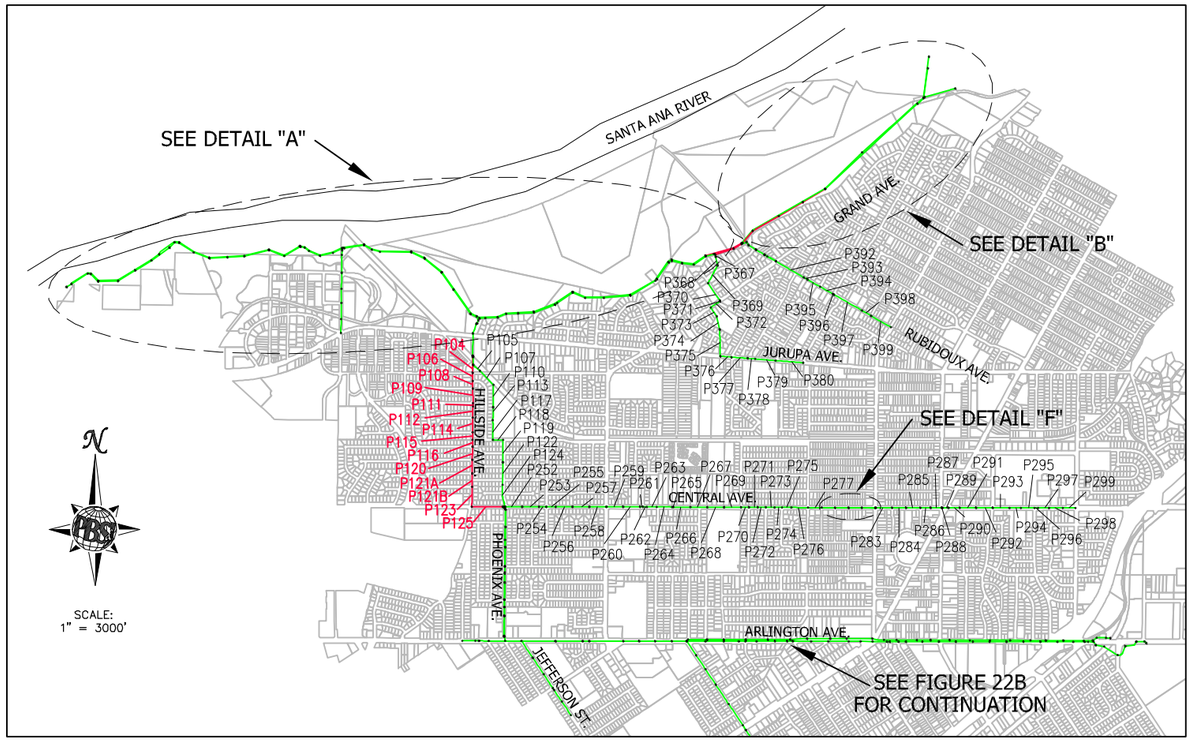
7.6 Cost Estimate

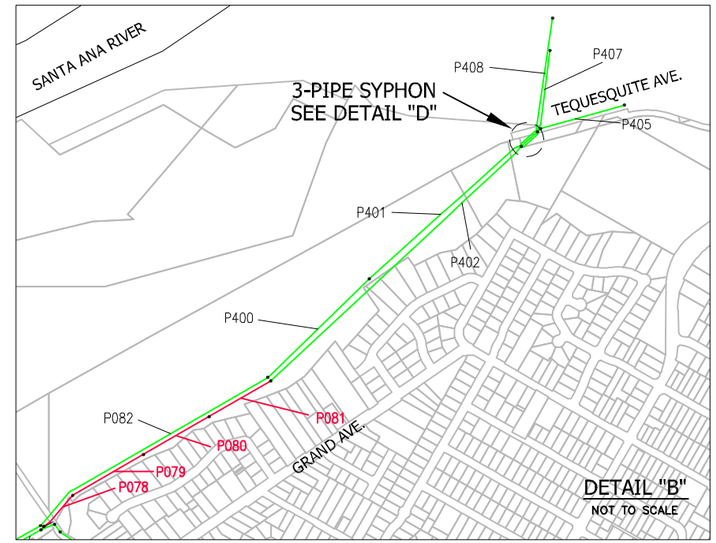
Unit costs of pipes are based on bid prices for similar projects and from the web site www.get-a-quote.net. The cost of construction includes labor, materials, excavation, backfill and all other items associated with pipe laying. To estimate total cost, cost of mobilization / demobilization (7%), traffic control (7%), bond (1%), contractor’s profit (15%) and construction contingency (25%) is added to the cost of construction. The cost of engineering, right of way acquisition, permits, soil conditions remediation and by-pass pumping is not included in the construction cost. For priorities “B” and “C”, the cost estimate is based on year 2005 prices and no escalation has been added to estimate future cost. Following is the summary of cost for the various priorities:

Priority “A” - $2.59 Million (2005 $’s) (See Figures 22A, 22B and Table 7-4 for details)

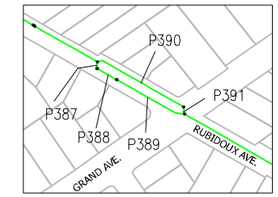
Priority “B” - $0.30 Million (2005 $’s) (See Figures 23A, 23B and Table 7-5 for details)

Priority “C” - $19.44 Million (2005 $’s) (See Figures 24A, 24B and Table 7-6 for details)

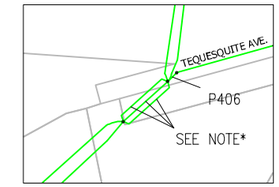




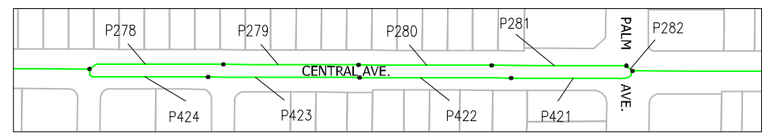
DETAIL "B"
NOT TO SCALE



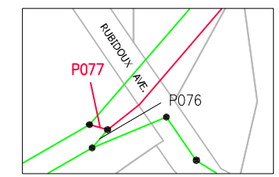
DETAIL "C"
NOT TO SCALE



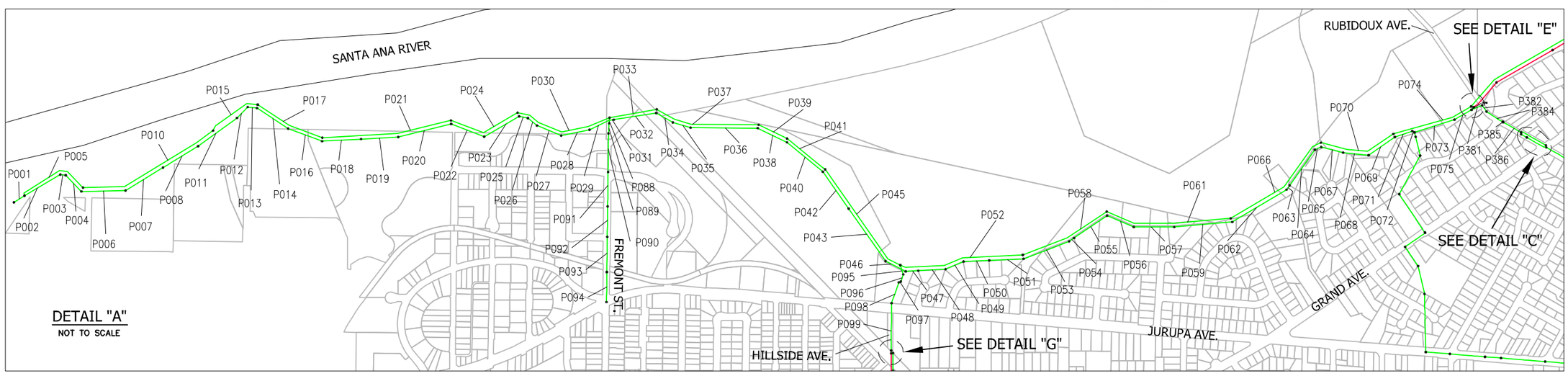
DETAIL "D"
NOT TO SCALE



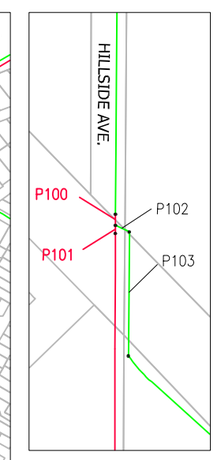
DETAIL "F"
NOT TO SCALE



DETAIL "E"
NOT TO SCALE



DETAIL "A"
NOT TO SCALE



DETAIL "G"
NOT TO SCALE

LEGEND

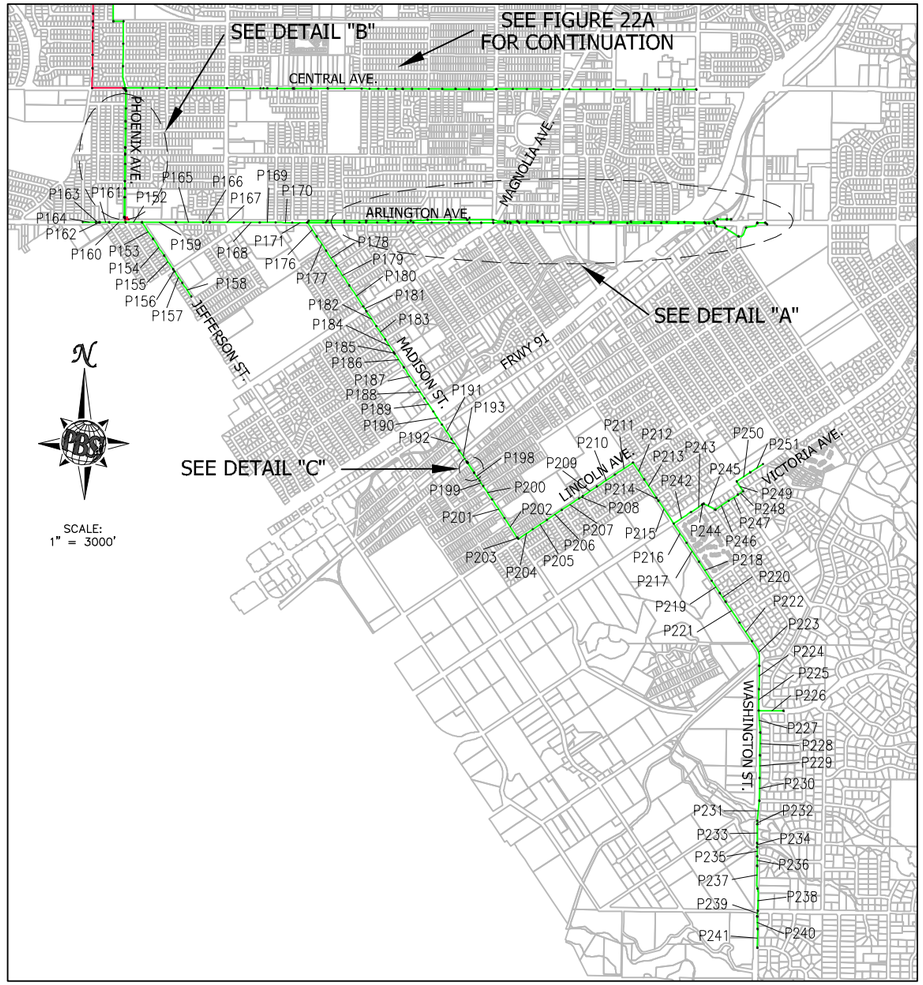
- GRAVITY SEWER
- IMPROVEMENT SEWER (2005 – 2010)
- P001 PIPELINE NUMBER

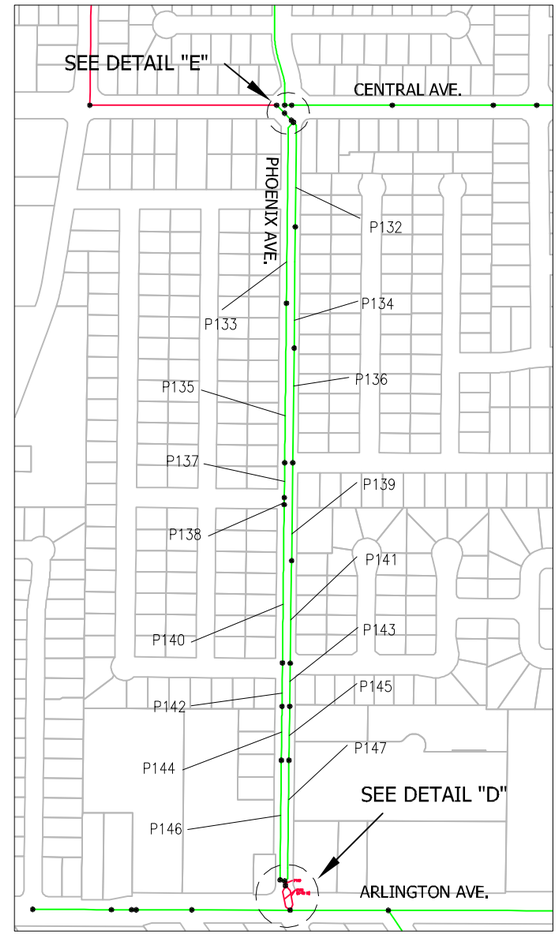
NOTE* THIS 3–PIPE SYPHON CONSISTS OF PIPELINE NUMBERS P409 THROUGH P420.

Engineering
Planning
Surveying
Construction Services
PBS&J
10370 Hemet Street
Suite 200
Riverside, CA 92503
Tel:(951) 358–1433
Fax:(951) 358–1434

DATE: 12/15/05	DWN BY: CD
CITY OF RIVERSIDE PHOENIX SEWER STUDY	FIGURE 22A
PRIORITY "A" - PART 1	

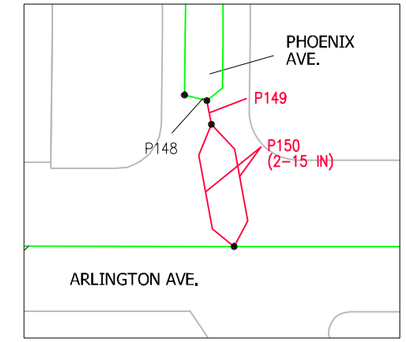
Y:\City of Riverside\Phoenix\DWG\Exhibits\PH-PriorityA-A.dwg, 9/28/2006 10:57:40 AM
H:\Client\Riversid_SAOW\7472A00\Rpt\Volume 03\Appendices\Ch01-AppxD-Phoenix Final 02-26-07.pdf



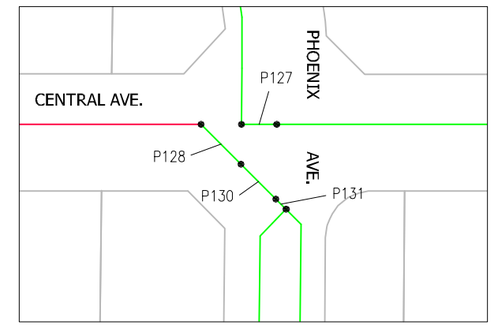


DETAIL "B"
NOT TO SCALE

DETAIL "C"
NOT TO SCALE



DETAIL "D"
NOT TO SCALE



DETAIL "E"
NOT TO SCALE

LEGEND

	GRAVITY SEWER
	IMPROVEMENT SEWER (2005 – 2010)
P001	PIPELINE NUMBER

DETAIL "A"
NOT TO SCALE

DATE: 12/15/05 | DWN BY: CD

Engineering
Planning
Surveying
Construction Services

PBS&J

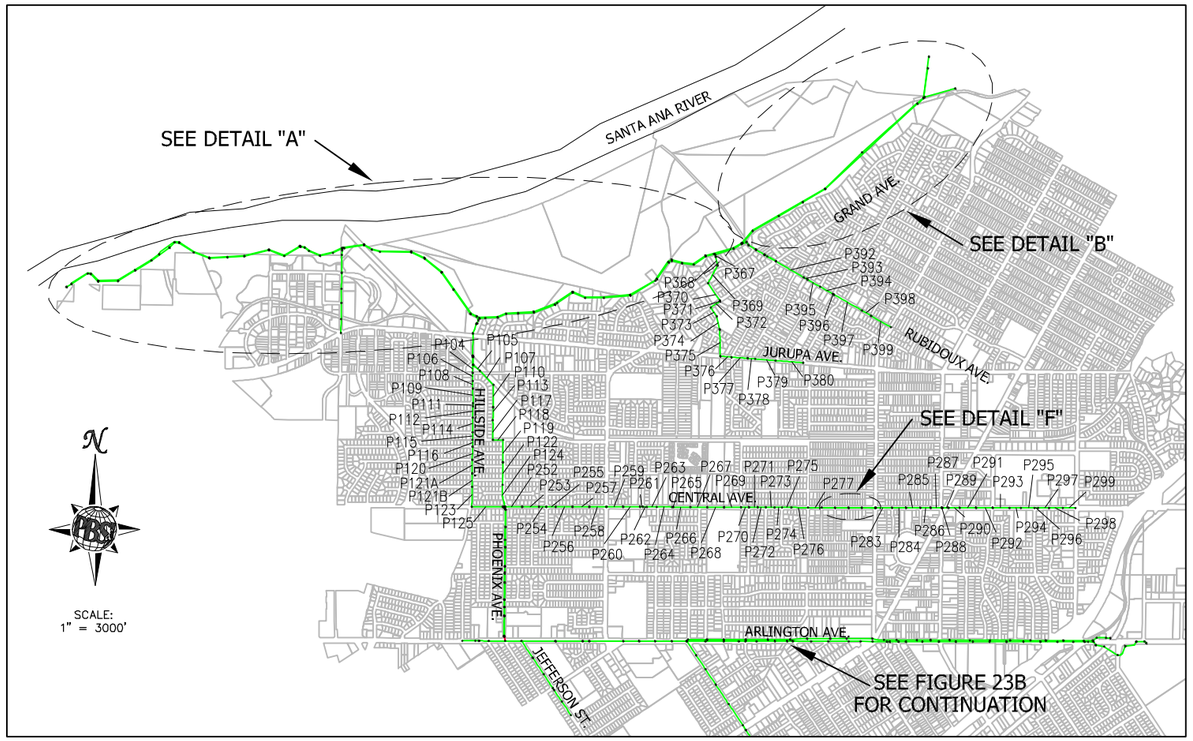
10370 Hemet Street
Suite 200
Riverside, CA 92503
Tel:(951) 358-1433
Fax:(951) 358-1434

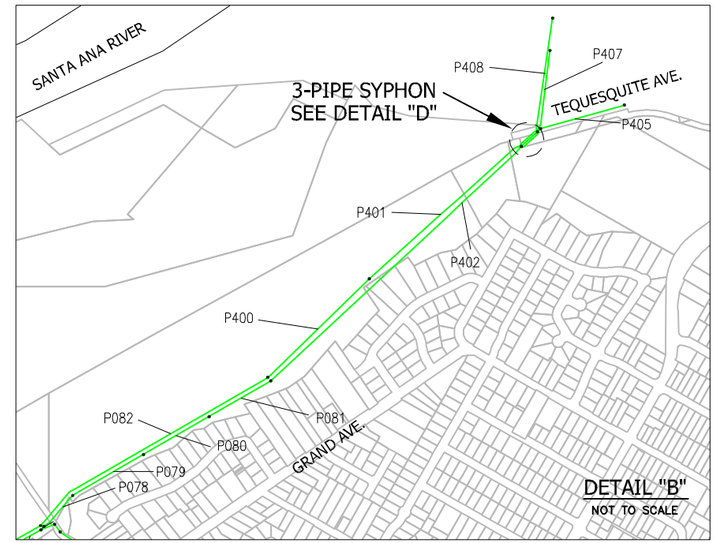
CITY OF RIVERSIDE
PHOENIX SEWER STUDY

FIGURE 22B

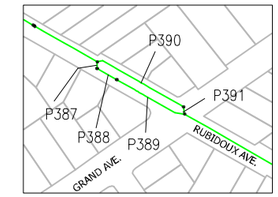
PRIORITY "A" - PART 2

Y:\City of Riverside\Phoenix\DWG\Exhibits\PH-PriorityA-B.dwg, 9/28/2006 11:01:15 AM

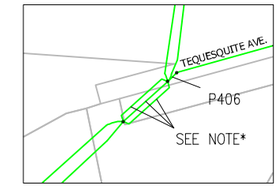




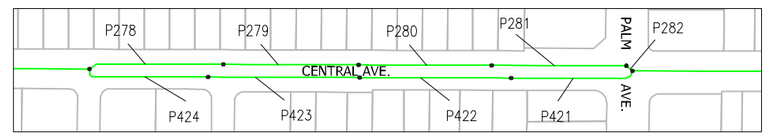
DETAIL "B"
NOT TO SCALE



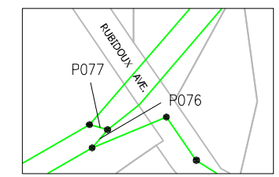
DETAIL "C"
NOT TO SCALE



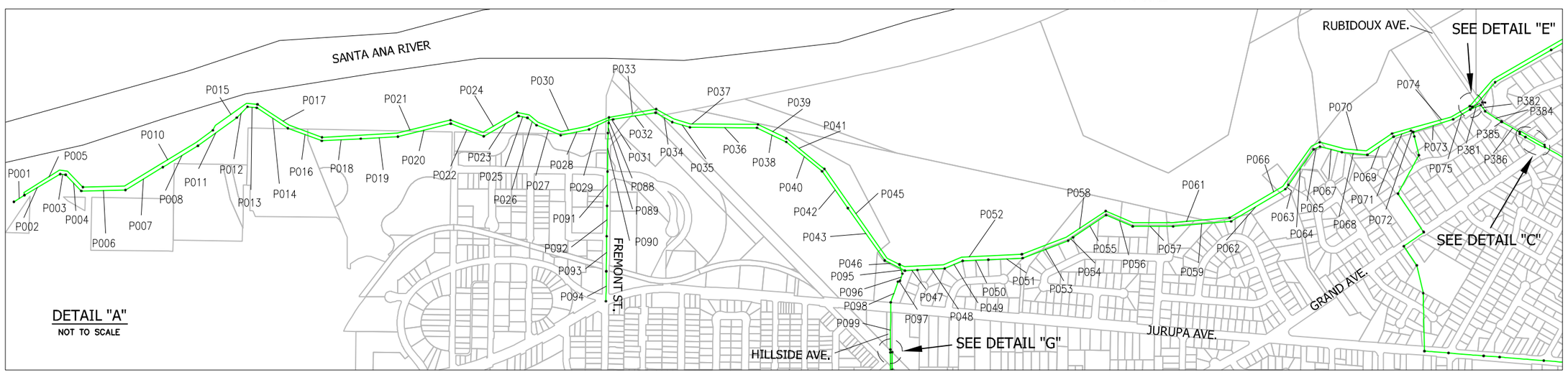
DETAIL "D"
NOT TO SCALE



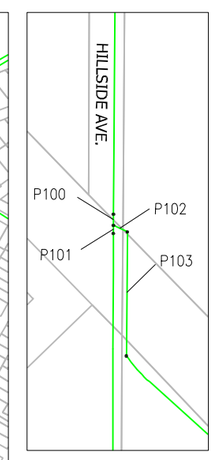
DETAIL "F"
NOT TO SCALE



DETAIL "E"
NOT TO SCALE



DETAIL "A"
NOT TO SCALE



DETAIL "G"
NOT TO SCALE

LEGEND

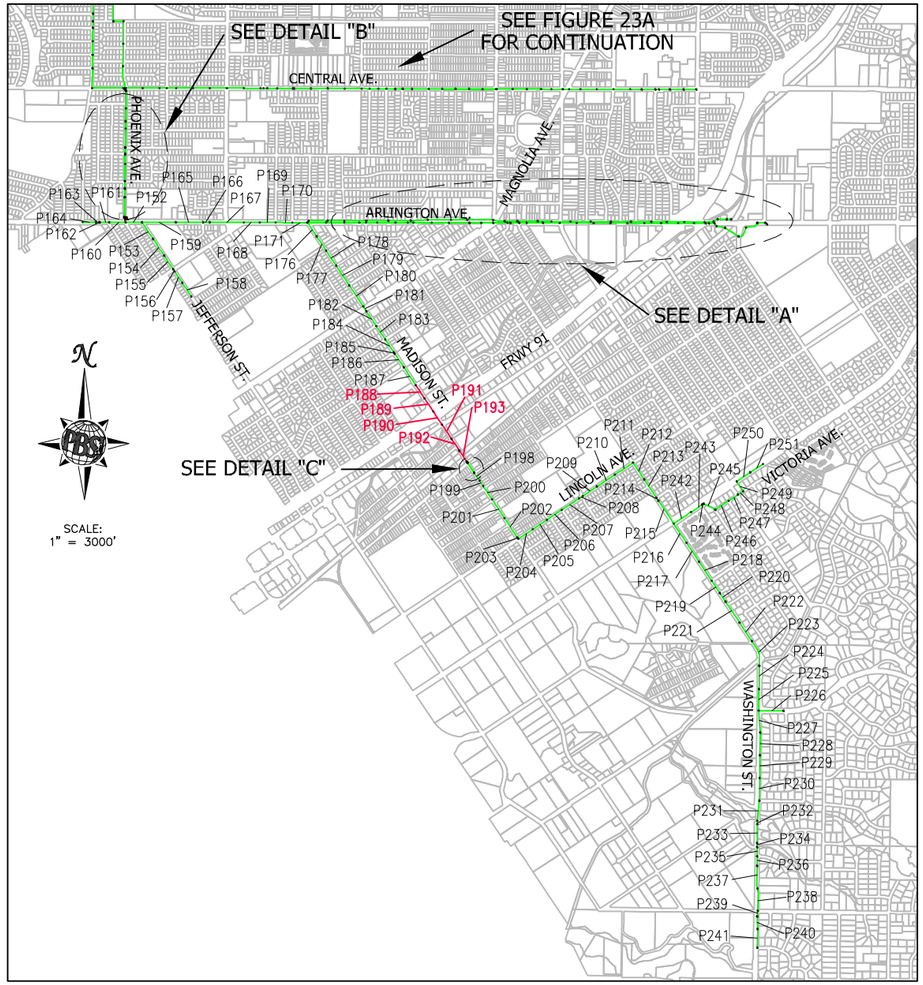
- GRAVITY SEWER
- IMPROVEMENT SEWER (2011 – 2015)
- P001 PIPELINE NUMBER

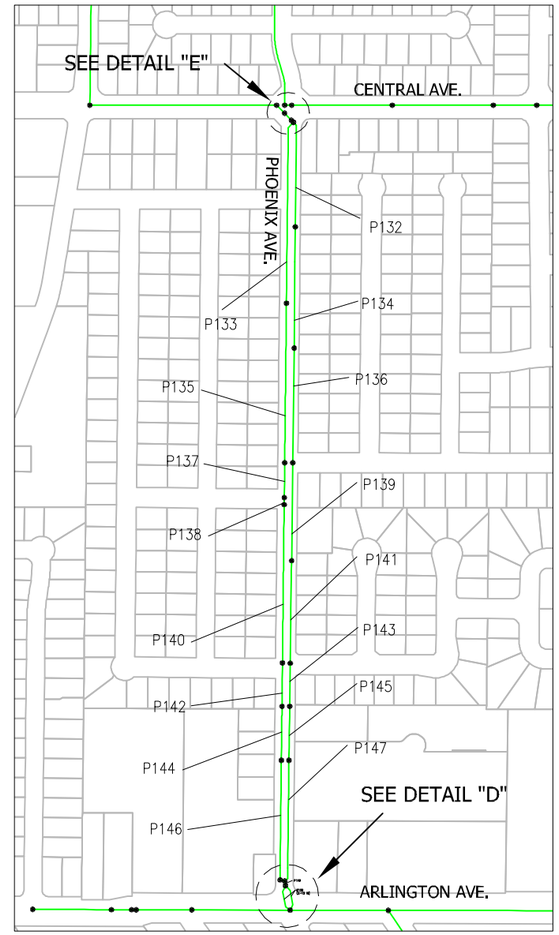
NOTE* THIS 3–PIPE SYPHON CONSISTS OF PIPELINE NUMBERS P409 THROUGH P420.

Engineering
Planning
Surveying
Construction Services
PBS&J
10370 Hemet Street
Suite 200
Riverside, CA 92503
Tel:(951) 358–1433
Fax:(951) 358–1434

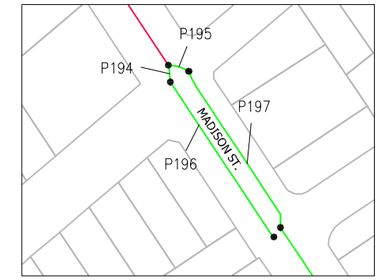
DATE: 12/15/05	DWN BY: CD
CITY OF RIVERSIDE PHOENIX SEWER STUDY	FIGURE 23A
PRIORITY "B" - PART 1	

Y:\City of Riverside\Phoenix\DWG\Exhibits\PH-PriorityB-A.dwg, 9/28/2006 11:02:13 AM
H:\Client\Riversid_SAOW\7472A00\Rpt\Volume 03\Appendices\Ch01-AppxD-Phoenix Final 02-26-07.pdf

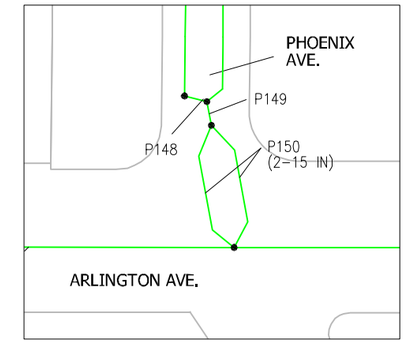




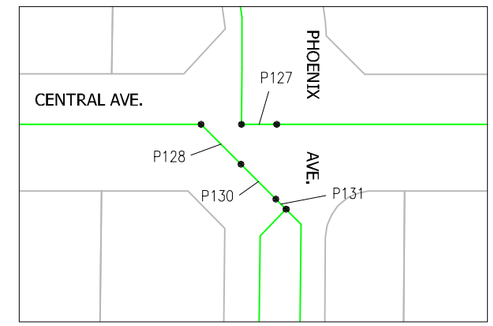
DETAIL "B"
NOT TO SCALE



DETAIL "C"
NOT TO SCALE



DETAIL "D"
NOT TO SCALE



DETAIL "E"
NOT TO SCALE

LEGEND

	GRAVITY SEWER
	IMPROVEMENT SEWER (2011 – 2015)
P001	PIPELINE NUMBER

DETAIL "A"
NOT TO SCALE

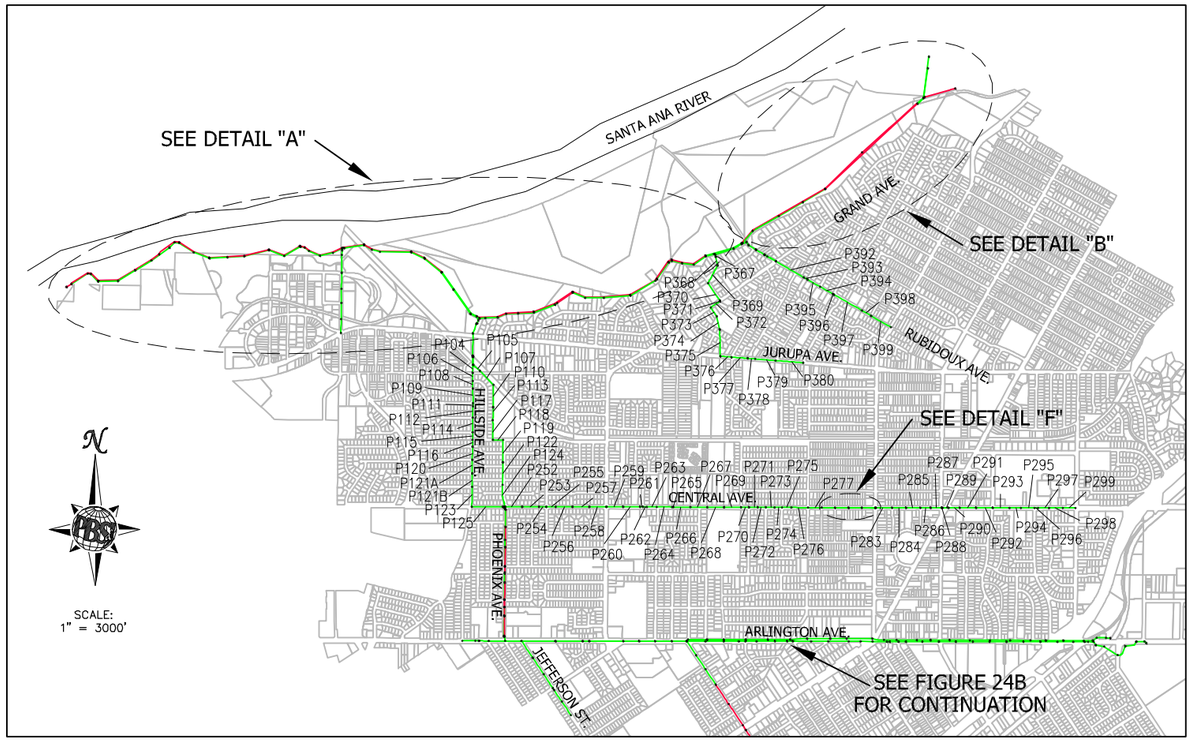
Engineering
Planning
Surveying
Construction Services

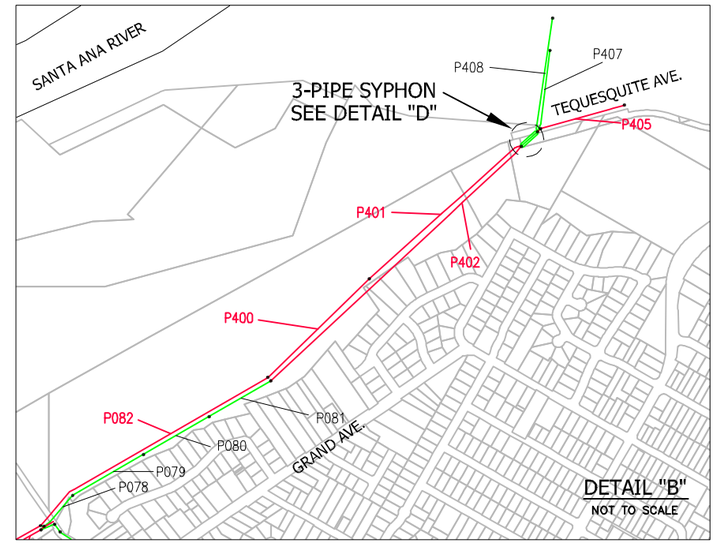
PBS&J

10370 Hemet Street
Suite 200
Riverside, CA 92503
Tel:(951) 358-1433
Fax:(951) 358-1434

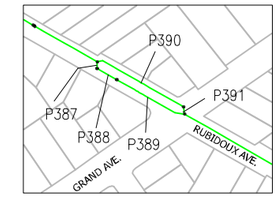
DATE: 12/15/05	DWN BY: CD
CITY OF RIVERSIDE PHOENIX SEWER STUDY	FIGURE 23B
PRIORITY "B" - PART 2	

Y:\City of Riverside\Phoenix\DWG\Exhibits\PH-PriorityB-B.dwg, 9/28/2006 11:03:05 AM

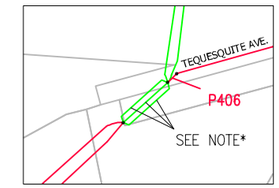




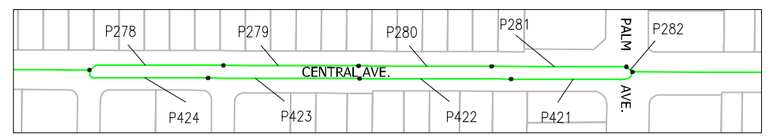
DETAIL "B"
NOT TO SCALE



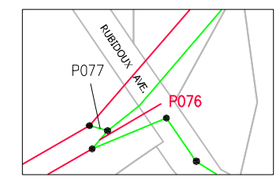
DETAIL "C"
NOT TO SCALE



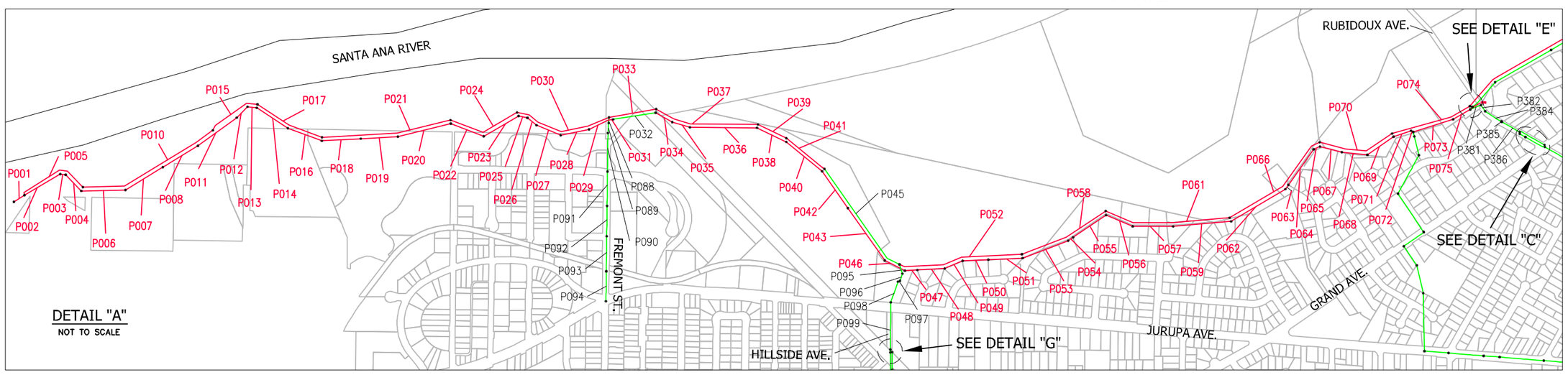
DETAIL "D"
NOT TO SCALE



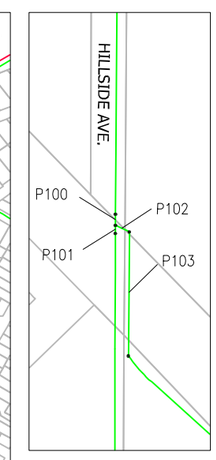
DETAIL "F"
NOT TO SCALE



DETAIL "E"
NOT TO SCALE



DETAIL "A"
NOT TO SCALE



DETAIL "G"
NOT TO SCALE

LEGEND

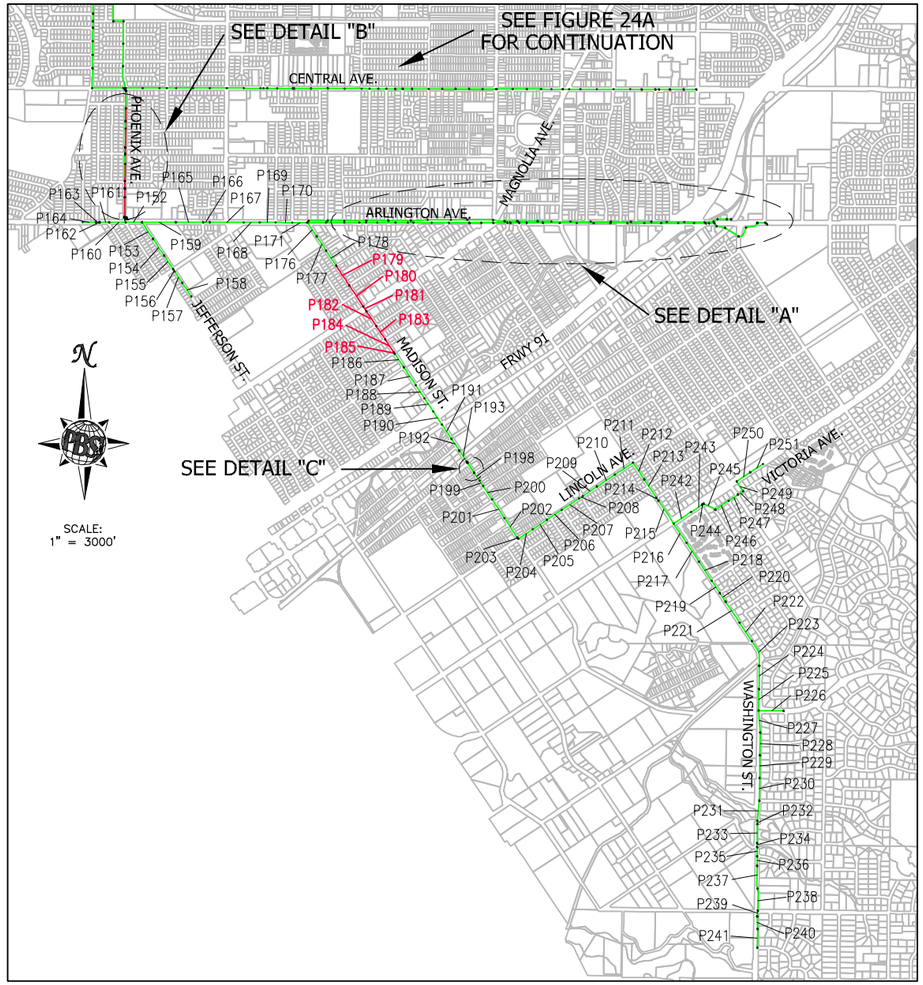
- GRAVITY SEWER
- IMPROVEMENT SEWER (2016 – 2020)
- P001 PIPELINE NUMBER

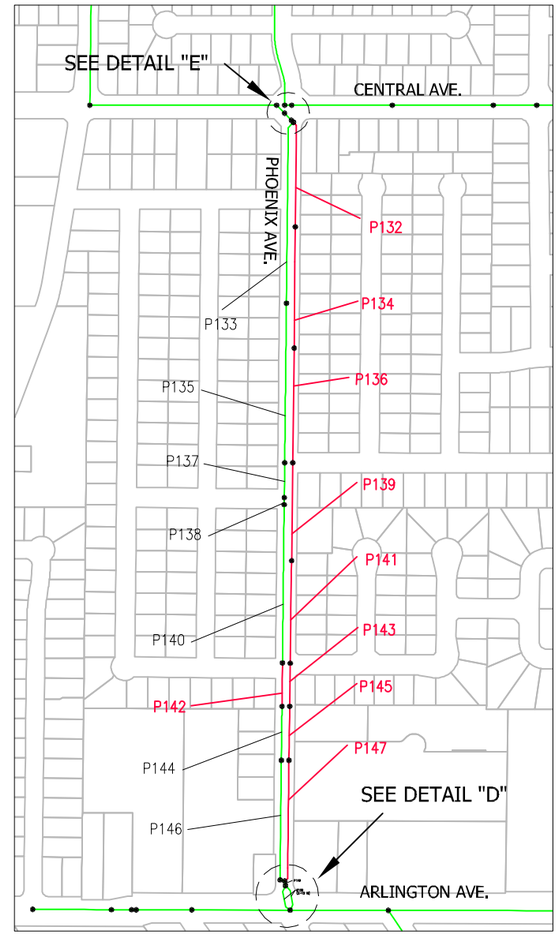
NOTE* THIS 3–PIPE SYPHON CONSISTS OF PIPELINE NUMBERS P409 THROUGH P420.

Engineering
Planning
Surveying
Construction Services
PBS&J
10370 Hemet Street
Suite 200
Riverside, CA 92503
Tel:(951) 358–1433
Fax:(951) 358–1434

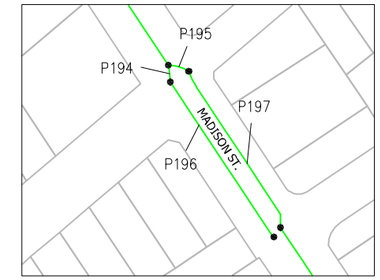
DATE: 12/15/05	DWN BY: CD
CITY OF RIVERSIDE PHOENIX SEWER STUDY	FIGURE 24A
PRIORITY "C" - PART 1	

Y:\City of Riverside\Phoenix\DWG\Exhibits\PH-PriorityC-A.dwg, 9/28/2006 11:04:22 AM
H:\Client\Riversid_SAOW\7472A00\Rpt\Volume 03\Appendices\Ch01-AppxD-Phoenix Final 02-26-07.pdf

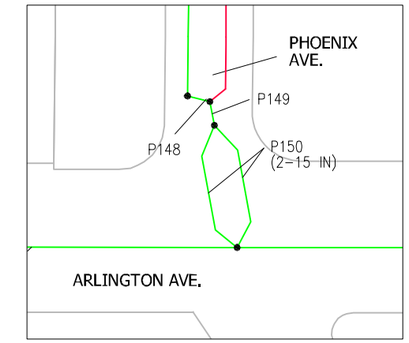




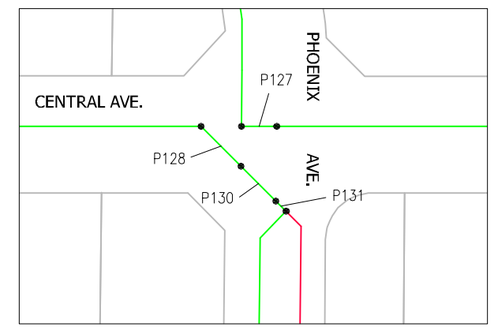
DETAIL "B"
NOT TO SCALE



DETAIL "C"
NOT TO SCALE



DETAIL "D"
NOT TO SCALE



DETAIL "E"
NOT TO SCALE

LEGEND

GRAVITY SEWER

IMPROVEMENT SEWER (2016 – 2020)

P001 PIPELINE NUMBER

DETAIL "A"
NOT TO SCALE

Engineering
Planning
Surveying
Construction Services

PBS&J

10370 Hemet Street
Suite 200
Riverside, CA 92503
Tel:(951) 358-1433
Fax:(951) 358-1434

DATE: 12/15/05	DWN BY: CD
CITY OF RIVERSIDE PHOENIX SEWER STUDY	FIGURE 24B
PRIORITY "C" - PART 2	

Y:\City of Riverside\Phoenix\DWG\Exhibits\PH-PriorityC-B.dwg, 9/28/2006 11:09:16 AM

Table 7-6
Preliminary Construction Cost Estimate For Priority "C" Projects
(2016- 2020 Replacement / Rehabilitation)

Location	Description	Existing Diameter (inch)	New Diameter (inch)	Unit	Quantity	Unit Cost	Approx Total Cost(2005 $'s)
Madison Street	Replace Pipes P179 to P181	18	24	LF	1079	$200	$215,800
	Replace Pipes P182 to P185	15	18	LF	1008	$145	$146,160
	Rehab / Replace Manhole			EA	8	$5,500	$44,000
	Reconnect Sewer Laterals			EA	21	$1,650	$34,650
						Total:	$440,610
Mobilization / Demobilization (7%)							$30,843
Traffic Control (7%)							$30,843
Bond (1%)							$4,406
Contractor's Profit(15%)							$66,092
Subtotal:							$572,793
Construction Contingency(25%)							$143,198
Total Construction Cost (Madison Street Sewer)							**$716,000**
Phoenix Avenue	Replace Pipes P132, P134, P136, P139, P141, P143, P145, P147	27	30	LF	2503	$220	$550,660
	Replace Pipes P142	21	24	LF	143	$200	$28,600
	Rehab / Replace Manhole			EA	10	$5,500	$55,000
	Reconnect Sewer Laterals			EA	26	$1,650	$42,900
						Total:	$677,160
Mobilization / Demobilization (7%)							$47,401
Traffic Control (7%)							$47,401
Bond (1%)							$6,772
Contractor's Profit(15%)							$101,574
Subtotal:							$880,308
Construction Contingency(25%)							$220,077
Total Construction Cost (Phoenix Avenue Sewer)							**$1,100,000**
Santa Ana River Pipeline	Replace Pipe P001	48	54	LF	115	$390	$44,850
	Replace Pipes P002, P003	24	30	LF	442	$220	$97,240
	Replace Pipes P004	24	27	LF	206	$205	$42,230

Table 7-6
Preliminary Construction Cost Estimate For Priority "C" Projects
(2016- 2020 Replacement / Rehabilitation)

Location	Description	Existing Diameter (inch)	New Diameter (inch)	Unit	Quantity	Unit Cost	Approx Total Cost(2005 $'s)
	Replace Pipes P006-P008, P011-P014, P016, P018-P020, P022-P023, P025-P029, P031, P034-P036	24	30	LF	6310	$220	$1,388,200
	Replace Pipes P038, P040, P042-P043, P046-P051, P053, P054, P056-P057, P059, P062, P063-P065, P067-P069, P071-P073, P075, P076	24	30	LF	7300	$220	$1,606,000
	Replace Pipes P055	24	33	LF	370	$245	$90,650
	Replace Pipes P033, P037	45	48	LF	1400	$340	$476,000
	Replace Pipes P005, P010, P015, P017, P021, P024, P030, P039, P041	45	51	LF	6704	$360	$2,413,440
	Replace Pipes P052, P058, P061, P066, P070	39	45	LF	5008	$320	$1,602,560
	Replace Pipes P074	39	48	LF	763	$340	$259,420
	Replace Pipes P082	36	42	LF	1983	$300	$594,900
	Replace Pipes P400 to P401	33	39	LF	2301	$275	$632,775
	Replace Pipe P406	27	30	LF	33	$220	$7,260
	Replace Pipe P402	24	30	LF	1906	$220	$419,320
	Replace Pipe P405	27	33	LF	632	$245	$154,840
	Rehab / Replace Manhole			EA	78	$5,500	$429,000
	Reconnect Sewer Laterals			EA	355	$1,650	$585,750
						Total:	$10,844,435
Mobilization / Demobilization (7%)							$759,110
Traffic Control (7%)							$759,110
Bond (1%)							$108,444
Contractor's Profit(15%)							$1,626,665
Subtotal:							$14,097,766
Construction Contingency(25%)							$3,524,441
Total Construction Cost (Santa Ana River Pipeline Sewer)							**$17,622,000**
TOTAL CONSTRUCTION COST FOR PRIORITY "C" PROJECTS							**$19,438,000**

City of Riverside
Phoenix Trunk Sewer Study

Appendices

Prepared By:

PBS&J
10370 Hemet Street, Suite 200
Riverside, CA 92503
(951) 358-1433

August, 2006

Appendix A

Flow Data at Meter Locations (On CD)

Appendix B

City of Riverside, Criteria for Sewer Facility Design

CITY OF RIVERSIDE
PUBLIC WORKS DEPARTMENT
ENGINEERING DIVISION

CRITERIA FOR SEWER FACILITY DESIGN

~~March 2000~~
Revised May 2004

Determination of Sewage Flows:

The sewer line shall be designed to flow 75% full during peak flows. Use a Manning's "n"=0.013.

Residential sewer flows are determined by using the following sources of information and criteria:

- Land use shown in the City's General Plan.
- Based on the Land Use determine the number of living units per acre.
- The capita per living unit can be determined from the latest census data for the study area. However, not less than an average 2.75 capita per living unit.
- Use 65 gallons per capita per day for average flows.
- Peak to average flow coefficient is to be determined from the attached graphs.

Peak flows for other types of development shall be determined using the following criteria:

- Industrial developments use: 0.012 cfs/acre
- Commercial developments use: 0.010 cfs/acre
- Offices: 30 gallons per capita per day (g/c/d)
- Schools: 30 g/c/d
- Laundromat: 580 gallons per machine per day

The Public Works Department must approve sewer flows for any other specific types of development.

Criteria for Sewage Pump Station Design:

Construction of a sewage pump station shall be considered the last resort for handling sewage flows from any development. An analysis of alternate gravity system alignments must be performed and submitted to the City for review. The analysis shall consider the economics of constructing and maintaining a pump station over a 20-year period versus obtaining right of way and constructing a gravity system.

If the analysis shows that a pump station is the most economical alternative the following criteria shall be used in its design.

Peak flows are determined by the criteria stated above in the Determination of Sewage Flows section.

Configuration of the components of the pump station shall be in such a way to permit easy access by maintenance equipment. Fencing shall be placed around the pump station components with gates provided at locations for access by maintenance personnel and equipment. The fencing is to be 6-feet in height and of materials and color permitted by the City's Planning Department. All metal parts are to be powder coated with the approved color.

All hatches and hardware shall be stainless steel.

The developer/contractor shall submit complete maintenance and spare parts information for all station components.

Force Main Design:

The force main shall be sized in such a way that the pumps will maintain a minimum flow velocity of 2 feet per second. The force main shall be no smaller than 4 inches in diameter and shall be made of ductile iron pipe. However, if the force main is small and located in a residential street, AWWA C900 PVC pipe may be used. The use of PVC pipe will require specific approval by the Public Works Department.

The force main shall have a continuous upward grade from the pump station to the outlet. No low or high points will be permitted between the pump station and outlet.

The force main shall outlet to a manhole connected to a gravity system. The outlet shall be at the flowline of the manhole and channeled as shown in City Standard Drawing No. 500. Within 30 feet of the manhole the force main shall have an elevation high enough to prevent sewage in the gravity system from flowing down the force main during the off cycle of the pumps.

The designer shall analyze bends in the force main for the need to use thrust blocks or restrained joints.

A force main cleaning station must be installed at approximately 500-foot intervals if the following conditions will exist in the completed system.

- Flows from the area served by the pump station are not enough to require the force main to be emptied every 4 hours.
- The force main is over 950 feet long.
- The difference in elevation between the force main at the valve vault and the outlet is greater than 25 feet.

Pump Design:

Pumps are to be sized to provide a minimum flow velocity of 2 feet per second in the force main.

Pumps shall be able to handle 4-inch solids.

Pump selection shall be based on the most efficient drive/pump/impeller combination for the force main system. The discharge flow velocity should be in the range of 10 to 14 feet per second. The designer shall graph the pipe system curve against the pump curve. If multiple pumps are used this graph shall show the curve for each pump. The minimum pump efficiency allowed is 60 percent.

Wet Well Design:

In stations that have 5 to 100 horsepower pumps the wet wells shall be sized to permit the pumps to cycle not less than 15 minutes between stops and starts. In addition the pumps must not run less than 10 minutes per cycle. Stations with pumps greater than 100 horsepower shall have a cycle time between pump stops and starts not be less than 20 minutes with a minimum run time of 15 minutes.

Pumps on and off elevations are to be shown on the plan. These elevations must be below the inlet elevation to the wet well. Flap gates on the wet well inlet are not permitted.

The wet well shall have a 6-foot minimum diameter and lined with PVC or City approved coating.

If the wet well is over 30 feet in depth there must be a "step off" landing designed in the well. The landing is a safety precaution to provide a location for maintenance personnel to step off the wet well access ladder.

All nuts, bolts, and washers shall be made of 304 or 316 stainless steel.

A wastewater recirculator or scum breaker shall be provided.

Valve Vault Design:

The vault shall be large enough to permit easy access by maintenance personnel. The bottom shall be a minimum 4-inch thick concrete slab. A 4-inch diameter PVC pipe shall be provided to drain the valve vault into the wet well.

All pipe and fittings from the pumps through the valve vault shall be made of ductile iron. Only flanged fittings shall be used. All nuts, bolts, and washers shall be made of 304 or 316 stainless steel.

Discharge and isolation valves shall be plug valves and not gate valves.

Controls and Electric Design:

A 480-volt three-phase power supply is required.

All conduits shall be schedule 80 PVC.

An emergency transfer switch shall be provided. Small stations will require a manual switch where large stations with emergency backup generators will require an automatic transfer switch. When a manual transfer switch is required a 100-amp plug and receptacle such as Killark 8581/21-407 and 8581/22-407 shall be provided. In addition, a minimum 30-foot long jumper cable shall be provided.

Lights shall be provided within the control panel to allow for night work.

The pump station shall have a communications link with the City's wastewater treatment plant. The equipment to provide this link shall be City approved.

An electric schematic diagram shall be provided on the pump station plans.

The wet well level measuring device shall be a Milltronics Hydroranger ultrasonic measuring device.

The station shall be controlled by a Modicon Quantum Programmable Logic Controller(PLC).

The station shall be equipped with a Motorola Moscad Radio Telemetry Unit(RTU).

This RTU shall be installed and completely functional prior to the acceptance by the City.

The Developer/contractor shall coordinate and pay for the integration of this RTU into the City's existing SCADA system.

Control system integration with the City's SCADA shall be performed by an integrator approved by the City.

Three phase 480 VAC power shall be the power source.

The power source for station controls shall be 120 VAC.

Two spare conduits shall be provided between the control panel and the wet well. This conduit shall same size of the largest conduit needed between the control panel and wet well.

One spare conduit shall be provided between the control panel and the valve vault. This conduit shall of the same size of the largest conduit needed between the control panel and valve vault.

The developer/contractor shall provide complete as built drawings of the electrical system. This shall include all wiring, general, and internal to the control panel

All wires must be individually tagged. They must be tagged at every termination and inside every junction box.

The developer/contractor shall provide a copy of the proposed PLC program for review prior to construction. A final fully annotated copy of the PLC program shall be provided, both in electronic format and in a hard copy printed format.

All panels shall be of the appropriate construction for the application. (minimum, NEMA 4X or 3R.

Pump Station Functional Requirements

Milltronics Hydroranger Ultrasonic Level Indicator/Controller

Shall provide analog level input to the Programmable Logic Controller (PLC)

Shall provide off & on starting of pumps in the event of PLC failure

Shall provide alternation of pumps in event of PLC failure

Shall provide ultrasonic failure Input to RTU

Float Switch

Shall provide an input to the RTU (high-high level)

Programmable Logic Controller (PLC)

Shall provide starting and stopping of the pumps in auto

Shall provide alternation of the pumps (after each cycle)

Recognize Milltronics failure and provide an input to the RTU

Shall recognize pump hand switch position and adjust the control logic

Shall provide all timing functions

Shall provide low level alarm output to RTU

Shall provide input to the RTU In event of seal failure of pumps (Each Pump)

Shall provide input to the RTU in event of Thermal overload

Shall call lag pump if required

Shall provide input to the RTU indicating pump failure and identifying the pump

Shall provide output to the RTU for high level alarm

A three-position selector switch shall interface with the PLC to provide for manual override of the automatic changing of lead and lag pumps, in case of pump failure (i.e.: P1-AUTO-P2)

Controls

A manual bypass shall be provided for water levels, PLC, Milltronics; etc. and shall directly energize the motor starters.

The auto function shall be controlled by the PLC or in the event of PLC failure, the Milltronics will start, stop, and alternate lead and lag pumps.

Radio Telemetry Unit (RTU)

Shall monitor only, not control

Transmit Dynamic Wet Well Level (Analog Output)

Indicate low level

Indicate high level

Indicate site entry

Indicate AC failure

Indicate individual pump failure

Indicate pump auto, pump not auto

Indicate pump run status

Indicate ultrasonic failure

Indicate Seal Failure

External Relays

(1) Intrinsically safe for the high, high level float

(2) For seal failure

(2) Motor starters

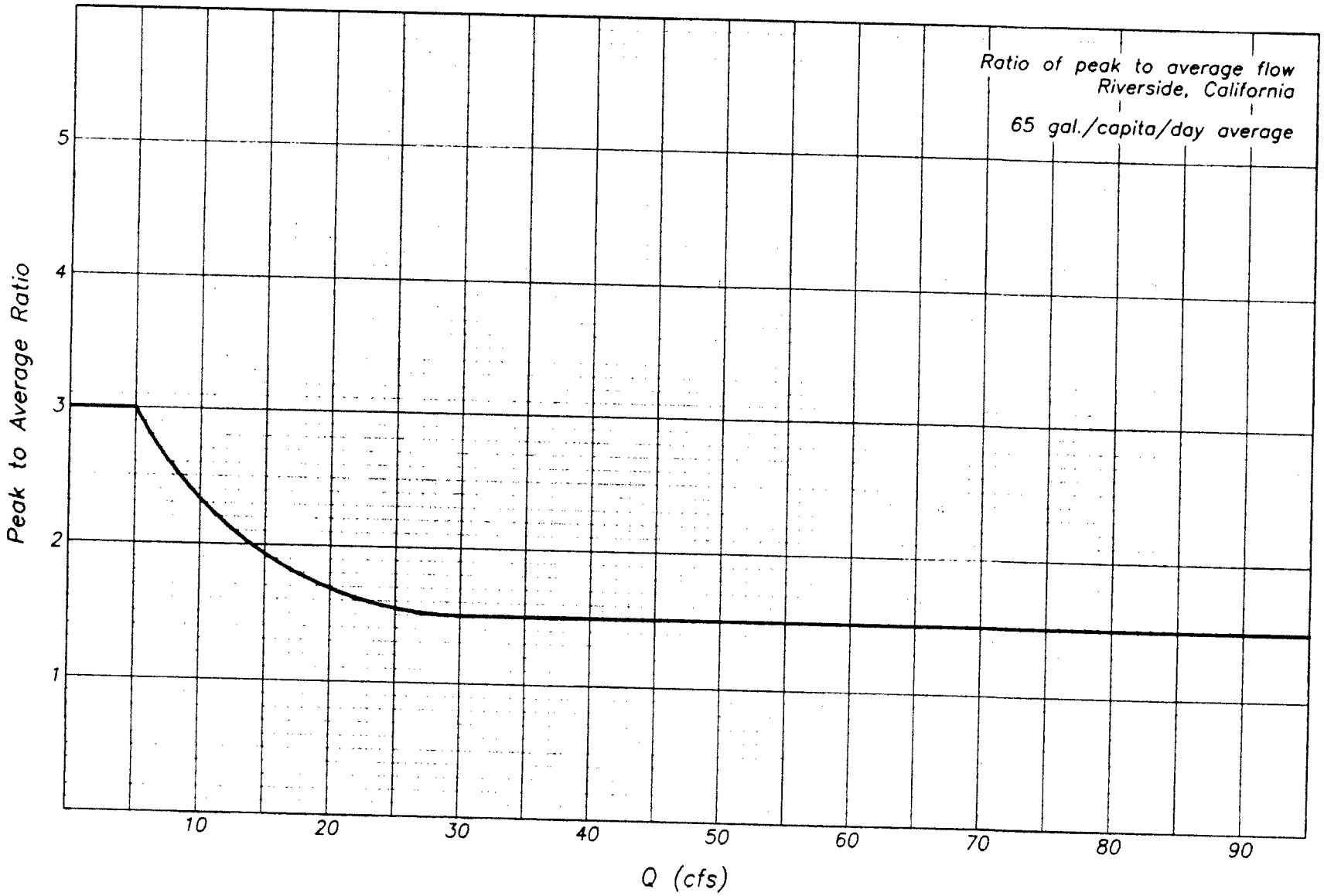
Criteria for Inverted Siphon Design:

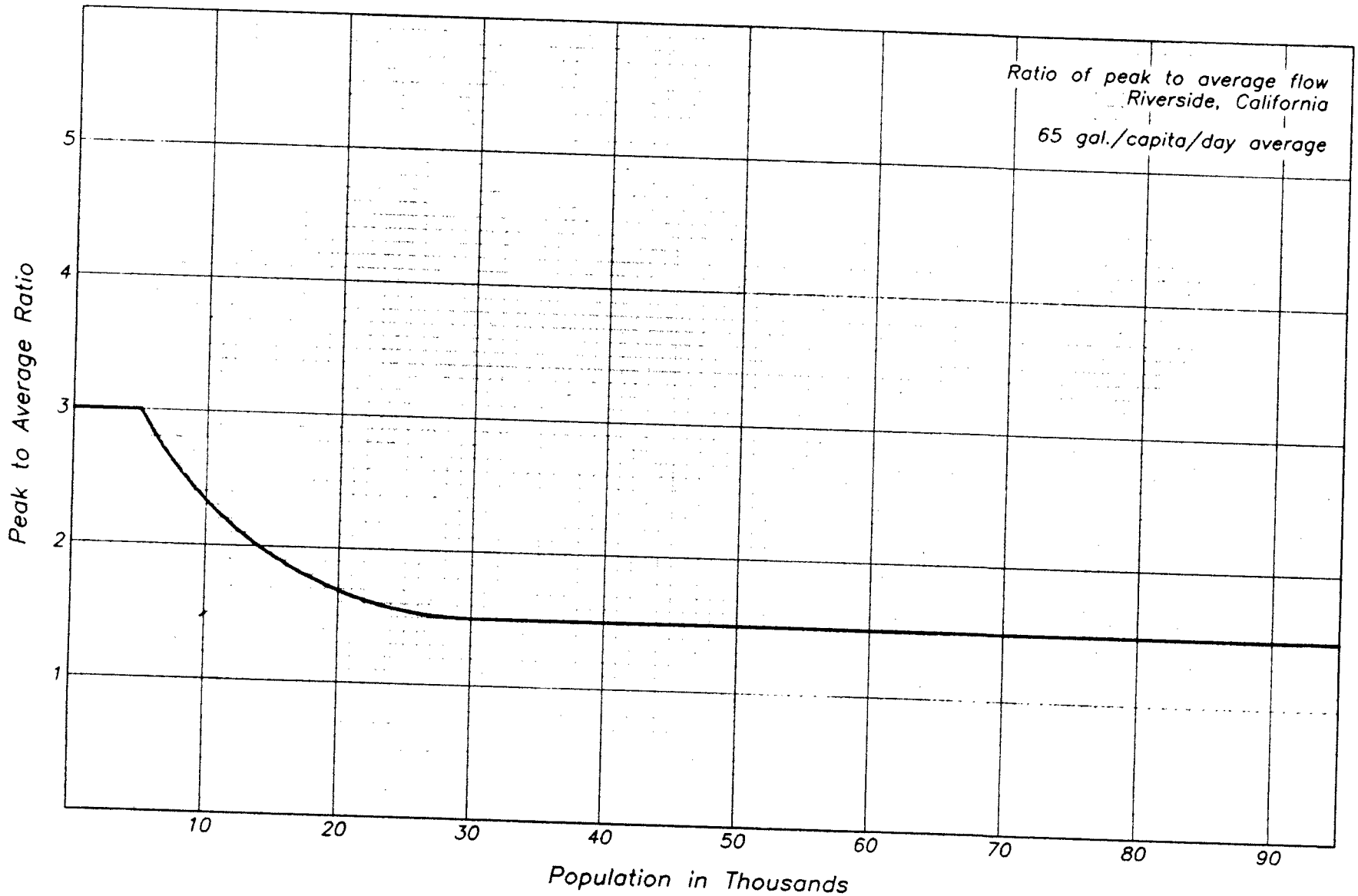
Minimum flow velocity of 3 feet per second and maximum velocity of 7 feet per second within the siphon pipe(s) is required. A multiple pipe design should be incorporated with the upstream manhole designed to direct the anticipated average daily flow into one pipe and the anticipated peak flow into all pipes of the siphon. If the siphon will serve future development it may be necessary to design the siphon with more than two pipes in order to maintain the minimum flow velocity until the future development is constructed. Weirs shall be cast into the base of the manholes.

Minimum pipe size to be used in the siphon is 6-inch. Either Vitrified Clay Pipe or Ductile Iron Cement Mortar Lined Pipe (DIP) shall be used in the siphon. Type V cement shall be used for the lining of the DIP. Internal pressure of the siphon shall be considered in material selection.

The siphon shall not exceed 350 feet in length with manholes installed at each end. Flow shall be directed straight through these manholes. No side connections to the manholes will be permitted. The manhole diameter shall be determined by the number, size, and spacing of the siphon pipes plus 3 feet. The shelf elevation shall be above the water level during ultimate peak flows.

During ultimate peak flow the water surface elevation at the first sewer lateral connection upstream of the siphon must be within the sewer main.


Ratio of peak to average flow
Riverside, California
65 gal./capita/day average
Peak to Average Ratio
5
4
3
2
1
10
20
30
40
50
60
70
80
90
Q (cfs)


Ratio of peak to average flow
Riverside, California
65 gal./capita/day average
Peak to Average Ratio
5
4
3
2
1
10
20
30
40
50
60
70
80
90
Population in Thousands

Appendix C
Study Sewer Lines

Table 7-4
Preliminary Construction Cost Estimate For Priority "A" Projects
(2005- 2010 Replacement / Rehabilitation)

Location	Description	Existing Diameter (inch)	New Diameter (inch)	Unit	Quantity	Unit Cost	Approx Total Cost(2005 $'s)
Central Avenue	Replace Pipe P125	24	36	LF	615	$260	$159,952
	Rehab / Replace Manhole			EA	2	$5,500	$11,000
	Reconnect Sewer Laterals			EA	6	$1,650	$9,900
						Total:	$180,852
Mobilization / Demobilization (7%)							$12,660
Traffic Control (7%)							$12,660
Bond (1%)							$1,809
Contractor's Profit(15%)							$27,128
Subtotal:							$235,108
Construction Contingency(25%)							$58,777
Total Construction Cost (Central Avenue Sewer)							**$294,000**
Hillside Avenue	Replace Pipe P100	27	33	LF	14	$245	$3,430
	Replace Pipes P123	24	30	LF	397	$220	$87,340
	Replace Pipes P101, P104, P106, P108-P109, P111-P112, P114-P116, P120, P121A, P121B	24	33	LF	2566	$245	$628,670
	Rehab / Replace Manhole			EA	16	$5,500	$88,000
	Reconnect Sewer Laterals			EA	30	$1,650	$49,500
						Total:	$856,940
Mobilization / Demobilization (7%)							$59,986
Traffic Control (7%)							$59,986
Bond (1%)							$8,569
Contractor's Profit(15%)							$128,541
Subtotal:							$1,114,022
Construction Contingency(25%)							$278,506
Total Construction Cost (Hillside Avenue Sewer)							**$1,393,000**
Phoenix Avenue	Replace Pipe P149	27	30	LF	16	$220	$3,520
	Replace Pipes P150	15	18	LF	142	$145	$20,590
	Rehab / Replace Manhole			EA	3	$5,500	$16,500
	Reconnect Sewer Laterals			EA	2	$1,650	$3,300
						Total:	$43,910

Table 7-4
Preliminary Construction Cost Estimate For Priority "A" Projects
(2005- 2010 Replacement / Rehabilitation)

Location	Description	Existing Diameter (Inch)	New Diameter (Inch)	Unit	Quantity	Unit Cost	Approx Total Cost(2005 $'s)
Mobilization / Demobilization (7%)							$3,074
Traffic Control (7%)							$3,074
Bond (1%)							$439
Contractor's Profit(15%)							$6,587
Subtotal:							$57,083
Construction Contingency(25%)							$14,271
Total Construction Cost (Phoenix Avenue Sewer)							**$71,000**
Santa Ana River							
	Replace Pipe P077	15	21	LF	15	$170	$2,550
	Replace Pipes P078	24	33	LF	309	$245	$75,705
	Replace Pipes P079 to P081	24	30	LF	1659	$220	$364,980
	Rehab / Replace Manhole			EA	6	$5,500	$33,000
	Reconnect Sewer Laterals			EA	20	$1,650	$33,000
						Total:	$509,235
Mobilization / Demobilization (7%)							$35,646
Traffic Control (7%)							$35,646
Bond (1%)							$5,092
Contractor's Profit(15%)							$76,385
Subtotal:							$662,006
Construction Contingency(25%)							$165,501
Total Construction Cost (Santa Ana River Sewer)							**$828,000**
TOTAL CONSTRUCTION COST FOR PRIORITY "A" PROJECTS							**$2,586,000**

Table 7-5
Preliminary Construction Cost Estimate For Priority "B" Projects
(2011- 2015 Replacement / Rehabilitation)

Location	Description	Existing Diameter (inch)	New Diameter (inch)	Unit	Quantity	Unit Cost	Approx Total Cost(2005 $'s)
Madison Street	Replace Pipes P191 to P193	15	21	LF	883	$170	$150,110
	Rehab / Replace Manhole			EA	4	$5,500	$22,000
	Reconnect Sewer Laterals			EA	9	$1,650	$14,850
						Total:	$186,960
Mobilization / Demobilization (7%)							$13,087
Traffic Control (7%)							$13,087
Bond (1%)							$1,870
Contractor's Profit(15%)							$28,044
Subtotal:							$243,048
Construction Contingency(25%)							$60,762
Total Construction Cost (Madison Street Sewer)							**$304,000**
TOTAL Construction COST FOR PRIORITY "B" PROJECTS							**$304,000**

Appendix E
NORTHSIDE TRUNK SEWER STUDY

City of Riverside
Northside Trunk Sewer Study

590110.30

Prepared By:

10370 Hemet Street, Suite 200
Riverside, CA 92503
(951) 358-1433

September, 2006

NORTHSIDE TRUNK SEWER STUDY

City of Riverside

Client Representative L.F.(Sandy) Caldwell, P.E.

PBS&J

Project Director Gary H. Eikermann

Project Engineer Barmeshwar Rai, P.E.

Technical Support Charlene Drake
Cristina Chavez

J.N. 590110.30

September, 2006

PBS&J 10370 Hemet Street, Suite 200, Riverside, CA 92503

TABLE OF CONTENTS

Page Number

Executive Summary

ES.1 *Introduction* *Ex-1*

ES.2 Existing Sewer System *Ex-1*

ES.3 Methodology *Ex-1*

ES.4 Project Priorities and Cost *Ex-2*

Table Ex-1 Summary of Priorities *Ex-3*

1.0 Introduction 1

1.1 Background 1

1.2 Study Area 1

1.3 Objective 2

1.4 Scope and Study Approach 2

2.0 Land Use 5

2.1 Existing Land Use 5

2.2 Proposed Land use 5

3.0 Existing Sewer System 6

3.1 System Overview 6

3.2 Collection System 6

3.3 System Description 7

3.4 Tributary Areas 10

4.0 Determination of Sewer Flows 12

4.1 Flow Monitoring 12

4.2 Results of Flow Monitoring 13

5.0 Estimated Ultimate Flow 15

5.1 Methodology 15

5.2 Flow Coefficients 15

5.3 Representative Diurnal Hydrographs 16

6.0 Computer Model Simulation Analysis 17

6.1 Methodology 17

6.2 Limitations of Modeling 18

7.0 *Deficiencies and Solutions* 19

7.1 Deficient and Marginally Deficient Pipes 19

7.2 Project Prioritization Methodology 20

7.3 Recommended Improvements 20

7.4 Grouping of Projects 21

7.5 Construction Schedule 21

7.7 Cost Estimate 21

LIST OF TABLES

Page Follows/On

2-1 Land Use that would produce Wastewater Flow within the Study Area 5

3-1 Developed Tributary Areas and Current Wastewater Generating Land Use 11

7-1 Sewer Analysis Results (Existing and Future Conditions) 18

7-2 Proposed Construction Prioritization and Schedule 20

7-3 Summary of Improvement Plans for Problem Areas…… 21

7-6-B Preliminary Construction Cost Estimate for Priority "B" Projects 21

7-6-C Preliminary Construction Cost Estimate for Priority "C" Projects ..... ……21

LIST OF FIGURES

Follows Page

1 Vicinity Map 1

2 Study Area 1

3A Zoned Land Use Plan 5

3B Land Use (Vacant Parcels)..... 5

4 Tributary Areas 6

5 Flow Monitoring Locations..... 6

6 Sewer System and Pipe Diameters 7

7 Manhole ID's 10

8 Pipe ID's 10

9 to11 Adjusted Flows at Meters 16

12 to14 Representative Diurnal Hydrographs 16

15 Existing Volume Deficiencies 20

16 Existing Velocity Deficiencies 20

17 Ultimate Volume Deficiencies 20

18 Priority "B" 21

19 Priority "C" 21

APPENDICES

Appendix A – Flow Data at Meter Locations

Appendix B – City of Riverside, Sewer Design Guidelines

Appendix C – Study Sewer Lines

Executive Summary

ES.1 Introduction

This report presents the results of the Northside Trunk Sewer System Capacity Study prepared by PBS&J for the City of Riverside. The report contains recommendations regarding system deficiencies as identified by hydraulic model XP-SWMM (XP Software, Version 9.1).

The City of Riverside is located in the County of Riverside at the intersection of three major freeways; Route 91, Route 60 and Interstate 215. The study area encompasses approximately 6,000 acres of mixed land use development and is generally bounded by Main Street to the North, Santa Ana River to the West, Spruce Street to the South and Pope Kirlos Avenue to the East. The study area is a developed community, comprised of single family residential, multi family residential, commercial and light industrial areas within the City limit with some vacant parcels within the County of Riverside that will be developed in the future. The portion of study area west of I-215 can be considered a mature community, comprised of residential, commercial and light industrial development. The portion of study area east of I-215 is primarily a Business Park / Light Industrial area. The vacant parcels east of I-215 and proposed Spring Mountain Ranch and Springbrook Estates developments would be major wastewater contributors to the sewer system.

ES.2 Existing Sewer System

The existing trunk sewer system within the study area is comprised of approximately 10 miles of gravity sewer mains. The gravity sewer main lines range in sizes from 8-inch to 36-inch in diameter and there are 176 manholes. These sewer lines are essentially VCP and the manholes are typically brick lined. The City of Riverside owns, maintains and operates the sewer system.

ES.3 Methodology

For determination of current wastewater flows, flow monitoring was performed at three (3) strategic locations. These meter locations were chosen to observe actual flow characteristics for various sub areas with a distinct land use pattern within the study area. The flow monitoring was accomplished over a two-week period. The flow results were carefully evaluated for accuracy and some adjustments were made based on depth of flow at meter locations. The readings of only one week were used for meters 1 and 2.

A theoretical estimate of wastewater flow from vacant areas was made based on factors from the City of Riverside “Criteria for Sewer Facility Design”. Residential wastewater flow was determined by using future

projected population, whereas commercial and industrial flow was determined based on acreage and City estimated flow coefficients.

The Computer Model Simulation Analysis involved evaluation of available capacity in the existing collection system under present and future development conditions. The results of the model runs were used to identify system deficiencies on a priority basis, and a phased facility improvement plan was developed to accommodate the projected growth within the study area.

ES.4 Project Priorities and Cost

Deficient and marginally deficient pipes were identified from the results of model runs and were prioritized for replacement/rehabilitation purposes. The pipes that are currently flowing more than 90% full under modeled existing maximum flow conditions and needing near term (2005-2010) replacement/rehabilitation are grouped under priority “A”. None of the pipes were found to flow more than 90% full under existing flow conditions, so there are no pipes under category “A”. The pipes that would flow more than 90% full in year 2015 under anticipated maximum future flow conditions are classified as priority “B”. The pipelines that are not included in priorities “B” and are anticipated to flow more than 75% full under future flow conditions are categorized as priority “C”. Some adjustment of priorities and combining of improvements was done for continuity and efficiency of improvements.

The time phased improvements for various priorities are listed in Table 7-2. The approximate cost of recommended improvements is summarized in Tables 7-6-B and 7-6-C.

Deficiencies predicted under ultimate flow conditions in year 2005 (Priority “B”) include 6,800 linear feet of inadequate sewer lines. The estimated capital cost to remedy these identified deficiencies (in year 2005 $) is approximately $1,759,000. The total length of pipelines under Priority “C” would be approximately 9,800 feet and the cost of Priority “C” remedial projects would be approximately $2,788,000. However, it is probable that the majority of Priority “C” improvements will not need to be actually implemented. Only those where surcharging (within manhole) and other problems are deemed imminent should be considered for improvement. Periodic flow monitoring is recommended to verify anticipated deficiencies and need for improvements. It is recommended that field observations of all pipes should be done where modeled results indicate surcharging conditions. The priorities are summarized in the table Ex-1:

Table Ex-1
Summary of Priorities

Priority	Approximate Pipeline Length (feet)	Location	Replacement Year	Total Project Cost (Year 2005 $)
"B"	6,800	Columbia Avenue, La Cadena Drive, Marlborough Avenue and Palmyrita Avenue	2011-2015	$1,759,000
"C"	14,000	Columbia Avenue, Fairmount Boulevard, Fairmount Trunk, Marlborough Avenue and Strong Street	2016-2020	$2,788,000

1.0 INTRODUCTION

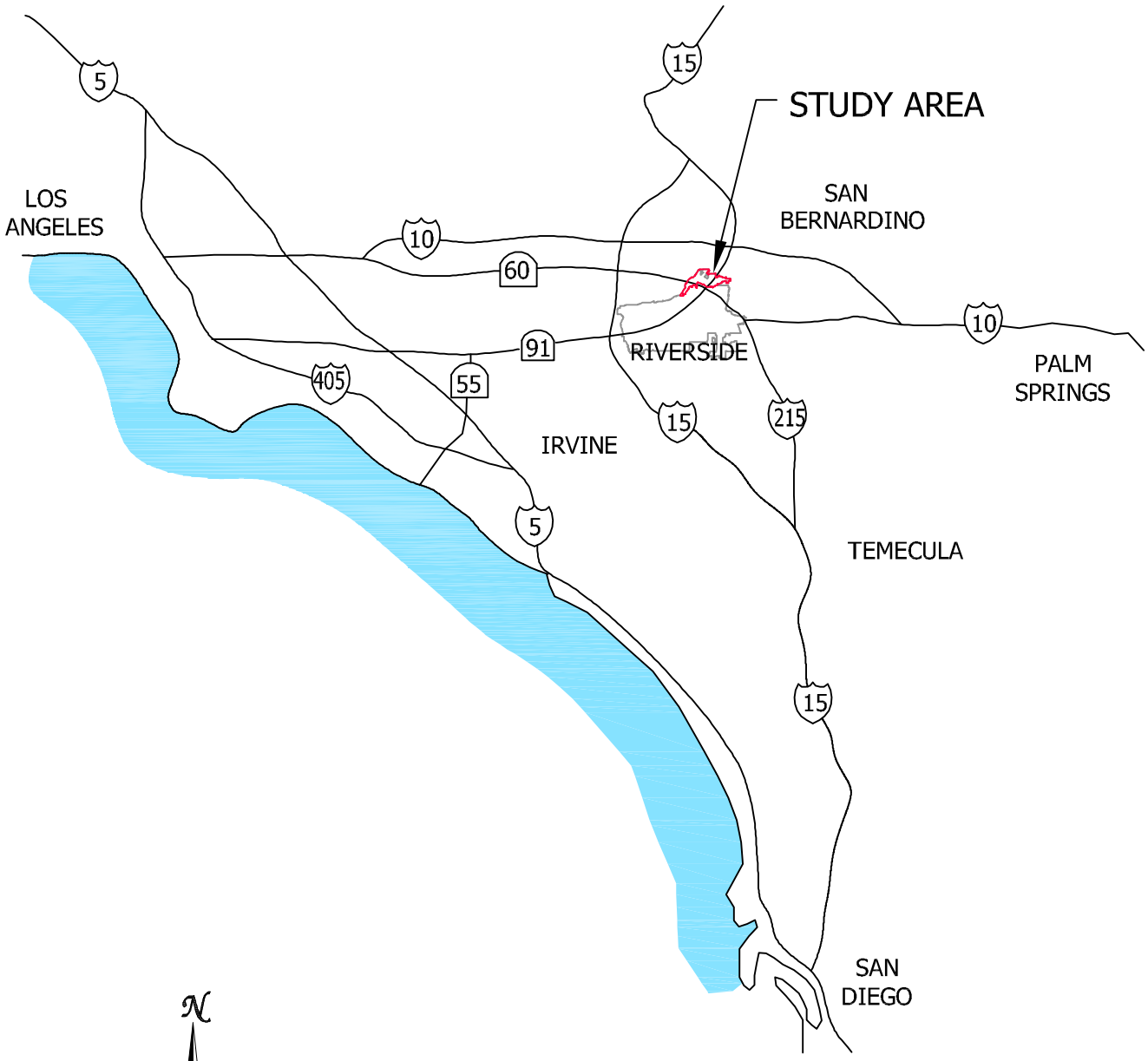
1.1 Background

The City of Riverside (City) retained PBS&J to prepare a Trunk Sewer System Study for the northern portion of the City. The sewer system has been designated as Northside Trunk Sewer System. The study is necessitated by the fact that the City desires to evaluate the capacity of the existing sewer system and identify needed improvements.

1.2 Study Area

The City of Riverside is located in the northwest corner of the County of Riverside at the intersection of three major freeways; Route 91, Route 60 and Route 215. Founded in 1870, the City is known for its citrus industry, world famous Mission Inn and other historical monuments. Figure-1 is a Vicinity Map depicting the City's location and its accessibility. Figure 2 shows the study area. The study area shown in Figure 2 encompasses approximately 6,000 acres and is generally bounded by Main Street to the North, Santa Ana River to the West, Spruce Street to the South and Pope Kirlos Avenue to the East. The southern portion of the study area also includes Fiarmount Park Golf Course Area west of Fairmount Boulevard. The areas not falling within City's jurisdiction but likely to contribute to the existing sewer system in the future have also been included in this study. For purpose of this study, the area has been divided into 26 tributary sub-areas, where downstream sub-areas intercept sewage flow from upstream sub-areas. To obtain actual observed flow information for this study, sewage flow meters were placed at three (3) strategic locations to monitor cumulative flows contributed from the tributary sub-areas.

The I-215 freeway divides the study area into two distinct parts. The study area west of I-215 is considered to be a mature community comprised of single family residential, multi-family residential, commercial and light industrial development. The study area east of I-215 is primarily a Business Park / Light Industrial area. The vacant parcels east of I-215 and designated as Light Industrial and Industrial Business Park would be the major contributors to increases in sewage flow within the study area. Another significant flow contribution would be from the



N

NTS

DATE: 01/04/06	DWN BY: CD

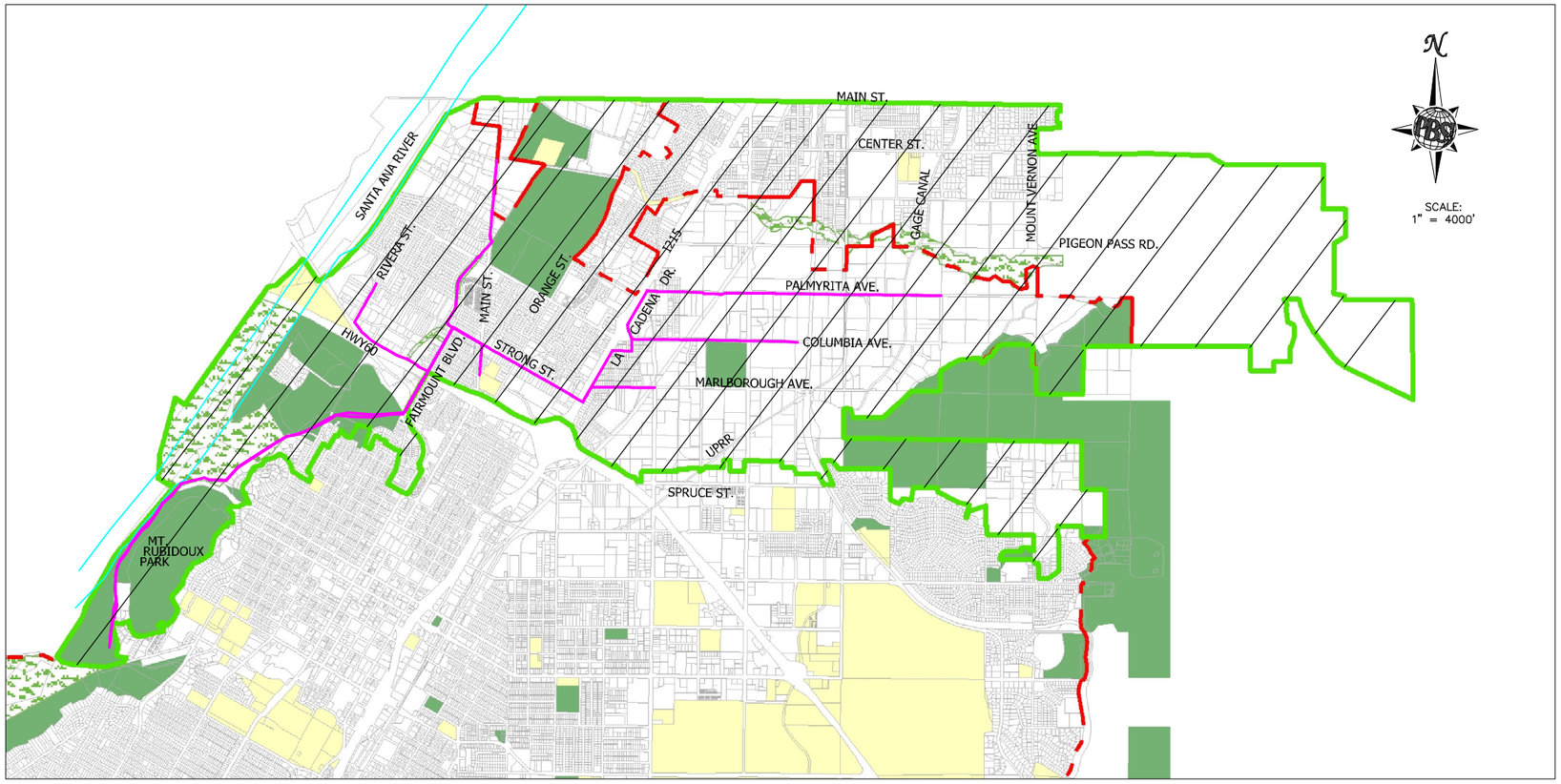
Engineering
Planning
Surveying
Construction Services
PBSJ
10370 Hemet Street
Suite 200
Riverside, CA 92503
Tel:(951) 358-1433
Fax:(951) 358-1434

CITY OF RIVERSIDE
NORTHSIDE SEWER STUDY

FIGURE 1

VICINITY MAP

Y:\City of Riverside\Northside\DWG\Exhibits\NS-Vicinity.dwg, 9/28/2006 9:23:03 AM



LEGEND

- STUDY AREA
- STUDY SEWER
- CITY LIMITS

Engineering
Planning
Surveying
Construction Services
PBS&J
10370 Hemet Street
Suite 200
Riverside, CA 92503
Tel:(951) 358-1433
Fax:(951) 358-1434

DATE: 01/04/06	DWN BY: CD
CITY OF RIVERSIDE NORTHSIDE SEWER STUDY	FIGURE 2
STUDY AREA	

Y:\City of Riverside\Northside\DWG\Exhibits\NS-StudyArea.dwg, 9/28/2006 9:18:00 AM

proposed Spring Mountain Ranch and Springbrook Estates developments.

1.3 Objective

The objective of this Sewer System Capacity Study is to provide a comprehensive evaluation of the capacity of the sewer system within the study area, identify deficiencies in the current system, and evaluate alternatives to enhance the conveyance capacity to accommodate ultimate wastewater flows anticipated to be generated in the study area.

1.4 Scope and Study Approach

Specific work tasks undertaken for this study are summarized as follows:

- Kickoff Meeting

  An initial meeting was held between PBS&J and the City to discuss the project scope, communication protocol, explanation of methodology and scheduling of flow monitoring. Field data and other digital files to be provided by the City were also discussed.

- Progress Meetings

  Informal Project Progress Meetings were held to discuss on-going issues and the progress of the study.

- Flow Monitoring and Hydrograph Development

  Downstream Services Inc. installed, maintained, and collected flow data from three (3) monitoring stations throughout the study area. They submitted the collected raw data in electronic/hard copy format to PBS&J. PBS&J then processed and reviewed this information and created a hydraulic database. The City provided a copy of City's General Plan for estimation of current and future flows. Other information including as-built plans of wastewater facilities were provided by the City as and when requested by PBS&J.

- Model Development

  Model development included input data collection, conversion of data and calibration. The City's GIS staff made available

data pertaining to roads, sewers, land use, buildings and other utilities in ArcView format on a CD. As-built plans for study sewer lines were reviewed. Data available from GIS system and as-built plans were placed in a database system (MS Excel) as a pre-processor for XP-SWMM model development. Calibration of model was done after construction of the model and additional data input.

- Draft Report

  Based on the model simulations and the City's criteria for Sewer Facility Design, a Draft Report was prepared that summarized the existing and future capacity situations. Where deficiencies were identified, alternatives were developed for needed sewer improvements, along with probable costs. The draft report was prepared for review by the City.

- Final Report

  Draft Report review comments from the City were incorporated into the Final Report along with any additional information or research, in order to reflect a final level of study completion. The Final Report includes data and information assembled, system deficiencies identified, alternatives evaluated, capital improvement recommendations to remediate anticipated deficiencies, prioritization of improvements, and approximate costs.

The comprehensive evaluation of the sewage collection system to accomplish the above-summarized scope of work features the following multi-step approach:

- Review of as built plans provided by the City to determine system configuration, inverts, pipe sizes and slopes
- Use of detailed database provided by the City in Arcview format
- Creation of computer hydraulic model using existing sewer system to study project area
- Identification of flow monitoring station locations
- Identification of tributary areas contributing sewage flow to meter locations or combinations
- Installation of flow meters and monitoring of flows at the selected locations on continuous basis for two-week period
- Review of current land use in study area per GIS information from the City and determination of existing land use, population and vacant land
- Assessment of ultimate land use and projected population
- Review and evaluation of metered data from flow monitoring stations

- Development of flow coefficients and representative diurnal flow patterns based on typical curves for various land uses and observed flows from monitored sub areas which are dominated by a specific land use
- Modeling of sewer system, deficiency identification, and model simulation of remedial alternatives using above-mentioned information as input data
- Evaluation of alternatives, optimization, cost comparison
- Prioritization of recommended improvements, including identification of critical pipelines which need immediate attention
- Draft Report and recommendations including phased improvements and costs
- Review of Draft Report by the City, comments and discussion
- Final Report

2.0 LAND USE

2.1 Existing Land Use

Land use is the basis for estimating sewage flow from the majority of the study area. The land use pattern for this study was developed from the GIS information provided by the City. Figure 3A shows land use within the study area based on the City's "Land Use" GIS layer. For the purpose of this study, land uses in the study area have been broadly classified into four categories: Single Family Residential (SFR), Multi Family Residential (MFR), Commercial and Industrial. The areas classified as Industrial Business Park are categorized under Industrial land use. Table 2-1 summarizes the land use areas within the study area that would generate wastewater flow.

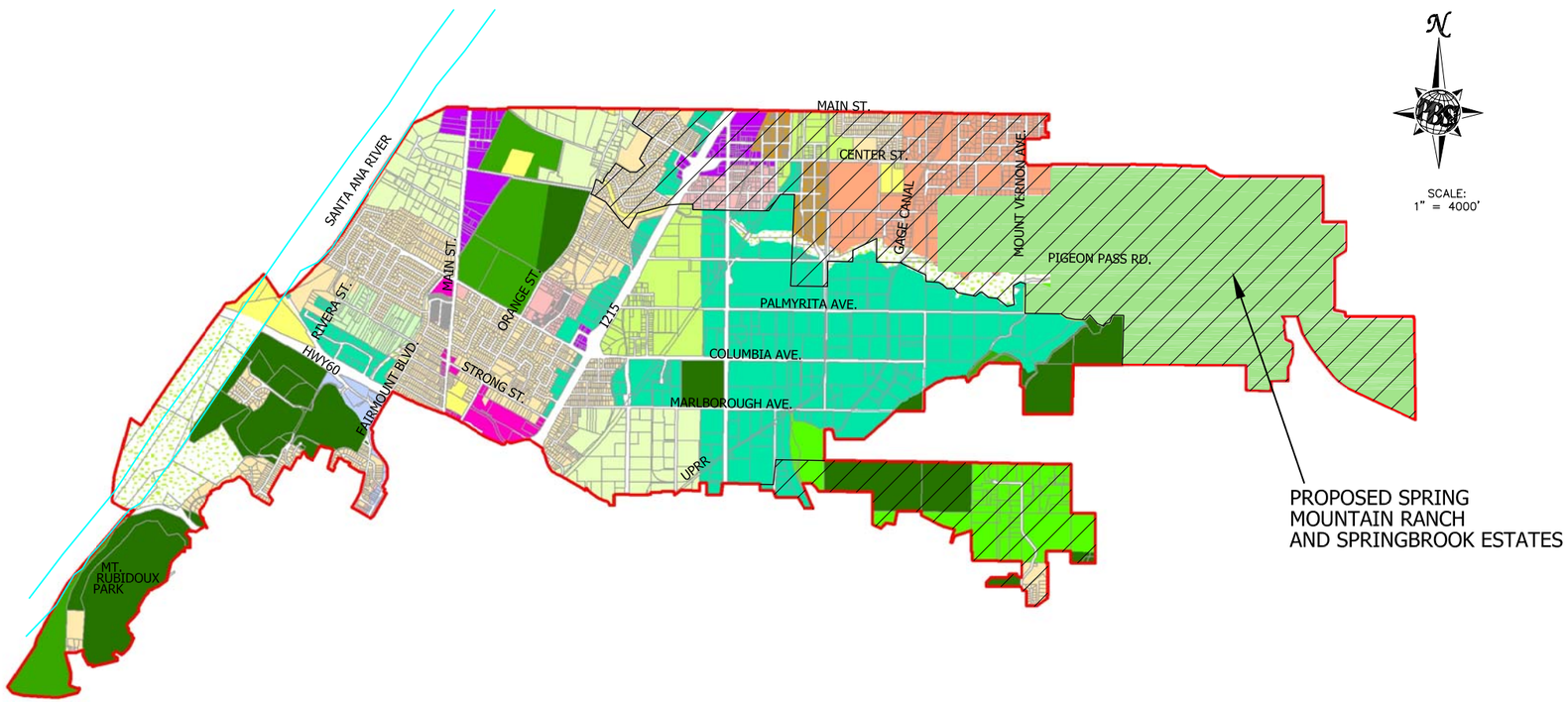
2.2 Future Land Use

The study area on west side of I-215 is primarily a mature community. The portion of study area on east side of I-215 has vacant parcels that would be developed in the future. This area is designated to be developed as Single Family Residential (SFR), Commercial and Industrial Business Park (IBP) / Light Industrial. The vacant parcels are shown in Figure 3B. It is assumed that the majority of vacant lots within the study area would be fully developed by year 2020.

Table 2-1
Land Use that would produce Wastewater Flow within the Study Area (Acres)

Category	Existing (Year 2005)	Future (Year 2020)	Change
Single-Family Residential (SFR)	700	2,250	1,550 (220 %)
Multi-Family Residential (MFR)	72	157	85 (118 %)
Commercial	108	213	105 (97 %)
Industrial /IBP	738	1,512	774 (105 %)

The areas that are marked as open space public facilities are not included in Table 2-1 because of zero wastewater flow generation.



N

SCALE:
1" = 4000'

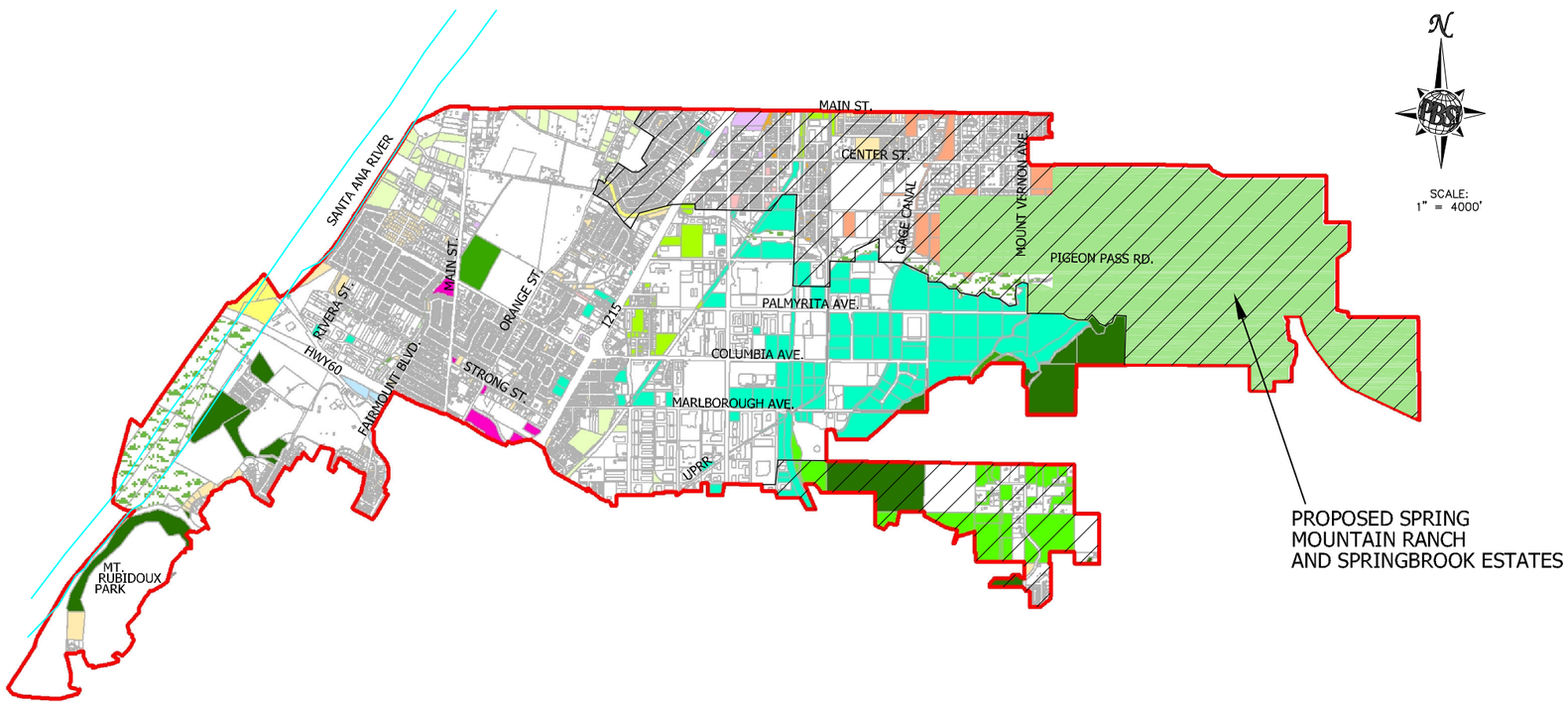
LEGEND

- Commercial – Business and Office
- Commercial – Service
- Downtown Specific Plan
- Industrial – Business Park
- Industrial – General
- Industrial – Light
- Natural Open Space
- Parks – Other Recreation
- Parks – Public
- Public Facilities and Open Space*
- Residential – Estate
- Residential – Hillside
- Residential – Low Density
- Residential – Medium Density
- Residential – Medium–High Density
- Residential – Semi–Rural
- County Area**
- Area Which May be Served by City
- Sewer Basin Boundary

*Includes schools and other public use facilities
**Assumed to be Low Density Residential

Engineering
Planning
Surveying
Construction Services
PBSJ
10370 Hemet Street
Suite 200
Riverside, CA 92503
Tel:(951) 358–1433
Fax:(951) 358–1434

DATE: 01/04/06	DWN BY: CD
CITY OF RIVERSIDE NORTHSIDE SEWER STUDY	FIGURE 3A
ZONED LAND USE	



N

SCALE:
1" = 4000'

LEGEND

- Commercial – Business and Office
- Commercial – Service
- Downtown Specific Plan
- Industrial – Business Park
- Industrial – General
- Industrial – Light
- Natural Open Space
- Parks – Other Recreation
- Parks – Public
- Public Facilities and Open Space*
- Residential – Estate
- Residential – Hillside
- Residential – Low Density
- Residential – Medium Density
- Residential – Medium–High Density
- Residential – Semi–Rural
- County Area**
- Area Which May be Served by City
- Sewer Basin Boundary

*Includes schools and other public use facilities
**Assumed to be Low Density Residential

Engineering
Planning
Surveying
Construction Services
PBSJ
10370 Hemet Street
Suite 200
Riverside, CA 92503
Tel:(951) 358–1433
Fax:(951) 358–1434

DATE: 01/04/06	DWN BY: CD
CITY OF RIVERSIDE NORTHSIDE SEWER STUDY	FIGURE 3B

ZONED LAND USE (VACANT PARCELS)

Y:\City of Riverside\Northside\DWG\Exhibits\NS-LandUse.dwg, 9/28/2006 9:11:17 AM

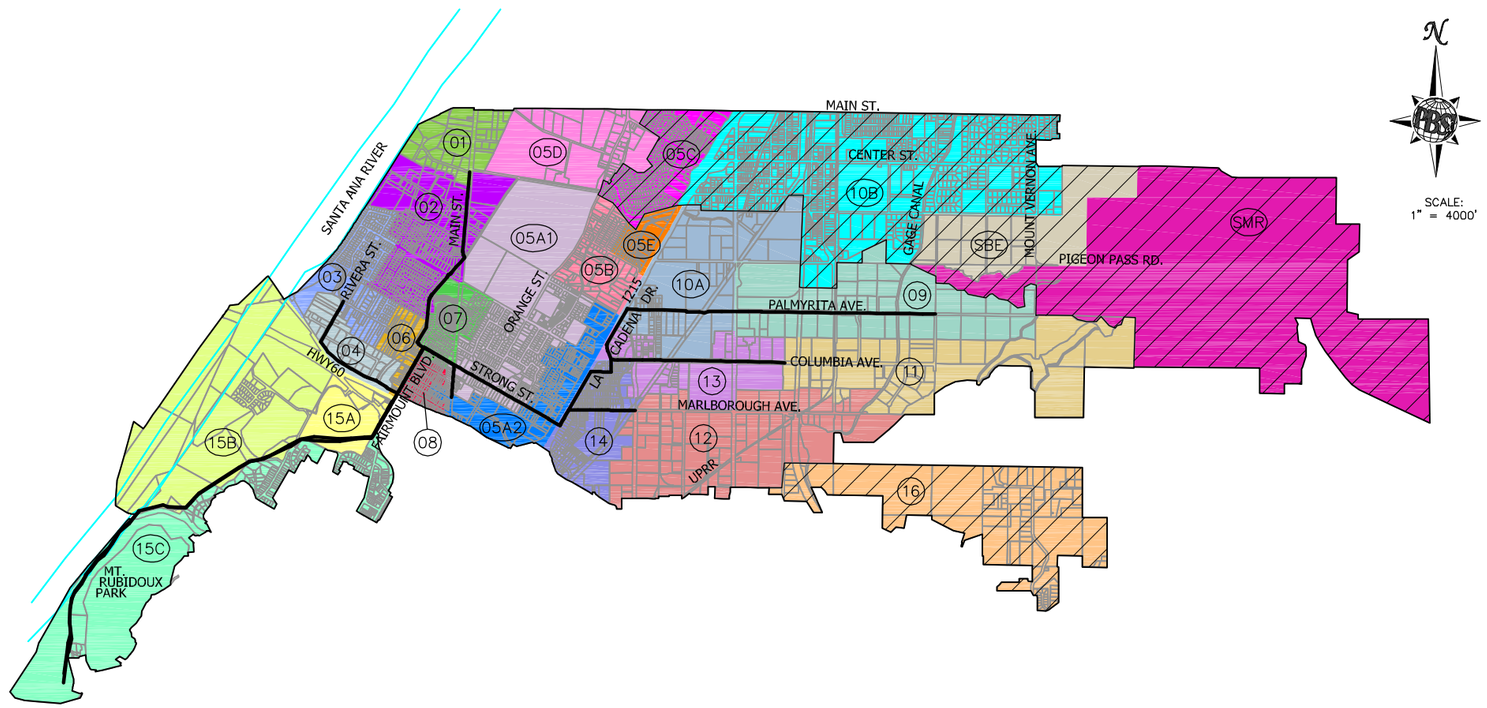
3.0 EXISTING SEWER SYSTEM

3.1 System Overview

As previously described, the Northside Trunk Sewer Study covers approximately 6,000 acres, which has been divided into 26 tributary sub-areas (See Figure 4). Each sub-area can be considered as a sewer sub-basin where wastewater flow from it is intercepted by a sewer trunk line. The wastewater flow generated from a sub-area can be measured at a meter location or can be reasonably assessed based on land use plan of that sub-area. The location of meters can be seen on Figure-5. The modeled gravity conveyance system is approximately 53,000 linear feet (10 miles) of gravity sewer system, with pipe sizes varying from 8 inches to 36 inches in diameter (See Figure 6). Most of the gravity sewer lines within the system are vitrified clay pipe (VCP).

3.2 Collection System

The wastewater generated within the study area flows in the southerly or westerly direction depending on general topography. The major trunk lines are along Palmyrita Avenue, Columbia Avenue, Marlborough Avenue, La Cadena Drive, Strong Street, Main Street, Rivera Street, Fairgrounds Street, Fairmount Boulevard and Rubidoux Mountain Sewer Easement. The trunk line in Palmyrita Avenue accepts sewage flow from Industrial Areas north of Columbia Avenue. The trunk line in Columbia Avenue picks up flow from the area between Palmyrita Avenue and Marlborough Avenue. The trunk line in Marlborough Avenue picks up wastewater flow from the area north of Spruce Street and south of Columbia Avenue. The trunk line in La Cadena Drive accepts flows from Palmyrita Avenue, Columbia Avenue and Marlborough Avenue sewer lines. The trunk line in Main Street conveys wastewater flow from residential and commercial areas west of I-215. The trunk line in Strong Street picks up flow from La Cadena and Main Street sewer lines. The trunk line in Rivera Street collects wastewater flow from the residential area north of Hwy 60. This sewage flow is pumped to the Fairmount trunk sewer line through a small lift station located at Fairgrounds Street. The trunk sewer lines in Fairmount Boulevard pick up flow from the Northside Study area as well as Spruce Study Area. Pipe sizes, lengths, and number of manholes have been tabulated for major segments of the modeled trunk system (See Appendix “C”).



N

SCALE:
1" = 4000'

LEGEND

- SUB AREA 01
- SUB AREA 02
- SUB AREA 03
- SUB AREA 04
- SUB AREA 05A1
- SUB AREA 05A2
- SUB AREA 05B
- SUB AREA 05C
- SUB AREA 05D
- SUB AREA 05E
- SUB AREA 06
- SUB AREA 07
- SUB AREA 08
- SUB AREA 09
- SUB AREA 10A
- SUB AREA 10B
- SUB AREA 11
- SUB AREA 12
- SUB AREA 13
- SUB AREA 14
- SUB AREA 15A
- SUB AREA 15B
- SUB AREA 15C
- SUB AREA 16
- SPRINGBROOK ESTATES (SBE) SUB AREA
- SPRING MOUNTAIN RANCH (SMR) SUB AREA
- COUNTY AREA THAT MAY BE SERVED BY CITY

LEGEND

STUDY SEWER

Engineering
Planning
Surveying
Construction Services
PBSJ
10370 Hemet Street
Suite 200
Riverside, CA 92503
Tel:(951) 358-1433
Fax:(951) 358-1434

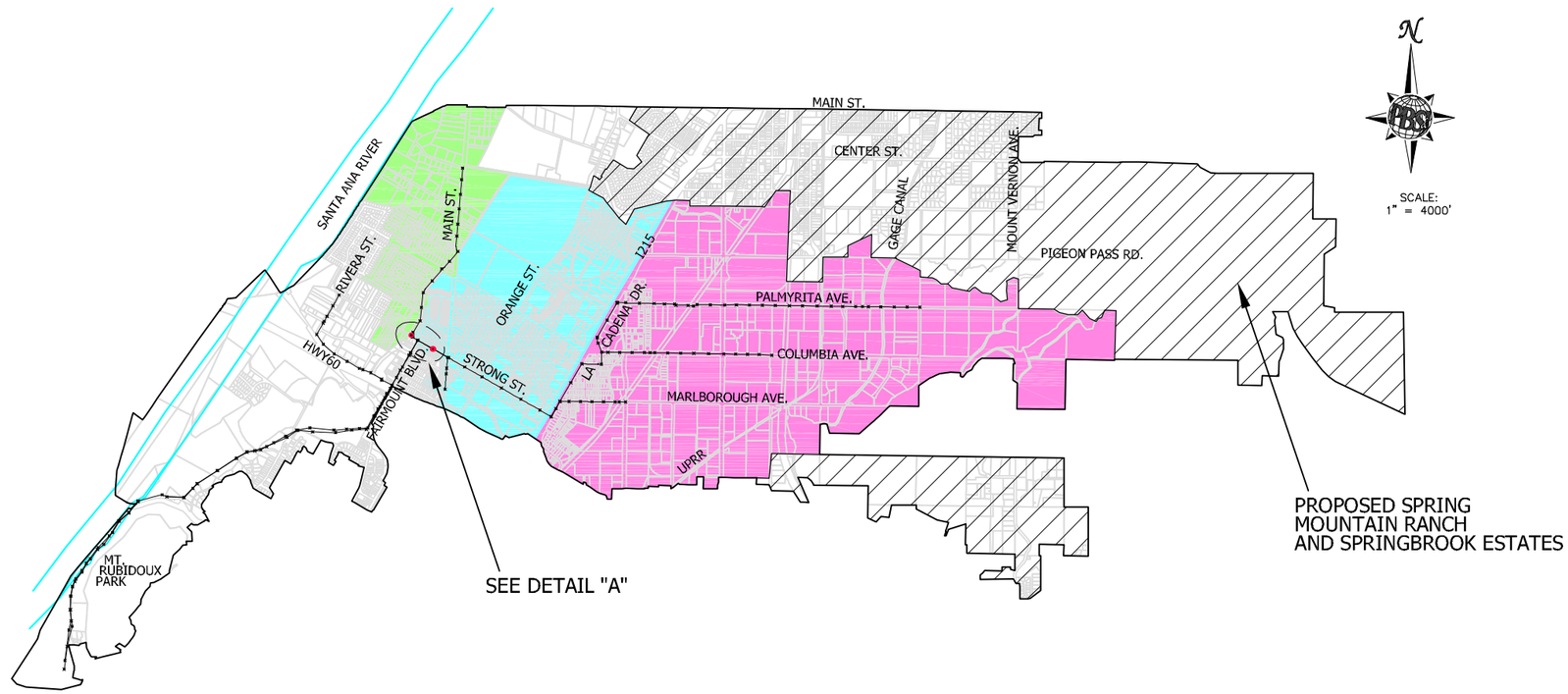
DATE: 01/04/06 | DWN BY: CD

CITY OF RIVERSIDE
NORTHSIDE SEWER STUDY

FIGURE 4

TRIBUTARY AREAS

Y:\City of Riverside\Northside\DWG\Exhibits\NS-TributaryAreas.dwg, 9/28/2006 9:18:35 AM

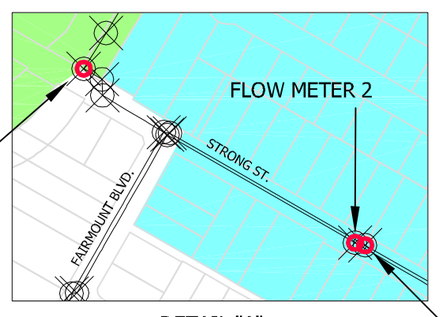


N

SCALE:
1" = 4000'

LEGEND

- STUDY MAIN AND MANHOLES
- FLOW METER 1
- FLOW METER 2
- FLOW METER 3
- FLOW METER LOCATION



FLOW METER 3

FLOW METER 1

DETAIL "A"
NTS

Engineering
Planning
Surveying
Construction Services
PBSJ
10370 Hemet Street
Suite 200
Riverside, CA 92503
Tel:(951) 358-1433
Fax:(951) 358-1434

DATE: 01/04/06	DWN BY: CD
CITY OF RIVERSIDE NORTHSIDE SEWER STUDY	FIGURE 5
FLOW MONITORING LOCATIONS	

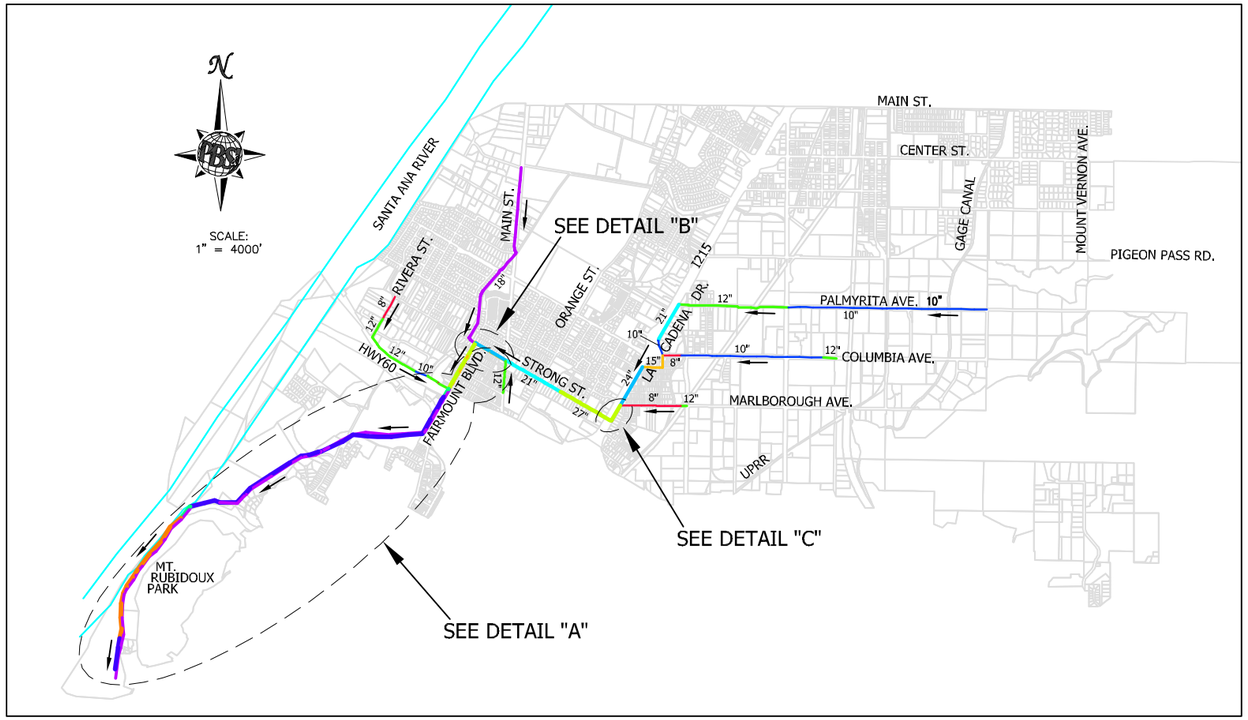
3.3 System Description

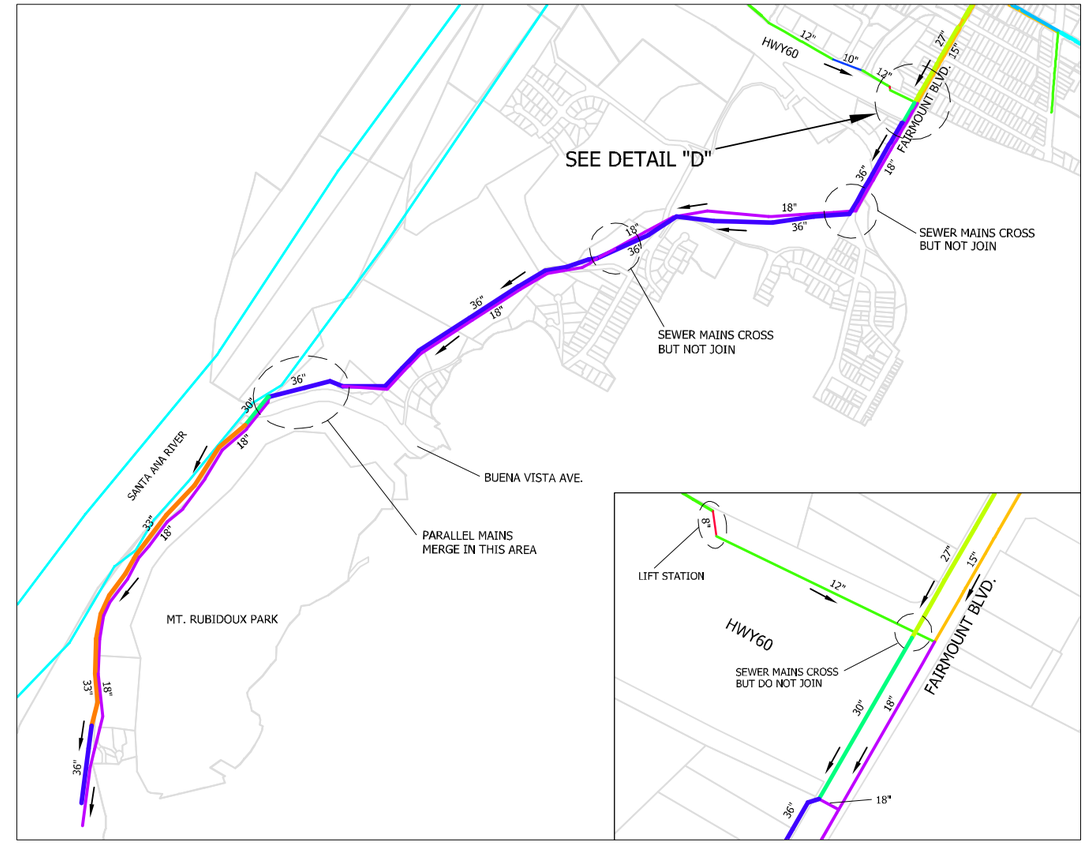
The existing trunk sewer system, which is the subject of this evaluation, is shown on Figure-6. The sewer collection system was constructed over a period of time (50 plus years) to accommodate increasing sewage flow during the development within the City. The GIS data and as-built plans provided by the City were studied to ascertain characteristics of the system. The existing sewer manholes and sewer lines can be seen in Figure-7 and Figure-8 respectively. The pipelines in the system are prefixed with letter "P" (for pipe) and the manholes are prefixed with letter "M" (for manhole) to match the Hydraulic Model. The sewer system is briefly described as follows:

- *Palmyrita Avenue Sewer Line:* The sewer line along Palmyrita Avenue begins at manhole M036P, located at the intersection of Palmyrita Avenue and Michigan Avenue. A 10-inch diameter line picks up flow from industrial development along Palmyrita Avenue. The line between manholes M036P and M036 is 10-inch and between manhole M036 and M025, 12-inch. The line between manholes M025 and M024 is 12-inch. It crosses the railroad on the west side of Iowa Avenue. At manhole M024 the line joins the trunk sewer line along La Cadena Drive.

- *Columbia Avenue Sewer Line*: The sewer line in Columbia Avenue begins at manhole M052 located between Iowa Avenue and Northgate Street. The flow is in a westerly direction. The size of the line between manholes M052 and M039 is 10-inch and between manholes M039 and M019, 8-inch. The line collects wastewater flow from the industrial area and office complexes located along Columbia Avenue. It crosses the railroad on the east side of Chicago Avenue. At manhole M019, it joins the trunk sewer line along La Cadena Drive.

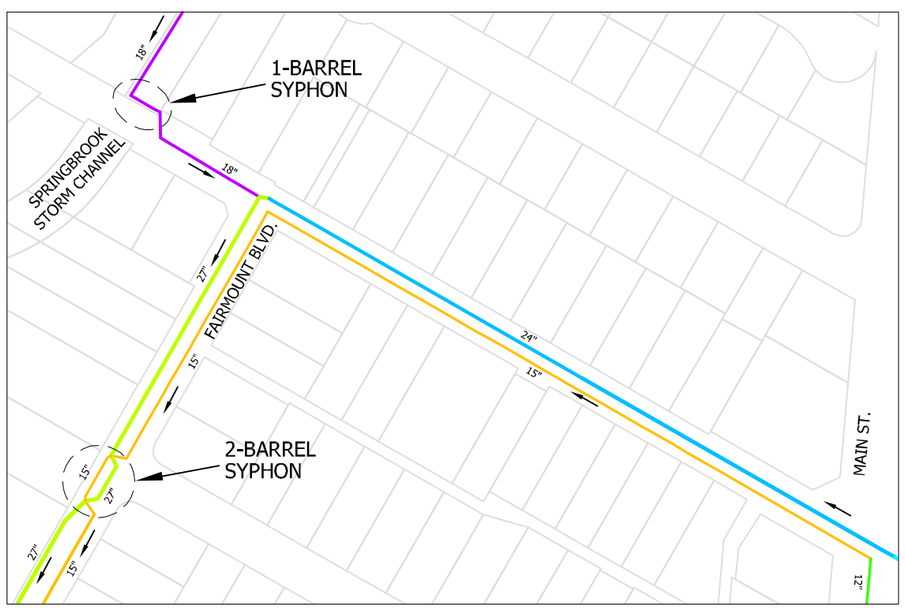
- *Marlborough Avenue Sewer Line*: A 12-inch sewer line along Marlborough Avenue begins at manhole M105 located at the intersection of Chicago Avenue and Marlborough Avenue. The flow is in a westerly direction. The size of the line is 12-inch between manholes M105 and M104 and 8-inch between manholes M104 and M098. The sewer line crosses the railroad west of Chicago Avenue. It picks up wastewater flow from the light industrial development along Chicago Avenue and single family residences along La Cadena Drive.



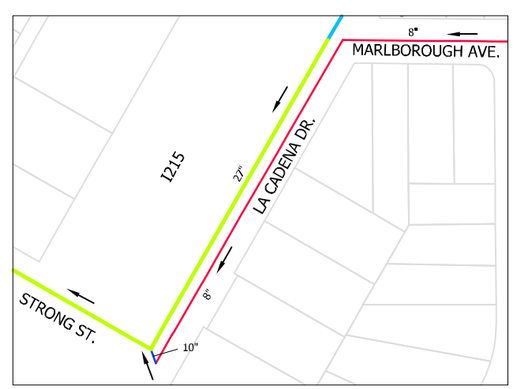


DETAIL "A"
NTS

DETAIL "D"
NTS



DETAIL "B"
NTS



DETAIL "C"
NTS

LEGEND

- 8" DIAMETER PIPE
- 10" DIAMETER PIPE
- 12" DIAMETER PIPE
- 15" DIAMETER PIPE
- 18" DIAMETER PIPE
- 21" DIAMETER PIPE
- 24" DIAMETER PIPE
- 27" DIAMETER PIPE
- 30" DIAMETER PIPE
- 33" DIAMETER PIPE
- 36" DIAMETER PIPE

Engineering
Planning
Surveying
Construction Services
PBS&J
10370 Hemet Street
Suite 200
Riverside, CA 92503
Tel:(951) 358-1433
Fax:(951) 358-1434

DATE: 01/04/06	DWN BY: CD
CITY OF RIVERSIDE NORTHSIDE SEWER STUDY	FIGURE 6
SYSTEM PIPE DIAMETERS	

Y:\City of Riverside\Northside\DWG\Exhibits\NS-SewerSysAndDia.dwg, 9/28/2006 9:17:00 AM

- *La Cadena Drive Sewer Line*: The sewer line along La Cadena Drive begins at manhole M025 located at the intersection of Palmyrita Avenue and La Cadena Drive. A 21-inch line collects wastewater flows from Palmyrita Avenue sewer line and the industrial areas north of Palmyrita Avenue. The flow is in a southwesterly direction, parallel to I-215. The size of the line between manholes M025 and M022 is 21-inch and between manholes M022 and M018, 10-inch. At manhole M019 the line collects flow from Columbia Avenue sewer line. In the reach M018 to M017A the size of the line is 15-inch and the flow is in a westerly direction. The size of the line between manholes M017A and M017 is 21-inch. At manhole M017, a 24-inch line continues to manhole M015. The size of the line between manholes M015 and M014 is 27-inch. The wastewater flow from Marlborough sewer line is intercepted by this line at manhole M014. A parallel sewer line in La Cadena Drive begins at manhole M098 and continues in the southwesterly direction. The size of the line between manholes M098 and M096 is 8-inch and between manholes M096 and M014, 10-inch. The trunk sewer line in La Cadena Drive collects all wastewater flows from study sub-areas east of Fwy. 215. The sewer line joins the trunk line in Strong Street at manhole M014.

- *Strong Street Sewer Line:* The sewer line along Strong Street begins at manhole M014, located at the intersection of Strong Street and La Cadena Drive. This trunk line picks up flow from all study sub-areas located east of Fwy. 215. The size of the line between manhole M014 and M011 is 27-inch and between manholes M011 and M008, 21-inch. A 24-inch line continues west of manhole M008 to manhole M006. Another line runs parallel to the trunk line in the reach between manholes M091 and M089. The size of this line is 15-inch. On the west side of Fairmount Boulevard there is an 18-inch sewer siphon along Strong Street that crosses under the storm drain channel. The sewer line along Strong Street joins the trunk sewer line along Fairmount Boulevard at manhole M005.

- *Main Street Sewer Line:* The sewer line along Main Street has two segments; one on the north of Strong Street and the other on the south. The north segment begins at manhole M069 located at the intersection of Main Street and Garner Road. At this location, an 18-inch sewer line continues along Main Street in a southeasterly direction to manhole M063 located at the intersection of Main Street and Witt Avenue. At this location, the line continues

through a sewer easement in a southwesterly direction to manhole M055 where it joins the siphon in Strong Street.

The southern segment of Main Street sewer line begins at manhole M094 located at the intersection of Main Street and Shamrock Avenue. A 12-inch line continues in a northwesterly direction along Main Street to manhole M091 located at the intersection of Main Street and Strong Street.

- *Rivera Street Sewer Line:* The sewer line begins at manhole M082 located at the intersection of Strong Street and Rivera Street. An 8-inch sewer line continues in a southerly direction to manhole M080. Then a 12-inch line continues to manhole M077 located north of Market Street. This line picks up wastewater flow from residential area north of Market Street and east of Santa Ana River. It joins Fairgrounds Street line at M077.

- *Fairgrounds Street Sewer Line:* The sewer line along Fairgrounds Street begins at manhole M077 located at the intersection of Rivera Street and Market Street. A 12-inch line continues in an easterly direction to manhole M073. Then a 10-inch line continues to manhole M071. The line between manholes M070 and M071 is 12-inch. A small lift station is located at manhole M070. From this location wastewater is lifted to manhole M095 through an 8-inch force main line. The flow between manholes M075 and M084 is through a 12-inch gravity sewer line.

- *Fairmount Boulevard Sewer Line:* The sewer line in Fairmount Boulevard is comprised of two parallel trunk lines and a siphon. A 27-inch sewer line continues in a southerly direction from manhole M005 and joins the siphon at manhole M004. A parallel 15-inch trunk sewer line also continues in a southerly direction and joins the siphon at manhole M004. The siphon is comprised of two parallel conduits (27-inch and 15-inch). These conduits cross under a single barrel box culvert storm drain. At manhole M003 the two trunk sewer lines join and continue in a southerly direction towards Hwy 60. These two sewer lines in Fairmount Boulevard pick up cumulative wastewater flow from the study area north of Hwy 60.

- *Fairmount Trunk (South of Hwy 60 up to Tequesquite Avenue) Sewer Line:* This sewer consists of two parallel trunk sewer lines. A 36-inch sewer line continues in a southerly direction from manhole M001 to manhole M182

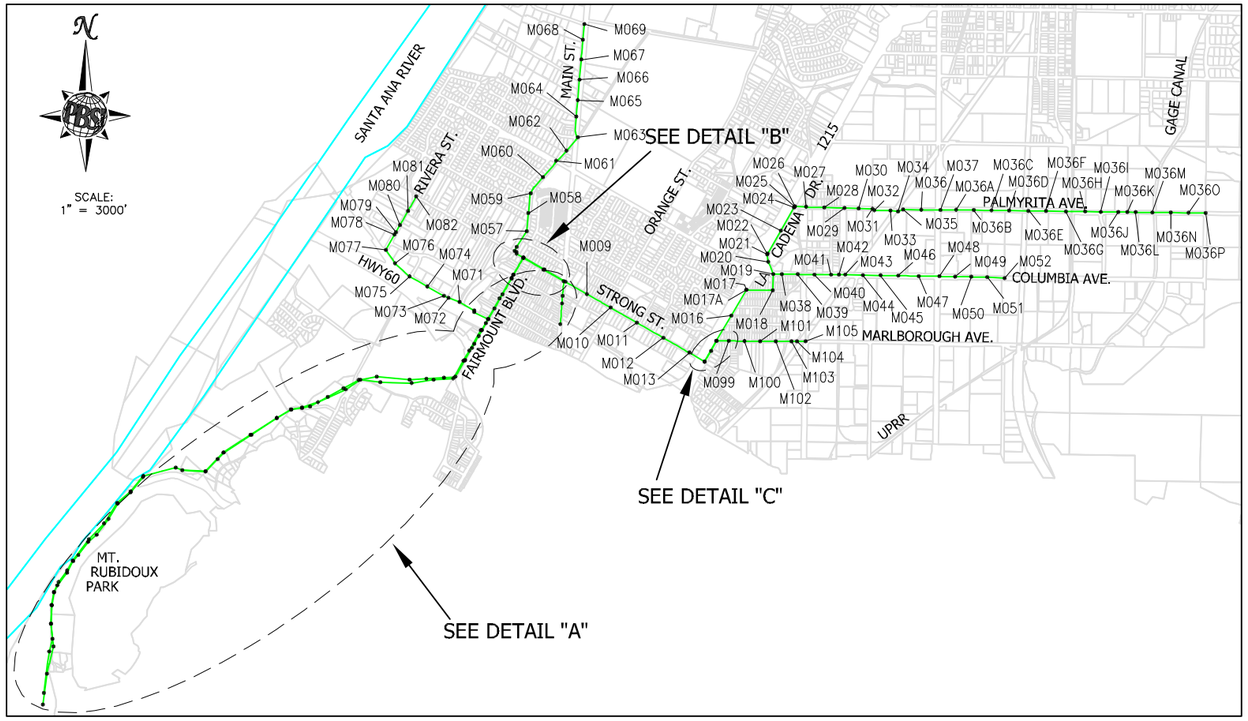
located at Buena Vista Avenue. From this location, a 30-inch line continues to manhole M183 where parallel sewer lines converge. A single 36-inch line continues to manhole M185 where the flow splits into two parallel lines 30-inch and 15-inch in size. At manhole M190 the larger trunk line changes to 33-inch and continues to the end of study area at manhole M220. The trunk line picks up the most of wastewater flows from Spruce Street Sewer Study area at manhole M153. The smaller trunk sewer line is 18-inch diameter in its entire reach. It picks up a small portion of the flow from Spruce Street Sewer Study Area at manhole M145.

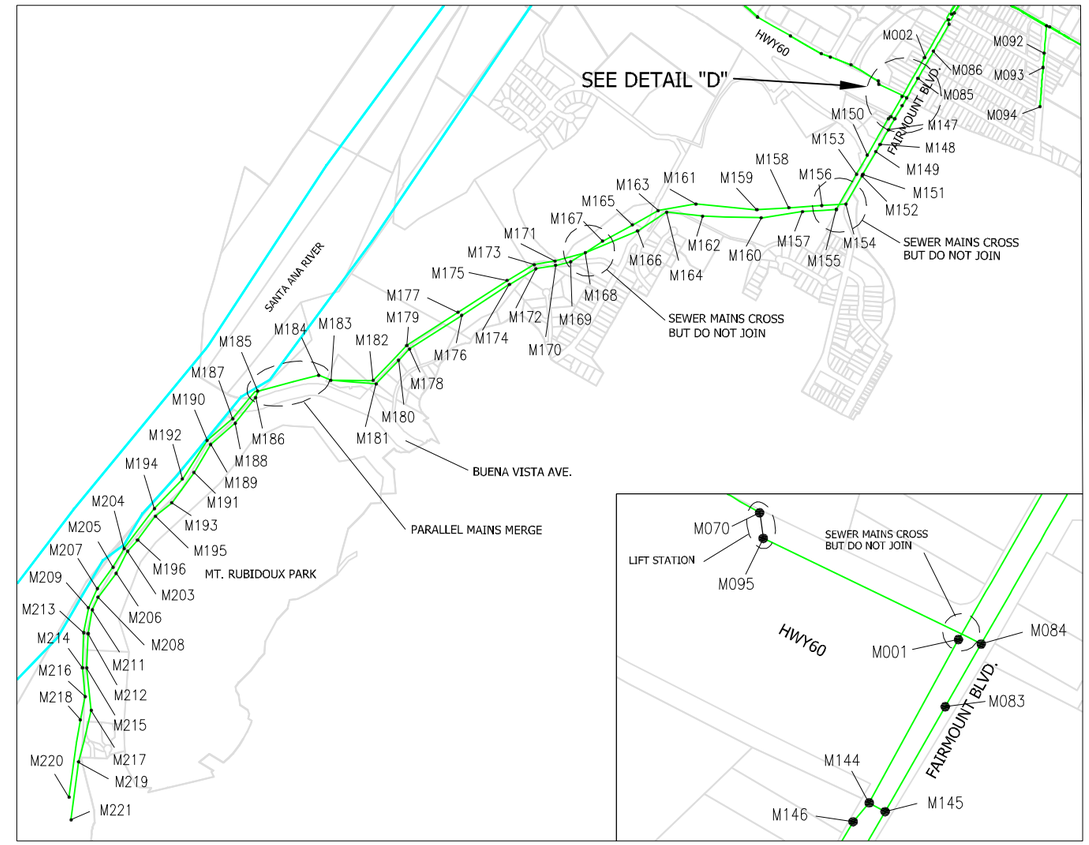
3.4 Tributary Areas

The study area is divided into 26 sub-areas, each area having a land use or flow pattern distinctive from the other. These sub-areas are tributary to a particular meter location either individually or collectively. Because of their strategic locations, meters upstream to a cumulative meter can be subtracted out to reduce the cumulative effect. See Figure 4 for details of tributary sub-areas and Figure 5 for meter locations. The following is the listing of tributary sub-areas and their contribution to a particular meter location.

1. Sub-areas 9, 10A, 11, 12, 13, and 14 are tributary to meter No. 1, located on Strong Street east of Fairmount Boulevard.
2. Sub-areas 5A1, 5A2 and 5E are tributary to meter No. 2 located on Strong Street east of Fairmount Boulevard.
3. Sub-areas 1, 2 and 5D are tributary to meter no. 3 located at the sewer easement north of Strong Street.

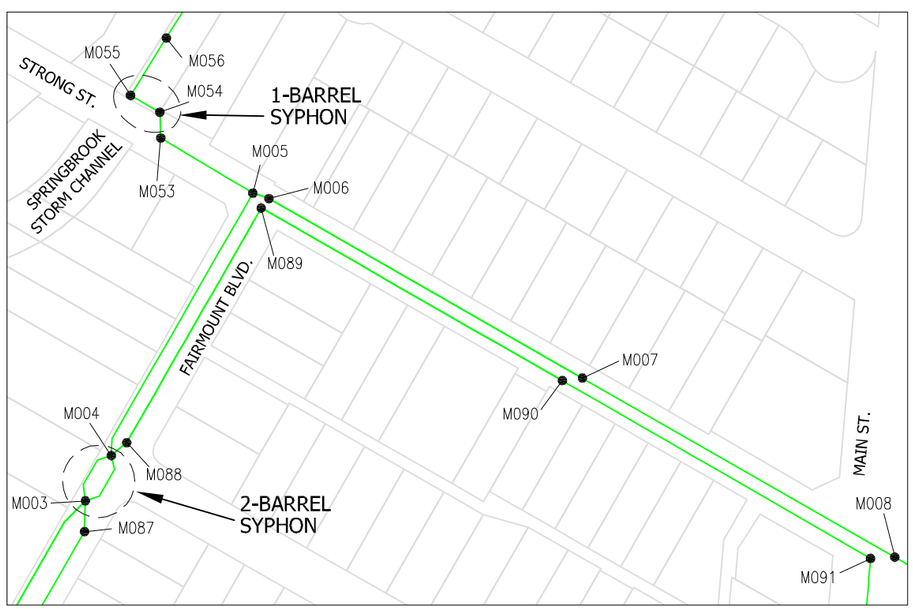
Within each sub-area there is generally a distinct mixture of land use that generates a unique quantity and diurnal pattern of wastewater flows. For identification of land use patterns, data provided by the City of Riverside in GIS Arcview format was used. Table 3-1 summarizes the sub-areas and land uses within the sub-areas that are currently contributing to the existing sewer system.



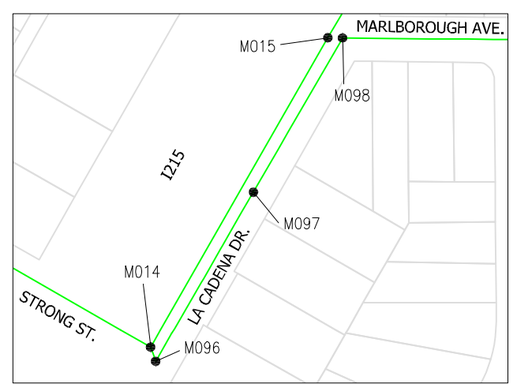


DETAIL "A"
NTS

DETAIL "D"
NTS



DETAIL "B"
NTS



DETAIL "C"
NTS

LEGEND

———	GRAVITY SEWER
M001	MANHOLE NUMBER

Engineering
Planning
Surveying
Construction Services
PBSJ
10370 Hemet Street
Suite 200
Riverside, CA 92503
Tel:(951) 358-1433
Fax:(951) 358-1434

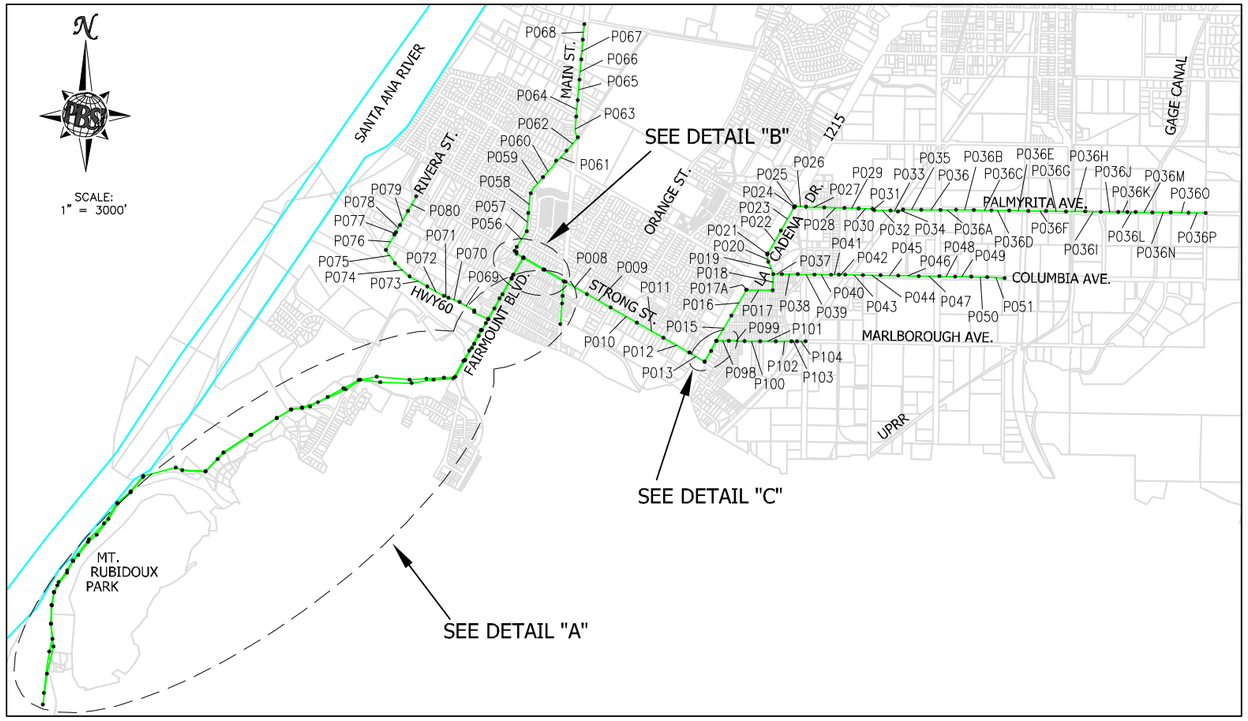
DATE: 01/04/06 | DWN BY: CD

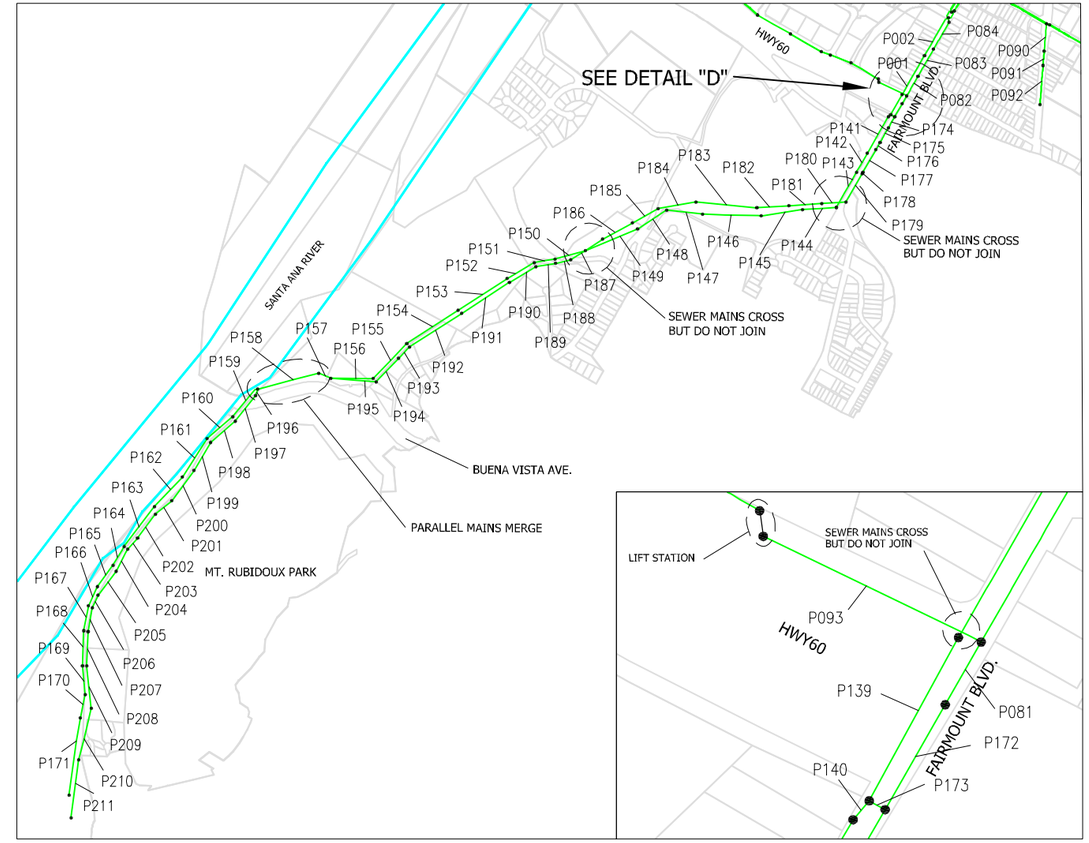
CITY OF RIVERSIDE
NORTHSIDE SEWER STUDY

FIGURE 7

EXISTING MANHOLES

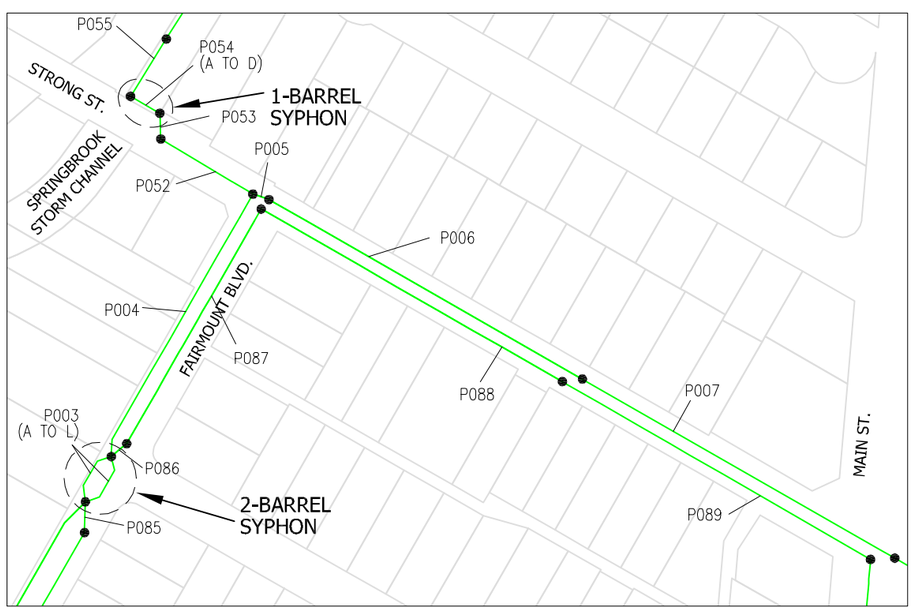
Y:\City of Riverside\Northside\DWG\Exhibits\NS-ManholeIDs.dwg, 9/28/2006 9:12:32 AM



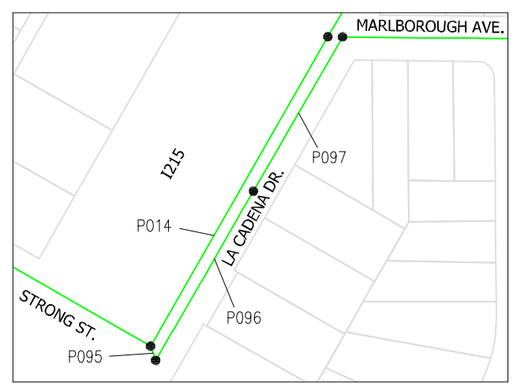


DETAIL "A"
NTS

DETAIL "D"
NTS



DETAIL "B"
NTS



DETAIL "C"
NTS

LEGEND

———	GRAVITY SEWER
P001	PIPE SEGMENT NUMBER

Engineering
Planning
Surveying
Construction Services
PBSJ
10370 Hemet Street
Suite 200
Riverside, CA 92503
Tel:(951) 358-1433
Fax:(951) 358-1434

DATE: 01/04/06 | DWN BY: CD

CITY OF RIVERSIDE
NORTHSIDE SEWER STUDY

FIGURE 8

EXISTING PIPES

Y:\City of Riverside\Northside\DWG\Exhibits\NS-PipeIDs.dwg, 9/28/2006 9:13:35 AM

Table 3-1

Developed Tributary Areas and Current Wastewater Generating Land Use

Sub Area	SFR (Acres)	MFR (Acres)	Commercial (Acres)	Industrial (Acres)	School (Acres)	Total (Acres)
1	-	-	29	17	-	46
2	80	-	29	35	-	144
3	78	-	-	-	-	78
4	1	-	-	44	-	45
5A1	40	-	-	16	9	65
5A2	98	28	10	-	-	136
5D	-	-	-	36	-	36
5E	12	-	-	10	-	22
6	34	-	-	-	-	34
7	35	12	2	-	-	49
8	25	-	-	-	-	25
9	-	-	-	110	-	110
10A	-	-	-	139	-	139
12	-	-	-	201	-	201
13	-	-	-	77	-	77
14	55	-	-	34	-	89
15A	-	-	4	-	-	4
15B	15	-	6	-	-	21
15C	124	-	6	-	-	130

SFR – Single Family Residential
MFR – Multi Family Residential

4.0 DETERMINATION OF SEWER FLOWS

4.1 Flow Monitoring

Flow Monitoring was conducted at three (3) sites in order to accomplish the following: (See Figure 5 for locations of Flow Monitoring Stations).

- Establish current flow levels.
- Verify or adjust flow coefficients.
- Establish characteristic flow patterns (Diurnal Curves) for the model (See Figures 12-14).
- Confirm peak to average flow relationships.
- Help prioritize recommend improvements.

Meter locations were chosen to observe actual flow characteristics for the various sub-areas and to provide a continuous record of measured flows over a period of time (two weeks for this study). Meter locations were also chosen in such a manner that current flow quantities along the Fairmount Boulevard Trunk Sewer could be quantitatively determined. The following is an amplification of the logic for placement of each flow meter.

- Meter No. 1; location on Strong Street east of Fairmount Boulevard – This location was chosen because it carries all the flow generated from the industrial area east of I-215. The flow pattern at this location reflects a diurnal pattern of mixed land uses consisting of light industrial, industrial business park and residential development.

- Meter No. 2; location on Strong Street east of Fairmount Boulevard – This location was chosen to observe flow generated from the residential area west of I-215. This meter intercepts most of the flow generated from the residential development (medium to high density) and the diurnal curve can be used for calibration of residential flow.

- Meter No. 3; location in sewer easement north of Strong Street – This location was chosen to measure the flow from residential areas (low to medium density) that are not contributory to flow at meter location 2.

4.2 Results of Flow Monitoring

Measurement of sewage flows is an imprecise science, as the in-line equipment is placed in a harsh environment and is subject to solids interference, turbulence and other problems, which can impede the accuracy. Installed equipments must be frequently inspected, calibrated, and maintained, and monitoring results interpreted, evaluated for reasonableness, and sometimes adjusted. In this particular application, metered flow information was generally good. However, some flows at specific meter locations did not display consistent values. Graphical results at each site were carefully reviewed for consistency and reasonableness, using the following general guidelines.

- Where the magnitude or daily pattern varies significantly from one non-holiday weekday to the next, the data is likely to be flawed.
- Where the base (low) flows are rising during the flow monitoring period, the data is suspect.
- Where the algebraic sum of flows from meters in series are significantly out of sync, the data from one or more meters may be faulty.
- Where minimum (nighttime) flows are abnormally high or algebraically inconsistent, the data is suspect.
- Where the measured depth data and velocity data are inconsistent, the data is suspect.

Metered flows displaying one or more of the above flaws were purged or adjusted based on reasonable assumptions.

At each meter location the flow-monitoring device measures depth of flow and velocity. Upon reviewing the report submitted by Downstream Services, and from discussions with their staff, it was determined the data (depth or velocity) that is more consistent should be used for determination of flow. By using depth of flow readings and inputting pipe characteristics from record drawings (slope, size and roughness “n” values), sewage flow can be calculated using Manning’s equation. The raw flow data have been included in Appendix “A”.

The flow data at each meter site, adjusted based on the depth measurement, are shown in Figures 9 through 11. The following relevant observations were made from evaluation of the measured flows:

- Flows from the study area east of I-215 are atypical because of the majority of study area being light industrial / commercial. These areas produce less flow than estimated

from the land use pattern because some of the parcels are being used for storage purposes only.

- Weekend hydrographs show generally lower flows and smaller peaks than weekday patterns, for the commercial / industrial area, usually due to closure of offices during the weekends.

- At meter location 1, the velocity and depth of flow readings are consistent for the period October 5-9, 2004. The flow during this monitoring period has been used for estimation of the maximum flow and calibration of the model.

- Flow measured at meter location 2 is higher than the anticipated theoretical flow from the land use. This is most likely attributable to a higher than anticipated resident population or "overcrowding" in this particular area. The diurnal flow patterns derived from meter no. 2 reveal a consistent high flow during night - time hours. This can be explained by the general nocturnal habits of people living in high-density residential areas. The people living in these areas usually work in multiple shifts and use the wastewater facilities in inconsistent ways. The flow pattern is similar to Kansas Street area of Spruce Street Sewer Capacity Study. The flow for the period September 30 – October10, 2004 shows a relatively consistent flow pattern which has been used for estimation of maximum flow and calibration of the model.

5.0 ESTIMATED ULTIMATE FLOW

5.1 Methodology

Future wastewater flows in the study area are estimated by applying unit (per acre or per capita) flow factors to the projected "ultimate" land use acreage or population in each sub area. As discussed in Section 2, ultimate land uses within the study area are estimated based on the City's current General Plan (which governs future development/redevelopment) and input from City staff. The major contributor to the projected wastewater flow in the future would be undeveloped industrial business park area in the eastern portion of I-215, proposed Spring Mountain Ranch (SMR) residential development and Springbrooks Estates Development. For purposes of this study it has been assumed that these areas will be developed by the year 2020.

5.2 Flow Coefficients

A review of commonly used flow coefficients (or unit factors) was performed to arrive at preliminary criteria, which is an appropriate starting point for the study.

Flow coefficients are commonly expressed in terms of cubic feet per second (cfs) of average dry weather flow (ADWF) per acre of a specific land use type. For population based estimates, flows are expressed in gallons per capita per day (gpcd). Peak flow generation rates can be estimated by applying peaking factors to the average flow, with factors often based on observed peak-to-average ratios from previous studies. However peaking factors and diurnal flow patterns vary greatly from one setting to another. Peaks for various uses differ not only in magnitude, but also in time of the day. The diurnal patterns are thus a composite picture of inflows that are not simultaneous, but rather staggered throughout the day. Also, peaks are attenuated by lag times and in-pipe storage as the flows move downstream. Notwithstanding the above, diurnal peaking factors are also estimated for each land use type to estimate peak generation rates.

For preliminary estimation of wastewater flow, the document "Criteria for Sewer Facility Design, Public Works Department, City of Riverside" was used. (See Appendix "B"). The document states the following general guideline for estimation of wastewater flows:

Flows from Residential Developments:

- Land use shown in the City's General Plan.
- No. of dwelling units per acre within a certain land use.
- Persons per living unit determined from the latest census data for the study area. However, it should not be less than an average of 2.75 persons per living unit.
- Average wastewater flow based on 65 gallons per capita per day.
- Peak to average flows to be determined from the graphs.

Flows from non-residential developments:

- Industrial Developments – Peak flow; 0.012 cfs per acre.
- Commercial Developments – Peak flow 0.01 cfs per acre.
- Offices – 30 gallons per capita (employee on site) per day peak flow.
- Schools – 30 gallons per capita per day.
- Laundromat – 580 gallons per machine per day peak flow.

5.3 Representative Diurnal Hydrographs

The study area is comprised of a variety of unique land uses. For the purpose of defining characteristic diurnal patterns, flow from each sub-basin was analyzed and percentage of flow contribution from each land use type was estimated. Although only a few of the tributary sub areas flowing to the meter locations are comprised of a single land use category, several are dominated by one or two categories, and are thus selected as being representative of the diurnal flow patterns for those land uses. The diurnal patterns were established at each meter location and the model was calibrated for mixed land use. In addition flow from Spruce Street Sewer Capacity Study (June, 2002) was used to determine flow pattern at manhole M153. The following diurnal patterns were used for the modeled peak flow evaluation.

- Flow at meter location 1: Mixed Land Use Pattern (Residential, Commercial and Light Industrial)

- Flow at meter location 2: Mixed Residential (SFR and MFR)

- Flow at meter location 3: Residential

These representative diurnal hydrographs are shown in Figures 12-14. The flow patterns are used in the model to estimate, for each land use type, the percentage of Average Dry Weather Flow (ADWF) contributed at specific times throughout the day.

Figure 9

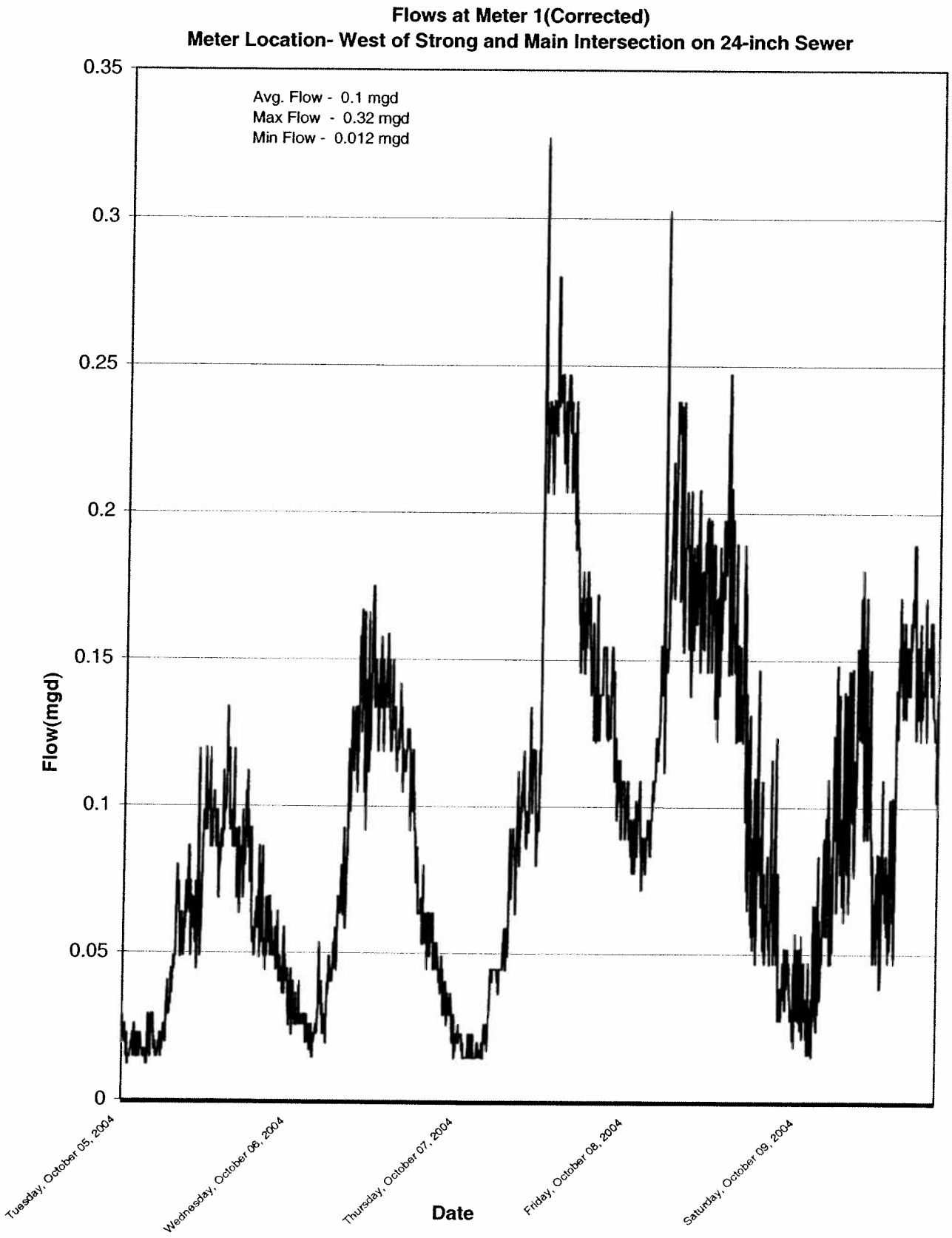

Flows at Meter 1(Corrected)
Meter Location- West of Strong and Main Intersection on 24-inch Sewer
Avg. Flow - 0.1 mgd
Max Flow - 0.32 mgd
Min Flow - 0.012 mgd
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
Flow(mgd)
Tuesday, October 05, 2004
Wednesday, October 06, 2004
Thursday, October 07, 2004
Friday, October 08, 2004
Saturday, October 09, 2004
Date

Figure 10

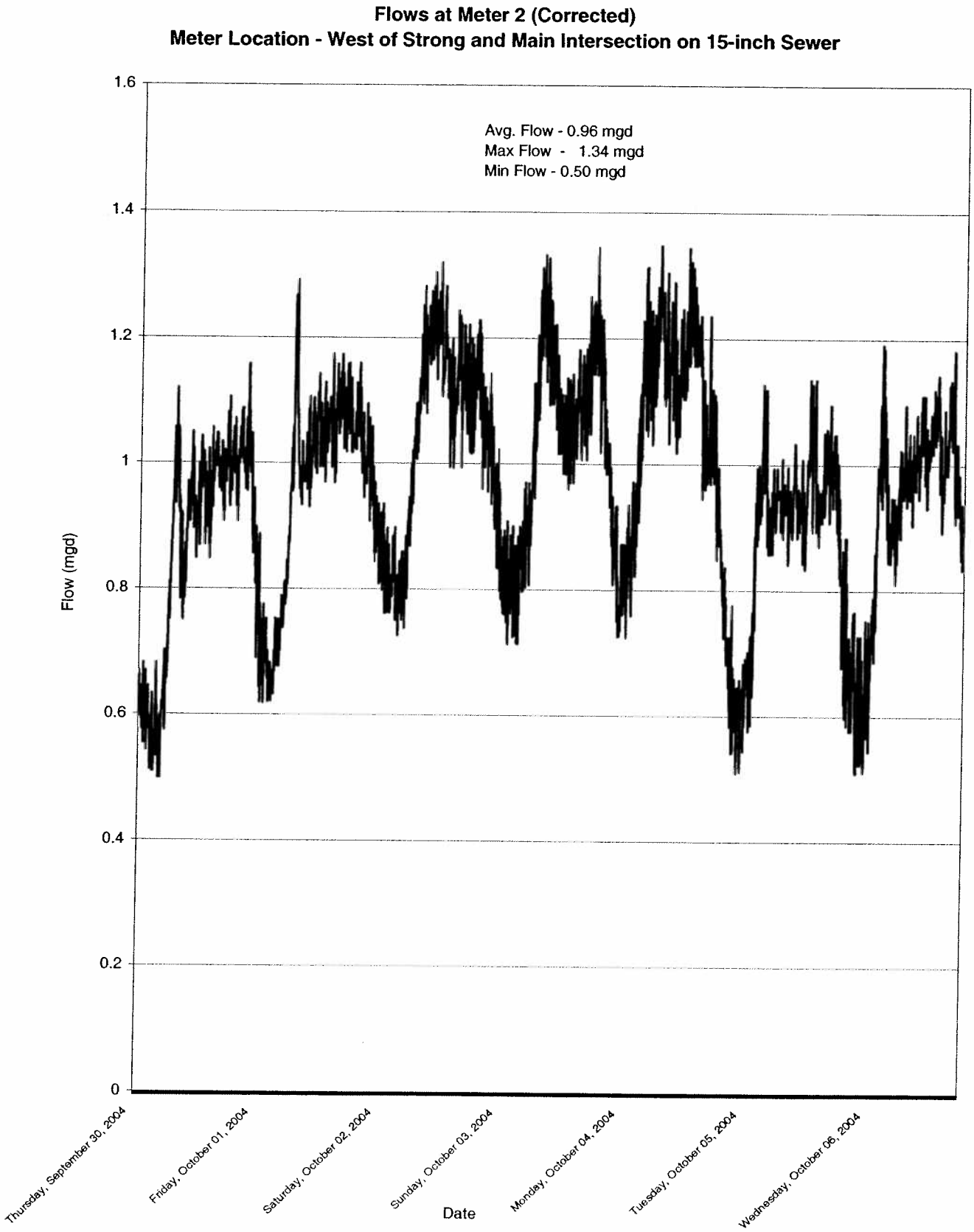

Flows at Meter 2 (Corrected)
Meter Location - West of Strong and Main Intersection on 15-inch Sewer
Avg. Flow - 0.96 mgd
Max Flow - 1.34 mgd
Min Flow - 0.50 mgd
Flow (mgd)
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
Thursday, September 30, 2004
Friday, October 01, 2004
Saturday, October 02, 2004
Sunday, October 03, 2004
Monday, October 04, 2004
Tuesday, October 05, 2004
Wednesday, October 06, 2004
Date

Figure 11

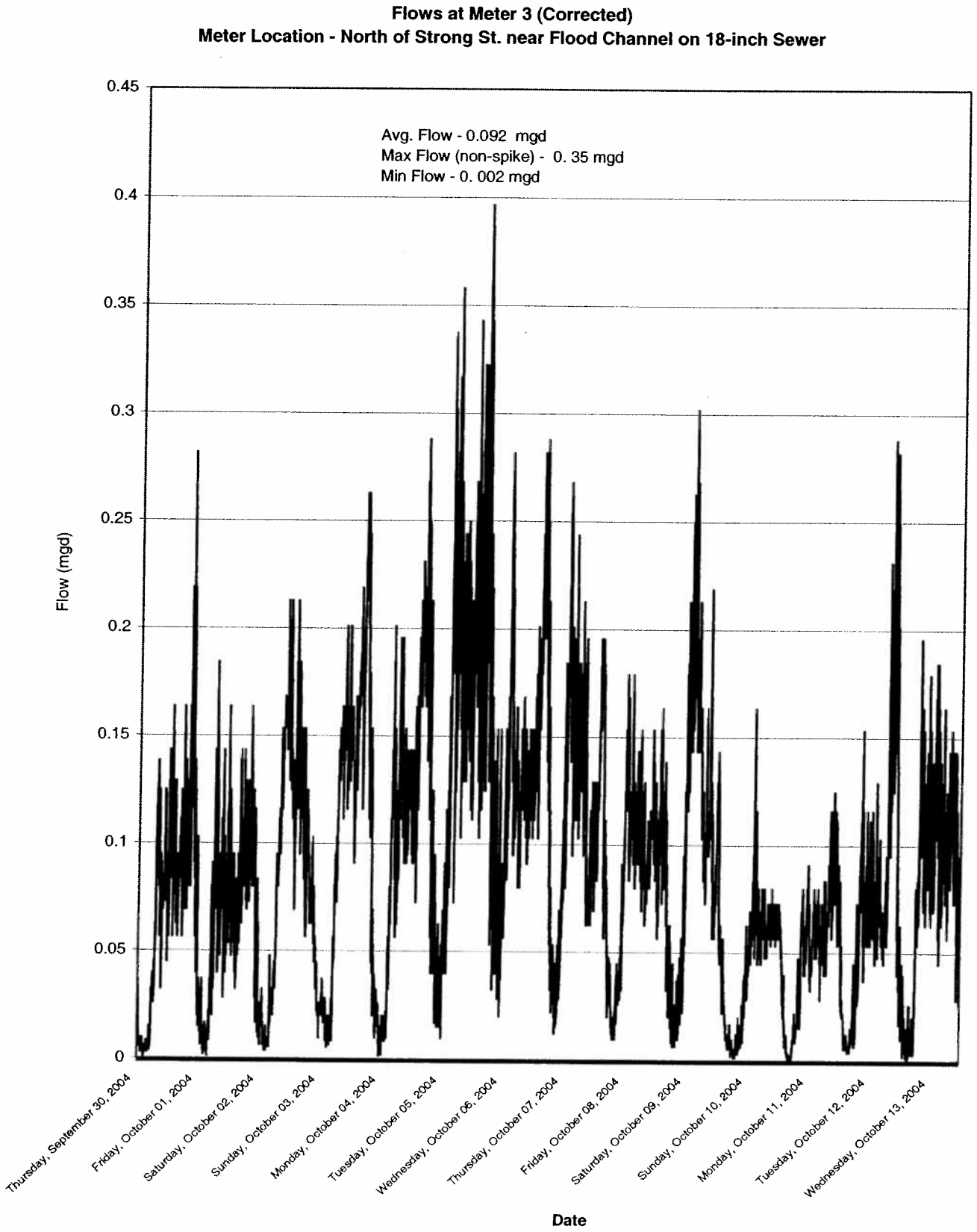

Flows at Meter 3 (Corrected)
Meter Location - North of Strong St. near Flood Channel on 18-inch Sewer
Avg. Flow - 0.092 mgd
Max Flow (non-spike) - 0. 35 mgd
Min Flow - 0. 002 mgd
Flow (mgd)
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
Thursday, September 30, 2004
Friday, October 01, 2004
Saturday, October 02, 2004
Sunday, October 03, 2004
Monday, October 04, 2004
Tuesday, October 05, 2004
Wednesday, October 06, 2004
Thursday, October 07, 2004
Friday, October 08, 2004
Saturday, October 09, 2004
Sunday, October 10, 2004
Monday, October 11, 2004
Tuesday, October 12, 2004
Wednesday, October 13, 2004
Date

Figure 12

Representative Diurnal Curve for Mixed Land Use (Residential and Industrial)
Meter Location 1

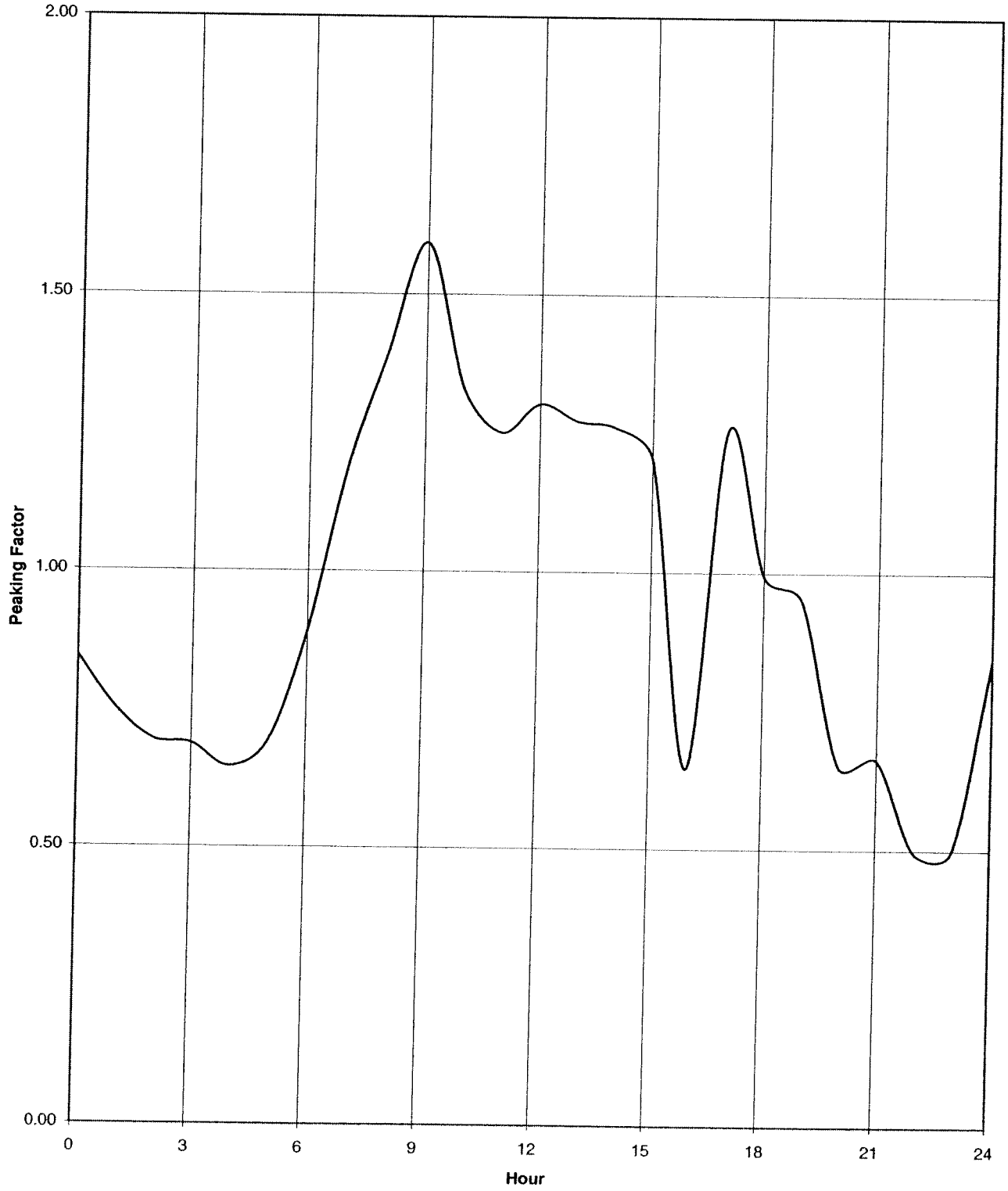


Figure 13

Representative Diurnal Curve for Residential (SFR and MFR), at Meter Location 2

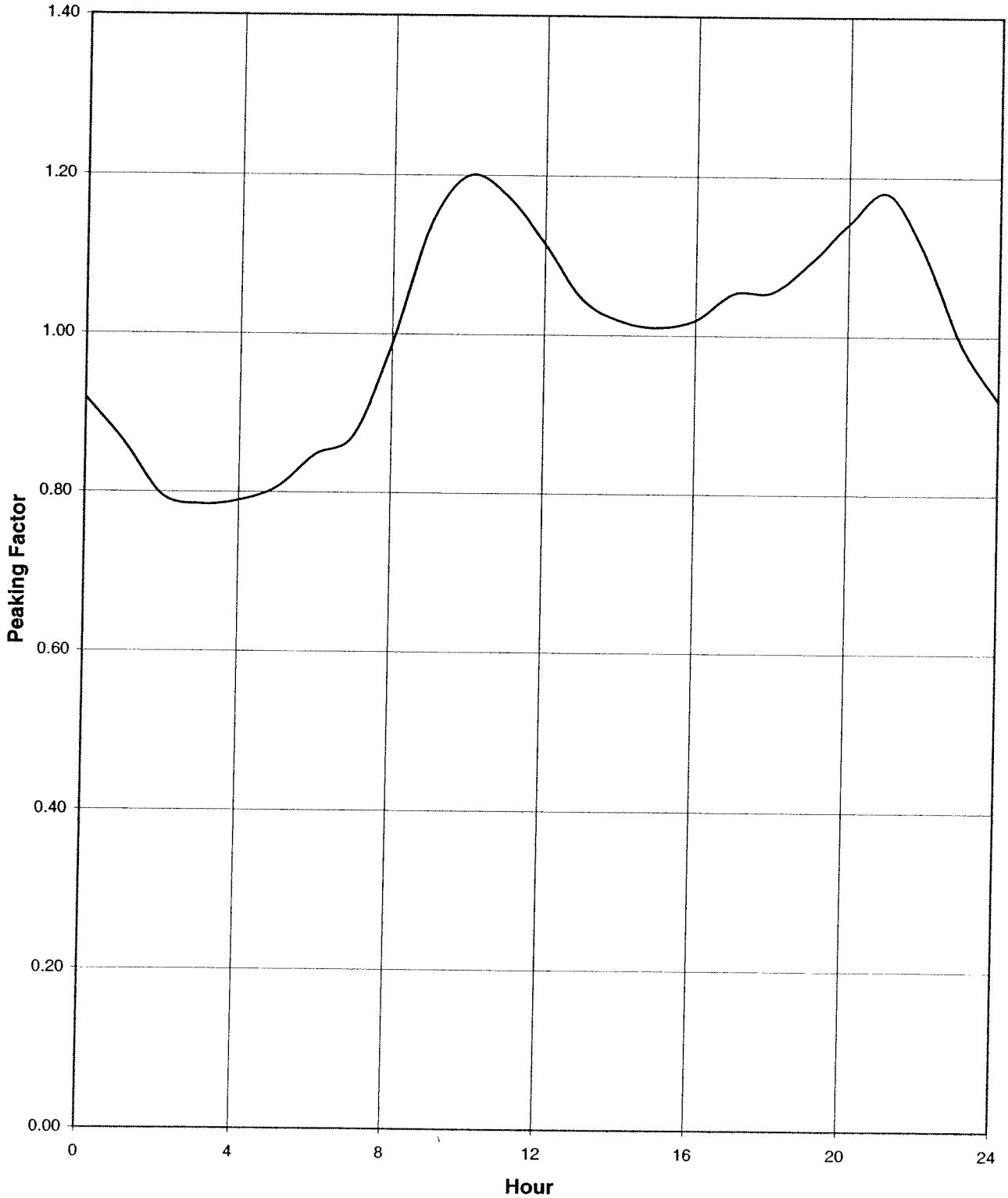
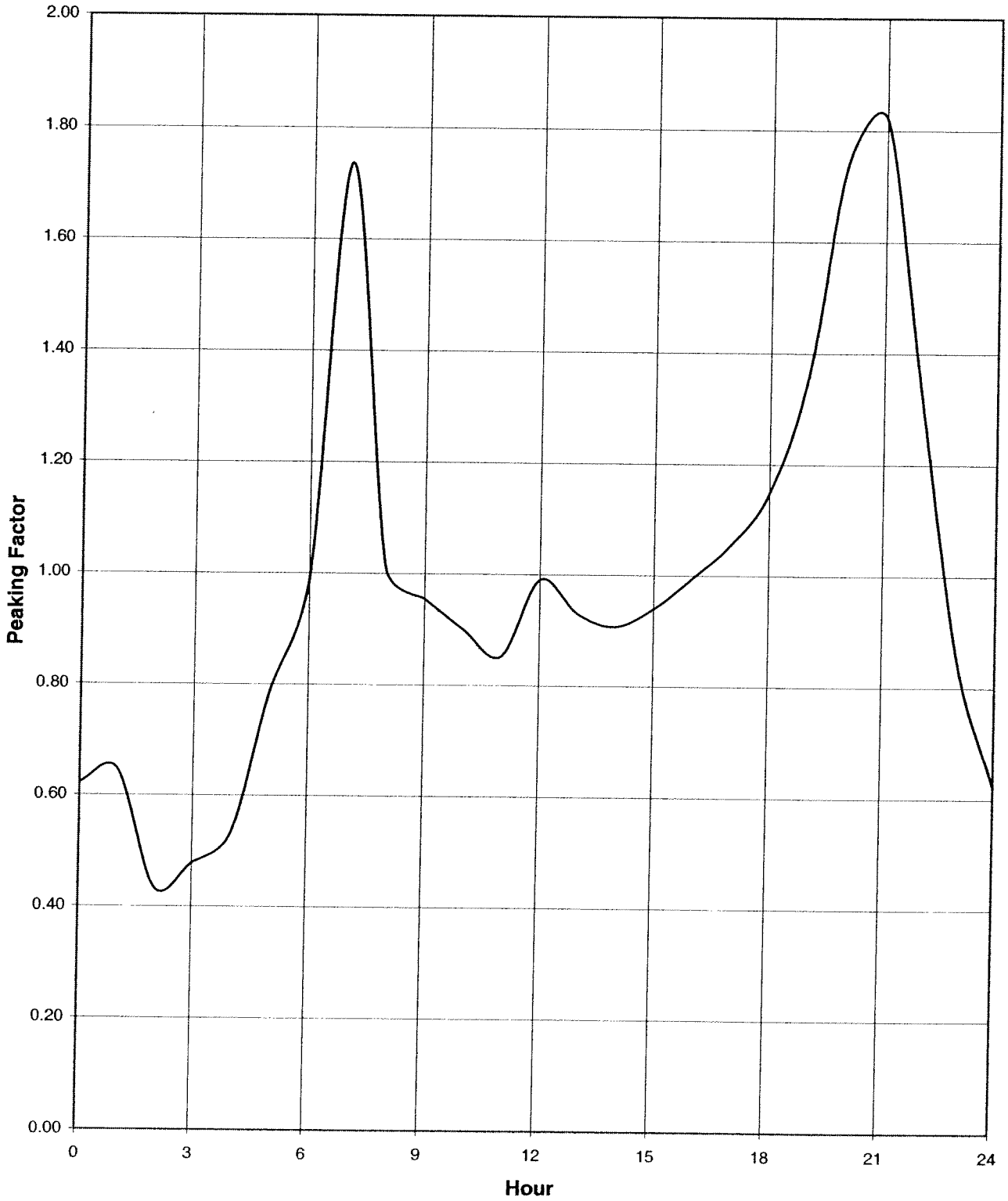


Figure 14

Representative Diurnal Curve for Land Use (Residential), at Meter Location 3



6.0 COMPUTER MODEL SIMULATION ANALYSIS

6.1 Methodology

Capacity analysis involved the evaluation of the available capacity in the existing collection system under present and future development conditions. Based on results of the analysis, phased facility improvements were identified to allow for projected growth within the service area.

This section describes the analytical methodology and hydraulic model development and summarizes the results of the analyses.

The principal tool utilized in the capacity analysis was a hydraulic model that simulates flow conditions using demand and piping characteristic input data. With this input information, the model is able to compute and output depth of flow, rate of flow, and velocity of flow, in selected pipes and manholes during different times of the day. The model selected for use in this study is XP-SWMM (XP Software, Version 9.12). This modeling software belongs to a class of software referred to as “dynamic wave models”. These types of models provide an accurate simulation of hydraulic flow conditions over an extended period of time.

Data required to create the model include information describing the physical wastewater collection system, such as pipe diameters and reach lengths, manhole invert elevations, and estimated pipe roughness coefficients. Additionally, data describing the sewage loading at selected manholes expressed as a varying flow rate over time (i.e. a diurnal curve), must be provided. Model output consists of a variety of hydraulic parameters, most importantly peak flow velocity and discharge rates.

Calibration of the model consisted of simulating existing sewer flow conditions and comparing the modeled flows with the recorded flows at the meter locations. The assumed diurnal curves that serve as input to the model were iteratively adjusted until the simulated and recorded sewage flow hydrographs achieved reasonable agreement.

Simulations of future sewage flow conditions were performed by developing input data sets that included sewage generation projections for the assumed ultimate development conditions. Pipe reaches in which simulated peak flows exceeded a specified trigger criteria, were identified as potential improvement reaches. Improvements required to provide adequate capacity for projected flows were then determined through an iterative modeling process. The process consists of simulating flow conditions after increasing the diameter of downstream portions of the identified

reaches. In subsequent iterations, additional lengths of pipe were increased in diameter until the projected peak flow could be conveyed through the reach without exceeding the specified design flow criteria.

6.2 Limitations of Modeling

The hydraulic model, which was utilized as the primary planning tool for the sewer capacity analysis, provides an accurate simulation of actual flow conditions within a sanitary sewer system in response to existing and future sewage loading. The accuracy of the simulation, however, is directly related to the accuracy of the model input data, including physical parameters and sewage loading projections. For example, in a case where roots had entered the pipeline, thereby causing a restriction of flow, the model would be unable to predict the reduction in flow through this obstruction. Consequently, a general understanding of the data sources is critical in interpreting the modeling results.

The physical parameters of the model, including the pipe diameter, slope, and roughness coefficients were based principally on City's GIS database information. Where this data appeared to be inaccurate, construction drawings were reviewed and the input data corrected.

Network connectivity refers to the flow path followed by sewage within the sewer system. The connectivity is a function of the relative slope of each sewer pipe and the relative invert elevations of the incoming and outgoing sewer pipes at manholes. For example, a manhole may have two or more sewer pipes, which could convey flow away from the manhole. If the invert (bottom) of one of these pipes is lower than the other, the downstream flow path at this manhole would follow the lower pipe.

Sewage loading projections were based on calibrated flow rates. As previously described, flow rates used for calibration were based on actual monitored flows at key points in the trunk system over a 2-week period in October 2004. This period included the two weekends.

Since a degree of uncertainty exists in both the physical data and the sewage loading projections used as model inputs, reaches identified by model simulations as near or at capacity should be subject to additional engineering evaluation prior to implementing improvements. Such evaluation may include field inspection, video monitoring and flow metering.

The results of model runs for existing and ultimate conditions are summarized in Table 7-1.

Table 7-1
Sewer Analysis Results (Existing and Future Conditions)

Name	Diameter, ft	Slope (%)	Theoretical "Full" Flow (cfs)	Existing Estimated Peak Flow (cfs)	Existing Estimated % Full	Year 2020 Estimated Peak Flow (cfs)	Year 2020 Estimated % Full
P001	2.25	0.2400	15.15	3.090	20%	11.086	73%
P002	2.25	0.1764	12.99	3.183	24%	11.087	85%
P003A	2.25	0.4878	Siphon	2.574		10.981	
P003B	2.25	-41.4266	Siphon	2.569		10.984	
P003C	2.25	-20.7000	Siphon	2.574		10.984	
P003D	2.25	0.0000	Siphon	2.490		10.984	
P003E	2.25	41.4013	Siphon	2.502		10.985	
P003F	2.25	0.9569	Siphon	1.788		10.994	
P003G	1.25	0.9569	Siphon	1.142		1.358	
P003H	1.25	41.4013	Siphon	1.164		1.358	
P003I	1.25	0.0000	Siphon	1.181		1.358	
P003J	1.25	-20.7000	Siphon	1.199		1.358	
P003K	1.25	-41.4266	Siphon	1.207		1.358	
P003L	1.25	0.4878	Siphon	1.279		1.358	
P004	2.25	0.2837	16.48	0.851	5%	8.563	52%
P005	2.25	0.4054	19.70	0.528	3%	7.285	37%
P006	2.00	0.4419	15.01	0.442	3%	7.150	48%
P007	2.00	0.4424	15.02	0.443	3%	7.149	48%
P008	1.75	1.1616	17.04	0.443	3%	7.149	42%
P009	1.75	4.1142	32.08	0.443	1%	7.150	22%
P010	1.75	2.2855	23.91	0.443	2%	7.150	30%
P011	2.25	0.3283	17.73	0.443	2%	7.150	40%
P012	2.25	0.3288	17.74	0.444	3%	7.151	40%
P013	2.25	0.5684	23.32	0.445	2%	7.151	31%
P014	2.25	0.5348	22.62	0.222	1%	5.895	26%
P015	2.00	0.4812	15.67	0.223	1%	5.895	38%
P016	2.00	0.4822	15.68	0.223	1%	5.896	38%
P017	1.25	0.3459	3.79	0.223	6%	5.896 21"	156%
P017A	1.75	1.0204	15.97	0.223	1%	5.896	37%
P018	1.25	0.3473	3.79	0.223	6%	5.896 21"	155%
P019	0.83	0.6178	1.71	0.147	9%	3.967 18"	231%
P020	0.83	0.6207	1.72	0.147	9%	3.967 18"	231%
P021	0.83	~~1.0000~~ 0.62	1.74 ~~2.18~~	0.147	8% ~~7%~~	3.967 18"	~~182%~~ 228%
P022	1.75	0.5486	11.71	0.147	1%	3.967	34%
P023	1.75	0.5465	11.69	0.147	1%	6.397	~~55%~~
P024	0.83	0.0870	0.64	0.147	23%	6.397 27"	~~996%~~
P025	1.25	0.1960	2.85	0.147	5%	3.516 18"	~~123%~~
P026	1.25 ~~1.00~~	~~1.0800~~ 0.35	3.85 3.69	0.110	3%	3.340	~~91%~~ 87%
P027	1.00	1.0800	3.69	0.110	3%	3.336	90%
P028	1.00	~~1.2000~~ 1.08	3.74 3.89	0.110	3%	3.333	~~86%~~ 89%
P029	1.00	1.2186	3.92	0.110	3%	3.984 18"	102%
P030	1.00	~~1.1978~~ 1.21	3.96 3.88	0.110	3%	3.984 18"	103%
P031	1.00	~~1.2400~~ 1.47	3.95	0.110	3%	3.984 18"	101%
P032	1.00	0.8400	3.25	0.110	3%	3.984 18"	122%
P033	1.00	0.8400	3.25	0.110	3%	3.985 18"	123%
P034	1.00	1.3400	4.11	0.110	3%	3.985	97%
P035	1.00	~~1.3056~~ 1.04	3.67 4.06	0.110	3%	3.986 18"	~~98%~~ 109%
P036	1.00	1.3134	4.07	0.110	3%	3.988	98%
P036A	0.83	2.1005	3.16	0.056	2%	2.552	81%
P036B	0.83	2.2000	3.23	0.056	2%	2.558	79%
P036C	0.83	2.5600	3.49	0.056	2%	2.580	74%
P036D	0.83	2.5600	3.49	0.056	2%	2.600	75%
P036E	0.83	1.9227	3.02	0.056	2%	2.599	86%
P036F	0.83	3.1457	3.86	0.056	1%	2.601	67%
P036G	0.83	2.6010	3.51	0.056	2%	2.601	74%

Table 7-1
Sewer Analysis Results (Existing and Future Conditions)

Name	Diameter, ft	Slope (%)	Theoretical "Full" Flow (cfs)	Existing Estimated Peak Flow (cfs)	Existing Estimated % Full	Year 2020 Estimated Peak Flow (cfs)	Year 2020 Estimated % Full
P036H	0.83	3.0000	3.77	0.056	1%	2.601	69%
P036I	0.83	3.0007	3.77	0.056	1%	2.602	69%
P036J	0.83	2.9677	3.75	0.056	2%	2.602	69%
P036K	0.83	2.9506	3.74	0.057	2%	2.603	70%
P036L	0.83	2.9203	3.72	0.057	2%	2.603	70%
P036M	0.83	3.0000	3.77	0.057	1%	2.603	69%
P036N	0.83	2.6393	3.54	0.057	2%	2.603	74%
P036O	0.83	2.6393	3.54	0.057	2%	2.604	74%
P036P	0.83	2.6342	3.54	0.057	2%	2.605	74%
P037	0.67	0.4000	0.41 0.76	0.041	18" 5%	2.065	272%
P038	0.67	0.4000	0.76	0.041	18" 5%	2.065	272%
P039	0.83	1.2849	2.45	0.041	2%	2.196	90%
P040	0.83	1.3050	2.49	0.041	2%	2.196	88%
P041	0.83	2.1999	3.20	0.041	1%	2.196	69%
P042	0.83	2.0498	3.12	0.041	1%	2.099	67%
P043	0.83	1.5029	2.67	0.041	2%	2.101	79%
P044	0.83	1.2971	2.48	0.041	2%	2.108	85%
P045	0.83	1.2657	2.45	0.041	2%	2.128	87%
P046	0.83	1.5366	2.70	0.041	2%	2.174	80%
P047	0.83	1.2000	2.39	0.041	2%	2.215	93%
P048	0.83	1.9600	3.05	0.042	1%	2.093	69%
P049	0.83	1.9700	3.06	0.049	2%	2.093	68%
P050	0.83	1.9371	3.03	0.040	1%	2.096	69%
P051	1 ~~0.83~~	0.3984	2.88 1.38	0.040	3%	2.096	~~152%~~ 73%
P052	1.50	0.1047	3.39	0.541	16%	2.180	64%
P053	1.50	0.3863	6.51	0.541	8%	2.180	33%
P054A	1.50	5.0000	Siphon	0.541		2.180	
P054B	1.50	-70.6666	Siphon	0.541		2.180	
P054C	1.50	0.3647	Siphon	0.541		2.180	
P054D	1.50	80.0000	Siphon	0.541		2.180	
P055	1.50	0.1247	3.70	0.530	14%	2.166	59%
P056	1.50	0.1178	3.60	0.531	15%	2.167	60%
P057	1.50	0.1201	3.63	0.531	15%	2.168	60%
P058	1.50	0.2250	4.97	0.267	5%	1.452	29%
P059	1.50	0.2250	4.97	0.269	5%	1.452	29%
P060	1.50	0.2222	4.94	0.269	5%	1.453	29%
P061	1.50	0.2234	4.95	0.269	5%	1.453	29%
P062	1.50	0.2244	4.96	0.269	5%	1.454	29%
P063	1.50	0.2201	4.92	0.269	5%	1.455	30%
P064	1.50	0.2188	4.90	0.269	5%	1.455	30%
P065	1.50	0.2198	4.91	0.269	5%	1.456	30%
P066	1.50	0.2202	4.92	0.270	5%	1.457	30%
P067	1.50	0.2202	4.92	0.270	5%	1.459	30%
P068	1.50	0.2188	4.90	0.271	6%	1.460	30%
P069	1.00	0.3555	2.12	0.068	3%	0.107	5%
P070	0.83	0.9928	2.17	0.068	3%	0.107	5%
P071	0.83	1.3006	2.48	0.068	3%	0.107	4%
P072	1.00	0.3490	2.10	0.068	3%	0.107	5%
P073	1.00	0.3282	2.03	0.068	3%	0.107	5%
P074	1.00	0.3483	2.09	0.068	3%	0.107	5%
P075	1.00	0.3512	2.10	0.068	3%	0.107	5%
P076	1.00	0.3486	2.10	0.068	3%	0.107	5%
P077	1.00	0.3507	2.10	0.069	3%	0.107	5%
P078	1.00	0.0523	0.81	0.069	8%	0.107	13%
P079	0.67	0.3477	0.71	0.069	10%	0.108	15%

Table 7-1
Sewer Analysis Results (Existing and Future Conditions)

Name	Diameter, ft	Slope (%)	Theoretical "Full" Flow (cfs)	Existing Estimated Peak Flow (cfs)	Existing Estimated % Full	Year 2020 Estimated Peak Flow (cfs)	Year 2020 Estimated % Full
P080	0.67	0.3490	0.71	0.069	10%	0.108	15%
P081	1.25	0.4198	4.17	0.262	6%	0.388	9%
P082	1.25	0.0781	1.80	0.025	1%	0.125	7%
P083	1.50	0.2034	4.73	0.026	1%	0.126	3%
P084	1.25	0.3252	3.67	0.026	1%	0.127	3%
P085	1.25	3.5714	12.17	0.000	0%	0.000	0%
P086	1.25	5.3571	14.90	2.068	14%	2.722	18%
P087	1.25	0.2003	2.88	2.068	72%	2.722	94%
P088	1.25	0.2010	2.89	2.069	72%	2.723	94%
P089	1.25	0.2002	2.88	2.070	72%	2.725	95%
P090	1.00	1.0000	3.55	0.613	17%	1.020	29%
P091	1.00	2.1527	5.21	0.613	12%	1.020	20%
P092	1.00	0.4386	2.35	0.613	26%	1.021	43%
P093	1.00	0.0744	0.97	0.228	24%	0.293	30%
P095	0.83	0.5896	1.67	0.232	14%	1.257	75%
P096	0.67	0.4000	0.76	0.232	31%	1.257	18" 166%
P097	0.67	0.4000	0.76	0.233	31%	1.257	18" 166%
P098	0.67	0.4000	0.76	0.207	27%	1.136	18" 150%
P099	0.67	1.0000	1.20	0.208	17%	1.137	95%
P100	0.67	1.6871	1.56	0.208	13%	1.140	73%
P101	0.67	1.3613	1.40	0.208	15%	1.170	84%
P102	0.67	1.8871	1.65	0.209	13%	1.175	71%
P103	0.67	1.9091	1.66	0.209	13%	1.176	71%
P104	1.00	0.9907	3.53	0.209	6%	1.176	33%
P139	2.50	0.4357	27.05	3.072	11%	11.086	41%
P140	3.00	0.8270	60.64	3.251	5%	11.344	19%
P141	3.00	0.1823	28.47	3.244	11%	11.343	40%
P142	3.00	0.2380	32.53	3.234	10%	11.335	35%
P143	3.00	0.2156	30.97	9.844	32%	19.928	64%
P144	3.00	0.2260	31.70	9.841	31%	19.927	63%
P145	3.00	0.2273	31.79	9.837	31%	19.927	63%
P146	3.00	0.2268	31.76	9.830	31%	19.927	63%
P147	3.00	0.2277	31.82	9.825	31%	19.926	63%
P148	3.00	0.2271	31.78	9.823	31%	19.926	63%
P149	3.00	0.2268	31.76	9.820	31%	19.925	63%
P150	3.00	0.2275	31.81	9.817	31%	19.925	63%
P151	3.00	0.2279	31.83	9.815	31%	19.925	63%
P152	3.00	0.2271	31.78	9.829	31%	19.940	63%
P153	3.00	0.2262	31.72	9.827	31%	19.940	63%
P154	3.00	0.2271	31.78	9.823	31%	19.939	63%
P155	3.00	0.2266	31.74	9.820	31%	19.938	63%
P156	3.00	0.1629	26.92	9.818	36%	19.938	74%
P157	3.00	0.4996	47.14	10.127	21%	20.303	43%
P158	3.00	0.2464	33.10	10.126	31%	20.303	61%
P159	2.50	0.6132	32.09	7.625	24%	15.488	48%
P160	2.50	0.6115	32.05	7.624	24%	15.488	48%
P161	2.75	0.3653	31.95	7.624	24%	15.488	48%
P162	2.75	0.3679	32.06	7.624	24%	15.488	48%
P163	2.75	0.3685	32.09	7.623	24%	15.488	48%
P164	2.75	0.3679	32.06	7.623	24%	15.488	48%
P165	2.75	0.3677	32.05	7.623	24%	15.488	48%
P166	2.75	0.3679	32.06	7.623	24%	15.488	48%
P167	2.75	0.3691	32.11	7.623	24%	15.488	48%
P168	2.75	0.3632	31.86	7.623	24%	15.488	49%
P169	2.75	0.3732	32.29	7.622	24%	15.488	48%

Table 7-1
Sewer Analysis Results (Existing and Future Conditions)

Name	Diameter, ft	Slope (%)	Theoretical "Full" Flow (cfs)	Existing Estimated Peak Flow (cfs)	Existing Estimated % Full	Year 2020 Estimated Peak Flow (cfs)	Year 2020 Estimated % Full
P170	2.75	0.3624	31.82	7.622	24%	15.488	49%
P171	2.75	0.2300	25.35	7.621	30%	15.488	61%
P172	1.50	0.2445	5.18	0.262	5%	0.388	7%
P173	1.50	0.2217	4.93	0.228	5%	0.299	6%
P174	1.50	0.2860	5.60	0.294	5%	0.370	7%
P175	1.50	0.0951	3.23	0.294	9%	0.370	11%
P176	1.50	0.3737	6.41	0.294	5%	0.370	6%
P177	1.50	0.1304	3.78	0.294	8%	0.370	10%
P178	1.50	0.3784	6.45	0.294	5%	0.370	6%
P179	1.50	0.2036	4.73	0.294	6%	0.370	8%
P180	1.50	0.2028	4.72	0.293	6%	0.369	8%
P181	1.50	0.3143	5.87	0.295	5%	0.371	6%
P182	1.50	0.2929	5.67	0.295	5%	0.371	7%
P183	1.50	0.3005	5.74	0.295	5%	0.371	6%
P184	1.50	0.3004	5.74	0.295	5%	0.371	6%
P185	1.50	0.3001	5.74	0.295	5%	0.371	6%
P186	1.50	0.2996	5.74	0.358	6%	0.434	8%
P187	1.50	0.3000	5.74	0.358	6%	0.434	8%
P188	1.50	0.2950	5.69	0.358	6%	0.434	8%
P189	1.50	0.3013	5.75	0.358	6%	0.434	8%
P190	1.50	0.2967	5.71	0.36	6%	0.434	8%
P191	1.50	0.2950	5.69	0.36	6%	0.434	8%
P192	1.50	0.3049	5.79	0.36	6%	0.433	7%
P193	1.50	0.2999	5.74	0.36	6%	0.433	8%
P194	1.50	0.2999	5.74	0.36	6%	0.433	8%
P195	1.50	0.3439	6.14	0.36	6%	0.433	7%
P196	1.50	0.2921	5.66	2.50	44%	4.815	85%
P197	1.50	0.3000	5.74	2.50	44%	4.815	84%
P198	1.50	0.3010	5.75	2.50	43%	4.815	84%
P199	1.50	0.5198	7.55	2.50	33%	4.815	64%
P200	1.50	0.5210	7.56	2.50	33%	4.815	64%
P201	1.50	0.2984	5.72	2.50	44%	4.815	84%
P202	1.50	0.3004	5.74	2.50	44%	4.815	84%
P203	1.50	0.3354	6.07	2.50	41%	4.815	79%
P204	1.50	0.3174	5.90	2.50	42%	4.815	82%
P205	1.50	0.3018	5.76	2.50	43%	4.815	84%
P206	1.50	0.2993	5.73	2.50	44%	4.81	84%
P207	1.50	0.2988	5.73	2.50	44%	4.81	84%
P208	1.50	0.3010	5.75	2.50	43%	4.81	84%
P209	1.50	0.6407	8.39	2.50	30%	4.81	57%
P210	1.50	0.2993	5.73	2.50	44%	4.81	84%
P211	1.50	0.2994	5.73	2.50	44%	4.81	84%

7.0 DEFICIENCIES AND SOLUTIONS

7.1 Deficient and Marginally Deficient Pipes

The Computer model simulations of the City's wastewater system have evaluated pipe reaches in terms of both volume and velocity criteria.

The City's design criterion for sewer lines allows pipes to flow at a ratio of 75% of "full" hydraulic capacity. Assuming that "full" capacity is the maximum hydraulic capacity of a pipe flowing under gravity (non-pressure) conditions, Manning's equation shows that maximum flow occurs when a pipe reaches a flow depth ratio of about 95% depth/diameter (d/D). For the purpose of this study, pipes flowing at 90% or greater capacity are considered "deficient", and pipes flowing at greater than 75% and less than 90% are considered "marginally deficient".

Pipe reaches which fail the "75% full" volume criterion for both existing and future flow conditions are shown in Table 7-2 and Figures 15 and 17. It is seen that under existing flow conditions none of the pipes in the system flow greater than 90% full. At ultimate conditions (year 2020) some of the reaches flow greater than 90% full and some greater than 75% full.

A velocity more than 10 feet per second is considered to be the threshold for scouring. The pipes having a maximum velocity of more than 10 feet per second are considered "deficient" in velocity, due to the potential erosion of the interiors of pipe walls over time. A velocity less than 2 feet per second is not considered self- cleansing and pipe reaches that have a maximum flow velocity less than 2 feet per second under existing flow conditions are also considered "deficient" in velocity. These pipes are shown in Figure 16.

7.2 Project Prioritization Methodology

The 75% full criterion is useful for analyzing deficient pipes and as a basis for sizing new facilities. However, the criterion is not necessarily the trigger point for replacement or augmentation of an existing sewer line. In most cases, a sewer entity would not implement a relief project until capacity problems are actually observed or known to be imminent.

A recommended system of project prioritization is the categorization of deficient sewer lines based on modeled % full results. The "A" priority projects are imminently needed and the "B" and "C" projects require further consideration for replacement. Priority classifications are described as follows:

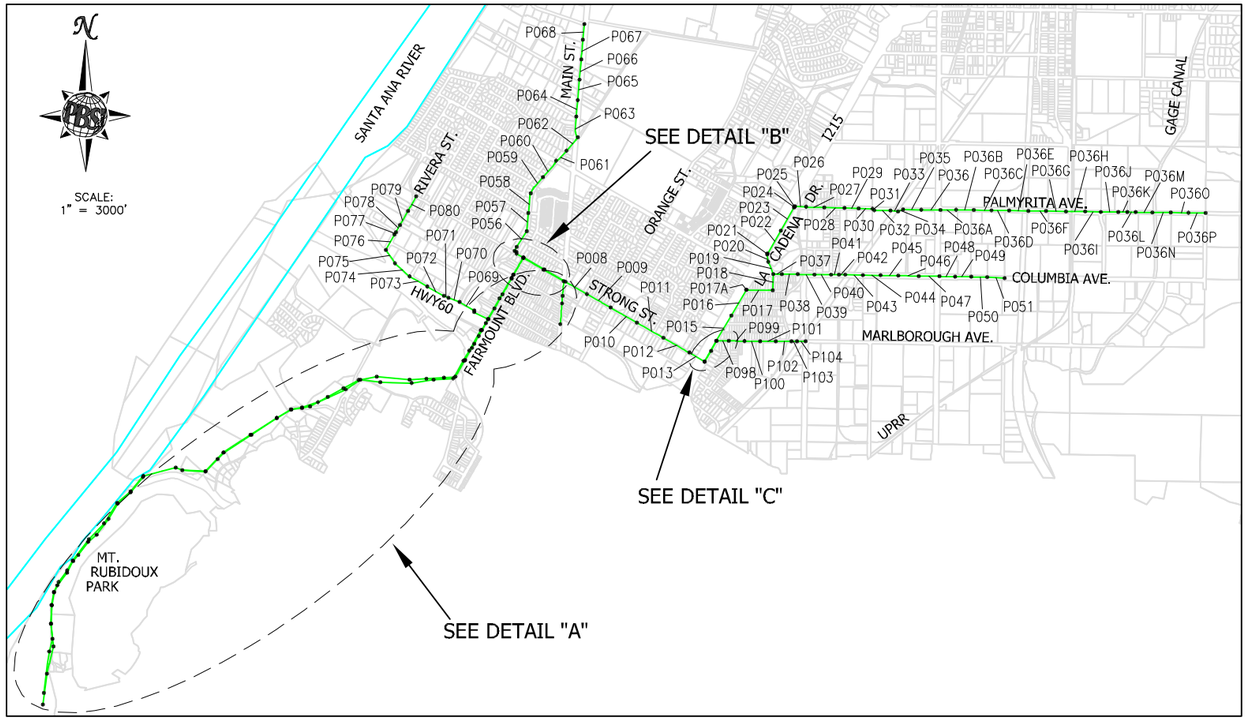
Priority "A" – The pipes listed within this priority are currently flowing more than 90% full under the maximum flow condition. Modeled results indicate that there are no pipes that are currently flowing more than 90% full.

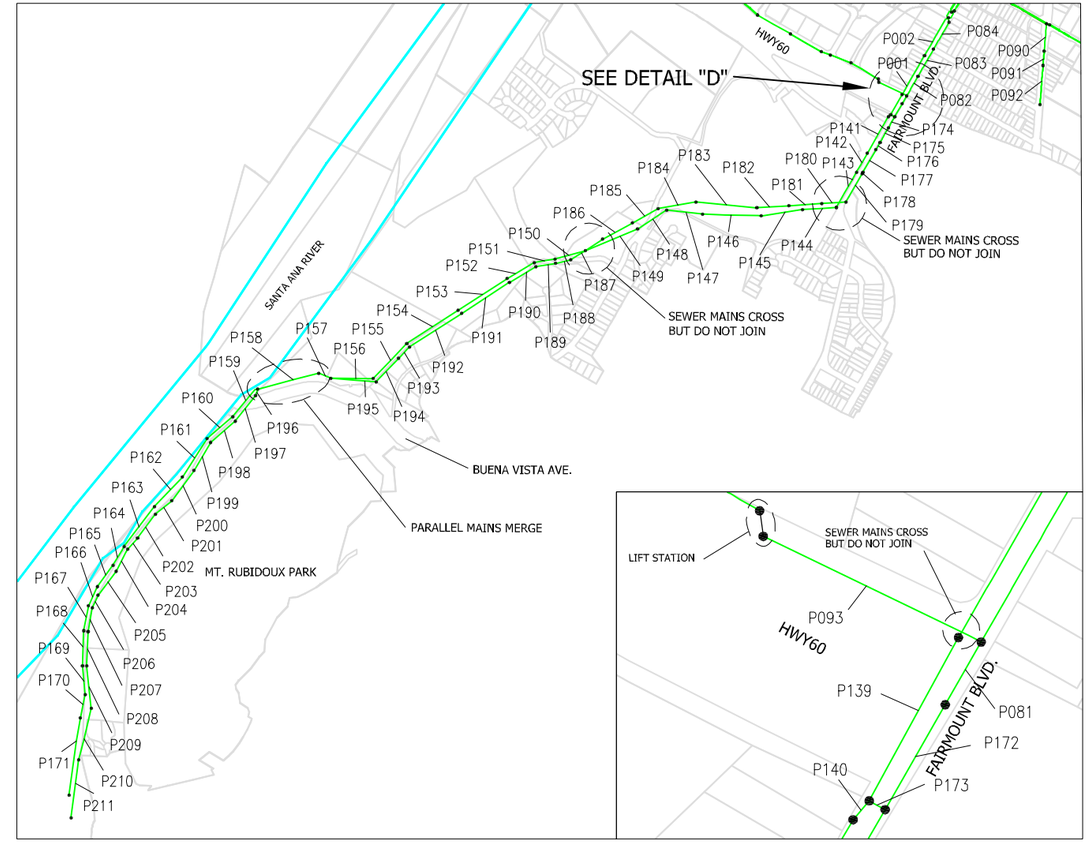
Priority "B" – The pipes listed in this priority are projected to be flowing more than 90% full in the future under estimated maximum flow conditions. A linear interpolation was done for anticipation of the mid-term flow in pipes between year 2005 and ultimate year (2020). The pipes that would be flowing more than 90% full in the year 2015 are placed under priority "B". These pipes need evaluation as new development takes place in the tributary areas. Flow monitoring within the study area should be considered for observation of actual flows. The pipes under this priority are grouped for replacement/re-habilitation in the period (2011-2015).

Priority "C" – The pipes listed in this priority would be flowing more than 75% full in the future under estimated maximum flow conditions. The pipes that are not part of priority "A" and "B" and will flow more than 75% full by the year 2020 are considered as priority "C". These pipes need evaluation as new development takes place in the tributary areas. These may or may not be replaced or paralleled depending on actual observed flow conditions in the future. Flow monitoring within the study area should be considered when significant development occurs. The pipes under this priority are grouped for possible replacement/re-habilitation in the period (2016-2020).

7.3 Recommended Improvements

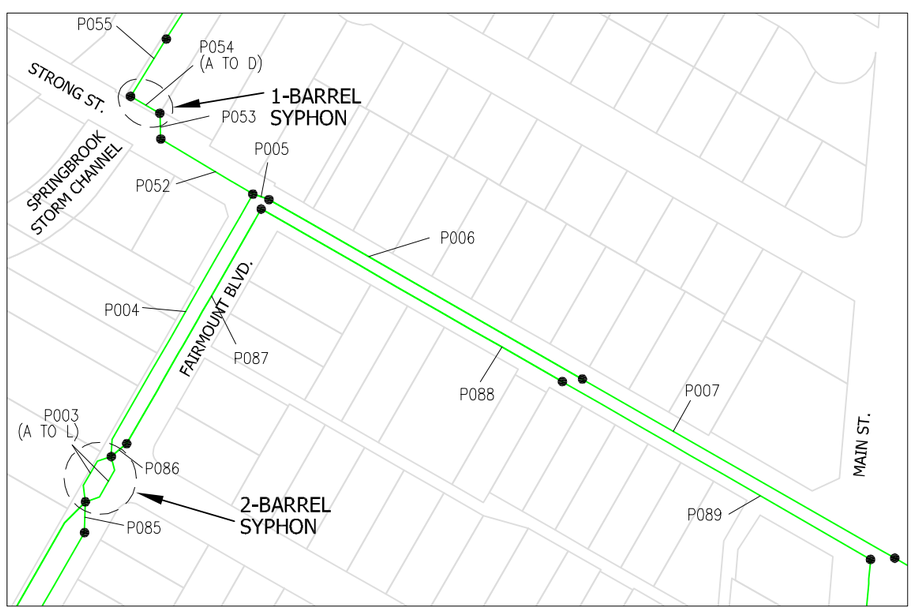
Table 7.3 lists project priority, project location, problem, solution and approximate cost for problem reaches. This table identifies future problems in the sewer lines and suggested solutions. The project cost is based on year 2005 indices.



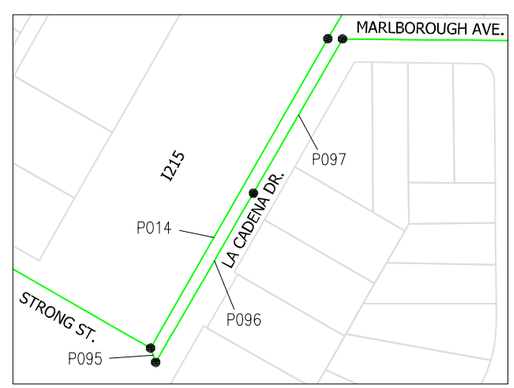


DETAIL "A"
NTS

DETAIL "D"
NTS



DETAIL "B"
NTS



DETAIL "C"
NTS

LEGEND

GRAVITY SEWER

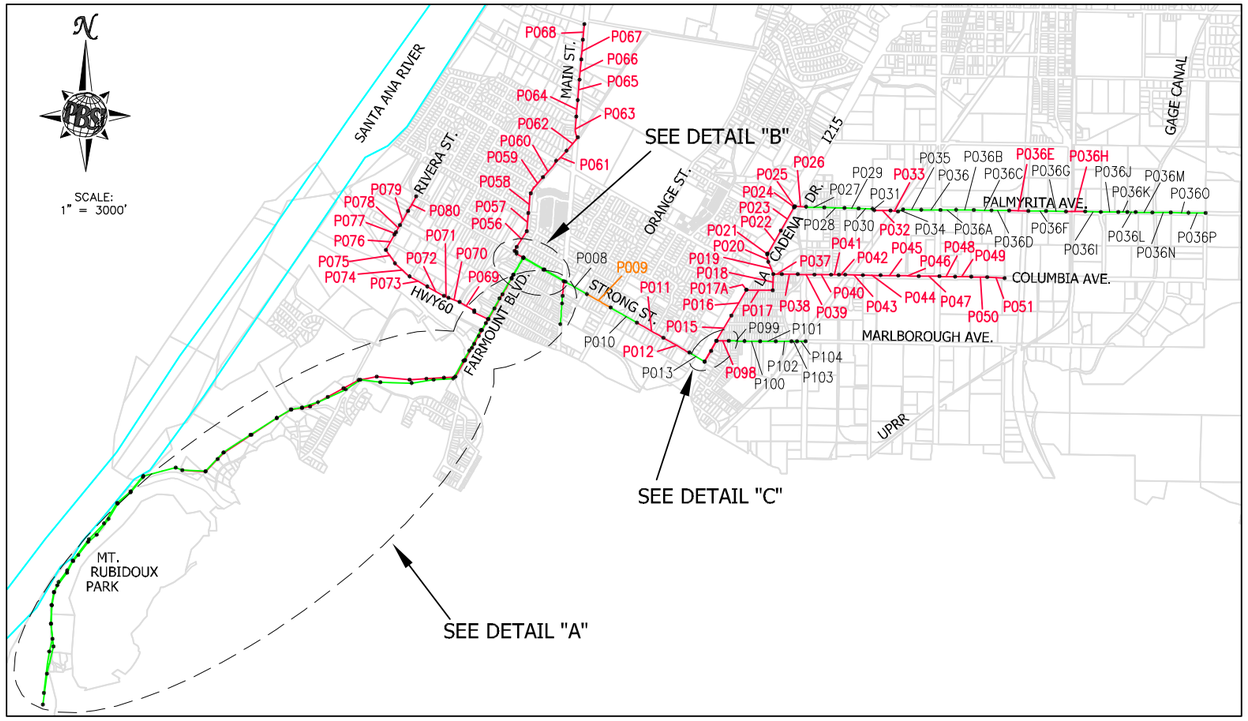
P001 PIPE SEGMENT NUMBER

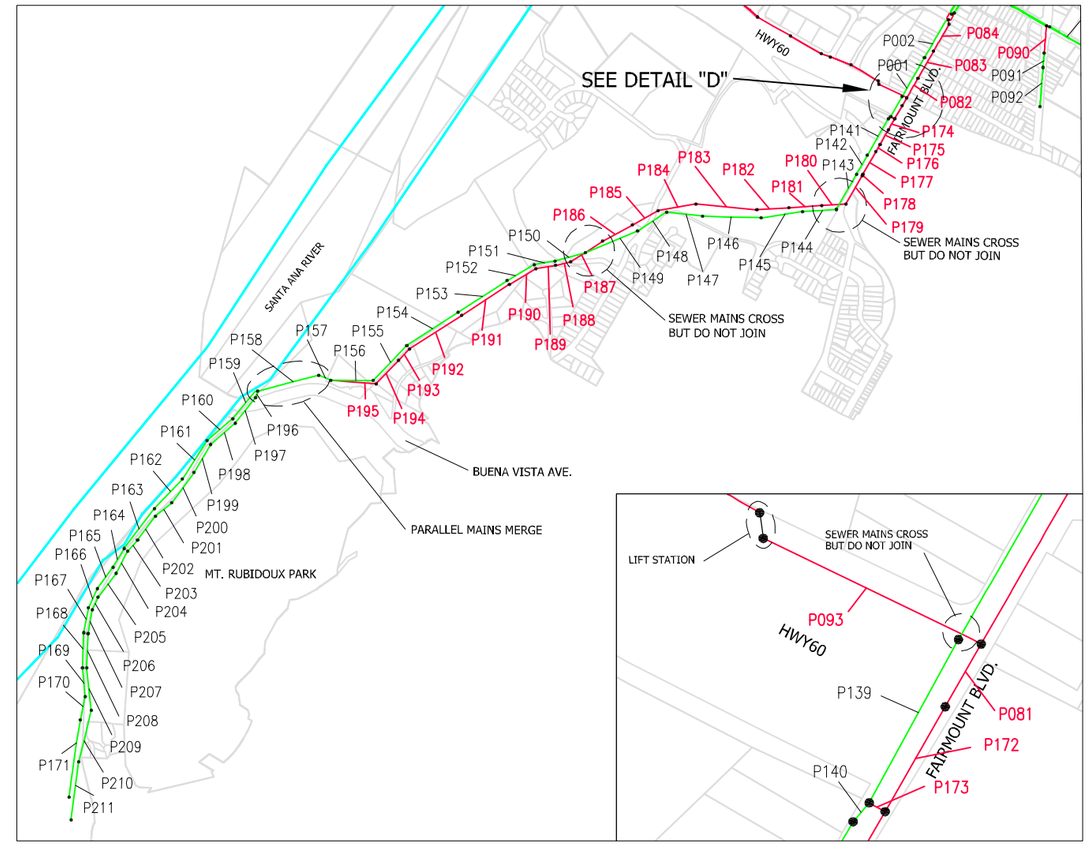
NO PIPE IS DEFICIENT IN CAPACITY UNDER EXISTING FLOW CONDITIONS

Engineering
Planning
Surveying
Construction Services
PBSJ
10370 Hemet Street
Suite 200
Riverside, CA 92503
Tel:(951) 358-1433
Fax:(951) 358-1434

DATE: 01/04/06	DWN BY: CD
CITY OF RIVERSIDE NORTHSIDE SEWER STUDY	FIGURE 15
EXISTING VOLUME DEFICIENCIES	

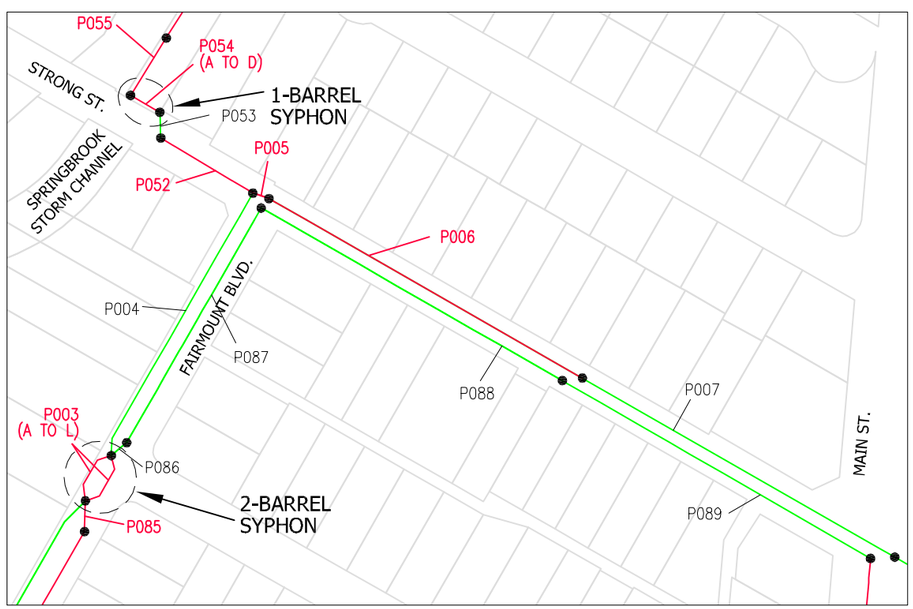
Y:\City of Riverside\Northside\DWG\Exhibits\NS-VolumeDeficient.dwg, 9/28/2006 9:23:34 AM



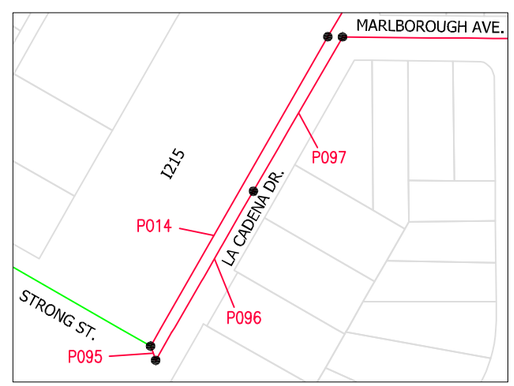


DETAIL "A"
NTS

DETAIL "D"
NTS



DETAIL "B"
NTS



DETAIL "C"
NTS

LEGEND

	GRAVITY SEWER
	VELOCITY > 10 FPS
	VELOCITY < 2 FPS
P001	PIPE SEGMENT NUMBER

Engineering
Planning
Surveying
Construction Services
PBSJ
10370 Hemet Street
Suite 200
Riverside, CA 92503
Tel:(951) 358-1433
Fax:(951) 358-1434

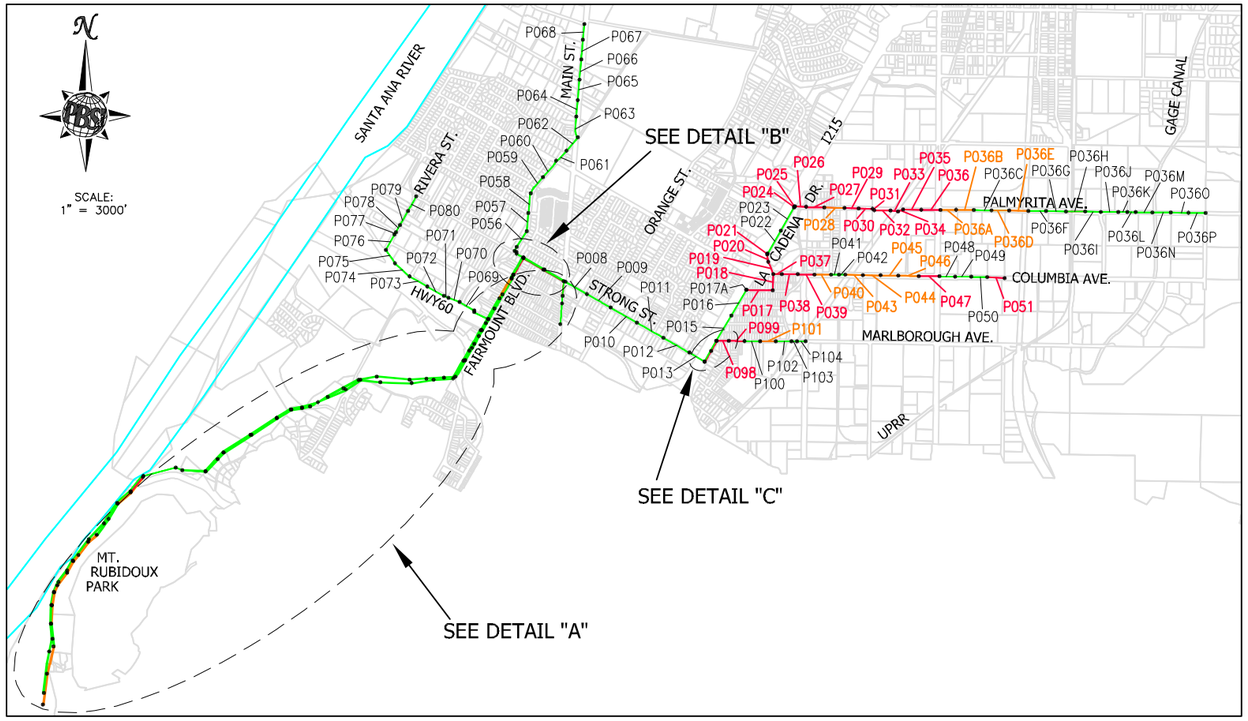
DATE: 01/04/06 | DWN BY: CD

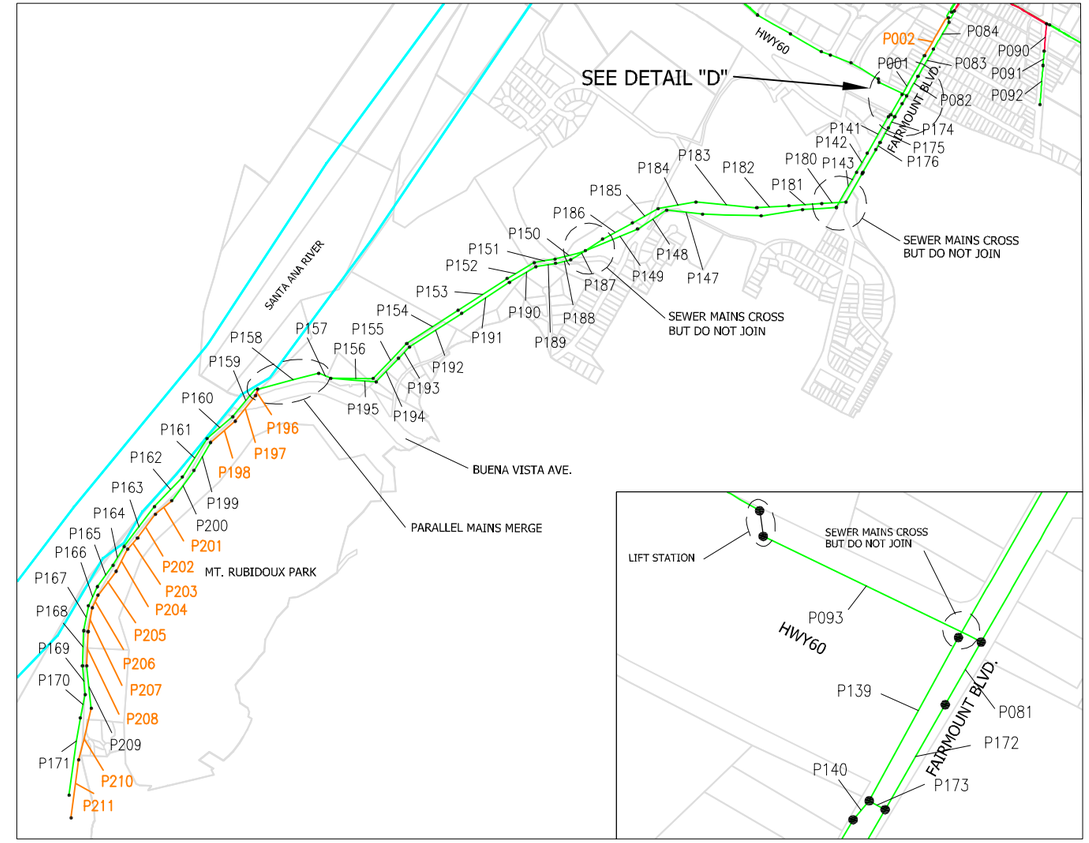
CITY OF RIVERSIDE
NORTHSIDE SEWER STUDY

FIGURE 16

EXISTING VELOCITY DEFICIENCIES

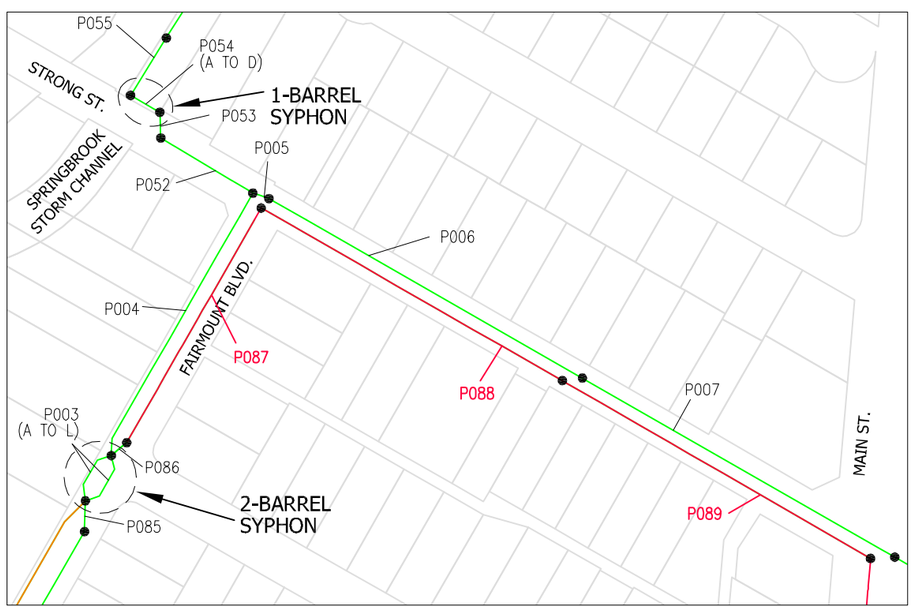
Y:\City of Riverside\Northside\DWG\Exhibits\NS-VelocityDeficient.dwg, 9/28/2006 9:22:12 AM



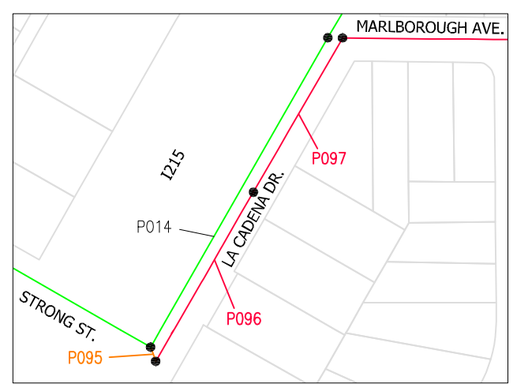


DETAIL "A"
NTS

DETAIL "D"
NTS



DETAIL "B"
NTS



DETAIL "C"
NTS

LEGEND

———	VOLUME ≤ 75 % FULL
———	VOLUME > 75 < 90 % FULL
———	VOLUME ≥ 90 % FULL
P001	PIPE SEGMENT NUMBER

Engineering
Planning
Surveying
Construction Services
PBSJ
10370 Hemet Street
Suite 200
Riverside, CA 92503
Tel:(951) 358-1433
Fax:(951) 358-1434

DATE: 01/04/06 | DWN BY: CD

CITY OF RIVERSIDE
NORTHSIDE SEWER STUDY

FIGURE 17

ULTIMATE VOLUME DEFICIENCIES

Y:\City of Riverside\Northside\DWG\Exhibits\NS-UltVolumeDeficient.dwg, 9/28/2006 9:21:00 AM

Table 7-2
Proposed Construction Prioritization and Schedule

Pipe Name	Pipe Length (ft)	Existing Pipe Size (Inch)	Existing Estimated % Full (Year 2005)	Year 2015 Estimated % Full	Future Estimated % Full (Year 2020)	Priority	New Diameter (Inch)	New % Full (Year 2020)	Approximate Replacement Period
P001	473	27	20.39%	55.56%	73.16%				
P002	465	27	24.50%	65.04%	85.32%	C	30	64%	2016-2020
P003A	6	27							
P003B	7	27							
P003C	10	27							
P003D	25	27							
P003E	13	27							
P003F	6	27							
P003G	6	15							
P003H	13	15							
P003I	25	15							
P003J	10	15							
P003K	7	15							
P003L	6	15							
P004	391	27	5.16%	36.37%	51.97%				
P005	15	27	2.68%	25.55%	36.99%				
P006	473	24	2.95%	32.72%	47.62%				
P007	475	24	2.95%	32.71%	47.59%				
P008	495	21	2.60%	28.83%	41.95%				
P009	534	21	1.38%	15.32%	22.29%				
P010	606	21	1.85%	20.55%	29.91%				
P011	600	27	2.50%	27.72%	40.34%				
P012	590	27	2.51%	27.71%	40.31%				
P013	373	27	1.91%	21.08%	30.66%				
P014	466	27	0.98%	17.70%	26.06%				
P015	584	24	1.42%	25.55%	37.62%				
P016	585	24	1.42%	25.53%	37.59%				
P017	520	15	5.89%	105.73%	155.67%	B	21	63%	2011-2015
P017A	7	21	1.40%	25.07%	36.91%				
P018	331	15	5.89%	105.52%	155.36%	B	21	63%	2011-2015
P019	256	10	8.55%	157.12%	231.42%	B	18	48%	2011-2015
P020	147	10	8.54%	156.89%	231.09%	B	18	48%	2011-2015
P021	18	10	6.73%	123.61%	182.07%	B	15	62%	2011-2015
P022	525	21	1.25%	23.00%	33.87%				
P023	527	21	1.26%	36.89%	54.72%				
P024	23	10	22.86%	671.27%	995.57%	B	30	53%	2011-2015
P025	7	15	5.15%	83.92%	123.31%	B	24	35%	2011-2015
P026	219	12	2.97%	61.36%	90.56%	B**	18	31%	2011-2015
P027	367	12	2.97%	61.29%	90.46%	B**	15	50%	2011-2015
P028	396	12	2.82%	58.09%	85.73%	B**	15	47%	2011-2015
P029	279	12	2.80%	68.72%	101.69%	B**	15	56%	2011-2015
P030	276	12	2.83%	69.32%	102.57%	B**	15	57%	2011-2015
P031	37	12	2.78%	68.13%	100.81%	B**	15	56%	2011-2015
P032	326	12	3.37%	82.78%	122.49%	B**	18	41%	2011-2015
P033	129	12	3.37%	82.78%	122.50%	B**	18	41%	2011-2015
P034	97	12	2.67%	65.55%	97.00%	B**	15	53%	2011-2015
P035	360	12	2.71%	66.43%	98.30%	B**	15	54%	2011-2015
P036	381	12	2.70%	66.26%	98.04%	B**	15	54%	2011-2015
P036A	315	10	1.78%	54.46%	80.80%	B**	12	50%	2011-2015
P036B	350	10	1.74%	53.34%	79.15%	B**	12	49%	2011-2015
P036C	350	10	1.61%	49.87%	74.01%				
P036D	350	10	1.62%	50.26%	74.58%				
P036E	375	10	1.86%	57.97%	86.03%	B**	12	53%	2011-2015
P036F	350	10	1.46%	45.34%	67.29%				
P036G	396	10	1.60%	49.87%	74.01%				
P036H	381	10	1.50%	46.44%	68.92%				
P036I	309	10	1.50%	46.45%	68.93%				
P036J	341	10	1.51%	46.72%	69.33%				
P036K	182	10	1.51%	46.86%	69.54%				
P036L	163	10	1.52%	47.10%	69.90%				
P036M	341	10	1.50%	46.48%	68.97%				
P036N	341	10	1.60%	49.56%	73.55%				
P036O	341	10	1.60%	49.57%	73.57%				
P036P	339	10	1.61%	49.64%	73.66%				

Table 7-2
Proposed Construction Prioritization and Schedule

Pipe Name	Pipe Length (ft)	Existing Pipe Size (inch)	Existing Estimated % Full (Year 2005)	Year 2015 Estimated % Full	Future Estimated % Full (Year 2020)	Priority	New Diameter (inch)	New % Full (Year 2020)	Approximate Replacement Period
P037	169	8	5.38%	183.29%	272.28%	B	15	51%	2011-2015
P038	315	8	5.38%	183.29%	272.27%	B*	15	51%	2011-2015
P039	319	10	1.69%	60.39%	89.76%	C	12	55%	2016-2020
P040	330	10	1.66%	59.35%	88.21%	C	12	54%	2016-2020
P041	159	10	1.29%	46.17%	68.61%				
P042	121	10	1.33%	45.29%	67.28%				
P043	350	10	1.55%	52.95%	78.66%	C	12	48%	2016-2020
P044	350	10	1.67%	57.18%	84.94%	C	12	52%	2016-2020
P045	350	10	1.69%	58.42%	86.80%	C	12	53%	2016-2020
P046	410	10	1.53%	54.17%	80.50%	C	12	49%	2016-2020
P047	402	10	1.74%	62.44%	92.79%	C	12	57%	2016-2020
P048	315	10	1.37%	46.19%	68.61%	C	12	42%	2016-2020
P049	319	10	1.61%	46.17%	68.45%				
P050	315	10	1.31%	46.51%	69.12%				
P051	351	10	2.89%	102.54%	152.39%	C*	15	52%	2016-2020
P052	162	18	15.95%	48.16%	64.27%				
P053	36	18	8.31%	25.08%	33.47%				
P054A	2	18							
P054B	8	18							
P054C	30	18							
P054D	8	18							
P055	88	18	14.33%	43.81%	58.55%				
P056	365	18	14.76%	45.08%	60.25%				
P057	358	18	14.63%	44.67%	59.69%				
P058	400	18	5.37%	21.26%	29.21%				
P059	400	18	5.40%	21.28%	29.22%				
P060	414	18	5.44%	21.42%	29.41%				
P061	291	18	5.43%	21.37%	29.34%				
P062	343	18	5.42%	21.33%	29.29%				
P063	423	18	5.48%	21.55%	29.59%				
P064	320	18	5.50%	21.63%	29.69%				
P065	410	18	5.48%	21.59%	29.64%				
P066	395	18	5.49%	21.59%	29.64%				
P067	395	18	5.50%	21.61%	29.66%				
P068	315	18	5.52%	21.70%	29.79%				
P069	301	12	3.22%	4.44%	5.05%				
P070	243	10	3.14%	4.33%	4.92%				
P071	132	10	2.75%	3.78%	4.30%				
P072	375	12	3.26%	4.49%	5.10%				
P073	375	12	3.36%	4.63%	5.26%				
P074	365	12	3.27%	4.50%	5.12%				
P075	336	12	3.26%	4.48%	5.10%				
P076	350	12	3.27%	4.50%	5.12%				
P077	60	12	3.26%	4.50%	5.11%				
P078	153	12	8.46%	11.65%	13.25%				
P079	325	8	9.71%	13.38%	15.21%				
P080	321	8	9.73%	13.39%	15.23%				
P081	95	15	6.28%	8.29%	9.29%				
P082	333	15	1.41%	5.12%	6.97%				
P083	329	18	0.54%	1.96%	2.67%				
P084	357	15	0.70%	2.53%	3.45%				
P085	13	15	0.00%	0.00%	0.00%				
P086	13	15	13.88%	16.80%	18.26%				
P087	400	15	71.77%	86.89%	94.46%	C	18	58%	2016-2020
P088	458	15	71.67%	86.76%	94.32%	C	18	58%	2016-2020
P089	465	15	71.85%	87.01%	94.60%	C	18	58%	2016-2020
P090	284	12	17.26%	24.92%	28.75%				
P091	131	12	11.76%	16.98%	19.59%				
P092	415	12	26.07%	37.64%	43.43%				
P093	309	12	23.52%	27.99%	30.23%				
P095	8	10	13.88%	54.70%	75.11%	B*	12	46%	2011-2015
P096	235	8	30.64%	120.69%	165.73%	B	12	56%	2011-2015
P097	235	8	30.69%	120.72%	165.75%	B	12	56%	2011-2015
P098	238	8	27.36%	109.00%	149.82%	B	12	51%	2011-2015

Table 7-2
Proposed Construction Prioritization and Schedule

Pipe Name	Pipe Length (ft)	Existing Pipe Size (inch)	Existing Estimated % Full (Year 2005)	Year 2015 Estimated % Full	Future Estimated % Full (Year 2020)	Priority	New Diameter (inch)	New % Full (Year 2020)	Approximate Replacement Period
P099	310	8	17.32%	68.99%	94.84%	C	10	53%	2016-2020
P100	310	8	13.37%	53.25%	73.20%				
P101	310	8	14.89%	60.74%	83.68%	C	10	46%	2016-2020
P102	310	8	12.66%	51.77%	71.33%				
P103	110	8	12.60%	51.51%	70.97%				
P104	171	12	5.91%	24.16%	33.29%				
P139	246	30	11.36%	31.11%	40.98%				
P140	16	36	5.36%	14.26%	18.71%				
P141	466	36	11.39%	30.36%	39.84%				
P142	218	36	9.94%	26.54%	34.84%				
P143	403	36	31.79%	53.50%	64.36%				
P144	389	36	31.04%	52.25%	62.86%				
P145	440	36	30.94%	52.10%	62.68%				
P146	617	36	30.96%	52.15%	62.75%				
P147	400	36	30.88%	52.04%	62.62%				
P148	348	36	30.91%	52.11%	62.71%				
P149	604	36	30.92%	52.13%	62.74%				
P150	334	36	30.86%	52.04%	62.64%				
P151	219	36	30.84%	52.01%	62.59%				
P152	326	36	30.93%	52.14%	62.75%				
P153	619	36	30.98%	52.24%	62.87%				
P154	638	36	30.91%	52.13%	62.74%				
P155	512	36	30.94%	52.19%	62.82%				
P156	460	36	36.48%	61.54%	74.07%				
P157	140	36	21.48%	35.88%	43.07%				
P158	666	36	30.59%	51.08%	61.33%				
P159	393	30	23.76%	40.09%	48.26%				
P160	357	30	23.79%	40.15%	48.33%				
P161	479	33	23.86%	40.27%	48.47%				
P162	432	33	23.78%	40.13%	48.31%				
P163	526	33	23.76%	40.09%	48.26%				
P164	228	33	23.77%	40.12%	48.30%				
P165	283	33	23.78%	40.14%	48.32%				
P166	217	33	23.77%	40.13%	48.30%				
P167	263	33	23.74%	40.06%	48.23%				
P168	369	33	23.93%	40.38%	48.61%				
P169	300	33	23.60%	39.84%	47.96%				
P170	257	33	23.95%	40.43%	48.67%				
P171	826	33	30.07%	50.75%	61.10%				
P172	160	18	5.05%	6.67%	7.48%				
P173	9	18	4.63%	5.58%	6.06%				
P174	133	18	5.25%	6.15%	6.60%				
P175	179	18	9.09%	10.66%	11.45%				
P176	88	18	4.59%	5.38%	5.78%				
P177	276	18	7.77%	9.11%	9.78%				
P178	19	18	4.56%	5.34%	5.74%				
P179	368	18	6.21%	7.28%	7.82%				
P180	222	18	6.22%	7.29%	7.83%				
P181	350	18	5.03%	5.89%	6.32%				
P182	338	18	5.21%	6.10%	6.55%				
P183	649	18	5.14%	6.02%	6.46%				
P184	366	18	5.14%	6.02%	6.46%				
P185	340	18	5.14%	6.02%	6.46%				
P186	357	18	6.25%	7.13%	7.57%				
P187	400	18	6.24%	7.12%	7.56%				
P188	159	18	6.29%	7.18%	7.62%				
P189	216	18	6.23%	7.10%	7.54%				
P190	330	18	6.27%	7.16%	7.60%				
P191	600	18	6.29%	7.18%	7.62%				
P192	656	18	6.19%	7.06%	7.49%				
P193	170	18	6.23%	7.11%	7.55%				
P194	343	18	6.23%	7.11%	7.55%				
P195	462	18	5.82%	6.64%	7.05%				
P196	21	18	44.15%	71.40%	85.02%	C	21	56%	2016-2020

Table 7-2
Proposed Construction Prioritization and Schedule

Pipe Name	Pipe Length (ft)	Existing Pipe Size (inch)	Existing Estimated % Full (Year 2005)	Year 2015 Estimated % Full	Future Estimated % Full (Year 2020)	Priority	New Diameter (inch)	New % Full (Year 2020)	Approximate Replacement Period
P197	391	18	43.56%	70.45%	83.90%	C	21	56%	2016-2020
P198	342	18	43.48%	70.33%	83.75%	C	21	55%	2016-2020
P199	350	18	33.09%	53.52%	63.74%				
P200	394	18	33.05%	53.46%	63.67%				
P201	218	18	43.66%	70.63%	84.12%	C	21	56%	2016-2020
P202	320	18	43.52%	70.39%	83.84%	C	21	56%	2016-2020
P203	161	18	41.18%	66.62%	79.34%	C	21	53%	2016-2020
P204	227	18	42.33%	68.48%	81.56%	C	21	54%	2016-2020
P205	315	18	43.41%	70.24%	83.65%	C	21	55%	2016-2020
P206	150	18	43.59%	70.52%	83.99%	C	21	56%	2016-2020
P207	261	18	43.62%	70.58%	84.06%	C	21	56%	2016-2020
P208	365	18	43.46%	70.31%	83.75%	C	21	55%	2016-2020
P209	451	18	29.78%	48.20%	57.41%				
P210	555	18	43.57%	70.52%	83.99%	C	21	56%	2016-2020
P211	618	18	43.55%	70.50%	83.98%	C	21	56%	2016-2020

* Placed under a different category due to geographical location.
** The proposed development affecting these pipelines is expected in the near future. So, these pipelines are placed under category "B".

7.4 Grouping of Projects

Proposed improvements under different priorities have been combined or grouped into projects to improve deficient and marginally deficient pipes based on following criteria:

Pipes identified as marginally deficient in near future (Priority "B"), and marginally deficient in more distant future (Priority "C") located geographically close to one another and requiring improvements, are grouped to reduce improvement costs.

It is anticipated that the proposed development of Spring Mountain Ranch and Springbrook Estates will be in the near future. This will increase flow in the pipes along Palmyrita Avenue, La Cadena Drive and downstream. Thus pipelines under priority "C" along this segment are placed in priority "B".

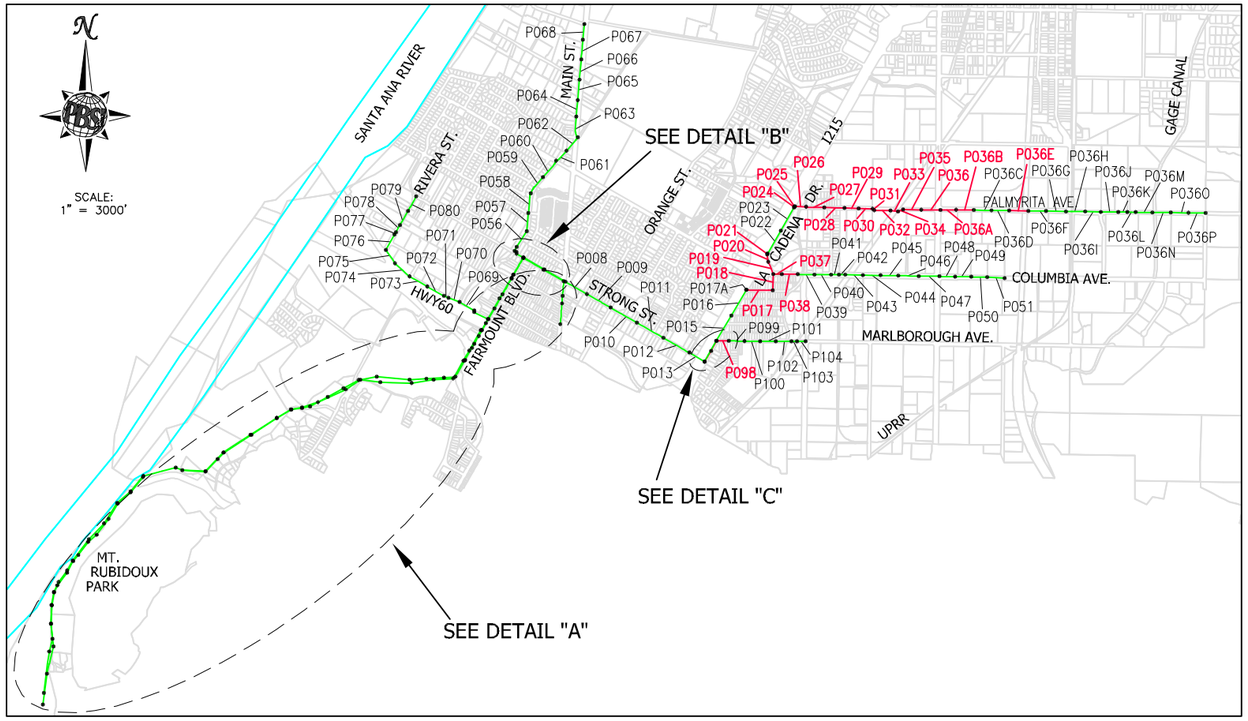
7.5 Construction Schedule

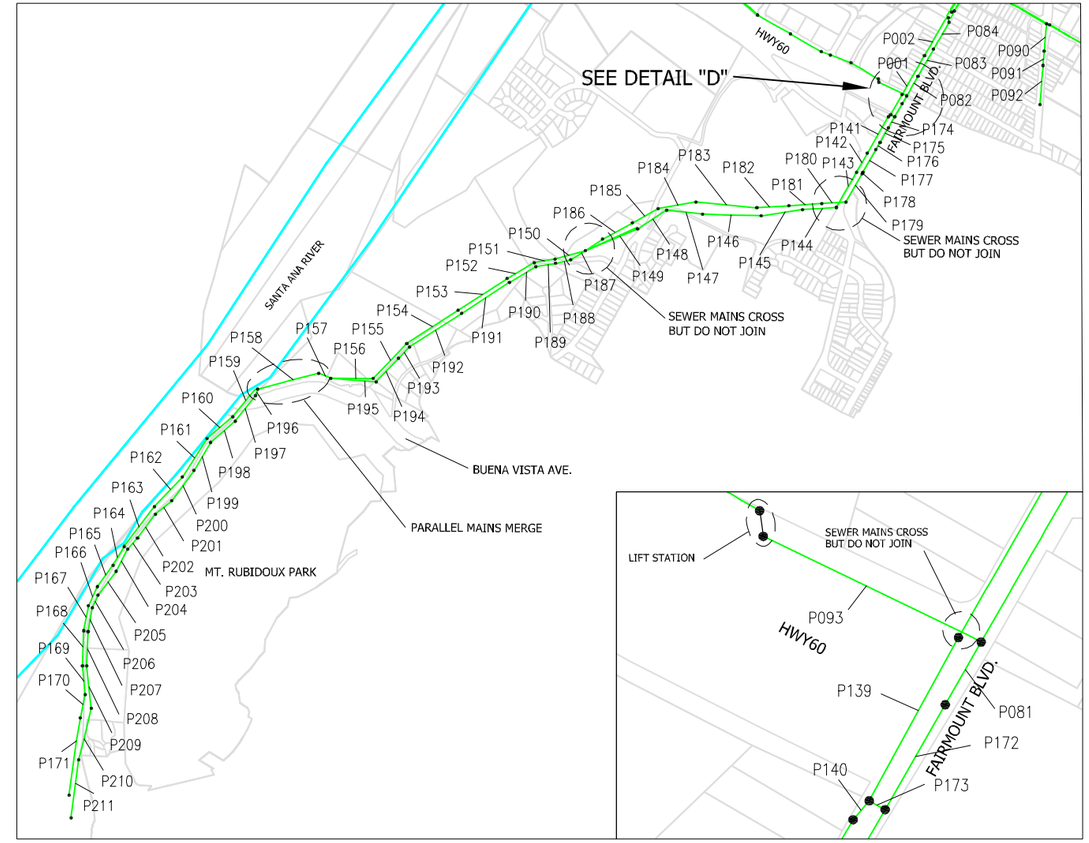
A summary of proposed construction prioritization and recommended scheduling is shown in Table 7-2. This table lists construction priorities and the year in which these activities are proposed. As previously discussed, the pipes included in priorities "B" and "C" will need re-evaluation before their replacement.

7.6 Cost Estimate

Unit costs of pipes are based on bid prices for similar projects and from the web site www.get-a-quote.net. The cost of construction includes labor, materials, excavation, backfill and all other items associated with pipe laying. To estimate total cost, cost of mobilization / demobilization (7%), traffic control (7%), bond (1%), contractor's profit (15%) and construction contingency (25%) is added to the cost of construction. The cost of engineering, right of way acquisition, permits, soil conditions remediation and by-pass pumping is not included in the construction cost. For priorities "B" and "C", the cost estimate is based on year 2005 indices and no escalation has been added to estimate future cost. Following is the summary of cost for the various priorities:

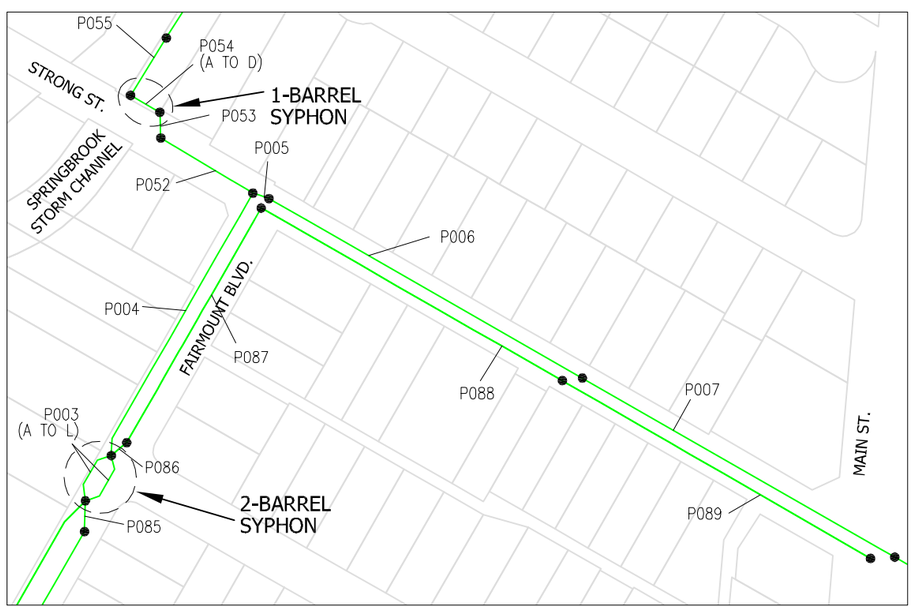
- Priority "B" - $1,759,000 (2005 $) (See Figure 18 and Table 7-6-B for details)
- Priority "C" - $ 2,788,000 (2005 $) (See Figure 19 and Table 7-6-C for details)



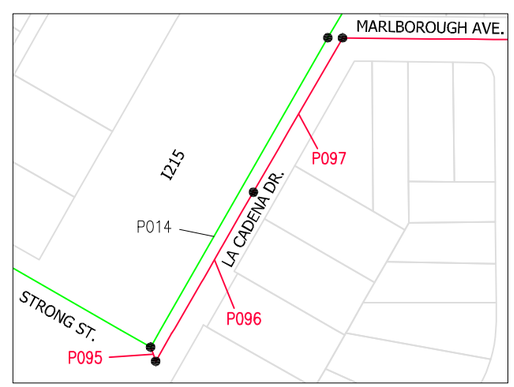


DETAIL "A"
NTS

DETAIL "D"
NTS



DETAIL "B"
NTS



DETAIL "C"
NTS

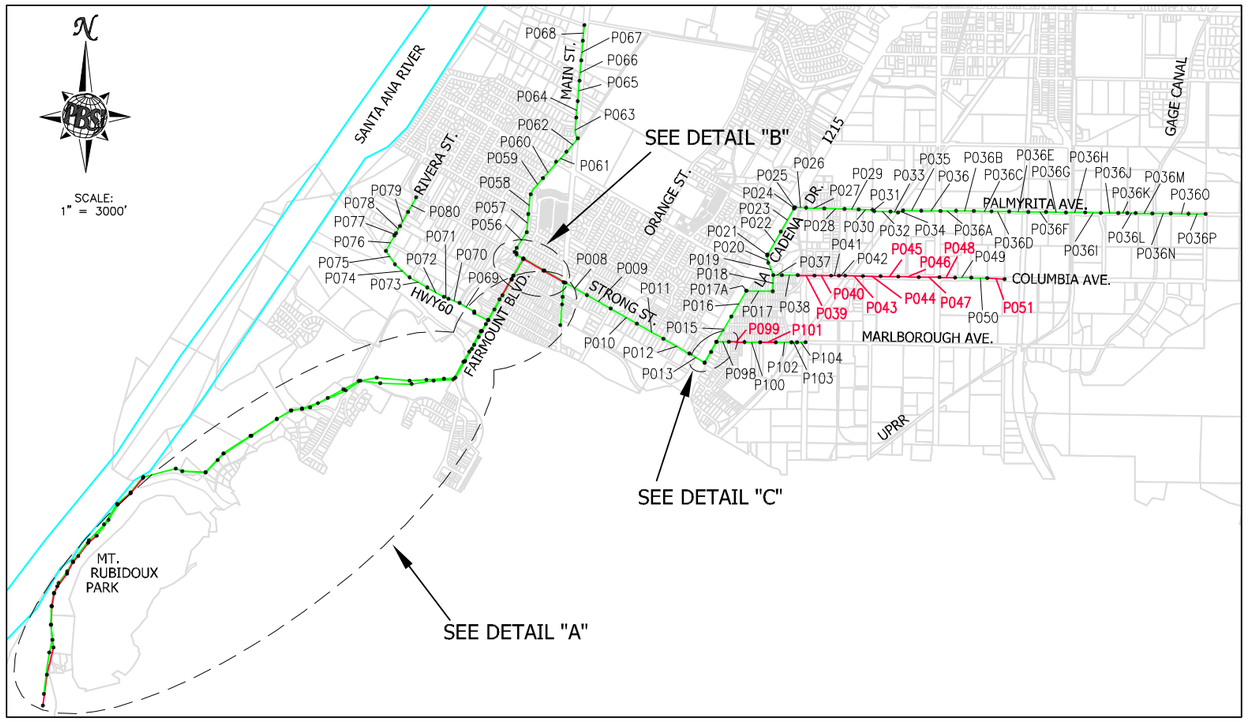
LEGEND

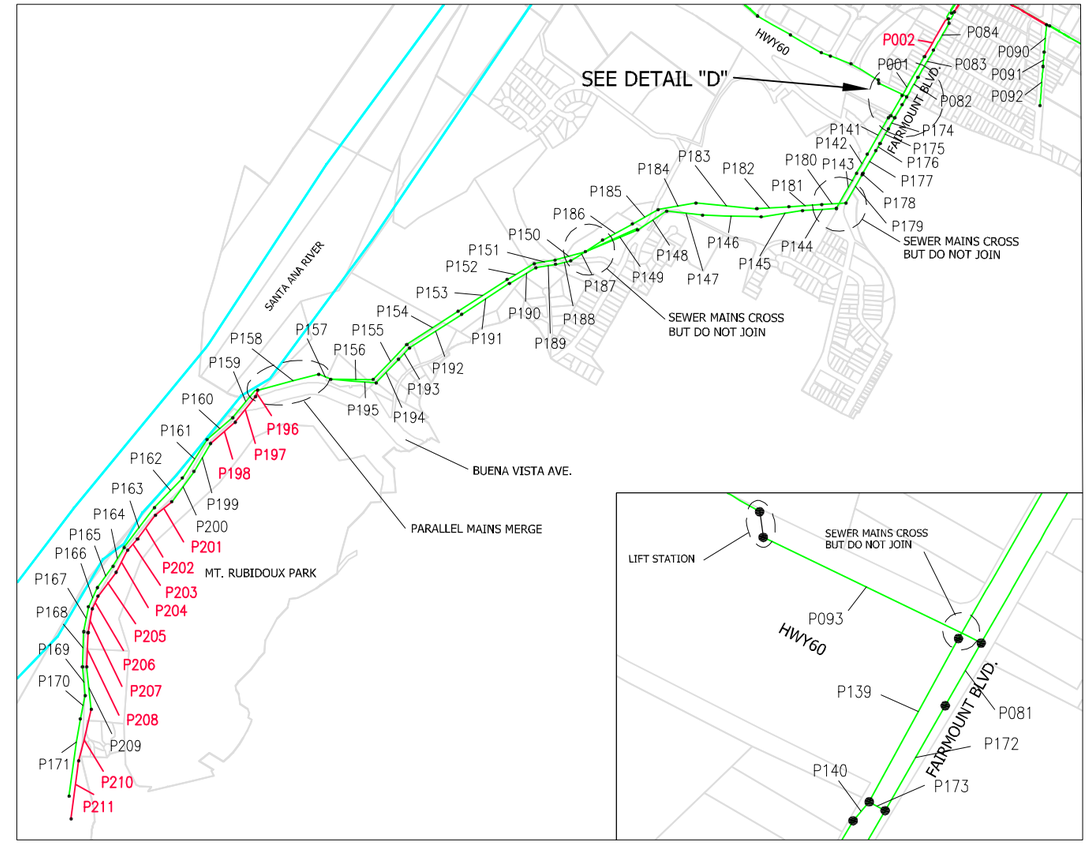
———	GRAVITY SEWER
———	IMPROVEMENT SEWER (2011 - 2015)
P001	PIPE SEGMENT NUMBER

Engineering
Planning
Surveying
Construction Services
PBSJ
10370 Hemet Street
Suite 200
Riverside, CA 92503
Tel:(951) 358-1433
Fax:(951) 358-1434

DATE: 01/04/06	DWN BY: CD
CITY OF RIVERSIDE NORTHSIDE SEWER STUDY	FIGURE 18
PRIORITY "B"	

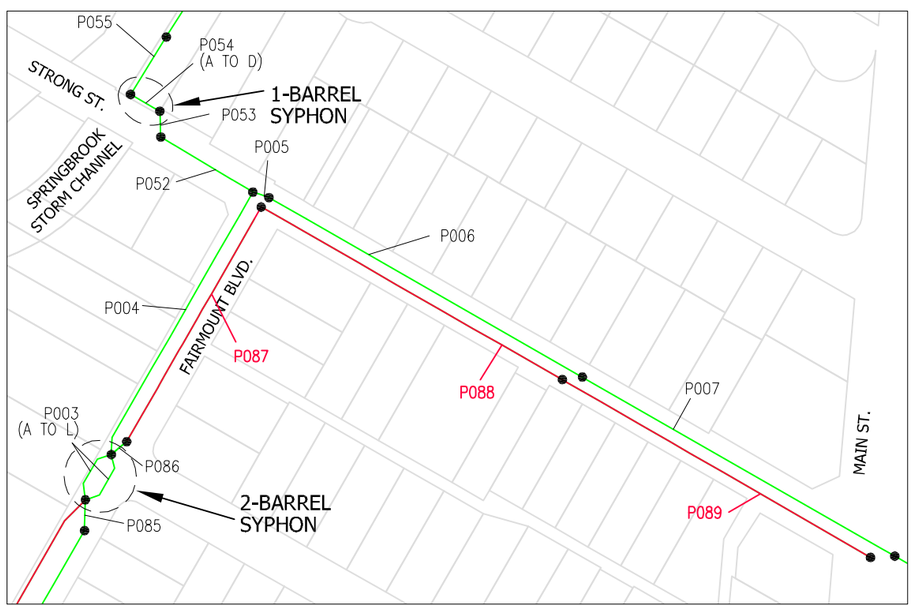
Y:\City of Riverside\Northside\DWG\Exhibits\NS-PriorityB.dwg, 9/28/2006 9:14:16 AM
H:\Client\Riversid_SAOW\7472A00\Rpt\Volume 03\Appendices\Ch01-AppxE-Northside02-23-07.pdf



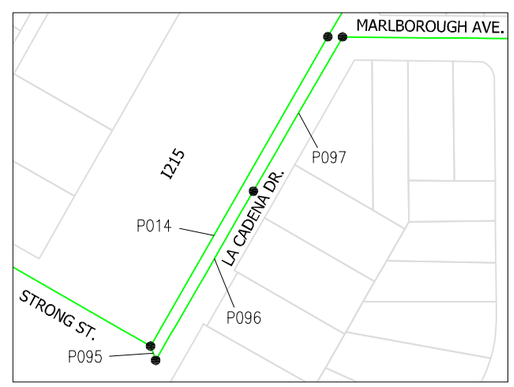


DETAIL "A"
NTS

DETAIL "D"
NTS



DETAIL "B"
NTS



DETAIL "C"
NTS

LEGEND

———	GRAVITY SEWER
———	IMPROVEMENT SEWER (2016 - 2020)
P001	PIPE SEGMENT NUMBER

Engineering
Planning
Surveying
Construction Services
PBSJ
10370 Hemet Street
Suite 200
Riverside, CA 92503
Tel:(951) 358-1433
Fax:(951) 358-1434

DATE: 01/04/06	DWN BY: CD
CITY OF RIVERSIDE NORTHSIDE SEWER STUDY	FIGURE 19
PRIORITY "C"	

Y:\City of Riverside\Northside\DWG\Exhibits\NS-PriorityC.dwg, 9/28/2006 9:16:17 AM

Table 7-3
Summary of Improvement Plans for Problem Areas
Priority "B"

Priority	Location	Pipes	Problem	Solution	Approx. Cost (2005 $'s)
"B" (See Figure 18 and Table 7-2 for details of pipes)	Columbia Avenue	Pipes P037 to P038	Future Capacity Problem in reaches M019 to M038 and M038 to M039 due to flat slopes, smaller pipe sizes and increased flow in the system.	Monitor flow in future to verify that it will exceed 90% criteria. Replace pipes with larger size pipes maintaining the same slope.	$131,000
	La Cadena Drive	Pipes P017 to P018, P019 to P021, P024, P095 to P097	Future Capacity Problem in reaches M017A to M018, M019 to M022, M024 to M025, M014 to M096 and M096 to M098 due to flat slopes, smaller pipe sizes and increased flow in the system.	Monitor flow in future to verify that it will exceed 90% criteria. Replace pipes with larger size pipes maintaining the same slope.	$565,000
	Marlborough Avenue	Pipes P098	Future Capacity Problem in reach M098 to M099 due to flat slope and increased flow in the system.	Monitor flow in future to verify that it will exceed 90% criteria. Replace pipes with larger size pipes maintaining the same slope.	$66,000
	Palmyrita Avenue	Pipes P025 to P036, P036A, P036B, P036E, P036H	Future Capacity Problem in reach M025 to M037H due to flat slopes, smaller pipe sizes and increased flow in the system.	Monitor flow in future to verify that it will exceed 90% criteria or needed as part of another project. Replace pipes with larger size pipes maintaining the same slope.	$997,000
				Total Construction Cost for Priority "B" Projects (2011-2015 Replacement / Rehabilitation)	**$1,759,000**

Table 7-3
Summary of Improvement Plans for Problem Areas
Priority "C"

Priority	Location	Pipes	Problem	Solution	Approx. Cost (2005 $'s)
"C" (See Figure 19 and Table 7-2 for details of pipes)	Columbia Avenue	Pipes P039 to P040, P043 to P048, P051	Future Capacity Problem in reaches M039 to M041, M043 to M049 and M051 to M052 due to smaller pipe sizes, flat slopes and increased flow in the system.	Monitor in future to verify that flows exceed 75% criteria. Replace with larger size pipes maintaining same slopes if surcharging appears imminent or if part of another needed project.	$746,000
	Fairmount Boulevard	Pipes P002 and P087	Future Capacity Problem in reaches M002 to M003 and M088 to M089 due to flat slopes and increased flow in the system.	Monitor in future to verify that flows exceed 75% criteria. Replace with larger size pipes maintaining same slopes if surcharging appears imminent or if part of another needed project.	$311,000
	Fairmount Trunk	Pipes P196 to P198, P201 to P208 and P210 to P211	Future Capacity Problem in reaches M186 to M189, M193 to M215 and M217 to M219 due to flat slopes and increased flow in the system.	Monitor in future to verify that flows exceed 75% criteria. Replace with larger size pipes maintaining same slopes if surcharging appears imminent or if part of another needed project.	$1,319,000
	Marlborough Avenue	Pipes P099, P101	Future Capacity Problem in reaches M099 to M100 and M101 to M102 due to flat slopes, smaller pipe sizes and increased flow in the system.	Monitor in future to verify that flows exceed 75% criteria. Replace with larger size pipes maintaining same slopes if surcharging appears imminent or if part of another needed project.	$144,000
	Strong Street	Pipes P088 to P089	Future Capacity Problem in reach M089 to M091 due to flat slope and increased flow in the system.	Monitor in future to verify that flows exceed 75% criteria. Replace with larger size pipes maintaining same slopes if surcharging appears imminent or if part of another needed project.	$268,000
				Total Construction Cost for Priority "C" Projects (2016-2020 Replacement / Rehabilitation)	**$2,788,000**

Table 7-6-B
Preliminary Construction Cost Estimate For Priority "B" Projects
(2011- 2015 Replacement / Rehabilitation)

Location	Description	Existing Diameter (inch)	New Diameter (inch)	Unit	Quantity	Unit Cost	Approx Total Cost(2005 $'s)
Columbia Avenue	Replace Pipe P037	8	15	LF	169	$115	$19,435
	Replace Pipe P038	8	15	LF	315	$115	$36,225
	Rehab / Replace Manhole			EA	3	$5,500	$16,500
	Reconnect Sewer Laterals			EA	5	$1,650	$8,250
						Total:	$80,410
Mobilization / Demobilization (7%)							$5,629
Traffic Control (7%)							$5,629
Bond (1%)							$804
Contractor's Profit(15%)							$12,062
Subtotal:							$104,533
Construction Contingency (25%)							$26,133
Total Construction Cost (Columbia Avenue Sewer)							**$131,000**
La Cadena Drive	Replace Pipe P017 - P018	15	21	LF	851	$170	$144,670
	Replace Pipe P019 - P020	10	18	LF	403	$145	$58,435
	Replace Pipe P021	10	15	LF	18	$115	$2,070
	Replace Pipe P024	10	30	LF	23	$220	$5,060
	Replace Pipe P095	10	12	LF	8	$110	$880
	Replace Pipe P096 - P097	8	12	LF	470	$110	$51,700
	Rehab / Replace Manhole			EA	10	$5,500	$55,000
	Reconnect Sewer Laterals			EA	18	$1,650	$29,700
						Total:	$347,515
Mobilization / Demobilization (7%)							$24,326
Traffic Control (7%)							$24,326
Bond (1%)							$3,475
Contractor's Profit(15%)							$52,127
Subtotal:							$451,770
Construction Contingency(25%)							$112,942
Total Construction Cost (La Cadena Drive Sewer)							**$565,000**
Marlborough Avenue	Replace Pipe P098	8	12	LF	238	$110	$26,180
	Rehab / Replace Manhole			EA	2	$5,500	$11,000

Table 7-6-B
Preliminary Construction Cost Estimate For Priority "B" Projects
(2011- 2015 Replacement / Rehabilitation)

Location	Description	Existing Diameter (inch)	New Diameter (inch)	Unit	Quantity	Unit Cost	Approx Total Cost(2005 $'s)
	Reconnect Sewer Laterals			EA	2	$1,650	$3,300
						Total:	$40,480
Mobilization / Demobilization (7%)							$2,834
Traffic Control (7%)							$2,834
Bond (1%)							$405
Contractor's Profit(15%)							$6,072
Subtotal:							$52,624
Construction Contingency(25%)							$13,156
Total Construction Cost (Marlborough Avenue Sewer)							**$66,000**
Palmyrita Avenue	Replace Pipe P025	15	24	LF	7	$200	$1,400
	Replace Pipe P026	12	18	LF	219	$145	$31,755
	Replace Pipe P027 - P031	12	15	LF	1355	$115	$155,825
	Replace Pipe P032 - P033	12	18	LF	455	$145	$65,975
	Replace Pipe P034 - P036	12	15	LF	838	$115	$96,370
	Replace Pipe P036A, P036B, P036E	10	12	LF	1040	$110	$114,400
	Rehab / Replace Manhole			EA	14	$5,500	$77,000
	Reconnect Sewer Laterals			EA	43	$1,650	$70,950
						Total:	$613,675
Mobilization / Demobilization (7%)							$42,957
Traffic Control (7%)							$42,957
Bond (1%)							$6,137
Contractor's Profit(15%)							$92,051
Subtotal:							$797,778
Construction Contingency(25%)							$199,444
Total Construction Cost (Palmyrita Avenue Sewer)							**$997,000**
TOTAL CONSTRUCTION COST FOR PRIORITY "B" PROJECTS							**$1,759,000**

Table 7-6-C
Preliminary Construction Cost Estimate For Priority "C" Projects
(2016- 2020 Replacement / Rehabilitation)

Location	Description	Existing Diameter (inch)	New Diameter (inch)	Unit	Quantity	Unit Cost	Approx Total Cost(2005 $'s)
Columbia Avenue	Replace Pipe P039 - P040	10	12	LF	649	$110	$71,390
	Replace Pipe P043 - P048	10	12	LF	2177	$110	$239,470
	Replace Pipe P051	10	15	LF	351	$115	$40,365
	Rehab / Replace Manhole			EA	10	$5,500	$55,000
	Reconnect Sewer Laterals			EA	32	$1,650	$52,800
						Total:	$459,025
Mobilization / Demobilization (7%)							$32,132
Traffic Control (7%)							$32,132
Bond (1%)							$4,590
Contractor's Profit(15%)							$68,854
Subtotal:							$596,733
Construction Contingency(25%)							$149,183
Total Construction Cost (Columbia Avenue Sewer)							**$746,000**
Fairmount Boulevard	Replace Pipe P002	27	30	LF	465	$220	$102,300
	Replace Pipe P087	15	18	LF	400	$145	$58,000
	Rehab / Replace Manhole			EA	3	$5,500	$16,500
	Reconnect Sewer Laterals			EA	9	$1,650	$14,850
						Total:	$191,650
Mobilization / Demobilization (7%)							$13,416
Traffic Control (7%)							$13,416
Bond (1%)							$1,917
Contractor's Profit(15%)							$28,748
Subtotal:							$249,145
Construction Contingency(25%)							$62,286
Total Construction Cost (Fairmount Boulevard Sewer)							**$311,000**
Fairmount Trunk	Replace Pipe P196 - P198, P201 - P208, P210 - P211	18	21	LF	3944	$170	$670,480
	Rehab / Replace Manhole			EA	14	$5,500	$77,000
	Reconnect Sewer Laterals			EA	39	$1,650	$64,350

Table 7-6-C
Preliminary Construction Cost Estimate For Priority "C" Projects
(2016- 2020 Replacement / Rehabilitation)

Location	Description	Existing Diameter (inch)	New Diameter (inch)	Unit	Quantity	Unit Cost	Approx Total Cost(2005 $'s)
						Total:	$811,830
Mobilization / Demobilization (7%)							$56,828
Traffic Control (7%)							$56,828
Bond (1%)							$8,118
Contractor's Profit(15%)							$121,775
Subtotal:							$1,055,379
Construction Contingency(25%)							$263,845
Total Construction Cost (Fairmount Trunk Sewer)							**$1,319,000**
Marlborough Avenue	Replace Pipe P099, P101	8	10	LF	620	$100	$62,000
	Rehab / Replace Manhole			EA	3	$5,500	$16,500
	Reconnect Sewer Laterals			EA	6	$1,650	$9,900
						Total:	$88,400
Mobilization / Demobilization (7%)							$6,188
Traffic Control (7%)							$6,188
Bond (1%)							$884
Contractor's Profit(15%)							$13,260
Subtotal:							$114,920
Construction Contingency(25%)							$28,730
Total Construction Cost (Marlborough Avenue Sewer)							**$144,000**
Strong Street	Replace Pipe P088 - P089	15	18	LF	923	$145	$133,835
	Rehab / Replace Manhole			EA	3	$5,500	$16,500
	Reconnect Sewer Laterals			EA	9	$1,650	$14,850
						Total:	$165,185
Mobilization / Demobilization (7%)							$11,563
Traffic Control (7%)							$11,563
Bond (1%)							$1,652
Contractor's Profit(15%)							$24,778

Table 7-6-C
Preliminary Construction Cost Estimate For Priority "C" Projects
(2016- 2020 Replacement / Rehabilitation)

Location	Description	Existing Diameter (inch)	New Diameter (inch)	Unit	Quantity	Unit Cost	Approx Total Cost(2005 $'s)
Subtotal:							$214,741
Construction Contingency(25%)							$53,685
Total Construction Cost (Strong Street Sewer)							**$268,000**
TOTAL CONSTRUCTION COST FOR PRIORITY "C" PROJECTS							**$2,788,000**

City of Riverside
Northside Trunk Sewer Study

Appendices

Prepared By:

10370 Hemet Street, Suite 200
Riverside, CA 92503
(951) 358-1433

September, 2006

Appendix A

Flow Data at Meter Locations (On CD)

Appendix B

City of Riverside, Criteria for Sewer Facility Design

CITY OF RIVERSIDE
PUBLIC WORKS DEPARTMENT
ENGINEERING DIVISION

CRITERIA FOR SEWER FACILITY DESIGN
~~March 2000~~
Revised May 2004

Determination of Sewage Flows:

The sewer line shall be designed to flow 75% full during peak flows. Use a Manning's "n"=0.013.

Residential sewer flows are determined by using the following sources of information and criteria:

- Land use shown in the City's General Plan.
- Based on the Land Use determine the number of living units per acre.
- The capita per living unit can be determined from the latest census data for the study area. However, not less than an average 2.75 capita per living unit.
- Use 65 gallons per capita per day for average flows.
- Peak to average flow coefficient is to be determined from the attached graphs.

Peak flows for other types of development shall be determined using the following criteria:

- Industrial developments use: 0.012 cfs/acre
- Commercial developments use: 0.010 cfs/acre
- Offices: 30 gallons per capita per day (g/c/d)
- Schools: 30 g/c/d
- Laundromat: 580 gallons per machine per day

The Public Works Department must approve sewer flows for any other specific types of development.

Criteria for Sewage Pump Station Design:

Construction of a sewage pump station shall be considered the last resort for handling sewage flows from any development. An analysis of alternate gravity system alignments must be performed and submitted to the City for review. The analysis shall consider the economics of constructing and maintaining a pump station over a 20-year period versus obtaining right of way and constructing a gravity system.

If the analysis shows that a pump station is the most economical alternative the following criteria shall be used in its design.

Peak flows are determined by the criteria stated above in the Determination of Sewage Flows section.

Configuration of the components of the pump station shall be in such a way to permit easy access by maintenance equipment. Fencing shall be placed around the pump station components with gates provided at locations for access by maintenance personnel and equipment. The fencing is to be 6-feet in height and of materials and color permitted by the City's Planning Department. All metal parts are to be powder coated with the approved color.

All hatches and hardware shall be stainless steel.

The developer/contractor shall submit complete maintenance and spare parts information for all station components.

Force Main Design:

The force main shall be sized in such a way that the pumps will maintain a minimum flow velocity of 2 feet per second. The force main shall be no smaller than 4 inches in diameter and shall be made of ductile iron pipe. However, if the force main is small and located in a residential street, AWWA C900 PVC pipe may be used. The use of PVC pipe will require specific approval by the Public Works Department.

The force main shall have a continuous upward grade from the pump station to the outlet. No low or high points will be permitted between the pump station and outlet.

The force main shall outlet to a manhole connected to a gravity system. The outlet shall be at the flowline of the manhole and channeled as shown in City Standard Drawing No. 500. Within 30 feet of the manhole the force main shall have an elevation high enough to prevent sewage in the gravity system from flowing down the force main during the off cycle of the pumps.

The designer shall analyze bends in the force main for the need to use thrust blocks or restrained joints.

A force main cleaning station must be installed at approximately 500-foot intervals if the following conditions will exist in the completed system.

- Flows from the area served by the pump station are not enough to require the force main to be emptied every 4 hours.
- The force main is over 950 feet long.
- The difference in elevation between the force main at the valve vault and the outlet is greater than 25 feet.

Pump Design:

Pumps are to be sized to provide a minimum flow velocity of 2 feet per second in the force main.

Pumps shall be able to handle 4-inch solids.

Pump selection shall be based on the most efficient drive/pump/impeller combination for the force main system. The discharge flow velocity should be in the range of 10 to 14 feet per second. The designer shall graph the pipe system curve against the pump curve. If multiple pumps are used this graph shall show the curve for each pump. The minimum pump efficiency allowed is 60 percent.

Wet Well Design:

In stations that have 5 to 100 horsepower pumps the wet wells shall be sized to permit the pumps to cycle not less than 15 minutes between stops and starts. In addition the pumps must not run less than 10 minutes per cycle. Stations with pumps greater than 100 horsepower shall have a cycle time between pump stops and starts not be less than 20 minutes with a minimum run time of 15 minutes.

Pumps on and off elevations are to be shown on the plan. These elevations must be below the inlet elevation to the wet well. Flap gates on the wet well inlet are not permitted.

The wet well shall have a 6-foot minimum diameter and lined with PVC or City approved coating.

If the wet well is over 30 feet in depth there must be a "step off" landing designed in the well. The landing is a safety precaution to provide a location for maintenance personnel to step off the wet well access ladder.

All nuts, bolts, and washers shall be made of 304 or 316 stainless steel.

A wastewater recirculator or scum breaker shall be provided.

Valve Vault Design:

The vault shall be large enough to permit easy access by maintenance personnel. The bottom shall be a minimum 4-inch thick concrete slab. A 4-inch diameter PVC pipe shall be provided to drain the valve vault into the wet well.

All pipe and fittings from the pumps through the valve vault shall be made of ductile iron. Only flanged fittings shall be used. All nuts, bolts, and washers shall be made of 304 or 316 stainless steel.

Discharge and isolation valves shall be plug valves and not gate valves.

Controls and Electric Design:

A 480-volt three-phase power supply is required.

All conduits shall be schedule 80 PVC.

An emergency transfer switch shall be provided. Small stations will require a manual switch where large stations with emergency backup generators will require an automatic transfer switch. When a manual transfer switch is required a 100-amp plug and receptacle such as Killark 8581/21-407 and 8581/22-407 shall be provided. In addition, a minimum 30-foot long jumper cable shall be provided.

Lights shall be provided within the control panel to allow for night work.

The pump station shall have a communications link with the City's wastewater treatment plant. The equipment to provide this link shall be City approved.

An electric schematic diagram shall be provided on the pump station plans.

The wet well level measuring device shall be a Milltronics Hydroranger ultrasonic measuring device.

The station shall be controlled by a Modicon Quantum Programmable Logic Controller(PLC).

The station shall be equipped with a Motorola Moscad Radio Telemetry Unit(RTU).

This RTU shall be installed and completely functional prior to the acceptance by the City.

The Developer/contractor shall coordinate and pay for the integration of this RTU into the City's existing SCADA system.

Control system integration with the City's SCADA shall be performed by an integrator approved by the City.

Three phase 480 VAC power shall be the power source.

The power source for station controls shall be 120 VAC.

Two spare conduits shall be provided between the control panel and the wet well. This conduit shall same size of the largest conduit needed between the control panel and wet well.

One spare conduit shall be provided between the control panel and the valve vault. This conduit shall of the same size of the largest conduit needed between the control panel and valve vault.

The developer/contractor shall provide complete as built drawings of the electrical system. This shall include all wiring, general, and internal to the control panel

All wires must be individually tagged. They must be tagged at every termination and inside every junction box.

The developer/contractor shall provide a copy of the proposed PLC program for review prior to construction. A final fully annotated copy of the PLC program shall be provided, both in electronic format and in a hard copy printed format.

All panels shall be of the appropriate construction for the application. (minimum, NEMA 4X or 3R.

Pump Station Functional Requirements

Milltronics Hydroranger Ultrasonic Level Indicator/Controller

Shall provide analog level input to the Programmable Logic Controller (PLC)

Shall provide off & on starting of pumps in the event of PLC failure

Shall provide alternation of pumps in event of PLC failure

Shall provide ultrasonic failure Input to RTU

Float Switch

Shall provide an input to the RTU (high-high level)

Programmable Logic Controller (PLC)

Shall provide starting and stopping of the pumps in auto

Shall provide alternation of the pumps (after each cycle)

Recognize Milltronics failure and provide an input to the RTU

Shall recognize pump hand switch position and adjust the control logic

Shall provide all timing functions

Shall provide low level alarm output to RTU

Shall provide input to the RTU In event of seal failure of pumps (Each Pump)

Shall provide input to the RTU in event of Thermal overload

Shall call lag pump if required

Shall provide input to the RTU indicating pump failure and identifying the pump

Shall provide output to the RTU for high level alarm

A three-position selector switch shall interface with the PLC to provide for manual override of the automatic changing of lead and lag pumps, in case of pump failure (i.e.: P1-AUTO-P2)

Controls

A manual bypass shall be provided for water levels, PLC, Milltronics; etc. and shall directly energize the motor starters.

The auto function shall be controlled by the PLC or in the event of PLC failure, the Milltronics will start, stop, and alternate lead and lag pumps.

Radio Telemetry Unit (RTU)

Shall monitor only, not control

Transmit Dynamic Wet Well Level (Analog Output)

Indicate low level

Indicate high level

Indicate site entry

Indicate AC failure

Indicate individual pump failure

Indicate pump auto, pump not auto

Indicate pump run status

Indicate ultrasonic failure

Indicate Seal Failure

External Relays

(1) Intrinsically safe for the high, high level float

(2) For seal failure

(2) Motor starters

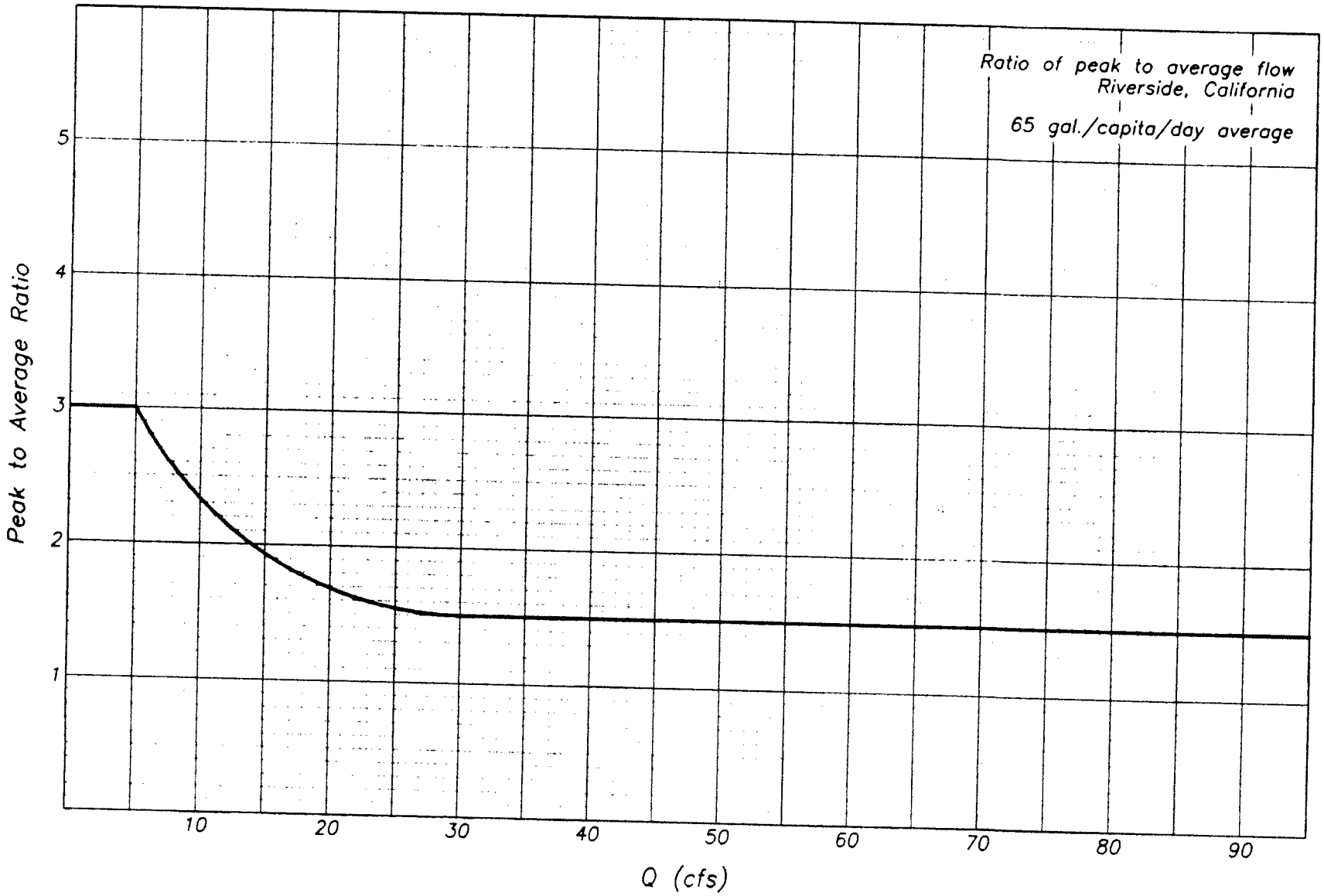
Criteria for Inverted Siphon Design:

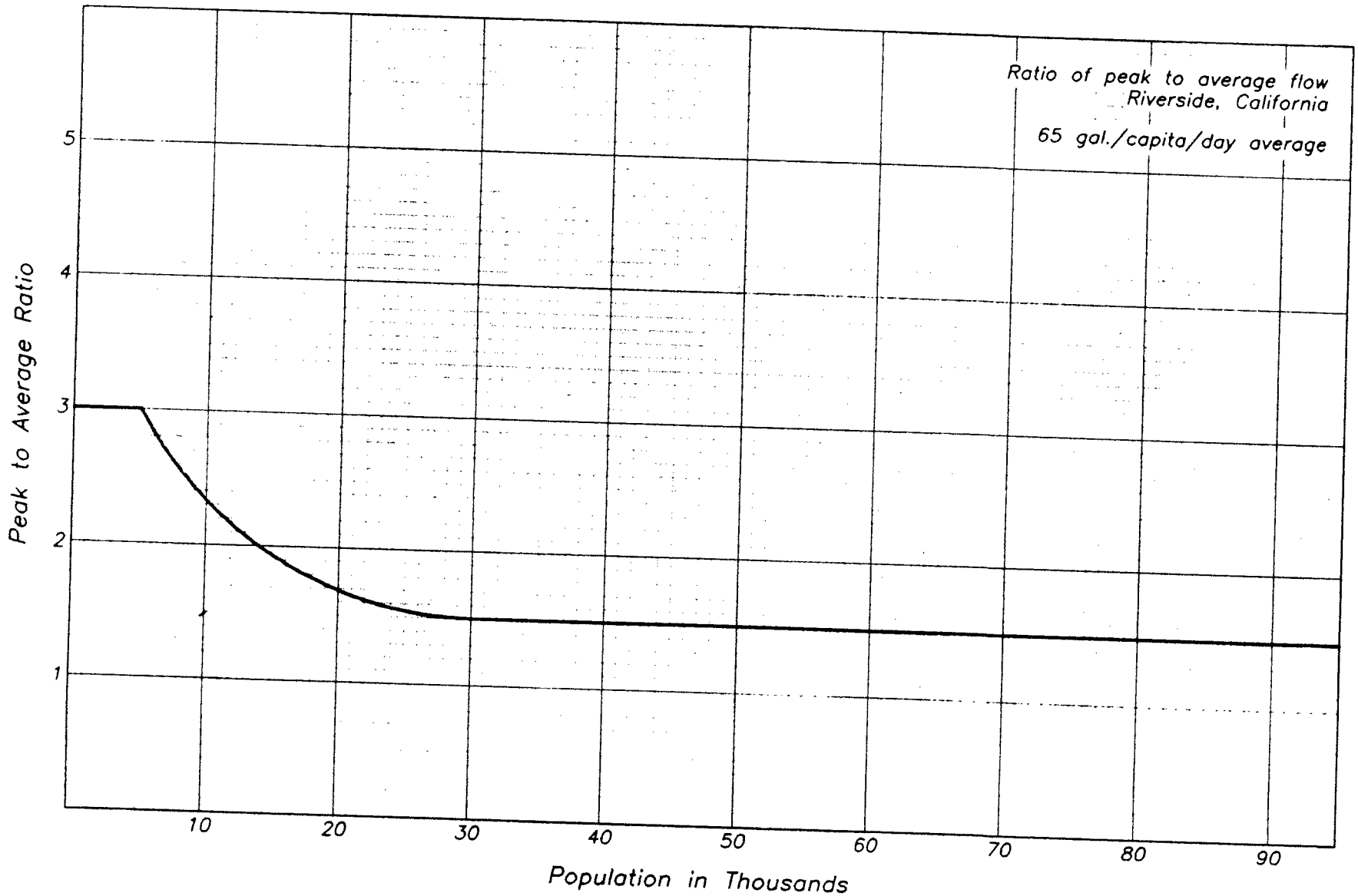
Minimum flow velocity of 3 feet per second and maximum velocity of 7 feet per second within the siphon pipe(s) is required. A multiple pipe design should be incorporated with the upstream manhole designed to direct the anticipated average daily flow into one pipe and the anticipated peak flow into all pipes of the siphon. If the siphon will serve future development it may be necessary to design the siphon with more than two pipes in order to maintain the minimum flow velocity until the future development is constructed. Weirs shall be cast into the base of the manholes.

Minimum pipe size to be used in the siphon is 6-inch. Either Vitrified Clay Pipe or Ductile Iron Cement Mortar Lined Pipe (DIP) shall be used in the siphon. Type V cement shall be used for the lining of the DIP. Internal pressure of the siphon shall be considered in material selection.

The siphon shall not exceed 350 feet in length with manholes installed at each end. Flow shall be directed straight through these manholes. No side connections to the manholes will be permitted. The manhole diameter shall be determined by the number, size, and spacing of the siphon pipes plus 3 feet. The shelf elevation shall be above the water level during ultimate peak flows.

During ultimate peak flow the water surface elevation at the first sewer lateral connection upstream of the siphon must be within the sewer main.


Ratio of peak to average flow
Riverside, California
65 gal./capita/day average
Peak to Average Ratio
5
4
3
2
1
10
20
30
40
50
60
70
80
90
Q (cfs)


Ratio of peak to average flow
Riverside, California
65 gal./capita/day average
Peak to Average Ratio
5
4
3
2
1
10
20
30
40
50
60
70
80
90
Population in Thousands

Appendix C
Study Sewer Lines

City of Riverside
Northside Trunk Sewer System: Study Sewer Lines

Location	Pipe Diameter	Length	Number of Manholes
	(inch)	(feet)	
Palmyrita Avenue	12	2,866	11
	15	8	2
Columbia Avenue	8	484	2
	10	4,090	14
Marlborough Avenue	8	1,588	6
	12	171	2
La Cadena Drive	8	479	1
	10	451	3
	15	829	2
	21	1,075	4
	24	1,169	2
	27	466	1
Main Street	12	830	4
	18	4,917	15
Strong Street	15	922	1
	18	246	2
	21	1,635	3
	24	948	1
	27	1,578	4
Fairgrounds Street	15	1,512	2
	27	1,396	6
Rivera Street	8	646	3
	12	563	2
Fairmount Boulevard	15	1,512	7
	27	1,396	4
Fairmount Trunk (South of Hwy 60 to Tequesquite Avenue)	18	10,400	39
	30	995	2
	33	4,180	10
	36	5,970	21
Total of Study Sewer Lines		**53,322**	**176**

Appendix F
INFILTRATION AND INFLOW STUDY

City of Riverside
Infiltration and Inflow Study

Prepared For:

Sandy Caldwell, P.E.

Principal Engineer
5950 Acorn Street
Riverside, California 92504

Prepared By:

10370 Hemet Street, Suite 200
Riverside CA, 92503
(951) 358-1433

May, 2005

INFILTRATION AND INFLOW (I & I) STUDY

City of Riverside

Client Representative Sandy Caldwell, P.E.

PBS&J

Project Manager Mark Iverson, P.E.

Technical Advisory Louis Atwell, P. E.

Project Engineer Barmeshwar Rai, P.E.

Technical Support Cristina Chavez

May, 2005

10370 Hemet Street Suite 200, Riverside, CA 92503 Ph: (951) 358-1433

Table of Contents

SECTION **PAGE**

Executive Summary ES-1

1 Introduction

1.1 General 1
1.2 Scope 1

2 Meter Locations

2.0 General 3
2.1 Meter No. 1 (Fairmount Boulevard) 3
2.2 Meter No. 2 (Spruce Street) 4
2.3 Meter No. 3 (Golf Course) 4
2.4 Meter No. 4 (Brockton Avenue) 4
2.5 Meter No. 5 (Tequesquite Avenue) 4
2.6 Meter No. 6 (Jurupa Avenue) 5
2.7 Meter No. 7 (Arlington Avenue) 5
2.8 Meter No. 8 (RWQCP) 5
2.9 Meter No. 9 (Jackson Street) 5

3 Description of Drainage Basins

3.0 General 6
3.1 Northside Drainage Basin 6
3.2 Spruce Drainage Basin 6
3.3 Tequesquite Drainage Basin 7
3.4 Phoenix Drainage Basin 7
3.5 Arlanza Drainage Basin 8

4 Data Evaluation Procedure

4.0 General 9
4.1 Rainfall Data 9
4.1.1 Storm Event I 10
4.1.2 Storm Event II 10
4.1.3 Storm Event III 10
4.1.4 Storm Event IV 10
4.2 Meter Flow Evaluation 11
4.2.1 Meter No. 1 (Fairmount) 11
4.2.2 Meter No. 2 (Spruce) 11
4.2.3 Meter No. 3 (Golf Course) 11
4.2.4 Meter No. 4 (Brockton) 12
4.2.5 Meter No. 5 (Tequesquite) 12
4.2.6 Meter No. 6 (Jurupa) 12

4.2.7 Meter No. 7 (Arlington) 13
4.2.8 Meter No. 8 (RWQCP) 13
4.2.9 Meter No. 9 (Jackson) 13

5 Flow Monitoring Findings

5.0 General 14
5.1 Meter No. 1 (Fairmount) 16
5.2 Meter No. 2 (Spruce) 16
5.3 Meter No. 3 (Golf Course) 16
5.4 Meter No. 4 (Brockton) 17
5.5 Meter No. 5 (Tequesquite) 17
5.6 Meter No. 6 (Jurupa) 18
5.7 Meter No. 7 (Arlington) 18
5.8 Meter No. 8 (RWQCP) 19
5.9 Meter No. 9 (Jackson) 19

6 Conclusions/Recommendations

6.0 General 20

TABLES

4-1 CIMIS Rainfall Data 9
5-1 Total I & I at Riverside Water Quality Control Plant (RWQCP) 14

FIGURES

..... Follows
1 Vicinity Map 1
2 Meter Locations and Drainage Basins 3
5.1.1 Flow Chart at Meter 1 - Fairmount 21
5.1.2 Meter 1 – I & I Graph for Rain Event I 21
5.1.3 Meter 1 – I & I Graph for Rain Event II 21
5.1.4 Meter 1 – I & I Graph for Rain Event III 21
5.1.5 Meter 1 – I & I Graph for Rain Event IV 21
5.2.1 Flow Chart at Meter 2 - Spruce 21
5.2.2 Meter 2 – I & I Graph for Rain Event I 21
5.2.3 Meter 2 – I & I Graph for Rain Event II 21
5.2.4 Meter 2 – I & I Graph for Rain Event III 21
5.2.5 Meter 2 – I & I Graph for Rain Event IV 21
5.3.1 Flow Chart at Meter 3 – Golf Course 21
5.3.2 Meter 3 – I & I Graph for Rain Event I 21
5.3.3 Meter 3 – I & I Graph for Rain Event II 21
5.3.4 Meter 3 – I & I Graph for Rain Event III 21
5.3.5 Meter 3 – I & I Graph for Rain Event IV 21
5.4.1 Flow Chart at Meter 4 - Brockton 21
5.4.2 Meter 4 – I & I Graph for Rain Event I 21

5.4.3 Meter 4 – I & I Graph for Rain Event II 21
5.4.4 Meter 4 – I & I Graph for Rain Event III 21
5.5.1 Flow Chart at Meter 5 - Tequesquite 21
5.5.2 Meter 5 – I & I Graph for Rain Event I 21
5.5.3 Meter 5 – I & I Graph for Rain Event II 21
5.5.4 Meter 5 – I & I Graph for Rain Event III 21
5.5.5 Meter 5 – I & I Graph for Rain Event IV 21
5.6.1 Flow Chart at Meter 6 - Jurupa 21
5.6.3 Meter 6 – I & I Graph for Rain Event II 21
5.6.4 Meter 6 – I & I Graph for Rain Event III 21
5.6.5 Meter 6 – I & I Graph for Rain Event IV 21
5.7.1 Flow Chart at Meter 7 - Arlington 21
5.7.2 Meter 7 – I & I Graph for Rain Event I 21
5.7.3 Meter 7 – I & I Graph for Rain Event II 21
5.7.4 Meter 7 – I & I Graph for Rain Event III 21
5.7.5 Meter 7 – I & I Graph for Rain Event IV 21
5.8.1 Flow Chart at Meter 8- RWQCP 21
5.8.2 Meter 8 – I & I Graph for Rain Event I 21
5.8.3 Meter 8 – I & I Graph for Rain Event II 21
5.8.4 Meter 8 – I & I Graph for Rain Event III 21
5.9.1 Flow Chart at Meter 9 - Jackson 21
5.9.2 Meter 9 – I & I Graph for Rain Event I 21
5.9.3 Meter 9 – I & I Graph for Rain Event II 21
5.9.4 Meter 9 – I & I Graph for Rain Event III 21
5.9.5 Meter 9 – I & I Graph for Rain Event IV 21

APPENDICES

A Flow Data from Downstream Services Inc. (CD included)
B Rainfall Data from CIMIS Web Site

Executive Summary

ES.1 Introduction

This report presents the results of the Inflow & Infiltration (I&I) Study prepared by PBS&J for the City of Riverside (City). The report contains recommendations on I&I into the City's sewer systems based on sewer flow data collected by Downstream Services, Inc.

The City of Riverside is located in the northwestern portion of the County of Riverside at the intersection of three major freeways: Route 91, Route 60 and Route 215. The study area encompasses approximately 78 square miles and includes five drainage basins: Northside, Spruce, Tequesquite, Phoenix and Arlanza. The study area is essentially a fully developed matured community with pockets of vacant lands to be developed in the future.

The City is currently experiencing higher levels of wastewater flow into its sewer system during rain events. For this reason, an I&I study was undertaken to evaluate the extent of I&I into the sewer system.

ES.2 Existing Sewer System

The existing sewer system within the City is comprised of approximately 800 miles of sewer lines ranging from 4-inches to 51-inches in diameter. There are approximately 16,500 manholes in the sewer system. These sewer lines are essentially VCP except for force main lines that are either cement mortar lined steel pipes or techite pipes. The manholes are typically brick-lined. The City of Riverside owns and operates the sewer system.

ES.3 Methodology

For determination of current wastewater flows, flow monitoring was performed at nine (9) strategic locations. These meter locations were chosen to observe actual flow characteristics for various drainage basins with a distinct land use pattern. The flow monitoring was performed over a two-month period (from January 8, 2005 to February 28, 2005), which contains four (4) significant rain events. The flow data were carefully evaluated for their accuracy and some adjustments were made considering depth of flow measurement was more reliable than flow velocity measurement. All readings at meter no. 6 (Jurupa) were discarded for inconsistencies.

Rainfall data was taken from the California Irrigation Management Information System (CIMIS) website for the months of January and February. For this period, four (4) significant rain events were identified. For each monitoring station, graphs were plotted for Dry and Wet Week flows versus rainfall intensity.

ES.4 Conclusions and Recommendations

This study concludes high inflow and infiltration for storm events I and IV (see below). It was evident that during peak (high intensity) rainfall periods, high inflows were measured as shown in the meter graphs. In some cases, infiltration would lag by hours following the rainfall event. High intensity rain events were the cause of I&I. Rainfall events II and III, which were milder in intensity, did not trigger any significant I&I. Based on the flow and rainfall data, a rough quantitative estimate of infiltration and inflow at RWQCP is as follows:

Storm event I (Saturday January 8th through Friday January 14th)

Total Rainfall (inches) – 3.73

Peak Intensity (inches/hour) – 0.65

Inflow – approximately 4.8 MG

Infiltration – approximately 2.7 MG

Storm Event IV (Friday February 18th through Monday February 28th)

Total Rainfall (inches) – 4.21

Peak Intensity (inches/hour) – 0.29

Inflow – approximately 3.3 MG

Infiltration – approximately 2.3 MG

These quantities are indicative only and need to be reconfirmed with further investigations and studies.

PBS&J recommends that further investigations be performed to "pinpoint" areas of I&I. This can be accomplished by strategically placing flow meters upstream of the meters in this report. The future meters could be located in upstream sub-basins. In addition, physical manhole inspections, smoke tests and CCTV inspections are also methods of determining I&I. Smoke tests would identify the problem areas, such as Storm Drain Connectors and/or manhole lid openings, while manhole and CCTV inspection would determine the condition and extent of damage within the sewer system.

Section 1
Introduction

1.1 GENERAL

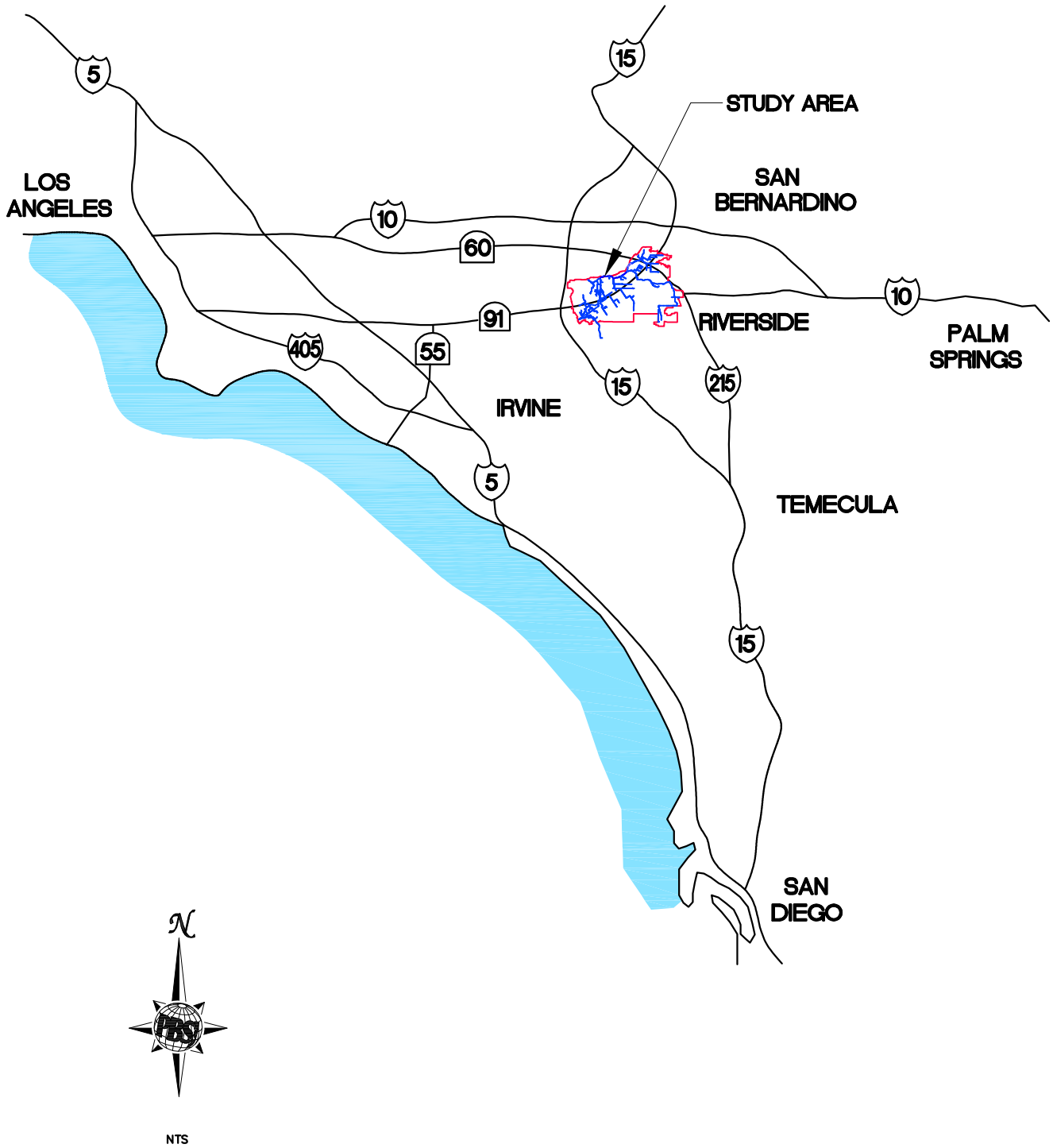
The City of Riverside (City) is located in the northwest portion of the County of Riverside at the intersection of three major freeways: 60, 91 and 215. The sewer system of the City is spread over an area of 78 square miles and treated at the Riverside Water Quality Control Plant (RWQCP) located at the intersection of Van Buren Boulevard and Jurupa Avenue. Figure –1 is the vicinity map showing City's location and accessibility.

In the recent years, excessive sewage flows have been recorded at RWQCP during rain events. This prompted the City to initiate an Infiltration and Inflow (I&I) study for the sewer system. The purpose of this report is to evaluate whether I&I of storm water takes place into the City's sewer system. The report summarizes findings of flow monitoring done for a long period of time (more than 2 months) at various strategic locations of the sewer system. The information gathered is critical in assessing the condition of the collection system and is used to plan future projects to help reduce I&I. This, in turn, should reduce sewage overflows and the possibility of fines that could be imposed by the Santa Ana Regional Water Quality Control Board (RWQCB). This evaluation will also be part of the new EPA requirements for Capacity, Management, Operation and Maintenance (CMOM), which would soon be implemented.

1.2 SCOPE

The following is an outline of the scope of work covered in this evaluation of the City's I&I Study:

- Evaluate Flow Meter Locations: Evaluate the City's collection system using the GIS information received from the City and recommend locations for flow meters. A minimum of one meter would be installed for each of the City's five (5) major drainage basins. Also, the meters would be installed at locations where I&I conditions are expected. A total of nine (9) meter locations have been selected.



Engineering
Planning
Surveying
Construction Services
PBSJ
10370 Hemet Street
Suite 200
Riverside, CA 92503
Tel:(951) 358-1433
Fax:(951) 358-1434

CITY OF RIVERSIDE
INFLOW AND INFILTRATION STUDY

FIGURE 1

VICINITY MAP

- Develop a Flow Monitoring Plan: Develop a flow monitoring plan to include the duration of the study, the routine data collection and the collection of data during and after rainfall events. The meters will be installed for a period of 30 to 90 days. The actual duration of the meter installations will depend on rainfall conditions and durations. A minimum of three significant rainfall events are needed to ensure validity of the data. The meters will be installed for a minimum period of 30 days.
- Installation of Meters: Arrange the services of a subcontractor to install flow meters at the selected locations. Schedule and coordinate the installation of the meters.
- Coordinate Data Collection: Coordinate the retrieval of the flow data from the instruments. The data will be retrieved weekly during non-rainy periods and immediately following significant rainfall events. Collect flow data from the subcontractor in an electronic format and store it.
- Evaluate and Analyze Flow Data: For evaluation, data will be organized and assessed for validity. Analyses will be performed to determine whether I&I occur from each of the five major drainage basins and from the sub-basins within these basins.
- Prepare Report: Prepare a report of the findings of I&I study. It will include flow data, summary of findings, recommendations of additional flow monitoring, tables, figures and maps. It will also include recommendations for the scope of work for follow-up studies that would be specific to individual drainage basins of the City.

Section 2
Meter Locations

2.0 GENERAL

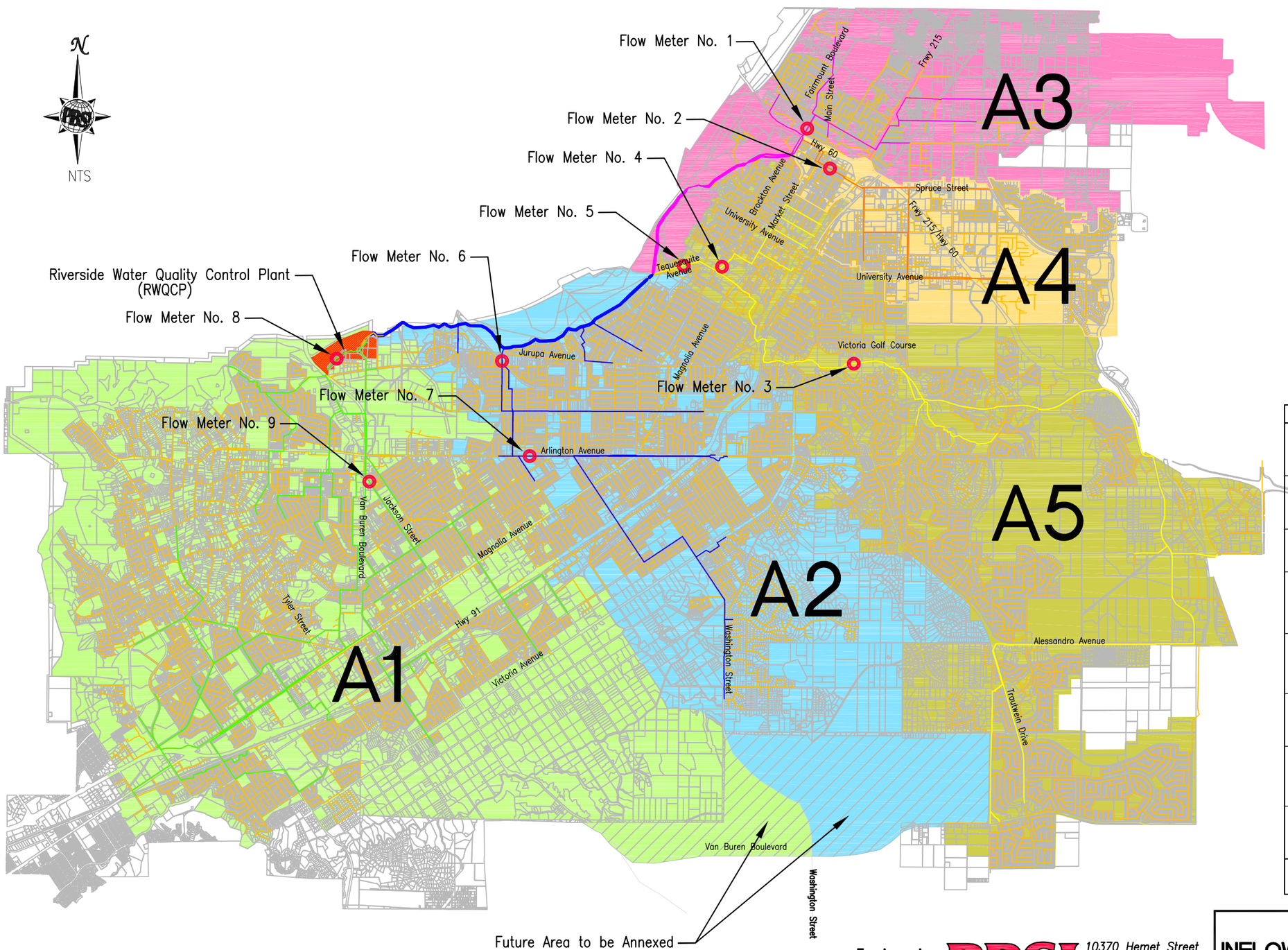
Flow Monitoring was conducted at nine (9) locations to accomplish the following:

- Determine current flow quantities.
- Determine average dry weather flow.
- Determine flow during rain events.
- Determine fluctuation of flow in the system per intensity of rain.
- Determine flow patterns following the rain events.

The location of each flow monitoring station can be seen in Figure –2. The locations of flow monitoring stations and logic behind selection of their locations is explained in the following sub-sections.

2.1 METER NO. 1 (FAIRMOUNT BOULEVARD)

The flow monitoring manhole is located on a 27-inch sewer line (Western Trunk Line) along Fairmount Boulevard, approximately 450-ft northeast of the intersection of Fairmount Boulevard and Fairgrounds Street. The sewer line at this location picks up almost the entire flow coming out of the Northside Drainage Basin. The Northside Drainage Basin comprises of mixed land uses: the area west of Fwy. 215 is primarily residential and the area east of Fwy. 215 is primarily commercial. Most of the future developments would take place in the northeastern portion of the drainage basin. The sewer system, west of the Fwy. 215 is older than the eastern sewer system. The flow monitoring station would measure almost total sewage flow generated from the Northside drainage basin.



Legend

- A1 (Arlanza System)
- A2 (Phoenix System)
- A3 (Northside System)
- A4 (Spruce System)
- A5 (Tequesquite System)
- Flow Meter Location

Proposed Flow Meter Locations

Meter No.	GIS Manhole No.	Sewer System	Location
1	3L4	Northside	The manhole is located on 27-inch sewer line (Western Line) along Fairmount Boulevard, approximately 450-ft northeast of Fairmount Bl. and Fairgrounds St. intersection.
2	3M65B	Spruce	The manhole is located on 18-inch sewer line (Northern Line) along Spruce Street between Orange St. and Mulberry St., approximately 350-ft east of Sedgwick Ave.
3	5M310	Tequesquite	The manhole is located on 21-inch sewer line within the Victoria Country Club Golf Course, approximately 850-ft east of Sedgwick Ave.
4	4K78	Tequesquite	The manhole is located on 15-inch sewer line along Brockton Avenue between 14th st. and Tequesquite Ave., approximately 390-ft northeast of Tequesquite Ave. and Brockton Ave. Intersection.
5	4J129	Tequesquite	The manhole is located on 27-inch sewer line along Tequesquite Avenue between Wong Way and San Andreas Ave., approximately 430-ft northeast of Tequesquite Ave. and San Andreas Ave. Intersection.
6		Phoenix	The manhole is located on 24-inch sewer line north of Jurupa Avenue and east of Tuckson Ct., between Jurupa Ave. and Trunk Sewer Line to the Treatement Plant
7	6H8	Phoenix	The manhole is located on 21-inch sewer line along Arlington Avenue between De Camp Ct. and Jefferson St., approximately 670-ft east of Jefferson St. and Arlington Ave. intersection.
8	5F48	Alranza	The manhole is located on 51-inch sewer line within Riverside Water Quality Control Plant northeast of Jurupa Ave. and Van Buren Bl. intersection.
9	6F28	Alranza	The manhole is located on 24-inch sewer line along Jackson St. within the Parking Lot of the Parcel.

Engineering
Planning
Surveying
Construction Services
PBS&J
10370 Hemet Street
Suite 200
Riverside, CA 92503
Tel:(951) 358-1433
Fax:(951) 358-1434

CITY OF RIVERSIDE
INFLOW AND INFILTRATION STUDY

FIGURE 2

METER LOCATION AND SEWER BASINS

2.2 METER NO. 2 (SPRUCE STREET)

The monitoring manhole is located on an 18-inch sewer line (Northern Line) along Spruce Street between Orange Street and Mulberry Street, approximately 350-ft east of Sedgwick Avenue. The sewer line picks up a majority of the wastewater flow coming from the Spruce Drainage Basin. One of the major contributors of the sewage flow is the University Of Riverside (UCR), which has experienced rapid growth in the recent years. The sewer system within the UCR campus is owned and operated by it.

2.3 METER NO. 3 (VICTORIA COUNTRY CLUB)

The monitoring manhole is located on a 21-inch sewer line within the Victoria Country Club Golf Course, approximately 850-ft east of Sedgwick Avenue. The wastewater flow from the Canyon Crest and Orange Crest areas of the City can be measured at this location. Within the country club, the sewer line is installed in a non-paved sewer right of way for a long stretch that makes it vulnerable for I&I.

2.4 METER NO. 4 (BROCKTON AVENUE)

The manhole is located on a 15-inch sewer line along Brockton Avenue between 14th Street and Tequesquite Avenue, approximately 390-ft northeast of the intersection of Tequesquite Avenue and Brockton Avenue. The sewer line at this location picks up flow from the downtown area of the City and residential developments east of Hwy. 91. The sewer system upstream of this location is perhaps the oldest sewer system within the City. The wastewater flow from the downtown commercial and office developments can be measured at this location.

2.5 METER NO. 5 (TEQUESQUITE AVENUE)

The manhole is located on a 27-inch sewer line along Tequesquite Avenue between Wong Way and San Andreas Avenue, approximately 430-ft northeast of the intersection of Tequesquite Avenue and San Andreas Avenue.

Total wastewater from Tequesquite Drainage Basin can be measured at this location.

2.6 METER NO. 6 (JURUPA AVENUE)

The manhole is located on a 24-inch sewer line north of Jurupa Avenue and east of Tuckson Ct., between Jurupa Avenue and the Trunk Sewer Line to the Treatment Plant. The flow monitor at this location will measure most of the sewage flow generated from the Phoenix Drainage Basin. Also, the sewer line near this location is installed in a non-paved sewer right of way, which is susceptible to I&I.

2.7 METER NO. 7 (ARLINGTON AVENUE)

The manhole is located on a 21-inch sewer line along Arlington Avenue between De Camp Ct. and Jefferson Street, approximately 670-ft east of the intersection of Jefferson Street and Arlington Avenue. The sewer line at this location picks up most of the residential flow generated from the southeastern portion of the Phoenix Drainage Basin. The combination of flow data at this location and meter number six (6) can be used to analyze wastewater flow characteristics of the Phoenix Drainage Basin.

2.8 METER NO. 8 (RWQCP)

The manhole is located on a 51-inch sewer line within the RWQCP, northeast of the intersection of Jurupa Avenue and Van Buren Boulevard. The wastewater flow generated from the Arlanza Drainage Basin can be measured at this location. Also, this flow can be compared to the daily flow data entering RWQCP from the Arlanza Trunk Sewer.

2.9 METER NO. 9 (JACKSON STREET)

The manhole is located on a 24-inch sewer line along Jackson Street, within the parking lot of the parcel near the intersection of Van Buren Boulevard and Jackson Street. The wastewater flow from the eastern portion of the Arlanza Drainage Basin (East of Van Buren Boulevard) can be measured at this location.

Section 3
Description of Drainage Basins

3.0 GENERAL

The general topography of the City follows the Santa Ana River, which flows at the western edge of the City in the southerly direction. In general, the northern and western portions of the City are higher in elevation and general surface flow is either in southerly or westerly direction. Based on the general topography and existing layout of the sewer system, the City has been divided into five (5) drainage basins. See Figure –2 for details of drainage basins. The drainage basins are described in the following sub-sections:

3.1 NORTHSIDE DRAINAGE BASIN

The Northside Drainage Basin, located in the northern portion of the City covers approximately 6,000 acres. It is generally bounded by Main Street to the North, Santa Ana River to the west, Spruce Street to the south and Pope Kirlos Avenue to the east. The eastern portion of the drainage basin (east of Fwy. 215) is primarily a business park / light industrial area and has scope for future development activities. The western portion is a mature community. Total sewage flow from the drainage basin can be measured at the meter location 1. In the future, significant sewage flow would be generated from the proposed Spring Mountain Ranch and Springbrooks Developments proposed in the eastern portion of the drainage basin. PBS&J has performed a trunk sewer study for Northside Drainage Basin for dry weather flow conditions. According to this study, the existing sewer system is efficient for current flows but the system would need rehabilitation / replacement of sewer segments to accommodate the future flows.

3.2 SPRUCE DRAINAGE BASIN

The drainage basin covers around 2,500 acres and is located north of the Riverside Downtown

neighborhood. It is generally bounded by Spruce Street to the north, University Avenue to the south, Fairmont Boulevard to the west and Watkins Drive to the east. PBS&J has performed trunk sewer capacity study for this drainage basin. According to this study, the Spruce Sewer System has current and future deficiencies. UCR is one of the major sewage contributors to the Spruce Sewer System. The drainage basin is a mature community comprised of residential, commercial, light industrial and educational facilities.

3.3 TEQUESQUITE DRAINAGE BASIN

The drainage basin encompasses around 13,000 acres in area and includes Downtown, Canyon Crest and Orangecrest neighborhoods of the City. It is generally bounded by UCR to the north, Van Buren Boulevard to the south, Tequesquite Avenue to the west and Fwy. 215 to the east. PBS&J has performed a trunk sewer capacity study for this drainage basin. According to this study, the Tequesquite Sewer System has current and future deficiencies. The area designated as an Industrial Business Park in the Sycamore Canyon neighborhood would be one of the major wastewater contributors to the Tequesquite Sewer System. The drainage basin is a mature community and comprises of residential, commercial, light industrial and educational facilities. The area marked as Sycamore Canyon Park is a reserved area. The sewer lines in the downtown area are quite old and may have I&I problems in addition to capacity deficiencies as identified in the Sewer Capacity Study.

3.4 PHOENIX DRAINAGE BASIN

The Phoenix Drainage Basin is located in the middle portion of the City and it covers approximately 11,000 acres. It is generally bounded by the Santa Ana River to the north, Woodcrest neighborhood of the County of Riverside to the south, Jefferson Street to the west and Alessandro Avenue to the east. PBS&J is currently performing a trunk sewer capacity study for this drainage basin that would determine current and future deficiencies for dry weather conditions. The drainage basin is a mature community comprised of residential, commercial, light industrial and educational facilities. The sewage flow from this drainage basin dumps into

the trunk sewer line that runs parallel to Santa Ana River.

3.5 ARLANZA DRAINAGE BASIN

The drainage basin encompasses around 20,000 acres and includes a southern portion of the City. It is generally bounded by the Santa Ana River to the north, Home Gardens neighborhood of the County of Riverside to the south, City of Norco to the west and Jefferson Street to the east. PBS&J is currently performing a trunk sewer capacity study for this drainage basin that would determine current and future deficiencies. The drainage basin is a mature community comprised of residential, commercial, light industrial and educational facilities. It can distinctly be divided into two portions: the area west of Tyler Street contributing to the pump station at Pierce Street and the area east of Tyler Street contributing to the RWQCP by gravity. The sewer system comprises of new and old (approximately 50 years) sewer lines. The wastewater flow from the western portion of the drainage basin is pumped through a force main line to the gravity sewer system and eventually it flows to RWQCP.

Section 4

Data Evaluation Procedures

4.0 GENERAL

Flow data for wastewater was collected and provided by Downstream Services, Inc from nine (9) metering locations. The data for each station was evaluated. The data was collected for the period of January 7, 2005 through February 28, 2005.

Two types of meters were installed, a Marsh-McBirney FloDar meter with a non-intrusive ultrasonic level and radar velocity sensors to measure depth, velocity and flow and an ISCO 2150 Area Velocity meter using a pressure transducer to measure depth and a Doppler to measure velocity. The Marsh-McBirney FloDar meter was installed at stations 2, 5 and 8; while the ISCO 2150 Area Velocity meter was installed at stations 1, 3, 4, 6, 7 and 9.

4.1 RAINFALL DATA

CIMIS, the California Irrigation Management Information System (http://www.cimis.water.ca.gov/cimis/data.jsp) is the source of information used for this study for the rainfall data. The rainfall data used for this study was for the months of January and February. The rainfall data can be seen in Appendix B. There were a total of four (4) storm events during the study period that were evaluated. The rainfall data for these four (4) storm events is summarized in the Table 4-1.

Table 4-1

City of Riverside, Station 44, CIMIS Rainfall Data for Jan/Feb 2005

Storm Event	Dates	Days	Total Rainfall (in)	Average Rainfall for Storm Event (in/hr)	Peak Intensity (in/hr)
I	1/8 to 1/14	7	3.73	0.02	0.65
II	1/26 to 2/01	7	0.23	0.001	0.09
III	2/9 to 2/15	7	0.88	0.01	0.16
IV	2/18 to 2/28	11	4.21	0.02	0.29

The storm events are described in more details in the following sub-sections.

4.1.1 STORM EVENT I

The Storm Event I began on January 8, 2005 and continued until January 14, 2005 for a period of 7 days. The intensity of rainfall gradually increased and the peak intensity (0.65 inch per hour) was recorded on January 09, 2005 at 17.00 hours. After that, the rainfall intensity decreased rapidly and finally diminished on January 12, 2005. The average rainfall for this storm event was 0.02 inch per hour and the total rainfall was 3.73 inch.

4.1.2 STORM EVENT II

The Storm Event II began on January 26, 2005 and continued until February 01, 2005 for a period of 7 days. The intensity of rainfall was mild in nature and the peak intensity (0.09 inch per hour) was recorded on January 28, 2005 at 16:00 hours. This was a minor storm event with scanty or negligible rainfall. The average rainfall for this storm event was 0.001 inch per hour and the total rainfall was 0.23 inch.

4.1.3 STORM EVENT III

The Storm Event III began on February 09, 2005 and continued until February 15, 2005 for a period of 7 days. The intensity of rainfall was mild in nature and the peak intensity (0.16 inch per hour) was recorded on February 11, 2005 at 12:00 hours. This storm event was a mild one with majority of rainfall falling on February 11, 2005. For the rest of the storm period, a scanty or negligible rainfall was recorded. The average rainfall for this storm event was 0.01 inch per hour and the total rainfall was 0.88 inch.

4.1.4 STORM EVENT IV

The Storm Event IV began on February 18, 2005 and continued until February 28, 2005

for a period of 11 days. The intensity of rainfall was mild to heavy in nature and the peak intensity (0.29 inch per hour) was recorded on February 19, 2005 at 13:00 hours. This storm event was spread over a longer period of time. It began with a mild intensity on February 18, 2005 and peaked on February 19, 2005. This continued until February 23, 2005 with two intermediate peaks on February 21, 2005 at 4:00 hours (0.20 inch per hour) and on February 23, 2005 at 3:00 hours (0.13 inch per hour). For the rest of the storm period, a scanty or negligible rainfall was recorded. The average rainfall for this storm event was 0.02 inch per hour and the total rainfall was 4.21 inch.

4.2 METER DATA COLLECTION / EVALUATION

4.2.1 METER NO. 1 (FAIRMOUNT)

At Station 1 (Fairmount), the sensor was positioned in the 27” VCP inflow pipe. Acquiring data at this location was difficult because debris would build up during low-flow conditions. For this reason, data for some of the dates were lost and the data collected from the hardware had to be salvaged and re-calculated for velocity and flow considering depth was reliable. This data was evaluated and a graph plotted to make a better representation of the storm events. A 30-period moving average was used to plot graphs for the Wet and Dry Week Periods. A figure for the flow data for the entire period is shown in Figure 5.1.1.

4.2.2 METER NO. 2 (SPRUCE)

At Station 2 (Spruce), the meter was installed at the inflow 18” VCP. This meter has a consistent depth of flow, velocity and flow data. The data collected at this station was converted to a 30-period moving average and used for plotting graphs. A figure for the flow data for the entire period is shown in Figure 5.2.1.

4.2.3 METER NO. 3 (GOLF COURSE)

At Station 3 (Golf Course), the meter was installed in the 27” inflow VCP pipe. The readings at this station are generally consistent and accurate. Data was used to calculate a 30-

period moving average for both the wet and dry-week periods. During rain events, some inconsistent spikes were experienced at this location for a small period of time. However, data was used to create graphs for a 30-period moving average for both wet and dry week periods. A figure for the flow data for the entire period is shown in Figure 5.3.1.

4.2.4 METER NO. 4 (BROCKTON)

At Station 4 (Brockton), the meter was installed at the 15” inflow VCP pipe. At this location, a major problem was encountered during flow monitoring. Flow surcharge caused the hardware to be dislodged on February 17th, and the damaged equipment could not be replaced until February 25th. For this reason, data is missing for this period so only two storm events were plotted using a 30-period moving average. A figure for the flow data for the entire period is shown in Figure 5.4.1.

4.2.5 METER NO. 5 (TEQUESQUITE)

At Station 5 (Tequesquite), the meter was installed at the inflow 27” VCP pipe. The data was analyzed using the 30-period moving average for both the Wet week and Dry Week Periods. Graphs for all four storm events were plotted. A figure for the flow data for the entire period is shown in Figure 5.5.1.

4.2.6 METER NO. 6 (JURUPA)

At Station 6 (Jurupa), the meter was installed in the 24” VCP line. The total flow quantity of both influent lines, 24” VCP and 27” VCP, were metered. The data at this location was analyzed for the influent flow of the 27” line. This station had debris and large objects flowing into the system that interfered with the readings. In mid January, the mounting ring became dislodged due to a mass of debris flowing into the pipeline. This caused a lot of the data at this station to be considered as erroneous and only one storm event in mid-February was plotted. A 30-period moving average was taken for the data that was salvaged. A figure for the flow data for the entire period is shown in Figure 5.6.1.

4.2.7 METER NO. 7 (ARLINGTON)

At Station 7 (Arlington), the meter was installed at the 21” VCP inflow pipe. Hydraulic conditions at this site were generally good, with moderately fast flow velocities. Brief accounts of surcharging were present. Data was used for a 30-period moving average for a graphical representation of all four storm events.

A figure for the flow data for the entire period is shown in Figure 5.7.1.

4.2.8 METER N0. 8 (RWQCP)

At Station 8 (RWQCP), the meter was installed in the 51” inflow pipe. Flow conditions monitored showed consistent flow, with moderate-to-fast velocity indications. The data of the entire period was used for a 30-period moving average and plotted for three storm events. Due to insufficient amount of data for February 18th through the 24th, representation of the fourth storm event was not done. A figure for the flow data for the entire period is shown in Figure 5.8.1.

4.2.9 METER NO. 9 (JACKSON)

At Station 9 (Jackson), the meter was installed in the 24” inflow pipe. All four storm events were plotted using data for a 30-period moving average. One problem with the collection of data was encountered for this station during the last two days of February, when zero readings were recorded by the meters for depth and flow. This period was ignored for graphical representation. A figure for the flow data for the entire period is shown in Figure 5.9.1.

Section 5
Flow Monitoring Findings

5.0 GENERAL

The analysis of data was performed and graphs plotted for the data collected. The total amount of wastewater flow at RWQCP is the sum of flows at meters 1, 2, 5, 6, 8 and 9. The details of I&I flow at the RWQCP are tabulated in table 5-1. The analysis of flow data for each metering station is described in detail in the following sub-sections.

Table 5-1

Total I&I at Riverside Water Quality Control Plant (RWQCP)

Storm Event I (From Saturday January 8th through Friday January 14th)					
Estimation of Inflow:					
Meter No.	**Location**	**Approximate Wet Day Flow (On Jan. 9) (MG)**	**Approximate Dry Day Flow (On Jan. 16) (MG)**	**Difference (MG)**	**Variation %**
1	Fairmount Boulevard	0.8	0.3	0.5	145%
2	Spruce Street	2.6	2.4	0.2	8%
5	Tequesquite Avenue	8.5	7.7	0.9	11%
6	Jurupa Avenue	3.9	2.5	1.4	57%
8	RWQCP	10.1	8.9	1.3	14%
9	Jackson Street	2.9	2.3	0.6	24%
	Total:	**28.78**	**24.01**	**4.77**	**20%**
Estimation of Infiltration:					
Meter No.	**Location**	**Approximate Wet Day Flow (On Jan. 12) (MG)**	**Approximate Dry Day Flow (On Jan. 19) (MG)**	**Difference (MG)**	**Variation %**
1	Fairmount Boulevard	0.5	0.3	0.1	38%
2	Spruce Street	3.1	2.9	0.2	6%
5	Tequesquite Avenue	8.5	8.1	0.4	5%
6*	Jurupa Avenue				

8	RWQCP	9.6	7.9	1.7	21%
9	Jackson Street	2.5	2.2	0.3	14%
	Total:	**24.13**	**21.41**	**2.72**	**13%**
Storm Event IV (From Friday February 18th through Monday February 28th)					
Estimation of Inflow:					
Meter No.	**Location**	**Approximate Wet Day Flow (On Feb. 20) (MG)**	**Approximate Dry Day Flow (On Feb. 6) (MG)**	**Difference (MG)**	**Variation %**
1	Fairmount Boulevard	0.9	0.3	0.70	209%
2	Spruce Street	2.7	2.5	0.2	9%
5	Tequesquite Avenue	6.6	6.5	0.2	2%
6**	Jurupa Avenue	3.9	3.8	0.1	2%
8	RWQCP	11.2	9.4	1.8	19%
9	Jackson Street	2.6	2.3	0.4	16%
	Total:	**28.04**	**24.79**	**3.25**	**13%**
Estimation of Infiltration:					
Meter No.	**Location**	**Approximate Wet Day Flow (On Feb. 12) (MG)**	**Approximate Dry Day Flow (On Jan. 20) (MG)**	**Difference (MG)**	**Variation %**
1	Fairmount Boulevard	0.3	0.3	0.02	6%
2	Spruce Street	3.1	2.9	0.3	9%
5	Tequesquite Avenue	8.0	7.1	0.9	12%
6**	Jurupa Avenue	3.9	3.8	0.03	1%
8	RWQCP	8.4	7.7	0.6	8%
9	Jackson Street	2.7	2.2	0.4	20%
	Total:	**26.32**	**24.07**	**2.25**	**9%**

Notes:

* Data was not available for these dates and could not be included in this calculation

** In case of missing data for Storm Event IV, corresponding flow data for similar rainfall intensity was used for Storm Event I.

5.1 METER NO. 1 (FAIRMOUNT)

The flow from the Northside Drainage Basin is measured at this location. Due to debris accumulation at low flows, the collection of data for this station was not consistent for the entire period of January 7th through February 28th. Meter malfunction was the cause of invalid velocity data. However, reliable readings that were considered useful were of the water level in the manhole (depth) for the period of the first storm event. This is why data was plotted on a graph for only the first storm event in January, from Saturday January 8th through Friday January 14th. The representation given on this graph shows several inflow spikes immediately following the wettest day, January 9th, for two 12-hour period cycles. The infiltration subsided by the end of the first storm period. The graph for the infiltration and inflow at this meter location can be seen in Figure –5.1.2 to Figure –5.1.5.

5.2 METER NO. 2 (SPRUCE)

At this location, the flow from Spruce Drainage Basin is measured. Four significant storm events were monitored for the whole two-month period. Graphs for all four storm events were plotted. Rain-induced inflow can be seen on the graphs. Storm events I and IV showed evidence of some inflow conditions for three 24-hour period cycles. This was seen with wet flows increasing for three consecutive cycles and being higher than dry flows for that week. This was followed by gradually decreasing infiltration for the rest of the week. Graphs plotted for storm events II and III show comparable flows for both dry and wet periods and do not show any evidence of infiltration or inflow. The graphs for the infiltration and inflow at this meter location can be seen in Figure –5.2.2 to Figure –5.2.5.

5.3 METER NO. 3 (GOLF COURSE)

Wastewater flows from Orangecrest and Canyon Crest neighborhoods of the City can be measured at this location. Surcharging was seen during some rain events at this location, causing

the water level to reach the top of the manhole at some instances. Storm event I shows high wet flows following the one-day peak rainfall event on January 9th. Inflow spikes were evident for 24-hour period cycles. Storm events II and III present steady flows for the one week period, so no conclusion of I&I was derived for these rain events. Storm event IV shows high wet flows for five out of eleven days plotted. This was due to four high rainfall days at the beginning of the period that might have caused inflow spikes followed by diminishing flows. The graphs for the infiltration and inflow at this meter location can be seen in Figure –5.3.2 to Figure –5.3.5.

5.4 METER NO. 4 (BROCKTON)

Wastewater flows from the downtown areas of the City can be measured at this location. Only two storm events were analyzed of this location: Storm I and II. This was because of inconsistencies in the data for storm events III and IV. Manning's formula was used to determine velocities and flows for the measured depths, assuming they were reliable. When zero readings were attained for some of the depths, no data was recovered and excluded from graphs. For the first storm event, I&I was evident following a peak rainfall day. The second graph does not provide reliable I&I information because the data is inconsistent. The graphs for the infiltration and inflow at this meter location can be seen in Figure –5.4.2 to Figure –5.4.4.

5.5 METER NO. 5 (TEQUESQUITE)

The total flow from Tequesquite Drainage Basin can be measured at this location. Significant inflow spikes were recorded during storm events I and IV for this station. This was primarily evident during storm event I. Infiltration evidence was seen for Storm I for a 24-hour period and diminishing after that. However, storm IV showed infiltration readings that were sporadic with dry periods being sometimes higher than wet periods for flow. This may have been caused by flawed meter readings that caused inconsistent data. The graphs for the infiltration and inflow at this meter location can be seen in Figure –5.5.2 to Figure –5.5.5.

5.6 METER NO. 6 (JURUPA)

Most of the wastewater flows from the Phoenix Drainage Basin can be measured at this location. Despite efforts to salvage a lot of the raw data collected for this station, it was difficult to draw conclusive information for the presence of inflow and infiltration from graphs. Only one storm event for the month of February was plotted and used to analyze flow data. Peaks representing high periods of the flow following high rainfall were attained from the plot, but only four consecutive days were representative for this occurrence. It was difficult to determine the presence of infiltration in one graph alone. In conclusion, data for this station was determined invalid and was not considered for this sewer study. The graph for the infiltration and inflow at this meter location can be seen in Figure –5.6.3 to Figure –5.6.5.

5.7 METER NO. 7 (ARLINGTON)

The wastewater flow from part of the Phoenix Drainage Basin can be measured at this location. Hydraulic conditions were reliable for the collection of raw data for this station. All four storm events were analyzed and plotted. Storm event I contains a peak rainfall day on the second day, for a 24-hour period, followed by high wet flows indicating inflow. A small quantity of infiltration can be seen on the graph; but nothing comparable to other stations. Storm events II and III demonstrated steady flows throughout the one week period. No indication of I&I was present for storm events II and III. Storm IV presents a cycle of events, with three peak rainfall days at the beginning of the period, followed by peak wet flows as well. Inflow was present throughout this period, with indications of high wet flows for five consecutive days. Very minimal infiltration was seen after five days. There were ambiguous dry flows being higher than wet flows that might have been caused by a brief period of surcharging in the system. The graphs for the infiltration and inflow at this meter location can be seen in Figure –5.7.2 to Figure –5.7.5.

5.8 METER NO. 8 (RWQCP)

Total wastewater flow from Arlanza Basin can be measured at this location. Collection of data for this station was made for the entire period, except for one week. This was due to failure of the meter's data logger for February 17th through February 24th. It was replaced on February 25th. The flow data for the first three storm events were plotted. The graph for storm event I show indication of inflow spikes, followed by mild infiltration that diminishes at the end of the storm period. Little or no indication of I&I was witnessed during storm events II and III. The graphs for the infiltration and inflow at this meter location can be seen in Figure –5.8.2 to Figure –5.8.4.

5.9 METER NO. 9 (JACKSON)

At this meter location, part of the wastewater flow from the Arlanza Basin can be measured. Flows for all four storm events were measured at this station. Storm event I contains a significant period of high rainfall for the first three days of the week, with the wettest day having a period of an 8-hour rainfall. High inflow indication followed this trend, with a diminishing wet flow occurrence after three subsequent days. Storm events II and III showed mild rainfall events, so no I&I was seen on the graphs. Storm event IV showed a series of high rainfall for the first five days. Significant wet period flows can be seen for this storm event followed by prolonged low diminishing flows. The graphs for the infiltration and inflow at this meter location can be seen in Figure –5.9.2 to Figure –5.9.5.

Section 6
Conclusion / Recommendations

6.0 GENERAL

This study concludes high inflow and infiltration for storm events I and IV. It was evident that during peak (high intensity) rainfall periods, high inflows were measured as shown in the meter graphs. In some cases, infiltration would lag inflow by hours following the rainfall event. High intensity rain events were the cause of I&I. Rainfall events II and III, which were milder in intensity, and did not trigger any significant I&I. Based on the flow and rainfall data, an approximate quantitative estimate of infiltration and inflow at RWQCP is as follows:

Storm event I (Saturday January 8th through Friday January 14th)
Total Rainfall (inches) – 3.73
Peak Intensity (inches/hour) – 0.65
Inflow – Approximately 4.8 MG
Infiltration – Approximately 2.7 MG

Storm Event IV (Friday February 18th through Monday February 28th)
Total Rainfall (inches) – 4.21
Peak Intensity (inches/hour) – 0.29
Inflow – Approximately 3.3 MG
Infiltration – Approximately 2.3 MG

These quantities are indicative only and need to be reconfirmed with further investigations and studies.

PBS&J recommends that further investigations be performed to “pinpoint” areas of I&I. This can be accomplished by strategically placing flow meters upstream of the meters in this report. The future meters could be located in upstream sub-basins. In addition, physical manhole inspections, smoke tests and CCTV inspections are also some of the recommendations that can help in the determination of I&I. Smoke tests would identify the problem areas, such as Storm Drain Connectors and/or manhole lid openings, while manhole and CCTV inspection would determine the condition and extent of damage of the sewer system.

Station 1

FAIRMOUNT

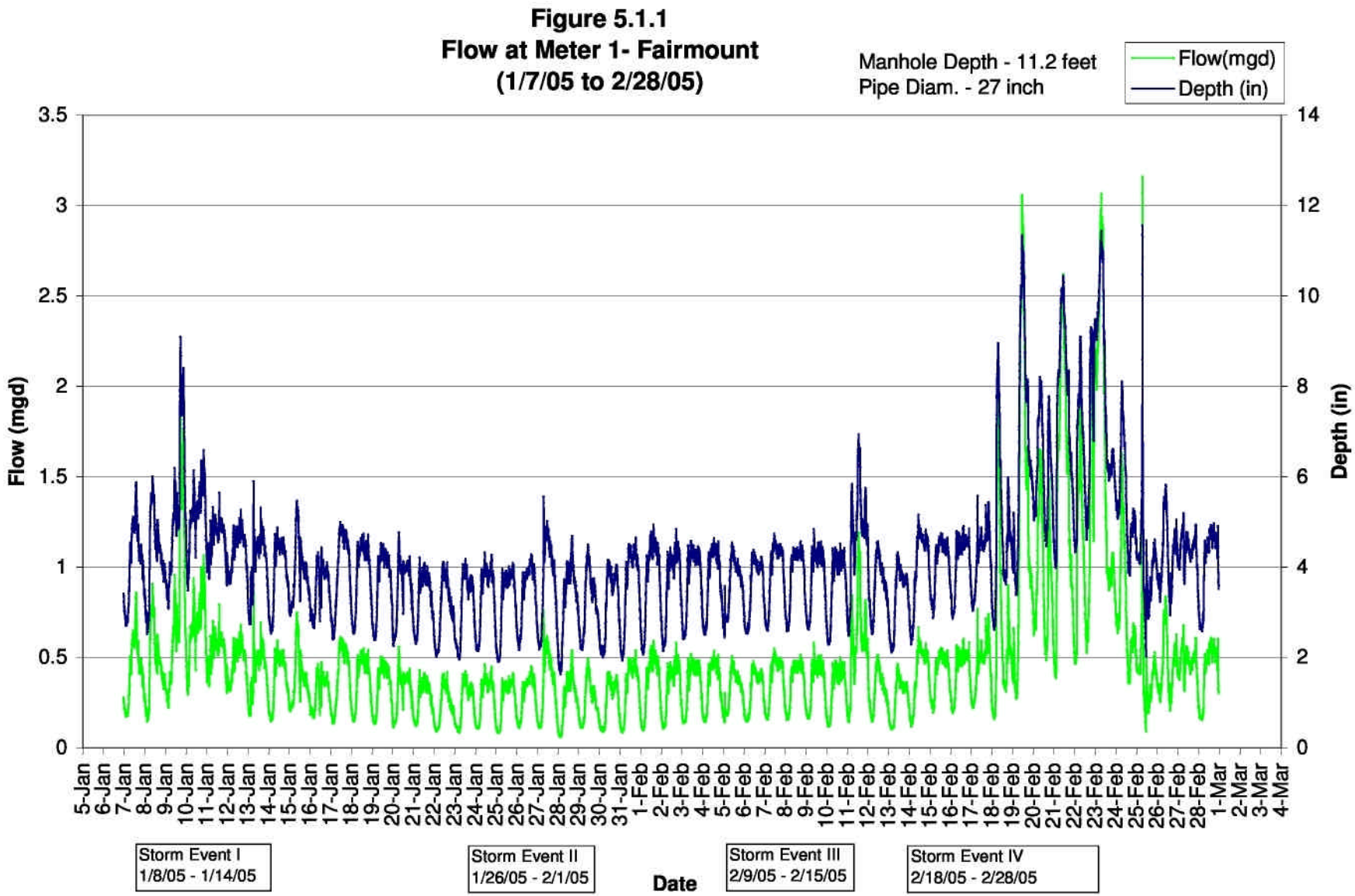
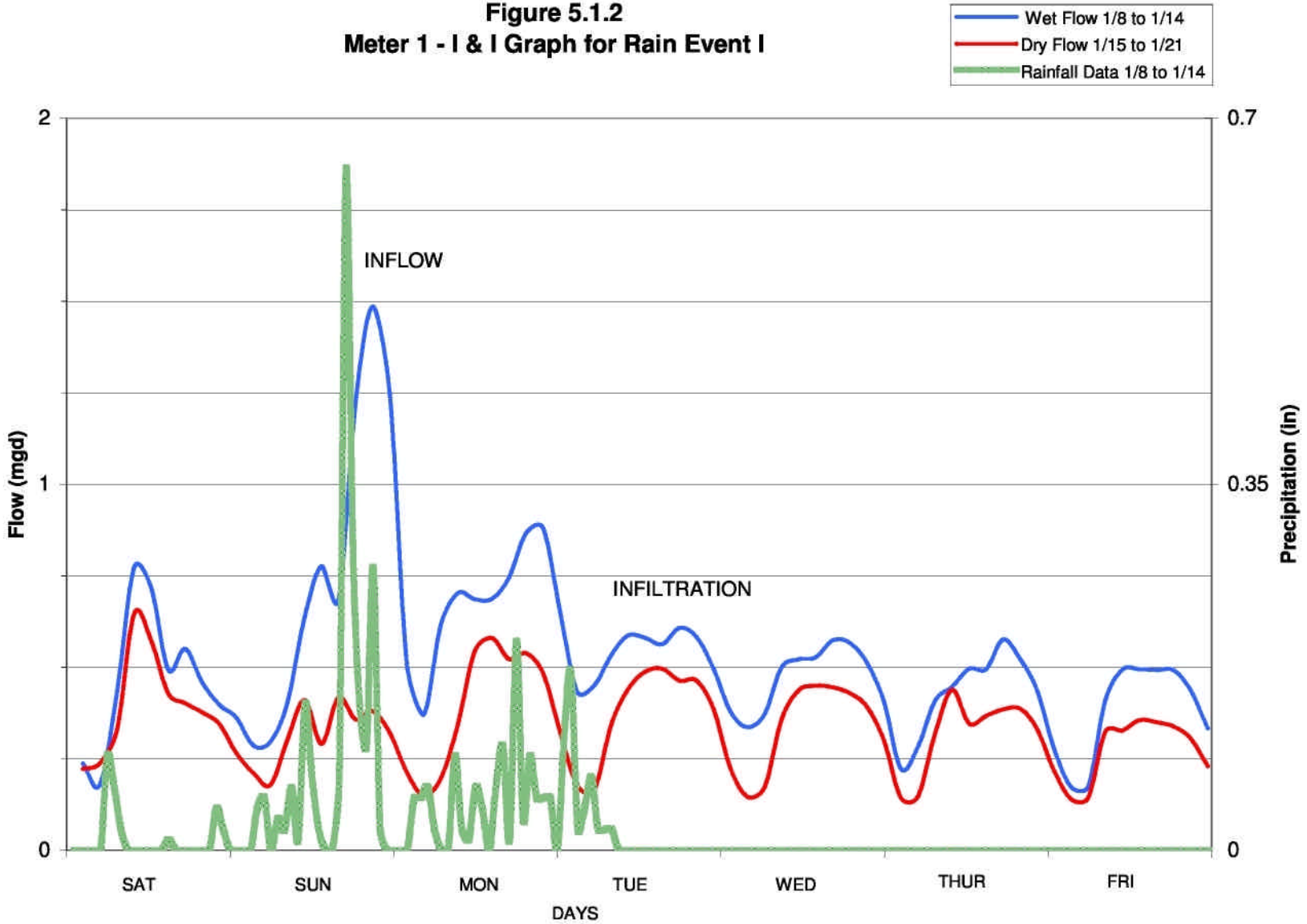


Figure 5.1.1
Flow at Meter 1- Fairmount
(1/7/05 to 2/28/05)
Manhole Depth - 11.2 feet
Pipe Diam. - 27 inch
Flow(mgd)
Depth (in)
Flow (mgd)
Depth (in)
Date
Storm Event I
1/8/05 - 1/14/05
Storm Event II
1/26/05 - 2/1/05
Storm Event III
2/9/05 - 2/15/05
Storm Event IV
2/18/05 - 2/28/05

Figure 5.1.2
Meter 1 - I & I Graph for Rain Event I



Storm Event 1 Jan. 05

Station 2

SPRUCE

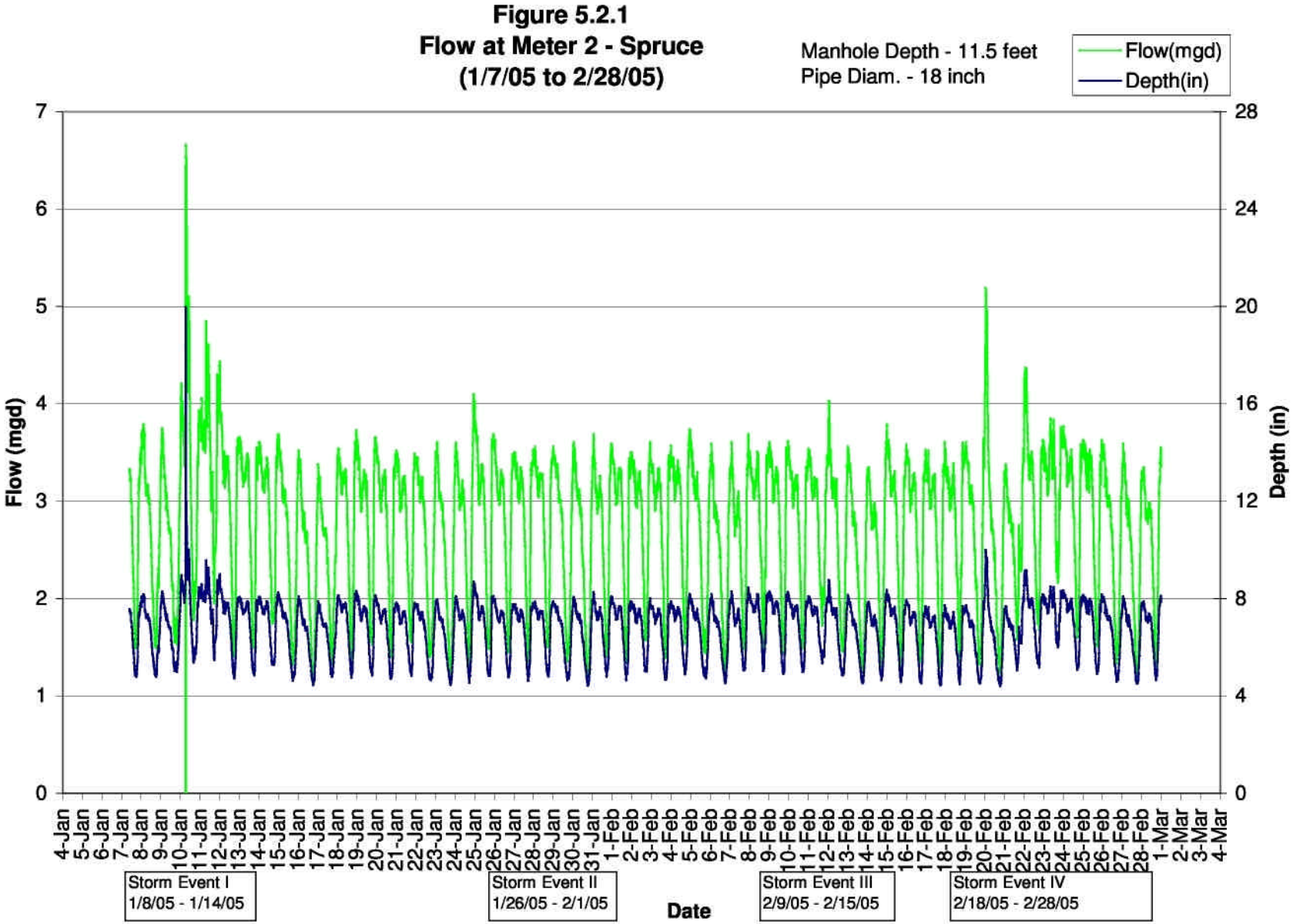
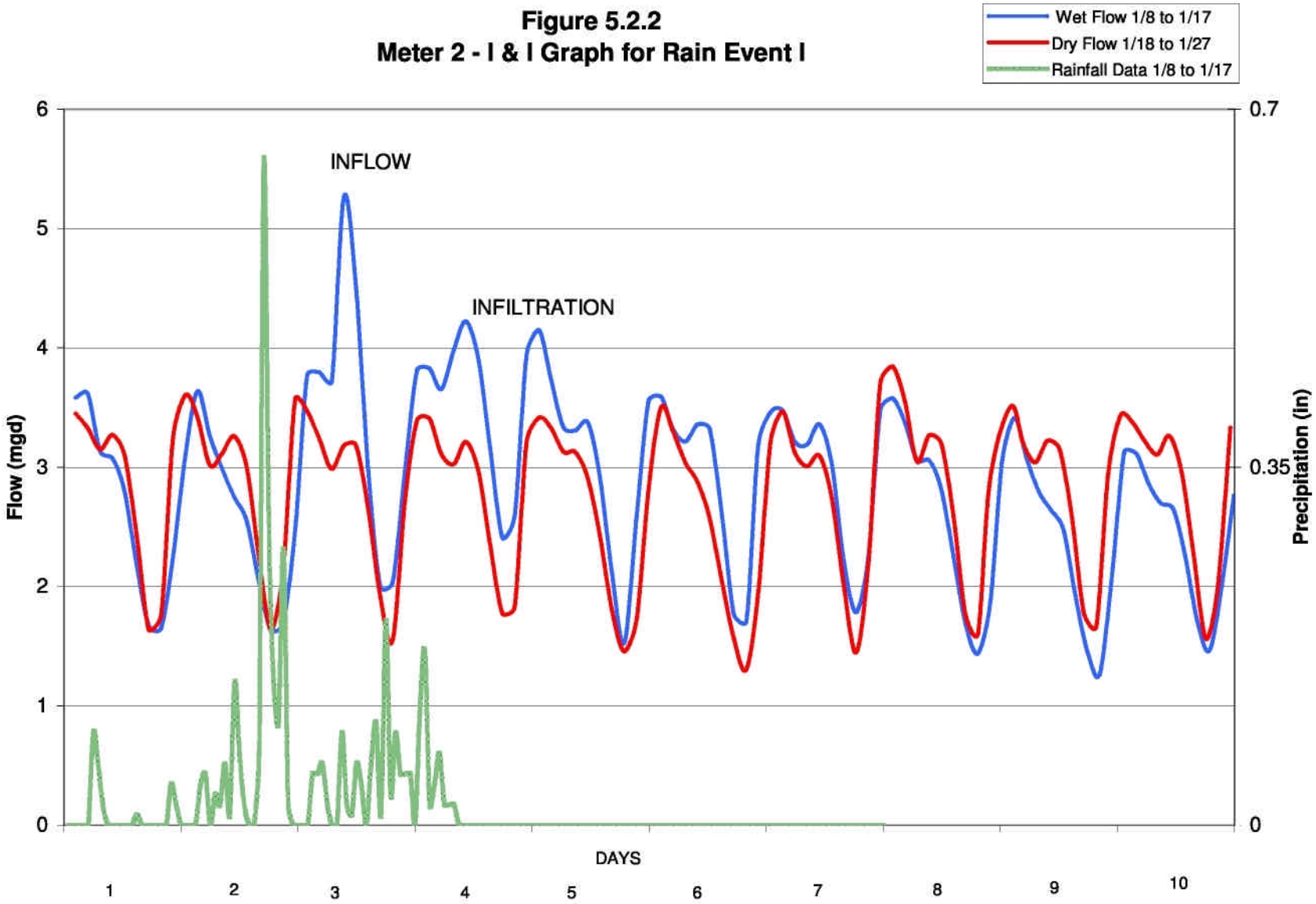


Figure 5.2.1
Flow at Meter 2 - Spruce
(1/7/05 to 2/28/05)
Manhole Depth - 11.5 feet
Pipe Diam. - 18 inch
Flow(mgd)
Depth(in)
Flow (mgd)
Depth (in)
Date
Storm Event I
1/8/05 - 1/14/05
Storm Event II
1/26/05 - 2/1/05
Storm Event III
2/9/05 - 2/15/05
Storm Event IV
2/18/05 - 2/28/05

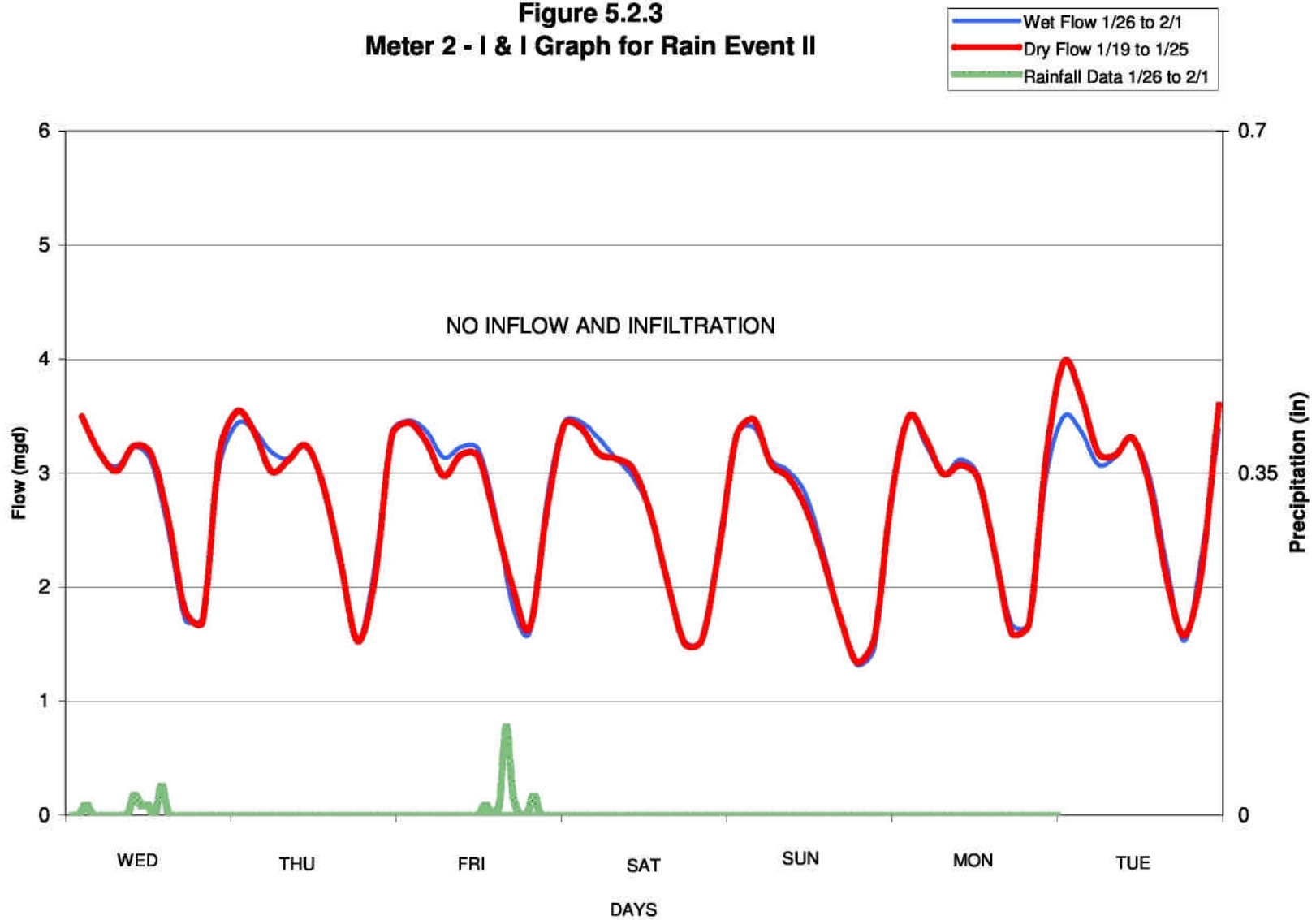
Figure 5.2.2
Meter 2 - I & I Graph for Rain Event I

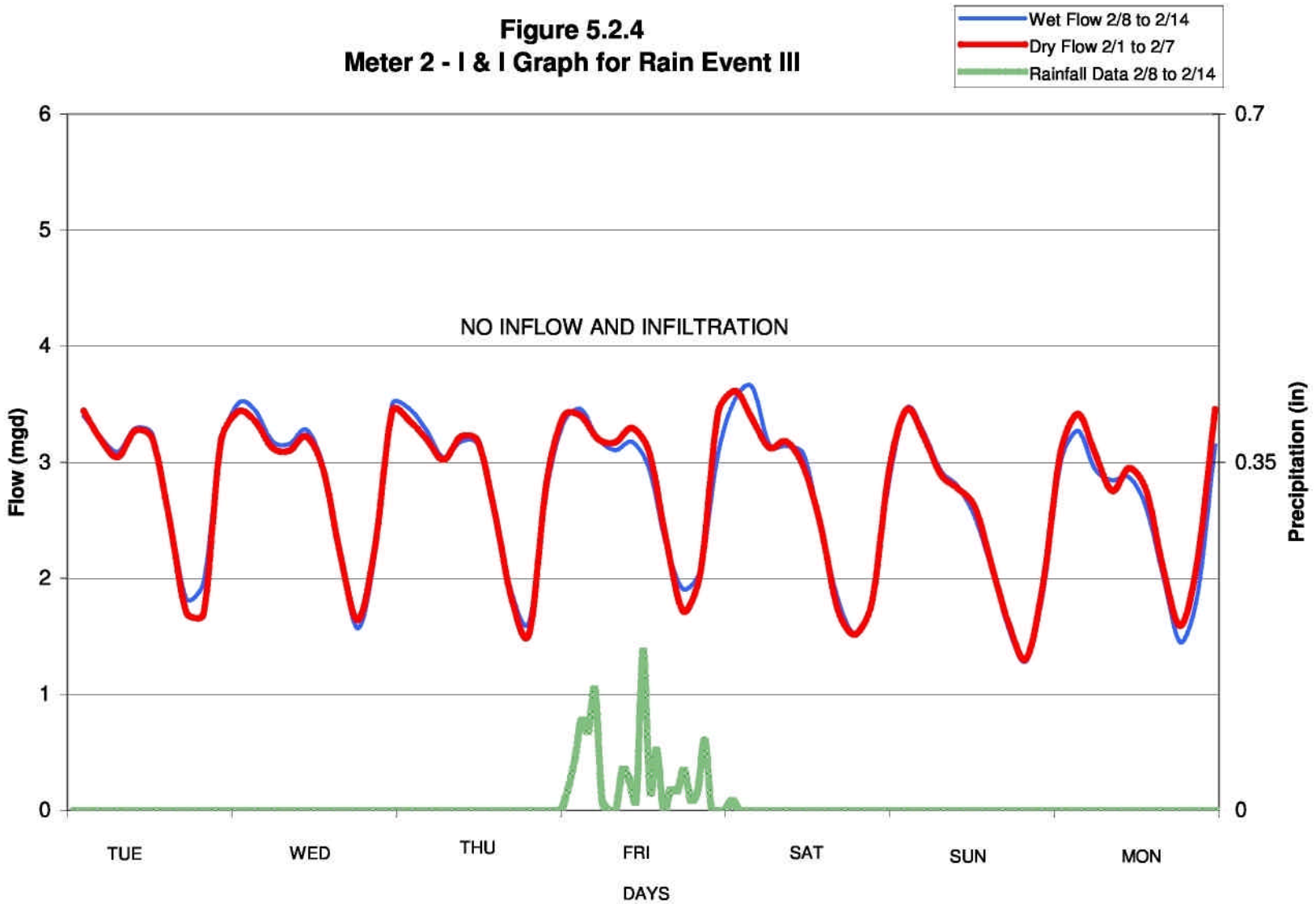


Storm Event I Jan, 05

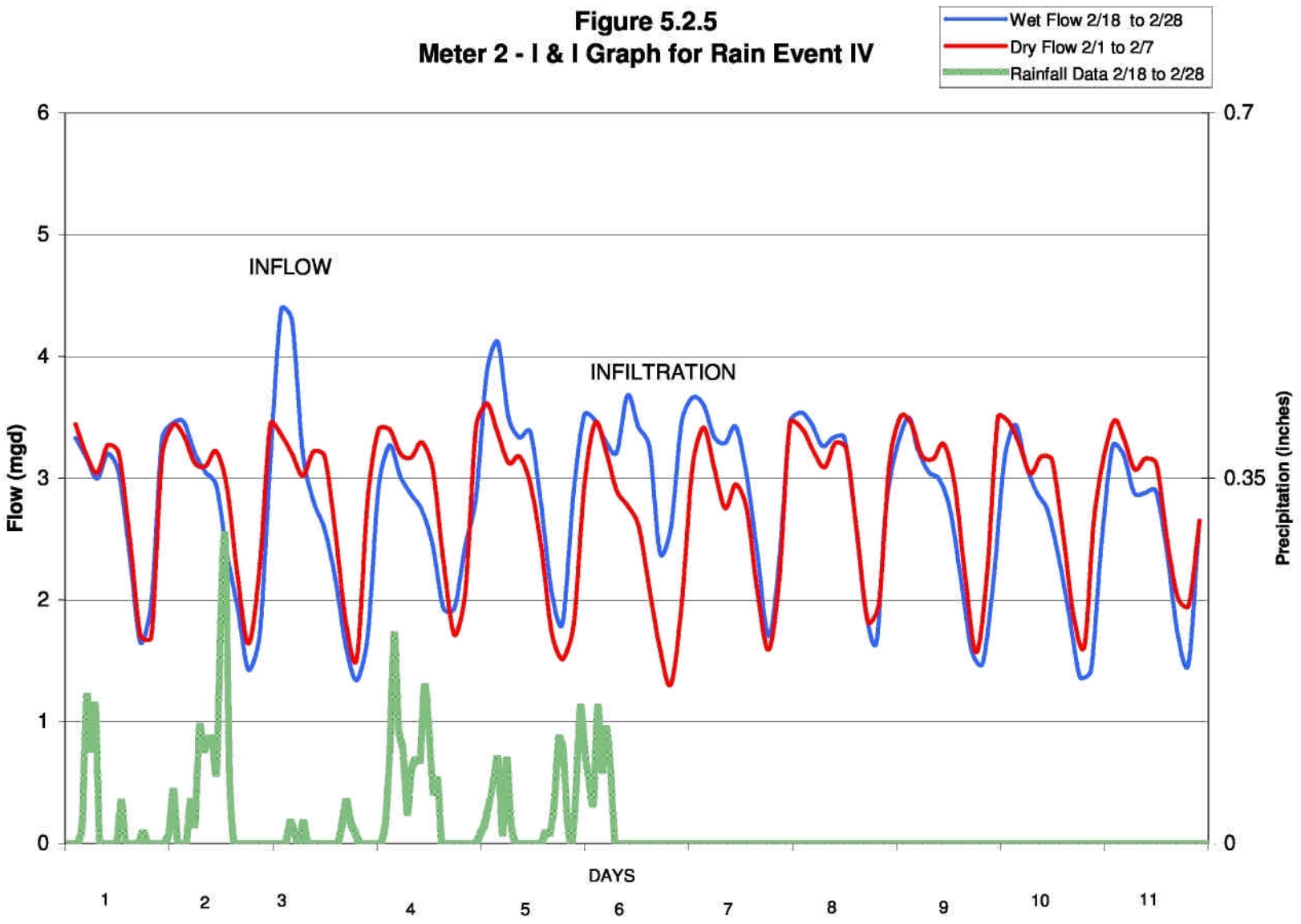
Note: A 10 day period was chosen for this storm event, starting and ending on different days.

Figure 5.2.3
Meter 2 - I & I Graph for Rain Event II





Storm Event III Feb. 05



Storm Event IV Feb, 05

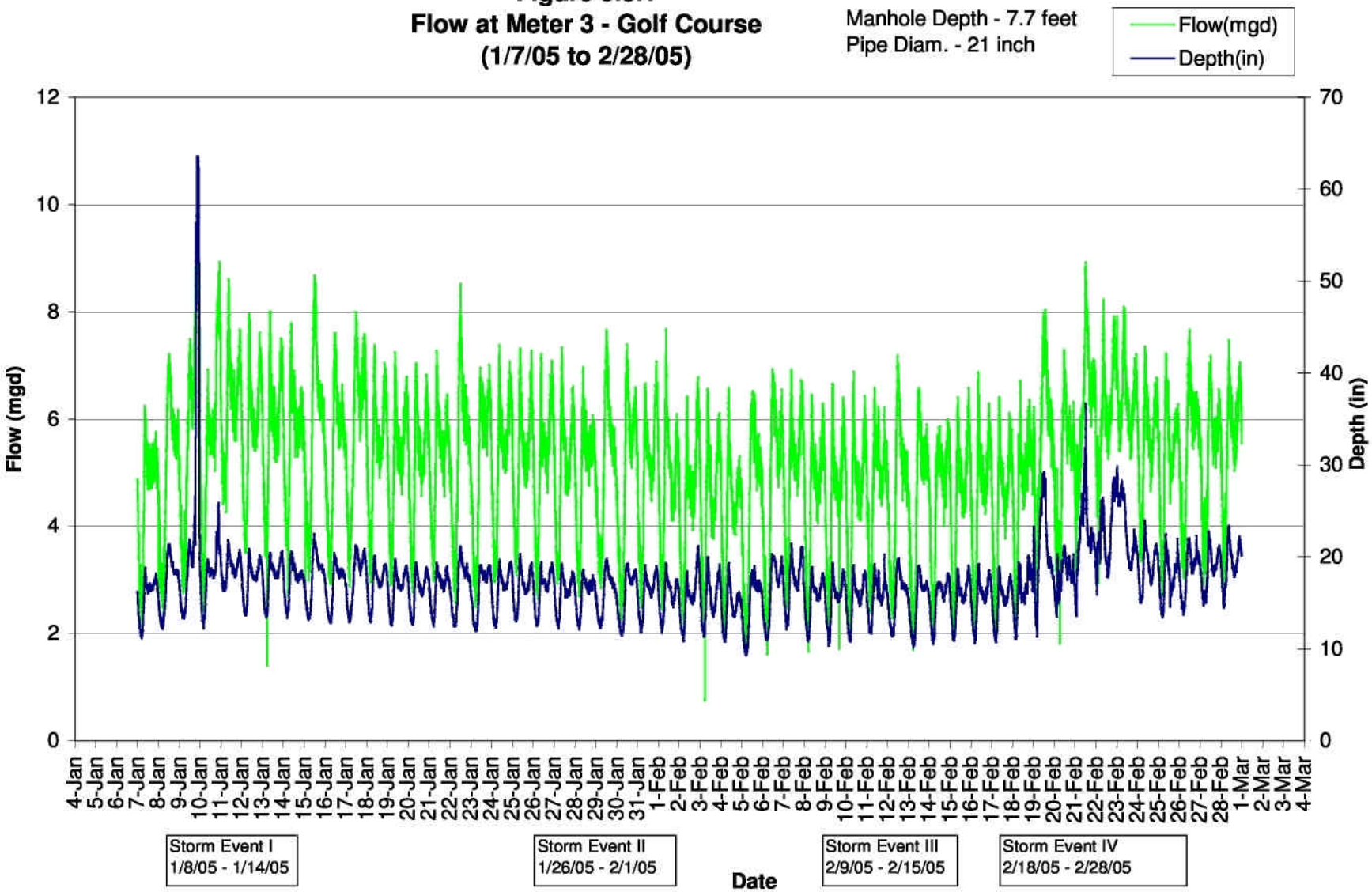
Note: An 11 day period was chosen for this storm event, starting and ending on different days.

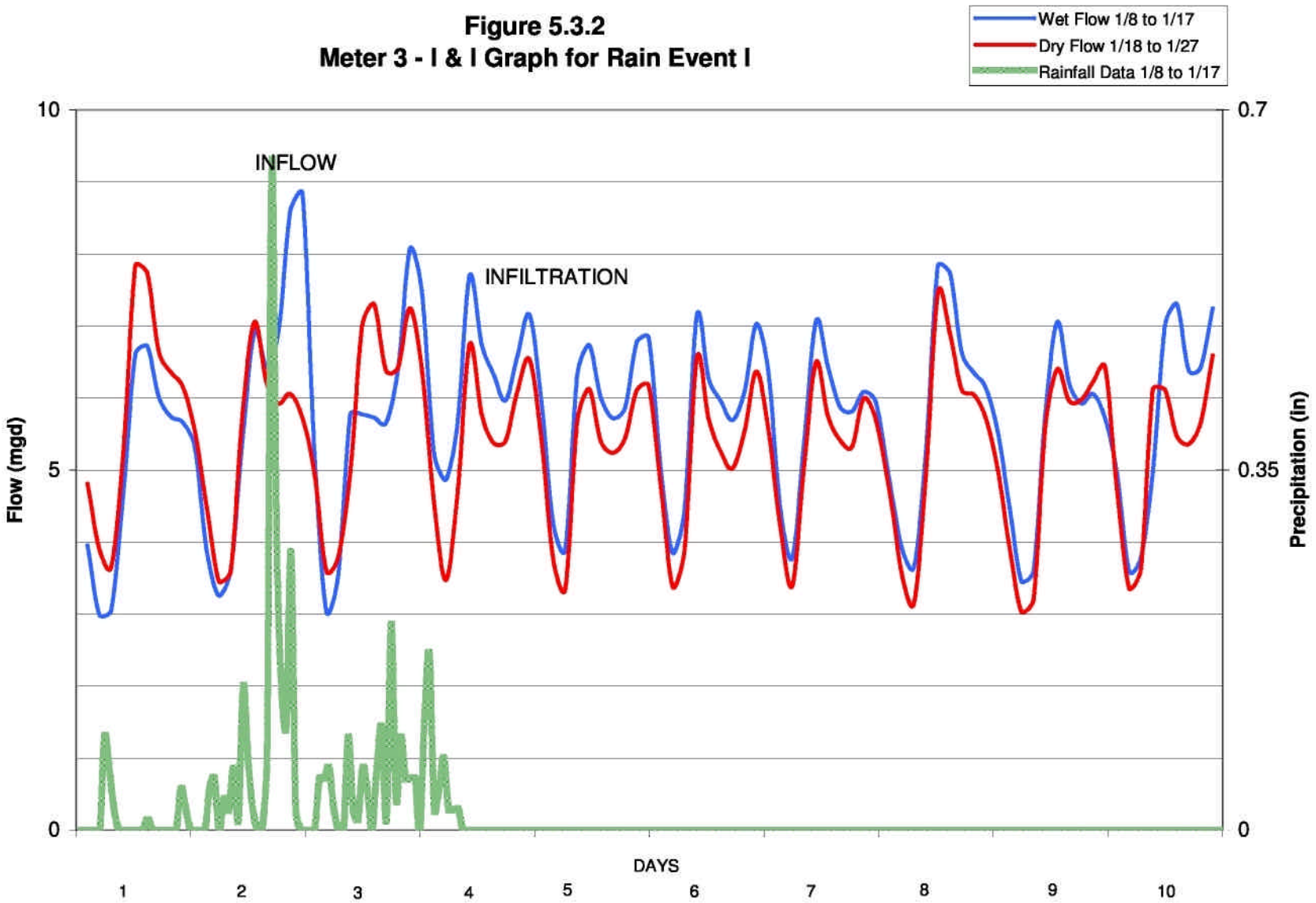
City of Riverside
Sewer I and I Study

Station 3

GOLF COURSE

Figure 5.3.1
Flow at Meter 3 - Golf Course
(1/7/05 to 2/28/05)





Storm Event I Jan, 05

Note: A 10 day period was chosen for this storm event, starting and ending on different days.

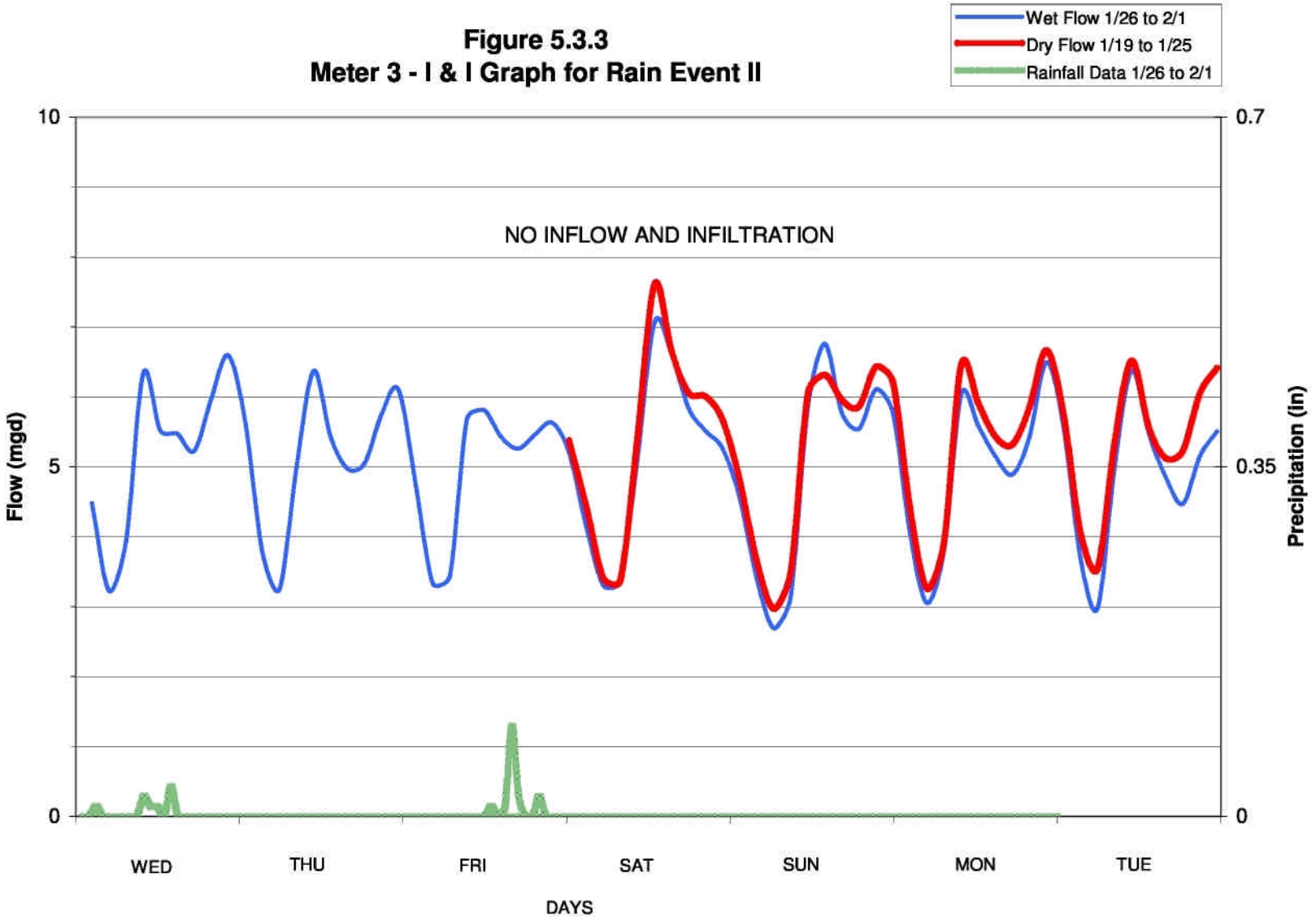
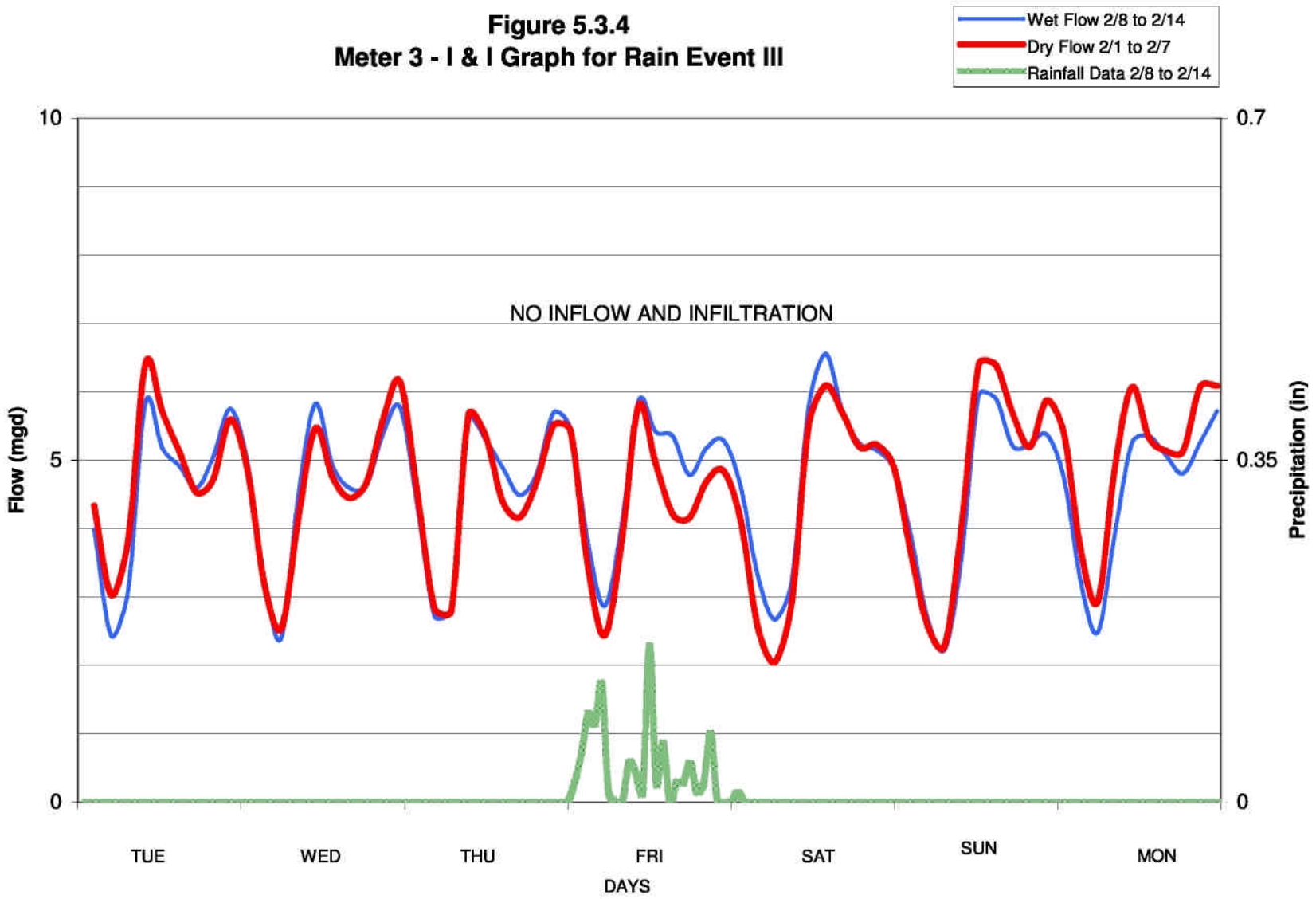
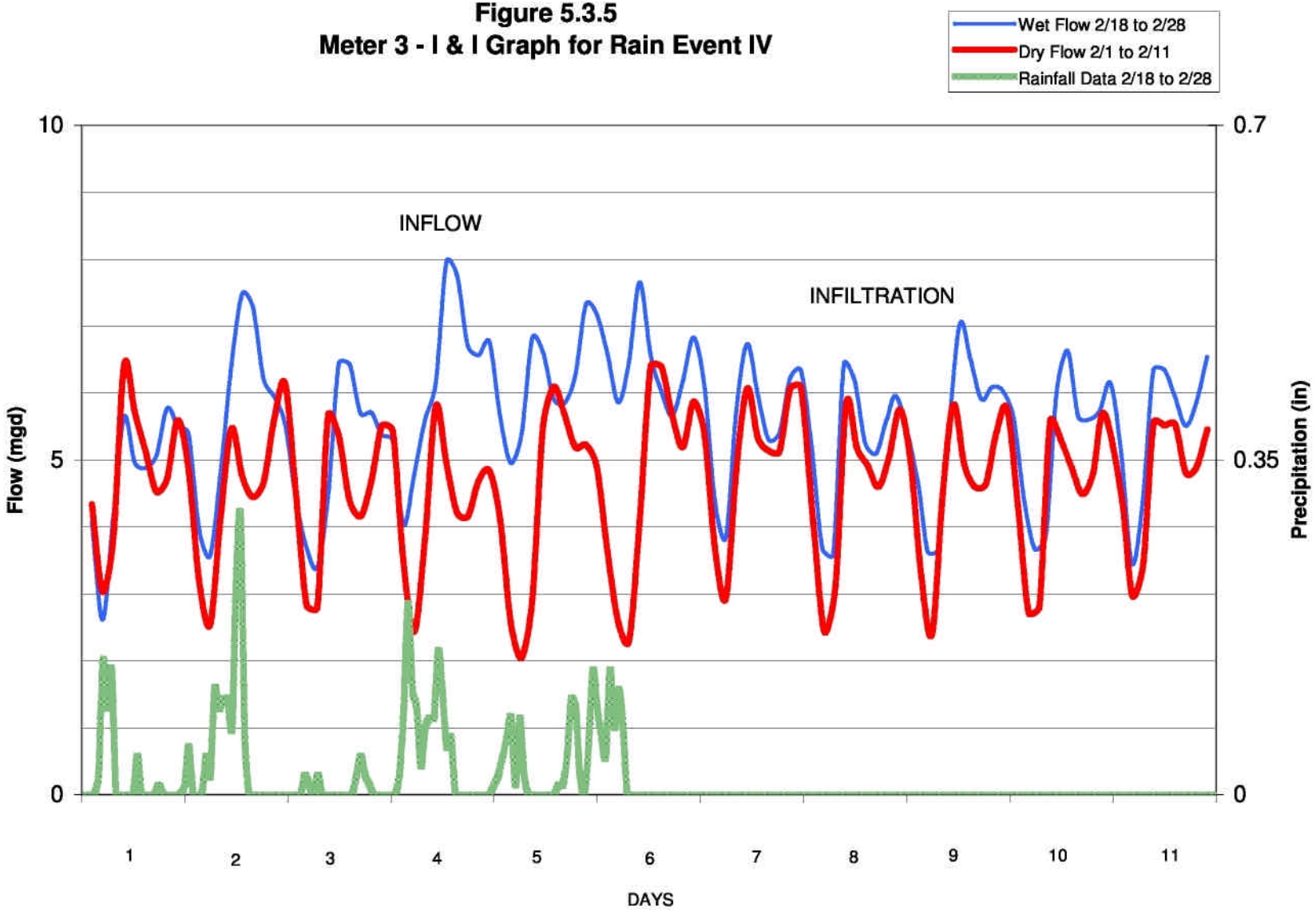


Figure 5.3.3
Meter 3 - I & I Graph for Rain Event II
Wet Flow 1/26 to 2/1
Dry Flow 1/19 to 1/25
Rainfall Data 1/26 to 2/1
NO INFLOW AND INFILTRATION
Flow (mgd)
Precipitation (in)
10
5
0
0.7
0.35
0
WED
THU
FRI
SAT
SUN
MON
TUE
DAYS



Storm Event III Feb. 05

Figure 5.3.5
Meter 3 - I & I Graph for Rain Event IV



Storm Event IV Feb, 05
Note: An 11 day period was chosen for this storm event, starting and ending on different days.

Station 4

BROCKTON

Figure 5.4.1
Flow at Meter 4 - Brockton
(1/7/05 to 2/28/05)

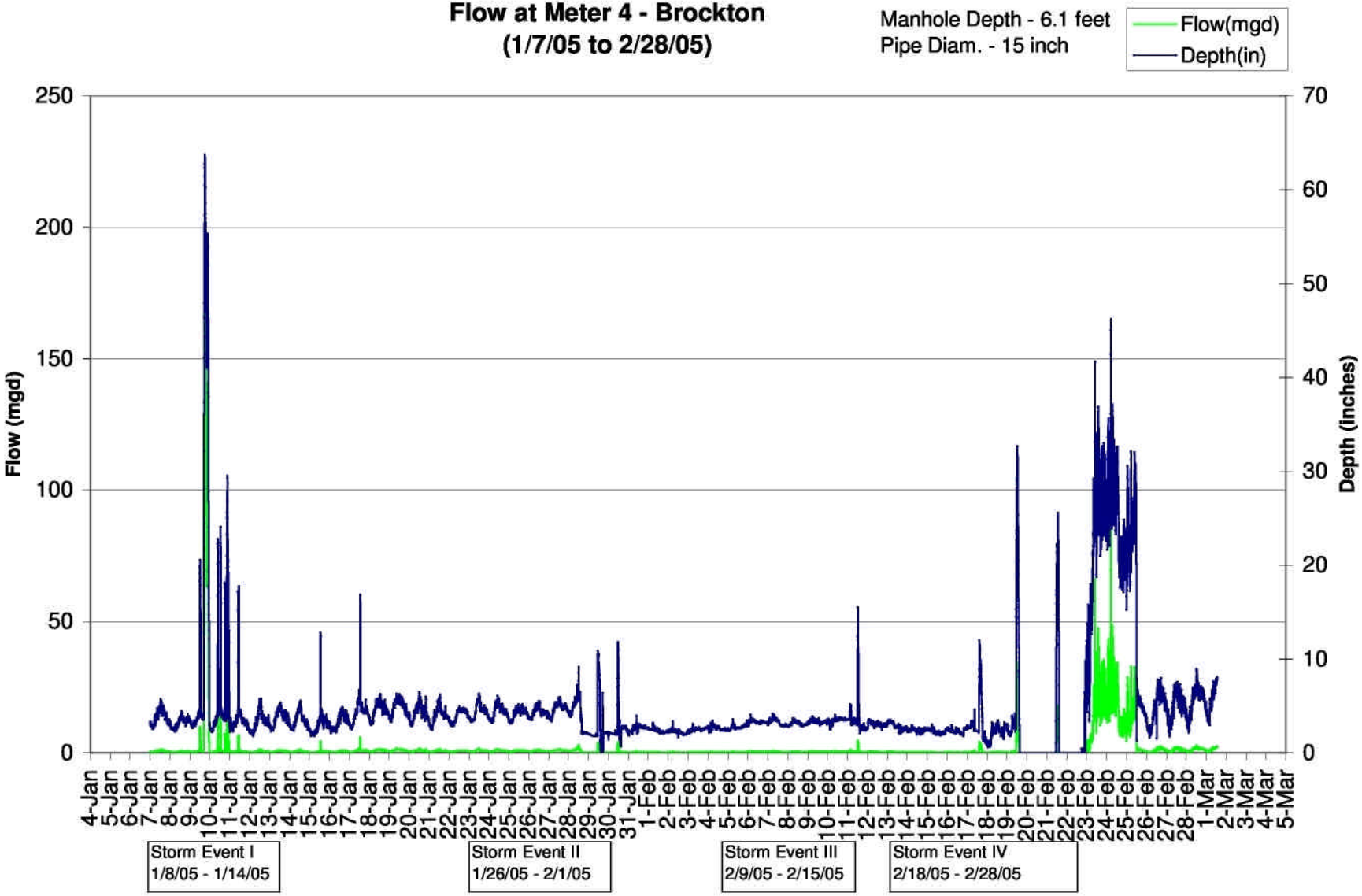
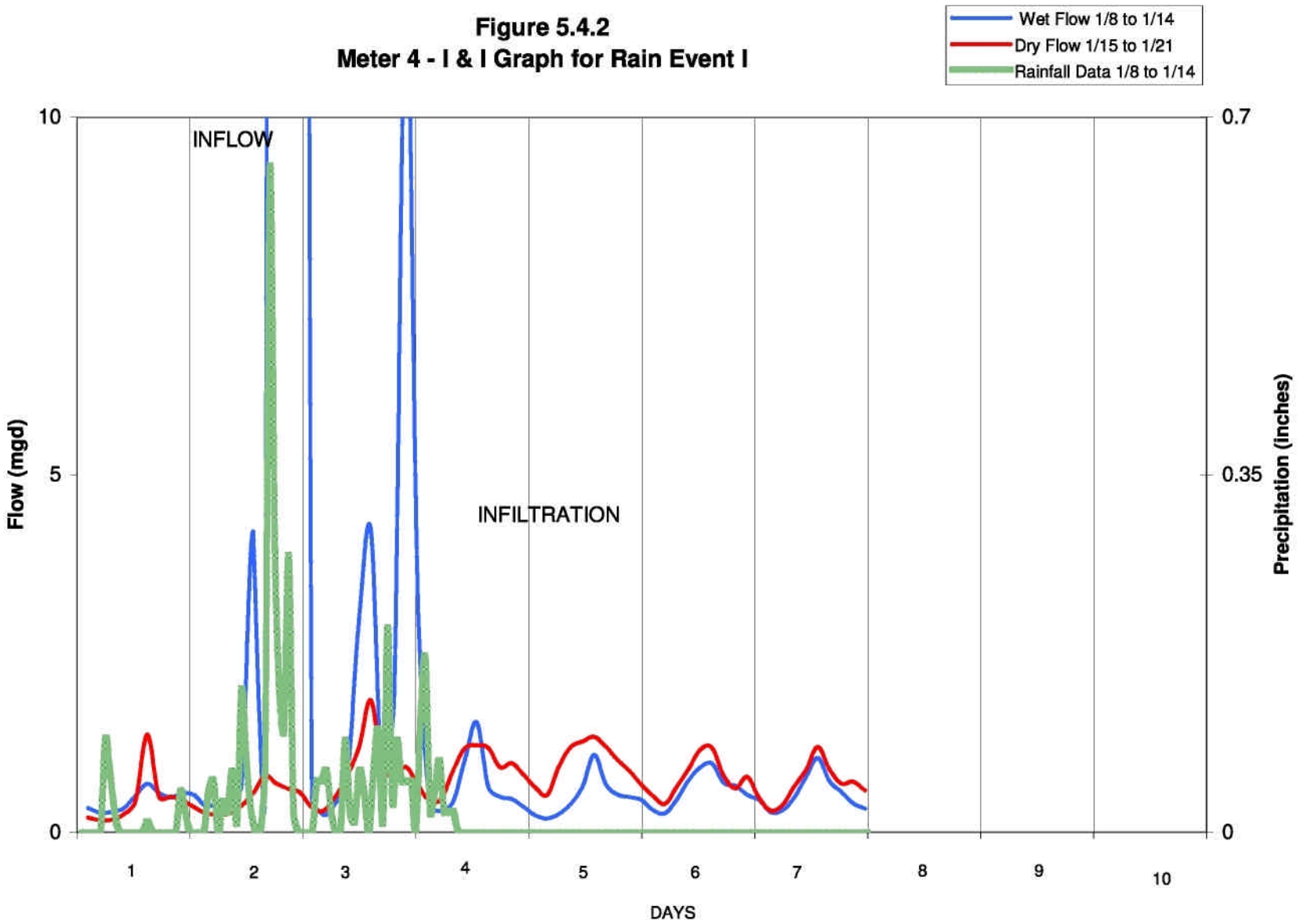


Figure 5.4.2
Meter 4 - I & I Graph for Rain Event I



Storm Event I Jan, 05
Note: A 10 day period was chosen for this storm event, starting and ending on different days.

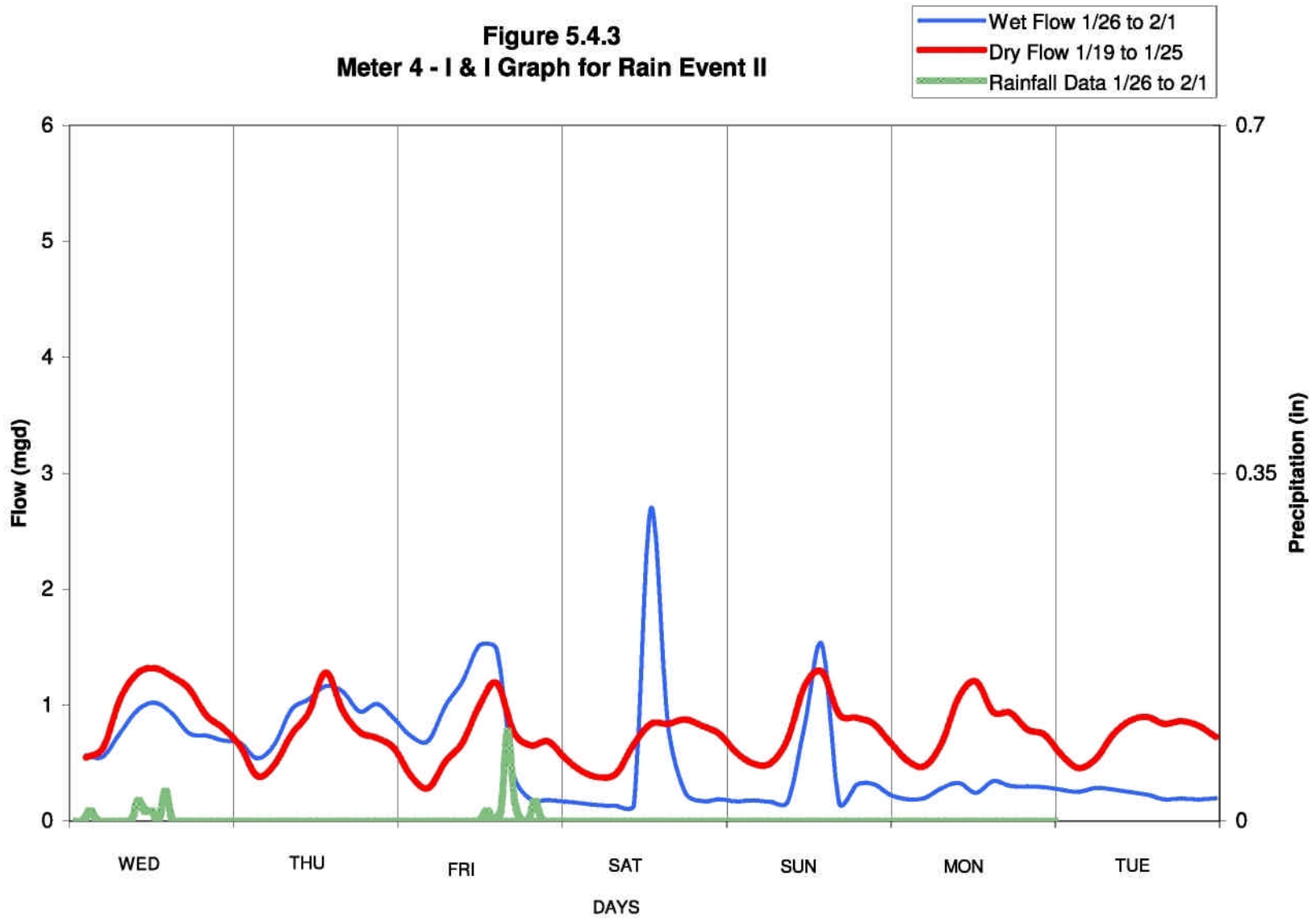


Figure 5.4.3
Meter 4 - I & I Graph for Rain Event II
Wet Flow 1/26 to 2/1
Dry Flow 1/19 to 1/25
Rainfall Data 1/26 to 2/1
Flow (mgd)
Precipitation (in)
6
5
4
3
2
1
0
0.7
0.35
0
WED
THU
FRI
SAT
SUN
MON
TUE
DAYS

Station 5

TEQUESQUITE

Figure 5.5.1
Flow Chart at Meter 5 - Tequesquite
(1/7/05 to 2/28/05)

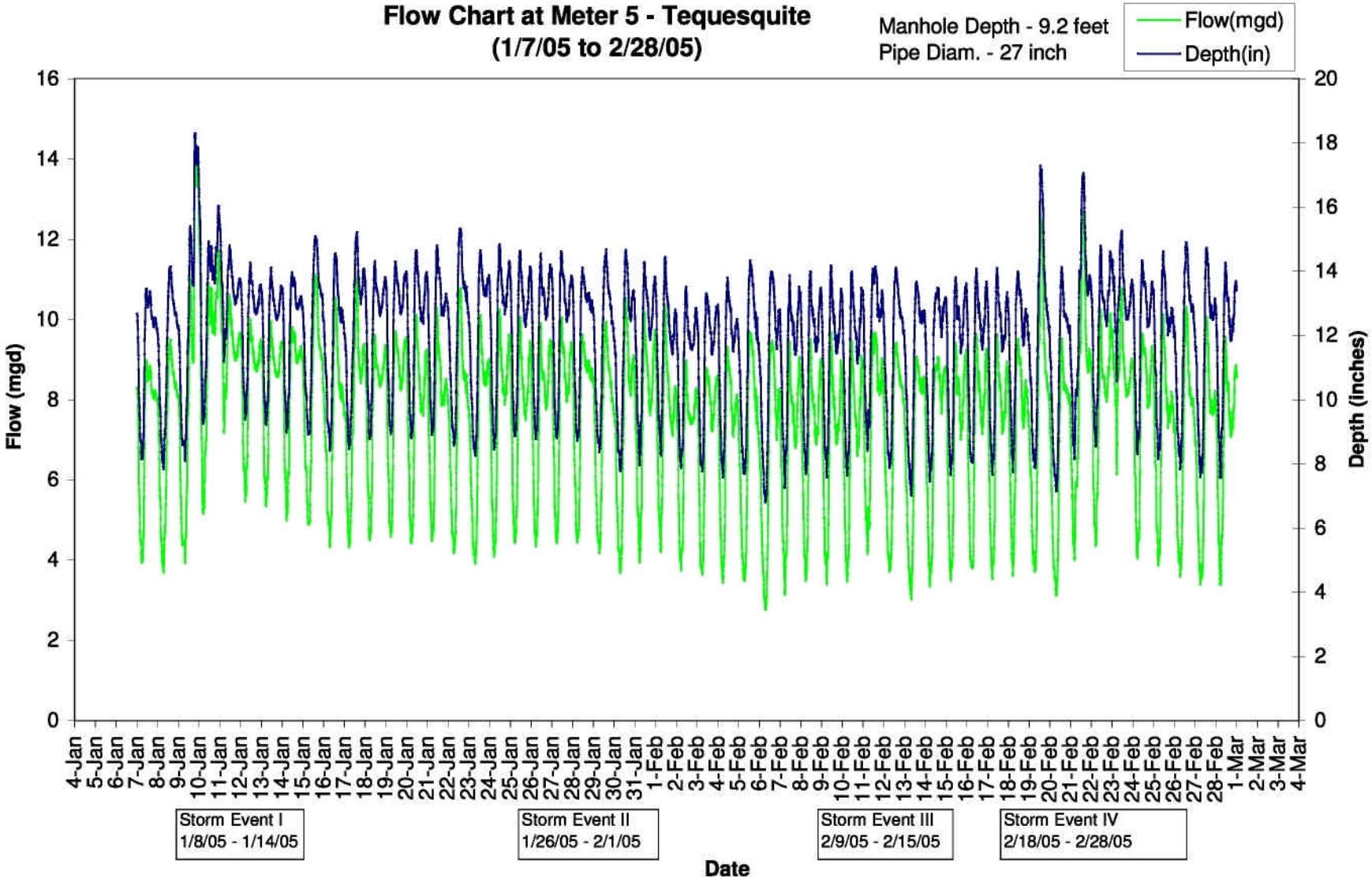


Figure 5.5.2
Meter 5 - I & I Graph for Rain event I

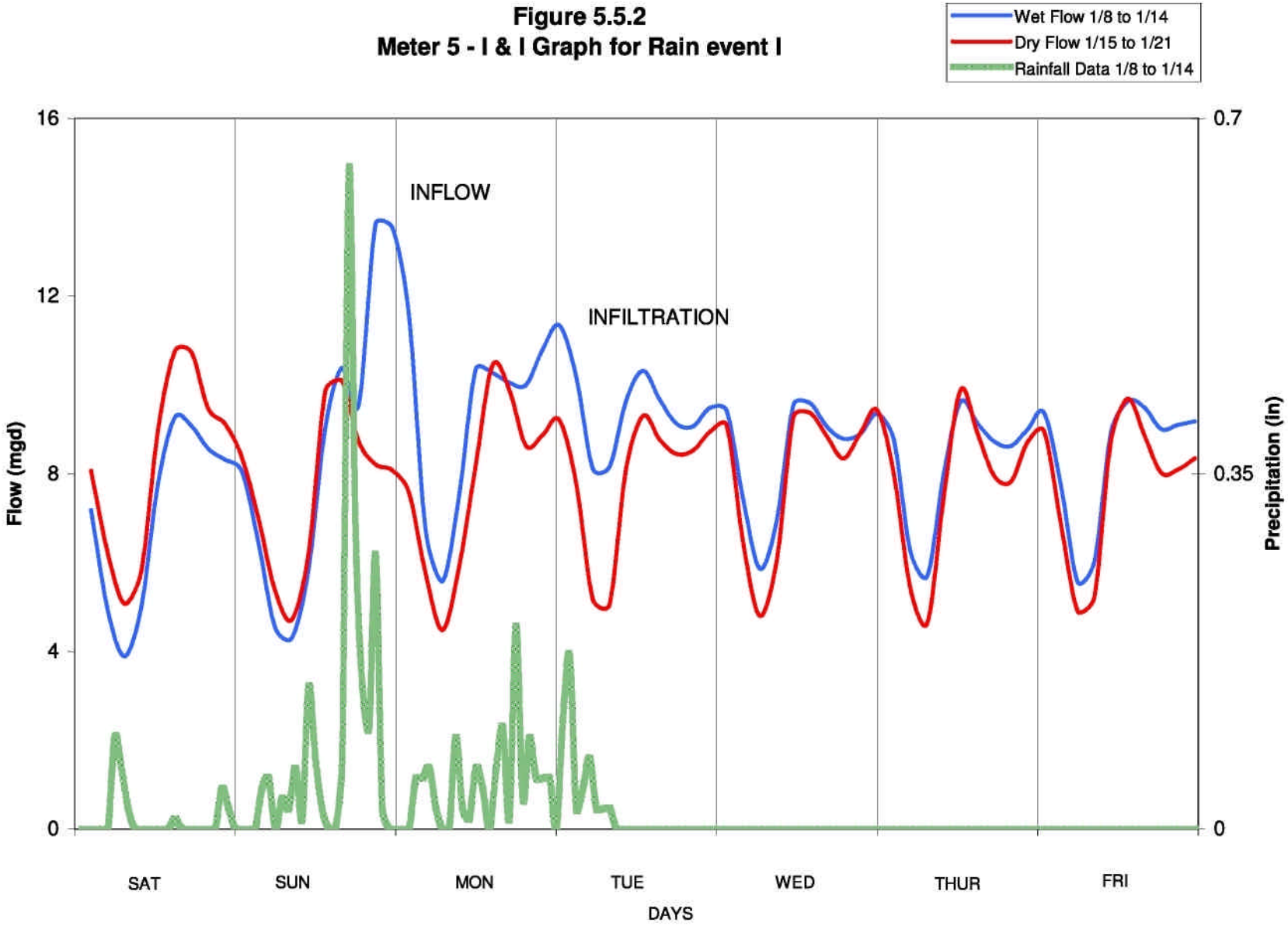
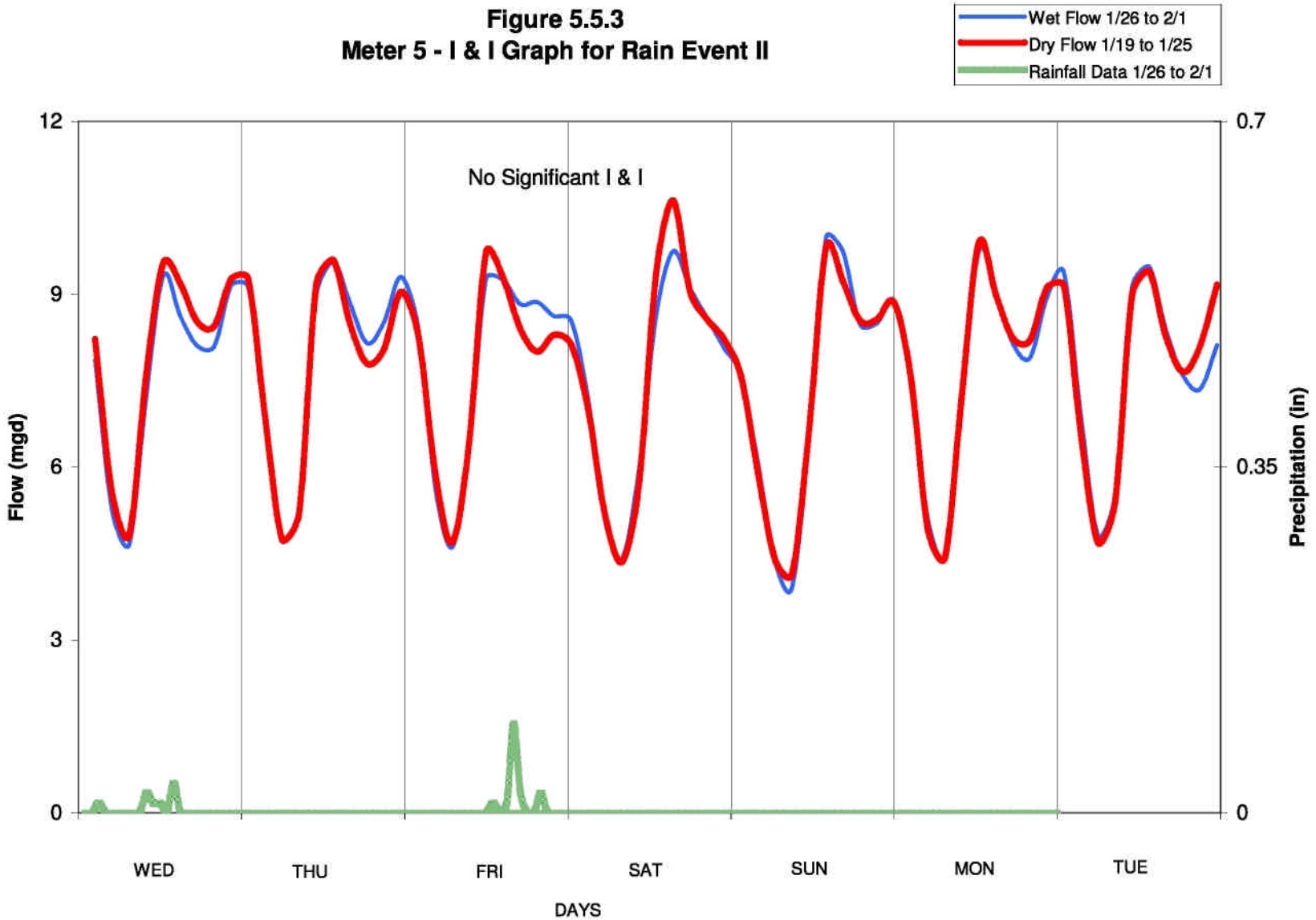


Figure 5.5.3
Meter 5 - I & I Graph for Rain Event II



Storm Event II Jan 05

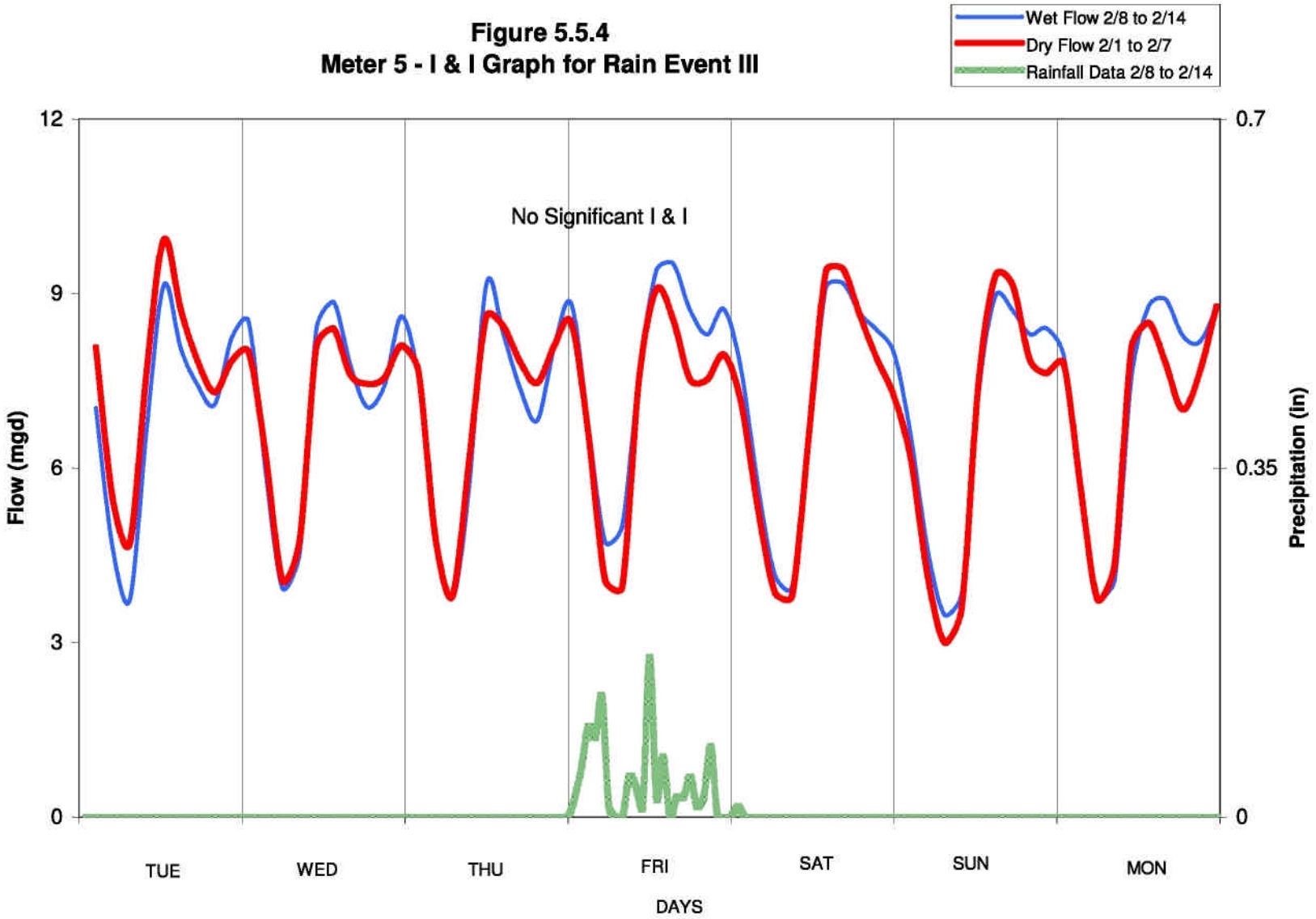


Figure 5.5.4
Meter 5 - I & I Graph for Rain Event III
Wet Flow 2/8 to 2/14
Dry Flow 2/1 to 2/7
Rainfall Data 2/8 to 2/14
No Significant I & I
Flow (mgd)
Precipitation (in)
12
9
6
3
0
0.7
0.35
0
TUE
WED
THU
FRI
SAT
SUN
MON
DAYS

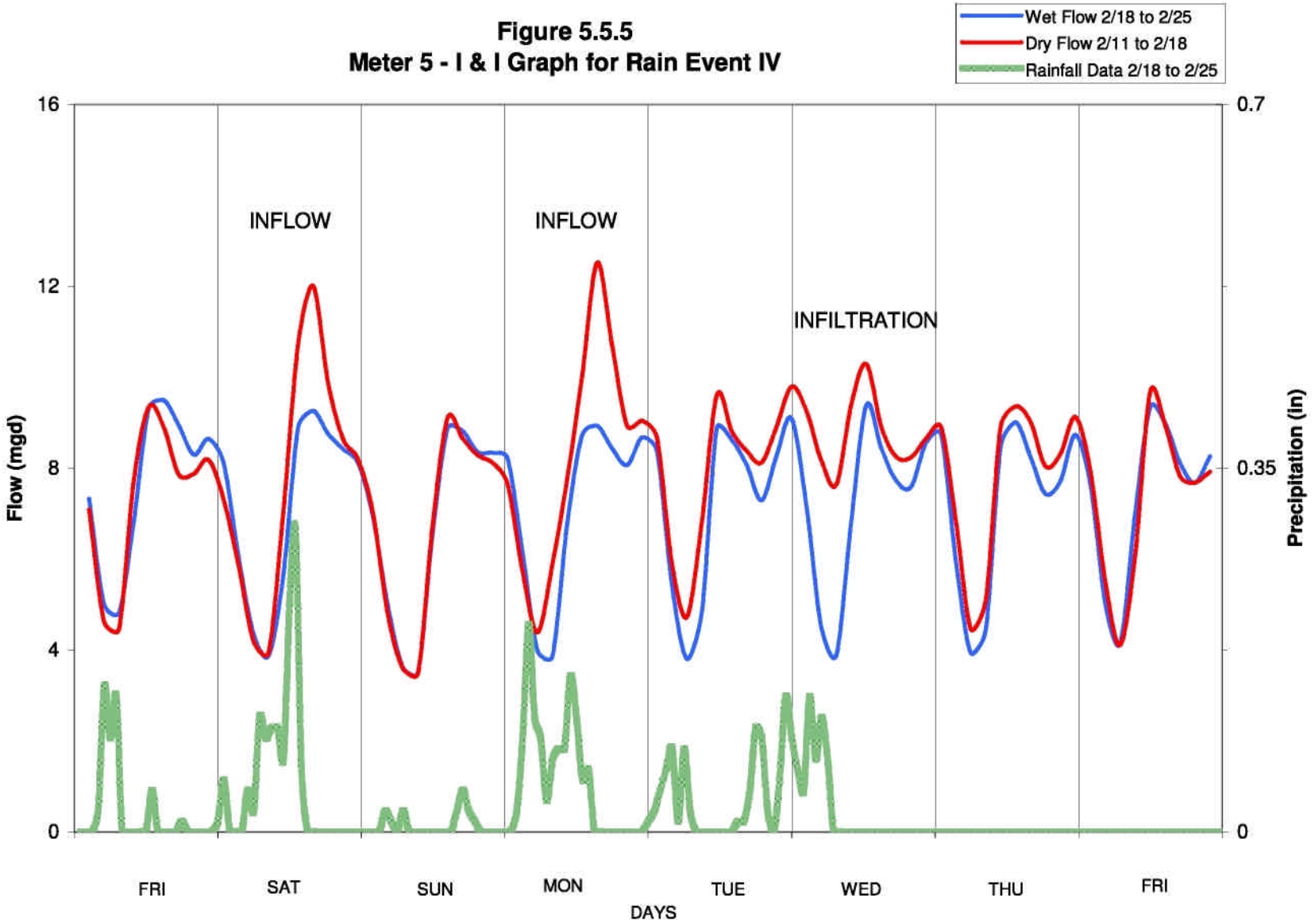
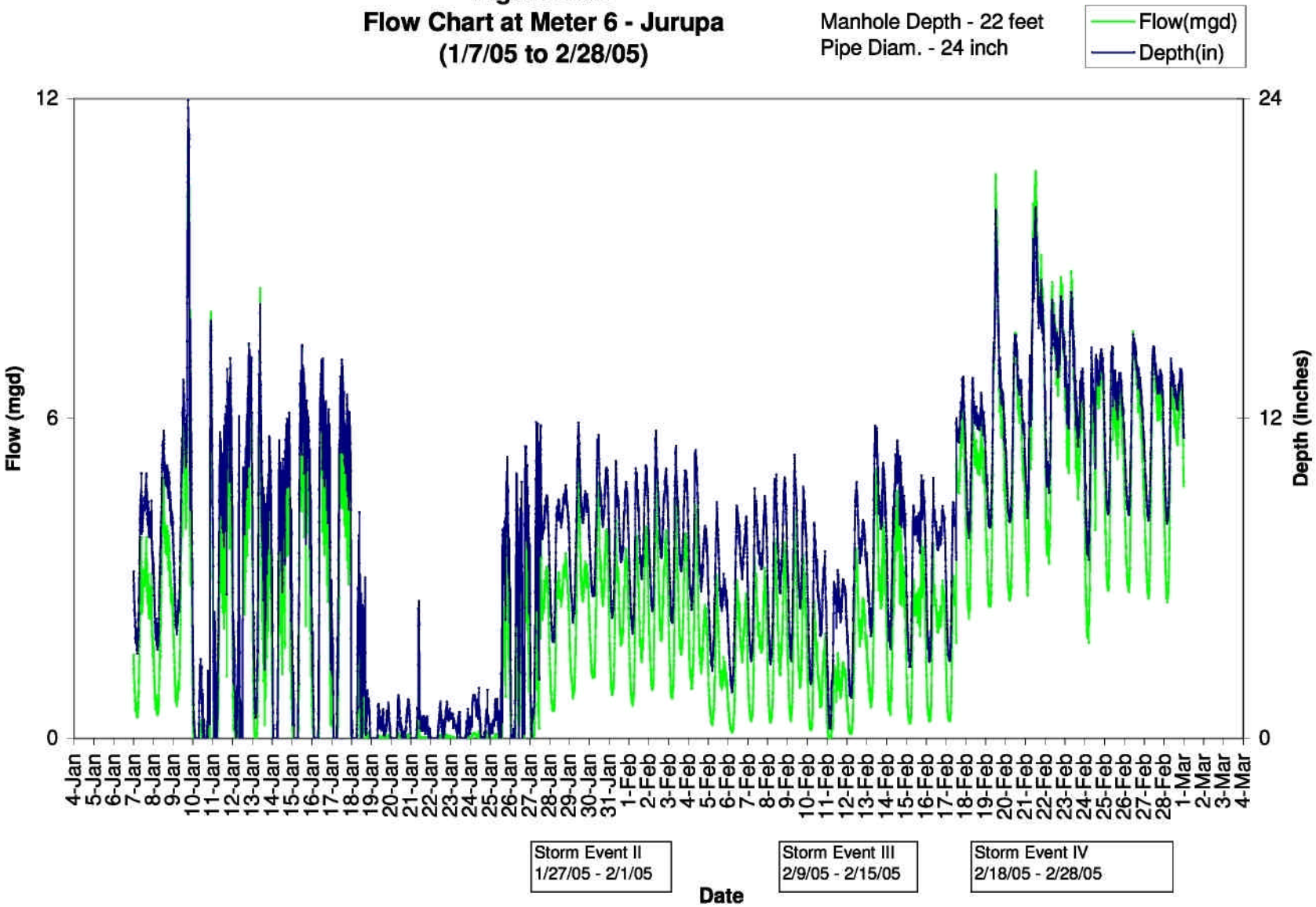


Figure 5.5.5
Meter 5 - I & I Graph for Rain Event IV
Wet Flow 2/18 to 2/25
Dry Flow 2/11 to 2/18
Rainfall Data 2/18 to 2/25
INFLOW
INFLOW
INFILTRATION
Flow (mgd)
Precipitation (in)
16
12
8
4
0
0.7
0.35
0
FRI
SAT
SUN
MON
TUE
WED
THU
FRI
DAYS

Station 6

JURUPA

Figure 5.6.1
Flow Chart at Meter 6 - Jurupa
(1/7/05 to 2/28/05)



Station 7

ARLINGTON

Figure 5.7.1
Flow Chart at Meter 7 - Arlington
(1/7/05 to 2/28/05)

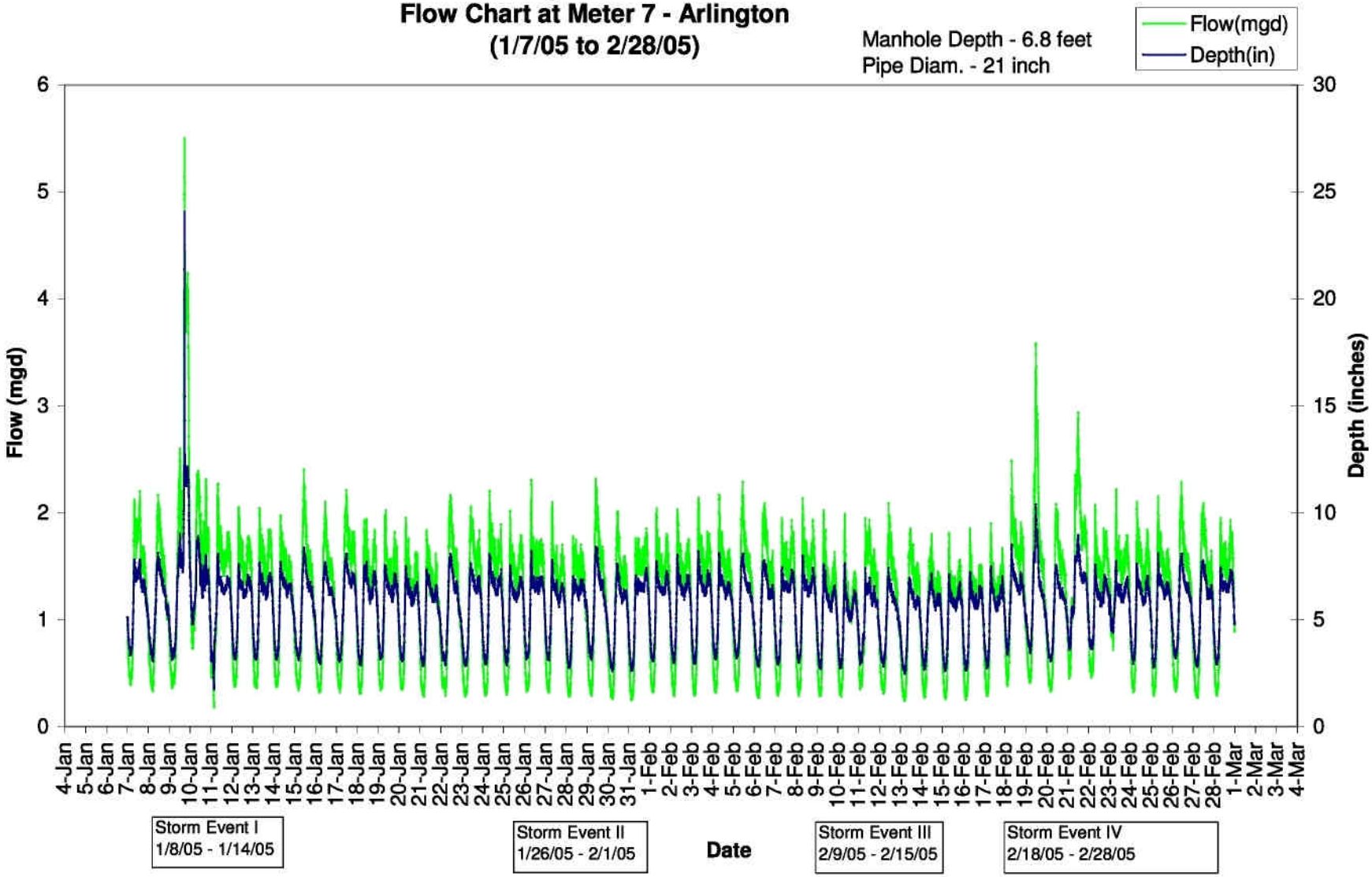
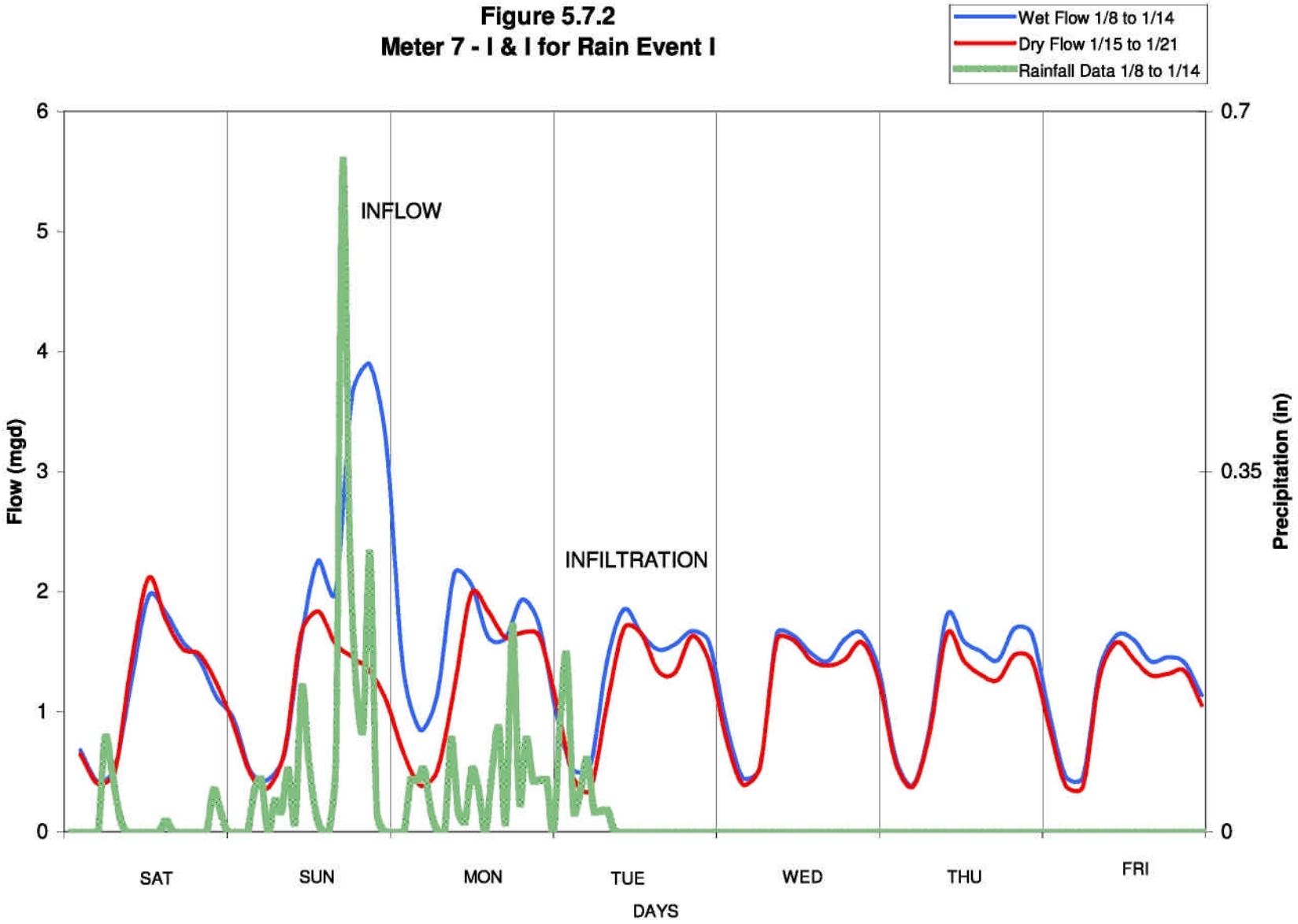


Figure 5.7.2
Meter 7 - I & I for Rain Event I



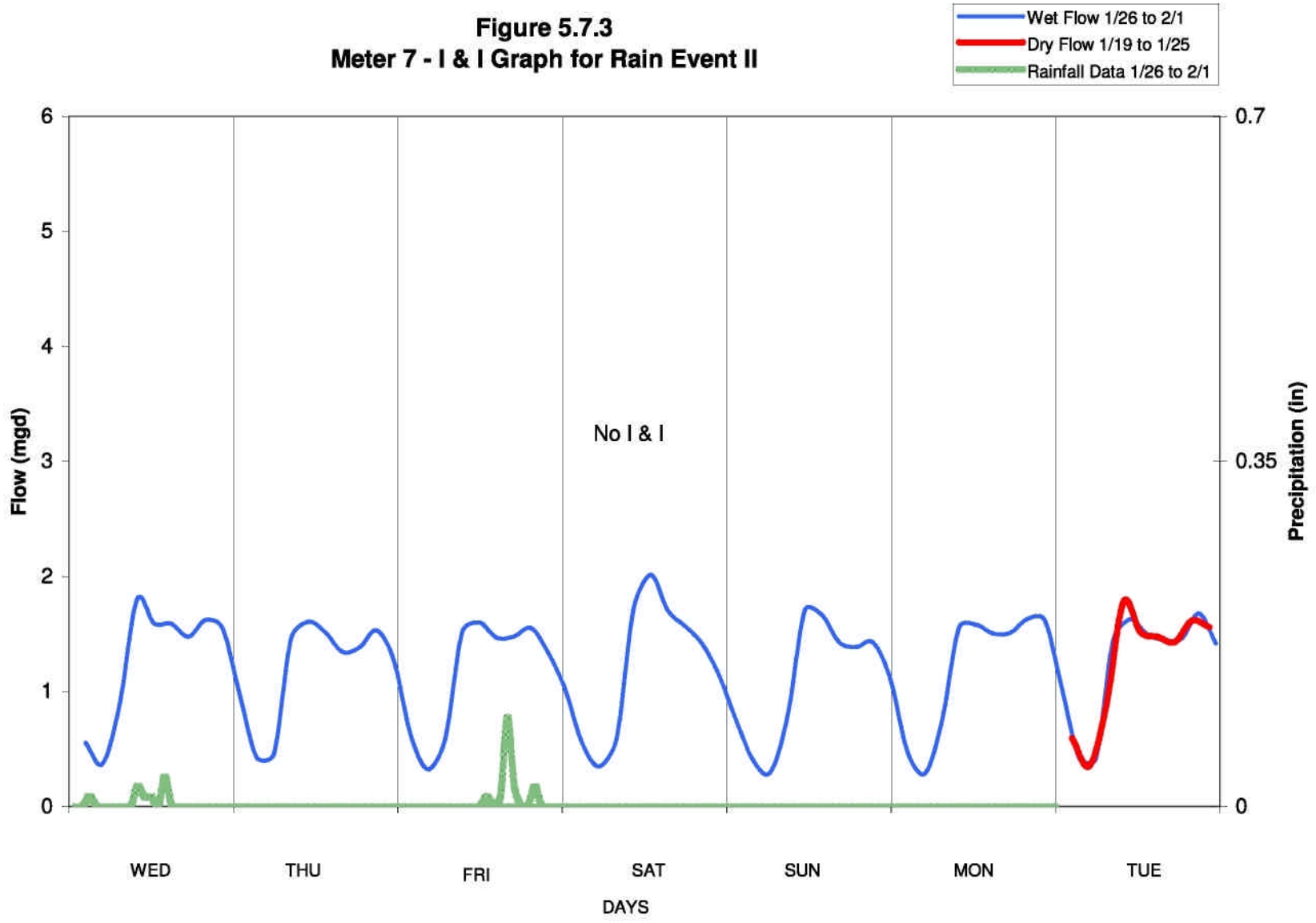


Figure 5.7.3
Meter 7 - I & I Graph for Rain Event II
Wet Flow 1/26 to 2/1
Dry Flow 1/19 to 1/25
Rainfall Data 1/26 to 2/1
Flow (mgd)
Precipitation (in)
6
5
4
3
2
1
0
0.7
0.35
0
No I & I
WED
THU
FRI
SAT
SUN
MON
TUE
DAYS

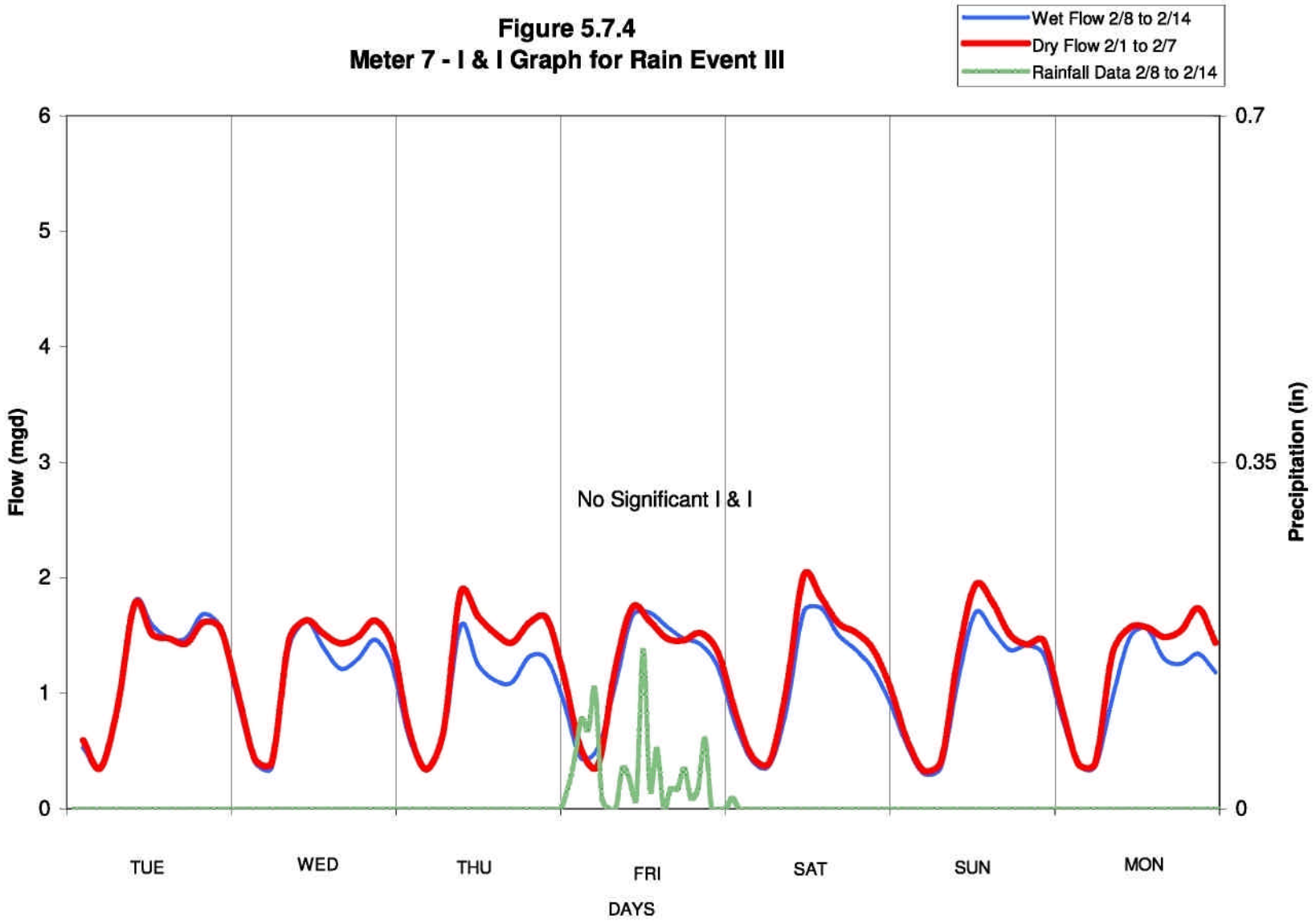
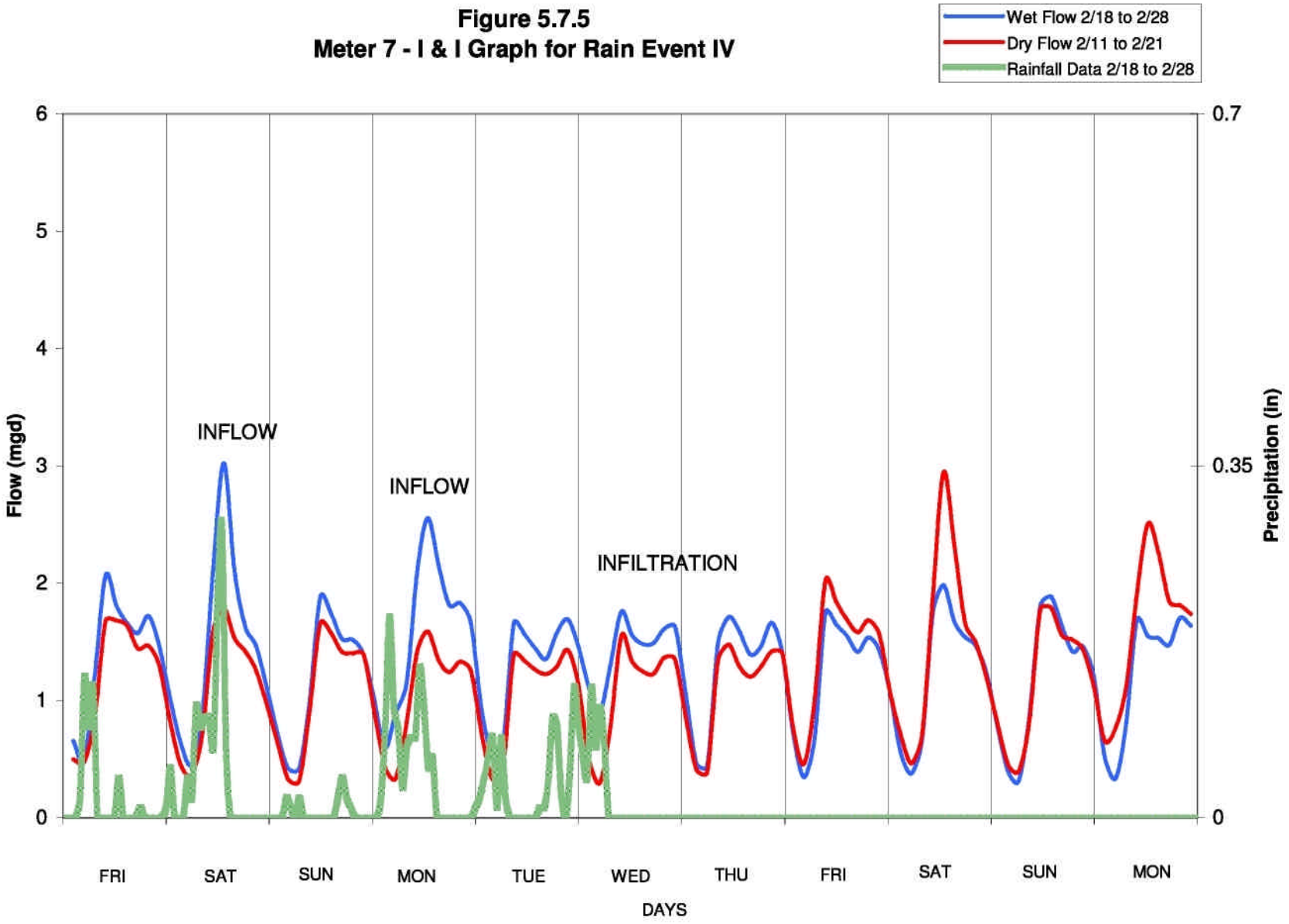


Figure 5.7.4
Meter 7 - I & I Graph for Rain Event III
Wet Flow 2/8 to 2/14
Dry Flow 2/1 to 2/7
Rainfall Data 2/8 to 2/14
Flow (mgd)
Precipitation (in)
6
5
4
3
2
1
0
0.7
0.35
0
No Significant I & I
TUE
WED
THU
FRI
SAT
SUN
MON
DAYS

Figure 5.7.5
Meter 7 - I & I Graph for Rain Event IV



Station 8

RWQCP

Figure 5.8.1
Flow Chart at Meter 8 - Treatment Plant
(1/7/05 to 2/28/05)

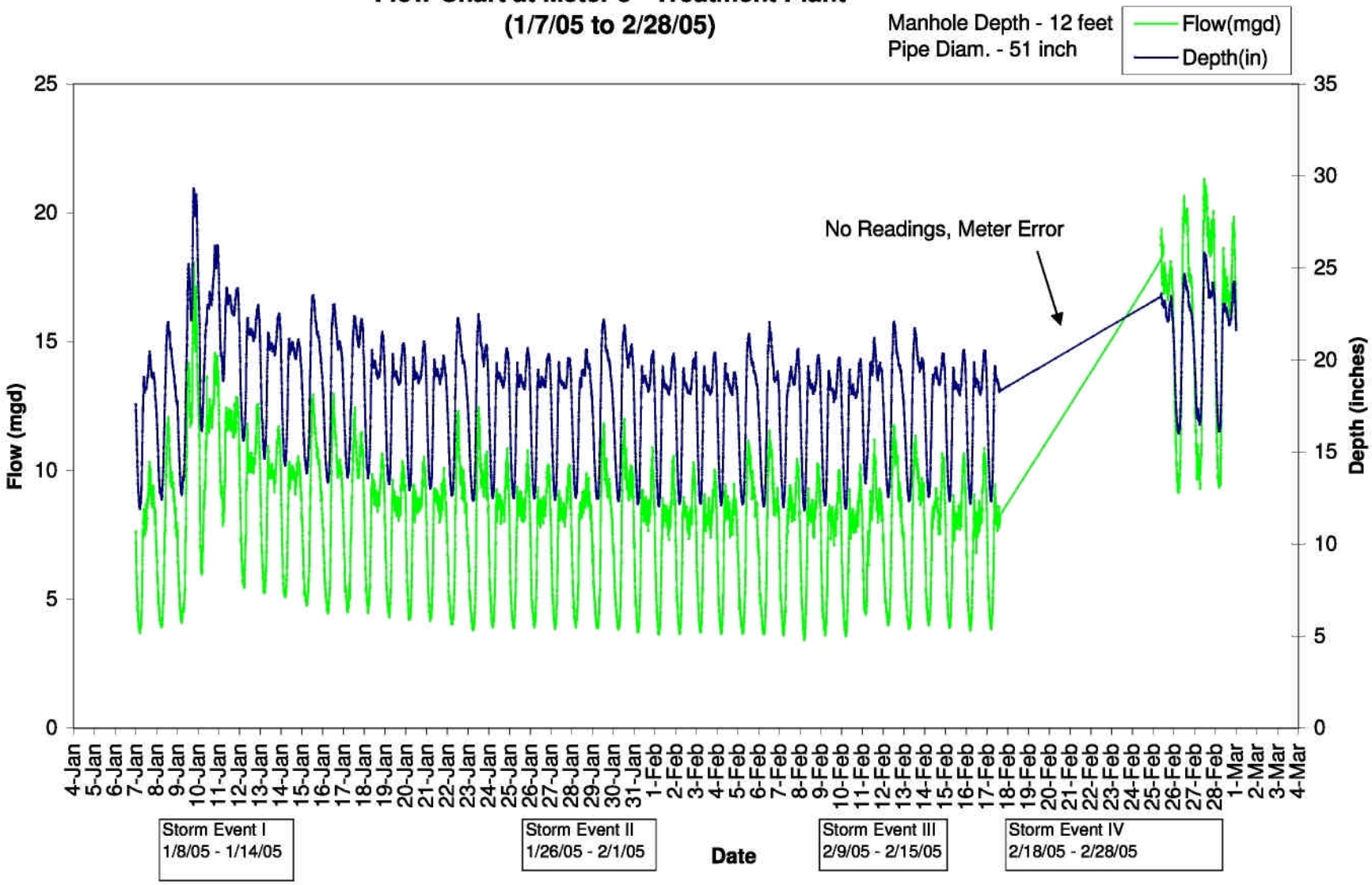
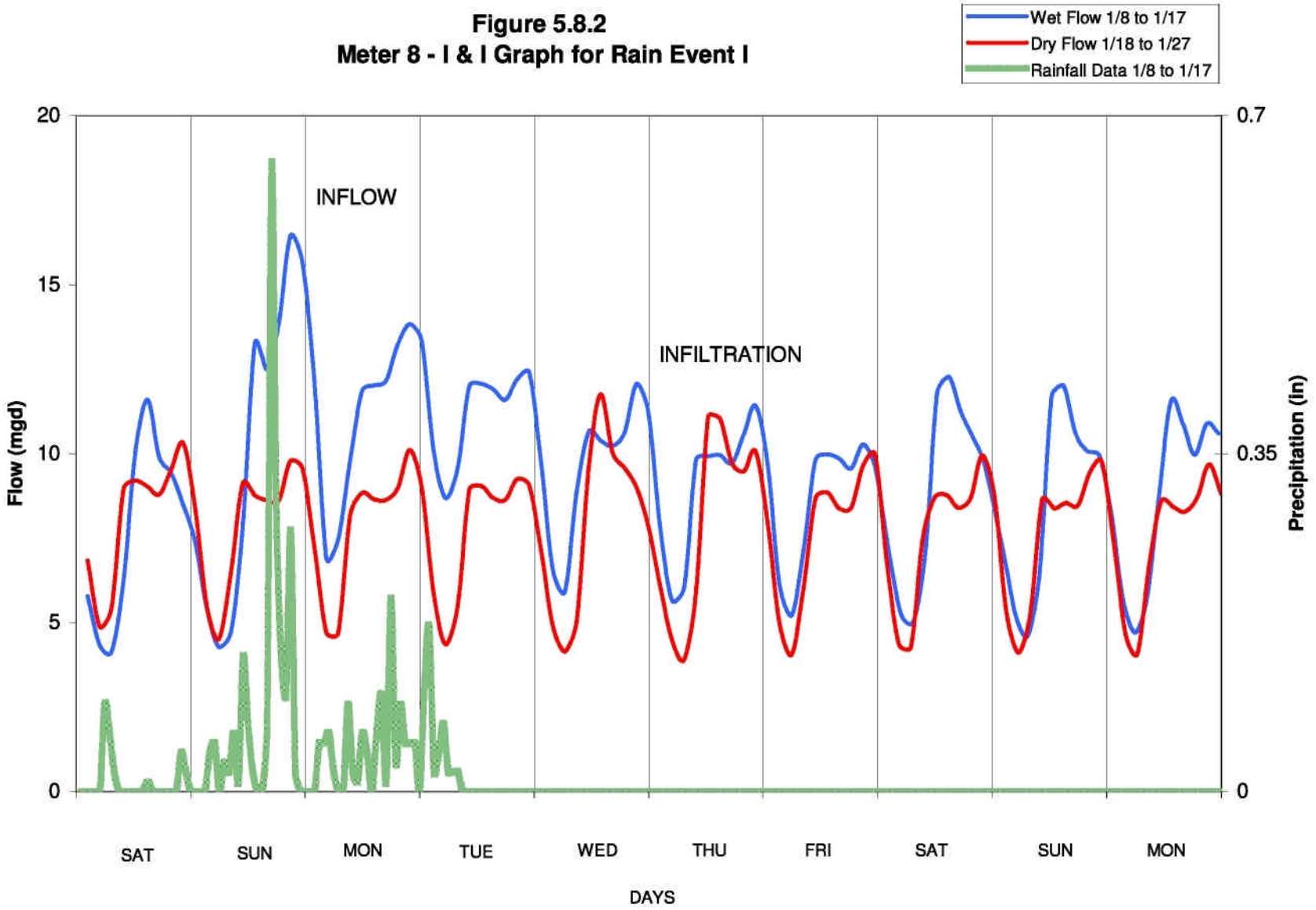


Figure 5.8.2
Meter 8 - I & I Graph for Rain Event I



Storm Event I Jan 05

Figure 5.8.3
Meter 8 - I & I Graph for Rain Event II

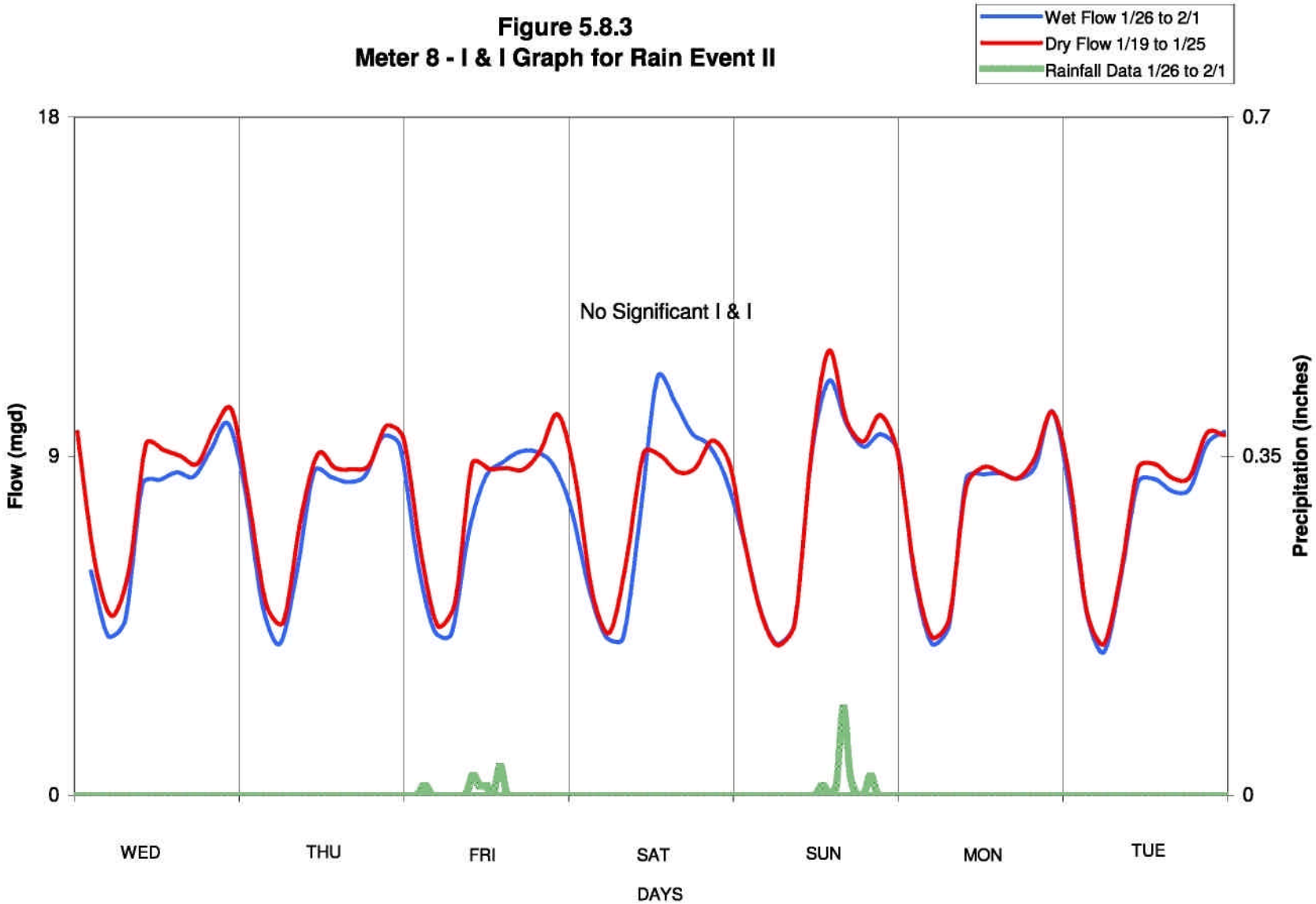
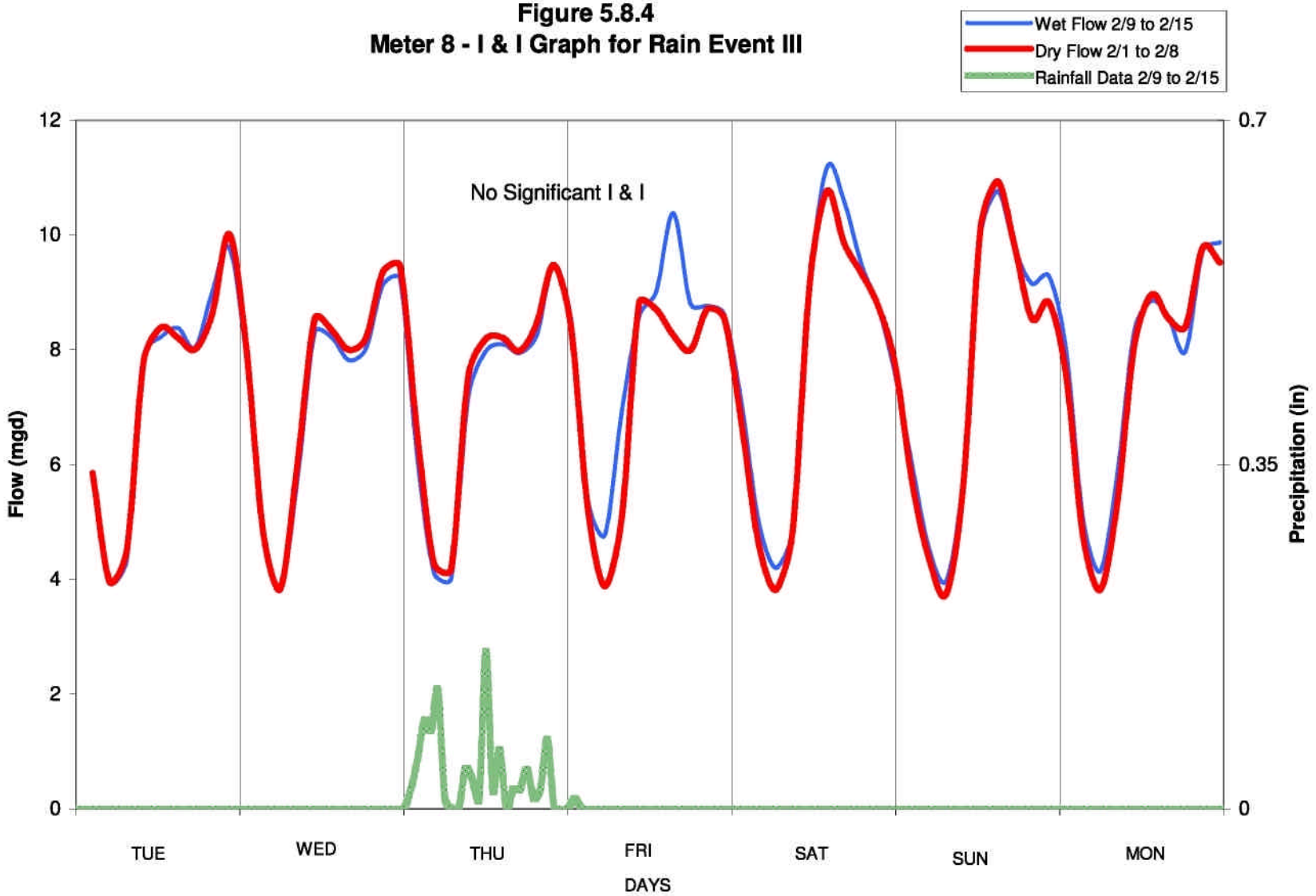


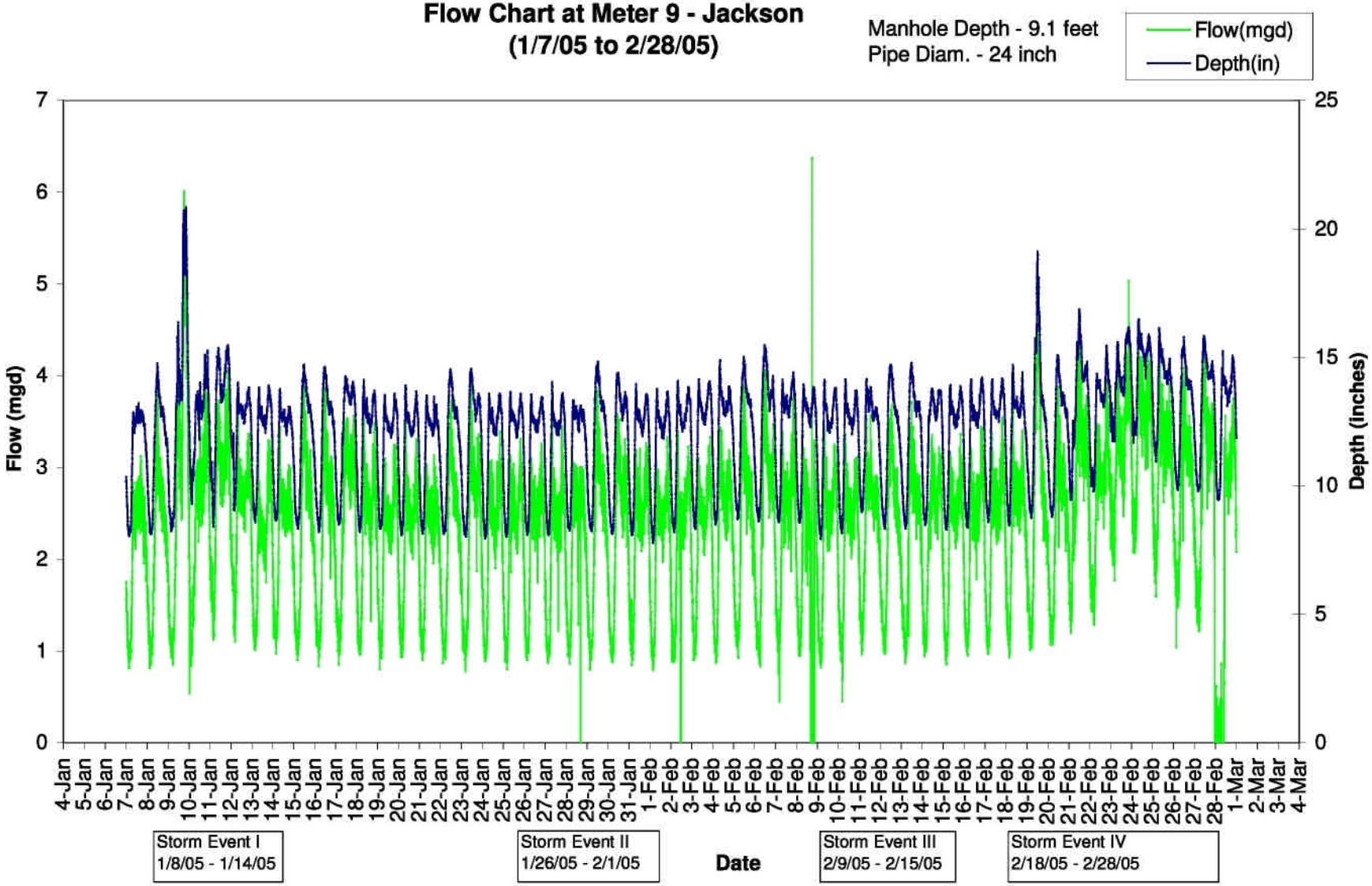
Figure 5.8.4
Meter 8 - I & I Graph for Rain Event III



Station 9

JACKSON

Figure 5.9.1
Flow Chart at Meter 9 - Jackson
(1/7/05 to 2/28/05)



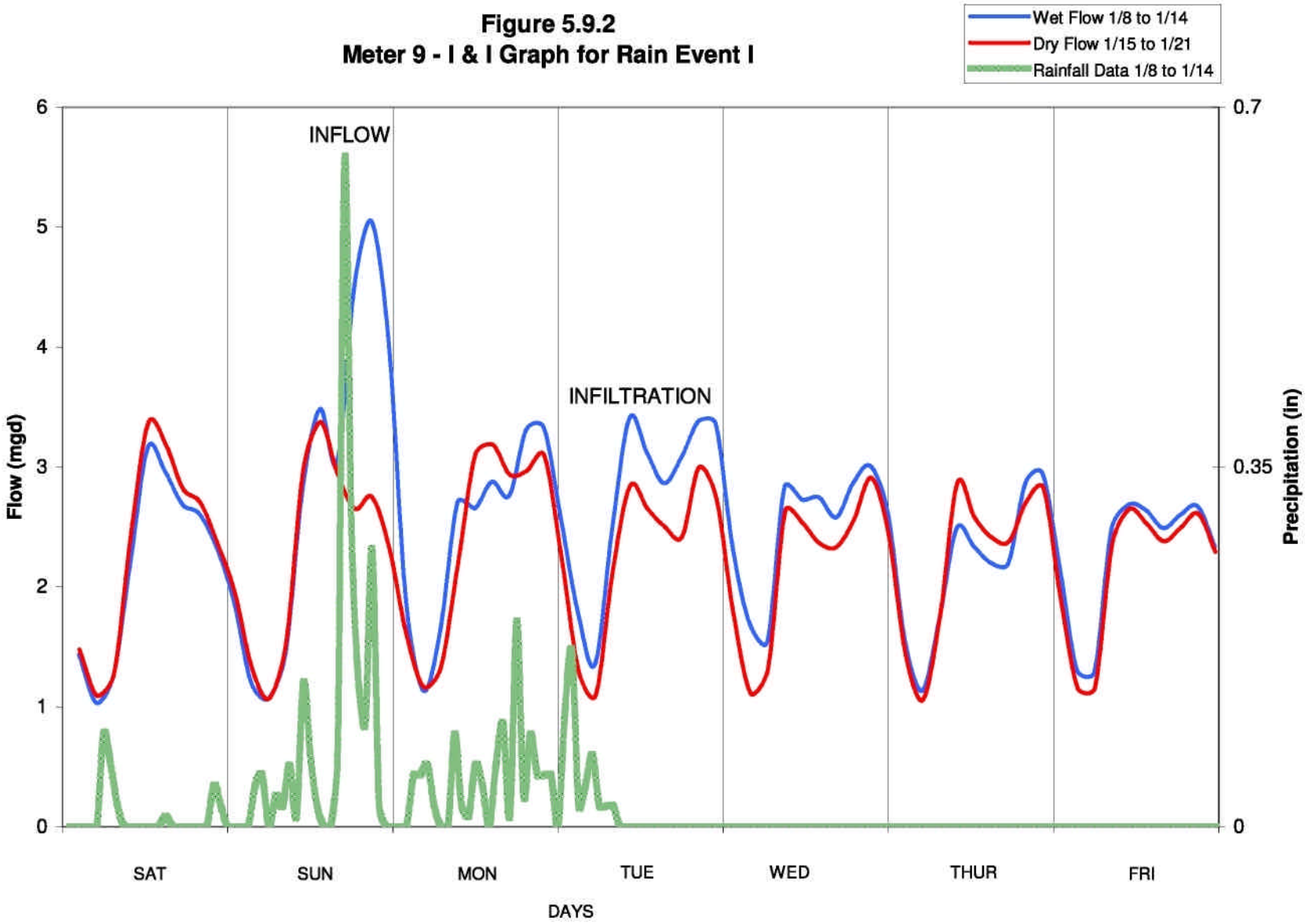


Figure 5.9.2
Meter 9 - I & I Graph for Rain Event I
Wet Flow 1/8 to 1/14
Dry Flow 1/15 to 1/21
Rainfall Data 1/8 to 1/14
INFLOW
INFILTRATION
Flow (mgd)
Precipitation (in)
6
5
4
3
2
1
0
0.7
0.35
0
SAT
SUN
MON
TUE
WED
THUR
FRI
DAYS

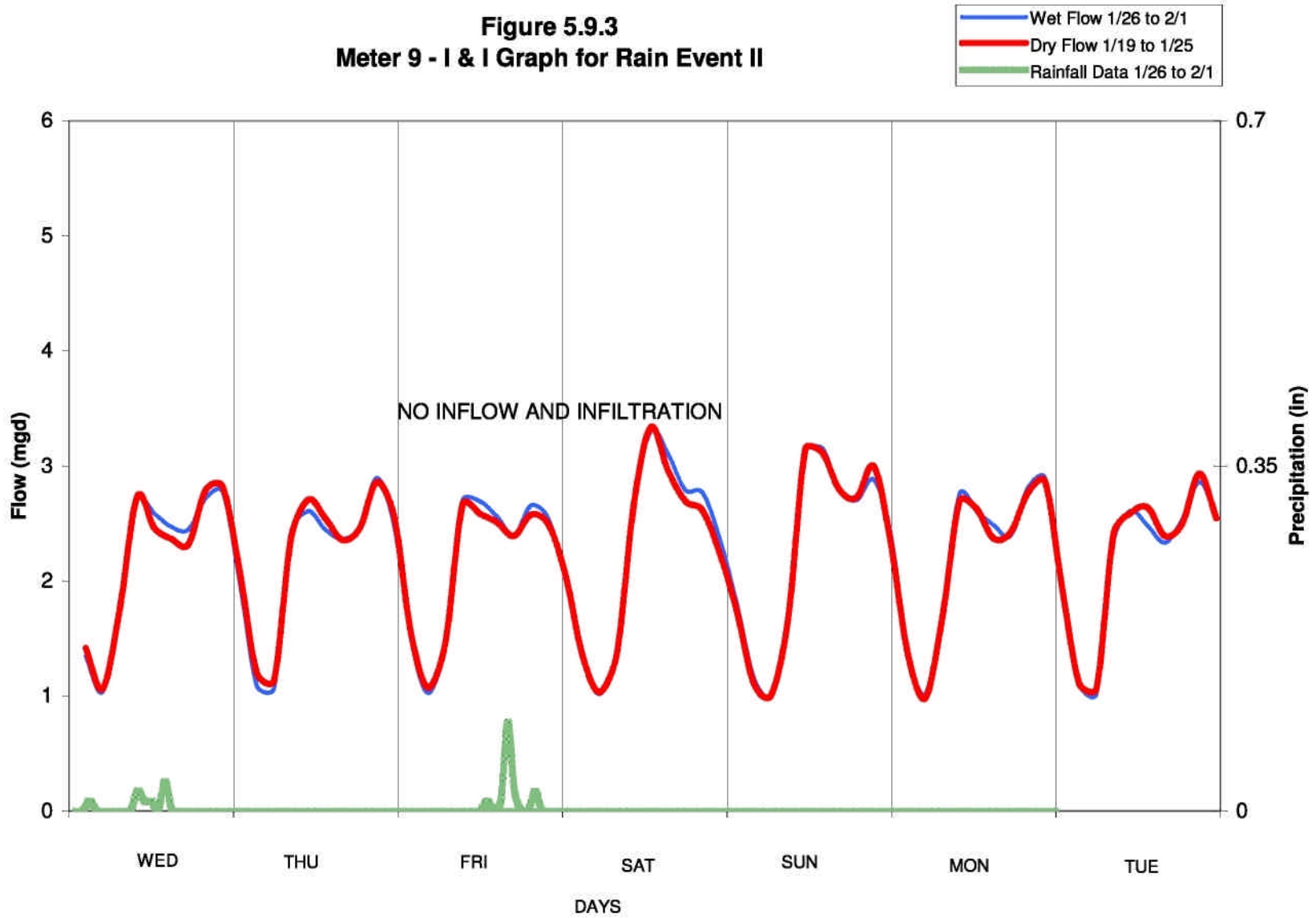


Figure 5.9.3
Meter 9 - I & I Graph for Rain Event II
Wet Flow 1/26 to 2/1
Dry Flow 1/19 to 1/25
Rainfall Data 1/26 to 2/1
NO INFLOW AND INFILTRATION
Flow (mgd)
Precipitation (in)
6
5
4
3
2
1
0
0.7
0.35
0
WED
THU
FRI
SAT
SUN
MON
TUE
DAYS

Figure 5.9.4
Meter 9 - I & I Graph for Rain Event III

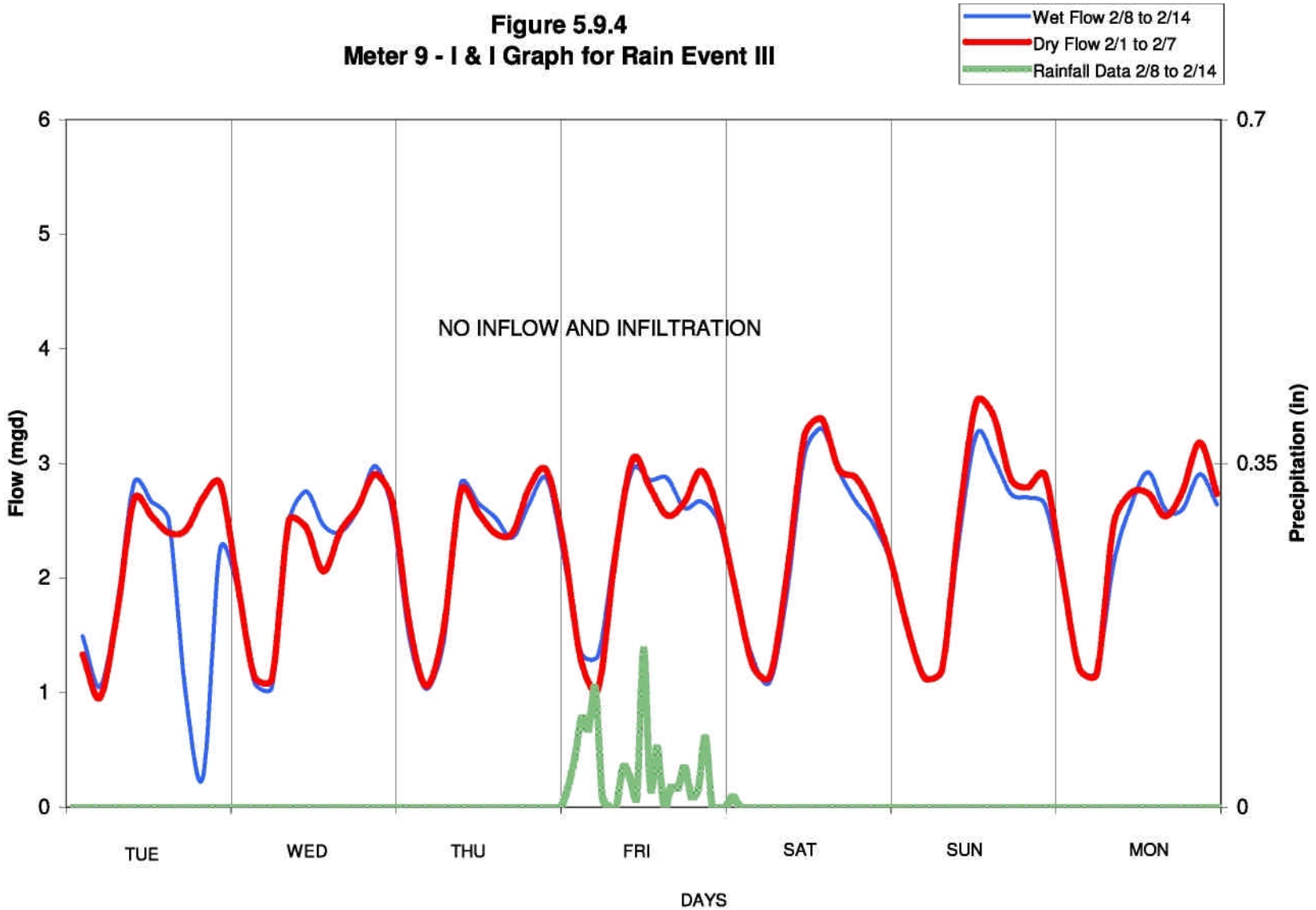
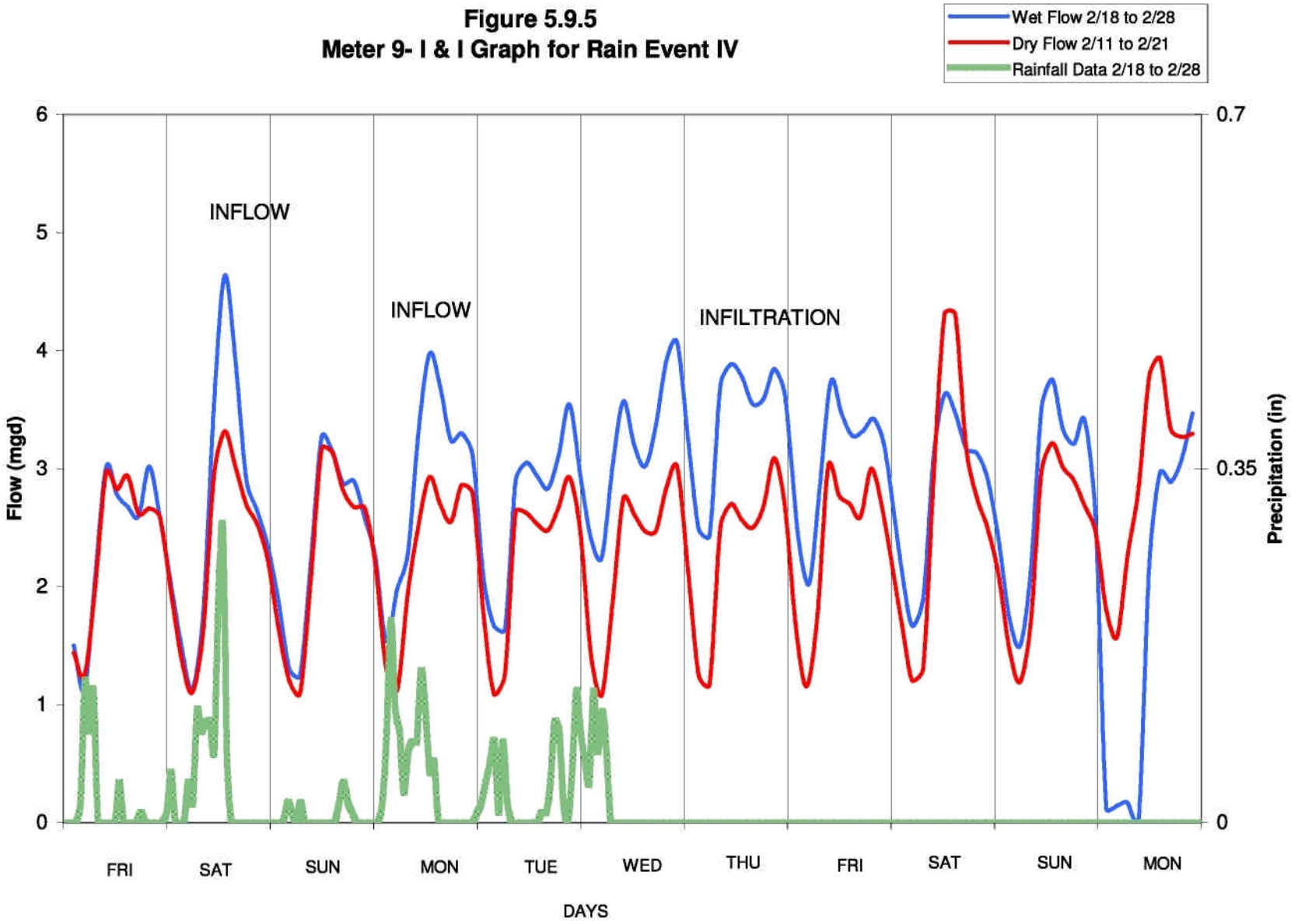


Figure 5.9.5
Meter 9- I & I Graph for Rain Event IV



Appendix A

Flow Data from Downstream Services Inc.

Appendix B

Rainfall Data from CMIS Web Site

Appendix G
COLLECTION SYSTEM COSTS

Table G-1 CSMP Project Costs
Wastewater Collection and Treatment Facilities Integrated Master Plan
City of Riverside

Project Study Area	Priority	Location[1]	Total Project Cost (Million Dollars)[2]	Annual CIP Costs (Million Dollars)[3][4]									
				2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Arlanza	A	Collett Avenue	$0.38	$0.04	$0.04	$0.04	$0.05	$0.05	$0.05	$0.05	$0.05	$0.06	$0.06
		Fillmore Street	$0.41	$0.04	$0.04	$0.05	$0.05	$0.05	$0.05	$0.06	$0.06	$0.06	$0.06
		Golden Avenue	$0.26	$0.03	$0.03	$0.03	$0.03	$0.03	$0.03	$0.04	$0.04	$0.04	$0.04
		RWQCP Sewer	$0.33	$0.03	$0.03	$0.04	$0.04	$0.04	$0.04	$0.04	$0.05	$0.05	$0.05
	B	Monticello Avenue	$1.59	$0.16	$0.17	$0.18	$0.19	$0.20	$0.21	$0.22	$0.23	$0.24	$0.24
	C	Acorn Street	$1.44	$0.14	$0.15	$0.16	$0.17	$0.18	$0.19	$0.20	$0.20	$0.21	$0.22
		Arizona Avenue	$0.69	$0.07	$0.07	$0.08	$0.08	$0.09	$0.09	$0.09	$0.10	$0.10	$0.11
		Collett Avenue	$0.90	$0.09	$0.09	$0.10	$0.11	$0.11	$0.12	$0.12	$0.13	$0.13	$0.14
		Fillmore Street	$0.62	$0.06	$0.07	$0.07	$0.07	$0.08	$0.08	$0.08	$0.09	$0.09	$0.10
		Golden Avenue	$0.73	$0.07	$0.08	$0.08	$0.09	$0.09	$0.10	$0.10	$0.10	$0.11	$0.11
		Harrison Street	$0.43	$0.04	$0.05	$0.05	$0.05	$0.05	$0.06	$0.06	$0.06	$0.06	$0.07
		Jackson Street	$1.78	$0.18	$0.19	$0.20	$0.21	$0.22	$0.23	$0.24	$0.25	$0.26	$0.27
		Jones Avenue	$1.07	$0.11	$0.11	$0.12	$0.13	$0.14	$0.14	$0.15	$0.15	$0.16	$0.16
		La Sierra Channel	$1.80	$0.18	$0.19	$0.20	$0.21	$0.23	$0.24	$0.25	$0.26	$0.27	$0.28
		Magnolia Avenue	$0.55	$0.06	$0.06	$0.06	$0.07	$0.07	$0.07	$0.08	$0.08	$0.08	$0.09
		Monroe Street	$0.51	$0.05	$0.05	$0.06	$0.06	$0.06	$0.07	$0.07	$0.07	$0.08	$0.08
		RWQCP Sewer	$0.64	$0.06	$0.07	$0.07	$0.08	$0.08	$0.08	$0.09	$0.09	$0.09	$0.10
		Van Buren Boulevard	$6.83	$0.68	$0.72	$0.77	$0.81	$0.86	$0.90	$0.93	$0.97	$1.01	$1.05

Table G-1 CSMP Project Costs
Wastewater Collection and Treatment Facilities Integrated Master Plan
City of Riverside

Project Study Area	Priority	Location[1]	Total Project Cost (Million Dollars)[2]	Annual CIP Costs (Million Dollars)[3][4]									
				2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Northside	B	Marlborough Avenue	$0.12	$0.01	$0.01	$0.01	$0.01	$0.02	$0.02	$0.02	$0.02	$0.02	$0.02
	C	Fairmount Boulevard	$0.57	$0.06	$0.06	$0.06	$0.07	$0.07	$0.08	$0.08	$0.08	$0.08	$0.09
		Fairmount Trunk	$2.43	$0.24	$0.26	$0.27	$0.29	$0.31	$0.32	$0.33	$0.34	$0.36	$0.37
		Marlborough Avenue	$0.26	$0.03	$0.03	$0.03	$0.03	$0.03	$0.03	$0.04	$0.04	$0.04	$0.04
		Strong Street	$0.49	$0.05	$0.05	$0.06	$0.06	$0.06	$0.06	$0.07	$0.07	$0.07	$0.08
Phoenix	A	Central Avenue	$0.54	$0.05	$0.06	$0.06	$0.06	$0.07	$0.07	$0.07	$0.08	$0.08	$0.08
		Hillside Avenue	$2.57	$0.26	$0.27	$0.29	$0.31	$0.32	$0.34	$0.35	$0.36	$0.38	$0.39
		Phoenix Avenue	$0.13	$0.01	$0.01	$0.01	$0.02	$0.02	$0.02	$0.02	$0.02	$0.02	$0.02
		Santa Ana River Pipeline	$1.52	$0.15	$0.16	$0.17	$0.18	$0.19	$0.20	$0.21	$0.22	$0.23	$0.23
	B	Madison Street	$0.56	$0.06	$0.06	$0.06	$0.07	$0.07	$0.07	$0.08	$0.08	$0.08	$0.09
	C	Madison Street	$1.32	$0.13	$0.14	$0.15	$0.16	$0.17	$0.17	$0.18	$0.19	$0.19	$0.20
		Phoenix Avenue	$2.03	$0.20	$0.21	$0.23	$0.24	$0.26	$0.27	$0.28	$0.29	$0.30	$0.31
Spruce	B	Chicago Avenue	$1.02	$0.10	$0.11	$0.11	$0.12	$0.13	$0.13	$0.14	$0.14	$0.15	$0.16
	C	Chicago Avenue	$0.44	$0.04	$0.05	$0.05	$0.05	$0.06	$0.06	$0.06	$0.06	$0.07	$0.07
Tequesquite	A	Eastridge Avenue	$0.21	$0.02	$0.02	$0.02	$0.03	$0.03	$0.03	$0.03	$0.03	$0.03	$0.03
	B	Eastridge Avenue	$0.73	$0.07	$0.08	$0.08	$0.09	$0.09	$0.10	$0.10	$0.10	$0.11	$0.11

Table G-1 CSMP Project Costs
Wastewater Collection and Treatment Facilities Integrated Master Plan
City of Riverside

Project Study Area	Priority	Location[1]	Total Project Cost (Million Dollars)[2]	Annual CIP Costs (Million Dollars)[3][4]									
				2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
		Trautwein Road	$0.65	$0.06	$0.07	$0.07	$0.08	$0.08	$0.09	$0.09	$0.09	$0.10	$0.10
	C	Tequesquitte Avenue	$0.31	$0.03	$0.03	$0.03	$0.04	$0.04	$0.04	$0.04	$0.04	$0.05	$0.05
		Wood Road	$0.85	$0.09	$0.09	$0.10	$0.10	$0.11	$0.11	$0.12	$0.12	$0.13	$0.13
		Total (Million Dollars)	**$37.71**	**$4.24**	**$4.49**	**$4.76**	**$5.05**	**$5.25**	**$5.46**	**$5.68**	**$5.90**	**$6.14**	**$6.39**

Notes:
(1) Projects categorized as "not required" and "completed" have been removed from the CIP list.
(2) Costs in August 2006 dollars.
(3) Costs are distributed evenly over the 10-year period.
(4) Costs are escalated from 2006 at 6% through 2011, and 4% thereafter.

Table G-2 Replacement & Rehabilitation Project Costs
Wastewater Collection and Treatment Facilities Integrated Master Plan
City of Riverside

Construction Year	Pipe Diameter (inch)	Total Project Cost[1]	Annual R&R Costs (Million Dollars)[2][3]											
			2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Before 1943	Unknown	$22.14	$0.47	$0.50	$0.53	$0.56	$0.58	$0.60	$0.63	$0.65	$0.68	$0.71	$0.74	$0.77
	4	$0.02	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
	6	$85.96	$1.82	$1.93	$2.05	$2.17	$2.26	$2.35	$2.44	$2.54	$2.64	$2.75	$2.86	$2.97
	8	$172.87	$3.66	$3.88	$4.12	$4.36	$4.54	$4.72	$4.91	$5.11	$5.31	$5.52	$5.74	$5.97

Table G-2 Replacement & Rehabilitation Project Costs
Wastewater Collection and Treatment Facilities Integrated Master Plan
City of Riverside

Construction Year	Pipe Diameter (inch)	Total Project Cost[1]	Annual R&R Costs (Million Dollars)[2][3]											
			2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
	10	$19.16	$0.41	$0.43	$0.46	$0.48	$0.50	$0.52	$0.54	$0.57	$0.59	$0.61	$0.64	$0.66
	12	$14.15	$0.30	$0.32	$0.34	$0.36	$0.37	$0.39	$0.40	$0.42	$0.43	$0.45	$0.47	$0.49
	14	$1.93	$0.04	$0.04	$0.05	$0.05	$0.05	$0.05	$0.05	$0.06	$0.06	$0.06	$0.06	$0.07
	15	$10.67	$0.23	$0.24	$0.25	$0.27	$0.28	$0.29	$0.30	$0.32	$0.33	$0.34	$0.35	$0.37
	16	$2.28	$0.05	$0.05	$0.05	$0.06	$0.06	$0.06	$0.06	$0.07	$0.07	$0.07	$0.08	$0.08
	18	$8.45	$0.18	$0.19	$0.20	$0.21	$0.22	$0.23	$0.24	$0.25	$0.26	$0.27	$0.28	$0.29
	20	$1.40	$0.03	$0.03	$0.03	$0.04	$0.04	$0.04	$0.04	$0.04	$0.04	$0.04	$0.05	$0.05
	21	$6.22	$0.13	$0.14	$0.15	$0.16	$0.16	$0.17	$0.18	$0.18	$0.19	$0.20	$0.21	$0.21
	24	$18.54	$0.39	$0.42	$0.44	$0.47	$0.49	$0.51	$0.53	$0.55	$0.57	$0.59	$0.62	$0.64
	27	$5.43	$0.12	$0.12	$0.13	$0.14	$0.14	$0.15	$0.15	$0.16	$0.17	$0.17	$0.18	$0.19
	30	$0.25	$0.01	$0.01	$0.01	$0.01	$0.01	$0.01	$0.01	$0.01	$0.01	$0.01	$0.01	$0.01
	36	$0.45	$0.01	$0.01	$0.01	$0.01	$0.01	$0.01	$0.01	$0.01	$0.01	$0.01	$0.01	$0.02
1944 to 1956	9	$0.49	$0.01	$0.01	$0.01	$0.01	$0.01	$0.01	$0.01	$0.01	$0.02	$0.02	$0.02	$0.02
	4	$0.04	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
	6	$1.01	$0.02	$0.02	$0.02	$0.03	$0.03	$0.03	$0.03	$0.03	$0.03	$0.03	$0.03	$0.03
	8	$39.86	$0.85	$0.90	$0.95	$1.01	$1.05	$1.09	$1.13	$1.18	$1.22	$1.27	$1.32	$1.38
	10	$2.64	$0.06	$0.06	$0.06	$0.07	$0.07	$0.07	$0.07	$0.08	$0.08	$0.08	$0.09	$0.09

Table G-2 Replacement & Rehabilitation Project Costs
Wastewater Collection and Treatment Facilities Integrated Master Plan
City of Riverside

Construction Year	Pipe Diameter (inch)	Total Project Cost[1]	Annual R&R Costs (Million Dollars)[2][3]											
			2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
	12	$2.25	$0.05	$0.05	$0.05	$0.06	$0.06	$0.06	$0.06	$0.07	$0.07	$0.07	$0.07	$0.08
	15	$0.55	$0.01	$0.01	$0.01	$0.01	$0.01	$0.02	$0.02	$0.02	$0.02	$0.02	$0.02	$0.02
	21	$0.76	$0.02	$0.02	$0.02	$0.02	$0.02	$0.02	$0.02	$0.02	$0.02	$0.02	$0.03	$0.03
Total (Million Dollars)		$418	$8.85	$9.38	$9.95	$10.54	$10.96	$11.40	$11.86	$12.33	$12.83	$13.34	$13.87	$14.43

Notes:
(1) Costs in August 2006 dollars.
(2) Costs are distributed evenly over A 50-yr period.
(3) Costs are escalated from 2006 by 6% through 2011, and by 4% thereafter.

Table G-2 Replacement & Rehabilitation Project Costs, Continued.
Wastewater Collection and Treatment Facilities Integrated Master Plan
City of Riverside

Construction Year	Pipe Diameter (inch)	Annual R&R Costs (Million Dollars)[2][3]												
		2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032
Before 1943	Unknown	$0.80	$0.83	$0.86	$0.90	$0.93	$0.97	$1.01	$1.05	$1.09	$1.13	$1.18	$1.22	$1.27
	4	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
	6	$3.09	$3.21	$3.34	$3.47	$3.61	$3.76	$3.91	$4.07	$4.23	$4.40	$4.57	$4.76	$4.95
	8	$6.21	$6.46	$6.72	$6.99	$7.27	$7.56	$7.86	$8.18	$8.50	$8.84	$9.20	$9.56	$9.95
	10	$0.69	$0.72	$0.74	$0.77	$0.81	$0.84	$0.87	$0.91	$0.94	$0.98	$1.02	$1.06	$1.10

Table G-2 Replacement & Rehabilitation Project Costs, Continued.
Wastewater Collection and Treatment Facilities Integrated Master Plan
City of Riverside

Construction Year	Pipe Diameter (inch)	Annual R&R Costs (Million Dollars)[2][3]												
		2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032
	12	$0.51	$0.53	$0.55	$0.57	$0.59	$0.62	$0.64	$0.67	$0.70	$0.72	$0.75	$0.78	$0.81
	14	$0.07	$0.07	$0.08	$0.08	$0.08	$0.08	$0.09	$0.09	$0.09	$0.10	$0.10	$0.11	$0.11
	15	$0.38	$0.40	$0.41	$0.43	$0.45	$0.47	$0.49	$0.50	$0.52	$0.55	$0.57	$0.59	$0.61
	16	$0.08	$0.09	$0.09	$0.09	$0.10	$0.10	$0.10	$0.11	$0.11	$0.12	$0.12	$0.13	$0.13
	18	$0.30	$0.32	$0.33	$0.34	$0.36	$0.37	$0.38	$0.40	$0.42	$0.43	$0.45	$0.47	$0.49
	20	$0.05	$0.05	$0.05	$0.06	$0.06	$0.06	$0.06	$0.07	$0.07	$0.07	$0.07	$0.08	$0.08
	21	$0.22	$0.23	$0.24	$0.25	$0.26	$0.27	$0.28	$0.29	$0.31	$0.32	$0.33	$0.34	$0.36
	24	$0.67	$0.69	$0.72	$0.75	$0.78	$0.81	$0.84	$0.88	$0.91	$0.95	$0.99	$1.03	$1.07
	27	$0.20	$0.20	$0.21	$0.22	$0.23	$0.24	$0.25	$0.26	$0.27	$0.28	$0.29	$0.30	$0.31
	30	$0.01	$0.01	$0.01	$0.01	$0.01	$0.01	$0.01	$0.01	$0.01	$0.01	$0.01	$0.01	$0.01
	36	$0.02	$0.02	$0.02	$0.02	$0.02	$0.02	$0.02	$0.02	$0.02	$0.02	$0.02	$0.02	$0.03
1944 to 1956	9	$0.02	$0.02	$0.02	$0.02	$0.02	$0.02	$0.02	$0.02	$0.02	$0.03	$0.03	$0.03	$0.03
	4	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
	6	$0.04	$0.04	$0.04	$0.04	$0.04	$0.04	$0.05	$0.05	$0.05	$0.05	$0.05	$0.06	$0.06
	8	$1.43	$1.49	$1.55	$1.61	$1.68	$1.74	$1.81	$1.89	$1.96	$2.04	$2.12	$2.21	$2.29
	10	$0.09	$0.10	$0.10	$0.11	$0.11	$0.12	$0.12	$0.12	$0.13	$0.14	$0.14	$0.15	$0.15
	12	$0.08	$0.08	$0.09	$0.09	$0.09	$0.10	$0.10	$0.11	$0.11	$0.12	$0.12	$0.12	$0.13

Table G-2 Replacement & Rehabilitation Project Costs, Continued.
Wastewater Collection and Treatment Facilities Integrated Master Plan
City of Riverside

Construction Year	Pipe Diameter (inch)	Annual R&R Costs (Million Dollars)(2)(3)												
		2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032
	15	$0.02	$0.02	$0.02	$0.02	$0.02	$0.02	$0.03	$0.03	$0.03	$0.03	$0.03	$0.03	$0.03
	21	$0.03	$0.03	$0.03	$0.03	$0.03	$0.03	$0.03	$0.04	$0.04	$0.04	$0.04	$0.04	$0.04
Total (Million Dollars)		$15.00	$15.60	$16.23	$16.88	$17.55	$18.26	$18.99	$19.74	$20.53	$21.36	$22.21	$23.10	$24.02

Notes:
(1) Costs in August 2006 dollars.
(2) Costs are distributed evenly over A 50-yr period.
(3) Costs are escalated from 2006 by 6% through 2011, and by 4% thereafter.

Table G-2 Replacement & Rehabilitation Project Costs, Continued.
Wastewater Collection and Treatment Facilities Integrated Master Plan
City of Riverside

Construction Year	Pipe Diameter (inch)	Annual R&R Costs (Million Dollars)(2)(3)												
		2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045
Before 1943	Unknown	$1.32	$1.38	$1.43	$1.49	$1.55	$1.61	$1.68	$1.74	$1.81	$1.89	$1.96	$2.04	$2.12
	4	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
	6	$5.14	$5.35	$5.56	$5.79	$6.02	$6.26	$6.51	$6.77	$7.04	$7.32	$7.61	$7.92	$8.24
	8	$10.34	$10.76	$11.19	$11.64	$12.10	$12.59	$13.09	$13.61	$14.16	$14.72	$15.31	$15.92	$16.56
	10	$1.15	$1.19	$1.24	$1.29	$1.34	$1.39	$1.45	$1.51	$1.57	$1.63	$1.70	$1.77	$1.84
	12	$0.85	$0.88	$0.92	$0.95	$0.99	$1.03	$1.07	$1.11	$1.16	$1.21	$1.25	$1.30	$1.36

Table G-2 Replacement & Rehabilitation Project Costs, Continued.
Wastewater Collection and Treatment Facilities Integrated Master Plan
City of Riverside

Construction Year	Pipe Diameter (inch)	Annual R&R Costs (Million Dollars)[2][3]												
		2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045
	14	$0.12	$0.12	$0.12	$0.13	$0.14	$0.14	$0.15	$0.15	$0.16	$0.16	$0.17	$0.18	$0.18
	15	$0.64	$0.66	$0.69	$0.72	$0.75	$0.78	$0.81	$0.84	$0.87	$0.91	$0.95	$0.98	$1.02
	16	$0.14	$0.14	$0.15	$0.15	$0.16	$0.17	$0.17	$0.18	$0.19	$0.19	$0.20	$0.21	$0.22
	18	$0.51	$0.53	$0.55	$0.57	$0.59	$0.62	$0.64	$0.67	$0.69	$0.72	$0.75	$0.78	$0.81
	20	$0.08	$0.09	$0.09	$0.09	$0.10	$0.10	$0.11	$0.11	$0.11	$0.12	$0.12	$0.13	$0.13
	21	$0.37	$0.39	$0.40	$0.42	$0.44	$0.45	$0.47	$0.49	$0.51	$0.53	$0.55	$0.57	$0.60
	24	$1.11	$1.15	$1.20	$1.25	$1.30	$1.35	$1.40	$1.46	$1.52	$1.58	$1.64	$1.71	$1.78
	27	$0.32	$0.34	$0.35	$0.37	$0.38	$0.40	$0.41	$0.43	$0.44	$0.46	$0.48	$0.50	$0.52
	30	$0.01	$0.02	$0.02	$0.02	$0.02	$0.02	$0.02	$0.02	$0.02	$0.02	$0.02	$0.02	$0.02
	36	$0.03	$0.03	$0.03	$0.03	$0.03	$0.03	$0.03	$0.04	$0.04	$0.04	$0.04	$0.04	$0.04
1944 to 1956	9	$0.03	$0.03	$0.03	$0.03	$0.03	$0.04	$0.04	$0.04	$0.04	$0.04	$0.04	$0.05	$0.05
	4	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
	6	$0.06	$0.06	$0.07	$0.07	$0.07	$0.07	$0.08	$0.08	$0.08	$0.09	$0.09	$0.09	$0.10
	8	$2.39	$2.48	$2.58	$2.68	$2.79	$2.90	$3.02	$3.14	$3.26	$3.39	$3.53	$3.67	$3.82
	10	$0.16	$0.16	$0.17	$0.18	$0.18	$0.19	$0.20	$0.21	$0.22	$0.22	$0.23	$0.24	$0.25
	12	$0.13	$0.14	$0.15	$0.15	$0.16	$0.16	$0.17	$0.18	$0.18	$0.19	$0.20	$0.21	$0.22

Table G-2 Replacement & Rehabilitation Project Costs, Continued.
Wastewater Collection and Treatment Facilities Integrated Master Plan
City of Riverside

Construction Year	Pipe Diameter (inch)	Annual R&R Costs (Million Dollars)(2)(3)												
		2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045
	15	$0.03	$0.03	$0.04	$0.04	$0.04	$0.04	$0.04	$0.04	$0.05	$0.05	$0.05	$0.05	$0.05
	21	$0.05	$0.05	$0.05	$0.05	$0.05	$0.06	$0.06	$0.06	$0.06	$0.06	$0.07	$0.07	$0.07
Total (Million Dollars)		$24.98	$25.98	$27.02	$28.10	$29.23	$30.40	$31.61	$32.88	$34.19	$35.56	$36.98	$38.46	$40.00

Notes:
(1) Costs in August 2006 dollars.
(2) Costs are distributed evenly over A 50-yr period.
(3) Costs are escalated from 2006 by 6% through 2011, and by 4% thereafter.

Table G-2 Replacement & Rehabilitation Project Costs, Continued.
Wastewater Collection and Treatment Facilities Integrated Master Plan
City of Riverside

Construction Year	Pipe Diameter (inch)	Annual R&R Costs (Million Dollars)(2)(3)											
		2046	2047	2048	2049	2050	2051	2052	2053	2054	2055	2056	2057
Before 1943	Unknown	$2.21	$2.29	$2.39	$2.48	$2.58	$2.68	$2.79	$2.90	$3.02	$3.14	$3.27	$3.40
	4	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
	6	$8.56	$8.91	$9.26	$9.63	$10.02	$10.42	$10.84	$11.27	$11.72	$12.19	$12.68	$13.19
	8	$17.22	$17.91	$18.63	$19.37	$20.15	$20.96	$21.79	$22.67	$23.57	$24.52	$25.50	$26.52
	10	$1.91	$1.99	$2.06	$2.15	$2.23	$2.32	$2.42	$2.51	$2.61	$2.72	$2.83	$2.94
	12	$1.41	$1.47	$1.52	$1.59	$1.65	$1.72	$1.78	$1.86	$1.93	$2.01	$2.09	$2.17

Table G-2 Replacement & Rehabilitation Project Costs, Continued.
Wastewater Collection and Treatment Facilities Integrated Master Plan
City of Riverside

Construction Year	Pipe Diameter (inch)	Annual R&R Costs (Million Dollars)[2][3]											
		2046	2047	2048	2049	2050	2051	2052	2053	2054	2055	2056	2057
	14	$0.19	$0.20	$0.21	$0.22	$0.22	$0.23	$0.24	$0.25	$0.26	$0.27	$0.28	$0.30
	15	$1.06	$1.11	$1.15	$1.20	$1.24	$1.29	$1.35	$1.40	$1.45	$1.51	$1.57	$1.64
	16	$0.23	$0.24	$0.25	$0.26	$0.27	$0.28	$0.29	$0.30	$0.31	$0.32	$0.34	$0.35
	18	$0.84	$0.88	$0.91	$0.95	$0.98	$1.02	$1.07	$1.11	$1.15	$1.20	$1.25	$1.30
	20	$0.14	$0.15	$0.15	$0.16	$0.16	$0.17	$0.18	$0.18	$0.19	$0.20	$0.21	$0.21
	21	$0.62	$0.64	$0.67	$0.70	$0.73	$0.75	$0.78	$0.82	$0.85	$0.88	$0.92	$0.95
	24	$1.85	$1.92	$2.00	$2.08	$2.16	$2.25	$2.34	$2.43	$2.53	$2.63	$2.73	$2.84
	27	$0.54	$0.56	$0.59	$0.61	$0.63	$0.66	$0.68	$0.71	$0.74	$0.77	$0.80	$0.83
	30	$0.02	$0.03	$0.03	$0.03	$0.03	$0.03	$0.03	$0.03	$0.03	$0.04	$0.04	$0.04
	36	$0.04	$0.05	$0.05	$0.05	$0.05	$0.05	$0.06	$0.06	$0.06	$0.06	$0.07	$0.07
1944 to 1956	9	$0.05	$0.05	$0.05	$0.05	$0.06	$0.06	$0.06	$0.06	$0.07	$0.07	$0.07	$0.08
	4	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.01	$0.01	$0.01	$0.01	$0.01	$0.01
	6	$0.10	$0.10	$0.11	$0.11	$0.12	$0.12	$0.13	$0.13	$0.14	$0.14	$0.15	$0.15
	8	$3.97	$4.13	$4.30	$4.47	$4.65	$4.83	$5.03	$5.23	$5.44	$5.65	$5.88	$6.11
	10	$0.26	$0.27	$0.28	$0.30	$0.31	$0.32	$0.33	$0.35	$0.36	$0.37	$0.39	$0.40
	12	$0.22	$0.23	$0.24	$0.25	$0.26	$0.27	$0.28	$0.30	$0.31	$0.32	$0.33	$0.35

Table G-2 Replacement & Rehabilitation Project Costs, Continued.
Wastewater Collection and Treatment Facilities Integrated Master Plan
City of Riverside

Construction Year	Pipe Diameter (inch)	Annual R&R Costs (Million Dollars)[(2)(3)]											
		2046	2047	2048	2049	2050	2051	2052	2053	2054	2055	2056	2057
	15	$0.05	$0.06	$0.06	$0.06	$0.06	$0.07	$0.07	$0.07	$0.07	$0.08	$0.08	$0.08
	21	$0.08	$0.08	$0.08	$0.09	$0.09	$0.09	$0.10	$0.10	$0.10	$0.11	$0.11	$0.12
Total (Million Dollars)		$41.60	$43.26	$44.99	$46.79	$48.66	$50.61	$52.64	$54.74	$56.93	$59.21	$61.58	$64.04

Notes:
(1) Costs in August 2006 dollars.
(2) Costs are distributed evenly over A 50-yr period.
(3) Costs are escalated from 2006 by 6% through 2011, and by 4% thereafter.