# CHAPTER 2

# EXISTING COLLECTION SYSTEM FACILITIES

## DESCRIPTION OF EXISTING COLLECTION SYSTEM

The City collection system is divided into seven sub-basins forming the current and future service areas. These basins are named according to prominent geographic or cultural landmarks. Mainline pipe lengths and basin areas are summarized in Table 2-1. The total area within the UGB is 8,300 acres, although the system currently serves approximately 2,800 acres. There are nearly 701,250 linear feet of sewer pipe in service, ranging in size from 4 to 54 inches in diameter. With the exception of a small area in the Downtown Basin, the system consists of a network of separate sanitary and storm sewers.

**Table 2-1. McMinnville Collection System Pipe Length and Sub-basin Gross Area Within the UGB**

| Basin Name | Total Length of Gravity and Pressure Pipe (feet) | Basin Area (acres) |
|---|---|---|
| Airport | 38,803 | 1,780 |
| Cozine | 195,326 | 1,901 |
| Downtown | 90,544 | 711 |
| Fairgrounds | 141,842 | 1,899 |
| High School | 110,317 | 674 |
| Michelbook | 102,864 | 1,135 |
| Yamhill | 21,554 | 199 |
| Total | 701,250 | 8,299 |
| Total Miles | 133<br>(31.2 miles modeled) | |

Because of the largely favorable topographic relief of the area, most of the City is served by gravity sewer lines. However, in those areas that have adverse topographic relief, pumping is required to transport wastewater to the gravity portion of the collection system. The flow from the gravity system is pumped to the Water Reclamation Facility (WRF) by the raw sewage pump station (RSPS). There are currently thirteen pump stations operating in the collection system as summarized in Table 2-2.

**Table 2-2. Pump Station Inventory**

| | No. of Pumps | Base Elevation | Rim Elevation | Pumps Off (Elev. ft.) | Lead Pump On (Elev. ft.) | Lag Pump On (Elev. ft.) | Wetwell Shape | Wetwell Diameter | Capacity Pump #1 (gpm) | Capacity Pump #2 (gpm) | Capacity All Pumps (gpm) | Firm Capacity[4] (gpm) | Emergency Power | Voltage/ Phase | Wet Well Capacity (gal) | Time to Overflow (min) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Oregon Street | 2 | 120.50 | | 121.50 | 124.50 | 125.00 | Circular | 6 | 250 | 277 | 234 | 250 | None | 240/3 | 1,500 | 15 |
| Autumn Ridge | 2 | 127.00 | 142.33 | 128.33 | 129.33 | 129.83 | Circular | 6 | 115 | 91 | 170 | 91 | On-site Generator | 240/3 | 3,100 | 155 |
| Kathleen Manor | 2 | 125.33 | 146.83 | 126.33 | 130.33 | 130.83 | Circular | 5 | 361 | 316 | 452 | 347 | Manual switchgear | 240/3 | 1,700 | 15 |
| Morgan Lane | 2 | 129.75 | 136.00 | 123.25 | 128.75 | 129.25 | Circular | 6 | 799 | 900 | 1,007 | 833 | On-site Generator | 240/3 | 3,000 | 10 |
| 3-mile Lane #3 | 2 | 124.50 | 152.00 | 127.50 | 133.00 | 133.50 | Circular | 7 | 1,091 | 1,002 | 1,800 | 972 | Manual Switchgear | 480/3 | 1,000 | 20 |
| 3-mile Lane #1 | 3 | 109.47 | 151.00 | 128.40 | 130.40 | 130.90 | Circular | 12 | 1,400 | 1,400 | 2,520[3] | 2,500 | On-site Generator | 480/3 | 12,000 | 116 |
| Cozine Woods | 2 | 104.59 | 123.96 | 105.59 | 109.19 | 110.40 | Circular | 6 | 202 | 201 | 322 | 208 | Gravity Flow | 240/3 | 1,500 | na |
| Northeast | 2 | 79.50 | 114.00 | 84.50 | 88.50 | 89.25 | Circular | 8 | 960 | 717 | 1,080 | 694 | On-site Generator | 480/3 | 6,000 | 15 |
| Westside | 2 | 134.00 | 152.00 | 135.00 | 137.00 | 138.00 | Circular | 5 | 443 | 399 | 568 | 399 | On-site Generator | 240/3 | 800 | 8 |
| Crestbrook | 2 | 95.60 | 126.90 | 100.27 | 102.27 | 103.27 | Circular | 5 | 35 | 46 | 123 | 35 | None | 240/1 | 4,800 | 240 |
| Riverside | 2 | 128.00 | 140.00 | 129.00 | 133.00 | 135.00 | Circular | 5 | 109 | 101 | 116 | 101 | None | 240/3 | 750 | 150 |
| Cozine | 4 | 77.00 | 102.17 | 79.52 | 81.02 | 95.00 | Semi-circular | -- | 2,500 | 1@2,500 2@4,000 | 10,500[1] | 7,986 | Automatic Switchgear (2 power feeds to station) | 480/3 | 100,000 | 54 |
| Raw Sewage | 5 | 105.00 | 119.50 | 110.00 | 111.52 | 113.80 | Semi-circular | -- | 6,000 | 2@11,000 | 22,200[2] | 26,389 | Automatic Switchgear (2 power feeds to station) | 480/3 | 100,000 | 25 |

[1]one small pump on, two large pumps on
[2]one small pump on, two large pumps on
[3]Same as firm capacity given downstream head losses
[4]Total capacity with largest pump out of service

## MODEL SELECTION AND DEVELOPMENT

A review and comparison of the leading software packages for wastewater collection system simulation was performed by considering hydraulic methods, user-interface amenities, database/geographic information system (GIS) compatibility, software developer, vendor support, project scope, and price.

To be considered by the City, models must have basic capability and functionality, including the following:

- Acceptable hydraulic methods
- Dynamic routing
- Computational speed
- Easy-to-learn and use through an advanced Graphical User Interface (GUI)
- GIS and database (ODBC) interface
- Accurate and reasonably precise computational results
- Adequate results presentation capabilities
- Supported by a experienced vendor who has been in the business for at least 5 years

### Model Selection Process

The model selection process attempted to balance the City's need for a usable tool that meets the general model capabilities listed above against the City's resources. The resources (most importantly staff, but also hardware and software) available to the City for the maintenance of the system database and upkeep of a comprehensive model were also considered in the selection process. The models included in the evaluation are commonly used to model the hydraulics of sanitary sewer systems. The review was based on available model documentation, published literature, and experience on previous projects.

After an initial screening, six models were identified as candidates for simulating existing conditions and for evaluating future conditions and capital improvement alternatives. The primary purpose of a hydraulic simulation model is to provide the City with a tool that can be used to gain a better understanding of the hydraulics of the wastewater collection system. The tool can be used to evaluate and potentially improve existing operations and to assess and plan for accommodating future conditions, including master planning, facility planning (capital improvement), and wet-weather flow management. The capabilities of the short-listed models were evaluated in more detail (See Appendix B).

### Recommendation

XP SWMM 5 was selected as the package of choice. This platform best met the City's needs for the model, including ease of use and cross-application for stormwater system modeling. This model selection recommendation supersedes the one conducted for the 1995 *City of McMinnville Infiltration and Inflow (I/I) Correction Plan*, where the HYDRA model from Pizer, Inc. was selected as the analysis tool to perform system modeling.

## DATA SOURCES AND MODELED SYSTEM ELEMENTS

### Modeled System Elements

In general, the modeled system includes all pipes 12 inches in diameter and greater. There are sections of the system that are 8 and 10 inches in diameter that have been included in the model to address key areas of system operation. The following seven existing pump stations were also incorporated into the model:

- 3 Mile Lane #1
- 3-Mile Lane #3
- Cozine
- Cozine Woods
- Northeast
- Kathleen Manor
- Raw Sewage Pump Station

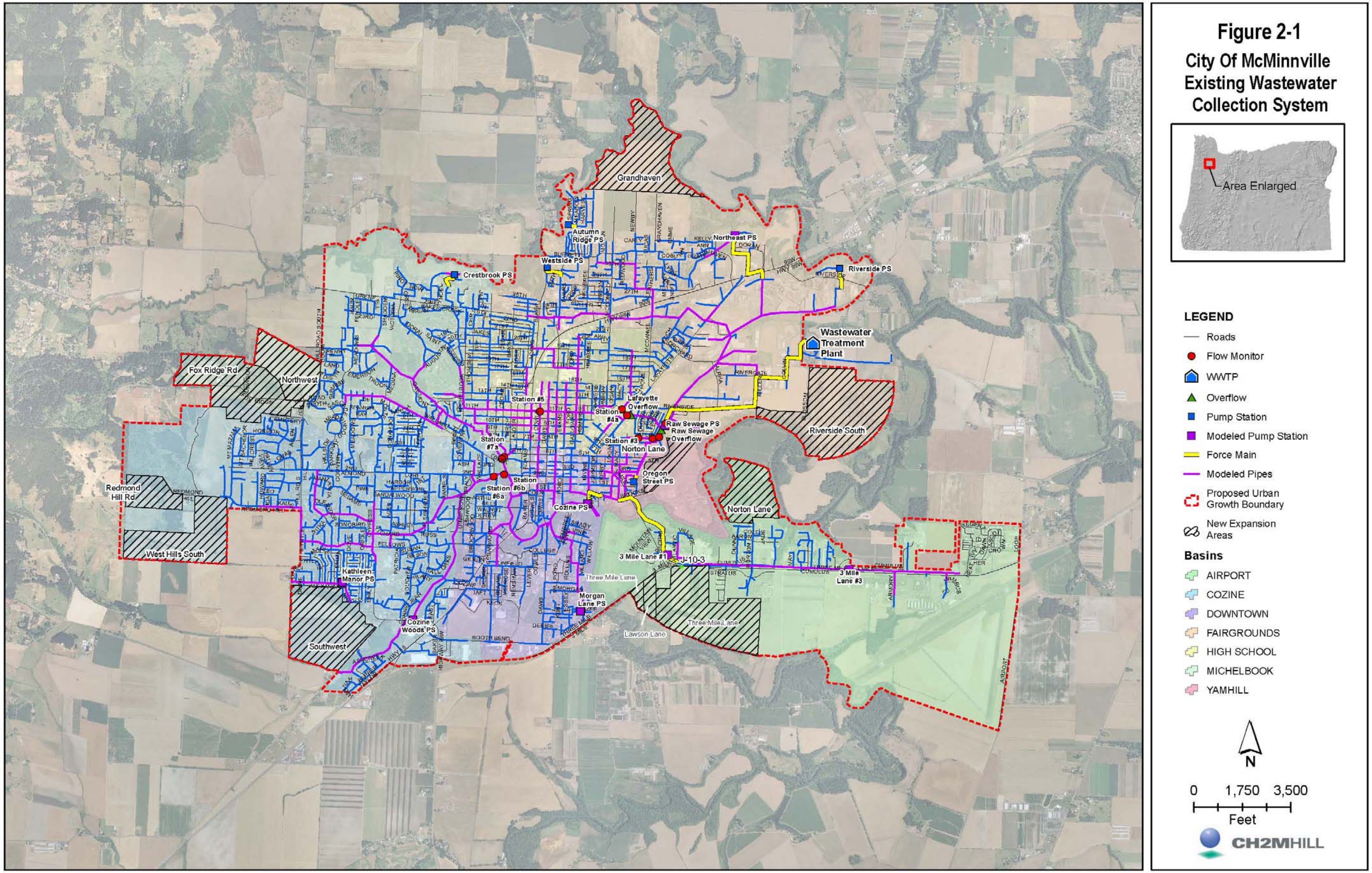
The only locations that the model allows flow to exit the system are the following diversions/ bypasses:

- Lafayette Bypass
- Diversion Structure at Raw Sewage Pump Station
- Cozine Pump Station

### Data Sources

Inventory data were obtained from a number of sources including the previous model developed for the finalized *1999 Wet Weather Overflow Management Plan*. Additional data sources included the Hansen CMMS and CAD mapping databases, review of as-built drawings, interviews with City staff regarding system configuration, and field investigations performed by City staff.

Figure 2-1 shows the drainage basin areas, collection system pipelines, modeled pipelines, pump stations and flow monitoring locations.




PDX \\ROSA\PROJ\WESTYOSTASSOCIATES\340411MCMINNVILLE\GIS\MXDS\FIGURE2-1_EXISTINGWWCOLLECTSYSTEM_PG.MXD 9/24/2008 14:15:47

## FLOW MONITORING

The objective of the flow monitoring plan is to assess total wet weather flow to the City's wastewater treatment plant from individual basins and to quantify infiltration and inflow (I/I).

This section summarizes the flow monitoring plan associated with the City of McMinnville Sanitary Sewer Master Plan Update project including a description of the monitoring period, contractor selection, and monitoring locations and types. The purpose of this section is to describe the monitoring objectives and the approach used for selecting and performing a comprehensive monitoring program using a combination of temporary monitors and pump station data are described. The process through which a flow monitoring contractor was selected is only discussed briefly, as this information was presented in a TM for Task 16 (Appendix B).

### Overview

Infiltration and inflow (I/I) contributions may be assessed by analyzing the relationship between collection system flow and rainfall. Collection systems show an increase in flow during periods of heavy rain and high groundwater. Flow monitoring data are used to quantify I/I and to identify its general area of origin. Infiltration may be distinguished from inflow by examining the response time of system flow following a rainfall event. Comparison of collection system monitoring records before and after system rehabilitation can be used to assess the effectiveness of I/I reduction efforts.

Temporary flow and rainfall monitoring was conducted through a private flow monitoring contractor for a period of 3 months (February – April 2006). Monitoring was conducted during wet weather conditions when soils are saturated, thus resulting in peak I/I conditions.

### Monitoring Contractor Selection

Three flow monitoring firms (SFE Global, ADS, and Geotivity) were contacted and asked to provide qualifications, references and a cost proposal for monitoring, installing and operating a flow monitoring system (maintenance, data downloads, etc.) for a duration of 3 months. All three firms submitted proposals. A rating system was used to evaluate the proposals based on price, monitoring method, field work, data access and quality, and references. SFE Global was selected to perform the monitoring.

### Monitoring Locations and Method

All flow monitoring was done within sanitary manholes using either field fabricated weirs or flow meters (area/velocity meters). SFE's preferred monitoring method uses weirs, based on their experience that this method provides the most stable (less data scatter) flow data. The preferred monitoring location is at the most downstream portion of the basin, however, site limitations based on access, velocities, or the orientation of multiple pipes entering or leaving a manhole resulted in multiple monitors being required for three basins. Several locations in the system required the placement of multiple monitors, including a small portion of the system that is combined (conveys both sanitary flow and surface drainage from street catch basins), and the High School basin where it was desired to assess recent system I/I reduction improvements.

Table 2-3 summarizes the final 11 monitoring locations and methods. To ensure that flows from the entire collection system are accounted for, the monitoring plan includes data from three existing pump stations and one rain gauge.

**Table 2-3. Final Monitoring Plan**

| SFE Site ID | City Manhole ID | Monitoring Method | Contributing Basin | Comments |
|---|---|---|---|---|
| 1 | J-7-20 | Area/Velocity | Fairgrounds | |
| 2a | J-7-48 | Weir | Yamhill | |
| 2b | J-7-44 | Area/Velocity | Downtown | |
| 3 | J-7-90 | Area/Velocity | Downtown | |
| 4a | J-7-68 | Area/Velocity | High School | |
| 4b | J-7-8 | Weir | High School | |
| 5 | I-7-3 | Weir | High School | Monitors flow from upstream section of the basin that has been rehabilitated. |
| 6a | H-8-102 | Area/Velocity | Cozine | |
| 6b | H-8-107 | Weir | Cozine | |
| 7a | H-8-93 | Area/Velocity | Michelbook | |
| 7b | H-8-112 | Weir | Michelbook | |
| Rain Gage | NA | Not Specified | NA | Installed at the Kathleen Manor Pump Station |
| Pump Station/Rain Gage | | Monitoring Method | Contributing Basin | Comments |
| 3 Mile Pump Station | | In-line Flow Meter(s) | Airport | Collect data from the most downstream of these three, in-series pump stations |
| Raw Sewage Pump Station | | In-line Flow Meter(s) | All | Flow from all basins passes through this pump station |
| Cozine Pump Station | | In-line Flow Meter(s) | Downtown | |
| WRF Rain Gage | | Not Specified | NA | |

Figure 2-1, identifies the location of the monitors within the City's collection system.

**Monitoring Installation/Removal and Data Monitoring**

A two-person field crew from SFE began monitor installation on January 28th, 2006 and completed installation on January 31st, 2006. Manholes identified for monitor installation had been previously marked by City staff for the SFE installers. Weirs were field fabricated for each manhole utilizing this monitoring method.

For the 3 month (February – April 2006) flow monitoring timeframe, SFE visited each site bi-weekly to download data and perform necessary required maintenance. Data reporting from SFE included spreadsheet flow data, hydrographs, and maintenance performed. Upon completion of the monitoring SFE removed the monitors and provided a final flow monitoring report (separately bound).

### Conclusion

The temporary flow monitoring and rainfall data, coupled with data from pump stations within the system, provided the data set from which to calibrate the sanitary sewer model and to evaluate the effects that I/I has on the collection system.

## MONITOR DATA EVALUATION

### Rainfall-Derived Infiltration and Inflow (RDII) Analysis

RDII is the flow entering the sewer system as a direct results of rain. RDII increases total flow volume and peak flow, and consists of two components: infiltration, which slowly percolates into the collection system; and inflow, which reaches a peak shortly after rainfall intensity is greatest and falls off rapidly when rain subsides. Since the flow monitors directly measure total flow, RDII may be estimated by subtracting the average base flow (ABF), comprising sanitary flow and base groundwater infiltration, from the total flow.

The purpose of the RDII analysis was to identify sewer basins that are large contributors of RDII, to quantify these wet weather flows, and to rank the basins for potentially cost effective RDII reduction. Based upon the flow monitoring during February through April 2006, regression equations were developed to predict flow based on rainfall and selected dry weather flow patterns. The flow estimates were used in modeling efforts to generate design storm hydrographs in the collection system.

#### *Wet Season Average Base Flow (ABF)*

The wet season ABF at a flow monitoring site was developed by selecting several days of flow data from a dry period (no precipitation) during the winter study period. An ABF hydrograph, composed of sanitary flow and base groundwater infiltration, was developed for each location. The composite 24-hour ABF hydrograph was created by determining the minimum flow for each hour from flow monitor data recorded over the dry days selected. The average base flow was used in the calculation of RDII.

#### *Flow Estimates*

Each flow monitor measures flow from all upstream sources, and in some instances is affected by backwater conditions from downstream pipes. To isolate RDII originating from a contributing area between two monitors, flows from upstream basins were subtracted from the flows measured at the downstream monitor. As is typical during any flow monitoring program, some of the monitors had occasional unreliable or missing data. In order to fill in these gaps and to replace unreliable data, regression derived data (described below) was used. This correction allowed for estimation of RDII for all of the basins for the calibration and design storms.

## REGRESSION ANALYSIS

Estimates of RDII are based on a regression relationship between rainfall and flow. RDII is flow resulting from rainfall that has entered the collection system over the past hours, days and weeks. For this analysis, it was assumed that a multiple variable linear equation was used to develop a relationship between RDII and past rainfall. Wet weather flow, ABF, and rainfall recorded at the nearest representative rain gage were extracted from the database and imported into an Excel spreadsheet. Rainfall during the 15 days (360 hours) before each hourly flow measurement was summed for the following nine periods: 1 hour, 2 to 3 hours, 4 to 6 hours, 7 to 12 hours, 12 hours to 1 day, 1 to 2 days, 4 to 7 days and 7 to 15 days. Excel was used to perform multiple linear regression on the correlation between the rainfall sums and the measured flow to determine the regression coefficients for each rainfall sum.

The regression equation was:

$RDII = C1*Rain_{1hr} + C2*Rain_{2hr}....+ C9*Rain_{360hr}$

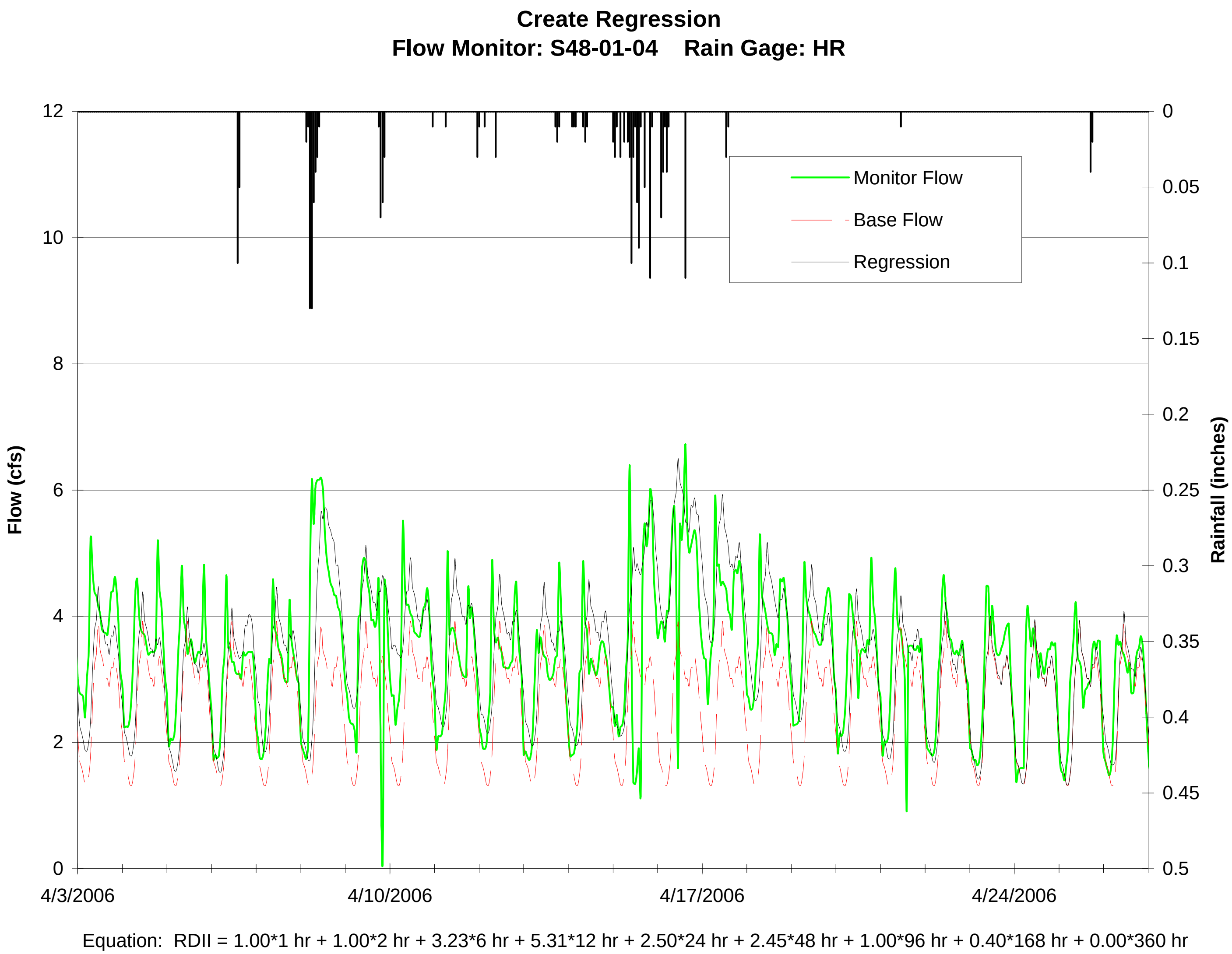
With:

Total Flow = ABF + RDII

Figure 2-2 is an example of the results of this analysis. The analysis was done for each monitoring station using software that allows interaction between an Access database where the monitoring data are stored and Excel (results are included in Appendix C). Once the regression equations are developed and visually checked, flow may be estimated for any period by applying the equation to precipitation data collected at other periods or for specific design storm events. The regression equations can be used to generate flow estimates when monitor data are missing or unreliable, provided rainfall data is available for the period of interest.

These regression equations were used in wastewater modeling efforts to generate design flow input to the collection system.

**Figure 2-2. Example of Regression Equation Creation**



## CALIBRATION

The flow monitoring program was performed to obtain data that was used not only to develop the regression equations but also to calibrate the wastewater model. The hydraulic model was used to characterize existing RDII volume and to evaluate the effectiveness of the RDII reduction alternatives under the 5-year, 24-hour winter storm design criterion specified by DEQ.

Calibration of the collection system model involves adjusting regression equation coefficients as well as flows and hydraulic parameters in the model such that model-predicted flows, depths and velocities more closely matched observed data. It differs from the initial development of the regression equations in that it compares peak flows from the hydraulic model to measured flows after the flow data from the regression analysis is distributed to multiple manholes upstream of the monitor location. Hydraulic routing of the flow in the collection system is thus accounted for. Calibration was performed based on model predicted versus monitored flows at the 11 monitor locations. In addition, due to the lack of large rainfall events during the monitoring period, flows at the Cozine and Raw Sewage Pump Stations during periods of greater rainfall (December 2005 and January 2006) were used in the calibration process.

Figures 2-3 through 2-4 compare modeled flows with monitored data at the Cozine pump station and RSPS for the model calibration period.

The ability to closely predict measured flows during large storm events indicate that the model has achieved an appropriate level of calibration and can be used to predict flows for the design rainfall event. Attributes including peak flow rate, hydrograph shape and volume are used to conclude the ability to predict performance in the system.

### Accuracy of Flow Estimates

Differences between flows computed from the regression equations and measured flows are a result of one or more of the following:

- *System Operation.* The effects of flow diversions, pump stations, and wet weather by passes are not consistent from storm to storm and result in potentially irregular system flows under similar rainfall events.
- *Rainfall Distribution.* The regression equations were generated from the rain gage that was thought to best represent the rainfall distributed over the entire monitor basin. However, variability of rainfall volume and intensity is normal across basins, resulting in differences in flow volume and timing.
- *Monitor Data.* It is common to have intermittent problems with flow measurement, particularly because of mismeasurement of velocity. The velocity probe on a flow monitor can be fouled by debris and scum, or backwater effects can change the velocity to depth relationships. In addition, some monitors were not operating during portions of the monitoring period. The regression equations were produced from storm events during periods where the monitor data appeared to be the most reliable. The majority of the monitored data are reasonable and appropriate for the uses of this study.

- *Antecedent Conditions.* RDII predicted by the regression equations will be most accurate when applied to periods when the storm intensity, duration and antecedent conditions are similar to those used to generate the regression equations.

## FUTURE FLOW MONITORING RECOMMENDATIONS

Because of potential variation in the I/I rate for future development, it is suggested that the currently established rate of 2,000 gpad for new development be used for the current analysis but periodically be reviewed through future ongoing monitoring of representative City basins and that the flow input for the model can be adjusted in the future as appropriate.

It is also advisable to monitor collection system I/I reduction projects before and after installation to quantify effectiveness of flow reduction and verify that they have produced the desired results.

**Figure 2-3**

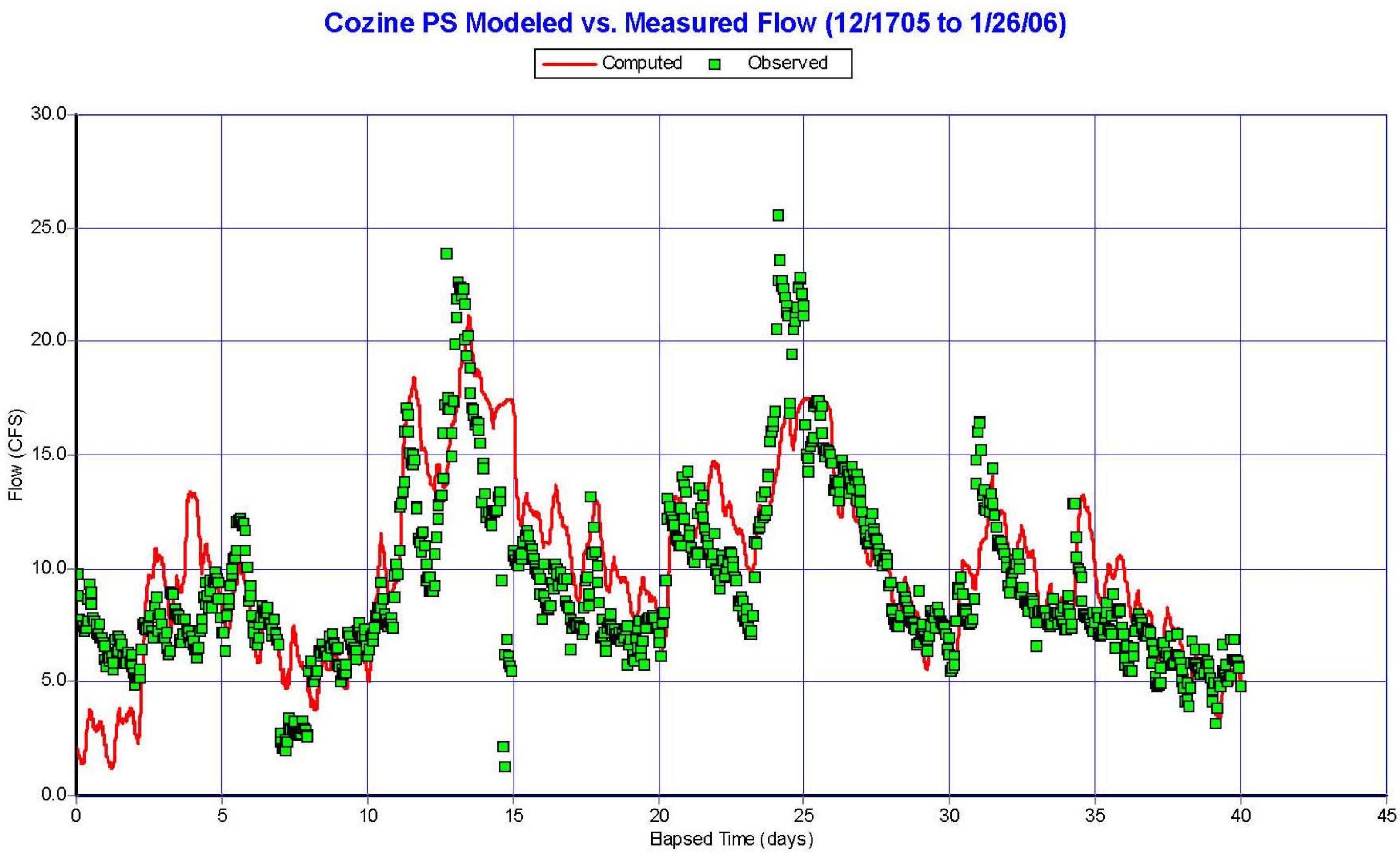
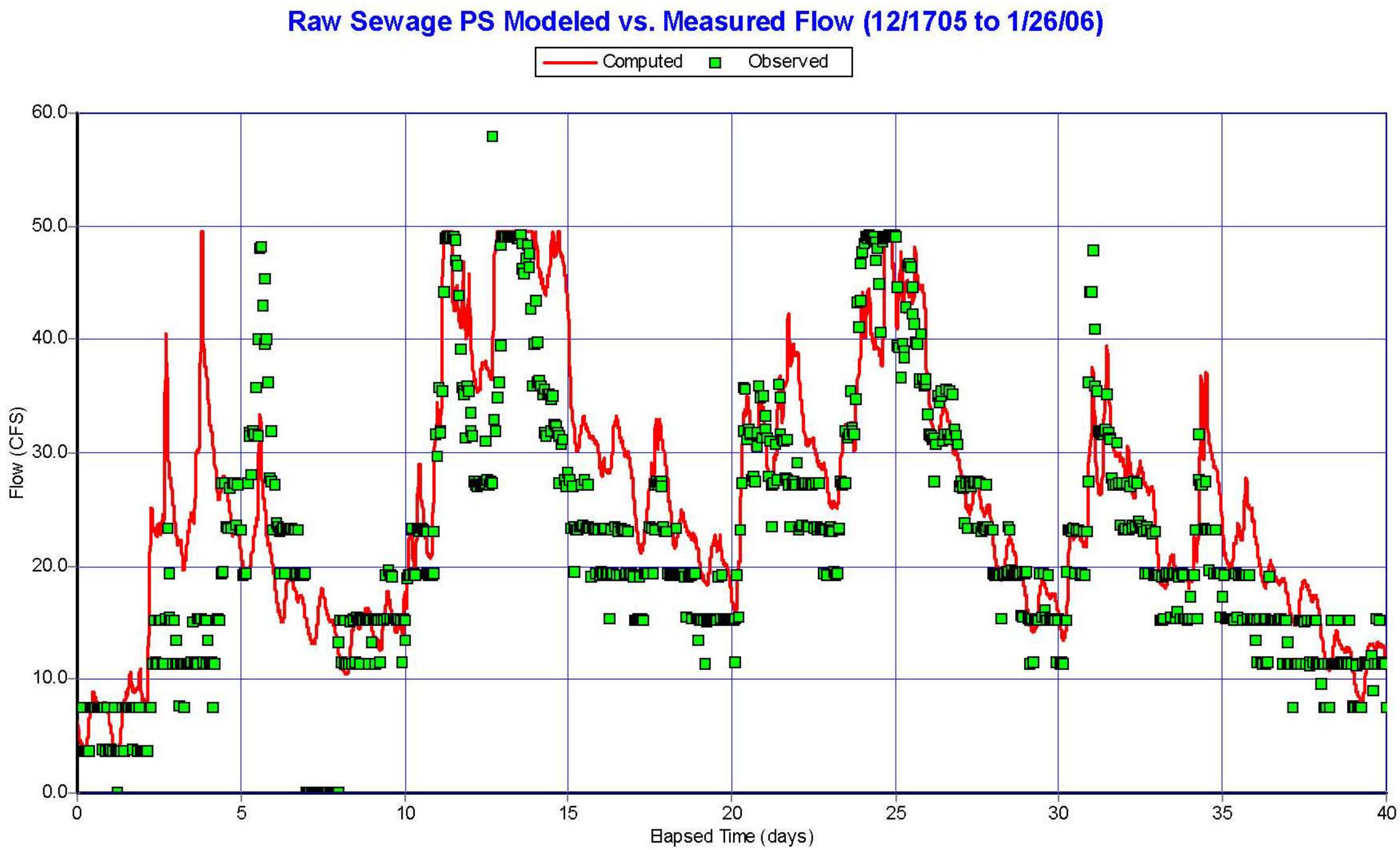

Cozine PS Modeled vs. Measured Flow (12/1705 to 1/26/06)
Computed
Observed
30.0
25.0
20.0
15.0
10.0
5.0
0.0
Flow (CFS)
0
5
10
15
20
25
30
35
40
45
Elapsed Time (days)

**Figure 2-4**



Raw Sewage PS Modeled vs. Measured Flow (12/1705 to 1/26/06)
Computed
Observed
60.0
50.0
40.0
30.0
20.0
10.0
0.0
Flow (CFS)
0
5
10
15
20
25
30
35
40
Elapsed Time (days)