City of Portsmouth, New Hampshire

Wastewater Master Plan

Technical Memorandum

TM 4

CSO ABATEMENT PROGRESS AND COLLECTION SYSTEM MODEL UPGRADE

Tasks:	4.1 through 4.10	
	Submitted to EPA/DES	10/30/09

Executive Summary

The City of Portsmouth, New Hampshire, has been actively working on abating the discharges from its combined sewer overflows (CSO) outfalls since the late 1980s. The City has spent more than $25 million abating CSOs since 1997.

Earlier abatement plans, most notably 1991 and 2005, included the development of a computerized hydraulic model of the collection system as a planning tool to assist in the development and evaluation of abatement alternatives and, in conjunction with flow monitoring, to document post-implementation improvements.

That model has again been updated as part of the development of the ongoing Wastewater Master Plan (WMP) which will contain an update of the CSO abatement plan. To assist in the model update, an extensive flow and rainfall monitoring program was conducted in 2008, during which time a number of significant rainfall and CSO discharge events occurred.

The updated model reveals that the City has continued to make progress in CSO abatement with a significant improvement noted since the last update of the CSO plan in 2005. Between 2000 and 2008, the two periods of intensive flow monitoring, the CSO discharges have been reduced by approximately 8.2 million gallons (MGal) in a typical year. Integral with the reduction of CSO discharges are the direct reduction of their inherent pollutants. This equates to roughly 10,500 pounds of total suspended solids that are no longer discharged, untreated, to the Piscataqua River and South Mill Pond on an annual basis. Also associated with these solids are fractions of organic nitrogen,

particulate phosphorus and heavy metals. Thus, the improvements made to the Portsmouth collection system have had positive and measurable impact to the area receiving waters.

Further volumetric reductions of CSO discharges, and their associated pollutants, will continue to occur as the City completes the implementation of pending and planned sewer separation projects. In addition, the City continues to fulfill its commitment to perform the good housekeeping practices within its collection system as called for in its Nine Minimum Control program.

4.1 Introduction and Purpose

Technical Memorandum 4 (TM 4) is one of a series of interim deliverables prepared as part of the development of the Wastewater Master Plan (WMP) for the City of Portsmouth, New Hampshire. This TM addresses two related topics:

- Assessment of compliance with regulatory requirements for CSO abatement.
- Establishment of baseline conditions using the collection system model as updated as part of the WMP process.

The WMP Work Plan, dated May 2007, included individual TMs for these topics. However, because of their interrelationship, they were combined into a single TM 4.

The TM is structured as follows: initially it describes the 2008 rainfall and flow monitoring program and is followed by a discussion of the CSO abatement activity that occurred following the submittal of the 2005 Long-Term Control Plan (2005 LTCP) which was submitted to EPA and DES in April 2005. Descriptions follow on how, by using these data, the hydraulic model of the collection system was updated. The updated model is then used to report on CSO abatement compliance. The last sections describe how the model was used to establish both existing and baseline conditions and how it will be used, later in the WMP process, to assist in the development and evaluation of further CSO reduction alternatives.

A map of the collection system showing the pump stations and WWTFs is provided for reference in Figure 4.1 (Note: All figures are located following text.)

4.2 2008 Monitoring Program

An extensive rainfall and flow monitoring program was undertaken in 2008 as part of the WMP. The program, performed by Flow Assessment Services, L.L.C., of Bedford, New Hampshire, included a combination of rainfall gauges, CSO and pump station metering coupled with the installation of temporary and permanent collection system flow meters.

The program was developed with three intended purposes:

- Establish a hydraulic water balance in, and around, the combined portions of the collection system.
- Track progress with respect to CSO abatement program recommended as part of the 2005 LTCP.
- Provide data to update the collection system hydraulic model that was previously updated and used for the 2005 LTCP.

A summary of the entire program is contained in the following report: "Portsmouth, NH Continuous Flow Monitoring Report, March 2008 to September 2008", prepared by Flow Assessment Services, L.L.C., dated October 6, 2008 (submitted under separate cover).

The 2008 monitoring program was structured around a similar program that was conducted in 2000 as part of the 2005 LTCP with some of the flow meters placed in the exact or nearly exact location for both programs. Figure 4.2 shows the location of metering sites that were used in the 2008 program, including the ongoing CSO meters and key pump stations. The location of the 2000 program flow meter sites is also shown. Where the same two locations were utilized for both the 2000 and 2008 programs, the same designated meter number was utilized.

The pump station data was collected from the existing magnetic meters from the three largest stations that serve, or pump into, the combined collection system: Mechanic Street, Deer Street and Lafayette Road. The meter locations and time frame for the 2008 program are listed in Table 4.1.

Table 4.1 2008 Flow Metering Program Locations and Dates

Site	Location	Data Range	Meter
5	167 Lincoln Avenue	3/28/08 – 8/14/08	Area Velocity Meter installed in an existing 30-inch circular pipe.
6	Puddle Lane at Strawberry Banke	3/28/08 – continuous	Area Velocity Meter installed in an existing 30-inch circular pipe.
11	Ricci Lumber	3/28/08 – 8/21/08	Area Velocity Meter installed in an existing 36-inch circular pipe.
11A	Islington Street at Elm Court	8/15/08 – 8/27/08	Area Velocity Meter installed in an existing 15-inch circular pipe.
11B	33 Jewel Court	8/15/08 – 8/27/08	Area Velocity Meter installed in an existing 35-inch circular pipe.
11C	Islington Street at Columbia Street	8/15/08 – 8/27/08	Area Velocity Meter installed in an existing 15-inch circular pipe.
11D	Bartlett Street	8/15/08 – 8/27/08	Area Velocity Meter installed in an existing 10-inch circular pipe.
12	Maplewood Avenue	3/27/08 – 8/21/08	Area Velocity Meter installed in an existing 24-inch circular pipe.
13	Franklin Drive	3/27/08 – 8/14/08	Area Velocity Meter installed in an existing 20.6-inch circular pipe.
14	Islington Street Dirt Access Road	4/02/08 – 8/14/08	Area Velocity Meter installed in an existing 17.5-inch circular pipe.
14A	Islington Street Dirt Access Road	3/27/08 – 4/02/08	Area Velocity Meter installed in an existing 17.5-inch circular pipe.
15	Route 1 Bypass	3/27/08 – 8/14/08	Area Velocity Meter installed in an existing 10-inch circular pipe.
16	Pierce Island Road at Mechanic Street	8/21/08 – continuous	Area Velocity Meter installed in an existing 24-inch circular pipe.

Table 4.1 2008 Flow Metering Program Locations and Dates

Site	Location	Data Range	Meter
Rain1	Lafayette Road Pump Station	3/27/08 – continuous	Electronic tipping bucket type rain collector
Rain2	City Hall	3/27/08 – continuous	Electronic tipping bucket type rain collector

As noted, two of the collection system meters (Sites 6 and 16) became permanent meters as they are located in key junctures of the collection system between CSOs 010A/010B, the Deer Street PS force main terminus and the downstream Mechanic Street PS.

As shown on Table 4.1, the major portion of the 2008 program occurred over a 4-1/2 month period between March 28 and August 14. During this period, approximately 26.8 inches of precipitation was recorded. The Lafayette Road rain gauge recorded 26.2 inches while the City Hall rain gauge recorded 27.39. This slight difference in total rainfall is not unusual where two gauges are used, and particularly in the summer when high-intensity storms occur. Individual storm-specific differences were even greater.

An intensive, short-term program was also undertaken between August 15 and August 27 in the vicinity of metering Site 11 located on the Deer Street Interceptor off of Islington Street. The purposes of this focused program were as follows:

- Gain a better understanding of the inflow sources upstream of the Deer Street PS following recently-completed sewer separation and rehabilitation projects.
- More accurately predict inflow reduction, and more importantly CSO 013 activity reduction, following the completion of a pending sewer separation project in the Bartlett Street area off Islington Street scheduled for construction in late 2009/early 2010.

While CSO activity occurred, both prior to and following the 2008 monitoring program, TM 4 primarily addresses those events that occurred during the duration of the program when all collection system, CSO and PS meters where active. Figure 4.3 shows a plot of CSO activity during this period along with the rainfall hyetographs while Table 4.2 contains a summary of the activations at each CSO location. As noted, CSO 010A continues to be the most active of the three with 15 days of activation, about twice that of CSOs 010B or CSO 013.

Table 4.2 CSO Activation Summary

CSO	Activation Days	Dates
010A	15	April 28 and 29; May 4, June 11, 15, 20 and 23; July 18, 20, 21, 23, 24, 25 and 31; and August 6
010B	8	June 11, 15 and 23; and July 18, 20, 23, 25 and 31
013	6	June 15 and 23; and July 18, 20, 21 and 23

Seven events in particular were analyzed in detail, the same events were used to update the collection system model as described later in TM 4. The general statistics of these events are presented in Table 4.3.

Table 4.3 Overflow Statistics for Select Storms

Event			South Mill Pond				Deer St	
			CSO 010A		CSO 010B		CSO 013	
Dates	Rainfall (in)	Peak 15-Minute Intensity (in/hr)	Total Volume (MGal)	Peak Rate (MGD)	Total Volume (MGal)	Peak Rate (MGD)	Total Volume (MGal)	Peak Rate (MGD)
6/14/2008 - 6/15/2008	2.61	1.36	2.09	14.8	0.25	8.1	0.09	1.5
6/23/2008	1.43	1.34	0.72	12.5	0.22	7.9	0.18	3.4
7/18/2008	1.86	3.36	0.82	9.9	0.47	11.1	0.33	5.4
7/20/2008 - 7/21/2008	2.35	1.98	1.14	13.7	0.57	10.2	0.04	4.8
7/23/2008 - 7/25/2008	3.3	1.66	1.48	9.7	0.24	6.3	0.05	1.4
7/31/2008	1.03	1.24	0.34	6.8	0.002	1.2	0	0
8/6/2008	0.98	0.68	0.13	4.5	0	0	0	0

Plots for each of the seven events that were summarized in Table 4.3 are shown graphically in Figures 4.4 through 4.10. These plots not only show the CSO hydrographs and rainfall hyetographs, but the hydrographs from the collection system and pump station meters as well.

As shown in Table 4.3 and the subsequent figures, these seven events were driven by significant amount of rainfall, five of which had total volumes ranging from 0.98 inches on August 6 to 2.61 inches on June 14-15. Peak 15-minute intensities were also significant with a low of 0.68 inches/hour on August 6 to a high of 3.36 inches/hour on July 18. Overall, these rainfall events were significantly greater than those captured during the 2000 monitoring program.

With regards to the three overflows, CSO 010A had peak rates of discharge in the 12.5 to 14.8 MGD range while CSO 010B peaked in the 10.2 to 11.1 MGD range; CSO 013 had peaks in the 4.8 to 5.4 MGD range. The volume of discharge, however, do not appear to be significant with the largest recorded volume being 2.09 MGal from CSO 010A on June 14-5. All of the recorded volumes from CSO 010B and 013 had highs in the 0.5 MGal range with the remaining volumes being significantly less.

Figure 4.11 shows the results of the intensive metering that occurred around Site 11 on the Deer Street Interceptor off Islington Street. As shown on Figure 4.12, these included metering Sites 11A, 11B, 11C and 11D. These plots clearly reveal that the vast majority of the inflow observed at Site 11 was emanating from Site 11B, the area earmarked for sewer separation beginning in the fall of 2009. It also revealed that previous rehabilitation and separation work upstream of Site 11, as plotted as Site 11A, were successful in reducing the rate of upstream inflow. These findings will play a key role as alternatives are developed and evaluated for CSO 013 for the 2010 LTCP Update.

4.3 CSO Abatement Activities Following 2005 LTCP

The City of Portsmouth has been very active with respect to CSO abatement activity, both prior to and following the completion of the 2005 LTCP, including a number of ongoing projects. The City has spent more than $25 million since 1997 on CSO abatement activities.

Figure 4.13 shows the location and extent of the sewer separation and pump station upgrade projects which were constructed from 2000 through 2006 and what is currently in design and ready for construction. Completed or pending sewer separation projects are listed in Table 4.4 along with their linear footage of project length.

Table 4.4 Completed and Pending Sewer Separation Projects

Project	Project Length	Alternative Designation	Status
Thaxter/Fells	4,900 ft.		Completed
Court St. – 1			Completed
Court St. – 2			Completed
Pleasant Point			Completed
South St.	2,200 ft.		Completed
Borthwick Interceptor			Completed
Brackett Rd.	2,200 ft.		Completed
Contract #1	3,600 ft.	Lincoln Ave. #1	Completed
Dennett St.	1,700 ft.		Completed
Contract #2	3,200 ft.	Lincoln Ave. #1A	Completed
State St.			Bid in 2009
Bartlett	3,325 ft.	Islington St. #1	Bid in 2009
Area 3-1	6,500 ft.	Lincoln Ave. #2,	Bid in 2010
Cass Area	3,100 ft.	Islington St. #2	Bid in 2011
Area 3-2	8,000 ft.	Lincoln Ave. #2A, 3 and 3A	TBD
Area 3-3	5,900 ft.		

The completed projects for Mechanic Street and Deer Street PSs were intended to bring both stations up to their previously-anticipated peak design capacity.

4.4 Collection System Model Overview

The objectives of the hydraulic modeling were to:

- Estimate the effectiveness of the collection system improvements completed between 2000 and 2006 in reducing CSO discharges (see Section 4.3).
- Estimate the impact of the planned sewer separation projects on CSO reductions.
- Support the evaluation of further CSO reductions.
- Support the evaluations involving rerouting of dry- and wet-weather flows as part of the overall Master Plan.
- Evaluate the capacity of the collection system under current and future conditions.

The collection system hydraulic model used for this 2009 LTCP Update is based upon the model that was developed and used during the development of the 2005 LTCP. The PCSWMM 2009 software was used to perform the hydraulic modeling. PCSWMM 2009 relies on the U.S. Environmental Protection Agency (EPA) Storm Water Management Model (SWMM) version 5 as a modeling engine. A map of the sewer model is shown in Figure 4.14.

The flows for the hydraulic model were developed using Brown and Caldwell's Capacity Assurance Planning Environment (CAPE) software. This is the same software that was used to develop the region-wide flows projections presented in TM 3, Flows and Loads – Existing and Forecasted Conditions. After developing the flows, CAPE generated flow files which were imported into the PCSWMM model for routing.

4.5 Collection System Model Updates

For purposes of clarity, the updated model will be referred to as the *Y2008 Model* while the model used by the 2005 LTCP will be referred to as the *Y2000 Model;* 2000 and 2008 are the years in which flow metering data were collected to calibrate the two models.

The updates that were incorporated into the Y2008 Model are summarized below:

- Converted the hydraulic model from SWMM version 4.4GU to PCSWMM 2009 (SWMM version 5).
- Georectified the manhole coordinates.
- Increased the Deer Street PS capacity from 9 to 10[1] MGD to reflect improvements completed in 2007.
- Increased the Mechanic Street PS capacity from 18.5 to 21 MGD to reflect improvements completed in 2008.
- Modified pipes and manholes to account for changes in the collection system as a result of the sewer separation projects and added a relief line from Lincoln/Richards Avenue to Parrott Avenue.
- Dry- and wet-weather flows were updated to 2008 conditions using CAPE. The calibrations were performed using the flow meter and rain gauge data measured during the spring/summer 2008 (see Section 4.2).

4.5.1 Flow Calibration

The dry- and wet-weather flows for the Y2008 Model were calibrated using rainfall and flow data collected during the 2008 monitoring program. A comparison of the measured versus calibrated model flows at CSO 010A and 010B are presented in Figures 4.15 through 4.21. Because these CSOs are co-located and hydraulically interdependent, the sum of the CSO 010A and CSO 010B hydrographs are presented together in the subsequent figures. A comparison of the measured versus calibrated model flows at CSO 013 is presented in Figures 4.22 through 4.25. Tables 4.5 and 4.6 provide a summary of the calibration for the CSO events which occurred from June 1–August 30, 2008, for CSO 010A/010B and CSO 013, respectively. The volumetric difference between the

[1] The peak flow capacity of the pump station is 12.6 MGD, but is being operated at a peak flow capacity of 10 MGD due to downstream system capacity limitations.

measured and simulated events for CSOs 010A/010B is less than 1 percent while the modeled volume for CSO 013 was about 17% higher than measured.

Table 4.5. Comparison of Measured versus Calibrated Model Flows South Mill Pond CSOs (010A/010B)

Date	Rain (in)	Measured		Calibrated Model Flow	
		Peak Flow (MGD)	Volume (MGal)	Peak Flow (MGD)	Volume (MGal)
6/11/2008	0.61	12.17	0.21	0	0
6/15/2008	2.61	17.91	2.33	16.51	2.27
6/20/2008	0.23	1.98	0.03	0	0
6/23/2008	1.39	20.83	0.93	17.18	1.13
7/18/2008	1.85	24.72	1.29	22.55	1.36
7/20/2008	2.29	27.09	1.72	27.93	2.35
7/23/2008	3.30	20.28	1.73	8.46	0.74
7/31/2008	1.03	10.47	0.34	9.68	0.58
8/6/2008	0.96	4.88	0.13	4.16	0.34

Table 4.6. Comparison of Measured versus Calibrated Model Flows Deer St CSO (013)

Date	Rain (in)	Measured		Simulated (Y2008 Model)	
		Peak Flow (MGD)	Volume (MGal)	Peak Flow (MGD)	Volume (MGal)
6/15/2008	2.61	1.59	0.09	2.30	0.08
6/23/2009	1.39	4.15	0.18	3.65	0.08
7/18/2008	1.85	6.33	0.33	8.27	0.37
7/20/2008	2.29	5.92	0.39	8.45	0.69
7/23/2008	3.30	1.71	0.05	0.00	0.00

4.6 CSO Reductions from System Improvements (2000 to 2006)

As discussed in Section 4.3, the City has performed numerous system improvements aimed at reducing CSO activations. This section estimates the impacts of these improvements on the CSOs.

4.6.1 Simulating Flows for Spring/Summer 2008 with the Y2000 Model

The Y2000 Model represents the conditions in the collection system that existed before the improvements discussed in Section 4.3 were completed. The Y2000 Model was run using rainfall from the 2008 monitoring period. The simulated flows from the model were then compared against measured flows from the 2008 monitoring period. In this manner, it was possible to estimate the level of CSO reduction directly attributable to the system improvements. The results are summarized in Table 4.7.

Table 4.7 Estimated Impact of System Improvements on CSOs during Summer 2008[1]

Location	Volume (MGal)			Number of activations		
	Before system improvements[2]	After system improvements	% Reduction	Before system improvements[2]	After system improvements	% Reduction
South Mill Pond CSOs (010A/ 010B)	9.7	8.8	9%	8	8	0
Deer St CSO (013)	5.2	1.0	81%	8	5	38%
Flooding	14.3	1.9[3]	87%	N/A	N/A	N/A
Total	29.2	9.8	66%	16	13	19%

Notes:

1. Covers period from June 1, 2008 – August 31, 2008
2. Estimate developed by running the Y2000 Model with rainfall from the 2008 monitoring period.
3. Flooding estimate based on differences between flows measured at flow meter 16 and the Deer Street Pump Station.

The analysis found that significant flooding would have occurred during the summer of 2008 if the system improvements had not taken place. It is estimated that 14.3 MGal would have been discharged from the collection system. Measurements during that period of time indicate that less than 2 MGal of flooding occurred representing a reduction of approximately 87%.

The analysis found a modest reduction of 9% in volumes discharged from CSOs 010A and 010B. The CSO discharges before the system improvements would have been higher if flows upstream had not been lost to flooding. This is often the case in CSO mitigation as system improvements must remove a certain threshold of flooding before downstream reductions at the CSO discharges can be realized. It appears that the City has crossed this threshold, at least for the magnitude of storms which occurred during the 2008 monitoring program; flow reductions achieved by future separation projects upstream of CSOs 010A/010B should translate into corresponding reduction on the CSOs.

The system improvements upstream of the Deer Street PS have significantly reduced overflow activity at CSO 013. Prior to the system improvements, it is estimated that 5.2

MGal would have been discharged from CSO 013 during the spring and summer of 2008. However, only 1 MGal was measured during that same period of time. This is more than an 80% reduction.

The number of activations at CSOs 010A/010B before and after system improvements remained unchanged. However, it appears that most of the benefits from the improvements upstream of these CSOs have come in the form of flooding mitigation. Further improvements are likely to reduce the frequency of activation.

The number of activation at CSO 013 has decreased due to system improvements. It is estimated that CSO 013 would have activated eight times during the summer of 2008 if the system improvements had not been performed, while only five activations were measured.

4.6.2 Typical Year CSO Statistics

The previous discussion demonstrated that significant CSO reductions have been achieved due to the system improvements. However, the discussion has so far only focused on the 2008 monitoring period. In order to develop a broader understanding of the CSO reductions, it is necessary to assess the reduction for typical year conditions.

The 2005 LTCP performed long-term simulations using the Y2000 Model to estimate the cumulative CSO volume, highest peak flow, and number of CSO events in a "typical" year. The typical year evaluation was performed by running the model using several years of rainfall and then analyzing the results to come up with averages for a typical year.

Because local, long-term rainfall records were not available, the 2005 LTCP used rainfall from the National Weather Service Durham, NH Station (NOAA 2001). This station had records from 1950–1998, but unfortunately much of the data was missing, or appeared to be inaccurate. Upon further review, it was determined that there were five years of good data which represented conditions close to average conditions. The years selected were 1968, 1988, 1989, 1990 and 1993. In particular, the total annual rainfall for these years was close to 44 inches per year.

Consequently, the 2005 LTCP performed long-term simulations using the Y2000 Model loaded with the five years with "average" rainfall conditions. The simulated flows were then analyzed to determine the typical year cumulative volume, the peak CSO flow and the number of CSO events. These results represent conditions before the system improvements described in Section 4.3 were completed. The results are shown in Table 4.8.

In order to estimate the typical year CSO statistics for conditions after the system improvements were completed, the Y2008 Model was run using the same five years of rainfall data. The simulated flows were then analyzed to calculate the typical year CSO statistics presented in Table 4.8.

Table 4.8 Estimated Typical Year CSOs Statistics

Condition	Cumulative CSO Volume (MGal)[3] South Mill Pond CSOs (010A/010B)	Cumulative CSO Volume (MGal)[3] Deer St CSO (013)
Before Improvements[1]	9.4	3.7
After Improvements[2]	4.4	0.5
Reduction	53%	86%

Notes:
1. Estimated typical year CSO statistics *before* the system improvements described in Section 4.3 were completed. Results from 2005 LTCP
2. Estimated typical year CSO statistics *after* the system improvements described in Section 4.3 were completed. Data developed from a long-term simulation performed using the Y2008 Model loaded with the same five years of rainfall data used by the 2005 LTCP long-term simulation
3. Values rounded to nearest 100,000 MGal.

The results of the long-term simulation indicate that the typical year CSO volume was reduced by approximately 53% at CSOs 010A/010B. These reductions are higher than the ones seen during the summer of 2008 because the storms were generally smaller in magnitude and did not result in as much flooding.

The estimated volume discharged from CSO 013 in a typical year is estimated to have been reduced by 86% due to the system improvements. This reduction is similar to the reduction estimated for the summer of 2008.

In addition to the 8.2 MGal volumetric reduction in typical year CSO discharges there is also a corresponding reduction in pollutants. Using 150 mg/L as a typical total suspended solids concentration would equate to roughly 10,500 pounds of solids that are no longer discharged, untreated, to the Piscataqua River and South Mill Pond in a typical year. Also associated with these solids are fractions of organic nitrogen, particulate phosphorus and heavy metals. Thus, the improvements made to the Portsmouth collection system have had positive and measurable impact to the area receiving waters.

4.7 Forecasted CSO Reductions from Planned Projects

The analysis presented in this section provides an estimate of how the previously-discussed system improvements will impact the CSOs under future conditions. A different version of the Y2008 Model was created to forecast these impacts and will be referred to as the *Y2014 Model* where the 2014 indicates the anticipated year when the City's currently planned system improvements will be completed.

The conditions represented by this model will be referred to as *baseline* conditions because the City is committed to completing the separation projects in the near future. Accordingly, the alternative evaluations will use this model as a starting point, or *baseline*, for evaluating alternatives.

The wet-weather flows parameters upstream of CSO 013 were adjusted to reflect impacts of the future separation projects. The wet-weather parameters were adjusted based on information gleaned from the intensive flow metering that occurred around Site 11. That data indicated that significant wet-weather flow emanates from the area upstream of Site 11B. Future projects will separate this portion of the system, which should result in a significant reduction of wet-weather flows to the DSPS. The wet-weather parameters were adjusted accordingly.

The wet-weather flow parameters upstream of CSOs 010A and 010B were adjusted based on the effectiveness of the projects which took place between 2000 and 2006. The reduction in the wet-weather parameters during this period were then extrapolated to the conditions represented by the baseline model.

The results of simulating the five years of average rainfall with the 2014 Model are shown in Table 4.9. It is estimated that the volume discharged from CSOs 010A and 010B during a typical year after the planned separation projects will be 2.1 MGal. This represents a further 2.3 MGal/year reduction from the estimated value of 4.4 MGal under current conditions (see Table 4.8). It is estimated that CSO 013 will not be active during a typical-year after the planned separation projects are completed.

Table 4.9 Estimated Typical Year CSO Statistics after Current Planned Improvements[1]

Location	Cumulative CSO Volume (MGal)
South Mill Pond CSOs (010A/010B)	2.1
Deer St CSO (013)	0

Notes:
1. Estimated typical year CSO statistics *after* the planned system improvements described in Section 4.3 are completed.

Figure 4.26 presents a comparison of the estimated typical year CSO discharges before system improvements, under current conditions, and after the planned system improvements are completed.

4.8 Compliance with Regulatory Requirements for CSO Reduction

The City of Portsmouth has been diligently implementing the recommendation of the 2005 LTCP. These have included the several sewer separation projects listed in Table 4.4 along with the upgrade of the Mechanic Street and Deer Street PSs. In addition to these capital projects, the City has been continuously monitoring the discharges at CSOs 010A, 010B and 013 and has continued its Nine Minimum Controls (NMC) program activities.

With regards to NMC, the City submitted its initial NMC documentation plan to EPA and DES in January 1997 in accordance with the requirements of the EPA CSO Control Policy; an update was submitted in August 2002. The City also submitted a CSO Status Report to the agencies in June 2004. These two NMC documents, and the 2004 status report, were completed prior to the 2005 LTCP; consequently, the 2010 LTCP Update will contain a complete update of the City's CSO abatement program from a historic perspective. Finally, as required by the City's NPDES Permit, the City also submits a brief annual CSO status report to EPA and DES which includes a statement of completed and planned projects and related collection system management activities that occurred during the reporting period.

As described earlier in this TM, the projects recommended in the 2005 LTCP that have been completed to date, and ongoing NMC activities, have had a very positive effect on CSO reductions. Using the updated collection system model, the 2010 LTCP Update will evaluate what additional CSO reduction measures will be required to bring the collection system into compliance with the applicable laws and regulations that were described in TM 2, Regulatory Requirements Review, and as set forth in the 2005 LTCP: the 1-year level of control. It should be noted that since the completion of TM 2 in October 2007, the City has entered into a Consent Decree (CD) with EPA. The CD reaffirms the requirement to update the 2005 LTCP as part of the WMP, complete the planned sewer separation work, and to continue implementing applicable NMC activities.

With respect to future CSO abatement measures emanating from the 2010 LTCP Update, it is important to note that because the WMP is addressing both the collection system, or CSOs, in addition to the upgrade of the Peirce Island WWTF to secondary treatment, these two components of the WMP are closely linked and need to be viewed in a comprehensive, systemwide manner. For example, if the new secondary WWTF is located on a site other than Peirce Island, this would free up advanced-primary treatment capacity for additional CSO treatment. Further, the timing of such relocation would impact the schedule for the potential additional CSO treatment. Finally, this additional treatment at Peirce Island could possibly be considered what was referred to in the 2005 LTCP as the "Plus Project"; the project or series of projects that would be required following the completion of the targeted sewer separation and PS upgrades in order to meet the desired level of CSO control.

One final point relative to the tracking of future compliance is the requirement for the development of a Post Construction Monitoring Plan (PCMP). The PCMP, required by the recently-enacted CD, will be prepared and made part of the 2010 LTCP Update and will include monitoring, modeling and related activities aimed at tracking the performance of the recommended CSO abatement facilities and programs as they become operational. This formal process for tracking compliance will be a valuable tool for the City of Portsmouth as it will provide a means of both modifying operation of the collection and treatment system as well as revising the nature and schedule of future capital expenditures. In essence, the PCMP will allow the City to make decisions on future abatement activities based on the documented effectiveness of what was previously constructed, all with the intended purpose of working toward attaining the CSO control levels that will be negotiated as part of the 2010 LTCP Update and overall WMP.

4.9 Collection System with 2030 Development Conditions

The Y2014 Model was updated to incorporate the 2030 population and employment forecasts discussed in *Technical Memorandum 3: Flows and Loads – Existing and Forecasted Conditions (TM3).*

TM3 identified three different employment growth scenarios: low (0.5%), medium (1.0%), and high growth (2.0%). The medium-growth scenario was incorporated into the 2014 Model. Under this scenario, sanitary flows to the Peirce Island WWTF are forecasted to increase from current levels of approximately 2.6 MGD to 3.1 MGD by the year 2030.

It was assumed that I/I will remain at the levels forecasted for the 2014 Model. This assumption is consistent with the ones used in TM 3 and is based upon the consideration that the City will likely continue to reduce the amount of extraneous flows entering the City's collection system. At the same time the system will continue to age and deteriorate with time, and that this will lead to more wet-weather flow entering the system. As a result, it is assumed that these two effects will balance the other so that rates of I/I remain relatively unchanged during the planning horizon.

Dry-weather flow simulations performed using the Y2014 Model with 2030 development conditions did not find any areas with insufficient capacity to handle the modest growth in flows due to population and employment growth.

Simulations using the five years of average rainfall indicate that CSO 013 will remain inactive during an average year while volumes discharged from CSOs 010A/010B will increase only slightly.

4.10 Planned Uses of Updated Model in Master Plan Completion

The updated collection system model will be an extremely valuable tool for the completion of the 2010 LTCP Update and overall WMP. Its primary use will be to assist in the development and evaluation of alternatives for additional CSO abatement if deemed necessary. Specifically, it will be used to determine the optimal combination of additional targeted sewer separation and/or rehabilitation projects and what was referred to in the 2005 LTCP as Plus Projects. The latter were various satellite treatment and/or storage facilities in the vicinity of the CSOs 010A, 010B and 013 outfalls.

What was not considered in the 2005 LTCP, but will be a significant consideration in the 2010 LTCP Update, is the potential exclusive availability of the advanced-primary Peirce Island WWTF for CSO treatment. This possibility would result if the new secondary WWTF is recommended for an off-island site. With this scenario of the Peirce Island WWTF being used exclusively for CSO treatment, the updated model will be used to evaluate what additional facilities and/or system modifications would be needed in order to maximize this available treatment capacity. For example, preliminary modeling revealed that even if excess capacity were available at the Peirce Island WWTF, sufficient rates of additional CSO flow could not reach the Mechanic Street PS due to hydraulic bottlenecks in the collection system along Parrott Avenue and Marcy Street. Thus, the model will be used to assist in determining the optimal means of debottlenecking the collection system between CSOs 010A and 010B and the downstream PS. Three alternatives will be evaluated: a new parallel line, up-sizing the existing line and a deep tunnel.

The model will then be used to determine the benefits of over-sizing the new line in order to gain a degree of in-system storage; such storage could be the difference between attainment or non-attainment of the 1-year level of CSO control from the 2005 LTCP.

Finally, in parallel with the evaluation of the WWTF upgrade components of the WMP, the model will be used to predict future CSO reductions over the negotiated implementation schedule. For example, the new WWTF would be implemented over a period of time as flow is redirected to the new site through PS upgrade and force main construction projects. There will be several PSs and associated force mains that would be involved in the redirection of flow from the Deer Street and Mechanic Street PSs toward the new WWTF. In addition to these two major PSs, the Gosling Road and Lafayette Road PSs would also be included in the mix along with possibly other smaller stations.

There would also be the need for a new dry-weather Mechanic Street PS to continually redirect dry-weather flow to the Deer Street PS for subsequent pumping to the new WWTF site; the existing Mechanic Street PS would be converted to wet-weather use only. A new diversion structure would be constructed to direct excess flow, beyond the capacity of the new dry-weather Mechanic Street PS, to the existing or what will become the dedicated wet-weather Mechanic Street PS.

The updated model will also be used to evaluate similar CSO reduction alternatives for CSO 013 in the vicinity of the Deer Street PS. Of primary importance will be to evaluate the effect of the pending sewer separation project in the Islington Street area along the Deer Street Interceptor with respect to reduction of CSO 013 activity. As described earlier in this TM, that portion of the 2008 monitoring program that focused on the Deer Street Interceptor/Islington Street area (metering Site 11) revealed that a significant portion of the inflow entering the interceptor originates from the area to be separated; the updated model will be used to confirm the level of reduction anticipated at CSO 013. As with CSOs 010A and 010B, the model will then be used to assist in the evaluation of alternatives that may be necessary beyond this separation to bring CSO 013 into compliance with the 2005 LTCP 1-year level of control.

As demonstrated, there are a number of completed, ongoing, and planned parallel activities that will impact the updated LTCP and overall WMP. Further, the sequence of the construction of the new secondary WWTF and associated PS and force main components will have a direct bearing on two critical WMP parameters:

- Percentage of dry-weather flow that is receiving secondary treatment.
- Percent-reduction in annual CSO discharge volume.

The updated model will allow for the accurate projection of both of these key parameters.

TECHNICAL MEMORANDUM #4
FIGURES

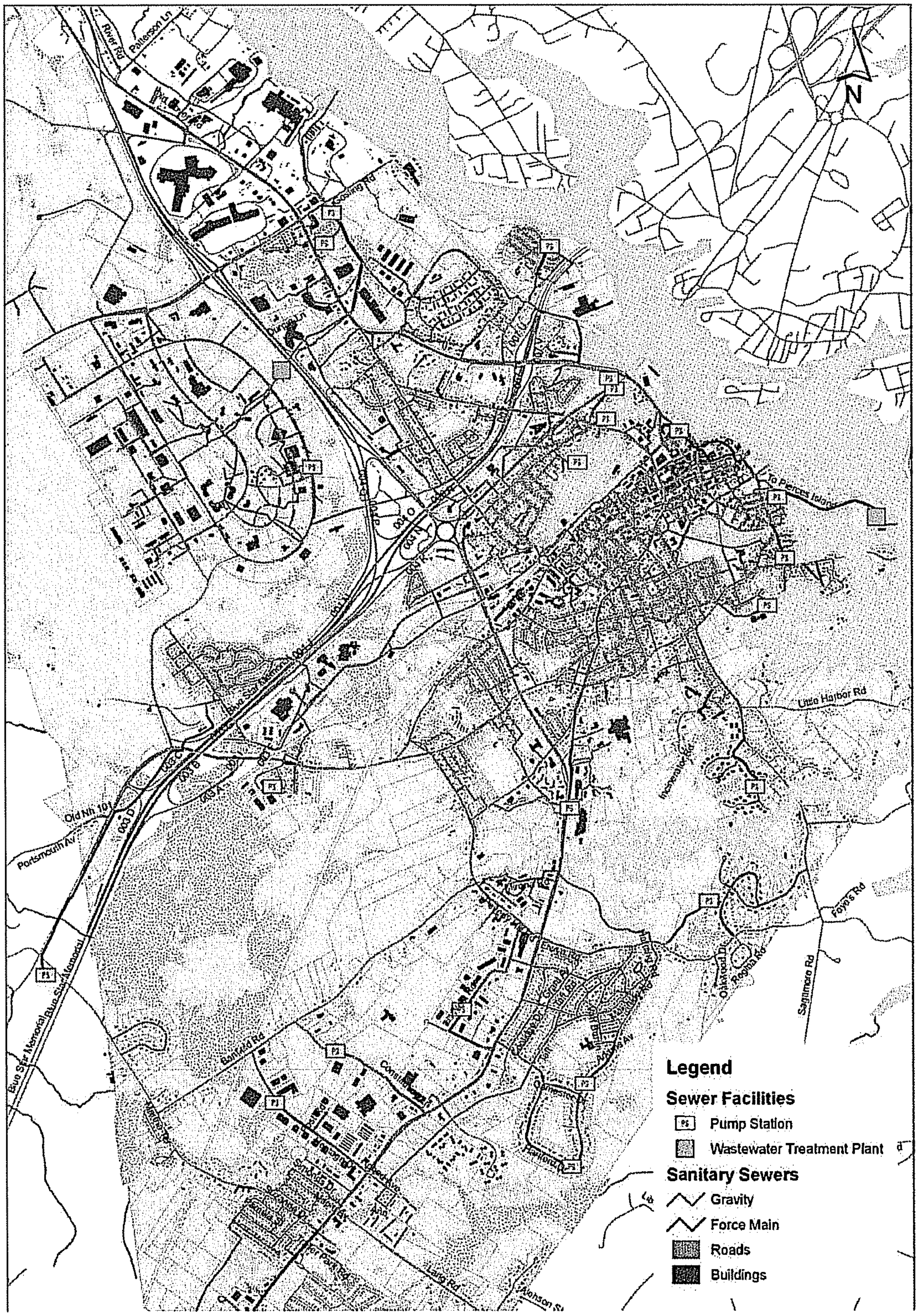

Figure 4.1 Collection System

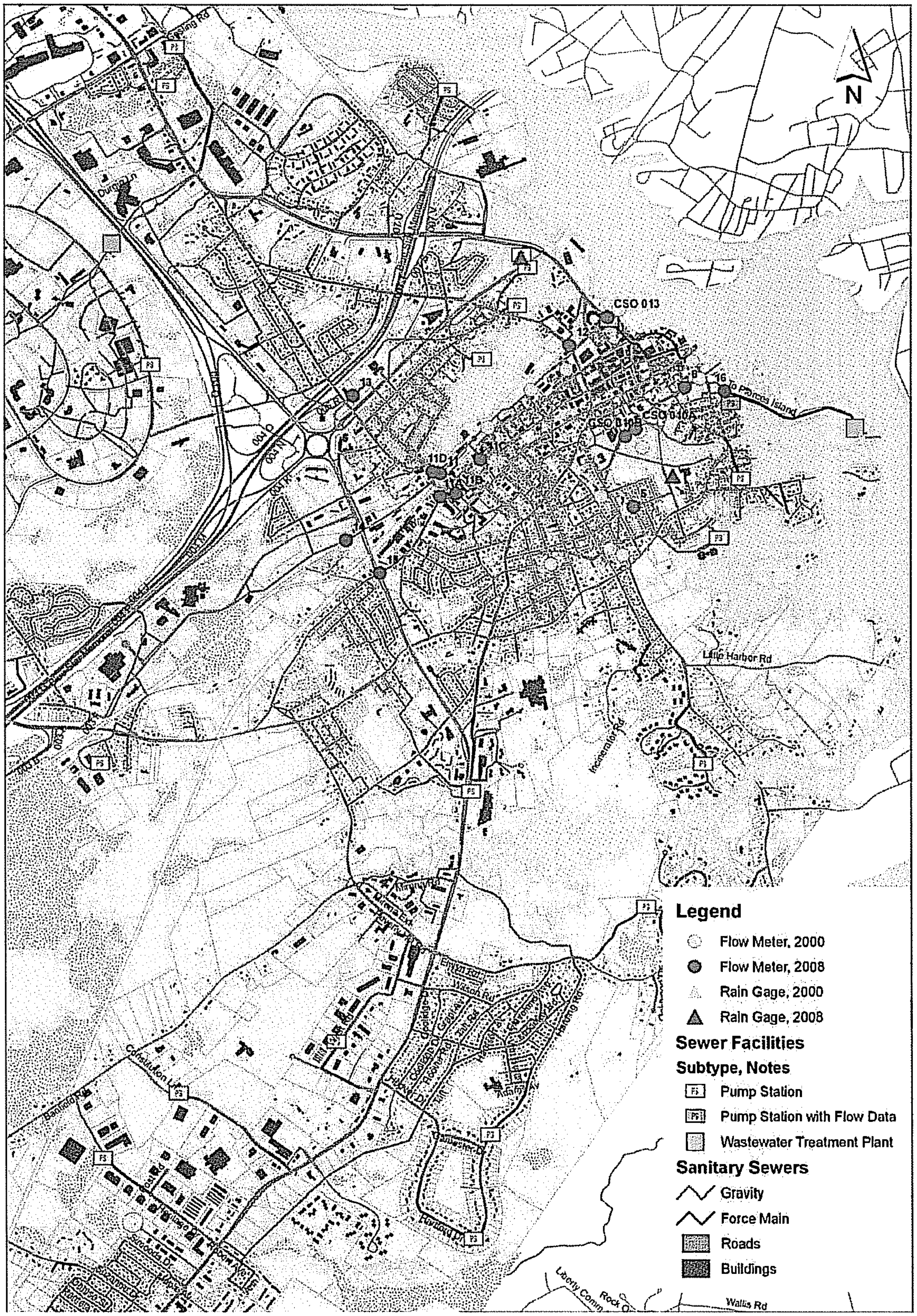

Figure 4.2 Flow and Rain Monitoring Locations

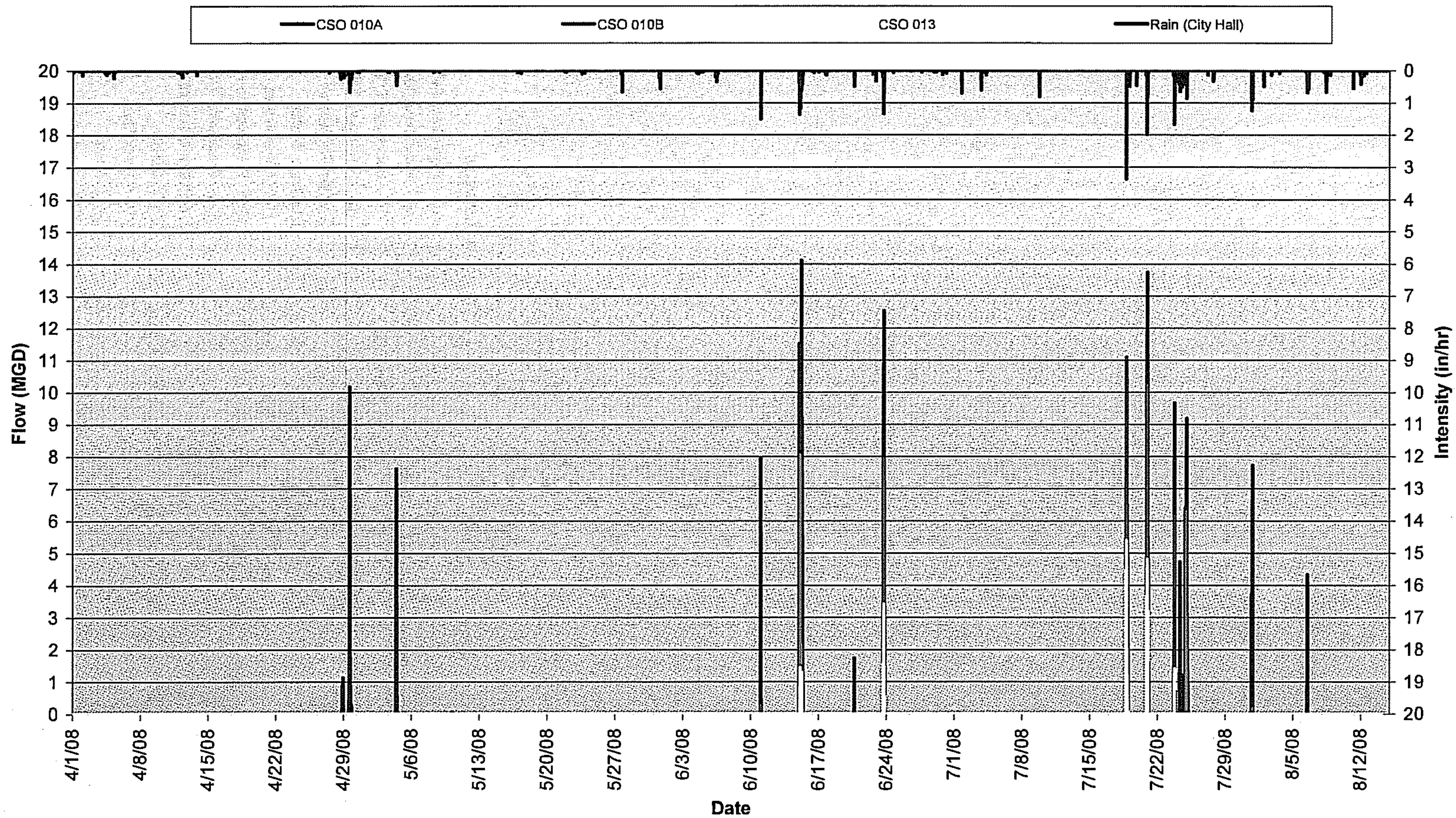

Figure4-3. CSO Activation During Flow Metering Period

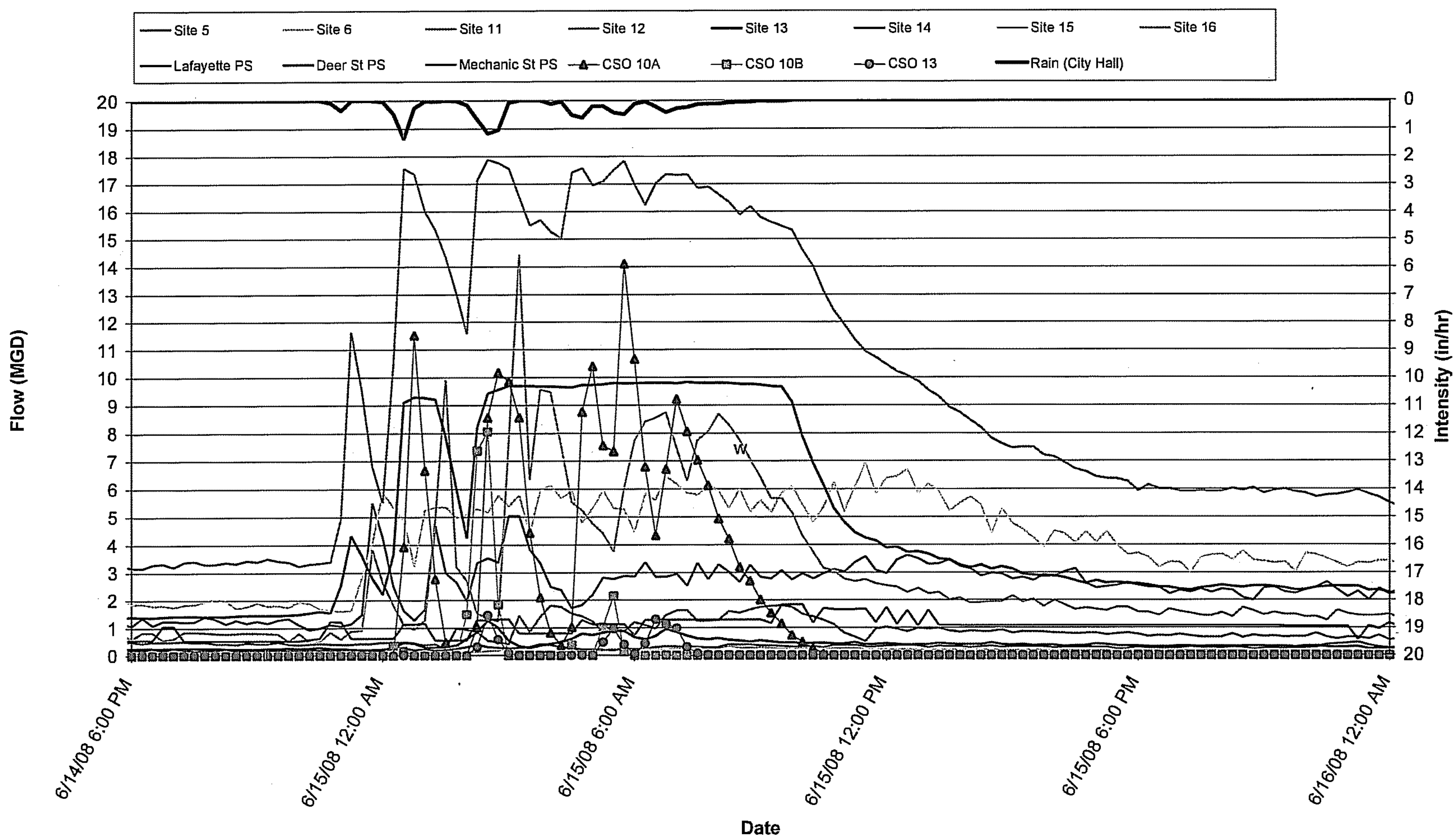

Figure 4.4. Storm of June 15, 2008

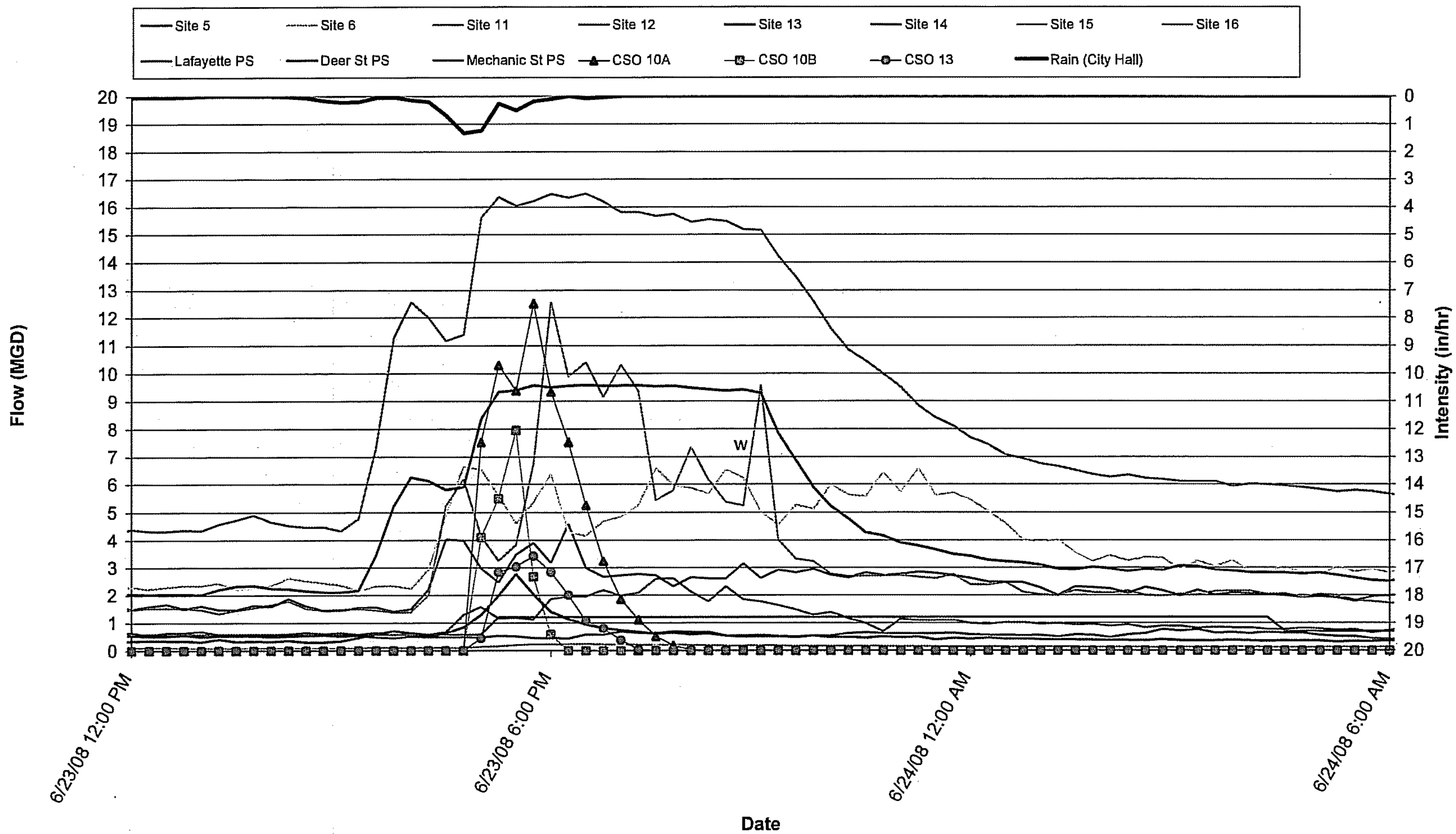

Figure 4.5. Storm of June 23, 2008

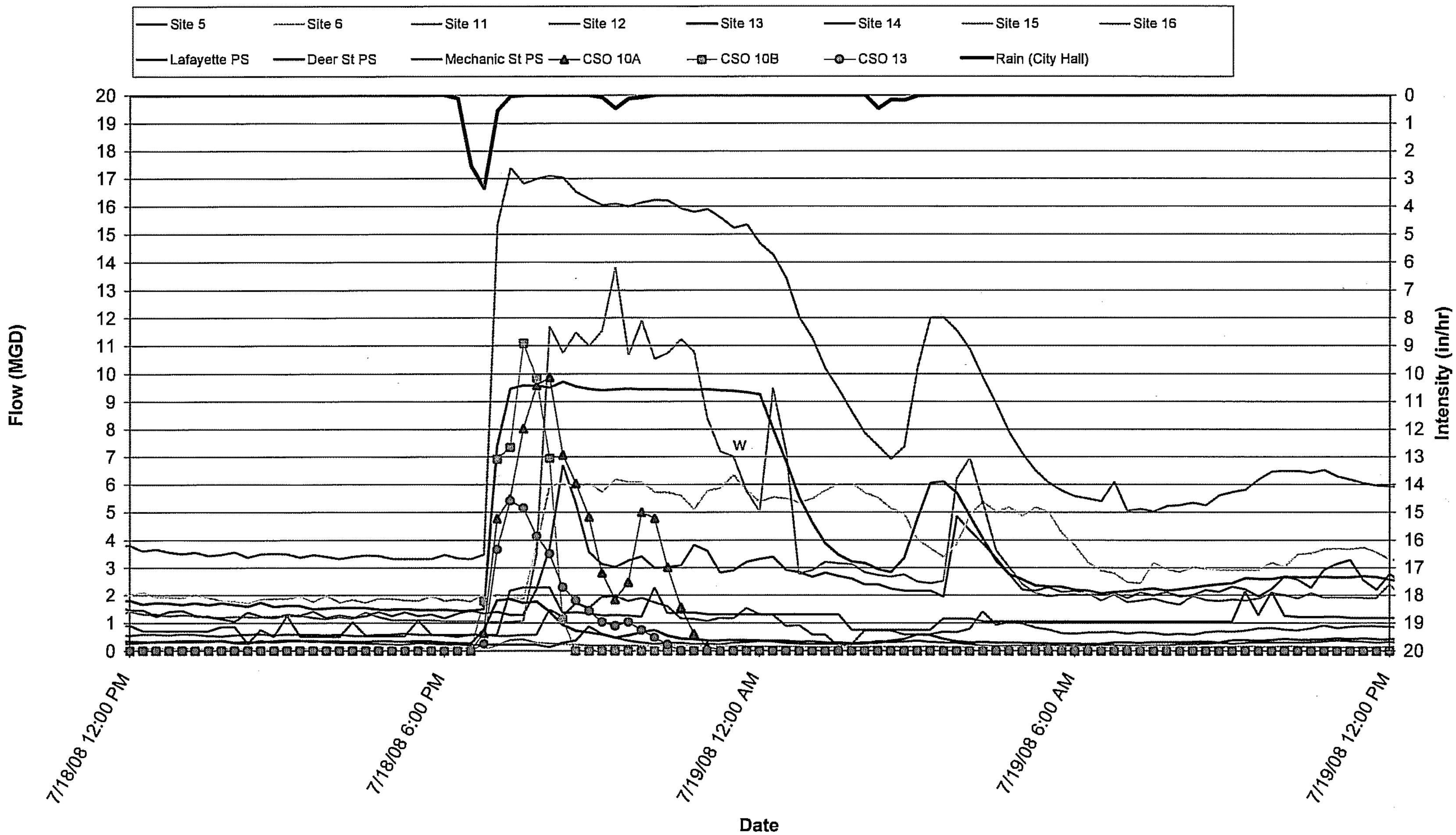

Figure 4.6 Storm of July 18, 2008

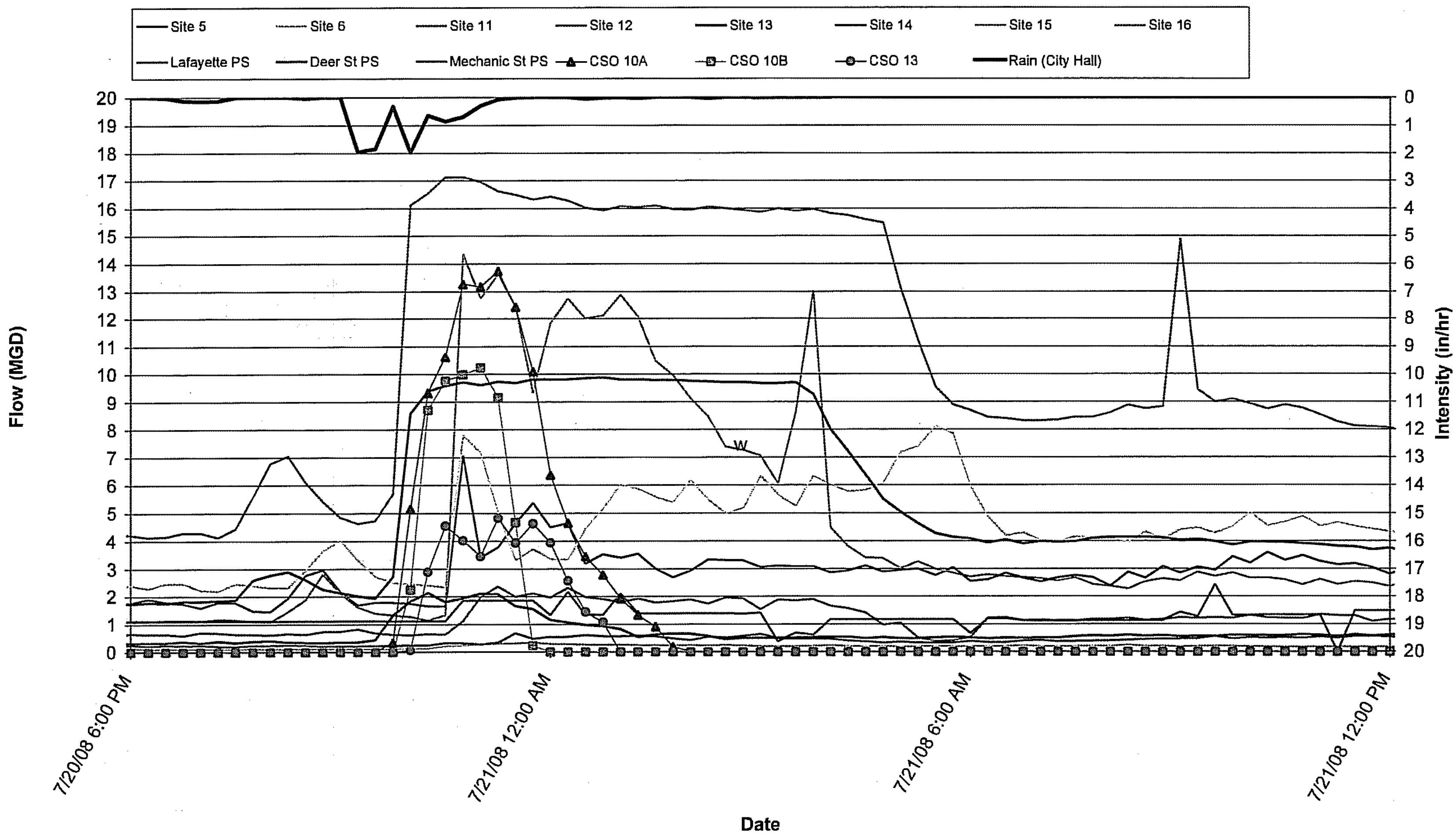

Figure 4.7 Storm of July 20, 2008

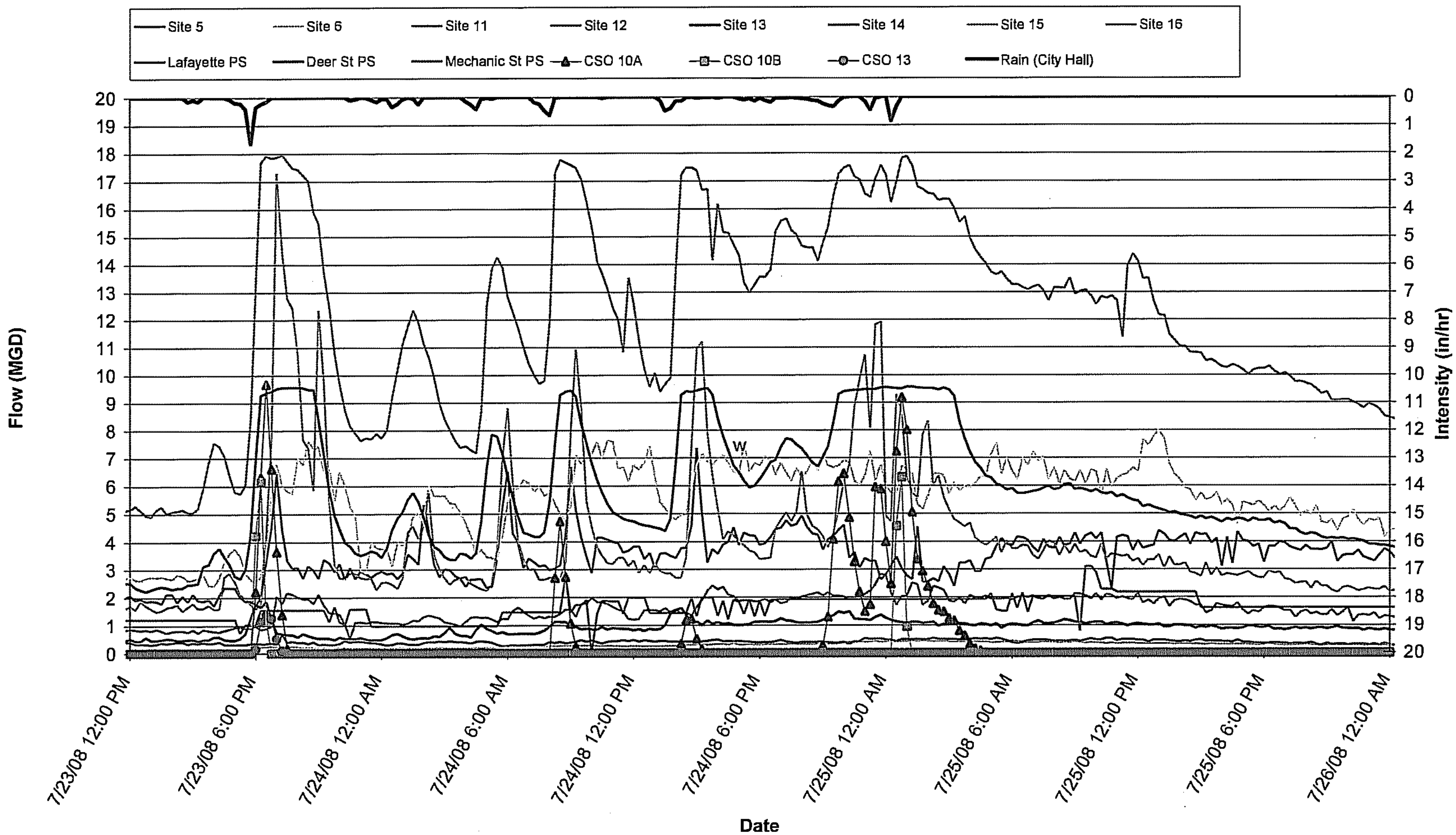

Figure 4.8 Storm of July 23, 2008

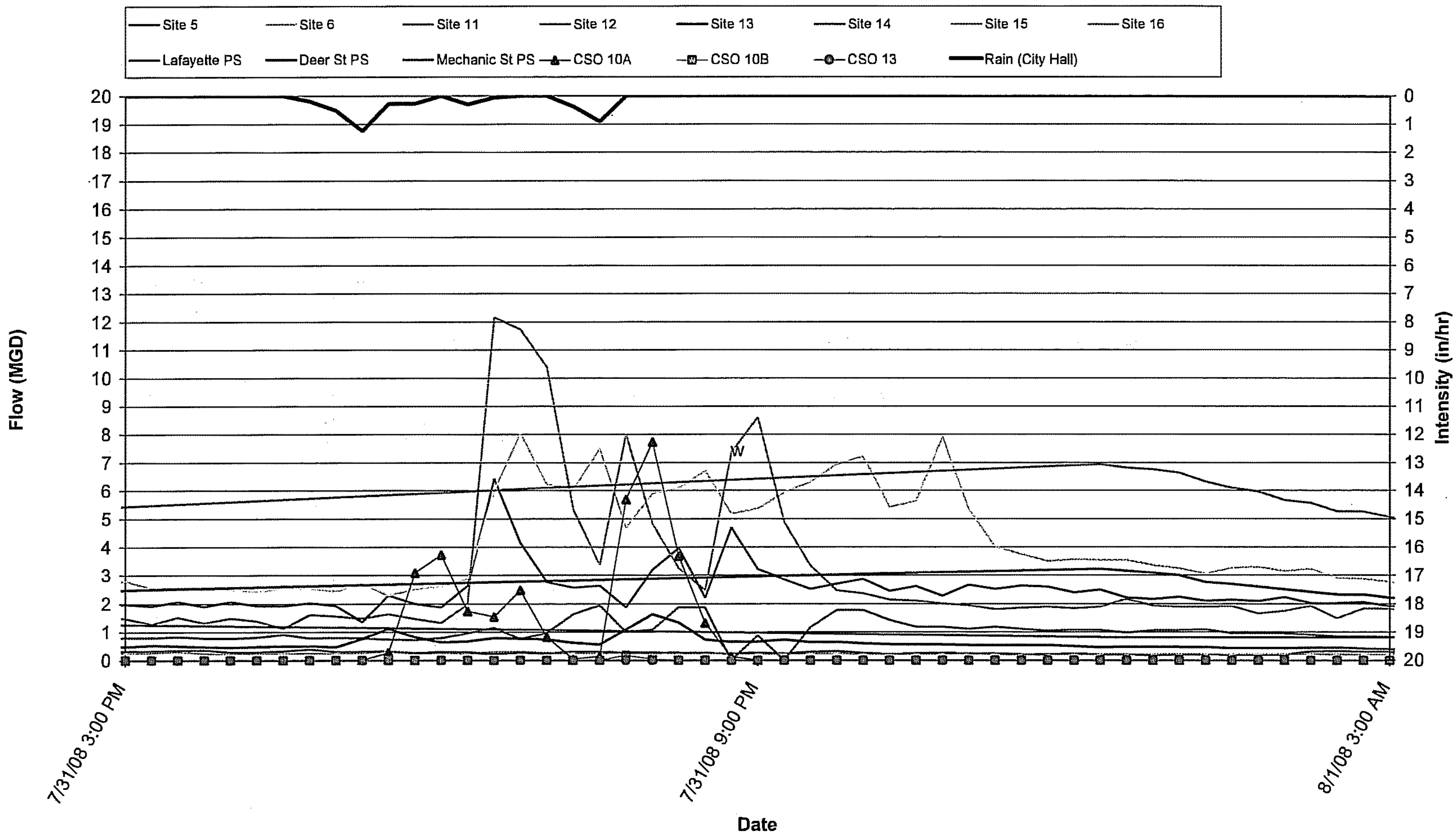

Figure 4.9 Storm of July 31, 2008

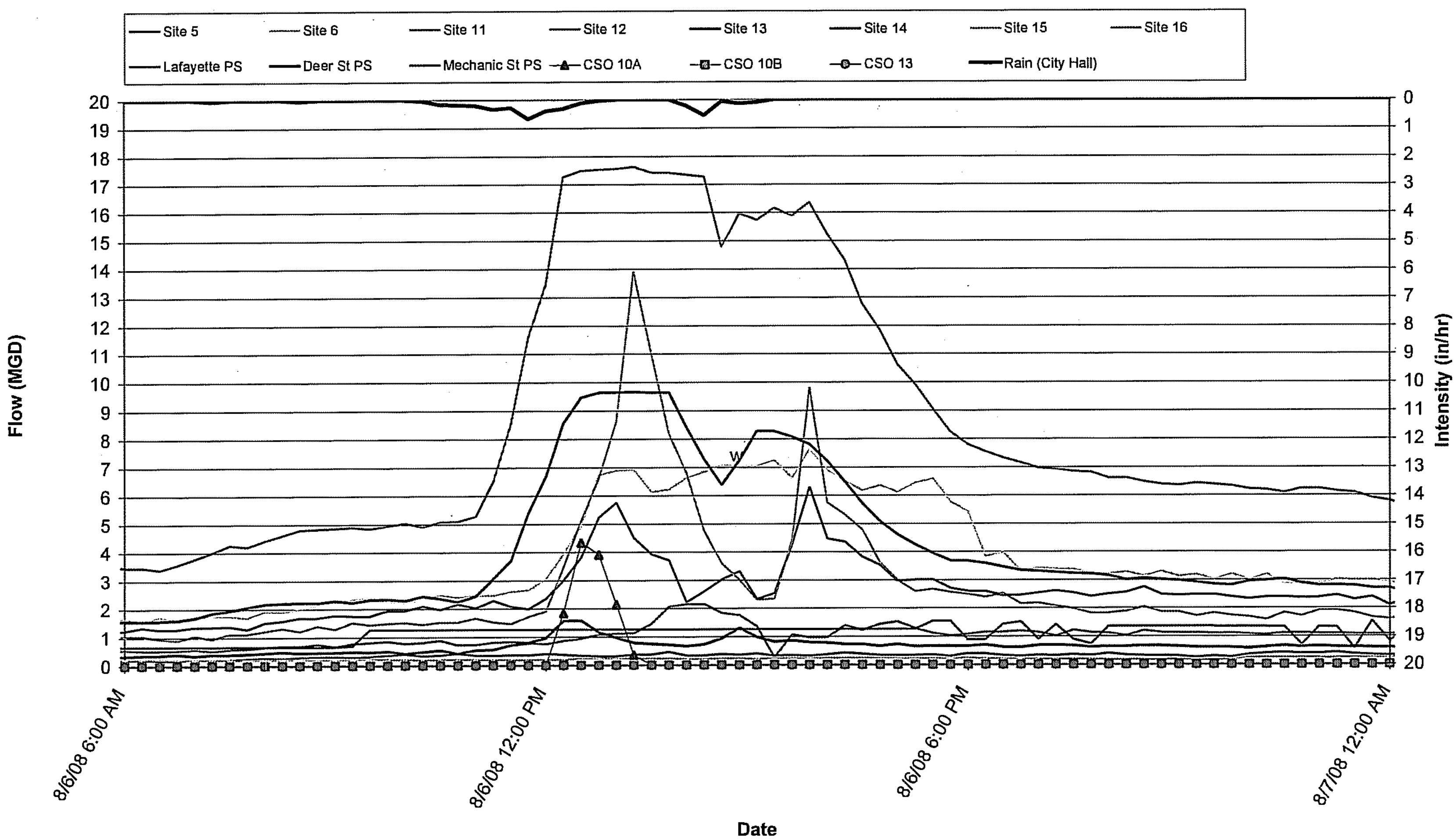

Figure 4.10 Storm of August 6, 2008

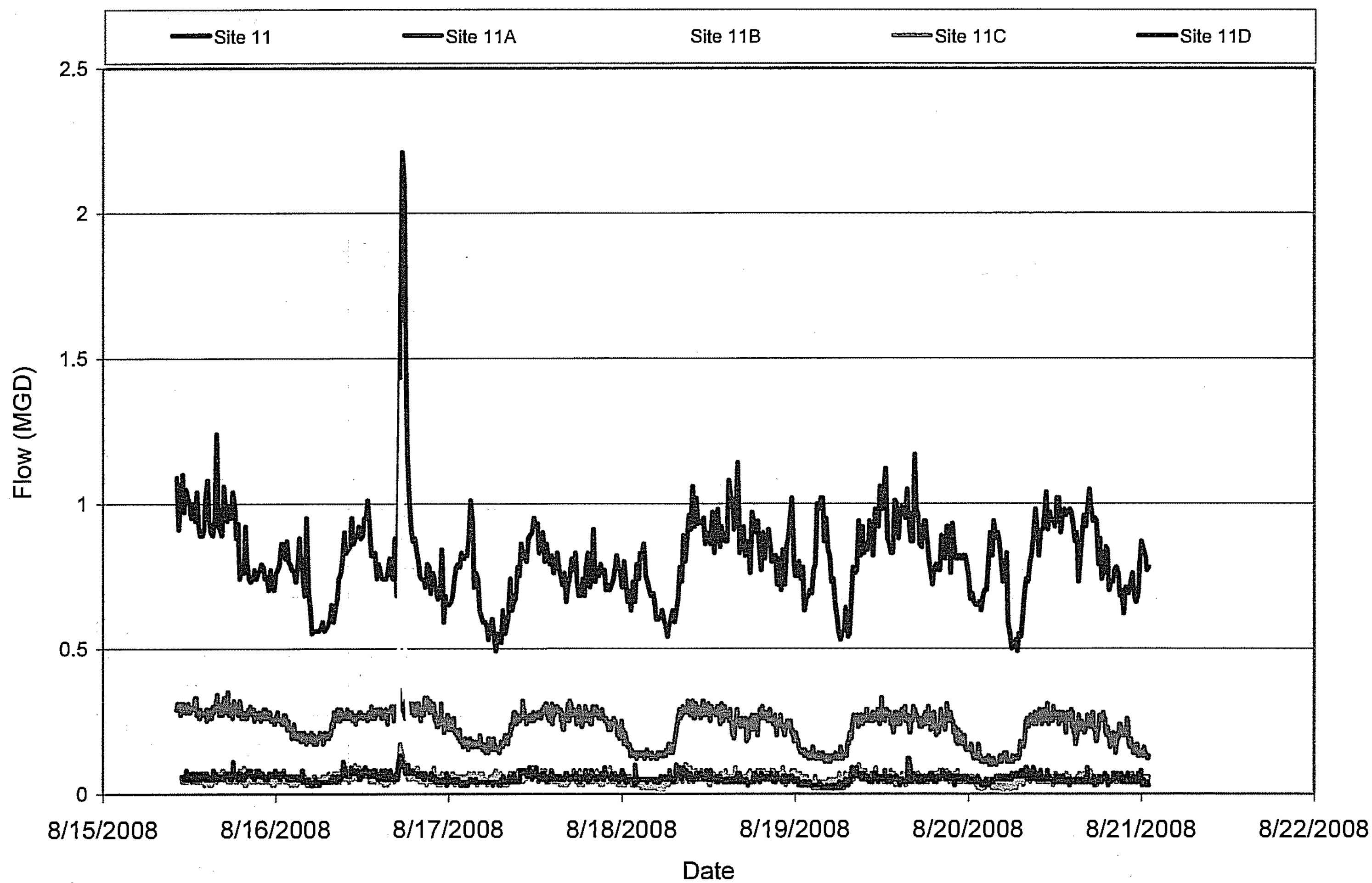

Figure 4.11 Site 11 Intensive Metering Results

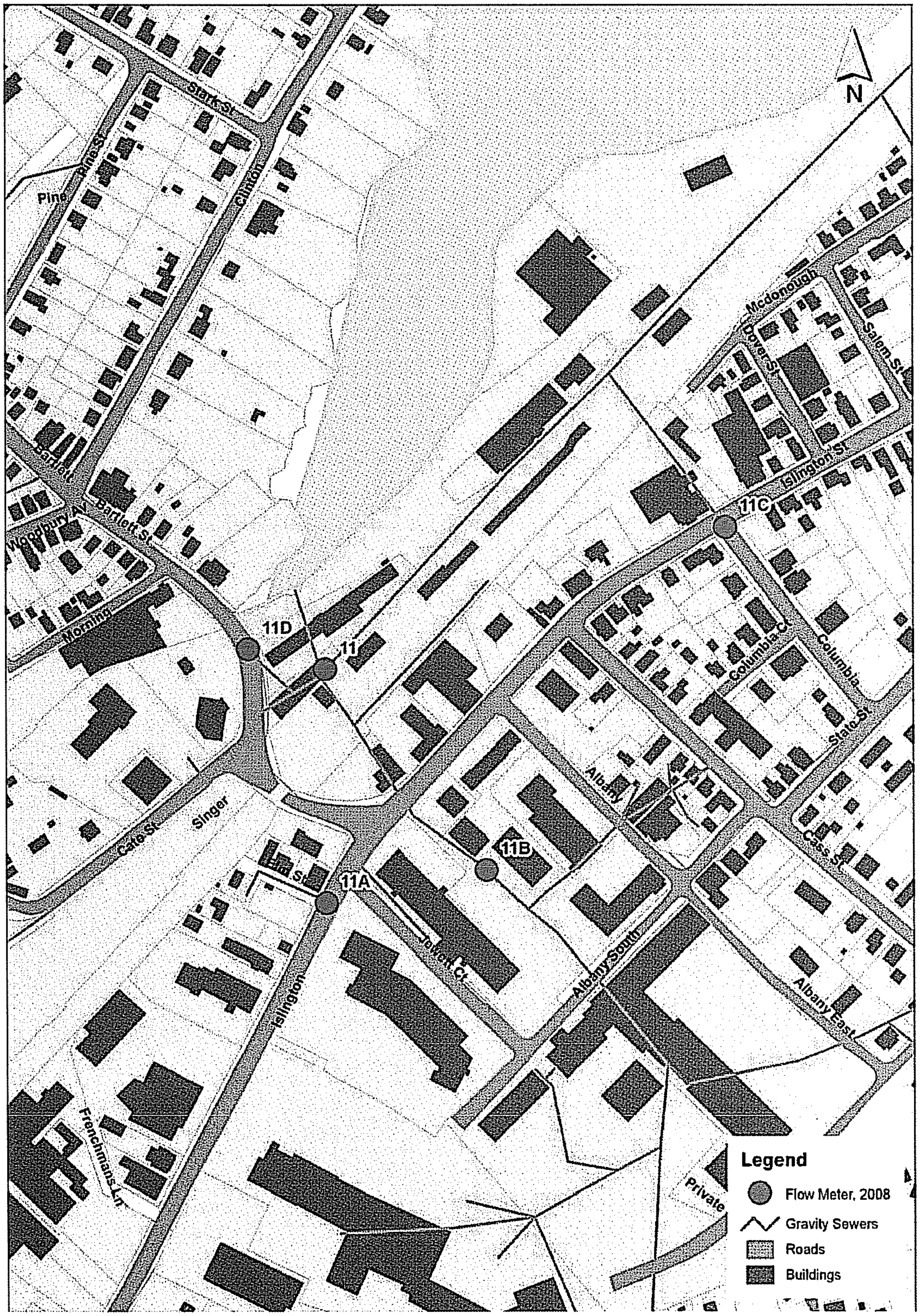

Figure 4.12 Locations of Site 11 Intensive Metering

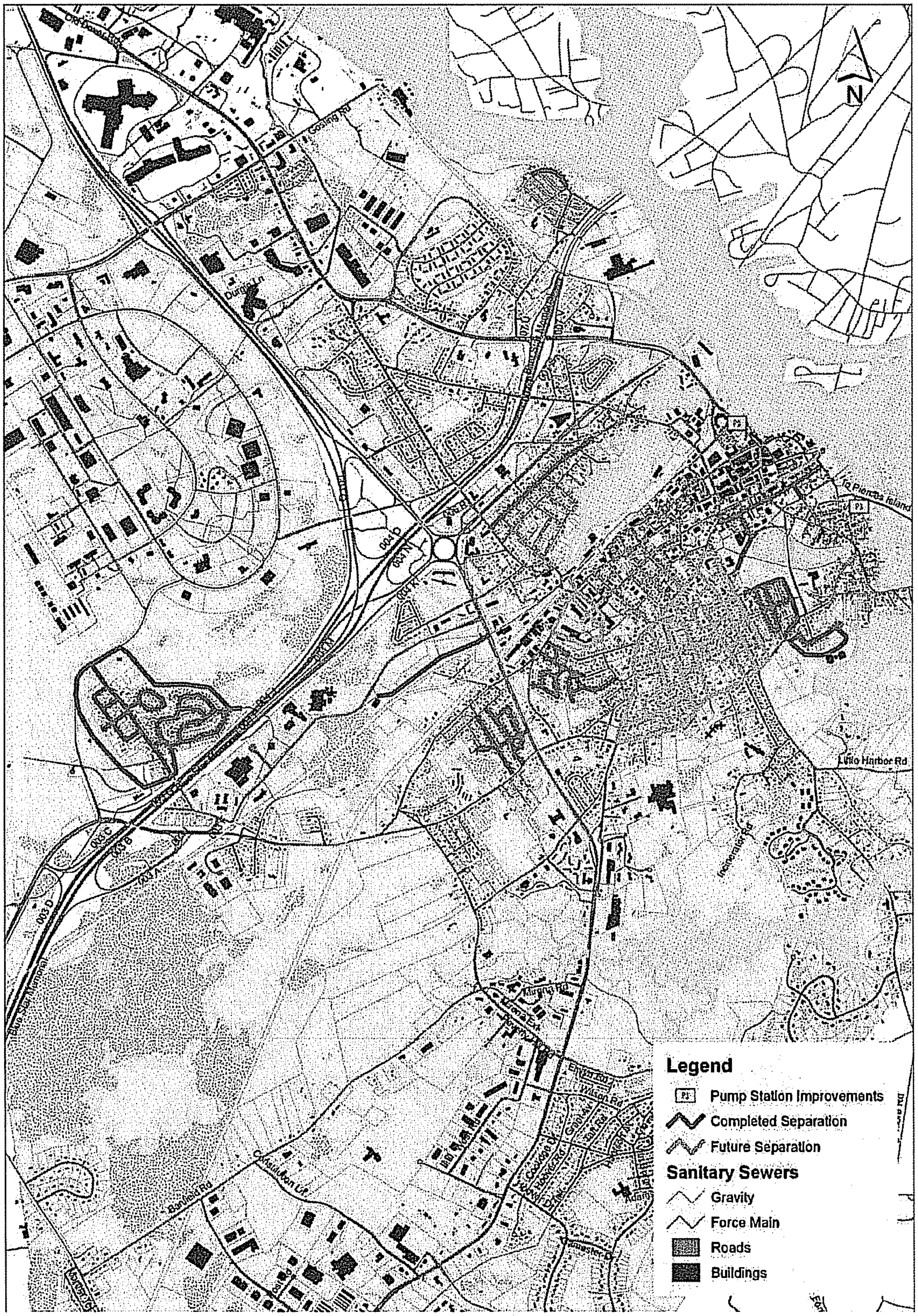

Figure 4.13 Sewer Separation and Pump Station Upgrades Project 2000-2006

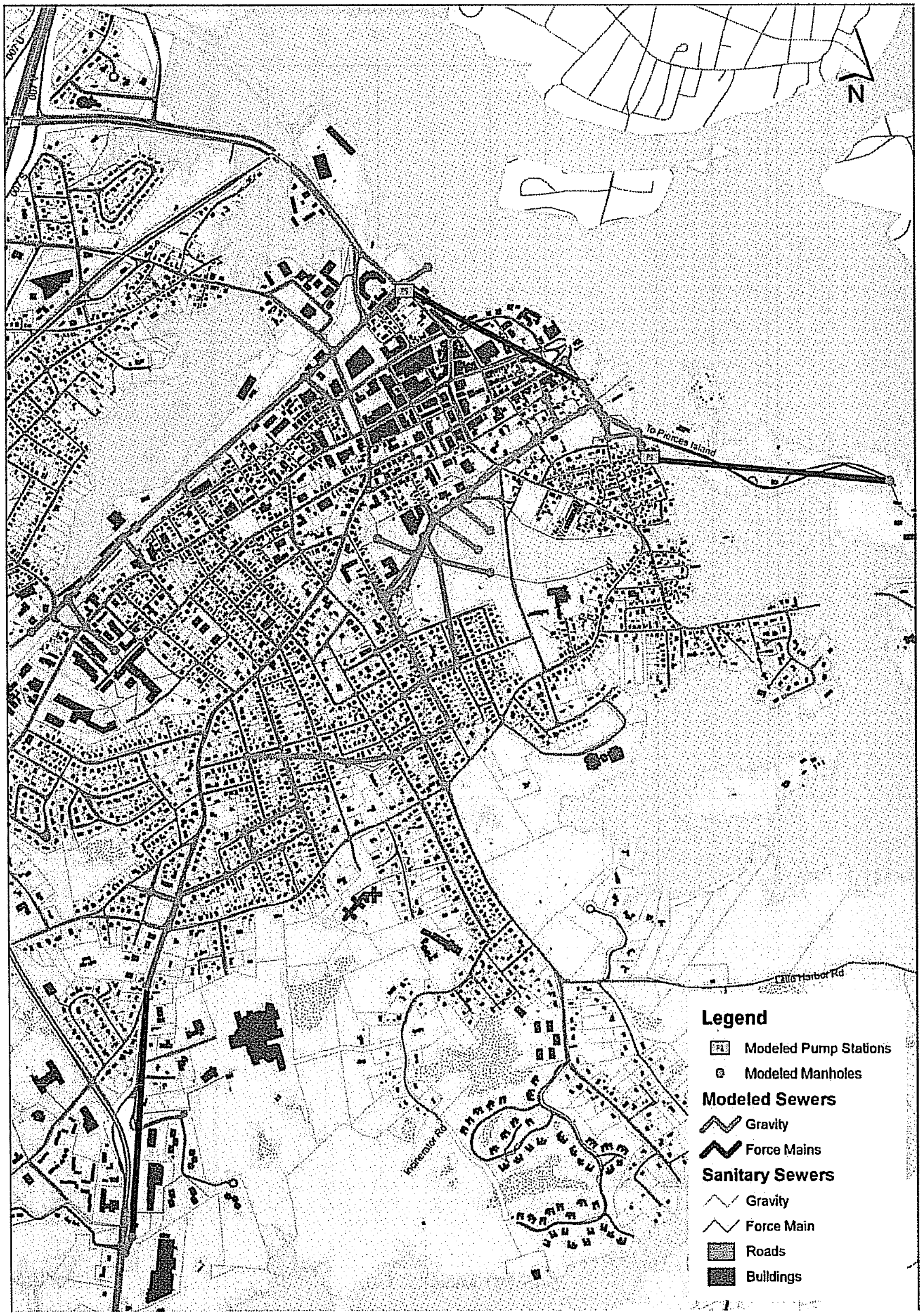

Figure 4.14 Hydraulic Model

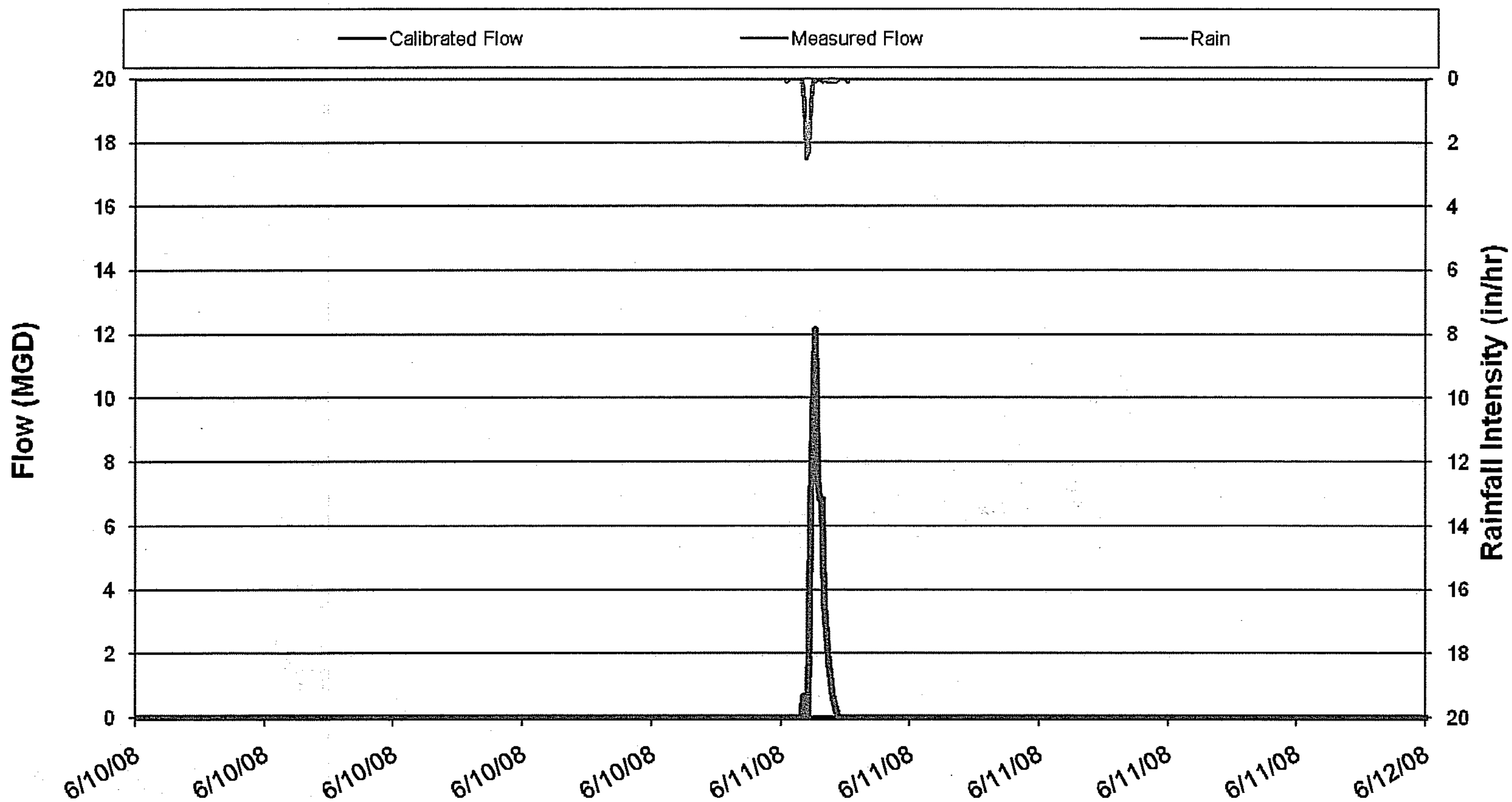

Figure 4.15 CSO 010A/CSO 010B Measured vs. Calibrated Model Flows for Storm of June 11, 2008

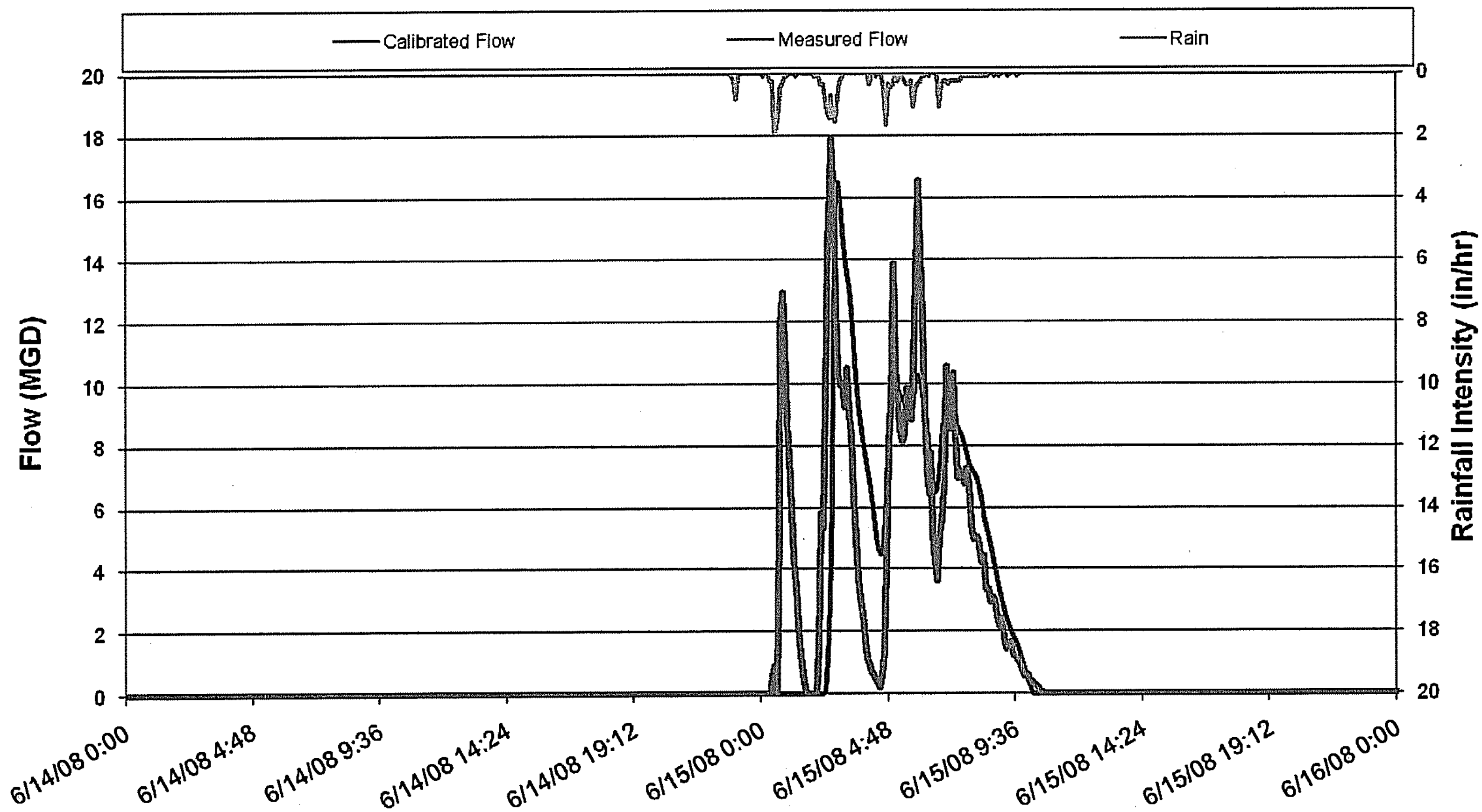

Figure 4.16 CSO 010A/CSO 010B Measured vs. Calibrated Model Flows for Storm of June 15, 2008

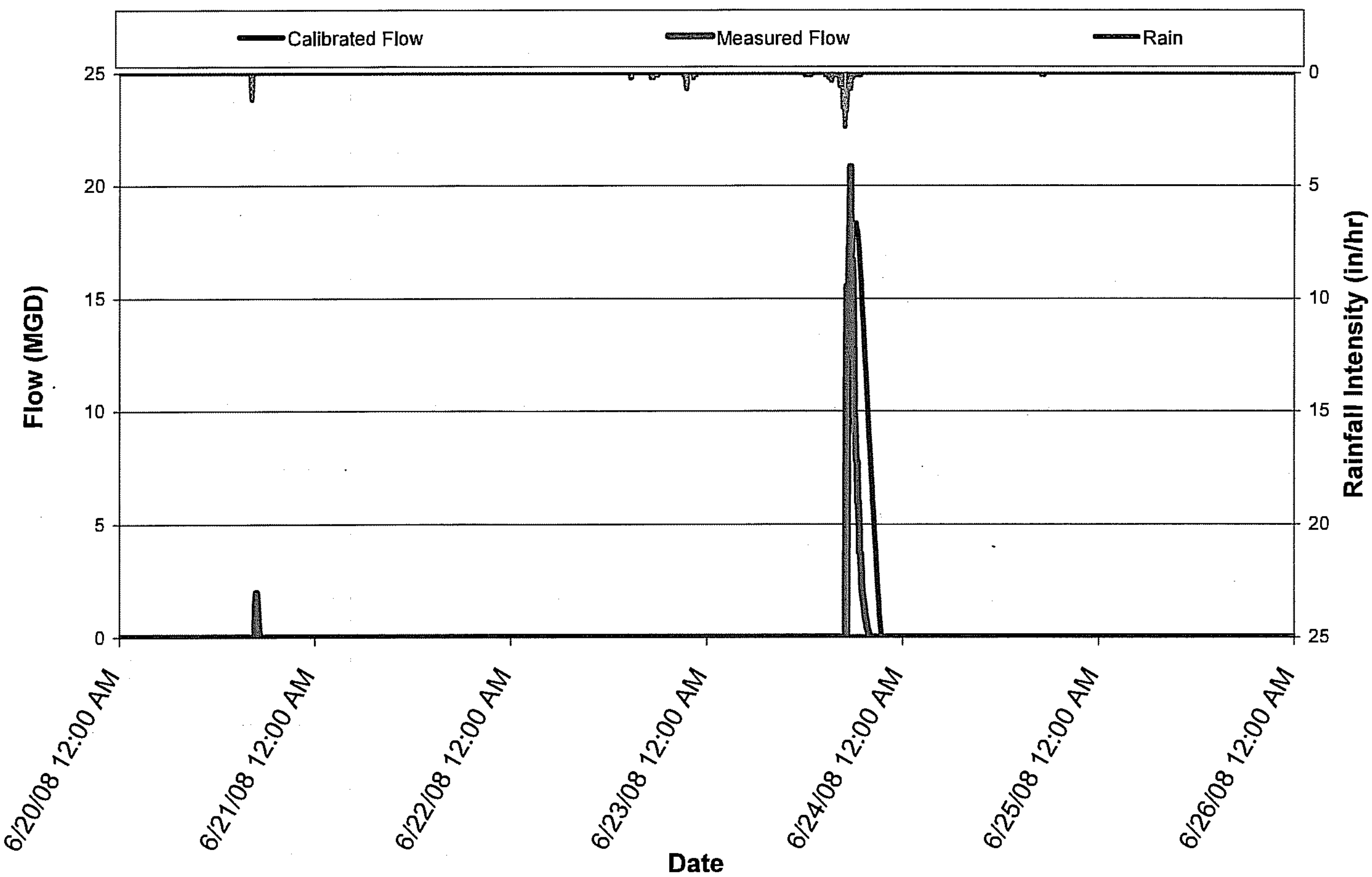

Figure 4.17 CSO 010A/CSO 010B Measured vs. Calibrated Model Flows for Storm of June 23, 2008

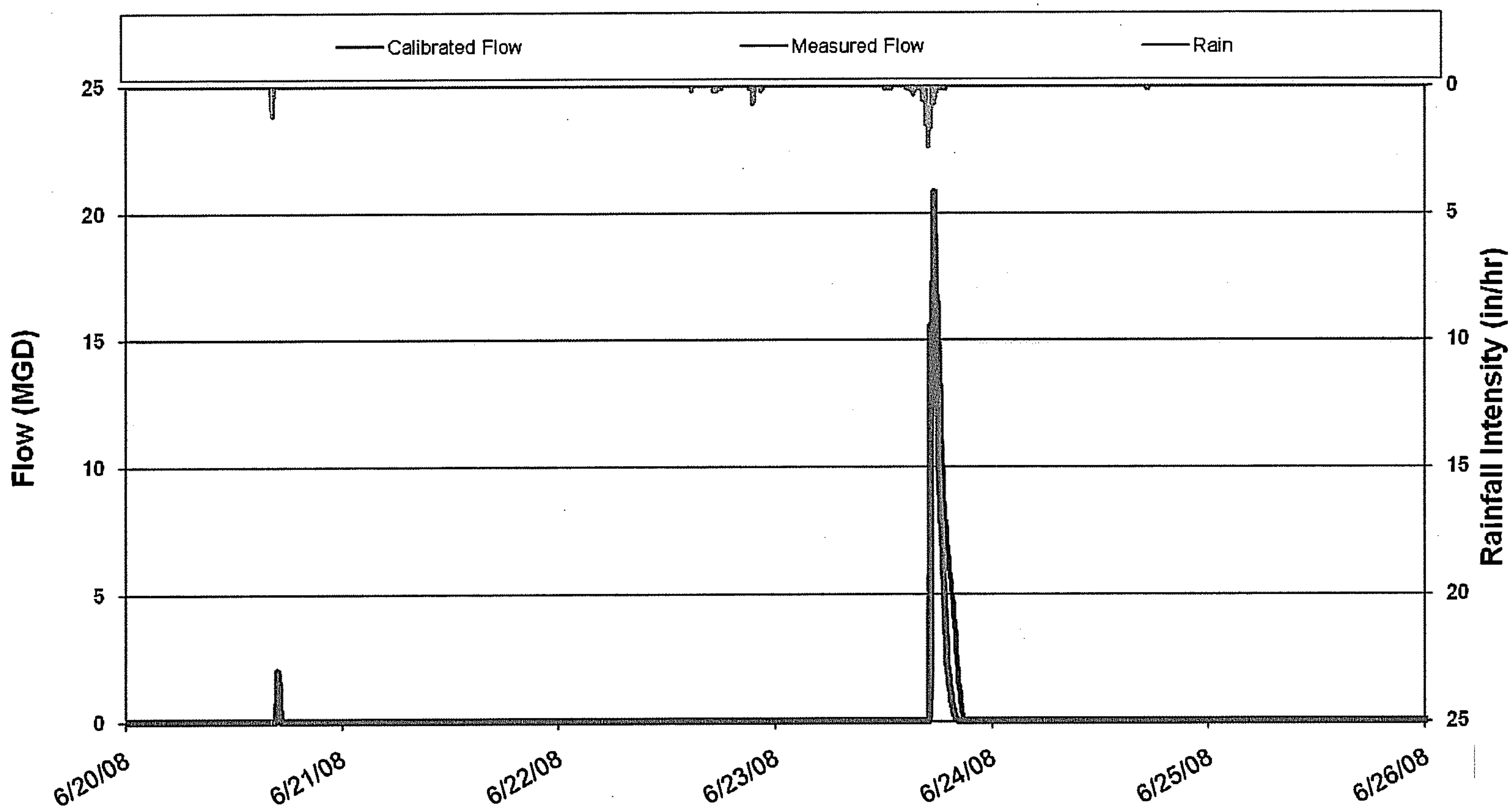

Figure 4.18 CSO 010A/CSO 010B Measured vs. Calibrated Model Flows for Storms of July 20 and 23, 2008

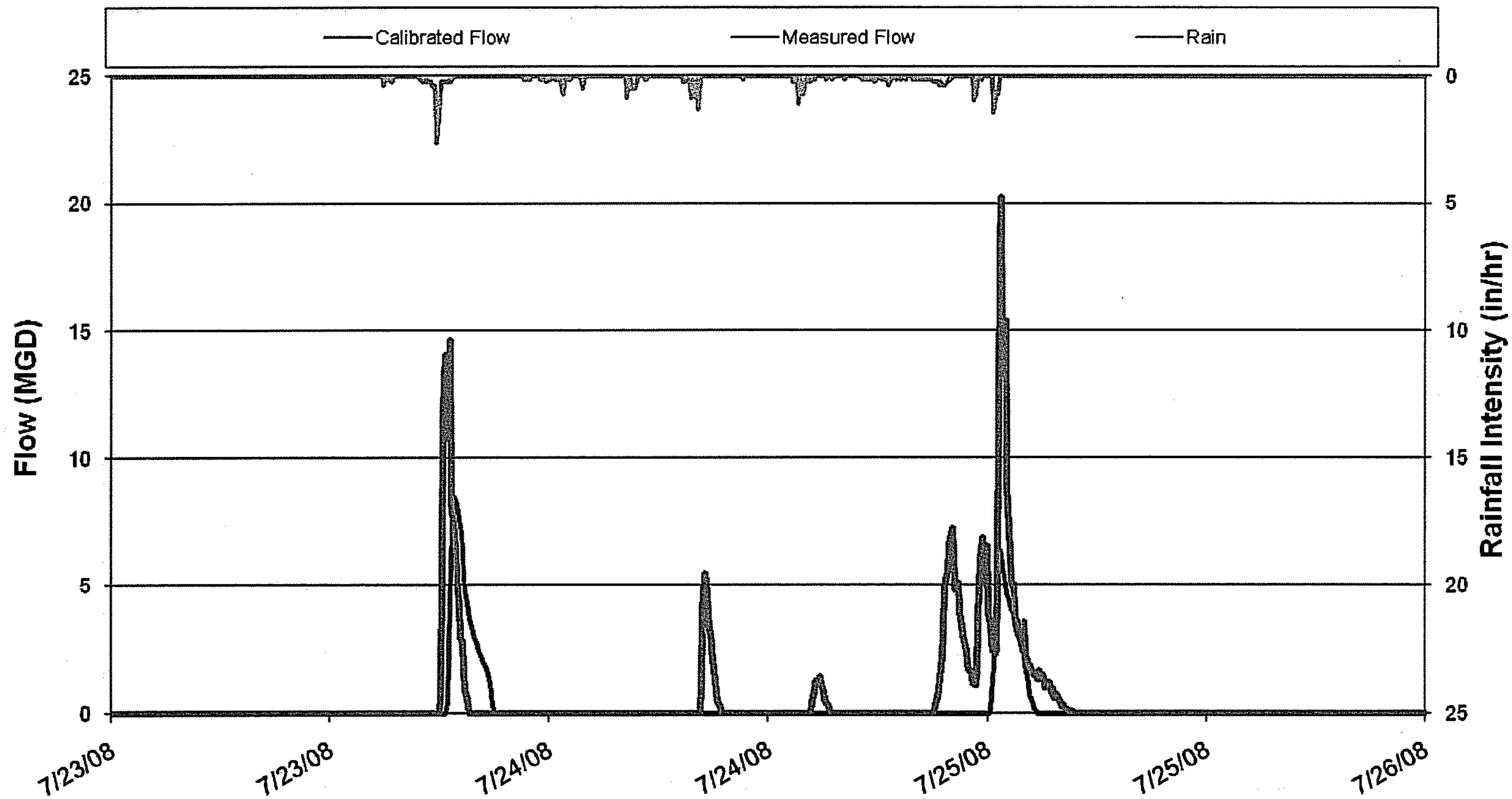

Figure 4.19 CSO 010A/CSO 010B Measured vs. Calibrated Model Flows for Storm of July 23, 2008

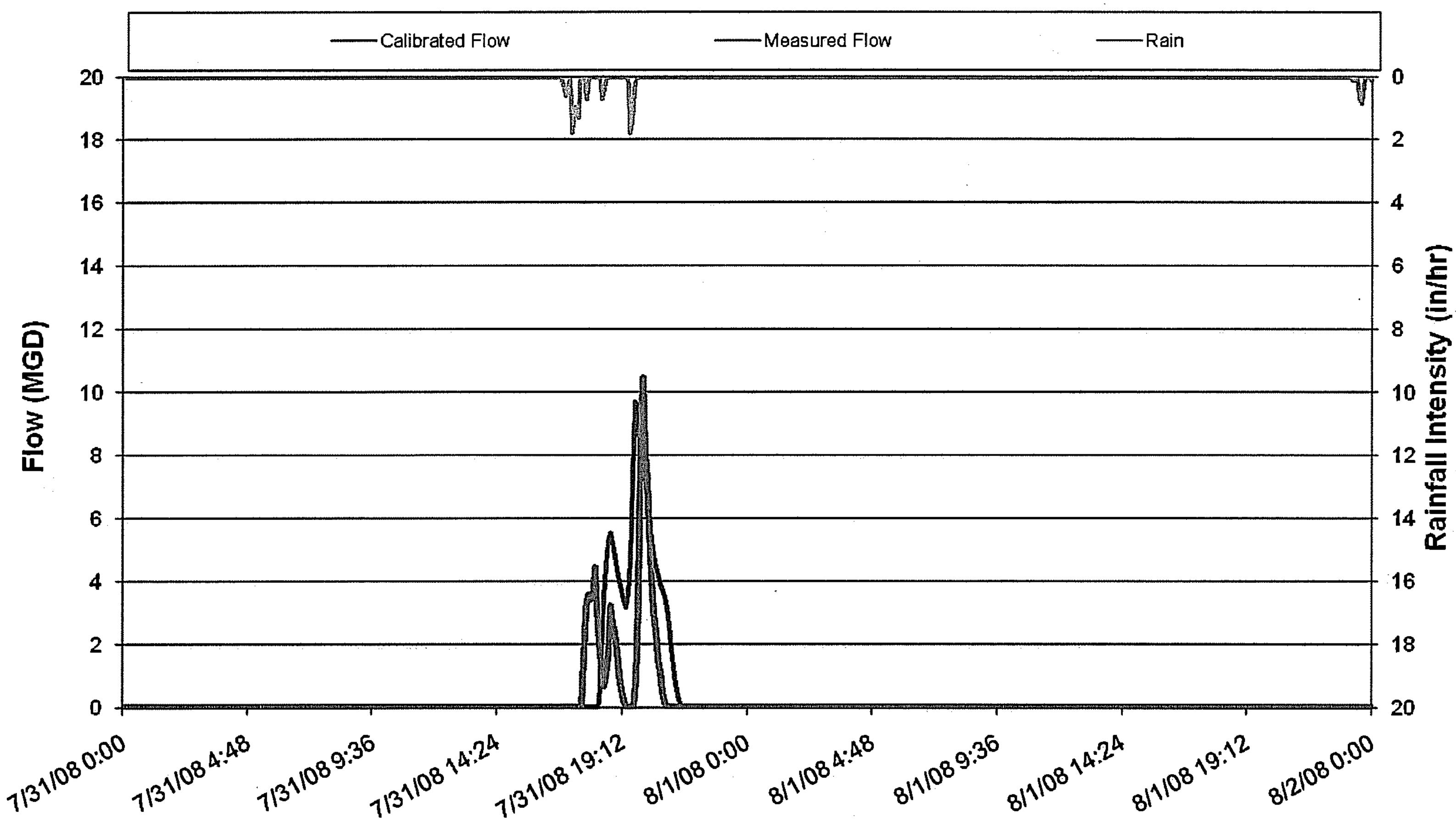

Figure 4.20 CSO 010A/CSO 010B Measured vs. Calibrated Model Flows for Storm of July 31, 2008

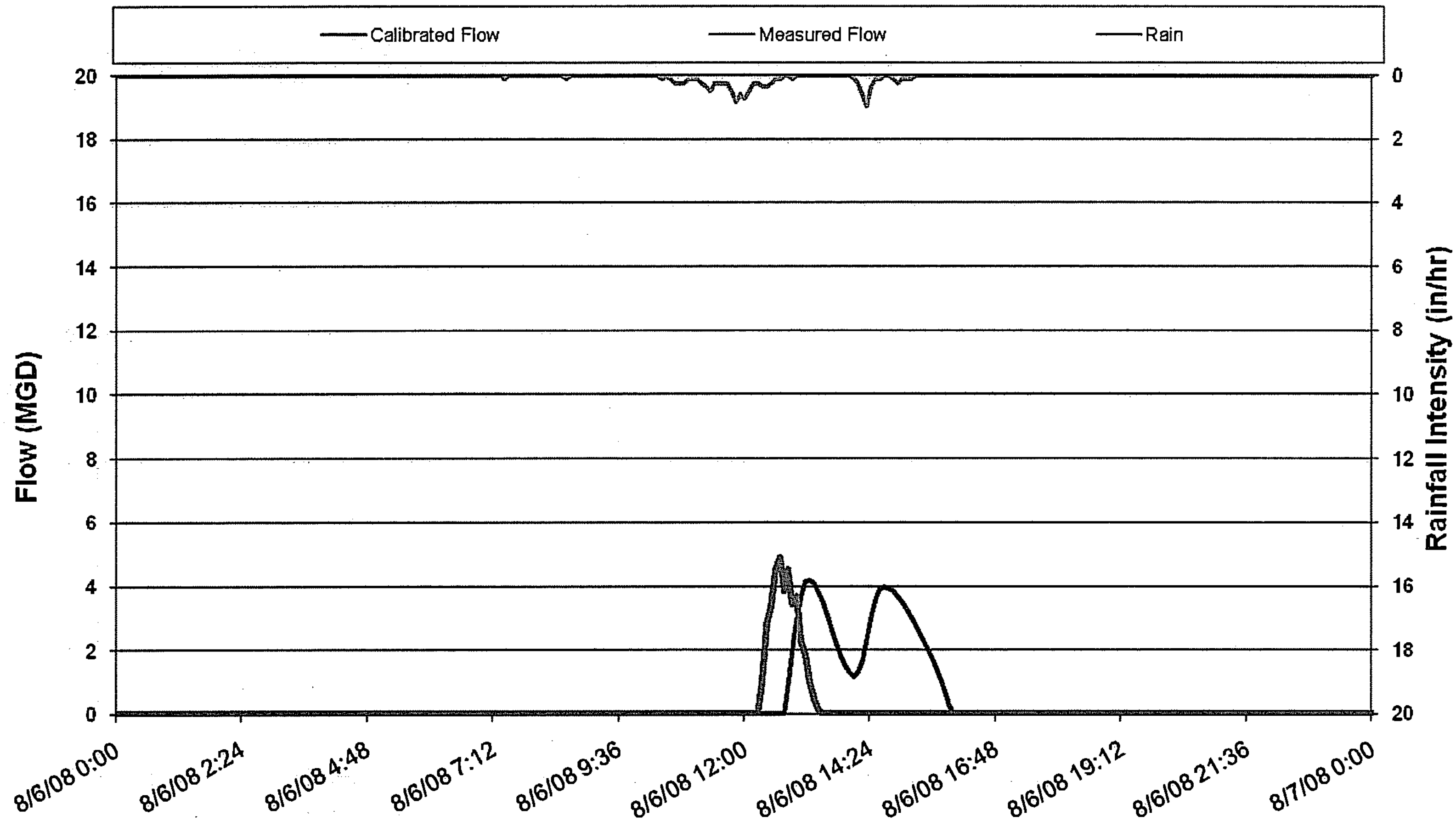

Figure 4.21 CSO 010A/CSO 010B Measured vs. Calibrated Model Flows for Storm of August 6, 2008

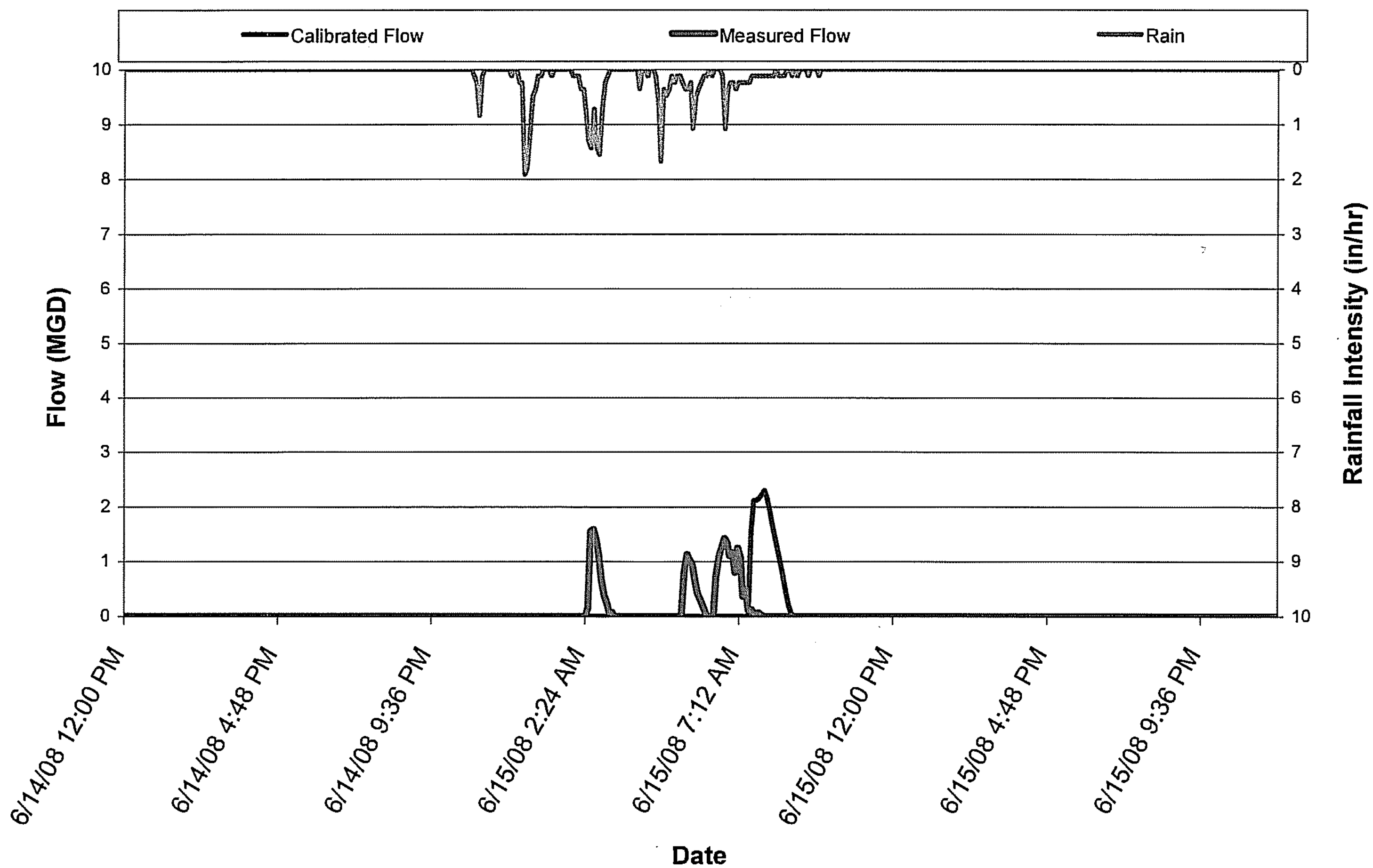

Figure 4.22 CSO 013 Measured vs. Calibrated Model Flows for Storm of June 15, 2008

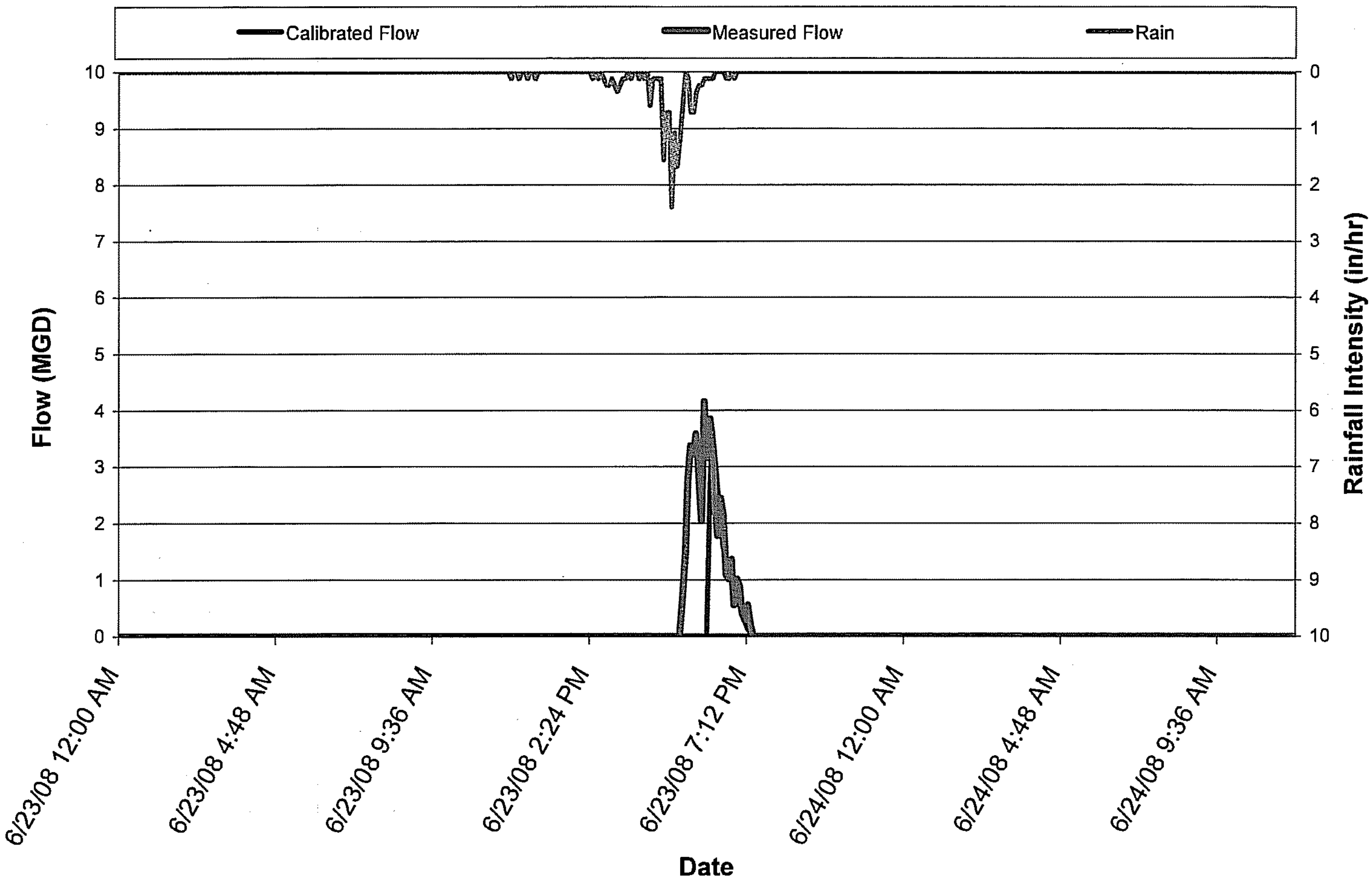

Figure 4.23 CSO 013 Measured vs. Calibrated Model Flows for Storm of June 23, 2008

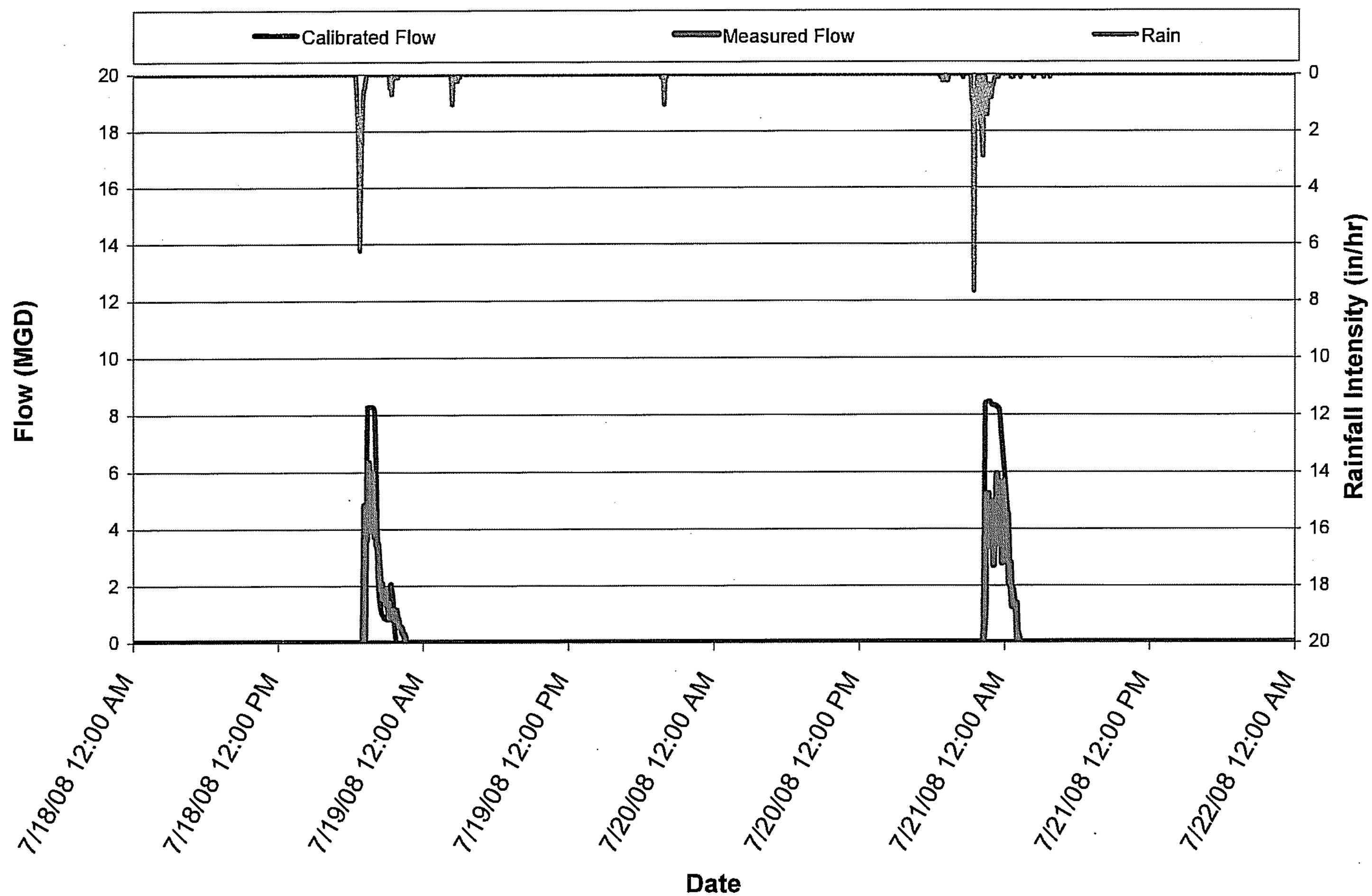

Figure 4.24 CSO 013 Measured vs. Calibrated Model Flows for Storm of July 18 and 20, 2008

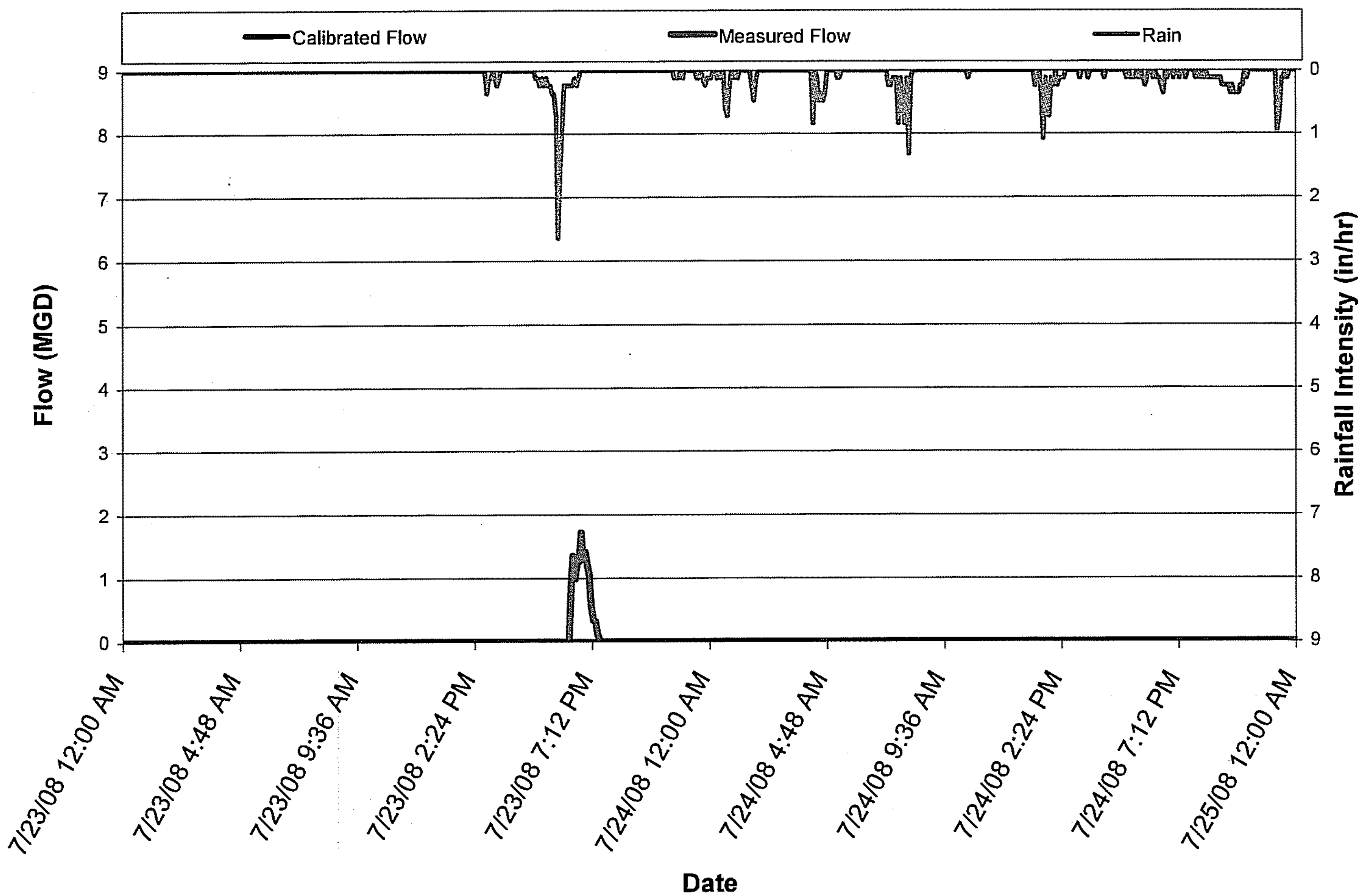

Figure 4.25 CSO 013 Measured vs. Calibrated Model Flows for Storm of July 23, 2008

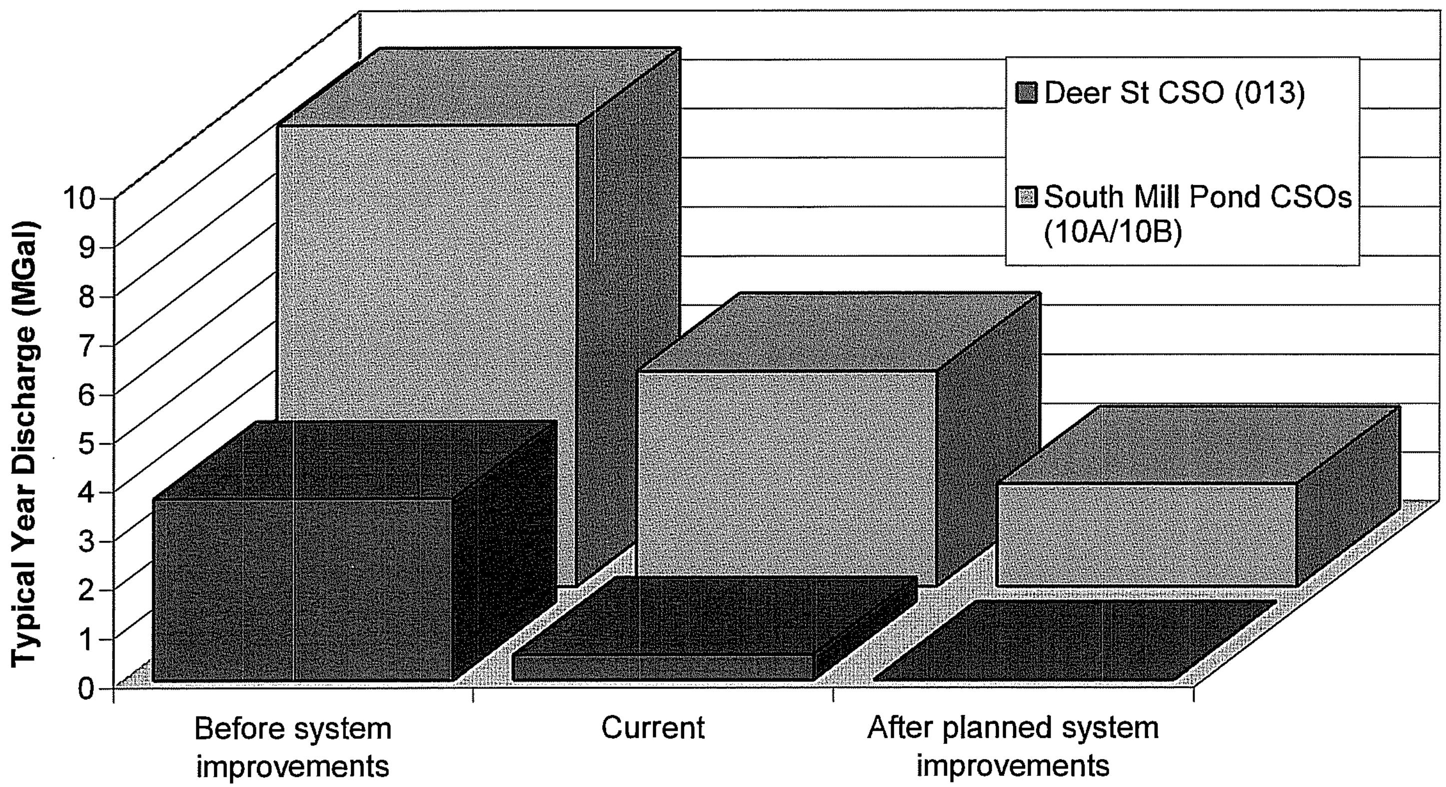

Figure 4.26 Estimated Typical Year CSO Discharges