# City of New Haven Long Term CSO Control Plan

The City of New Haven

New Haven Water Pollution Control Authority

## Technical Memorandum #3
## System Inventory and Model Results

December, 1998

CH2MHILL

CH2M HILL
25 New Chardon Street
Suite 500
Boston, MA
02114-4774
Tel 617.523.2260
Fax 617.723.9036



November 15, 1999

135807.BA.02

Mr. Raymond Smedberg, P.E.
City of New Haven
Water Pollution Control Authority
East Shore Water Pollution Abatement Facility
345 East Shore Parkway
New Haven, CT 06512

Mr. Larry Smith, P.E.
City of New Haven
City Engineer's Office
200 Orange Street, 5th Floor
New Haven, CT 06510

Dear Sirs:

Subject: New Haven LTCP Project
Task 2 – Model Development

Attached for your review and comment is an addendum to Technical Memorandum #3. This addendum documents the recent data collection efforts of the block testing program and diving inspection of the Boulevard Interceptor. It also describes resulting changes to the model to refine the calibration based on new data. This submittal completes the model development task. Please let us know if you have any questions or comments.

Sincerely,

CH2M HILL

Perrin Niemann

Perrin Niemann/BOS
Staff Engineer

cc: Cliff Bowers/CH2M HILL
Peter von Zweck/CH2M HILL

CH2M HILL
50 Staniford Street
10th Floor
Boston, MA
02114-2517
Tel 617.523.2260
Fax 617.723.9036

CH2MHILL

December 23, 1998

135807.BA.02

Mr. Richard Miller, P.E.
City of New Haven
City Engineer's Office
200 Orange Street, 5th Floor
New Haven, CT 06510

Mr. Raymond Smedberg, P.E.
City of New Haven
Water Pollution Control Authority
East Shore Water Pollution Abatement Facility
345 East Shore Parkway
New Haven, CT 06512

Dear Sirs:

Subject: New Haven LTCP Project
Task 2 – Model Development

Attached for your review and comment is a draft of Technical Memorandum #3. This memorandum documents the system inventory and model development activities performed for Task 2 of the Long Term Control Project.

Sincerely,

CH2M HILL

Chris Goz/BOS
Task Manager

cc: Cliff Bowers/CH2M HILL
Peter von Zweck/CH2M HILL

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# CITY OF NEW HAVEN LONG TERM CSO CONTROL PLAN

TECHNICAL MEMORANDUM #3

System Inventory and Model Results

Prepared for

The City of New Haven
The New Haven Water Pollution Control Authority

Prepared by

CH2M HILL
25 New Chardon Street, Suite 500
Boston, MA 02114

**December 1998**
**Addendum, November 1999**

135807.BA.02

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# Introduction

## Project Background

The City of New Haven and the New Haven Water Pollution Control Authority (WPCA) operate a wastewater collection and treatment system that serves approximately 130,500 residents in the City of New Haven. Through inter-local agreements, the WPCA also accepts sanitary flow from the Towns of Woodbridge, Hamden, and East Haven (East Haven accepts some wastewater flow from North Branford), which constitutes an additional population of approximately 86,000.

The areas served by the treatment plant include approximately 250 miles of both combined and separated sewers. Many older neighborhoods in New Haven are served by a single sewer system designed to collect both sanitary sewage and stormwater runoff (combined sewers). The surrounding communities and other areas of New Haven are served by two separate sewer systems: one to collect sanitary waste and the other to collect stormwater runoff (separated sewers). The schematic shown in Figure 1 illustrates a typical combined sewer system and common sources of inflow.

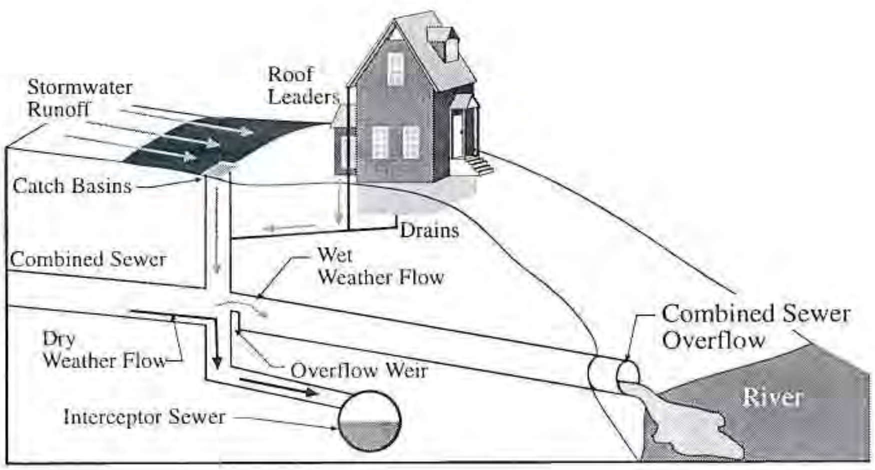
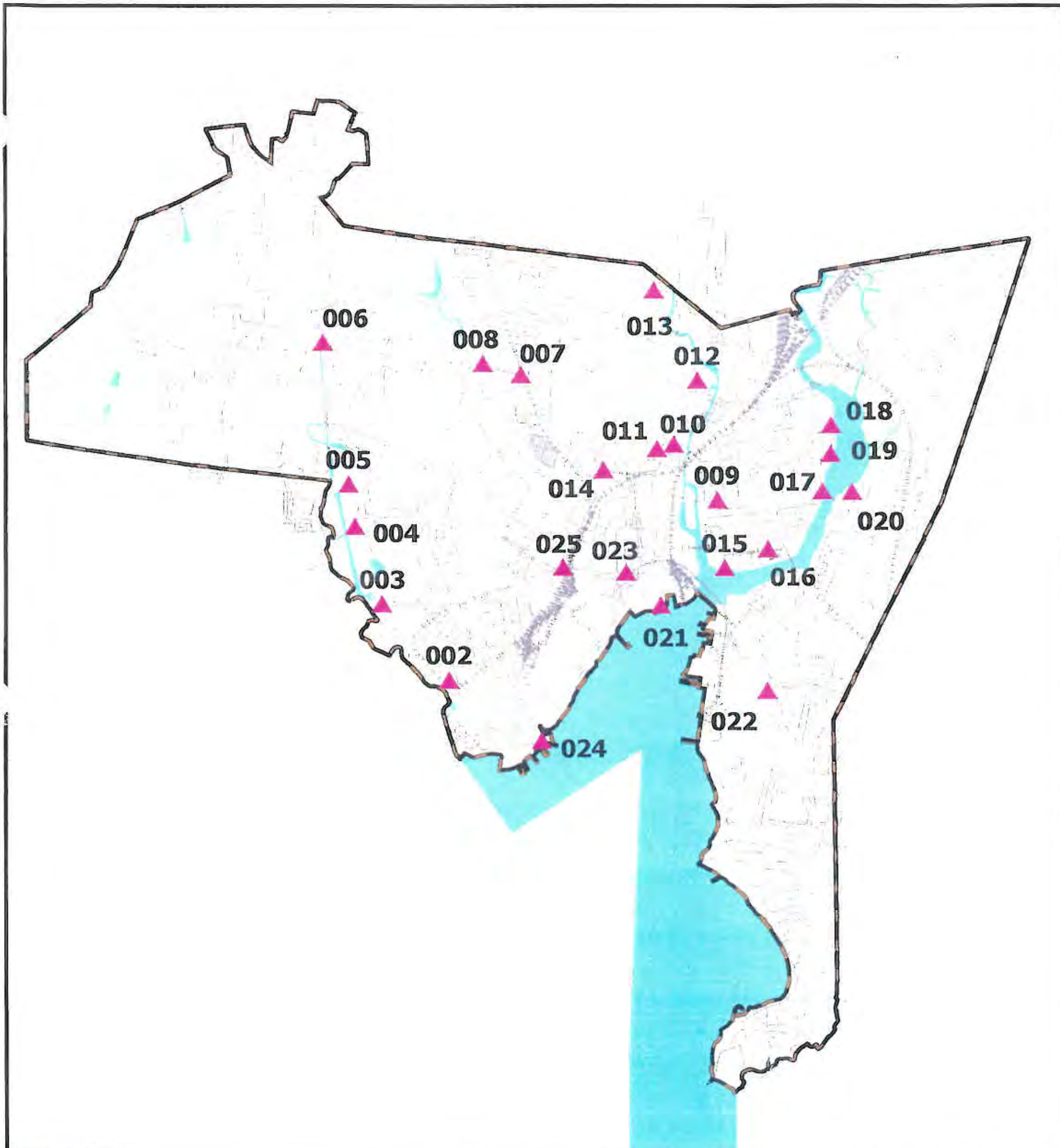



*Figure 1: Schematic of a Typical Combined Sewer System*

During dry weather, New Haven's sewer systems transport a combination of sanitary flow and base groundwater infiltration to the East Shore Water Pollution Abatement Facility (WPAF). All dry weather flows receive secondary treatment and disinfection at the WPAF prior to discharge into New Haven Harbor.

During wet weather, large quantities of stormwater enter the combined sewers. If the sewer system receives more water than it can convey to the WPAF, it will become overloaded and surcharge. Regulating structures provide some relief by allowing excess flow to leave the system and discharge to the receiving waters of New Haven. These discharges are called combined sewer overflows. The 24 NPDES permitted CSO regulators which have been installed throughout the New Haven system are shown in Figure 2.




New Haven City Boundary
NPDES Regulator
Roads
Railroads

2000 0 2000 4000 Feet

# Figure 2

## Location of NPDES Permitted Regulators in New Haven

New Haven Long Term CSO Control Plan

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A facility plan, which evaluated alternative methods for controlling CSOs, was completed in 1981 and updated in 1988. The plan evaluated controls required to convey, treat, or store overflows associated with a 10-year storm. The plan concluded that sewer separation was the most cost-effective method of meeting the evaluation criteria. Approximately 35 percent of the planned sewer separation is now complete. However, because of the significant advancements in regulatory requirements and technological issues, the City has decided to reevaluate this approach.

## Project Objectives

As mentioned previously, the City of New Haven has been undertaking a program of sewer separation for several years but has recently decided to reevaluate its approach to controlling CSOs through development of a Long Term CSO Control Plan.

The objectives of this project identified in the Scope of Work and Technical Memorandum #1, *Project Goals and Approach*, are to:

- reduce the overall cost of constructing CSO controls,
- produce documents required for CSO-related issues described in the WPCA's existing NPDES permit, and
- develop a Long Term CSO Control Plan that, in general, is consistent with guidance provided in the US EPA's CSO Control Policy (April, 1994).

Tasks of the project include the following:

Task 1: Establish Project Goals and Approach
Task 2: Model Development
Task 3: Monitoring Program
Task 4: Hydraulic Characterization
Task 5: Nine Minimum Controls
Task 6: Evaluation of CSO Control Alternatives
Task 7: Design Development
Task 8: Long Term CSO Control Plan

## Task Overview

The specific objective of the Model Development task is to provide a tool that can be used to characterize New Haven's combined/sanitary sewer system and evaluate CSO control alternatives. This tool is a computer model. A four-step process was performed to develop the computer model:

- System Inventory: collect New Haven sewer facility data,
- GIS development: store the system inventory data in electronic databases,
- Model Development: replicate the New Haven sewer system as a computer model, and
- Model Calibration: verify that the computer model can predict system performance under a range of conditions.

Figure 3 illustrates the relationship between the model, the GIS and the overall goals of the project. The GIS is also used for other purposes such as displaying data at stakeholder's meetings and other activities involving the public.

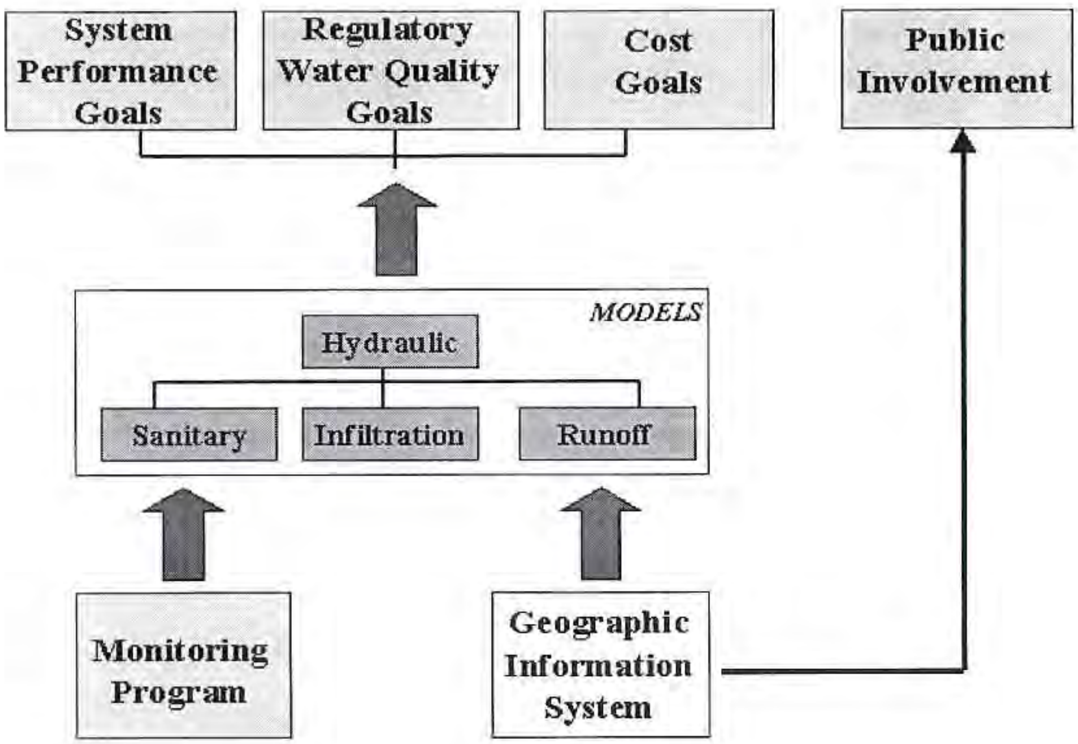



*Figure 3: Summary of Project and Modeling Goals*

Brief discussions of the primary goals to be supported by the model follow. Specific goals can be found in the technical memorandum for each respective task, Technical Memorandum #1, *Project Goals and Approach* and Technical Memorandum #2, *Database Design and System Modeling Approach.*

The computer model developed as part of Task 2 will be applied to support the goals of Tasks 4, 5, and 6. Task 4 requires that the model be able to characterize system performance, such as:

- computing average annual overflow statistics (volume, frequency) and estimating associated pollutant loads under varying storm conditions, and
- identifying system performance problems, such as surcharging, basement flooding, and sediment accumulation.

Tasks 5 and 6 require that the model be able to evaluate the impacts of short- and long-term controls, such as:

- estimating how short-term controls may improve system performance, such as reducing wet weather surcharging, eliminating dry weather overflows, or maximizing conveyance to the East Shore WPAF, and
- evaluating the potential impacts of long term controls on the reduction of overflows and pollutant loads to the receiving waters (continued sewer separation, construction of storage facilities or high-rate treatment facilities, modifications to the East Shore WPAF).

In addition, the model should be able to assess topics such as

- estimating the impacts of roof leader connections to the combined and partially separated sewer systems, and identifying a plan for managing roof leader connections and disconnections, and
- investigating the feasibility of reducing the number of pump stations in the system.

These objectives were discussed in more detail at the initial workshops for Tasks 1 and 2. They are currently being reviewed and refined at both internal and external stakeholder meetings.

## Purpose of this Report

This report summarizes the model development work completed for Task 2. It documents the development of a model and a geographic information system (GIS), including data requirements, the data conversion and management process, and the construction and calibration of the model. Tool selection and the proposed approach to data conversion and modeling was discussed in Technical Memorandum #2.

A general overview describing computer models and geographic information systems is provided in the next chapter. Subsequent chapters describe in greater detail the construction of the GIS, and the development of hydrologic and hydraulic models including their calibration.

# Overview of Models and GIS

A combined sewer system is a complex system that responds to external factors such as rainfall and sanitary wastes. Given a certain set of circumstances, this response can lead to an overloaded sewer system and combined sewer overflows (CSOs). By replicating the systems in New Haven with a computer model, simulations can be performed to evaluate control alternatives that minimize CSOs and their impacts to the receiving waters in and around New Haven.

In the initial stages of developing the scope of this project, it was realized that a GIS would be necessary for two main reasons. The first objective is to manage the vast amounts of data required to develop the computer models. Because the model is capable of directly interfacing with the GIS, the amount of effort required to set up the initial model was reduced. The second objective is to support the City/WPCA's efforts for maintaining an accurate inventory of their sewer system. As new sewers are built, the GIS can provide an electronic snapshot of the entire system.

Figure 4 shows the relationships between sewer inventory data, the GIS, and the model. Inventory data is collected and stored in the GIS. The model extracts the data that it needs from the GIS, and performs the hydrologic and hydraulic analyses. The GIS is available for future needs of the City of New Haven and the WPCA.

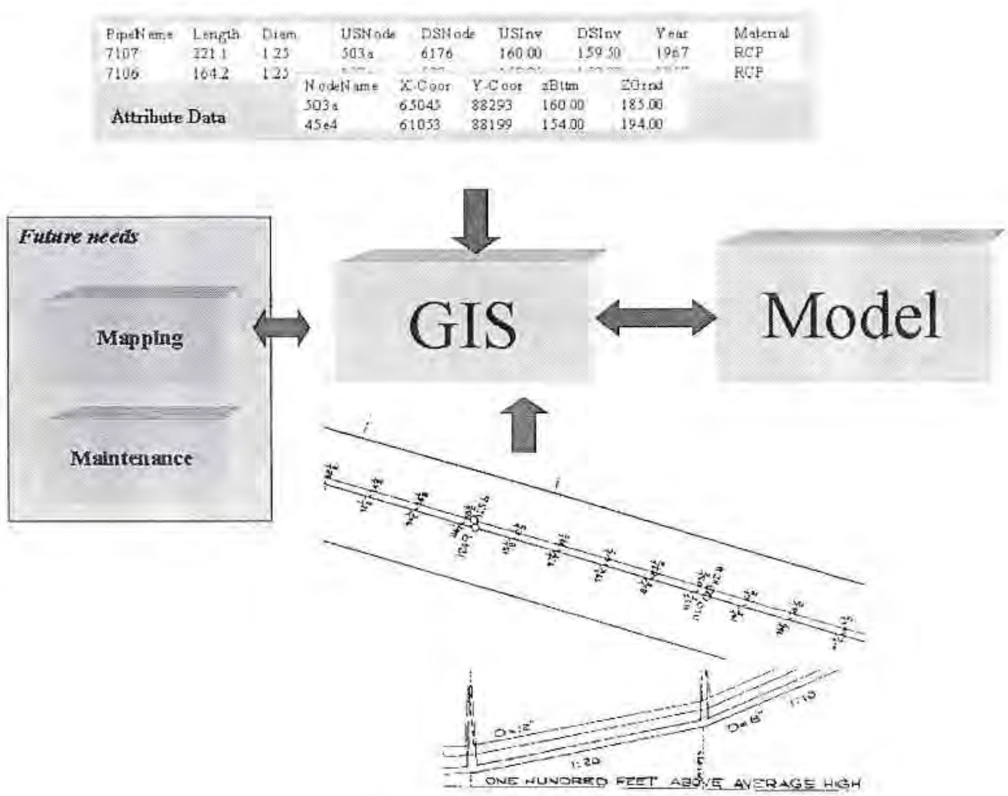



*Figure 4: Relationship Between the Model and GIS*

## Computer Models

Urban drainage systems involve complex and interdependent processes, consisting of wastewater generation, urban hydrology, and the various structural elements designed to convey the hydraulic loads. Computer models, which are mathematical representations of a process or series of processes, are often used to understand the interactions within these systems. Processes of interest related to studies of combined sewer systems include:

- the generation of sanitary wastewater flows,
- the conversion of precipitation to stormwater runoff, and
- the collection and conveyance of flows.

In general, hydrologic models refer to models that create inflow to the sewer system, while hydraulic models route inflows through the sewer system. A computer model has been developed to simulate these processes within the service area tributary to the East Shore WPAF. The general goals for the model are to support the understanding of how the sewer network responds to a range of rainfall events and to predict how its performance may be improved. Many of the future tasks in the project will use the calibrated model to make such predictions and to evaluate alternatives for controlling CSOs.

A model of the sanitary system in New Haven was developed in the 1970's using EPA SWMM. Changes in New Haven's sanitary sewer system as a result of the ongoing sewer separation program required the creation of a new model. Recent advancements in computer hardware and modeling software provided an opportunity to develop a more complex model. Details outlining the software selection process can be found in Technical Memorandum #2, *Database Design and System Modeling Approach*. Based on that process, DHI's MOUSE software was selected to build the various models. Factors having significant impacts on the decision included:

- the existence of a proven link between an ESRI GIS and the modeling software,
- a strong graphical representation of input and output data,
- an automated network simplification algorithm,
- the low cost of the hydraulic model and linkage, and
- the ability to incorporate other models (sediment transport, real-time controls, or receiving water modeling) in the future, if needed.

## Geographic Information Systems

In general, a geographic information system (GIS) is a computerized database that consists of elements with real world coordinates and the attributes that describe them. Elements sharing common attributes, such as pipes and manholes, are collected and grouped together in coverages or themes.

In order to be compatible with the GIS proposed by the City of New Haven's Plan Department, ESRI's ARC/INFO was selected as the GIS inventory software for the sewer system data.

With ARC/INFO, a geographic feature consists of a spatial shape (point, line, polygon) and related attributes that describe it. Shapes have the following properties:

- Location: the object exists at some known point in space,
- Form: the object has a geometric representation, and
- Descriptive Properties: the object has specific attributes.

Shapes can have many geometric representations, but for the New Haven GIS, shapes are one of the following types:

- Point: a single coordinate pair representing a location in space (e.g., manhole, outlet),
- Line: an ordered list of coordinate pairs that are not self-intersecting (e.g., sewer)
- Polygon: an ordered list of coordinates that does not cross itself and closes to represent an area. A single polygon shares boundaries with adjoining polygon boundaries, but does not overlap them (e.g., subcatchments).

In relational databases, data are stored in tables consisting of rows and columns. Rows represent a particular entity, while columns contain attributes describing the entity. Attributes can have many formats, such as text strings or numbers. The GIS provides a transparent link between the spatial object and the non-spatial table related to the object.

Each model, hydrology and hydraulic, requires different types of data in different formats. The physical features of catchments (slope, length, percent impervious) are required to construct the flow model, while the characteristics of each structural element (pipes, pumps, manholes) are required to build the hydraulic model.

The GIS in this project was created to promote systematic conversion of archived data into model data. The electronic storage and conversion capabilities of a GIS greatly facilitate the model construction process. The next chapter of this report describes in more detail how the New Haven GIS was created. In the future, the GIS can become a central platform for information and facilities management long after the Long Term CSO Control Project is completed.

# GIS Construction

This chapter summarizes the key features of the GIS developed in Task 2. It is intended to provide an overview of the various sources of data incorporated into the GIS, the coverages that were created, their structure, and the data transfer process. The specific data requirements and formats are defined in the modeling chapters of this report. The organization of this chapter is as follows:

- a brief description of the GIS database design,
- a definition of baseline conditions, and
- a step-by-step description of the data conversion process.

The main purpose of the GIS database is to increase access to information about the sewer systems of New Haven. During its life and history, the City has accumulated numerous strip maps and construction drawings that are stored at the City's Engineering Department. By collecting this information and storing it in a GIS, the data is made more available to more people and can be used in a wider variety of ways. In particular, it can be used to build computer models. It can also be linked to operation and maintenance schedules, and used to track the status of sewer construction projects. It is flexible enough that it can create mapping and tabular information for any particular area in New Haven and show any combination of data as specified by the user in a timely and efficient manner.

## Database Design

The GIS was designed to serve two purposes: to be used to support the specific data requirements of the modeling task, and to be general enough that other applications can be added to it in the future. Once its purpose was decided, the design of the database structure was outlined. It was important to be specific—a properly designed database defines data requirements and formats, allowed values, and relationships between data and data representation. Once designed, the database was constructed and populated with the required attribute information. Figure 5 illustrates the flow of sewer facility data into the GIS, where it is stored as graphic and nongraphic data. Once built, the GIS shares the attribute data that it contains with the model.

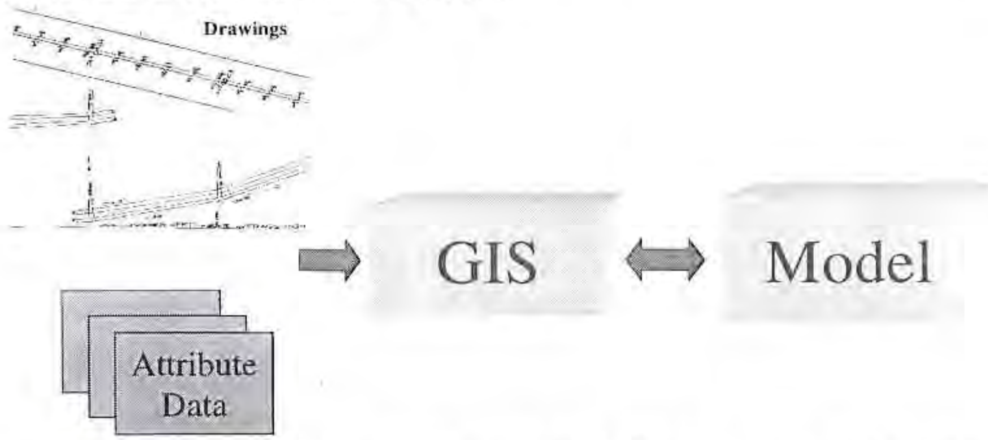



*Figure 5: Relationship Between Sewer Facility Data, the GIS and the Model*

## Graphic Data Layers

As defined in the Scope of Work, graphic data related to the sanitary sewer and storm sewer facilities in New Haven were collected and archived into the GIS. This included the manholes and sewers in both the storm and combined/sanitary systems. In addition to the sewer facilities, a variety of other graphic data required to build the models was also created and stored in the GIS.

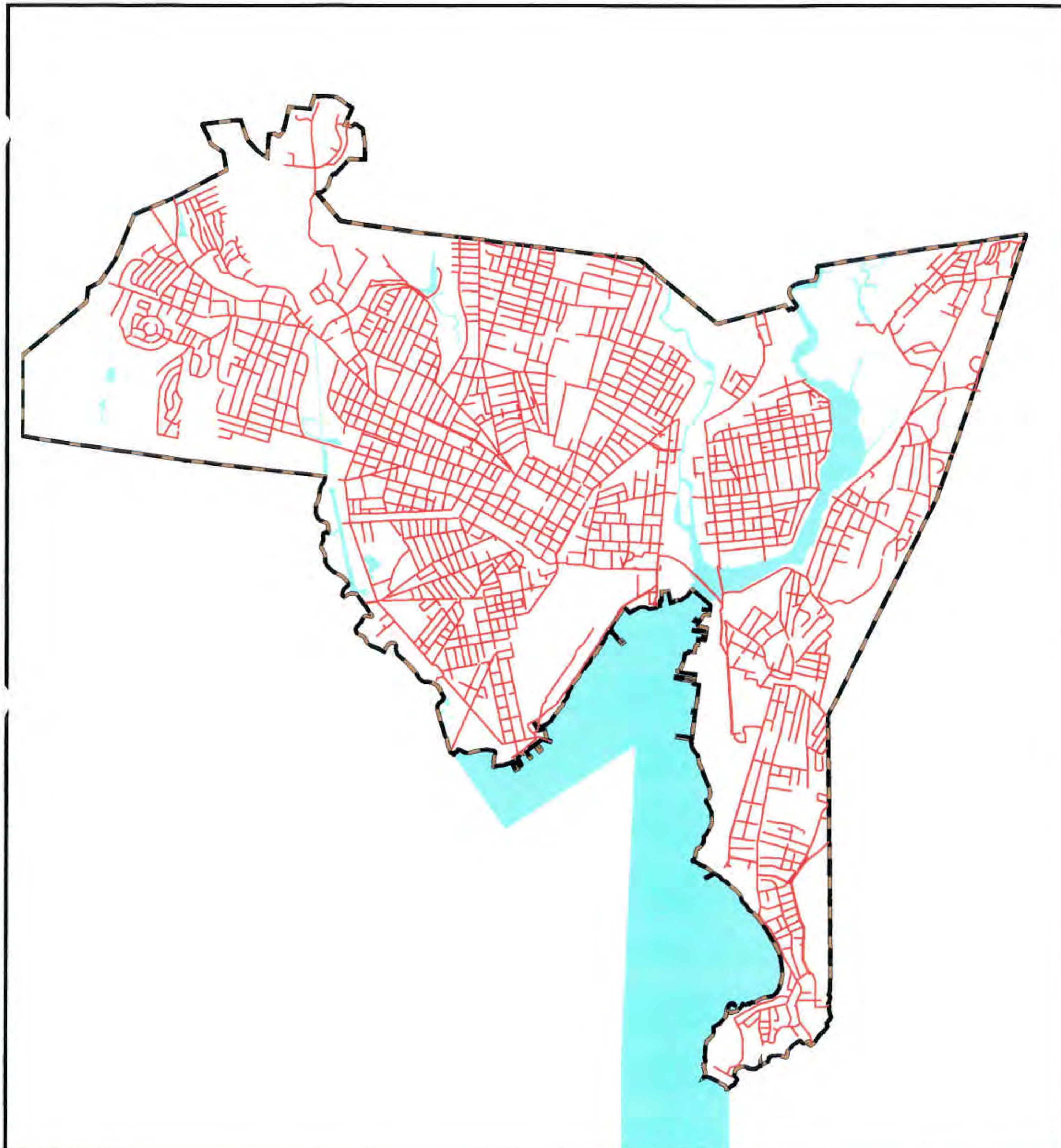
The graphic data layers are ARC/INFO coverages that are georeferenced to the State Plane Coordinate System, NAD83 with elevation data referenced to the USCGS datum. The coverages are vector data and were created from 1"=40' scale maps. Although the data coverages are registered spatially in the GIS and may be presented at any scale, the horizontal accuracy of the facility data is schematic in nature, similar to those that had been completed by the City and WPCA. In general, sewer facilities are shown in the middle of the streets, and are intended to be used at planning levels only.

A temporary basemap was created by scanning twenty-one 1"=100' planimetric maps obtained from the New Haven City Plan Department. This raster data was used to delineate sewersheds and for data presentation.

Table 1 lists the various facility coverages that were created as part of this project. Figure 6 shows the 8,855 combined and sanitary sewer segments contained in the SANLINK coverage totaling approximately 250 miles in length. Figure 7 shows the extent of the 6,168 existing and proposed storm sewer segments contained in the STMLINK coverage totaling approximately 160 miles. Additional figures that illustrate the content of the GIS are included in Appendix A. The ARC/INFO coverages are available on the CD contained in Appendix B.

**Table 1. ARC/INFO Sewer Facility Coverages Created in Task 2**

| Coverage Name | Description | Feature |
|---|---|---|
| SANNODE | Sanitary sewer manholes, blind connections, pump station wetwells, system outfalls | Point |
| SANLINK | Sanitary sewers, pumps, forcemains, weirs, orifices | Line |
| STMNODE | Storm sewer manholes, blind connections, system outfalls | Point |
| STMLINK | Storm sewers | Line |
| NHSUB | Sewershed subcatchments | Polygon |
| STMCB | Catchbasins | Point |
| STMLAT | Catchbasin laterals | Line |
| SANCR | Location of identified cross connections, valve chambers | Point |
| IMPCOV | Impervious cover | Polygon |
| XX.TIF | 21 images for basemap purposes (XX refers to the integer map name, e.g., "45.TIF") | Raster Image |



New Haven City Boundary

Combined/Sanitary Sewer

2000 0 2000 4000 Feet

# Figure 6

## Combined/Sanitary Sewers in New Haven

New Haven Long Term CSO Control Plan

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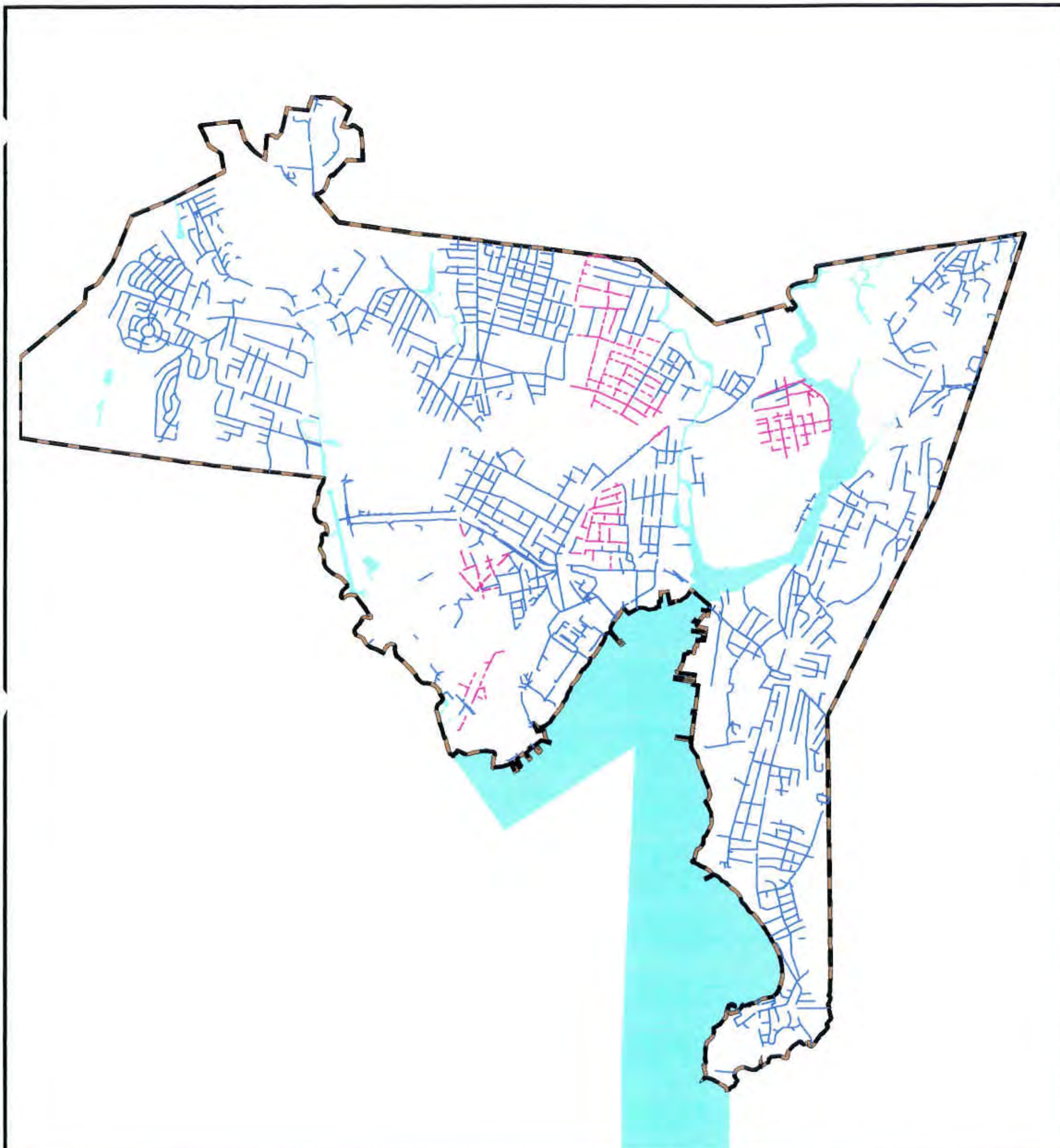

New Haven City Boundary
Storm Sewer, Existing
Storm Sewer, Proposed

2000 0 2000 4000 Feet

# Figure 7

## Storm Sewers in New Haven

New Haven Long Term CSO Control Plan

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Table 2 lists additional data that was obtained from outside sources. Some of this data was required for model development while some was needed for forming an interim basemap.

**Table 2. New Haven GIS Coverages Obtained in Task 2**

| Coverage Name | Description | Source | Feature |
|---|---|---|---|
| ALLRWA | 1996 Metered water consumption data | Regional Water Authority | Point |
| 83TB093 | Political boundaries | University of Connecticut | Polygon |
| 83PG093 | Population | University of Connecticut | Polygon |
| 83ST093 | Streets | University of Connecticut | Line |
| 83RR093 | Rail Roads | University of Connecticut | Line |
| 83HS093 | Water bodies | University of Connecticut | Polygon |

## Nongraphic Data

Although the spatial orientations of the facilities are stored with the graphic data, tabular data is linked to the pump and weir features. The two relational databases, PUMP and WEIR are linked to their respective GIS feature. The databases include information obtained from construction drawings, field visits, and personal interviews.

# Baseline Conditions

The analysis of the Long Term CSO Control Plan began with differentiating between existing and baseline conditions. This approach allows us to understand the existing conditions of the system and use it as a starting point for developing control measures.

Existing conditions were defined as the status of the sewer system as of the fall of 1997. However, as the GIS was being constructed, nine ongoing sewer separation projects were in various stages of completion. During the initial stages of Task 2, it was decided to include all of the proposed separation projects in the GIS to form the project's baseline conditions. Table 3 lists the construction plans (as of February 1998) that were obtained from the Engineering Department and included in the GIS. These proposed sanitary and storm sewer data were transferred to the basemaps and incorporated in the GIS as baseline conditions for the development of the Long Term CSO Control Plan.

**Table 3. Baseline Conditions Included in the GIS**

| Project | City Reference Number | Drawing Date |
|---|---|---|
| Orange St. | 94-70-1 | November 1997 |
| Orange, Bishop and Clinton | 94-71-1 | October 1997 |
| Lombard St. East | 94-72-1 | May 1997 |
| Wooster Square | 94-128-1[1] | March 1997 |
| Humphrey St. | 95-125-1 | None |
| Kimberly Ave and Columbus | 95-99-1 (95-146-1) | October 1997 |
| East Rock Rd. | 90-130-1 | March 1997 |
| Livingston St. | 90-131-1<br>90-132-1 (Phase II) | March 1997<br>December 1992 |

[1] New City Reference Number

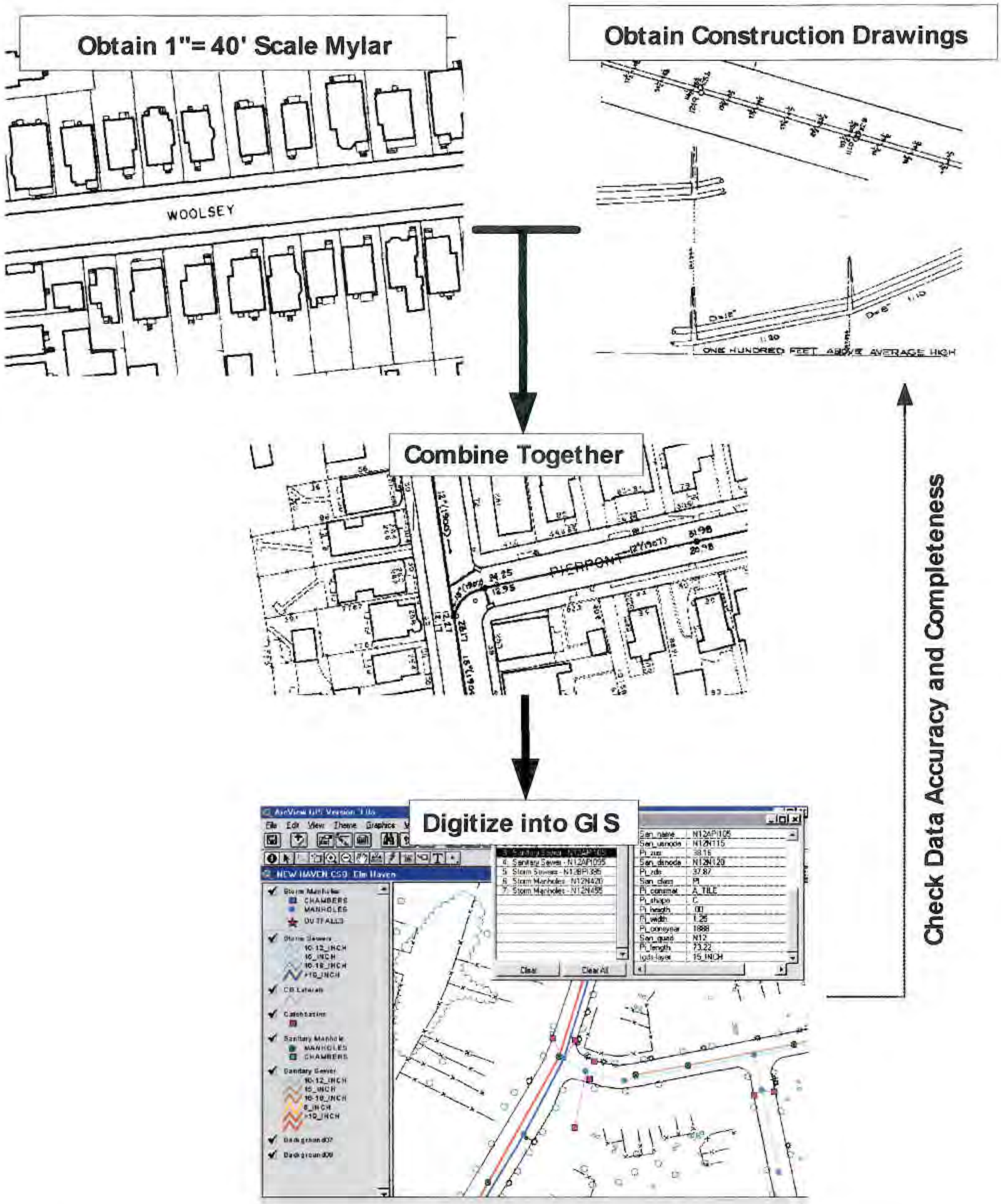
# Data Conversion Plan

The databases identified in Table 1 were created as part of Task 2 according to the three-step data conversion plan outlined in Technical Memorandum #2, *Database Design and System Modeling Approach*, and illustrated in Figure 8. The outline below describes how the sewer facility data was transferred from multiple sources to 1"=40' scale mylar planimetric maps that were in turn scanned and digitized into GIS coverages. The particular attribute requirements are defined in the Hydrologic Model and Hydraulic Model chapters of this report.

## Step 1: Data Transfer

The first step of the plan was data transfer. The City of New Haven provided approximately 350 planimetric mylar maps to which the consulting team manually added sanitary, storm, and combined sewer data. These maps serve as both the basis of input data to the GIS and as permanent records for the City of New Haven.

The primary sources of data for these tasks included about 2,300 11"x24" strip maps, as-built plans, record drawings, and input from City staff. Information from the maps provided by the City included manhole locations, overflow structures, pump stations, pipe dimensions, and pipe construction materials. Most maps contained profile information showing ground and/or sewer lines and the invert elevations at the manholes. If inverts were not shown, elevations were scaled and shown on the maps in parentheses to differentiate the sources. Sizes shown for the egg-shaped and elliptical pipes were equivalent to their multidimensional sizes. Actual pipe sizes were obtained from previous reports and studies, and limited fieldwork was performed to verify questionable data. The locations of facilities were shown schematically in the middle of the streets. A legend prepared by the consulting team was included on each of the maps.




# Figure 8

Data Conversion Plan

Communications were established with Mr. Henry Goetz, Jr., Chief Records Engineer of the Water Pollution Control Authority, who has extensive knowledge of the sewer system. Meetings were held to discuss data problems and conflicts during the data transfer process. Mr. Goetz also provided many drawings from the City Engineering Department's vault that contained recent information not shown on the strip maps.

## Step 2: Data Digitization

The second step of the plan was to scan the 1"=40' mylar planimetric maps and digitize the data they contained into ARC/INFO coverages. As the features were digitized, the attribute databases were populated with the appropriate data. Rules established in Technical Memorandum #2 were used to ensure proper system connectivity, that attribute data was complete, and that special coding conventions were followed.

## Step 3: Validation

The validation step identified potential errors introduced in the transfer/digitizing process. Database queries identified missing or questionable attribute data. Each item was checked against the strip maps to ensure that the information was transferred correctly and completely. In some cases, additional mapping was used to solve the discrepancy. For the remaining questions, a survey team obtained the data required for the development of the models. Missing data were also identified for the storm sewers. It was decided that the City would obtain missing storm facility information, including such attributes as ground and invert elevations of manholes, and inverts and diameters of pipes.

The catchbasin (STMCB) and catchbasin lateral (STMLAT) coverages contain about 50% of the structures reported by City and WPCA officials. Although a concerted effort was taken to gather all relevant and available data from the Engineering Department, it appears that a large number of the catchbasins and catchbasin laterals were not shown on the strip maps.

Appendix C provides a complete data dictionary for each of the GIS coverages listed previously in Table 1. There, the reader can find a detailed description of the data that is stored in each database, including the format of each field (e.g., integer, character) and relevant coding notations. With the framework of the GIS defined, the databases were populated with the attribute data required by the flow and hydraulic models, as described in the next two chapters.

# Hydrologic Model

Base sanitary flow, stormwater runoff, and groundwater infiltration all can be components of the flow in a sewer system. Physical parameters describing urban catchments—the basic unit required by a hydrologic model—are used to determine the hydrologic loads due to these flows. In the New Haven hydrologic model, the total flow is calculated for each catchment and introduced into the hydraulic model of the City's combined and sanitary sewer system. Model input parameters vary by the type of flow.

The City was divided into approximately 800 drainage catchments, with an average size of 10 acres, on 1:6000 scale basemaps that were digitized into ARC/INFO coverages (see Figure 9). Catchment boundaries were defined as lines around those areas that contribute flow to the sewer system at specific points throughout the City. Typically, overland slope was the key factor in determining each boundary in the outlying areas of the City. In the inner, developed areas, rainfall from lots drains to the streets where wet weather flow enters the sewer system. For these catchments, the sewer network and cadastral framework were the primary factors used to delineate catchment boundaries. Once catchments had been delineated, the hydrologic parameters required by MOUSE that describe each catchment were determined.

In addition to the flows generated within the City of New Haven, the sewer system also receives flow from neighboring communities. The long term flow monitors shown in Figure 9 record the amount of water that the Towns of Hamden, Woodbridge and East Haven contribute to the system. To accurately model the flow characteristics of the sewer system, synthetic catchment models of the external areas were developed for the tributary area to each flow monitor and included in the overall system model.

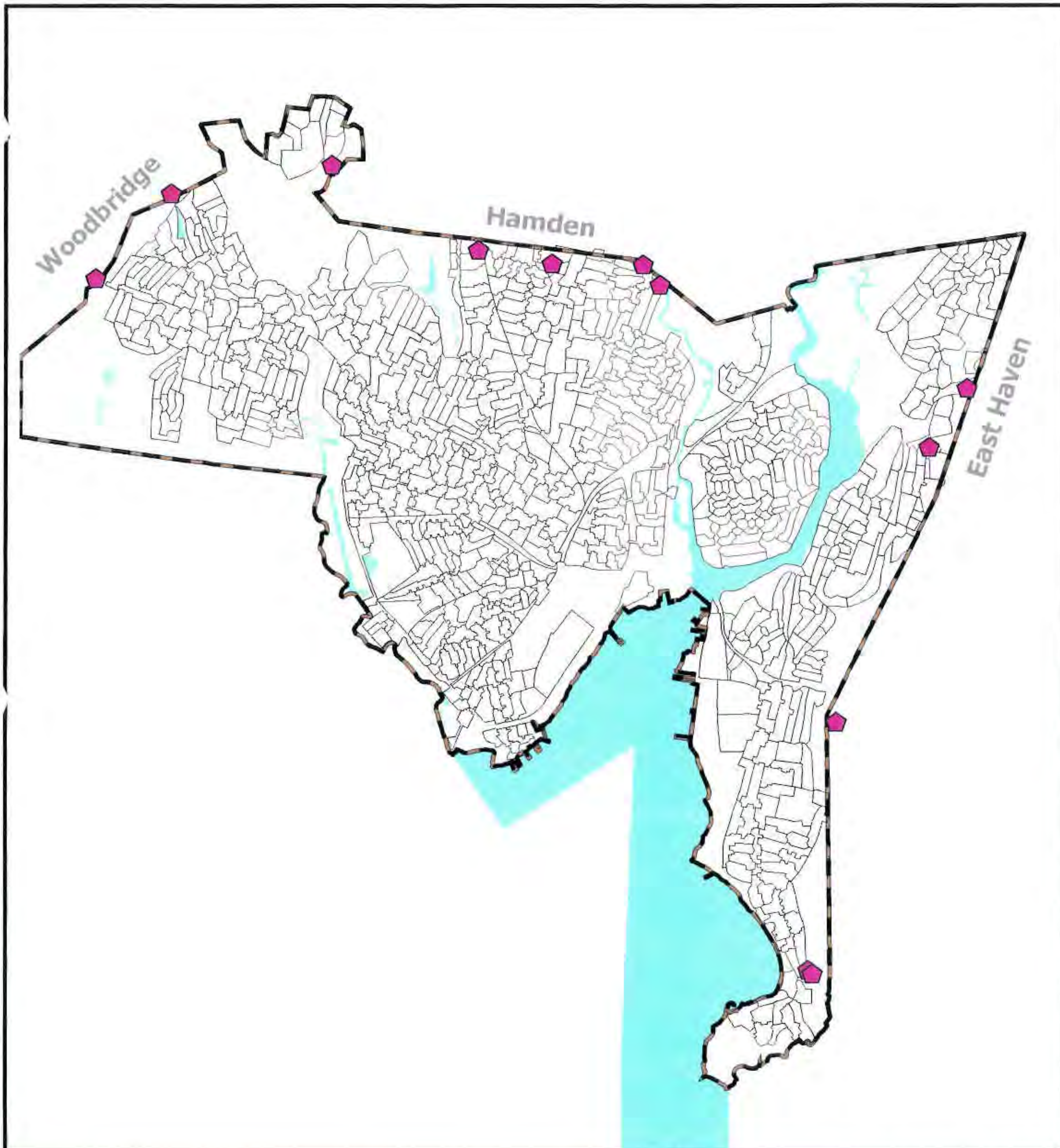
The core of this chapter is divided into three sections:

- Base Sanitary Flow,
- Groundwater Infiltration, and
- Stormwater Runoff.

Within each section, model requirements, database design, and methodology are discussed. Two additional sections at the end describe global parameters relating to hydrology and the process used to construct the hydrologic model from the GIS.

## Base Sanitary Flow

Dry weather flow consists of base sanitary flow (BSF) and groundwater infiltration. BSF is the result of wastewater generated by human activities, and typically varies during the day. Infiltration is the result of water entering sewers in the ground from saturated areas and high water tables through cracks and misalignments in the sewers and is typically at a constant rate but varies seasonally. The input data required by the computer model for base sanitary flow is described in this section, and that for groundwater infiltration is treated separately in the next section.




New Haven City Boundary

Subcatchment Boundary

Metered Flow Contribution from External Area

2000 0 2000 4000 Feet

# Figure 9

## Modeling Subcatchments and External Flow Contributions

New Haven Long Term CSO Control Plan

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## Model Requirements

The MOUSE model computes BSF from three parameters:

- the average rate of sanitary waste generated per person per day,
- the catchment population, calculated from the density of people in a subcatchment and the area, and
- the hourly variation in the sanitary flow pattern, given as a set of peaking factors (PF).

Figure 10 shows a screen capture from MOUSE that indicates the per capita BSF data requirements of the model.

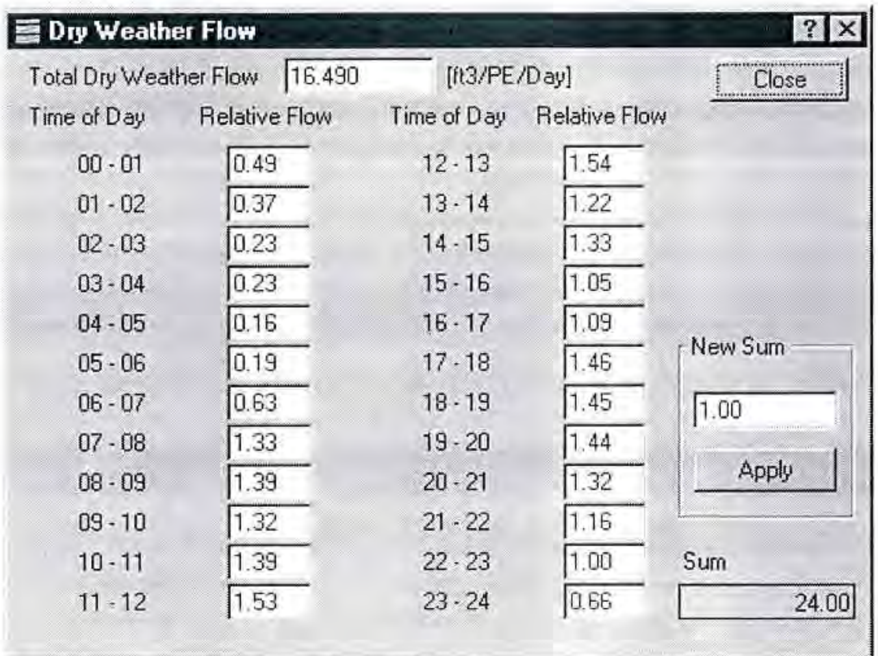



*Figure 10: Base Sanitary Flow Dialog Box from MOUSE*

## Database Design

An ARC/INFO polygon coverage named NHSUB was created by delineating and digitizing the physical boundaries of the 800 sewersheds. It contains attributes for each of those catchments that were required to develop the flow models. The database also contains other information pertinent to the catchments but not required by MOUSE. Table C-5a in Appendix C lists all of the attributes stored in the NHSUB coverage.

Parameters needed for modeling BSF, such as the population density, area, and water consumption rate of each catchment, are stored in three fields of the coverage database: PE_acre, Area_acre, and RWA_rt_cfs, respectively. Other data that can be applied globally to all catchments, such as the peaking factors and the average wastewater generation rate, are stored separately from these data in MOUSE (see Figure 10).

## Methodology

MOUSE computes BSF using the following equation:

$$BSF = \lfloor CR_{avg} \rfloor \times [PE/acre] \times [A] \times [PF] \qquad (1)$$

where:

$CR_{avg}$ = average wastewater generation rate ($ft^3$/cap/day, or cfpcpd)

PE/acre = population density (person equivalents [PE]/acre)

A = catchment area (acre)

PF = diurnal peaking factors

The development of each of these parameters (with the exception of area) for the New Haven BSF model is described below.

### Average Wastewater Generation Rate ($CR_{avg}$)

Assuming that water consumed is eventually directed to the sewers as wastewater, the average water consumption rate can be substituted for the average wastewater generation rate needed for the BSF model. A GIS database for water consumption rates was obtained from the Regional Water Authority. The rates were given as average annual consumption rates during 1996 for individual users. The average annual water consumption rate for New Haven during 1996 was computed to be 16.1 MGD. This number was composed of 56% residential users, 23% commercial users, 11% industrial users, and 10% public authority users.

To determine the average wastewater generation rate based on the water consumption rates, the population of New Haven was needed. A GIS coverage of 1990 census data, obtained from the University of Connecticut, indicated that the population of the City of New Haven was 130,550 people.

Assuming that the wastewater generation rate is equal to the water consumption rate, the average wastewater generation rate is then:

$$CR_{avg} = \frac{16.1\, MGD}{130{,}550\, PE} \times \frac{10^6\ gal}{MG} \times \frac{ft^3}{7.481\, gal} = 16.5\ cfpcpd \qquad (2)$$

This rate is significantly higher than typical published values for residential rates. It is important to realize that it encompasses all users, including non-residential users such as industrial sources. The actual residential rate could be calculated as 56% of 16.5 cfpcpd, or 9.2 cfpcpd, which is more representative of residential water consumption or wastewater production rates (Tchobanoglous, 1981). Use of the 16.5 cfpcpd rate allowed MOUSE to correctly calculate the wastewater generated for the whole system.

### Population Density (PE/acre)

The population in a catchment was determined by multiplying the density of people by the area of the catchment. Densities of people in each catchment were estimated through use of the following equation:

$$\frac{PE}{acre} = \frac{(RWA\_rt) \times (86400\ s/day)}{(A) \times (CR_{avg})} \qquad (3)$$

where:

$RWA\_rt$ = rate of water consumption in a catchment (cfs), obtained from the Regional Water Authority (RWA) (described further below)

$CR_{avg}$ = average wastewater generation rate ($ft^3$/cap/day, or cfpcpd)

$A$ = catchment area (acre)

The numerator represents the volume of flow consumed in a catchment during one day. By dividing it by the average wastewater generation rate, the equivalent number of people in the catchment was approximated. This estimate represents a "synthetic" population because the average consumption rate includes residential, commercial, industrial, and public authority uses. Thus, the equation above provided an estimate of the number of people that *would be* residing in a catchment if all the water use were residential. Dividing by the catchment area then provided the ratio of person equivalents per acre that MOUSE requires.

Population densities calculated by the above equation were zero for some catchments due to a lack of RWA water taps in those catchments or small consumption rates. It was clear from examining the land cover types in these catchments that they should contribute some base sanitary flow component to the model. For these areas, a population density of 1 PE/acre was assumed in the database.

### Diurnal Peaking Factors (PF)

Base sanitary flow typically varies throughout the day. For example, a peak generally occurs in the morning when many people use water for showers, toilets, etc and again in the evening during dinner time. This variation can be described by a set of peaking factors normalized to 1.0 for the average value, with values greater than 1.0 representing peaks. To determine these factors, periods of dry weather were identified from rainfall records and corresponding flow monitoring hydrographs were obtained. Seven sets of diurnal peaking factors were developed for five different sites, including the East Shore Water Pollution Abatement Facility (WPAF) and metering sites NH10 (Morris Cove), S1 (Westville), C1 (Fair Haven), and RL2 (Downtown). For the WPAF and NH10, two sets of peaking factors each were developed, one in September (based on data from 9/22/97 to 9/26/97) and one in April (4/6/97 – 4/10/97) to examine any seasonal impacts. The remaining three sites used data from September. Figure 11 shows the seven sets of peaking factors graphed versus time of day. The diurnal pattern for site S1 shows a stronger peak than the other patterns, likely due to the particular land use and wastewater generation in that catchment. The peaking factors from site C1 were chosen as most representative, as they had neither the most nor the least extreme peaks. They provided an average curve while still maintaining a peak early in the day, which was more representative of smaller upstream catchments than the delayed peak of the entire sewershed observed at the WPAF.

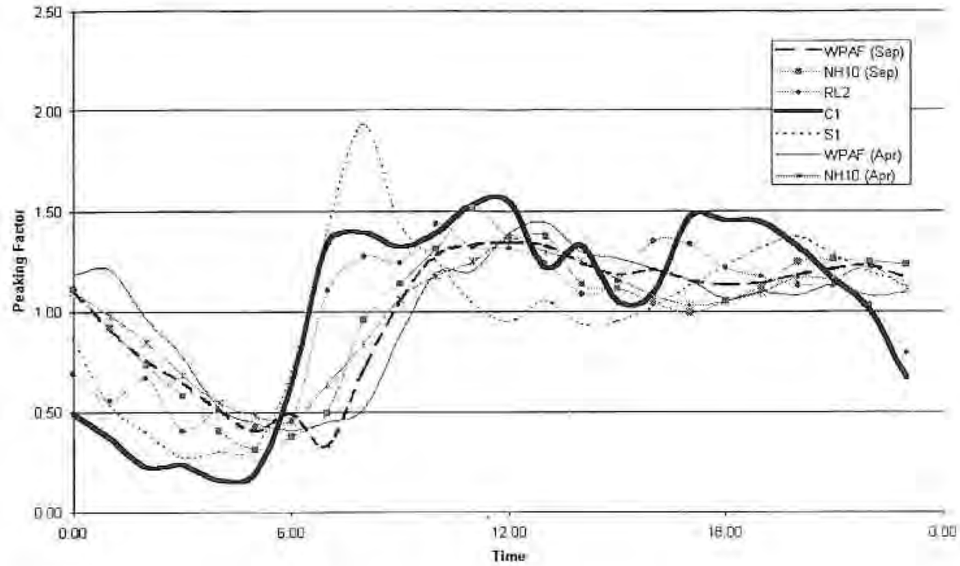



*Figure 11: BSF Peaking Factors Developed for Sites Throughout New Haven*

### RWA Consumption Data (RWA_rt)

The Regional Water Authority's GIS provided the water consumption data that was the basis for determining wastewater generation rates at the subcatchment level. Of the 16.1 MGD consumed on average in 1996, 13.5 MGD had been matched with specific geographical locations in the GIS. Approximately 2.6 MGD that had not been geographically matched by the RWA had to be assigned by further investigation or by apportioning it throughout the catchments on a consumption-weighted basis.

All basins with water consumption were included in the model, except for a few cases when the land cover type indicated it was appropriate to assign the consumption rate to a nearby basin—for example, when a catchment was almost entirely a cemetery. In general, these reassignments were necessary because some subcatchment boundaries were drawn such that they enveloped a few water taps that really belonged in a neighboring catchment. Catchments without water consumption (e.g. undeveloped land, highways) were not modeled.

### Base Sanitary Flow from the External Areas

Flow contributions from areas outside of the New Haven City boundary were modeled with synthetic catchments. This simplified approach was taken because sewershed boundaries and the extent of sewer separation were not readily available. One catchment was defined for each of the 11 external flow meters. Compared to the 10 acre catchments used within the City of New Haven, 60 acre to 4900 acre catchments were defined for the external areas. The parameters obtained for these lumped catchments were refined through a separate modeling exercise and then later included in the New Haven model to provide inflows from the external areas.

The process used to simulate base sanitary flow for the external areas was similar to that used for New Haven. The major exception lay in the calculation for population density, which is dependent on the water consumption rate for estimating the wastewater generation rate (see Equation 3). In New Haven, this value was obtained from the RWA's GIS (RWA_rt), but for the external areas, no GIS coverage had been obtained. A substitution was made according to the following procedure:

- calculate the average dry weather flow over several dry days (during the fall of 1996 or 1997) from flow monitoring records,
- subtract a groundwater component from each of the averages (described in the next section) to obtain average base sanitary flow for each meter, and
- substitute the average base sanitary flow values for the water consumption rate in the equation for population density (Equation 3).

The process thereafter was the same as that used for New Haven.

# Groundwater Infiltration

Groundwater can enter a sewer system through cracks and misalignments in sewers. Infiltration typically varies by season because it is affected by the amount of groundwater available, with spring having the highest infiltration and autumn the least. Inflow can vary widely different catchments based on the condition of the sewers they contain.

## Model Requirements

MOUSE 4.01 does not directly simulate seasonal or wet weather variations in the groundwater infiltration component[1]. However, the model does allow the addition of a constant flow (in cfs) to each catchment. This was the method used to incorporate groundwater infiltration in New Haven's hydrologic model.

## Database Design

Groundwater infiltration for each catchment is stored in the Addtl_flow field of the NHSUB coverage.

## Methodology

The impact of groundwater infiltration (GWI) to New Haven's system was estimated by examining two periods during which there was neither rain nor peak tide levels due to a full moon. The periods identified were in April and September, when GWI was typically high and low, respectively. Flow data for the WPAF and the twelve external flow meters and the RWA's water consumption data were used to estimate the magnitude of the GWI during the wet and dry seasons. The primary difference between the total measured dry weather flow and the wastewater flow was the groundwater infiltration into the sanitary sewer system. Therefore, flows entering New Haven from the three nearby communities and those measured by the RWA were subtracted from the total flows measured at the WPAF to

[1] To simulate seasonal or wet weather variations in GWI, a separate hydrologic model (MOUSE NAM) must be used.

estimate the inflow to the sewer system due to groundwater. In this analysis, it was assumed that the RWA's water consumption data were comparable to sanitary flows (i.e., that all water taken from water taps is returned to the sewers). Table 4 shows these values.

**Table 4. Flows Throughout the System Without Rainfall or Peak Tides (MGD)**

| | WET SEASON 4/14/97 – 4/16/97 | DRY SEASON 9/22/97 – 9/26/97 |
|---|---|---|
| East Shore WPAF (WPCA) | 38.2 | 29.5 |
| Woodbridge, Hamden, and East Haven (ADS) | 15.8 | 10.6 |
| New Haven water consumption (RWA) | 15.6 | 15.6 |
| Estimated GWI in New Haven | 6.8 | 3.3 |

The GWI values stored in the GIS database were derived from the September estimate. Because the magnitude of the groundwater component was quite small in comparison to peak wet weather rates, (primary treatment capacity at the WPAF is 100 MGD), the fluctuation between seasons was not modeled.

The total infiltration for the dry season of 3.3 MGD was distributed to each subcatchment on an areally-weighted basis, so that larger catchments received a larger portion of the total GWI. Values for individual subcatchments ranged from 0.0005 MGD to 0.0347 MGD, with an average of 0.0042 MGD. To be consistent with the requirements of MOUSE, the GWI values were stored in the GIS in units of cfs.

### Groundwater Infiltration for the External Areas

For each of the external catchments, a GWI constant was determined for the same September periods as were used for the development of base sanitary flows for the external areas. However, for simplicity, the values were set to 80% of the minimum instantaneous hourly flow measurement during the analysis period for each catchment as illustrated by the hydrograph in Figure 12. As for the New Haven values, no seasonal variation in groundwater was modeled.

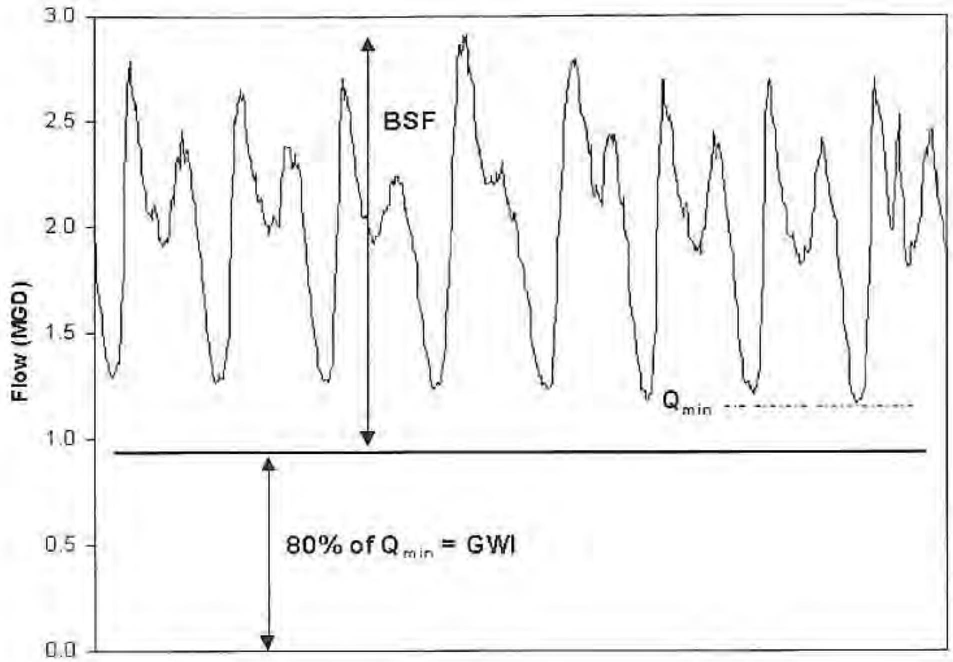



*Figure 12: Groundwater Infiltration for External Areas*

## Stormwater Runoff

A catchment can be described as a combination of pervious and impervious areas that are largely defined by the type of land use. Pervious lands such as grassy surfaces have the ability to absorb a portion of the precipitation through the process of infiltration, depending on the type of soil. There is a limit to the infiltration rate, after which additional precipitation results in surface runoff from pervious lands. Impervious lands include roadways, parking lots, rooftops, and other similar surfaces. Impervious land may have small depressions that store some of the initial precipitation, but once these spaces are filled, additional precipitation results in immediate surface runoff from impervious lands. Both sources of runoff can be collected by the sewer system.

Percent impervious is a key parameter for converting rainfall to runoff. In combined sewer service areas, flow from impervious surfaces is collected by the combined sewer system. In areas that are partially separated, flow from roadways and parking lots enters the storm sewer while flow from rooftops and foundation drains enters the sanitary system through connected downspouts and sump pumps. In fully separated areas, all runoff is directed into the storm sewers.

Rainfall-derived inflow and infiltration (RDII) is the unintentional input of wet weather flow into sewers during and immediately after a rainfall event. RDII originates from near-surface infiltration seeping around and into manhole structures, direct inflow into manholes from streets and parking lots, and increased infiltration from higher soil moisture following storm events. In combined sewers, RDII contributions are significantly smaller than stormwater runoff and are often not modeled. In separate sanitary sewers, special considerations are required to incorporate RDII into the computations.

In the New Haven model, calibrating the runoff model to flow metering data indirectly incorporated RDII, thus allowing the calibration parameters to include RDII as a portion of the runoff.

## Model Requirements

For a runoff model, the study area was divided into drainage subcatchments, or sewersheds. The sewersheds were described in terms of land area, percent impervious, surface slope, catchment length, type of land cover (e.g. industrial), and degree of sewer separation. The data requirements that define catchments are presented in Table 5 and are described in more detail in the sections below. Figure 13 shows the dialog box in MOUSE that controls model input for catchment data, including that used for base sanitary flow and groundwater infiltration.

**Table 5. MOUSE Data Requirements for Stormwater Runoff**

| Description | Units | Format | Sample Data |
|---|---|---|---|
| Inlet Node Name | | Character | T13N470 |
| Catchment Area | ac | Real | 7.70 |
| Catchment Slope | $^0/_{00}$ | Integer | 1 |
| Hydraulic Catchment Length | ft | Integer | 869 |
| Representative Land Cover | | Integer | 4 |
| Percent Impervious | % | Integer | 45 |

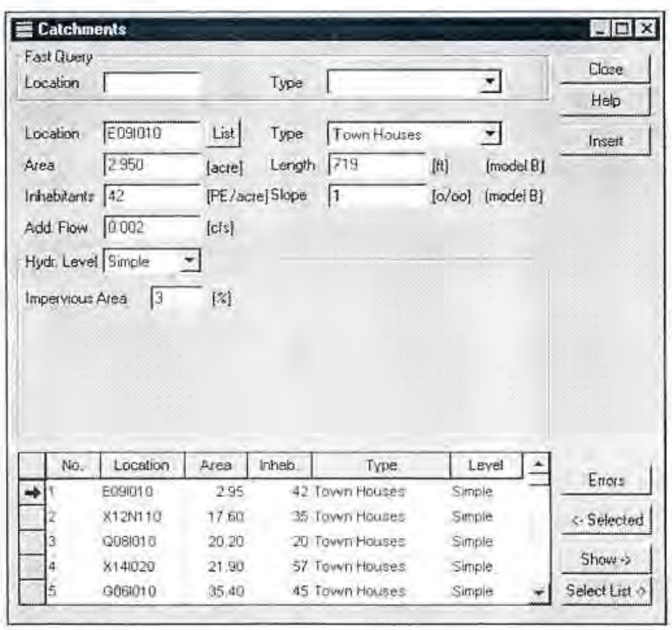


*Figure 13: Catchment Dialog Box from MOUSE*

## Database Design

Table 6 shows the fields in the NHSUB coverage that contain data for the various runoff parameters required by MOUSE. Further information is given about each parameter in the next section.

**Table 6. Relationship Between MOUSE Catchment Parameters and NHSUB Database Fields**

| Parameter | Field |
|---|---|
| Degree of Sewer Separation | BASIN_TYPE |
| Inlet Node Name | INLET_SYS, INLET_INTR |
| Catchment Area | AREA_ACRE |
| Hydraulic Catchment Length | LENGTH_FT |
| Catchment Slope | SLOPE_PCT |
| Representative Land Cover | LU_TYPE |
| Percent Impervious | PCT_MOD |

## Methodology

MOUSE calculates stormwater runoff by applying rainfall to a subcatchment. The magnitude of the stormwater response observed in the combined/sanitary sewer depends in part on the degree of sewer separation. This response is simulated in MOUSE by several catchment parameters that affect the shape and rate of surface runoff. The development of parameters that are key to simulating runoff in the hydrologic model, which include catchment length, surface slope, land cover type, and imperviousness, is discussed below.

### Degree of Sewer Separation

This parameter is not required by MOUSE, but it was needed to simulate the different runoff responses that occur in catchments with different degrees of sewer separation. Possible values for this parameter include the following:

- S – **fully separated**; runoff from streets, parking lots, and rooftops is captured by the storm sewer system.
- P – **partially separated**; runoff from streets and parking lots enters the storm system, while roof leaders and foundation drains are connected to the sanitary system.
- C – **combined**; all sanitary and storm flows are conveyed together to the WPAF in combined sewers.
- FP – **future partial**; combined sewersheds that are affected by ongoing sewer separation project were calibrated as combined sewersheds but will be considered as partially separated in the baseline conditions.
- NS – **non-sewered area**; these areas include cemeteries, parks, highways, open space, quarries, water, undeveloped areas, and areas with storm sewers only. Many of these

polygons exist because they were framed in the GIS by the boundaries of neighboring polygons. These catchments were not modeled.

- **EH – catchment flowing to East Haven**; the flow from several basins on the east side of the city is conveyed out of New Haven and then to the WPAF combined with flows from East Haven. These catchments were included in the model with the external flow contributions from East Haven.

Adjustments made to this parameter are described in the Model Calibration and Results chapter.

Initially, the BASIN_TYPE values were assigned based on the extent of sanitary and storm sewers in each catchment using the GIS. Some catchments were easily identified as being separated or combined, but others required further information. Once the initial assignments had been made, a meeting with the City and WPCA was held to finalize the assignment in other catchments. Additionally, catchments affected by ongoing sewer separation projects (BASIN_TYPE=FP) will be included in the baseline model as partially separated. These catchments were modeled as combined during the model calibration because the catchments were still combined when flow metering data was collected during Task 3.

### Inlet Nodes

Inlet nodes were identified to link the hydrologic model to the hydraulic model. The nodes included in the model were uniquely-named SANNODE point features. By defining a common node, proper connectivity between the two parts of the model was ensured.

Two inlet nodes were defined for each catchment. One is for the system-wide model, and the other is for the interceptor model that includes fewer pipes and manholes. (More information about the two models can be found in the Hydraulic Model chapter.) In the system-wide model, inlet nodes were chosen to be near the centroids of the basins, or at a nearby node that was deemed to be suitable.

For the interceptor model, inlet nodes were moved to the nearest downstream node that was included in the simplified model. There were fewer unique inlet nodes in this model, as some nodes were common to multiple upstream catchments.

### Catchment Area

The values for this parameter were the areas of each catchment polygon in the GIS coverage. It was the gross area of land, in units of acres, serviced by sanitary or combined sewers.

### Hydraulic Catchment Length

The effective length for each catchment was calculated by the following equation:

$$L_{eff} = 2\sqrt{A(ac) * 43560 ft^2 / ac} \qquad (4)$$

where:

$A$ = catchment area (acre)
$L_{eff}$ = hydraulic catchment length (ft)

This method of estimating lengths was verified by comparing the computed lengths of several basins to the actual lengths manually measured from the basemaps. It was determined that this method estimated the lengths of slender, elongated basins rather well but tended to overestimate the lengths of short, wide basins. In general, the calculated lengths were within the accuracy of other parameters used for modeling hydrology in New Haven.

### Catchment Slope

This variable is used to describe the average ground slope (feet per 1000 feet) for portions of the basin subject to overland flow. To estimate slope, the maximum and minimum ground elevations that occur at nodes within each catchment were determined from the GIS. Hydraulic catchment lengths, which had been previously calculated, were used to determine the slopes according to the following equation:

$$S = \frac{z\_grd_{\max} - z\_grd_{\min}}{L_{eff}} * 1000 \qquad (5)$$

where:

$S$ = surface slope ($^0/_{00}$) or (ft/1000 ft)
$z\_grd_{max}$ = maximum ground elevation at a node (ft)
$z\_grd_{min}$ = minimum ground elevation at a node (ft)
$L_{eff}$ = hydraulic catchment length (ft)

The calculation resulted in slopes ranging between 0 and 83 ft/1000ft, where zero slopes were a result of rounding error (MOUSE restricts the number of digits that can be used). Because there should not be any catchments with zero slope in the model, the five basins with a zero value were assigned a slope of 0.001. In addition, nine catchments had only one or no manholes, and as a result the calculation could not be performed. After examination of a topographical map, estimates of the slopes in these catchments were made or the slope calculated for a nearby, similar catchment was substituted.

This method of estimating surface slope was verified by estimating the vertical drop and horizontal length of the flow path in several catchments on a topographical map. For basins where the sewer follows the overland flow characteristics, this method provided a good estimate. The variation in surface slopes throughout the City was not extreme, and since this method was based on physical parameters and was simple to use, the estimates using this method were considered suitable for use in the model.

### Land Cover

A GIS coverage roughly depicting the land cover throughout New Haven (IMPCOV) was created using general knowledge of the area and references to general maps and the City of New Haven Plan Department's Zoning Maps (City of New Haven, 1996). Using this GIS coverage, the percentage of the area in each catchment that was associated with each land cover type was determined. For the kinematic wave runoff model, MOUSE uses land cover type to determine the distribution of pervious, semi-pervious, and impervious land.

**Table 7. Land Cover Types and Imperviousness**

| Land Cover Type | New Haven Model Imperviousness (%) | Reference Imperviousness (%) |
|---|---|---|
| Open or Undeveloped | 0 | 0 |
| Cemetery or Park | 5 | 0-15 |
| School (primarily Yale) | 30 | ** |
| Low-Density Housing | 35 | 35-65 |
| Middle-Density Housing | 50 | 65 |
| High-Density Housing | 65 | 75 |
| Commercial or Industrial | 80 | 70-85 |

* Standard Handbook of Environmental Engineering, R.A. Corbett, 1990.
** No suitable category was found for comparison.

### Impervious Cover

This variable describes the percentage of impervious cover in each basin. An areally-weighted average of the percent impervious associated with each land cover type in a catchment was calculated using the GIS. Table 7 shows the percent impervious assigned to each land cover type and includes a comparison with values from a standard reference.

A draft GIS coverage that included building footprints, roads, parking lots, driveways, and sidewalks was made available from the City's GIS consultant after model development had been completed. With some effort it was possible to calculate the area of buildings and roads in each catchment to estimate the percentage of impervious land and provide a comparison to the estimates in the model. Because of the way the data were represented in the coverages obtained from the GIS consultant, considerable effort would have been required to reformat the data to include other impervious areas in the calculation (i.e., parking lots, driveways, sidewalks). A direct comparison was therefore beyond the scope of spot checking because of its considerable effort. In general, it was found that the model imperviousness (average of 51%) was higher than that in the comparison coverage (31% average)—a result that would be expected due to the mixed comparison.

### Stormwater Runoff from External Areas

It is the consulting team's understanding that the catchments in the three communities which direct flow into New Haven—Woodbridge, Hamden, and East Haven—are all served by separated sewer systems. However, a review of flow monitoring data, indicated that there was a stormwater response in these systems during wet weather. Therefore, it was appropriate to create a hydrologic model that simulated stormwater runoff from the external areas. As mentioned previously, the external areas were modeled with synthetic catchments to simplify the modeling process. The parameters used in modeling stormwater runoff for the external areas are described below.

### Area (A)

Rough catchment boundaries were determined from sewer maps for the three communities and were added to the GIS, from which areas were computed. It was assumed that not all the land in a catchment would contribute to stormwater runoff; therefore, a smaller effective area that would provide a more representative runoff response was calculated. Final calibration parameters included effective areas of 5 to 25% of the actual areas.

### Hydraulic Catchment Length ($L_{eff}$)

The length for each catchment was calculated by the following equation using the size of the effective area:

$$L_{eff} = c\sqrt{A(ac) * 43560\, ft^2 / ac} \qquad (6)$$

where:

$L_{eff}$ = hydraulic catchment length (ft)

c = a calibration coefficient

A = catchment area (acre)

Calibrated values for the coefficient ranged from 1.5 to 3.

### Slope

For the external catchments, slopes were assumed to be 0.001 feet per 1000 feet and were not varied in model calibration.

### Land Cover Type

For simplicity, the type of land cover for all synthetic catchments was assumed to "Townhouses".

### Impervious Cover

The percentage of the effective area that was considered to be impervious was adjusted during calibration, with values ranging from 2 to 15%.

# Global Hydrologic Parameters

Some parameters, such as evaporation rate, infiltration rates, and surface roughness are often specified globally for the entire study area. The parameters can vary depending on surface permeability—the MOUSE runoff model allows several values to be defined for each of these parameters.

Figure 14 shows the dialog box in MOUSE used for entering these global values. The numbers used are discussed below. Although values could be specified for semipervious land, for simplicity, the catchments in New Haven were divided into pervious and impervious sections only.

## Evaporation Rate

A rate of $1.9 \times 10^{-7}$ ft/s, or 0.2 in/day was utilized. For comparison, the National Climatic Data Center has evaporation data for two locations in Connecticut. The average daily pan evaporation rates for Norfolk and Coventry are 0.11 in/day and 0.16 in/day, respectively (EarthInfo, 1998).

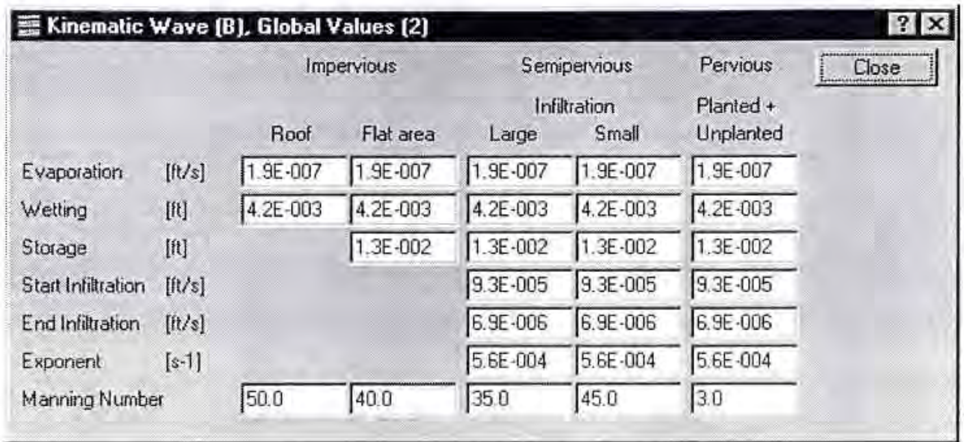



*Figure 14: Global Hydrologic Parameters Dialog Box from MOUSE*

## Wetting Depth

The depth required to initially wet the land surface was set to $4.2 \times 10^{-3}$ ft, or 0.05 in.

## Depression Storage

A depth of $1.3 \times 10^{-2}$ ft, or 0.15 in, was used for depression storage. Comparison values that have been used in successful modeling exercises range between 0.005 in and 0.25 in (Huber and Dickinson, 1988).

## Infiltration

Horton's infiltration is defined by the following equation:

$$f(t) = f_c + (f_0 - f_c)e^{-kt} \qquad (7)$$

where

$f(t)$ = infiltration rate as a function of time
$f_c$ = final infiltration rate
$f_0$ = starting infiltration rate
$k$ = decay constant

An initial infiltration rate of $9.3 \times 10^{-5}$ ft/s, or 4 in/hr, was used. Representative values for sandy and loam soils under dry conditions are 5 in/hr and 3 in/hr, respectively (Huber and Dickinson, 1988). New Haven principally has sandy-loam soils.

The final infiltration rate was set to $6.9 \times 10^{-6}$ ft/s, or 0.3 in/hr. Sandy soils generally have rates of 0.45 to 0.30 in/hr, while slightly less permeable soils have rates of 0.30 to 0.15 in/hr (Huber and Dickinson, 1988).

The decay constant was defined as $5.6 \times 10^{-4}$ $s^{-1}$, or 2 $hr^{-1}$. This value reduces the infiltration capacity 76% within the first hour of rainfall (Huber and Dickinson, 1988).

## Manning Number

Manning's numbers of 50 for roofs, 40 for flat areas, and 3 for pervious land, corresponding to Manning's n values of 0.020, 0.025, and 0.333, respectively, were used. These values are comparable to those specified in the literature for similar surfaces.

# Model Construction

Once the subcatchment coverage had been created and its corresponding attribute table had been populated with data, the hydrologic model could be created. This section briefly describes the process used to transfer hydrologic data from the GIS into the MOUSE modeling environment

As mentioned previously, the subcatchment coverage is made up of polygons that have attributes described in an associated table. However, the GIS also contains polygons that do not contribute flow to the New Haven sewer system (i.e., cemeteries, open space). Therefore, catchments required in the model were selected in the GIS and exported to an interim data table. MOUSE GIS extracted the hydrologic data required by MOUSE according to the 1:1 mapping defined between the data fields in the GIS (data table) and the model. The relationship between the GIS database (catch.dbf) and the fields required by MOUSE to model base sanitary flow, groundwater infiltration and stormwater runoff is depicted in Figure 15.

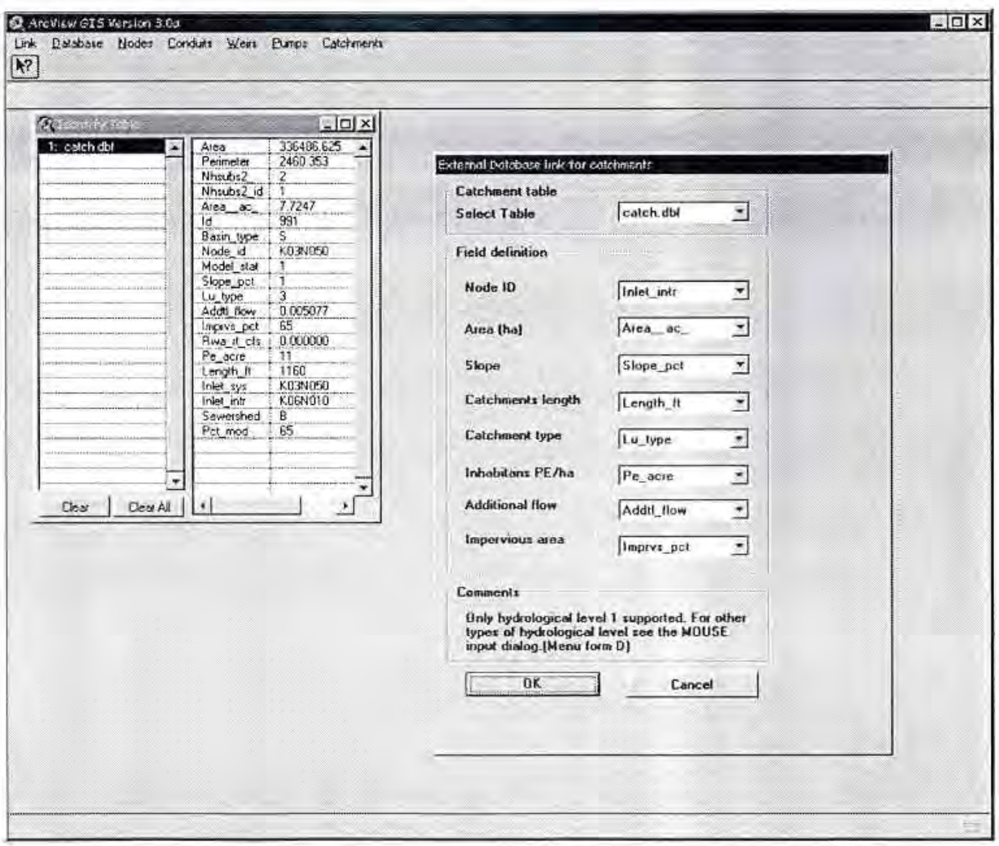



*Figure 15: MOUSE GIS Screen Capture of Catchment Data Extraction*

Once the 1:1 mapping was defined, the required data was extracted from the GIS. MOUSE GIS presents each subcatchment schematically as an equivalent square with its center at the inlet to the hydraulic model, as shown in Figure 16. The hydrologic data is exported to the MOUSE modeling environment as a MOUSE-formatted text file.

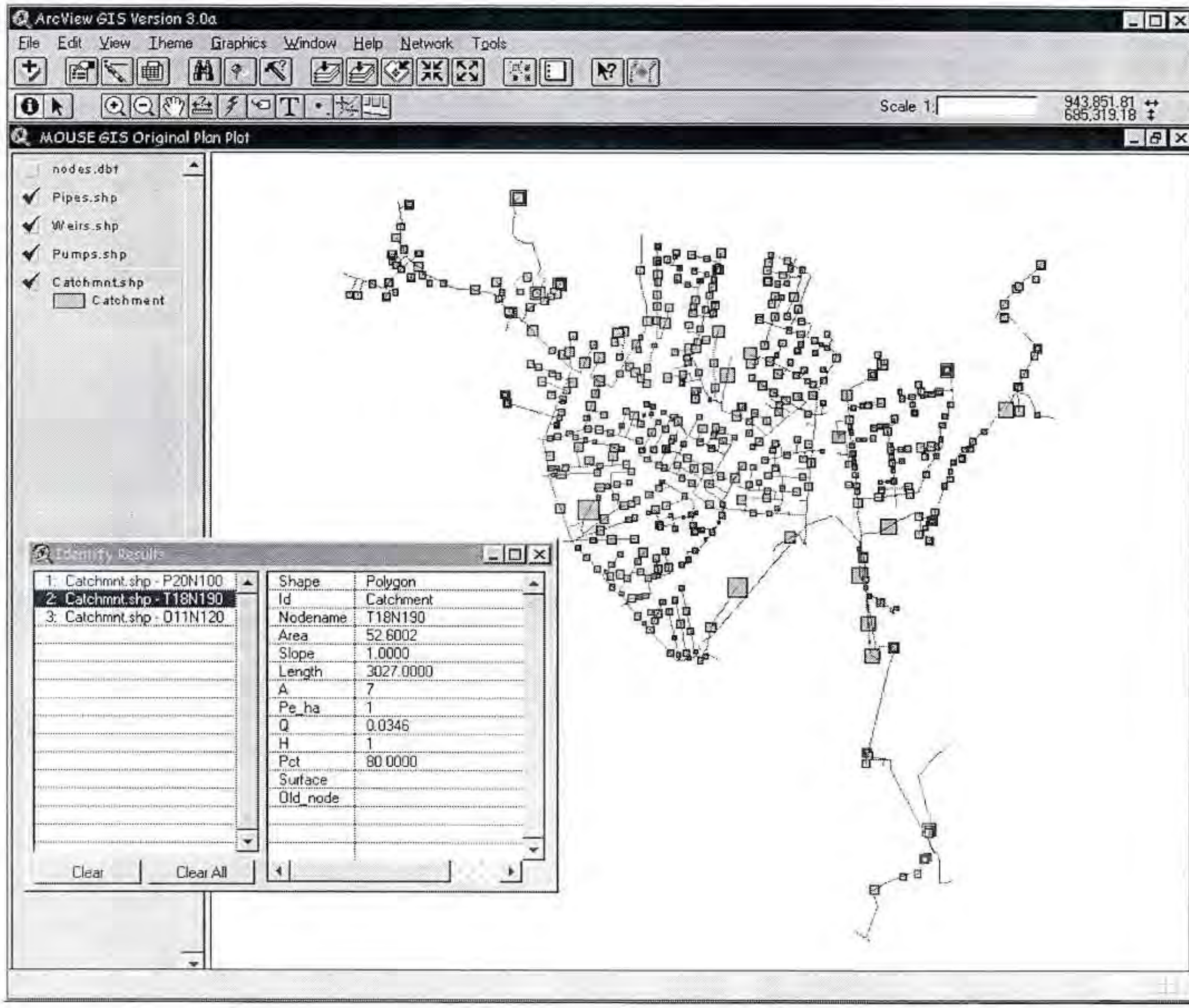



*Figure 16: Schematic Representation of the Hydrologic Model in MOUSE GIS*

# Hydraulic Model

To complete the modeling of the New Haven CSO system, a hydraulic model was developed to simulate how the collection system performs during dry and wet weather conditions.

In MOUSE, the sewer system is represented as a series of nodes that are connected by links. Inflows to the system are introduced at selected nodes throughout the system. In the model, nodes represent manholes, pump station wet wells, and outfalls. Links convey flow through the system. In the model, links represent pipes and forcemains. In addition, flow can pass between nodes through pumps and weirs.

The data describing the hydraulic features of each structural element is stored in the GIS databases created as part of Task 2: SANNODE and SANLINK. In addition, two relational databases were created to store the necessary information related to the pump stations and weirs: PUMP and WEIR. MOUSEGIS extracted the data required by the MOUSE model from the GIS and converted them into model input parameters.

This chapter outlines the construction of the MOUSE hydraulic model according to the four major components:

- Nodes,
- Links,
- Pumps, and
- Weirs.

Within each section, model requirements, database design and methodology is discussed. The chapter concludes with a description of how the data stored in the four separate databases were simplified and refined into a model of major interceptors of New Haven.

## Nodes

Nodes are structural elements like manholes, outfalls or user-defined structures (pump station wet wells). They also represent points throughout the sewer system that may accept inflow, such as those calculated by the hydrologic model.

### Model Requirements

All nodes require four basic parameters: a unique name, an X- and Y-coordinate and an invert elevation. The other parameters listed in Table 8 are particular to each type of node. The screen captures in Figure 17 show the three dialog boxes from MOUSE that control model input for each node element. Basins are used to define available storage in pump station wet wells and require additional cross sectional information that describes the surface and sectional areas with respect to depth.

To ensure connectivity between the two models, each inlet node defined in the hydrologic model must correspond to a node in the hydraulic model.

**Table 8. MOUSE Data Requirements for Nodes**

| Node Element | Description | Units | Format | Sample Data |
|---|---|---|---|---|
| All nodes | Node name | | Character | T13N060 |
| | X-coordinate | ft | Real | 560760.436 |
| | Y-coordinate | ft | Real | 176283.457 |
| | Invert Elevation | ft | Real | 32.38 |
| Manholes only | Ground Elevation | ft | Real | 38.76 |
| | Outlet Shape | | Integer | 2 |
| | Node Diameter | ft | Real | 6.50 |
| Outlets only | Water Surface Elevation | ft | Real | 27.25 |
| Basin Only | Ground Elevation | ft | Real | 38.76 |
| | Depth H | | | |
| | Surface Area at Depth H | $ft^2$ | Real | 165.10 |
| | Sectional Area at Depth H | $ft^2$ | Real | 50.3 |
| | Outlet Shape | | Integer | 2 |

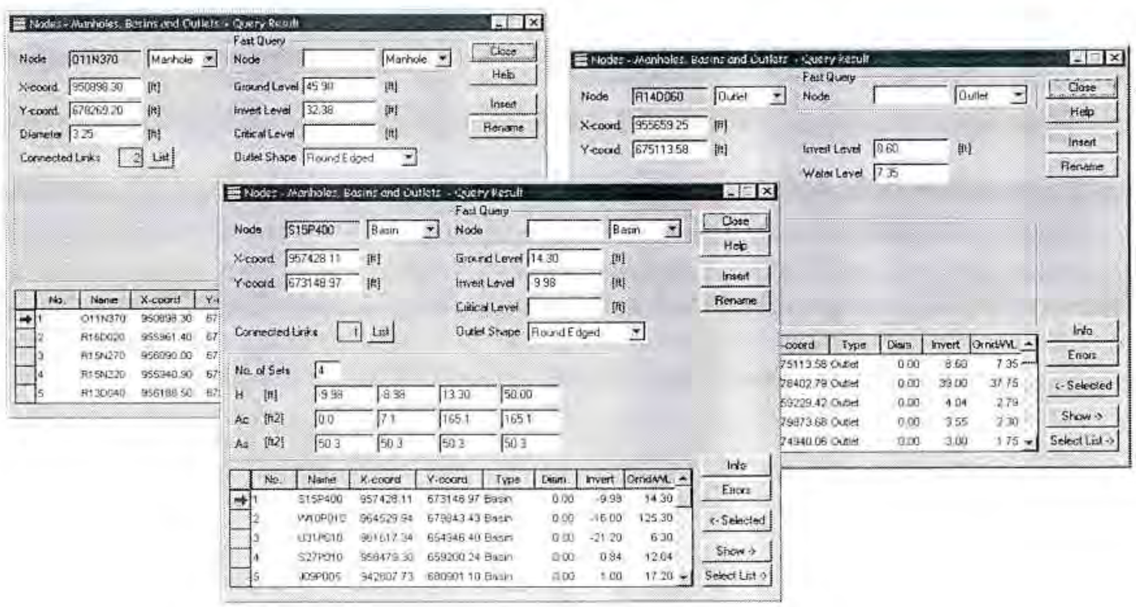


*Figure 17: Node Data Dialog Boxes from MOUSE*

## Database Design

The SANNODE point coverage indicates the physical location of sanitary sewer nodes and contains relevant information describing each feature. Table 9 shows the fields in the coverage that contain data for the various node parameters required by MOUSE.

**Table 9. Relationship Between MOUSE Node Parameters and SANNODE Database Fields**

| Parameter | Field |
|---|---|
| Node name | SAN_NAME |
| X-coordinate | SAN_XPOS |
| Y-coordinate | SAN_YPOS |
| Invert Elevation | SAN_ZBTTM |
| Ground Elevation/Water Surface Elevation | SAN_ZGRD |
| Outlet Shape | OUTLET_INT |
| Node Diameter | Diameter |

The cross section information required for basin nodes was entered directly into the MOUSE model, and was not stored in the GIS.

Table C-1a in Appendix C shows all of the fields that were created for the SANNODE database, and the definitions for each field. Some of the information is relevant to the manhole (e.g., name of mylar sheet containing the feature), but not required by the MOUSE model.

Further information about each NODE parameter required by the MOUSE hydraulic model is provided in the next section.

## Methodology

NODE parameters required by the model were obtained during the data transfer process. Before the GIS was built, the types of data required for simulating hydraulic conditions in the sewer system were identified from strip maps, as-builts or record drawings and transferred to a set of mylar planimetric maps. Some of the parameters were not readily available from existing information and were obtained afterwards from field investigations. This data was also stored in the GIS.

Additional data required to define the configuration of wet wells was entered directly into the MOUSE model, and was not stored in the GIS.

### Node Name

Nodes are identified by their unique name, SAN_NAME. These unique identifiers were derived from the 1"=40' planimetric map name and the type of node the spatial object represents. The naming scheme consisted of seven alphanumeric characters: the first three characters contained the mylar sheet number, the fourth character was a letter identifying the type of feature as follows:

- N: node (manhole, proposed manhole, manhole chamber, manhole catch basin),
- P: pump station,

- O: outfall,
- R: regulator location,
- I: inlet location, and
- D: dummy node

The fifth through seventh characters denoted a unique number for the feature within the mylar grid tile, in increments of 10. For example, a value of *Q11N050* in the SAN_NAME field denotes a location within planimetric map *Q11*, and is a node (*N*), with a unique number *050*.

### (X, Y) Coordinate Pair

Pavement edges and building footprints displayed on the mylar maps were used to fix the position of the sewer facilities, as described in the Project Scope of Work. The locations were schematic in nature, and were intended for planning level purposes. Point features were transferred from construction plans to 1"=40' mylar planimetric maps and digitized into the SANNODE coverage in the GIS as described in the GIS Construction chapter. The (x,y) location of each node was referenced to the NAD83 coordinate system.

### Invert/Ground Elevation

Elevation information was obtained from construction plans with respect to the USCGS datum and digitized into the SANNODE coverage for each node.

### Outlet Shape

The outlet shape refers to the entrance and exit head loss calculations at a manhole or basin. A round edged outlet shape was assumed for all manholes and basins. Outlets do not require this information.

### Node Diameter

This parameter defines the cross sectional diameter of a manhole, and is not used for outlets or basins. It was assumed that all manholes had a standard diameter of 3.25 ft. Equivalent diameters were entered for regulators and other structures where necessary.

### Cross Sectional Area of Basins

The parameters used by basins to describe the change in storage with depth required special attention. Basins were defined at the 16 pump stations in New Haven. Dimensions were scaled from available construction drawings and entered directly into the model.

# Links

Links represent the sewers and forcemains modeled in MOUSE.

## Model Requirements

A link is defined as a straight line passing flow between two nodes (upstream node to downstream node). Links can be standard shapes (egg, circular, square or O-shaped) or user-defined shapes for irregular pipes. User-defined shapes are arbitrary coordinate pairs that describe the cross section profile for atypical sewer segments. NEWHAVEN was a separate database that contained the cross section definitions for user-defined sewer shapes referred to by MOUSE.

Table 10 presents the nine types of data required to define standard and database cross section links in MOUSE. The two screen captures in Figure 18 show the two dialog boxes from MOUSE that control model input for each type of link.

**Table 10. MOUSE Data Requirements for Links**

| Description | Units | Format | Sample Data |
|---|---|---|---|
| Upstream Node Name | | Character | U13N220 |
| Upstream Invert Elevation | ft | Real | 11.38 |
| Downstream Node Name | | Character | U13N230 |
| Downstream Invert Elevation | ft | Real | 9.51 |
| Construction Material | | Integer | 2 |
| Pipe Shape | | Integer | 3 |
| Cross Section Database Name* | | Character | NEWHAVEN |
| Cross Section Name* | | Character | FRNT1 |
| Height (Characteristic Dimension) | ft | Real | 4.25 |

*Required for non-standard shapes.

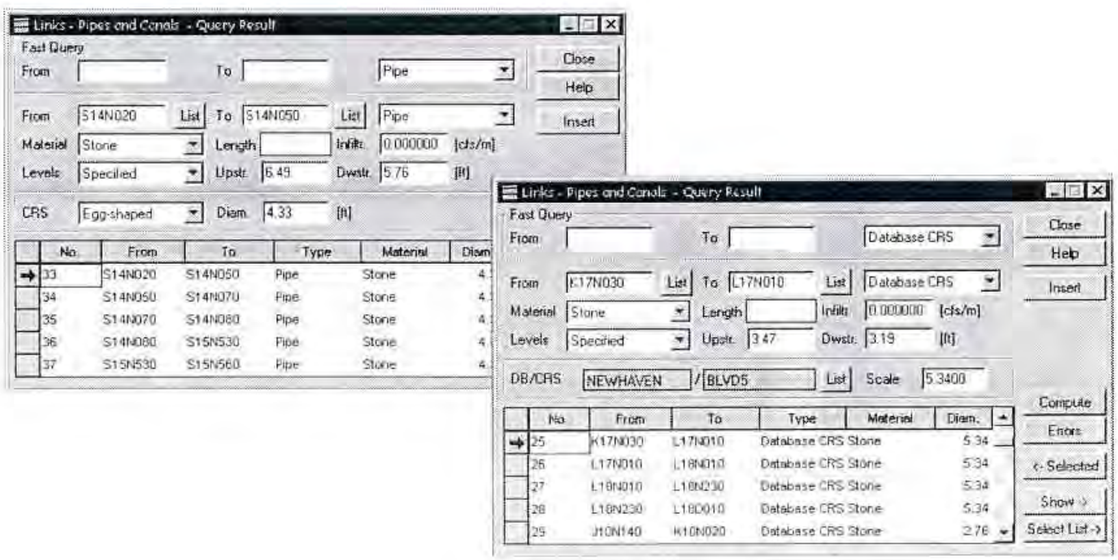


*Figure 18: Link Dialog Boxes from MOUSE*

## Database Design

The SANLINK line coverage indicates the physical location of sewer segments in the combined and sanitary system and contains relevant information describing each feature. Table 11 shows the fields in the coverage that contain data for the various link parameters required by MOUSE.

**Table 11. Relationship Between MOUSE Link Parameters and SANLINK Database Fields**

| Parameter | Field |
|---|---|
| Upstream Node Name | Us_node |
| Upstream Invert Elevation | Us_inv |
| Downstream Node Name | Ds_node |
| Downstream Invert Elevation | Ds_inv |
| Construction Material | Mouse_mat |
| Pipe Shape | Mouse_shp |
| Cross Section Database Name | Mouse_db |
| Cross Section Name | Mouse_xsec |
| Height (Characteristic Dimension) | Height |

Table C-2a in Appendix C shows all of the attributes that were collected in the SANLINK database, and the definitions for each field. As can be seen, MOUSE does not require all of the data included in the database. Some of the additional attributes are relevant information related to other planning or maintenance activities for the sanitary sewer system, such as date of construction.

Further information about each LINK parameter required by the MOUSE hydraulic model is provided in the next section.

## Methodology

LINK parameters required by the model were obtained during the data transfer process. Before the GIS was built, the types of data required for simulating hydraulic conditions in the sewer system were identified from strip maps, as-builts or record drawings and transferred a set of mylar planimetric maps. Some of the parameters were not readily available from existing information and were obtained afterwards from field investigations. This data was also stored in the GIS.

For the most part, the data stored in the GIS and used in the model reflect the system as it was designed and documented on strip maps, and may not reflect actual field conditions. Though attempts were made to locate records of system improvements, undocumented construction was not included in either the GIS or the model.

### Link Name

In the GIS, links are identified by their unique name, SAN_NAME. Although MOUSE refers to a link by the names of the upstream and downstream nodes, SANLINK features were named during the data digitizing process. Each feature was given a unique integer value for the

SAN_NAME field. This unique identifier in the GIS will allow relational databases to be joined to the SANLINK coverage in the future.

### Upstream/Downstream Node Name

The node names were obtained when each link was digitized during the data transfer process. The direction of flow was usually defined as higher to lower elevation, but some negatively sloped pipes were found to exist in New Haven.

### Upstream/Downstream Invert

Invert information was transferred from strip maps to the 1"=40' mylar planimetric maps and digitized into the GIS, as described in the GIS Construction chapter. Elevations are in units of feet, and are referenced to the US Coastal Geodetic Survey datum. Where sewer inverts were not recorded on the plan section, they were scaled from the sewer profile provided in the drawing.

### Length

MOUSE assumes that a sewer segment is a straight line between two nodes. In the model, the length of each segment was calculated from the coordinates of its endpoints. The length was similarly calculated during the construction of the GIS and is stored in the LENGTH_FT field.

### Construction Material

When known or available on the strip maps, the material from which the sewers were constructed was recorded on the mylar maps and entered into the GIS. Five common construction materials for the New Haven sewers were tile, concrete, brick, plastic, and iron. Other materials encountered were variations on these (e.g., cast iron, and ductile iron). Unfortunately, construction material information was often not available for older sewers. In such cases, the construction material was assumed according to rules established in Technical Memorandum #2, *Database Design and System Modeling Approach*. In general, relationships between pipe size, year of construction, and pipe material were established and used to determine the missing parameter as illustrated in Figure 19. Construction Materials assumed in this manner were prefaced with "A_" as in, *A_RCP* for a pipe assumed to be made from reinforced concrete. The original values determined during the data conversion are stored in the CONSMAT field in the GIS coverage.

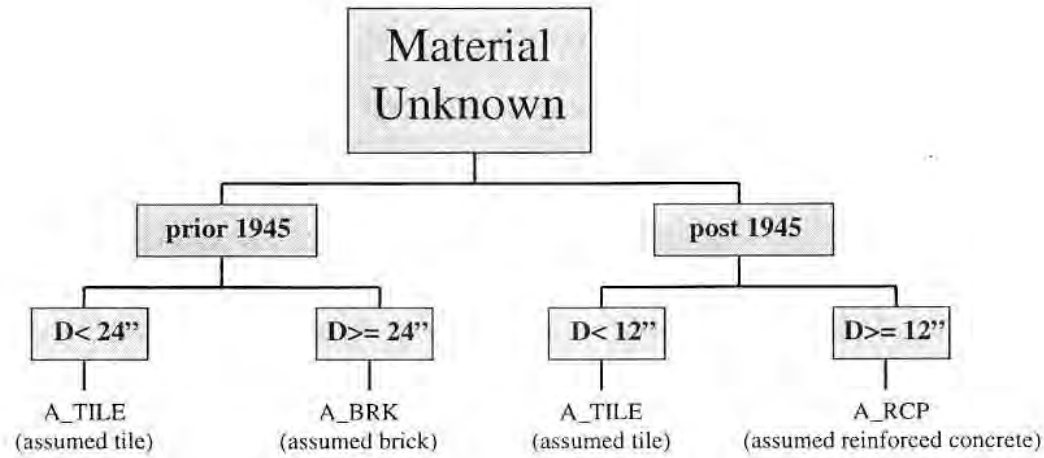



*Figure 19: Rules for Determining Sewer Construction Material*

MOUSE assigns friction losses to sewer elements for hydraulic routing according to pipe material. The categories defined in the GIS were simplified into five categories: cement, plastic, iron, brick, and tile. A sixth classification was incorporated for the pseudo sewer segments of pumps, weirs and orifices. These six material types were stored in the MATERIAL field and were converted to the integer values in MOUSE_MAT field, as required by MOUSE. Table 12 shows the relationships between the three attributes.

**Table 12. Relationships Between Construction Material Fields in the SANLINK Coverage**

| MOUSE Integer Value (MOUSE_MAT) | Simplified Material (MATERIAL) | Material Code (CONSMAT) |
|---|---|---|
| 2 | Cement | RCP, A_RCP, ACP, TRN, CEM |
| 4 | Plastic | PVC |
| 5 | Iron | DIP, CIP, CI |
| 7 | Brick | BRK, A_BRK |
| 8 | Tile | TIL, A_TIL, VC, VCP,VT, VP |

## Pipe Shape

Most new sewers have circular cross sections. In the past, however, a wide variety of noncircular sewer sections were used, including egg-shaped, semielliptical, horseshoe and elliptical. Not all pipe shapes were specified on the strip maps. However, when available, the shape of the cross section was recorded on the mylar and incorporated into the GIS database. The MOUSE_XSEC field has a text description of the shape and the MOUSE_SHP field stores the integer value that MOUSE requires.

### Pipe Size

Pipe sizes were obtained from the strip maps, digitized into the GIS and stored in the HEIGHT and WIDTH fields during the data conversion process described in the GIS Construction chapter of this report. Initially, dimensions indicated on the maps for egg-shaped or irregular-shaped sections were recorded as the equivalent circular cross section. For example, a 52"H x 35"W egg-shaped sewer was referred to as an equivalent 42" circular sewer. These values have been modified in the GIS as described below.

### Adjustments to Pipe Material, Shape and Size

Strip maps were the primary source of information for the GIS and model. However, they often recorded a single attribute, describing the size of a sewer segment, as illustrated in Figure 20. Usually, the drawing did not contain any reference to construction materials or sewer shape. As a result, 70% of the construction materials transferred to the GIS were assumed based on specified pipe diameter and age, and 98% were coded as a circular section with an equivalent diameter. For example, references to 42" diameter sewers constructed in 1910 should have been coded as 52H x 35W egg-shaped brick sewers and not 42" circular sewers.

To address this deficiency in the data transfer process, detailed maps of sewer cross sections were obtained from the archives at the Engineering Department. The maps, some dating to the late 1800's, identified the shape, dimension and location of sewers that were constructed under various contracts throughout the City. Included in this collection were the construction criteria for several distinct shapes. Using this data, standard shapes and dimensions were established for egg and circular sections. MOUSE recognizes egg and circular sections as standard shapes, and only the height specified in the MOUSE_DB field of the GIS was required.

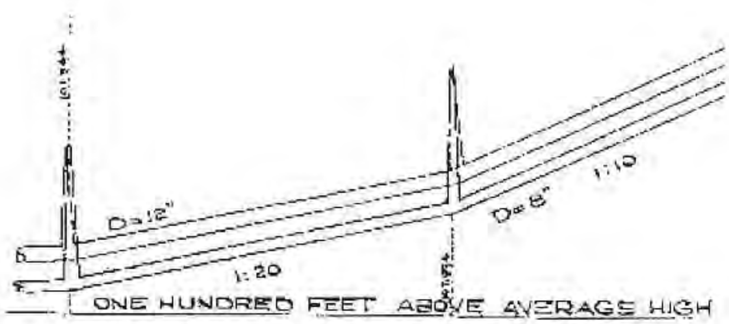



*Figure 20: Typical Strip Map*

Meetings with Mr. Henry Goetz were used to establish rules that were used to convert pipe shapes and dimensions for the remainder of the database. The conversion from equivalent round sections to actual shapes was done in five steps, according to the material of construction and the reported dimensions of the sewers, as illustrated in Figure 21. Subsequent meetings were used to clarify questions that arose during this process.

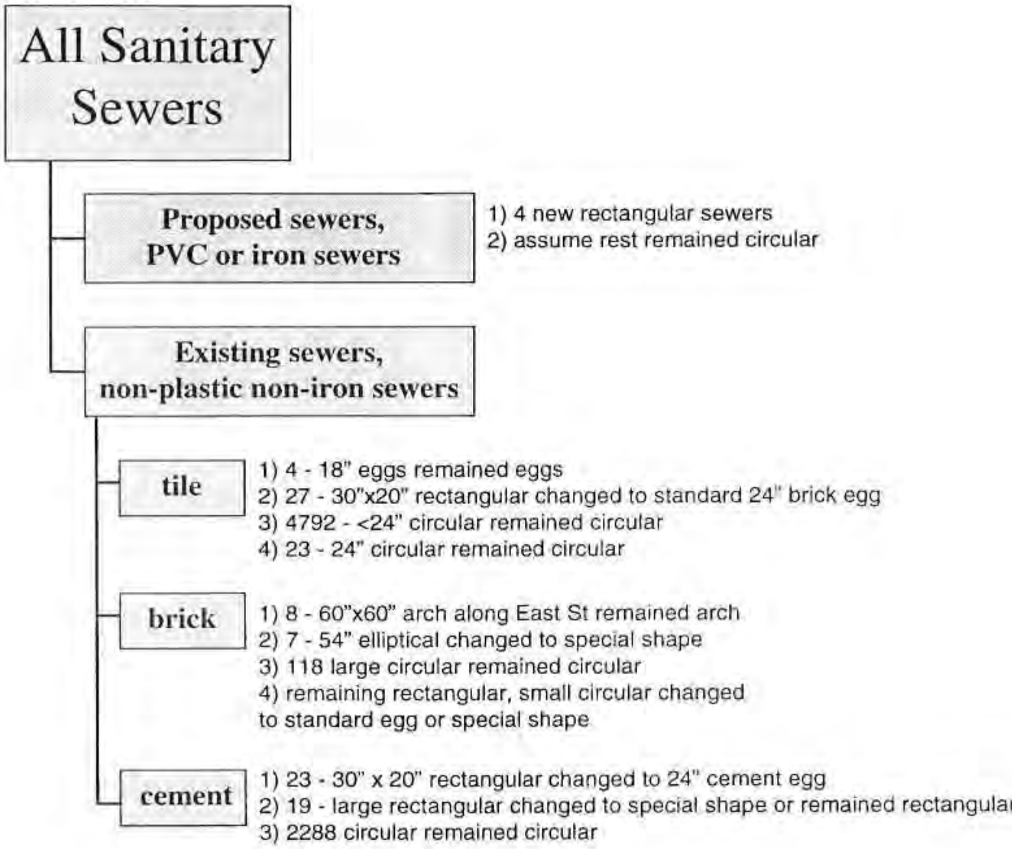



*Figure 21: Rules for Determining Sewer Shapes*

Some of the larger diameter brick sewers in New Haven have non-standard cross sections. For these sewers, special cross sections were defined and stored in a cross section database, NEWHAVEN. The MOUSE_DB field for these sewers contained the value "NEWHAVEN". The MOUSE_XSEC field in the GIS was modified to contain the name of the individual cross section within the database.

MOUSE allows the user to incorporate any non-standard shape in the hydraulic model through the use of a set of (x, z) coordinate pairs that describe the cross section, as depicted in Figure 22.

The cross sections were defined as a particular shape with unit height, similar to scaling performed by MOUSE for regular sections. During hydraulic simulations, the unit cross section was converted to its real world size by MOUSE.

The 22 special cross sections developed for use in the New Haven model are described and illustrated in Appendix D.

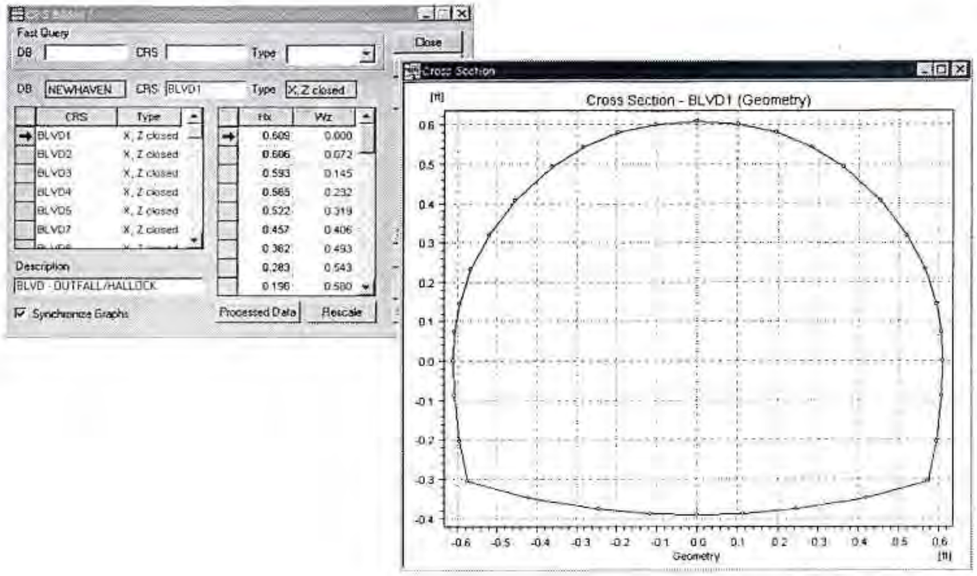



*Figure 22: Defining Special Sewer Shapes in MOUSE*

# Pumps

Pump stations connect two nodes together and pass flow between them according to established rules that simulate the operation of the pumps. There were 16 pump stations in the New Haven hydraulic model. They were defined at a node in the hydraulic model and transferred flow to another node according to the relationships established in the model.

## Model Requirements

In MOUSE, pumps are modeled with a rating curve, which can be described as:

- Q/dH: the pump capacity is specified as a function of the water level difference between the upstream and the downstream side of the pump, or
- Q/H: the pump capacity is specified as a function of the water level in the pump basin.

The Q/H relationship was used to simulate the performance of all of the pump stations. A maximum of three pumps are allowed in each Q/H curve. The information required by MOUSE to define the behavior of the pumps at each pump station is provided in Table 13. The dialog box that controls input of Q/H pump data is shown in Figure 23.

**Table 13. MOUSE Data Requirements for Pumps**

| Description | Units | Format | Sample Data |
|---|---|---|---|
| Location of Pump | | Character | O23P010 |
| Point of Discharge | | Character | O23D080 |
| Pump Relationship | | Integer | 1 |
| Number of pumps | | Integer | 3 |
| Pump#1 Start* | ft | Real | -9.00 |
| Pump#1 Stop* | ft | Real | -10.30 |
| Number of values describing Pump#1 discharge curve* | | Integer | 4 |
| Elevation1* | ft | Real | -12.00 |
| Flow1* | cfs | Real | 2.000 |
| Elevation2* | ft | Real | -8.50 |
| Flow2* | cfs | Real | 9.000 |
| Elevation3* | ft | Real | -7.00 |
| Flow3* | cfs | Real | 16.000 |
| Elevation4* | ft | Real | -6.00 |
| Flow4* | cfs | Real | 24.000 |

* Information repeated for each pump, to a maximum of 3 pumps.

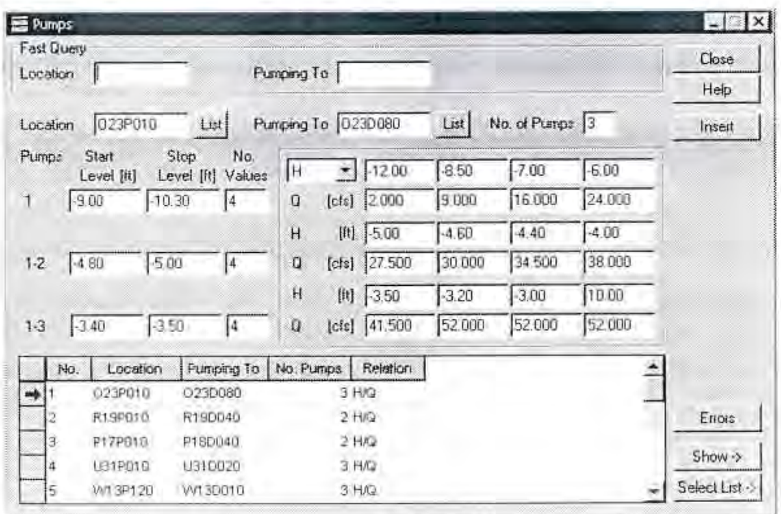



*Figure 23: Pump Dialog Box from MOUSE*

## Database Design

A pump was represented in the GIS as a *PU* link between the pump location and discharge node. The PUMP relational database was linked to the SANNODE coverage through the US_NODE attribute. Table 14 shows the fields in the database that contain data for the various pump parameters required by MOUSE. Table C-7a in Appendix C provides the data field definitions in the PUMP database.

**Table 14. Relationship Between MOUSE Pump Parameters and PUMP Database Fields**

| Parameter | Field |
|---|---|
| Location of Pump | PSNODE |
| Point of Discharge | DISCHARGET |
| Pump Relationship | RELATION |
| Number of pumps | NPUMP |
| Pump#1 Start* | START1 |
| Pump#1 Stop* | STOP1 |
| Number of values describing Pump#1 discharge curve* | NPTS1 |
| Elevation1* | H11 |
| Flow1* | Q11 |
| Elevation2* | H12 |
| Flow2* | Q12 |
| Elevation3* | H13 |
| Flow3* | Q13 |
| Elevation4* | H14 |
| Flow4* | Q14 |

Further information about each PUMP parameter required by the MOUSE hydraulic model is provided in the next section.

## Methodology

The location of each pump station, and the facilities associated with it (overflow, wet well, forcemain) were identified during the data transfer process. Each feature was digitized into the various GIS database coverages. However, pumps require specific information that is not relevant to other types of links. Therefore, the graphical representation of a pump and pump station are contained in the SANLINK and SANNODE coverages respectively, but the attribute data is stored in the relational database, PUMP, that can be linked to the features in the GIS.

The PUMP database was populated with data obtained from field surveys, interviews with WPCA staff, and the information obtained from the pump manufacturers. This data reflects the design capacity and operational logic for each facility. However, not all facilities are operated according to their original design capacities or operational rules. Therefore, adjustments were made during model calibration to reflect observed capacities and operational schemes. Table 15 lists the 16 pump stations, their design capacities, and the maximum pumping rates that have been included in the MOUSE hydraulic model and identified in Technical Memorandum #7, *Nine Minimum Controls Report*.

### Pump Node

Each pump was located in a node contained in the SANNODE coverage. The name stored in the PSNODE field was the node name corresponding to the pump station wet well. Following the naming convention established for the SANNODE coverage, pumps were located at nodes that have a *P* as the fourth character in their name (e.g., *R19P010*).

**Table 15. Pump Station Capacities in the MOUSE Hydraulic Model**

| Pump Station | Number of Pumps | Design Capacity | Maximum Pump Rate (MGD) |
|---|---|---|---|
| Boulevard [1] | 3 | 46 | 34 |
| East Street [1] | 2 | 57 | 29 |
| Union/State [1] | 2 | 35 | 19 |
| Morris Cove | 3 | 14.5 | 14.5 |
| Quinnipiac | 2 | 8.3 | 5.2 |
| Barnes | 2 | 2 | 2 |
| New Grand Ave | 2 | 0.3 | 0.3 |
| Old Grand Ave | 2 | 2 | 2 |
| Long Wharf | 2 | 1 | 1 |
| Humphrey | 2 | 0.5 | 0.5 |
| Mitchell | 2 | 1.2 | 1.2 |
| Stone Street | 2 | 0.5 | 0.5 |
| West Rock | 2 | 0.4 | 0.4 |
| Fort Hale | 2 | 0.9 | 0.9 |
| Market Place | 2 | 0.5 | 0.5 |
| Lighthouse Point | 2 | 0.7 | 0.7 |

[1] Pump station operational logic modified.

### Discharge Node

This parameter stored in the DISCHARGET field is the name of the dummy node in the SANNODE coverage that is used as the point of discharge from the pump. It is also the conceptual start of the pump station's forcemain.

### Pump Relationship

The integer value *1* stored in the RELATION field defined that the pump information provided to MOUSE was flow and depth.

### Number of Pumps

NPUMPS informs MOUSE how many pumps are defined at each pump station.

### Pump Start/Stop

The START1/STOP1 fields in the database define the wet well elevation that turns a pump on or off.

### Rating Curve

The idealized pump curve was defined as a flow/depth relationship. The Q/H data pairs were stored in the Qxy/Hxy fields in the database. The *x* refers to the pump, and the *y* refers to the data point. For example, *Q32* denotes the second flowrate defined for the third pump.

# Weirs

Weirs connect two nodes together and pass flow between them according to mathematical equations that simulate flow over a weir. The nineteen weirs in the New Haven hydraulic model occur at most of the CSO regulators.

## Model Requirements

To incorporate weirs into a hydraulic model, MOUSE needs the parameters outlined in Table 16. The dialog box that controls input of weir data to MOUSE is shown in Figure 24.

**Table 16. MOUSE Data Requirements for Weirs**

| Description | Units | Format | Sample Data |
|---|---|---|---|
| Upstream Node name | | Character | R18R015 |
| Downstream Node name | | Character | R18D010 |
| Weir Crest Elevation | ft | Real | 6.3 |
| Modeling Method | | Integer | 1 |
| Type of Weir | | Integer | 1 |
| Constant Inflow | cfs | Real | 0.00 |
| Width of Weir | ft | Real | 6.45 |
| Shape of Weir Crest | | Integer | 1 |

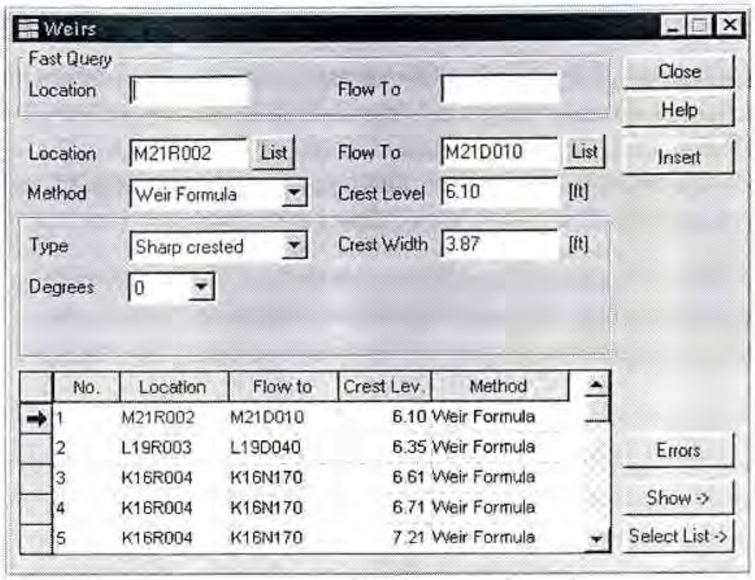



*Figure 24: Weir Dialog Box From MOUSE*

## Database Design

A weir was represented in the GIS as a *WR* link between the pump location and discharge node. The WEIR relational database was linked to the SANNODE coverage through the US_NODE attribute. Table 17 shows the fields in the database that contain data for the various weir parameters required by MOUSE. Table C-8a in Appendix C provides the data field definitions in the WEIR database.

**Table 17. Relationship Between MOUSE Weir Parameters and WEIR Database Fields**

| Parameter | Field |
|---|---|
| Upstream Node name | US_NODE |
| Downstream Node name | DS_NODE |
| Weir Crest Elevation | ELEVATION_ |
| Modeling Method | METHOD |
| Type of Weir | TYPE |
| Width of Weir | WIDTH_FT |
| Shape of Weir Crest | CREST |

Further information about each WEIR parameter required by the MOUSE hydraulic model is provided in the next section.

## Methodology

The location of each weir was identified during the data transfer process. Each feature was digitized into the GIS SANLINK coverage. However, weirs require specific information that is not relevant to other types of links. Therefore, only the graphical representation of a weir was contained in the SANLINK coverage. The specific attribute data is stored in the relational database, WEIR, that can be linked to the features in the GIS.

The WEIR database was populated with data obtained from field surveys and interviews with WPCA staff. The results of the field survey (sketches and photos) were documented in Flow Regulator Notebooks distributed earlier under a separate cover.

### Weir Node

Each weir was located at a node contained in the SANNODE coverage. The name stored in the US_NODE field was the CSO regulator that contained the weir. For most of the weirs, the weir occurred at a regulator accessible by a manhole. For the rest, the node was located at a dummy node. Following the naming convention established for the SANNODE coverage, weirs were located at nodes that have an *R* as the fourth character in their name (e.g., *K16R004*). The last three characters refer to the NPDES permit number given to each overflow regulator. In the preceding example, the weir would be at NPDES#004, or the Boulevard Interceptor at Legion Avenue.

### Discharge Node

The DS_NODE field in the WEIR database defined the point of discharge from the weir. The name corresponds to a dummy node in the SANNODE coverage.

### Weir Elevation

The elevation of the top of the weir is stored in the ELEVATION_ field of the relational database, in units of feet referenced to the USCGS datum.

### Weir Method

MOUSE used the integer value *2* stored in the METHOD field as an indicator that the model was to calculate flow over the weir by applying the general weir formula.

### Weir Type

MOUSE determined whether the weir was a side weir or transverse weir by the integer value stored in the TYPE field. A value of *1* was used to identify a side weir, and a value of *2* was used to identify a transverse weir.

### Weir Width

The WIDTH_FT field stored the effective width of the weir in feet.

### Crest Type

The integer value stored in the CREST field described whether the weir was broad-crested or sharp-crested. A value of *1* was used for sharp-crested weirs, and the value *2* was used to indicate a broad-crested weir.

# Model Construction

The complete inventory of the combined and sanitary sewer system in New Haven is shown in Figure 25. The graphical data that reside in the GIS contain approximately 8,800 sewer segments and 8,900 nodes. Some of these features represent rehabilitation projects that will be built in the future and therefore, are not included in the model used during the calibration process. The model was calibrated to conditions in the Fall of 1997, and therefore, only the elements of the sewer system at that time were included. The INCL_SYS attribute was added to the SANNODE and SANLINK coverages to indicate if the feature should be included (value=1) or excluded (value=0) in the interceptor model.

To minimize the computational demands of a computer model containing every pipe included in the GIS database, a skeleton model of the sewer system was created. As illustrated in Figure 26, data flowed from the GIS to the model which was built in five steps:

- reduce spatial extent of system included in the model
- combine sewers into hydraulically equivalent pipes
- create MOUSE system database file
- add other hydraulic data required by MOUSE
- debug the system

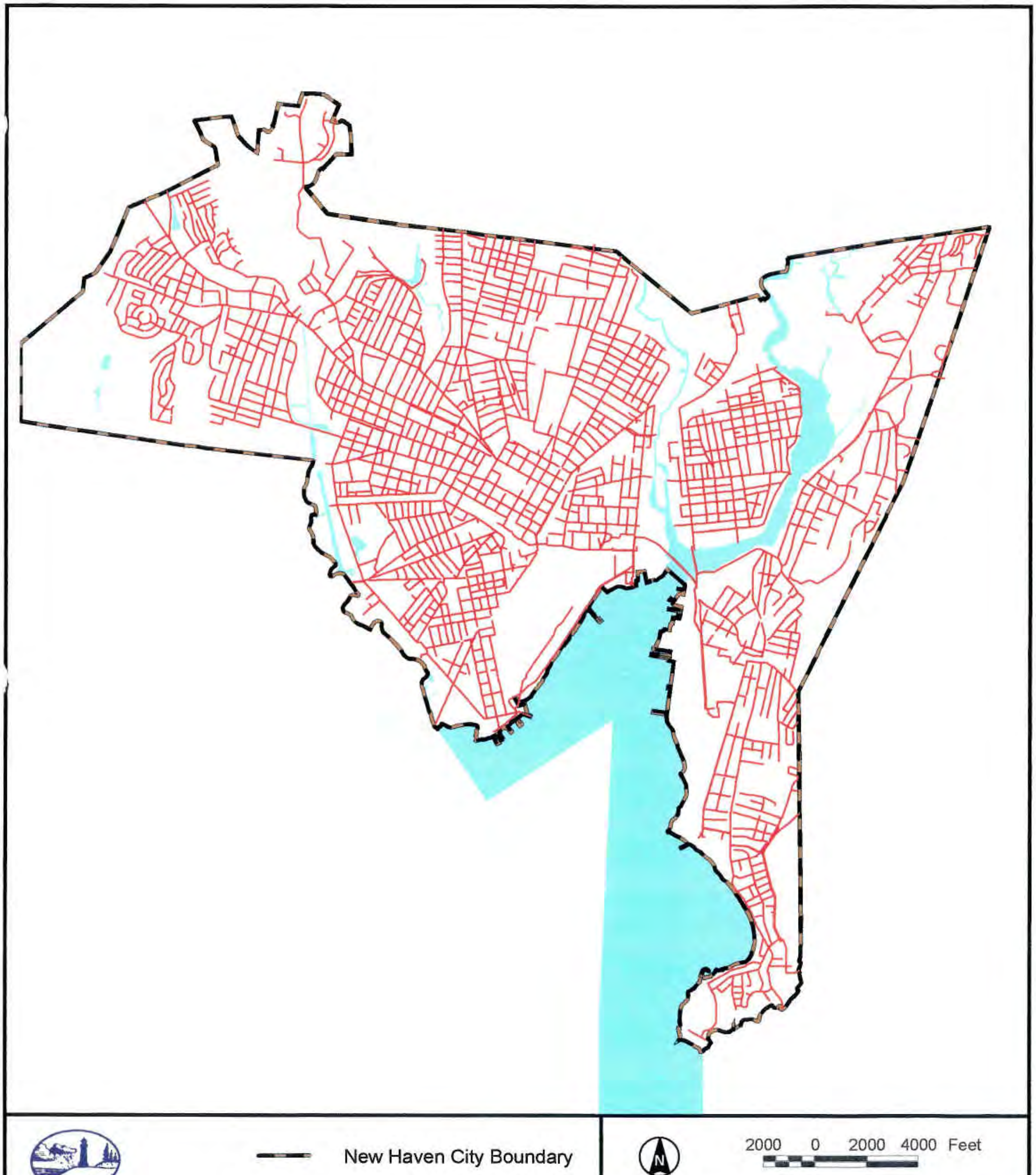
Table 18 lists the reduction of nodes and pipes through each step of the process. Each step is described in more detail in the following sections of this chapter.

**Table 18. Reduction of Modeled Elements During Model Construction**

| Step in Process | Nodes | Pipes (standard) | Pipes (special) |
|---|---|---|---|
| Total Number in GIS | 8,782 | 8,657 | 200 |
| Reduced Spatial Extent of Model | 2,611 (30%)[1] | 2,408 (28%) | 188 (94%) |
| Combined Hydraulically-Equivalent Pipes | 1,938 (22%) | 1,735 (20%) | 188 (94%) |
| Built and debugged Model | 1,948 (22%) | 1,728 (20%) | 206 (103%)[2] |

1. Number of elements remaining after each step and percent change from original GIS.

2. Standard pipes modified to include sediment deposition were converted to special pipes in the model.




# Figure 25

Inventory of Combined and Sanitary Sewers in New Haven

New Haven Long Term CSO Control Plan

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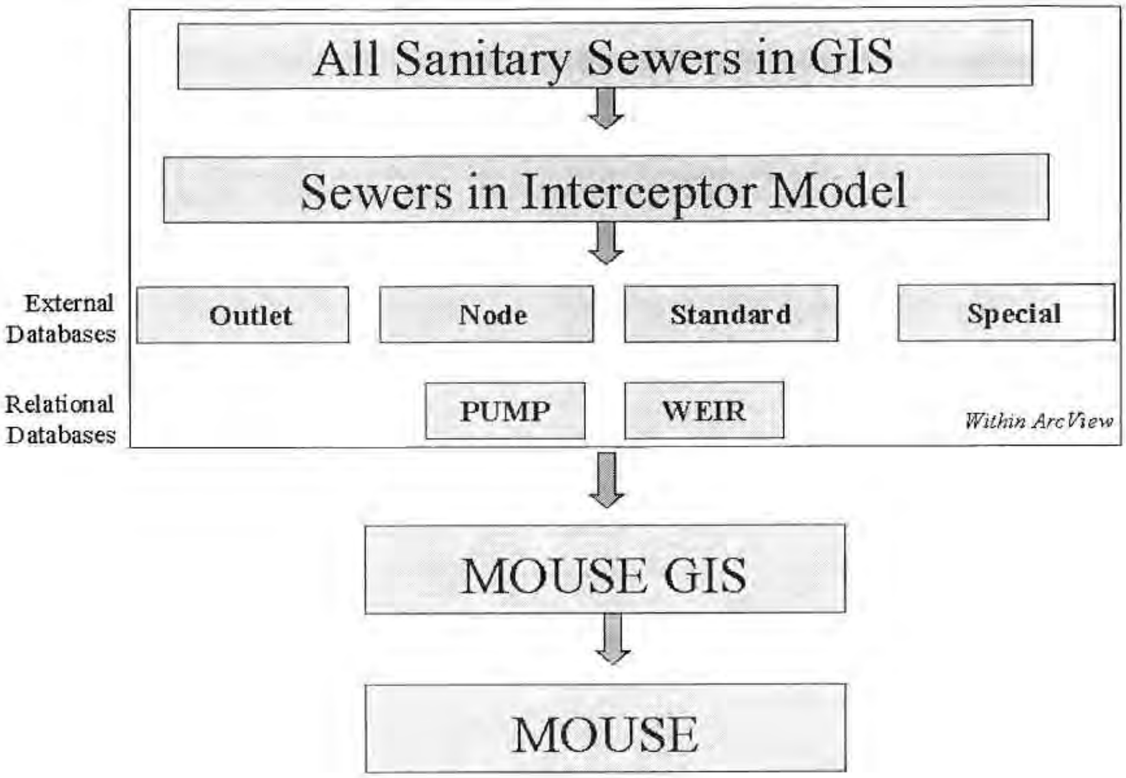


*Figure 26: Flow of Data from the GIS to MOUSE*

## Step 1: Reduce Spatial Extent of Modeled System

The skeletonized model of the major interceptors of New Haven, referred to as the interceptor model, consisted of sewer segments 18 inches in diameter and larger, and all of the major sewer facilities. In some areas, sewer segments were added to the interceptor model to include subsystems where monitoring data was collected.

AVENUE scripts were created in ArcView to query the entire GIS and export interceptor model data as four separate tables, as listed in Table 19. These four tables and the two relational databases (PUMP and WEIR) are loaded into MOUSE GIS, as shown in Figure 27.

**Table 19. Databases Tables Exported from GIS**

| Table Name | Description |
|---|---|
| NODE | All nodes that are not outlets |
| OUTLET | All nodes that are outlets |
| STANDARD | Sewers with standard shapes (circle, egg) |
| SPECIAL | Sewers with user-defined cross sections |
| PUMP | All pumps |
| WEIR | All weirs |

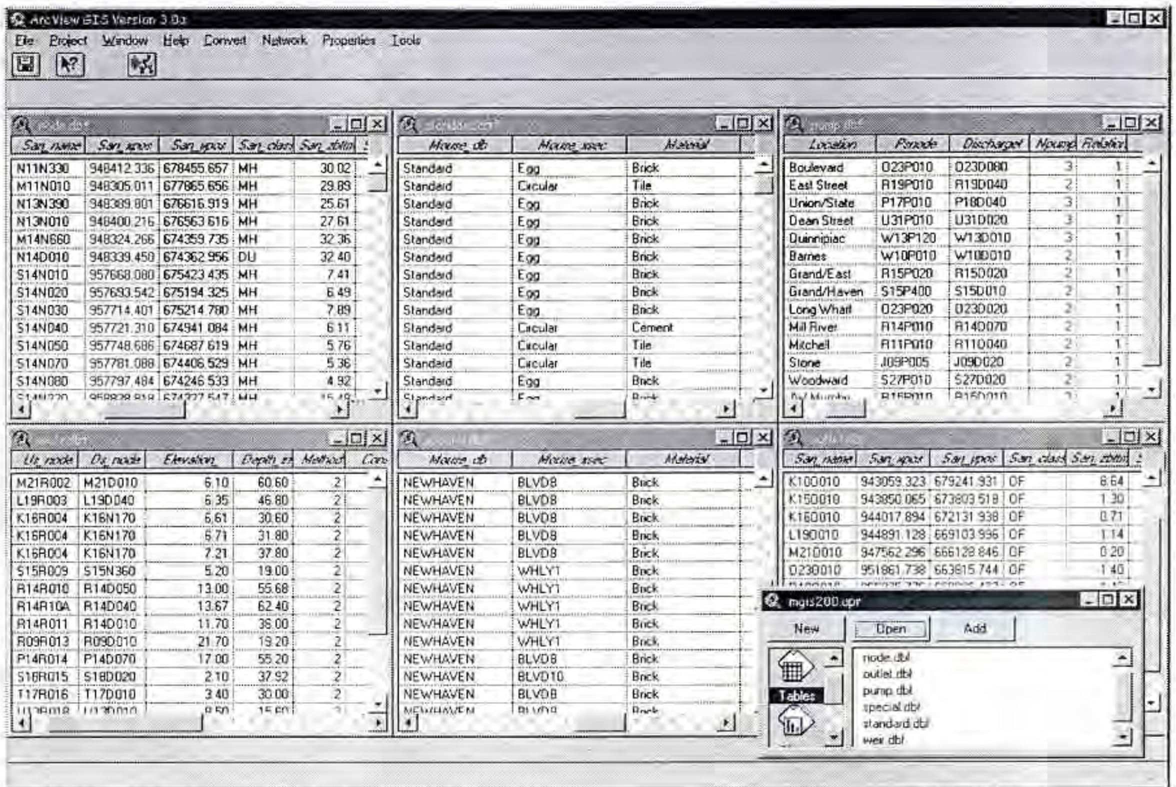

*Figure 27: Databases Imported into MOUSE GIS*

## Step 2: Define Link Between Databases and MOUSE GIS

As with the hydrologic model, before MOUSE GIS can use the data exported from the GIS, a link between the external data source and the internal MOUSE GIS database had to be established. This was accomplished through a number of dialog boxes, as illustrated in Figures 28, 29 and 30. In each dialog box, the external data source was selected, and the link between each field and the internal MOUSE GIS database was defined.

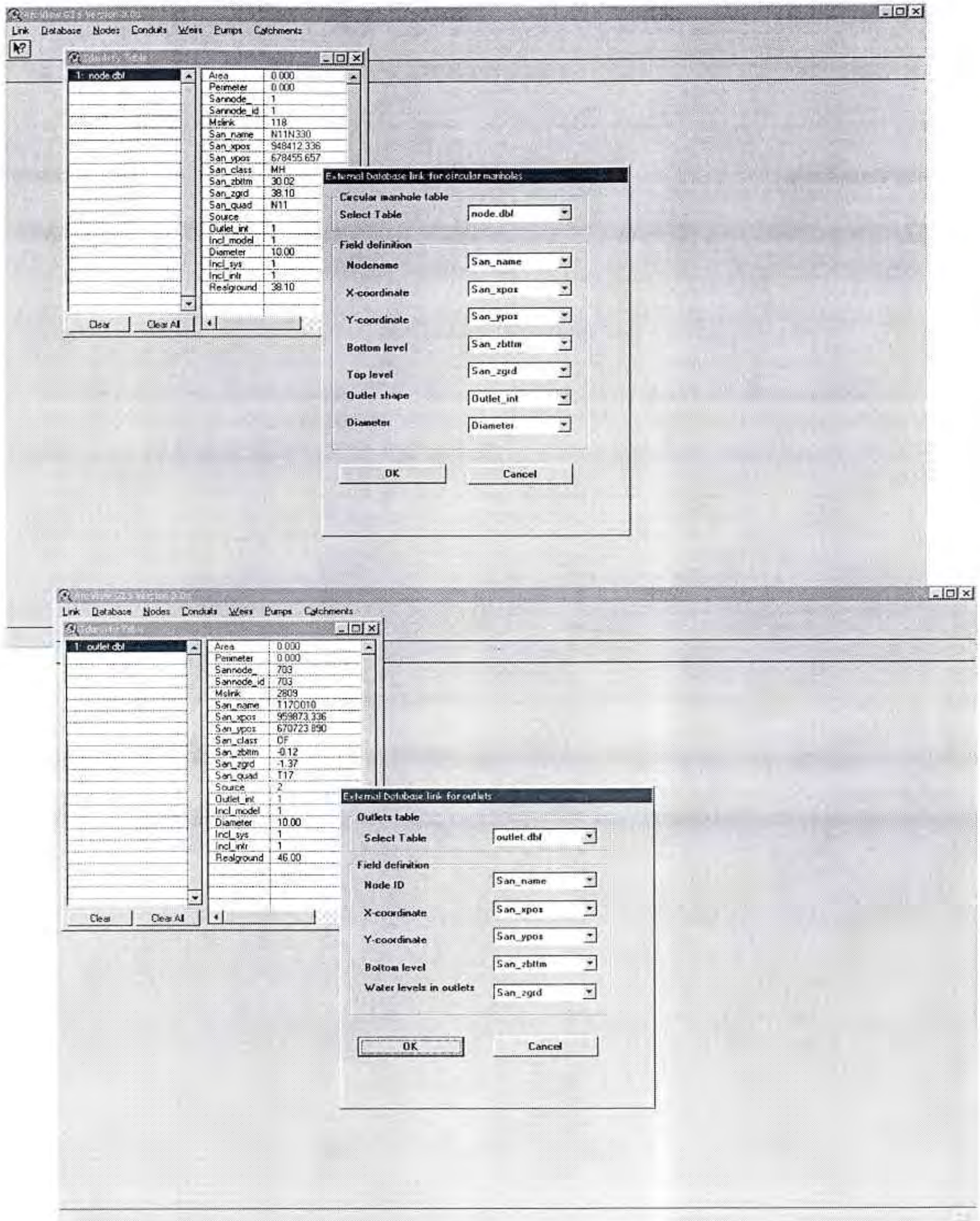


*Figure 28: MOUSE GIS Screen Capture of Node and Outlet Data Extraction*

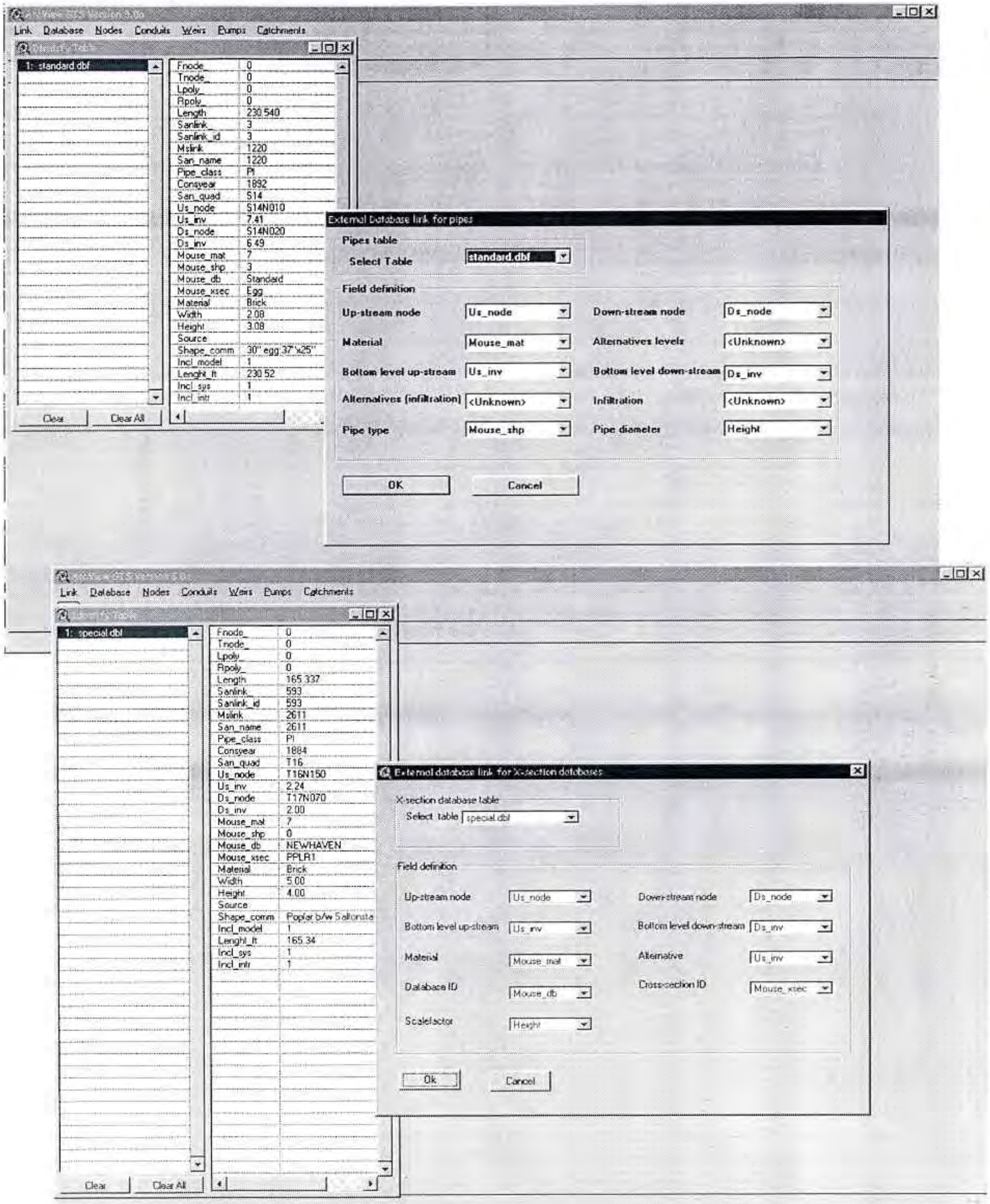


*Figure 29: MOUSE GIS Screen Capture of Link Data Extraction (Standard and Special)*

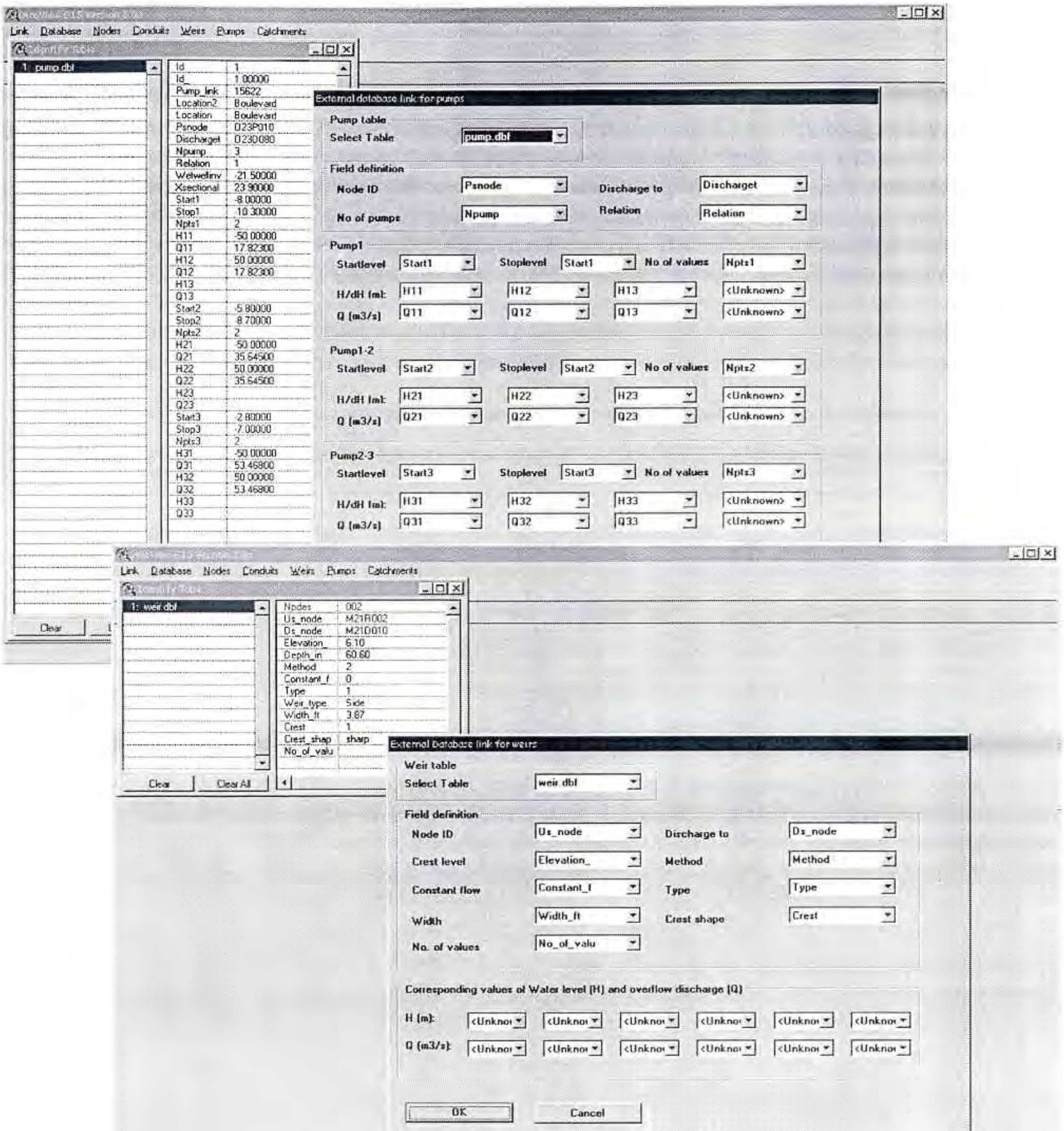


*Figure 30: MOUSE GIS Screen Capture of Pump and Weir Data Extraction*

Once defined, MOUSE GIS extracted the data from the six external databases and rebuilt the sewer network.

## Step 3: Simplify Model Network

Using MOUSE GIS, the network can be further simplified according to specified criteria. The simplified system created during this procedure is a hydraulically-equivalent system that requires less time for hydrodynamic computations. Using the criteria listed in Table 20, an equivalent representation of the interceptor was created. For example, two 50-foot long pipes with a change in diameter < 10% and having similar slopes and direction of flow are computationally equivalent to one 100-foot long pipe (neglecting losses in appurtenances). MOUSE GIS allowed the data simplification rules to be saved, allowing a systematic and repeatable process to be followed in the creation of models for the other tasks of this project. This series of nodes and links was exported as a MOUSE-formatted text file.

**Table 20. Criteria Used to Create Hydraulically-Equivalent Pipes**

| Parameter | Criteria |
|---|---|
| Change in Pipe Slope | < 5 (ft/thousand) |
| Change in Diameter | <20% |
| Change in Flow Capacity | <10% |
| Change in Flow Direction | <45 degrees |
| Change of Invert Level | +/- 0.1 feet |

## Step 4: Build MOUSE Interceptor Model

The text file from the previous step was imported into the MOUSE modeling environment. This basic model contained all of the sewers, manholes, pumps, and weirs that represent the interceptors of the New Haven sewer system. The additional information described below was required to build a complete interceptor model.

### Refine Weir Discharge

Some of the combined sewer overflows in New Haven discharge to storm sewers, as listed in Table 21. Storm sewers were not included in the hydraulic model. These regulators were included in the hydraulic model by adding a fictitious node and pipe at the point of discharge.

**Table 21. CSOs that Discharge to Storm Sewers**

| ID | Location |
|---|---|
| OF010A | East Street and I-91 |
| OF012 | Mitchell Drive |
| OF014 | Orange St and Trumbull St |
| OF025a | Union St |
| OF025b | George and Temple |

In the hydraulic model, it was assumed that the CSO was a free discharge into the storm sewers, and that no inflow from the storm sewer to the combined/sanitary system occurred.

### Equivalent Pipes

Features such as orifices, sluice gates and bar screens cannot be directly modeled with MOUSE. Since hydraulic losses through these sewer elements can be significant, they need to be incorporated into the model. To do so, these features were simulated as sewer segments with equivalent hydraulic characteristics. For the orifices, the standard orifice discharge equation was equated with the Manning pipe flow equation. The orifice conduits were assumed to have the same cross-sectional area as the orifice opening. Similarly, the sluice gate and bar screens were modeled as equivalent pipes by equating the Manning pipe flow equation to the approximate head loss through each feature. The locations of features modeled as equivalent pipes are listed in Table 22.

**Table 22. Location of Equivalent Pipes**

| Feature | Location |
|---|---|
| Orifice | REG005 at Derby and Boulevard |
| Orifice | REG015 at James St. Siphon |
| Sluice Gate | Entrance to Boulevard Pump Station |
| Bar Screens | Boulevard Pump Station |
| Bar Screens | East Street Pump Station |

### Pump Stations

Data was added at pump stations to describe the dimensions of the wet wells. Each pump station wet well was changed from a node to a basin to better simulate the storage and improve the stability of pump operation in the model. The cross section area and sectional area were scaled from available construction drawings and were added to the MOUSE model.

In addition, provisions required to simulate the hydraulic characteristics of Headworks Facilities at the Boulevard and East Street pump stations were added to the model. Though these features were not included in the GIS, the various gates, weirs and bar screens at these major facilities have been added to the model.

### Manning's Pipe Roughness Coefficients

Default values for Manning's roughness coefficients were defined for each class of pipe, as indicated in Table 23 (Tchobanoglous, 1981). For the equivalent pipes calculated for MOUSE, coefficients were defined for each specific sewer segment.

Table 23. Default Roughness Coefficients

| Material | Manning's n |
|---|---|
| Concrete | 0.0133 |
| Plastic | 0.0125 |
| Iron | 0.0143 |
| Brick | 0.0170 |
| Tile | 0.0150 |

### Non-Return Valves

Non-return valves were used to prevent water from flowing into the system at outfalls protected by tide gates. They were used at the 4 outfalls listed in Table 24.

Table 24. Non-Return Valves in the MOUSE Hydraulic Model

| Site | Upstream Node | Downstream Node |
|---|---|---|
| Boulevard OF024 | O23D030 | O23N240 |
| East Street OF021 | R19N070 | R19O010 |
| James St Siphon OF015 | S18D020 | S18O010 |
| Poplar Street OF016 | T17N290 | T17O010 |

### Sedimentation

The sewers contained in the GIS reflect the information contained on the strip maps. As such, they are representative of the original clean condition and may not reflect the current field conditions. Through discussions with City and WPCA staff, areas with chronic sedimentation problems were identified and documented in Technical Memorandum #7, *Nine Minimum Controls Report*. Since sedimentation reduces the flow capacity of a sewer, it was important to account for it in the model. Areas with significant levels of sedimentation that were identified in Task 5 are listed below and shown in Figure 31.

- James Street between Chapel Street and River Street
- Front Street from Middletown Avenue to River Street
- River Street from Front Street to James Street
- Whalley Avenue from the West River to Osborn Street (near Boulevard)
- Boulevard near Orange Avenue

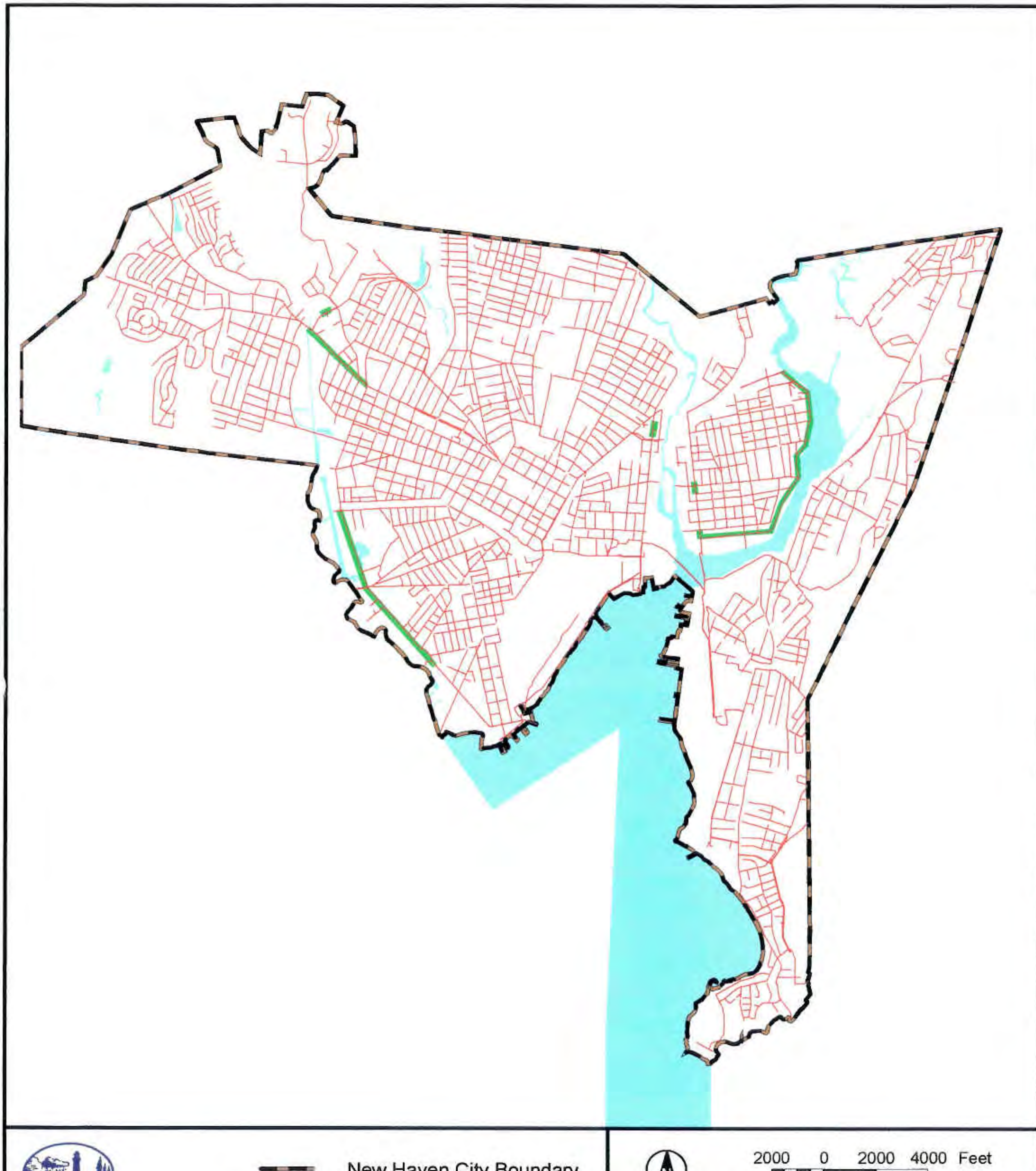


Figure 31

Sewers with Reported Sediment Deposition

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Approximate sediment depths that had been reported by WPCA staff and by ADS Environmental Services during the monitoring program were compiled and the estimates were sent to the WPCA and the City for review.

The sediment depths that were reported along the Front Street interceptor were highly variable. To address this concern, the WPCA commissioned a sewer sediment survey along Front Street and River Street. Upon completion of the survey, the sediment profile along the interceptor was prepared. Sewer segments that contained chronic and significant sedimentation were included in the model.

The effect of sediment deposition is reduced flow area. Therefore, pipe cross sections were modified according to the depth of sediment reported. Figure 32 shows the effect of 11" of sediment on the cross section of a 42"egg-shaped sewer. The new sections that represent sewers with chronic sediment deposition were added to the existing cross section database, NEWHAVEN.

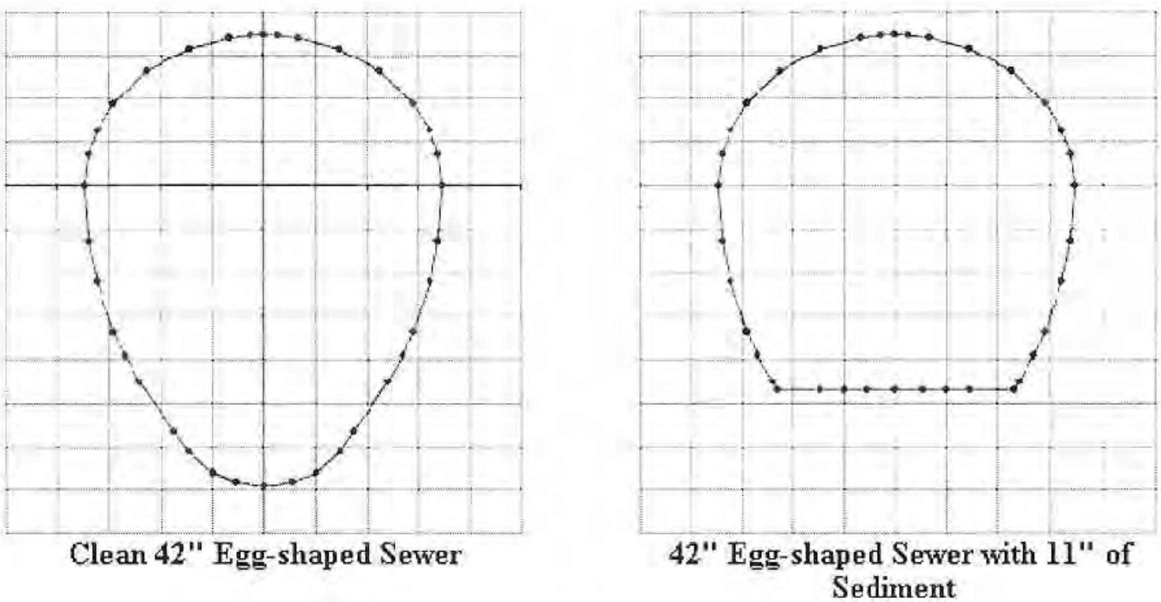



*Figure 32: Effect of Sediment Deposition on Sewer Cross Section*

### Cross Section Database

The cross section database contained various conduit cross sectional shapes that were defined as special sections. The database had to be loaded separately into MOUSE. These cross sections are described and illustrated in Appendix D.

## Step 5: System Debugging

First attempts to route flow through the interceptor model resulted in the identification of several data general problems, such as missing pipes and surface flooding. Significant work was performed to better simulate the operation of the three major pump stations.

## General

During the data capture in the GIS, all pipes with a diameter of 18" or larger were selected. At three locations, double barrel sewer segments smaller than 18" were used to connect larger sewers. As a result, flow from portions of the model could not reach the WPAF. Several iterations between the GIS and MOUSE corrected these problems.

Surface flooding occurred along forcemains and at pump stations where the modeled hydraulic grade line (HGL) was above the ground elevation. At these locations, the model incorrectly allowed the flows to pond on the surface. To contain the flows in the interceptor model, the ground elevations along these forcemains were artificially raised to 125.30 ft. Similarly, water was found to leave the system at other locations in the model. Upon investigation between the original data source and the GIS, errors introduced during the data transfer process were identified and corrected.

## Pump Stations

The pump stations in New Haven vary from small lift stations (West Rock, New Grand Ave) that pump flows short distances to major stations (Boulevard, East Street, Union) that serve as the outlet of major sewersheds.

Information related to all of the pump stations was obtained through discussions with WPCA staff, from available construction drawings and manufacturer's equipment specifications, and several field investigations. In most cases, it is believed that the operation of the pump station closely follows the original design specifications. However, variations in the operation of the three major stations from the original design can have significant impacts on the system's performance during wet weather. The following discussion describes the detailed work that was performed to obtain model parameters for the Boulevard, East Street and State/Union Pump Stations.

### *Boulevard Pump Station*

The Boulevard Pump Station contains four 8,000 gpm (11 MGD) pumps. From a review of available flow data, it was identified that the Boulevard pump station is operated at different rates for different events. However, in general it appears that a maximum rate of 34 MGD is its normal operating capacity. Therefore this rate is used in the model and was entered into the PUMP database.

To increase the stability of the model, the pump curves for Boulevard Pump Station were adjusted so that the dry weather flow entering the station was effectively handled by one pump. The start/stop points for the second and third pump were adjusted to switch on/off during the monitored events.

As a result of a field visit, internal structures were added to the model of the Boulevard Pump Station. A sluice gate restricting the influent pipe was added to the model at the pump station inlet. It was noted that the gate provided a 59% reduction in flow area (approximately 41% open). An equivalent pipe was substituted for the gate by equating head losses through the gate to head losses in a pipe flowing full. Similarly, head losses through the bar screens were added to the model using equivalent pipes.

### East Street Pump Station

The East Street Pump Station contains four 9,900 gpm (14 MGD) pumps. From a review of available data, the maximum pumping rate for this station has been recorded as approximately 50 MGD. However, flow records frequently record the peak pumping rate for the station as 28 MGD - the two pumps on condition. From a review of the data collected during the Task 3 Monitoring Program, it appears that the operation of this station was highly variable. Therefore, a two-pump scheme with a capacity of 28 MGD was entered into the model and PUMP database to reflect the more frequent operation of the East Street Pump Station.

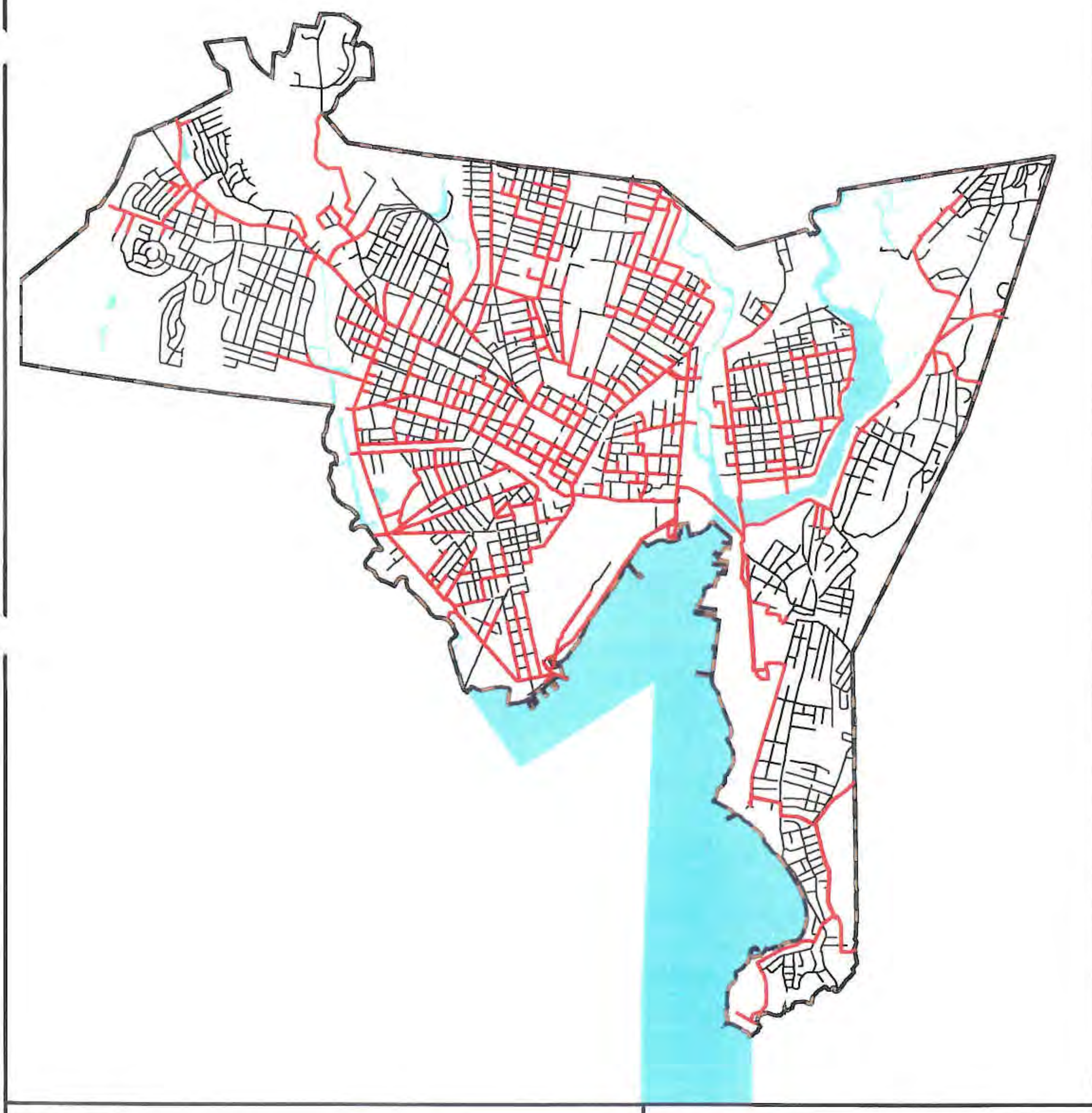
As a result of a field visit, internal structures were added to the model of the East Street Pump Station. A sluice gate was added to the model at the entrance to the Inlet Works of the pump station. Since the gate was considered fully open and inoperable, the modeled gate provided no reduction in flow area. Bar screens and the weir located before the Operations Building were added into the hydraulic model to account for the significant head losses that could occur through these structures.

### State/Union Pump Station

The State/Union Pump Station contains four pumps: two rated at 8,300 gpm (12MGD), one rated at 4800 gpm (6.9MGD) and one rated at 2300 gpm (3.3 MGD).

When modeled according to its design capacity (3 pumps on, or 35 MGD), surface flooding downstream of the State Street pump station was predicted. Through discussions with WPCA staff, it was determined this actually has occurred when the pump station was operated at its design capacity of 35 MGD. To prevent surface flooding, and better simulate the WPCA's actual operating procedures, the pump capacity used in the model was restricted below the design capacity. Discussion with WPCA staff indicated that the maximum pump rate was 14 MGD. However, a review of available flow monitoring data recorded at the pump station indicated that the station regularly pumped at a rate of approximately 20 MGD. This understanding was included in the PUMP database and modified in the MOUSE model.

The final extent of the hydraulic model of the interceptors in New Haven is shown in Figure 33. A larger figure is also provided in Appendix F. The interceptor model contains 1,728 standard sewer segments, 206 pipes with special sections, 1,903 manholes, 29 outlets, 16 pump stations and 16 wet wells.



New Haven City Boundary
Sewer, Modeled
Sewer, not Modeled

2000 0 2000 4000 Feet

# Figure 33

## Extent of Interceptor Model

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# Model Calibration and Results

The primary purpose of calibrating and validating a model with measured data is to assure that it will provide a realistic simulation within the level of accuracy needed for its ultimate goal. Some of the specific objectives that were identified at the beginning of this report include:

- computing overflow statistics (volume, frequency) and estimating associated pollutant loads under varying storm conditions,
- identifying system performance problems, such as surcharging, basement flooding, and sediment accumulation,
- estimating how short term controls may improve system performance, such as reducing wet weather surcharging, eliminating dry weather overflows, or maximizing conveyance to the East Shore WPAF,
- estimating the impacts of roof leader connections to the combined and partially separated sewer systems, and identifying a plan for managing roof leader connections and disconnections, and
- evaluating the potential impacts of long term controls on the reduction of overflows and pollutant loads to the receiving waters.

In general, a two step process was followed in calibrating the model. The initial step focused on dry weather flows. Observed data and model results for dry weather periods were compared to ensure that base sanitary flow and groundwater infiltration were realistically simulated. Once significant differences in the observed and model data were resolved, the second step of the calibration was started. This step focused on wet weather flows and the system's conveyance characteristics. Observed data and model results for a range of wet weather events were compared to ensure that the system's wet weather characteristics were realistically simulated in the model. In many cases, the initial values used in the model's development produced reasonable results.

Throughout the process, when significant differences were noted between the observed data and the model, additional investigations were performed and or meetings were held with WPCA staff to discuss them. In most cases specific reasons were identified for the discrepancies and, when necessary, the model or metering data were corrected to address these issues. Examples of issues which were resolved in this manner include: recycled flows at the WPAF meters, pump station operating rules, additional flow sources from outside the City limits, tidal impacts, and sediment within the interceptors. In cases where no satisfactory resolution could be reached, potential sources of error are identified and recommendations for further field work are discussed. Few of the model's parameters were "calibrated" on a site specific basis.

This chapter describes the various sources of calibration data and the process of calibrating the model, including:

- monitoring data used for calibration,
- dry weather flow calibration,

- wet weather flow calibration, and
- summary and conclusions.

# Calibration Data

The objective of Task 3 of the project was to gather and evaluate new and existing metered flow data to support the calibration of the New Haven model. More details about Task 3 can be found in Technical Memorandum #5, *Monitoring Program Results*. Figures 34 and 35 show the metering locations and a summary of the collected data, respectively. The following sections describe the data.

## Water Pollution Abatement Facility and Major Pump Stations

Flow data for the wastewater treatment facility (WPAF) and three major pump stations (Boulevard, East Street, and East Shore) was acquired from the Water Pollution Control Authority's hand-written records. This data was recorded at hourly intervals for each of the four sites. Data from January 1996 to May 1997 and from September to December 1997 was entered into a computer database so that they could be used for analysis and comparison with model results.

In March 1998, it was discovered that the range used to interpret telemetered signals from the Boulevard Pump Station to the Water Pollution Abatement Facility (WPAF) was calibrated incorrectly. As a result, flow data reported for the site prior to March 1998 was corrected by increasing the reported flows by a factor of 25%.

As described in the DWF discussions, flows at the East Shore Pump Station include approximately 4.1 MGD of recycled flows from the WPAF. This amount was subtracted from the metered flow values in the database for comparison with the model.

## External Meters

The WPCA has several flow meters installed at points along the boundaries of New Haven with Woodbridge, Hamden, and East Haven to gauge the flows coming from these communities, as described in the Hydrologic Model chapter. During the calibration events, there were 12 meters in operation, although one (NH08) measures flows exiting New Haven that are augmented by East Haven flows and then measured again at NH09. Therefore, NH08 was not used in calibration.

## Monitoring Program

As part of the Long Term Control Project, a short term monitoring program was conducted to collect depth, velocity, and flow data for combined sewer overflows and representative combined, separated, and partially separated sewer systems. The representative measurements were accomplished using seven flow meters that were placed in locations throughout the City. Their measurements could be extended to other basins with similar characteristics to provide a picture of the type of runoff response expected in combined, separated, or partially separated catchments. Twenty-three flow meters were installed in interceptors and overflow pipes to measure in-system flows and estimate overflow volumes, frequencies, and durations. As previously mentioned, three of these storm events were used for calibration of the models. For these events, flows at many points in the sewer system could be compared to modeled flows.

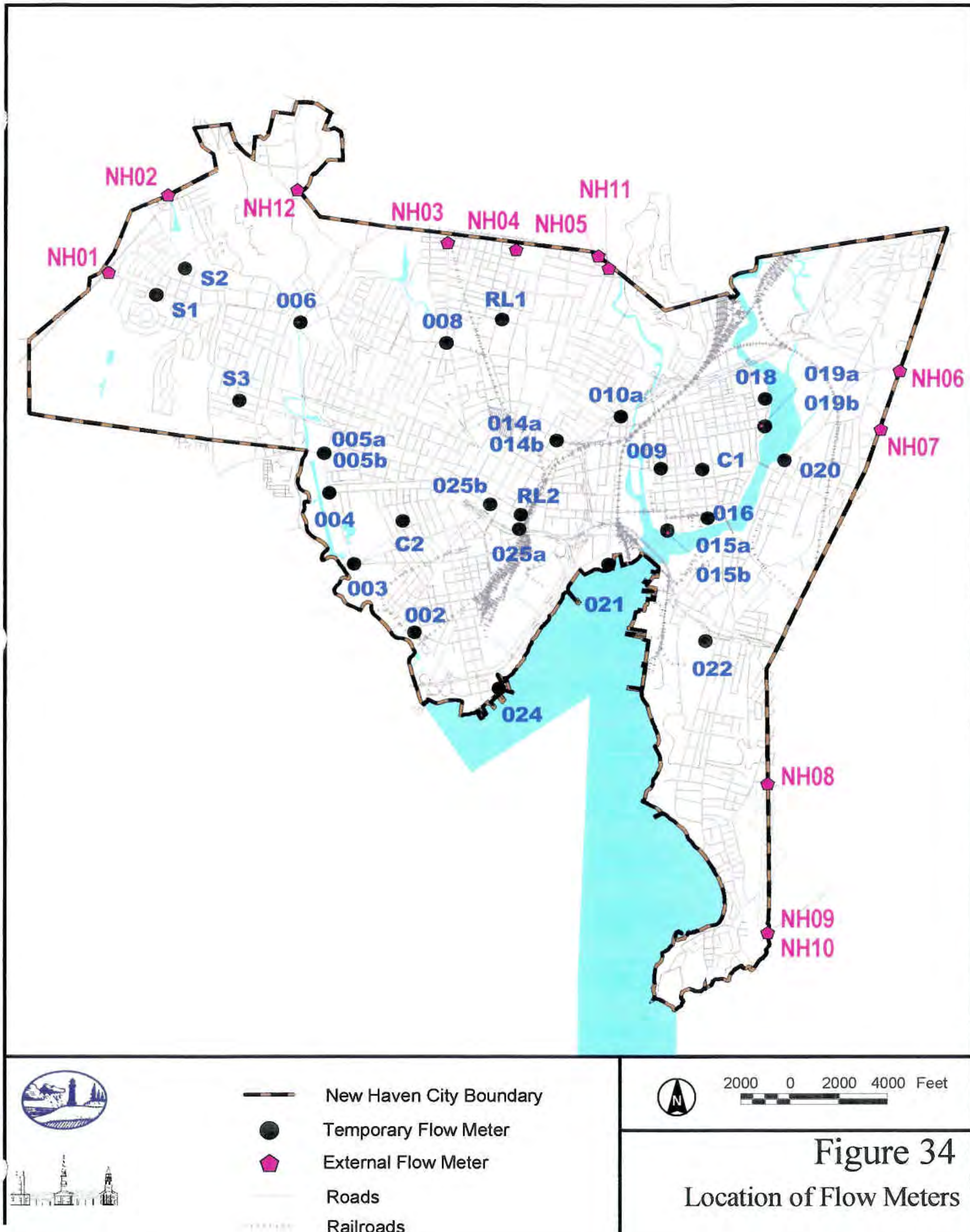


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Figure 34
Location of Flow Meters

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| Data Type and Location of Gauge or Meter | Source | Measurement Interval | | | 1993 | 1994 | 1995 | Jan-96 | Feb-96 | Mar-96 | Apr-96 | May-96 | Jun-96 | Jul-96 | Aug-96 | Sep-96 | Oct-96 | Nov-96 | Dec-96 | Jan-97 | Feb-97 | Mar-97 | Apr-97 | May-97 | Jun-97 | Jul-97 | Aug-97 | Sep-97 | Oct-97 | Nov-97 | Dec-97 | Jan-98 | Feb-98 | Mar-98 | Apr-98 | May-98 | Jun-98 | Jul-98 | Aug-98 | Sep-98 | Oct-98 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **RAIN** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| East Shore WPAF | WPCA | 30 minutes | | | | | | | | | | | | | | | | | | | | | | | problem with gauge | | | | | 1/2 | | | | | | | | | | 1/2 | |
| Whitney | Regional Water Authority | daily | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Whitney | Regional Water Authority | 15 minutes | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 1/2 | | |
| Dawson, Wepawaug | Regional Water Authority | 15 minutes | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| S. Cheshire | Regional Water Authority | 15 minutes | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Gaillard | Regional Water Authority | 15 minutes | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 1/2 | | |
| Saltonstall | Regional Water Authority | 15 minutes | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Tweed Airport | EarthInfo | daily | 1948-1969 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Tweed Airport | EarthInfo | hourly | 1967 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Lake Saltonstall | EarthInfo | daily | 1978-1995 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Lake Saltonstall | EarthInfo | hourly | 1991-1995 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Bradley Airport - Hartford | EarthInfo | hourly | 1954-1994 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Sikor Airport - Bridgeport | NCDC Website | monthly | 1804-1983 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| WSO Airport - Bridgeport | EarthInfo | hourly | 1951-1996 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Green Airport - Providence | EarthInfo | hourly | 1948-1994 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **FLOW, DEPTH, VELOCITY** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| City Boundary Long-Term Meters | ADS Env. Services | 15 minutes | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| NH01 to NH10 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| NH11 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| NH12 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Fair Haven Temporary Meters | ADS Env. Services | 15 minutes | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Wooster Street Interceptor | City of New Haven | 10 minutes | *Not in electronic form.* | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **FLOW** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| East Shore WPAF | WPCA | daily | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Park, Arch, Brookside Pump Stations | WPCA | bi-monthly | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Welton Pump Station | WPCA | bi-monthly | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 1/2 | | | | |
| Boulevard, East Street, East Shore, WPAF | WPCA | hourly | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 1/2 |
| | | | | | | | | | | | Storm S6 | | | | | | Storm S5 | | | | | | | | | | | | | Storm S2 | | Storm S3 | Storm S1 | Storm S7 | | | | | | | Storm S4 | | |

Legend: [shaded] data acquired; 1/2 same as above but only half a month



**Figure 35**
Timeline of Calibration Data

## Dry Weather Flow Calibration

The first step in calibrating the New Haven model was to ensure that the dry weather flow was modeled correctly. One goal of the dry weather flow model was to assess the ability of the sewer system to provide a self-cleansing scour velocity. Failure to reach scouring velocities (approximately 2 ft/s) can lead to sediment deposition, which may result in the loss of system capacity and possible dry weather overflows. A well-calibrated dry weather flow model can help pinpoint troublesome spots in the sewer system, and provides a basis for calibrating the model to wet weather conditions. This section describes the process of refining the model to achieve a calibrated dry weather flow model and presents hydrographs for some selected sites. A complete set of modeled versus metered DWF hydrographs can be found in Appendix E.

The approach to calibrating the dry weather flow model first involved reviewing the fluctuations in DWF due to seasonal groundwater infiltration and/or tidal intrusion. To demonstrate the range of expected flows at the WPAF, Technical Memorandum #7 (*Nine Minimum Controls Report*) reported that WPAF flows could vary from 29.5 MGD during the dry season to 42.1 MGD during spring with full moon tides. As described in the model development section, a dry period that had detailed meter data from the monitoring program was selected as the basis for the calibration. The model was then run for the weeklong period between 10/1/97 and 10/7/97, which had an average flow rate of 29.6 MGD. An iterative approach of identifying issues, seeking solutions, and rerunning the model was then taken.

### Model Refinements

A meeting that was held to discuss the initial DWF results identified four areas that did not show good agreement between the measured and modeled flows. The problems and resolutions are discussed below.

#### Welton Street Pump Station

A flow meter was installed at the intersection of James St and Grand Ave near NPDES Regulator 009[1] during the Task 3 monitoring program. Modeled flows at this location were significantly lower than the measured values (see Figure 36). After some investigation, it was discovered that flow from the Welton Street Pump Station in Hamden was not included in the model. Enough data were available from the WPCA to establish a long term average flow rate out of the pump station, and a catchment was added to the model to simulate the flows from that area. After the addition was made, excellent agreement was found between the modeled and measured flows (see Figure 37).

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[1] Regulators were named according to the NPDES permit numbers. For the purposes of this report, REG009 refers to the in-system flow and OF009 refers to the CSO discharge at NPDES site #009.

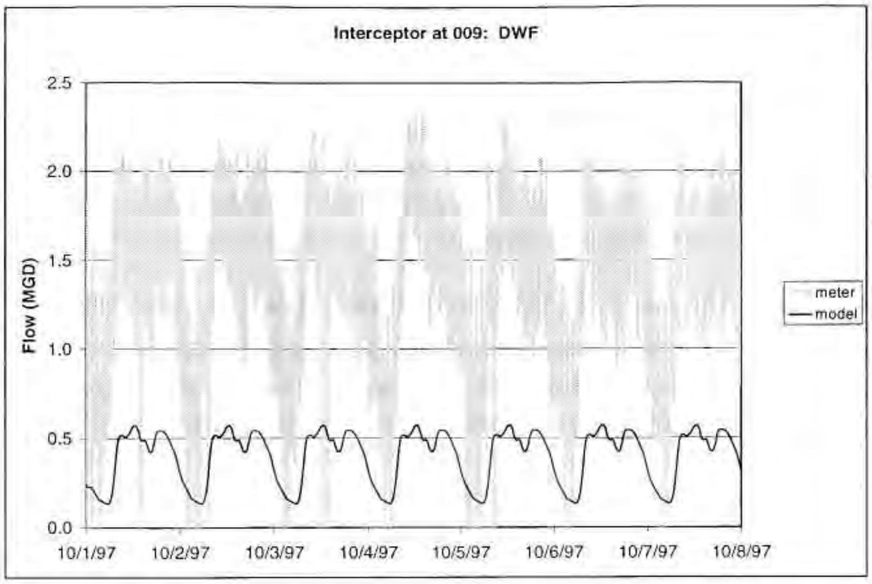


*Figure 36: DWF Hydrographs at James St/Grand Ave Prior to Adjustment*

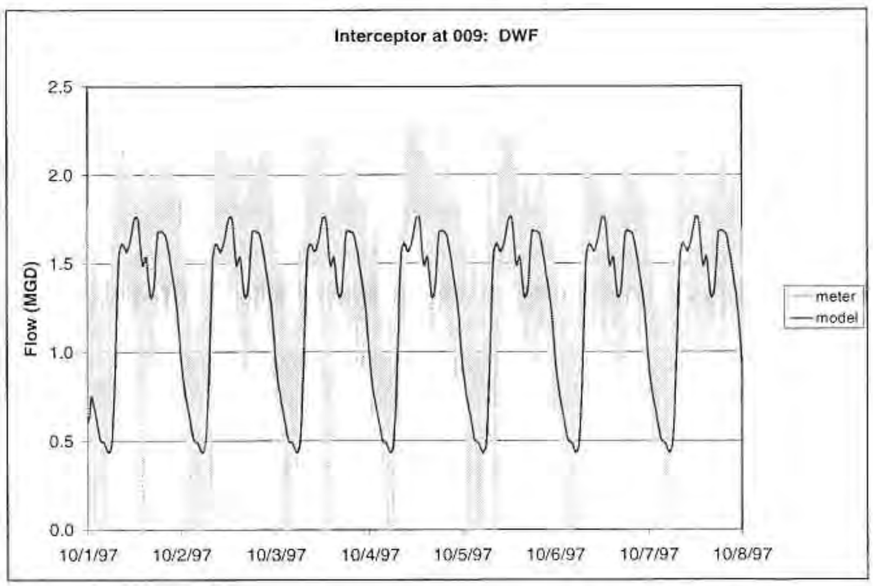


*Figure 37: DWF Hydrographs at James St/Grand Ave After Adjustment*

## East Shore Pump Station

Initial model results showed that modeled flows were consistently lower than measured flows at the East Shore Pump Station. After discussions with WPCA staff, it was determined that the likely source of the discrepancy was the recycling of flows within the treatment plant. Data were obtained from WPCA staff that included recycled flows from the scrubber, primary sludge, belt press, and filtrate. The data indicated that, on average, about 4.1 MGD is recycled[1]. During the period for which dry weather flow was modeled, it

[1] The 4.1 MGD average consists of about 1.7 MGD scrubber, 2.0 MGD primary sludge, 0.1 MGD belt press, and 0.3 MGD filtrate.

appears that recycling was not occurring or was occurring at a smaller rate. However, the dry periods before and after the wet weather events used in other calibration simulations showed a stronger match between metered and modeled flows once the recycled flows were subtracted from the meter values. In general, the results indicate that flows tributary to the pump station are modeled correctly.

### East Street and I-91

The third site where there was a discrepancy between the meter and model was at REG010, at East Street and I-91. The average flow rate during a dry period according to the meter was 2.83 MGD, while the model predicted a higher average flow of 4.54 MGD. Two ADS meters which gauge inflow from Hamden are upstream of this site: NH05 and NH11. As they are based on long term records (more than 2 years), the data from these meters are believed to be reliable. In addition, they are permanent installations, which suggests that their locations were carefully chosen and the installations are dependable. Temporary installations may not have the same reliability. The average flows for the permanent meters during the dry period were 0.05 MGD and 2.74 MGD for NH05 and NH11, respectively. Adding these two flows together leads to an average flow of 2.79 MGD at the New Haven boundary. The meter at REG010, which had an average of 2.83 MGD, should have reflected significant inflow from the New Haven neighborhoods that contribute flow downstream of the two Hamden meters, but the measurement indicates only a negligible difference. The discrepancy is therefore considered to be due to metering difficulties at REG010, and the modeled flows are regarded as more representative of conditions at this site.

### Boulevard Interceptor

At several meetings, differences between the meters and model along the Boulevard Interceptor were discussed. The meters in question are temporary installations M4, M3, M2, and M24. Some adjustments were made by ADS to the data for M24 and M3 due to an unusual velocity profile and a changing sediment profile, respectively. (More information can be obtained from Technical Memorandum #5, *Monitoring Program Results*, ADS' Final Report [ADS, 1998a], and ADS' report on the drawdown tests for the Boulevard and East Street Pump Stations [ADS, 1998b]). Table 25 provides a summary of some possible causes for the discrepancies and methods of confirming whether each cause is contributing to the differences. Minutes for a modeling meeting held on December 3, 1998, provide additional detail about the issues discussed in the table.

**Table 25. Potential Reasons and Investigation Methods for Model/Meter Discrepancies Along Boulevard**

| Possible Cause | Analysis Method |
|---|---|
| Flow metering | Perform additional metering; continue with block testing program |
| Sediment | Perform a detailed sediment survey |
| Exfiltration from the interceptor | Inspect Boulevard Interceptor |
| Unusual field conditions (cave-ins, blockages, cross-connections) | Inspect sewers in the Boulevard sewershed |

It appears that an extensive amount of survey work needs to be performed in order to obtain a satisfactory answer to the questions along Boulevard. Under the assumption that the meters were correct because they were generally consistent in measuring smaller flows than were modeled, a factor was applied to reduce dry weather flow in the Boulevard sewershed. This factor was the only real calibration that was performed for the dry weather flow model. At the outlet to this sewershed—the Boulevard Pump Station, where recent tests have confirmed the accuracy of the magnetic flow meters—the metered flow was 82% of the modeled flow. This reduction factor was applied to the groundwater infiltration and base sanitary flow derived from each subcatchment to reduce flows. Although the calibration worsened at a few local meters, the resulting model provided a better match between the modeled and metered flows along the Boulevard Interceptor and the Boulevard Pump Station. Although this step allowed the model to better simulate metered flows, the issue cannot be completely resolved until additional field work is completed to identify which of the issues identified in Table 25 is the primary cause.

## Calibration Results

The total dry weather flows modeled and the observed DWF at the treatment plant show good agreement (see Figure 38). The sharp decline in the modeled flows at midday reflects the exaggerated diurnal pattern that was utilized. However, the overall dry weather flow pattern for the entire WPAF sewershed closely resembled the metered data. The average daily flow rate for this period was 30.1 MGD (model), as compared to 29.6 MGD (meter). The following figures and commentary highlight some of the variability in the DWF calibration. Additional plots showing hydrographs for the metering sites can be found in Appendix E.

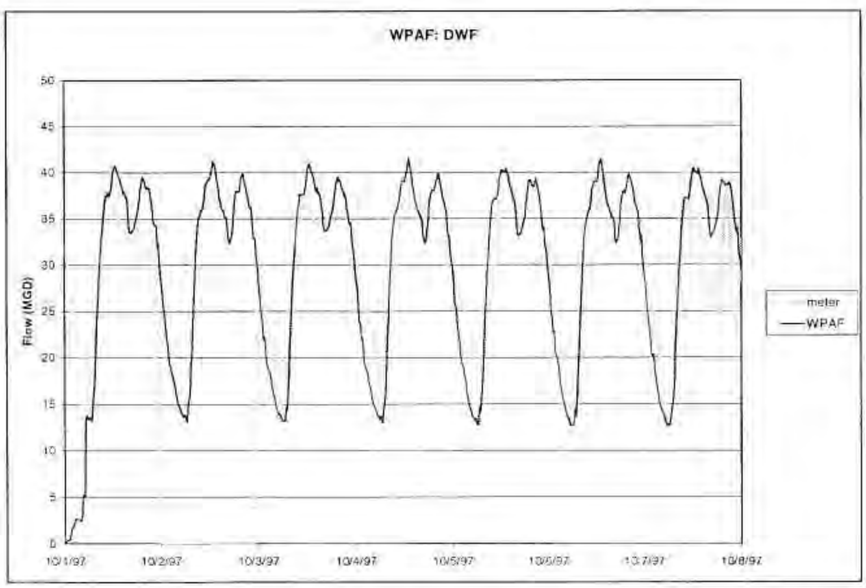


*Figure 38: Modeled and Metered DWF Hydrographs at the WPAF*

Figure 39 shows a hydrograph near the Boulevard Pump Station, at REG002 (Boulevard/Lamberton). It can be seen that there is a good match between the modeled and the metered dry weather flow.

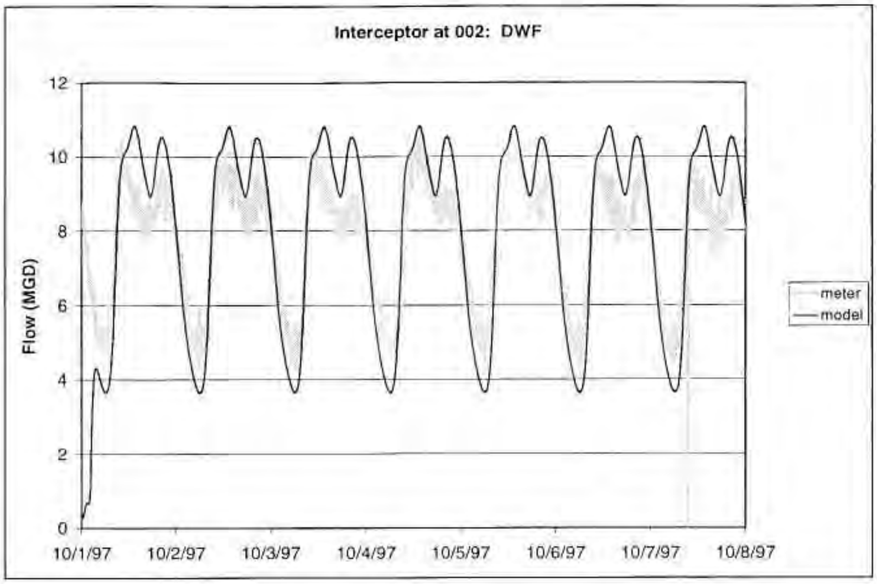


*Figure 39: DWF Hydrographs in Boulevard Interceptor at Lamberton St*

Figure 40 shows the modeled and metered DWF at the East Shore Pump Station. It is evident from the figure that the model over-predicts the amount of DWF during this period. As discussed previously, the metered data was adjusted downward by approximately 4 MGD to account for internal recycle at the WPAF.

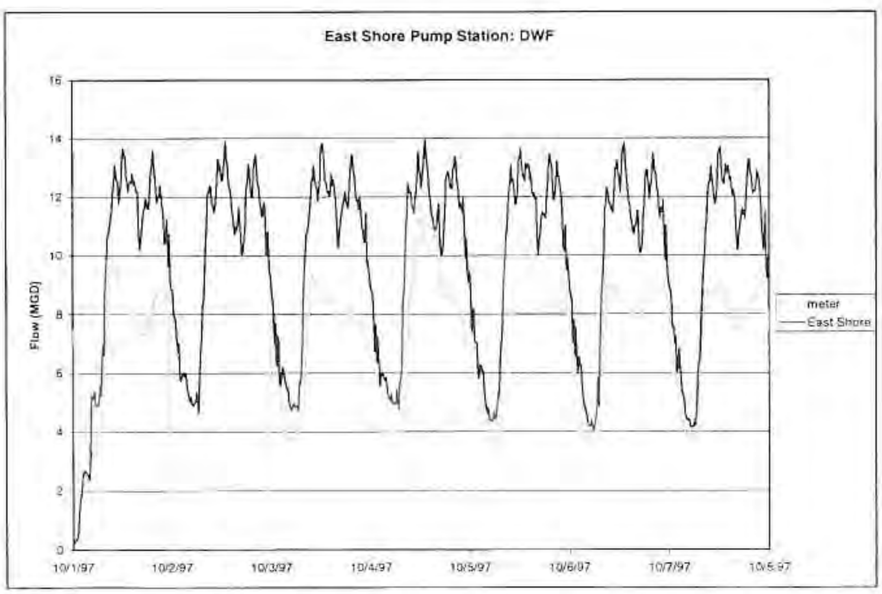


*Figure 40: DWF hydrographs at the East Shore Pump Station*

Figure 41 shows the hydrographs that were modeled and metered for one of the external areas that contributes flow to the New Haven sewer system. Good agreement between the two can be seen.

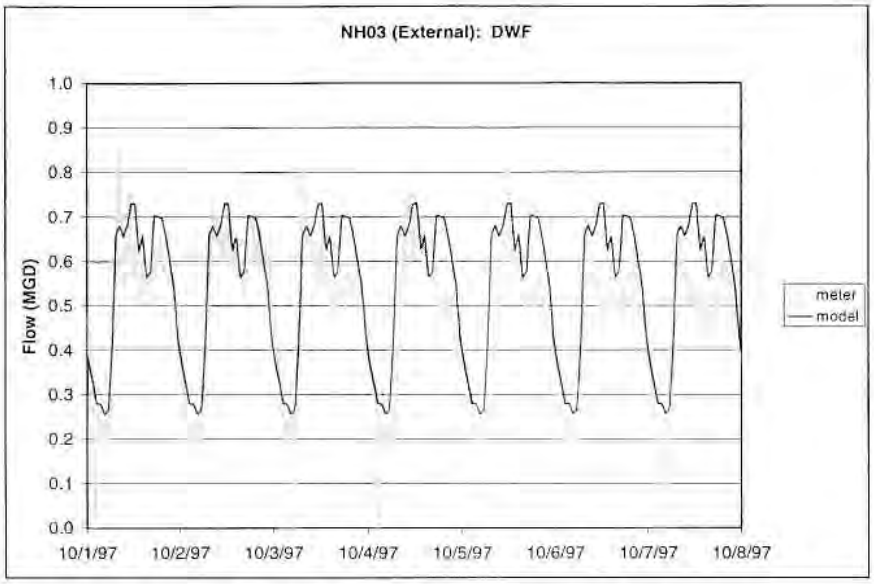


*Figure 41: DWF Hydrographs Along Dixwell Ave*

Figure 42 shows a schematic of the sewer system with the average dry weather flow rates noted at each metering site, for an overall picture of the dry weather flow model. The figure is helpful because it shows the modeled and metered flows at each site and how the sites influence each other. The schematic, which was originally created by ADS for the monitoring report, differentiates between temporary and permanent meter installations, shows pump stations, and highlights meters that were placed in dry overflow pipes.

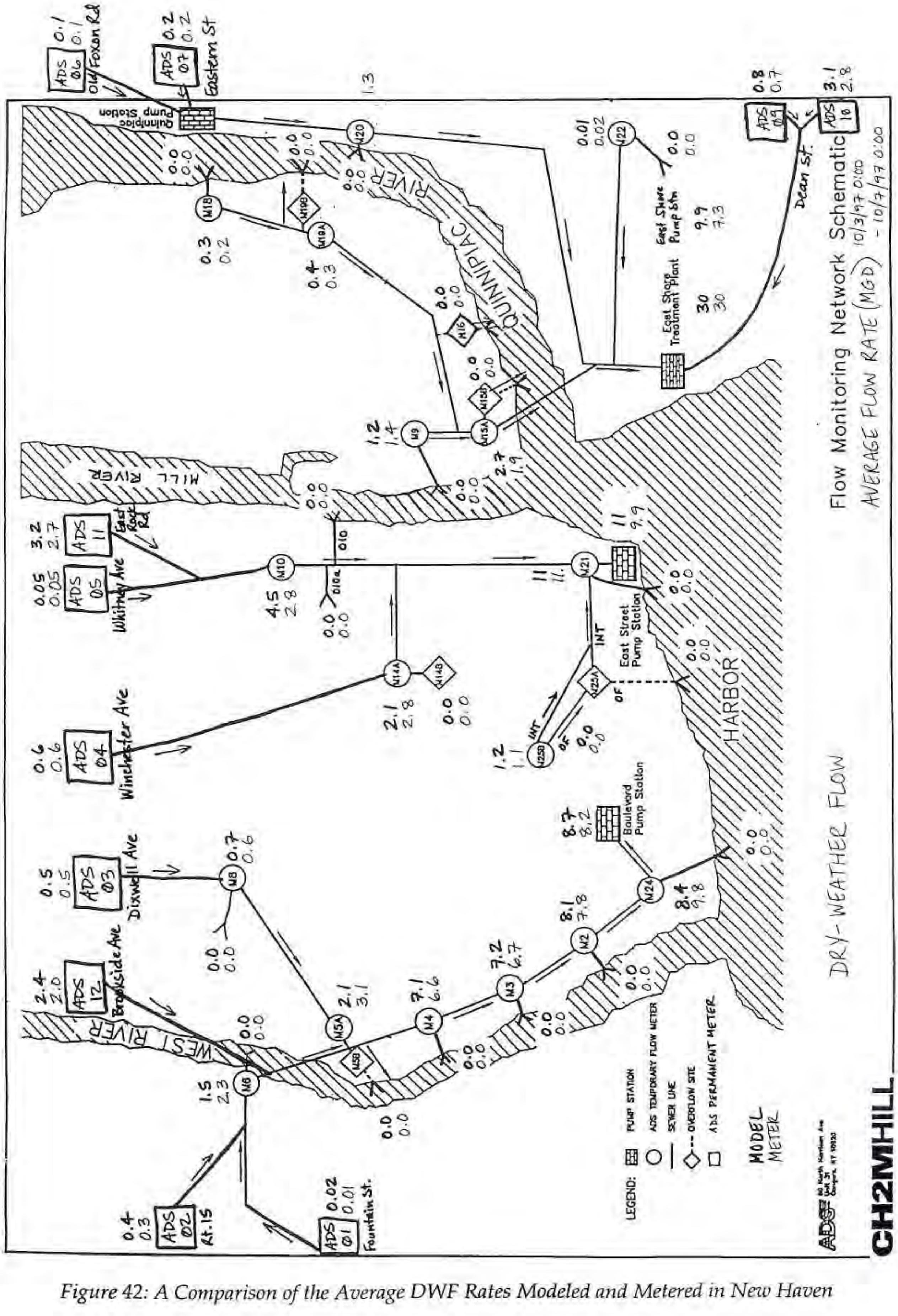


*Figure 42: A Comparison of the Average DWF Rates Modeled and Metered in New Haven*

# Wet Weather Calibration

Combined sewer overflows occur as a result of a sewer system becoming overloaded during wet weather and being relieved through regulating structures. The wet weather model is used for estimating the volume, frequency, and duration of CSOs, which can then be used to estimate pollutant loadings to receiving waters or to size CSO control facilities.

The process used to calibrate the model for wet weather simulations was the same as that followed for dry weather: realistic values were applied, the model was run, differences between the model and meters were noted, reasons for the discrepancies were sought, and the model was adjusted based on the findings. Several iterations of this process were used to refine the model. The initial focus was on three storms from the monitoring program, but it was later expanded to include additional storms that represented a greater range of event volumes and intensities.

This section describes the process and results for the wet weather calibration. It includes segments providing discussion on:

- tide level and rainfall data inputs,
- calibration adjustments used to distinguish combined, partially separated, and fully separated catchments,
- results for storms from the monitoring period that include measurements of CSOs,
- extended sewer system responses from large storms, and
- a summary of CSO statistics and general observations.

## Boundary Conditions

Much of the data that was used to build the models has already been discussed in the Hydrologic Model and Hydraulic Model chapters. However, some additional data were needed to define the boundary conditions of the model. They include tidal elevations and rainfall data.

### Tides

Tides are known to impact five CSO outfalls in New Haven. These locations, shown in Figure 43, include:

- OF015 – James Street Siphon
- OF016 – Poplar Street and River Street
- OF021 – East Street Pump Station
- OF024 – Boulevard Pump Station
- OF025 – Union Pump Station

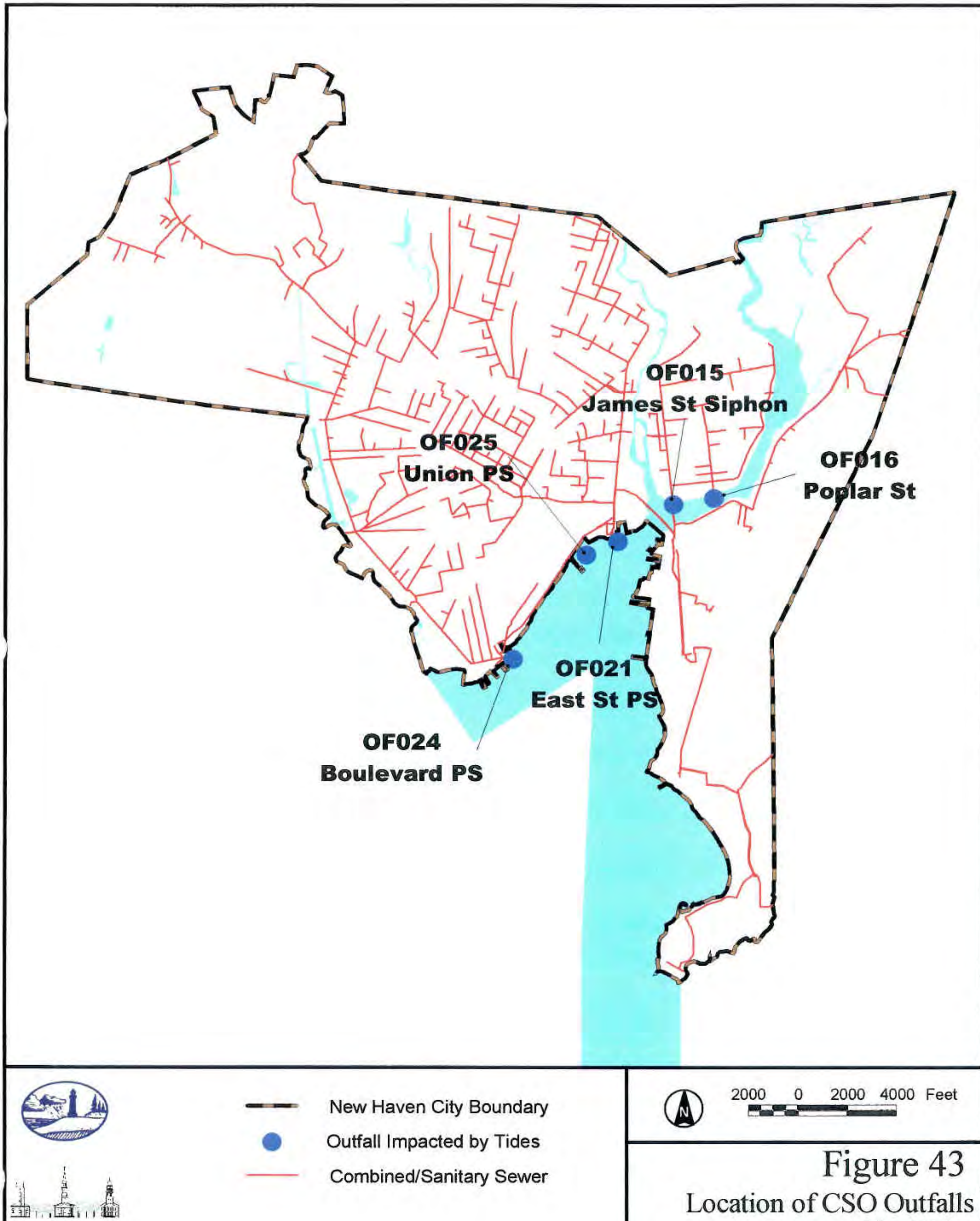


Figure 43
Location of CSO Outfalls Impacted by Tides

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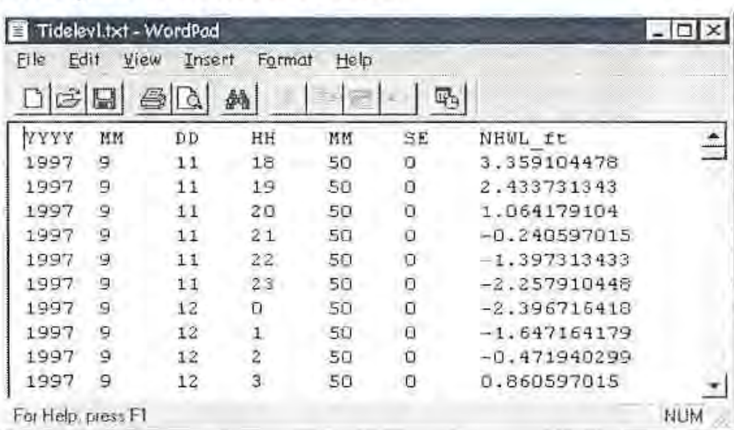
Many (but not all) of these sites have tide gates to prevent significant inflow to the sewer system from the rivers and harbor, although some tidal intrusion is known to occur (see Technical Memorandum #7, *Nine Minimum Controls Report*). Tides can also impact the sewer system by restricting overflows when tide gates cannot open against high water levels. Table 26 provides more information about each site, including receiving waters, tide gates, and weir elevations. With respect to the USCGS datum, mean sea level is considered to be 0.0 ft, and the mean high tide is approximately 3.3 ft. During the monitoring period, the highest tidal elevation was about 5.9 ft according to data from the National Oceanic and Atmospheric Administration (NOAA). It can be seen that all weirs listed in the table except the East Street Pump Station regulating weir are below the highest tidal elevation during the period. In addition, the diversion weir at the James Street Siphon and the weepholes at the Union/State Pump Station regulating weir are below even the mean high tide elevation. Thus, tidal inflow to the sewer system is possible.

**Table 26. CSO Outfalls That Are Impacted By Tides**

| NPDES # | Location | Receiving Water | Tide Gate | Weir Elevation |
|---|---|---|---|---|
| 015 | James St Siphon | Quinnipiac | circular flap valve | 2.1 ft |
| 016 | Poplar St / River St | Quinnipiac | square flap valve | 3.4 ft |
| 021 | East St PS | New Haven Harbor | flex valve | 6.3 ft |
| 024 | Boulevard PS | New Haven Harbor | 2 circular flap valves | 3.6 ft |
| 025 | Union/State PS | New Haven Harbor | none | 4.2 ft with weepholes at 2.0 ft |

Tidal elevations observed at Bridgeport, CT, were obtained from the National Oceanic and Atmospheric Administration's website (NOAA, 1998). To reflect tides in New Haven, the Bridgeport data were offset according to literature values by subtracting 10 minutes and decreasing the level rise by 8% (White and White, Jr., 1997). A text file (see Figure 44) was used to include the water levels in the MOUSE model. Non-return valves were specified in the model at the four outfalls with tide gates to simulate the prevention of tidal inflow. The primary influence of the high water levels in the model was to prevent water from exiting the outfalls. Leaky tide gates were not simulated.




| YYYY | MM | DD | HH | MM | SE | NHWL_ft |
|---|---|---|---|---|---|---|
| 1997 | 9 | 11 | 18 | 50 | 0 | 3.359104478 |
| 1997 | 9 | 11 | 19 | 50 | 0 | 2.433731343 |
| 1997 | 9 | 11 | 20 | 50 | 0 | 1.064179104 |
| 1997 | 9 | 11 | 21 | 50 | 0 | -0.240597015 |
| 1997 | 9 | 11 | 22 | 50 | 0 | -1.397313433 |
| 1997 | 9 | 11 | 23 | 50 | 0 | -2.257910448 |
| 1997 | 9 | 12 | 0 | 50 | 0 | -2.396716418 |
| 1997 | 9 | 12 | 1 | 50 | 0 | -1.647164179 |
| 1997 | 9 | 12 | 2 | 50 | 0 | -0.471940299 |
| 1997 | 9 | 12 | 3 | 50 | 0 | 0.860597015 |

*Figure 44: Example of Tide Level Input File for MOUSE.*

### Rainfall

The goal in choosing storm events is to select a set of storms that will allow verification of the model's ability to simulate a range of storm sizes, seasons, and antecedent conditions. Using a range of storms will help explain where and under what storm conditions overflows will occur. Three calibration storms were chosen from the monitoring program during the fall of 1997 (S1, S2, and S3). However, during that period there were not any events exceeding a 6-month storm, and it was decided that data for some additional storms should also be evaluated. Therefore, four additional storms were selected to provide a wider range of volumes and intensities. The seven storms are summarized in Table 27 below.

**Table 27. Characteristics of Calibration and Comparison Storms**

| Storm Number | Date | Storm Duration (hr) | Antecedent Conditions | Rainfall Depth (in) | Depth Return Period | Peak 1-Hr Intensity (in/hr) | Intensity Return Period | Peak 30-Min Intensity (in/hr) | Peak 10-Min Intensity (in/hr) |
|---|---|---|---|---|---|---|---|---|---|
| S1 | 30 Nov – 1 Dec, 1997 | 15.6 | dry | 0.18 | 7 days | 0.05 | 6 days | 0.04 | 0.06 |
| S2 | 28-29 Sep 1997 | 9.2 | very dry | 0.58 | 15 days | 0.21 | 18 days | 0.32 | 0.48 |
| S3 | 8-9 Nov 1997 | 32.7 | moist | 2.10 | 4.7 months | 0.37 | 1.6 months | 0.38 | 0.42 |
| S4 | 17-18 Aug 1998 | 18.5 | moist | 2.47 | 7.9 months | 1.55 | 6.9 years | 1.90 | n/a |
| S5 | 19-20 Oct 1996 | 25.0 | dry | 4.32 | 3.6 years | 0.42 | 2.1 months | 0.44 | n/a |
| S6 | 16 Apr 1996 | 20.8 | wet | 5.64 | 6.7 years | 1.04 | 2.1 years | 1.08 | n/a |
| S7 | 23-24 Jan 1998 | 21.0 | moist | 3.01 | 1.2 years | 0.48 | 2.7 months | 0.56 | n/a |

As shown in the table, the seven storms had depths ranging from 0.18" to 5.64" and one-hour intensities from 0.05 in/hr to 1.55 in/hr. The storms also spanned a range of seasons and antecedent conditions.

One of the applications of the model will be to run a simulation for an average year to encompass the effects of antecedent conditions and multiple events and predict the impacts of pollutants on receiving waters. The year 1967 was chosen (in Task 4) to represent an average year based on total precipitation (45.05"), number of events (110), and maximum event depth (3.19", return period 1.6 years) and intensity (0.85 in/hr)[1]. Figure 45 shows all events that occurred during 1967, ranked by decreasing volume, and the volume of the seven storms used for calibration. All but 2 of 110 events in 1967 had rainfall depths smaller than that of storm S3. Thus, if the model's calibration is confirmed for storms of up to the depth of S3 (2.10"), the figure suggests that it will perform satisfactorily for 108 out of 110 events included in the annual simulation and that the model will fully support the pollutant load analysis.

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[1] Documentation for the analysis of long term precipitation record and selection of the 1967 data was prepared under Task 4, and will be submitted under separate cover.

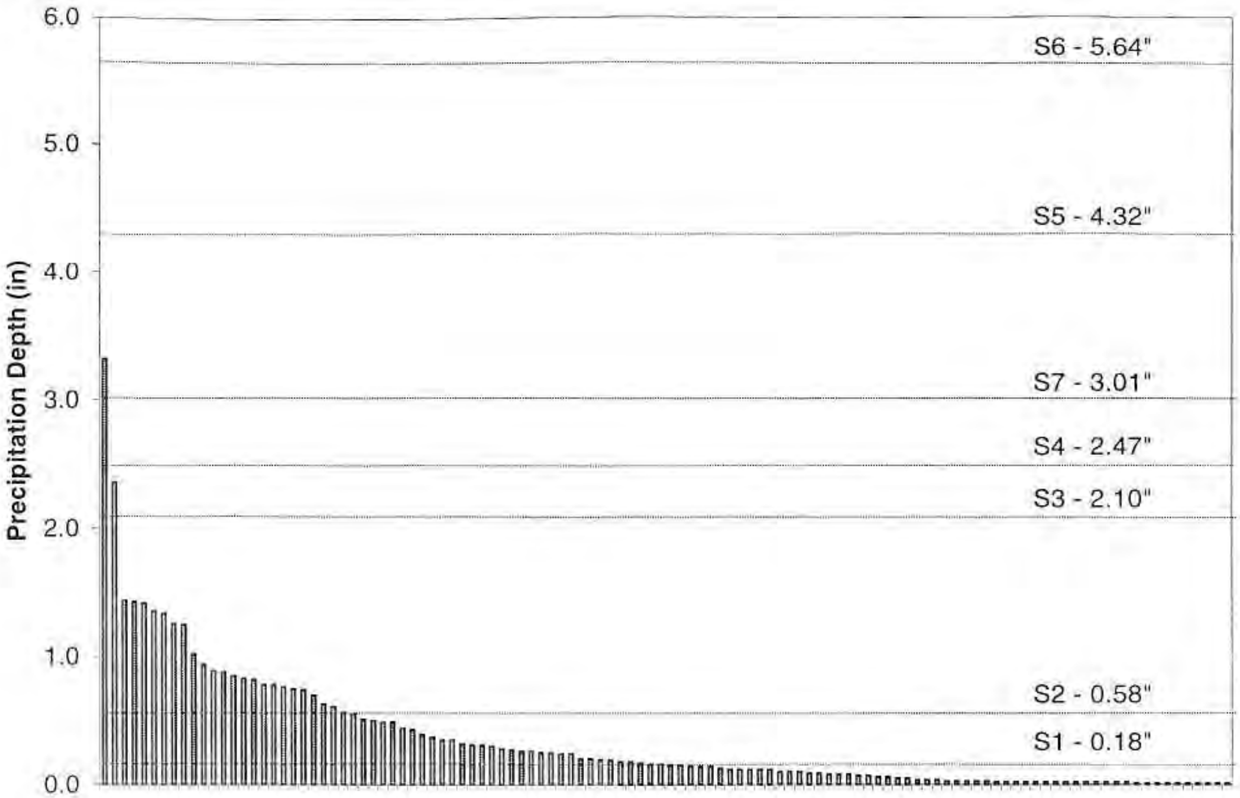
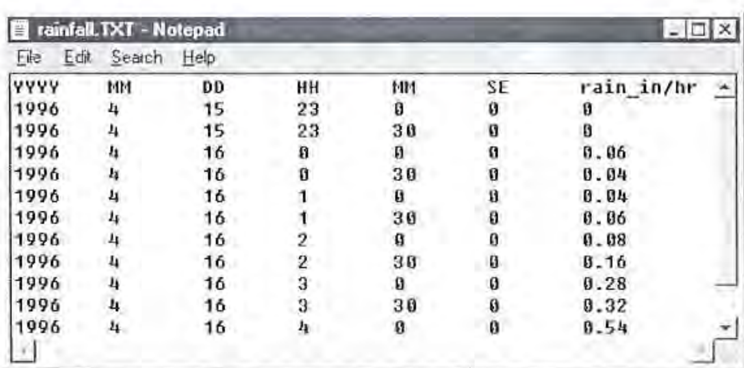



*Figure 45: Events During 1967, Ranked by Decreasing Volume, and the 7 Calibration Storms*

For the events that occurred during the monitoring program (S1, S2, S3), rainfall depths were obtained from 4 rain gauges (RG1, RG2, RG3, RG4), that were installed as part of that program. The gauges measured rainfall using 5-minute timesteps. For the remaining four storm events (S4, S5, S6, S7), data were obtained from the WPCA's rain gauge, which uses a 30-minute increment. The rain gauge locations are shown on the next page in Figure 46. The figure also shows where rainfall from each gauge was applied in the MOUSE hydrologic model.

Any number of discrete storm events or continuous rainfall time series can be simulated with the MOUSE model. Rainfall records in the format shown in Figure 47, can be imported directly into MOUSE.




| YYYY | MM | DD | HH | MM | SE | rain_in/hr |
|---|---|---|---|---|---|---|
| 1996 | 4 | 15 | 23 | 0 | 0 | 0 |
| 1996 | 4 | 15 | 23 | 30 | 0 | 0 |
| 1996 | 4 | 16 | 0 | 0 | 0 | 0.06 |
| 1996 | 4 | 16 | 0 | 30 | 0 | 0.04 |
| 1996 | 4 | 16 | 1 | 0 | 0 | 0.04 |
| 1996 | 4 | 16 | 1 | 30 | 0 | 0.06 |
| 1996 | 4 | 16 | 2 | 0 | 0 | 0.08 |
| 1996 | 4 | 16 | 2 | 30 | 0 | 0.16 |
| 1996 | 4 | 16 | 3 | 0 | 0 | 0.28 |
| 1996 | 4 | 16 | 3 | 30 | 0 | 0.32 |
| 1996 | 4 | 16 | 4 | 0 | 0 | 0.54 |

*Figure 47: Example of Rainfall Data Input File for MOUSE*

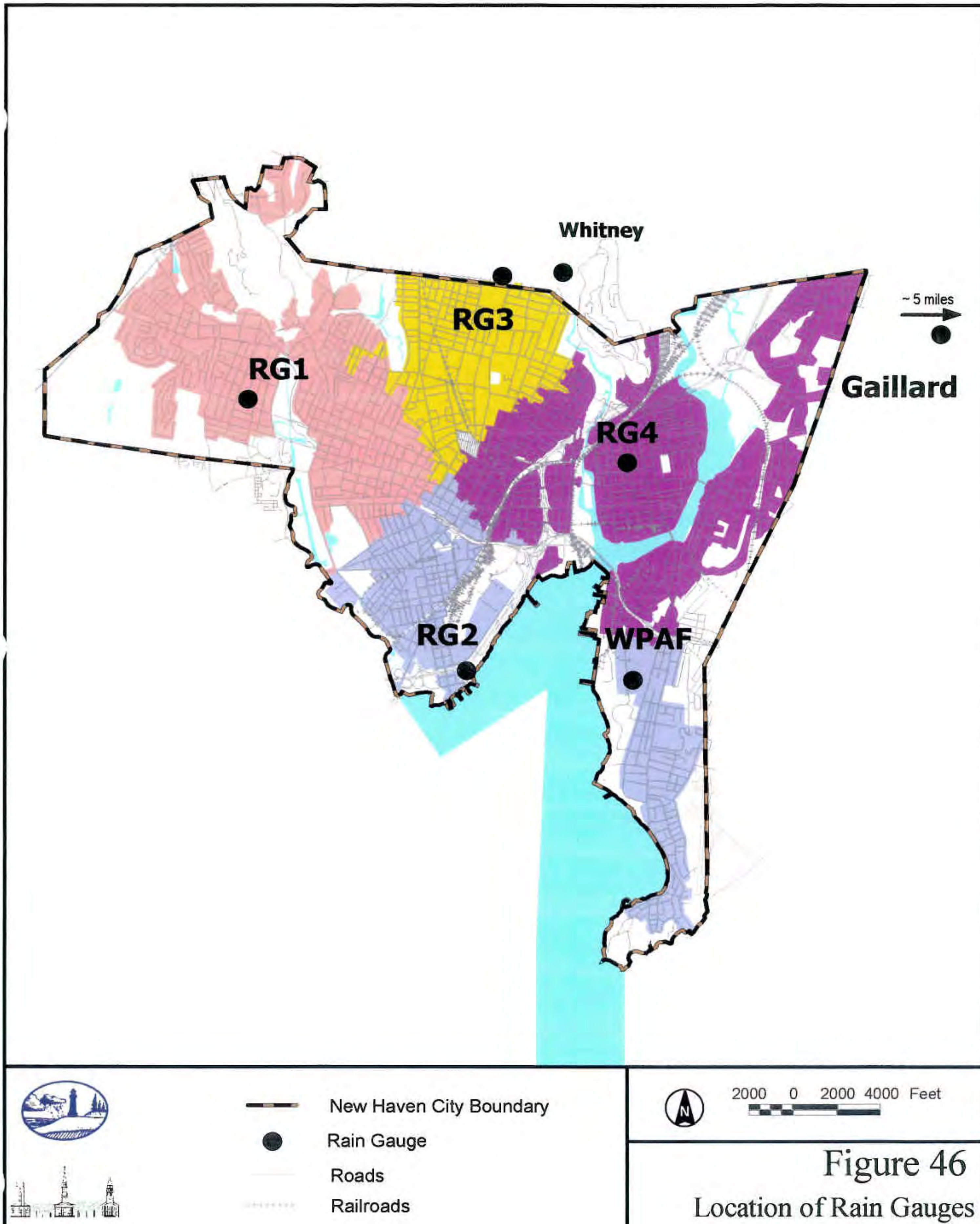



Figure 46
Location of Rain Gauges

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## Parameter Adjustments

### Areal Reduction Factors

Because of the differences between combined, separated, and partially separated sewer systems, runoff responses in each neighborhood can be quite varied. A systematic method of differentiating between the three types of systems was needed to capture the distinct runoff responses. It was important to use a systematic method because of the large number of subcatchments and because the model will be used to simulate alternatives for controlling CSOs.

Although most of the runoff from an area served by separated sewers is directed to storm sewers, many separated areas show significant responses to wet weather conditions. A way of simulating the wet weather impacts in these types of catchments is to decrease the area of the catchment to its hydrologically "effective" area. Similarly, even neighborhoods served by combined sewers do not capture 100% of the rain because of surface ponding, or direct runoff to receiving waters.

As mentioned previously, seven meters were installed during the monitoring program to gauge flows in the three types of sewer systems. The data from these meters indicated that there were indeed varying levels of response between the types. Figure 48 shows the flows measured at sites C1, RL1, and S2 during storm S3. Because of the differences in catchment size, the flows have been normalized so that the units on the y-axis are cfs/acre. C1, a gauge in the combined sewers in Fair Haven, shows a peak of 0.12 cfs/acre (7.7 MGD), while RL1 (partially separated, downtown) shows 0.04 cfs/acre (0.9 MGD) and S2 (separated, Westville) shows 0.01 cfs/acre (0.2 MGD). Though it is difficult to see at this scale, all these catchments show a response to the rain event.

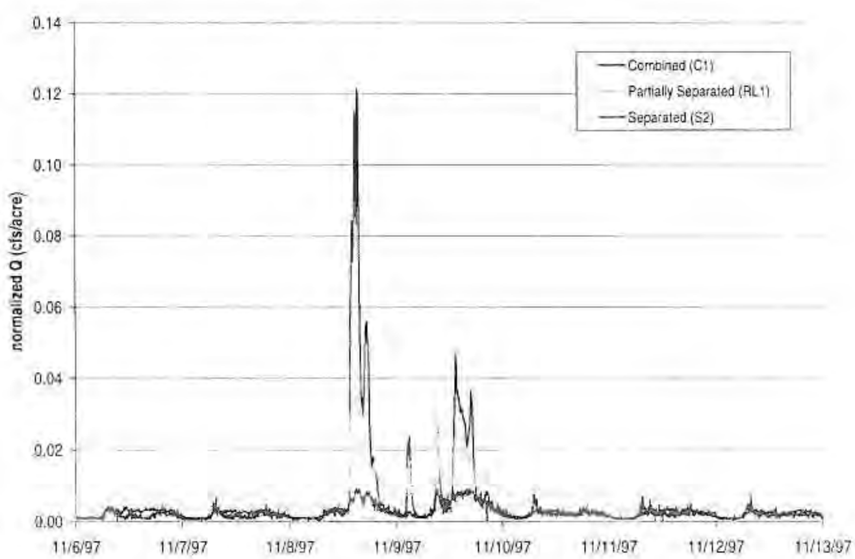



*Figure 48: Effect of Separation Status on Runoff Response*

Areal reduction factors, or ARFs, were used to simulate the "effective" areas for each type of sewer system and to reflect the variation in their response. The ARFs were adjusted over a series of model runs. Figure 49 shows a schematic representation of the impact of the areal reduction factors using a 10-acre, 50% impervious catchment.

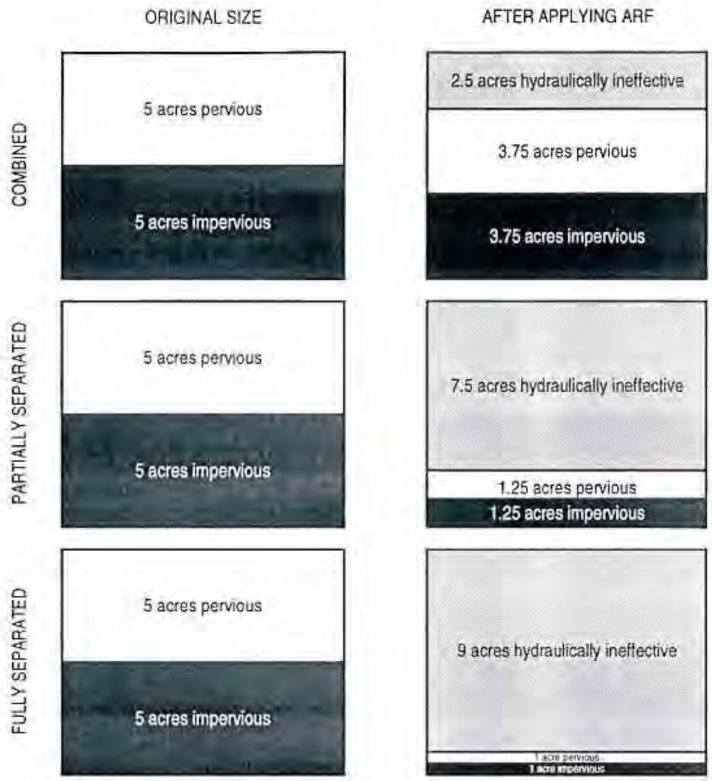



*Figure 49: Schematic Showing Impact of Areal Reduction Factors*

For combined areas, it was assumed that about 25% of rainfall is lost on or in direct runoff to water bodies or poorly drained areas, so that only 75% of the catchment can be considered hydraulically effective. In partially separated areas, construction projects have rerouted runoff from streets into storm sewers, but runoff from roofs is still directed into the sanitary sewers. The ARF used for partially separated catchments was 25%. For separated areas, in which some response to rainfall was seen, the ARF was set to 10%, allowing for a small runoff contribution to the sanitary sewers.

Extensive plots that show comparisons between the modeled and metered flows at the monitoring sites can be found in Appendix E. The appendix is divided first by precipitation event, and within each event, by major sewershed. In the discussions that follow, significant findings during the calibration of the wet weather model are highlighted.

## Calibration of S1, S2, and S3

Storms S1, S2, and S3 represent a range of storms that occurred during the monitoring program. Of the seven calibration storms, they are the only ones that include detailed data for the estimation of CSO volumes and peak rates. Since the amount of pollution contributed to receiving waters and the size of the CSO control facilities are directly dependent on their volumes, it is critical to be able to develop a model that can accurately simulate the response of the sewer system to wet weather within a reasonable tolerance. The primary focus in calibration was on these three storms, which will be discussed in sequence in the next few sections.

### Storm S1

Between November 30 and December 1, 1997, Storm S1 produced 0.18" of rainfall and had a peak 10-minute intensity of 0.06 in/hr. It was the smallest storm used in the calibration of the model. As can be seen in Figure 50, there is negligible response to the storm event recorded in the modeled and metered flows at the WPAF. Overall, this storm served to reconfirm the calibration of the dry weather flow model.

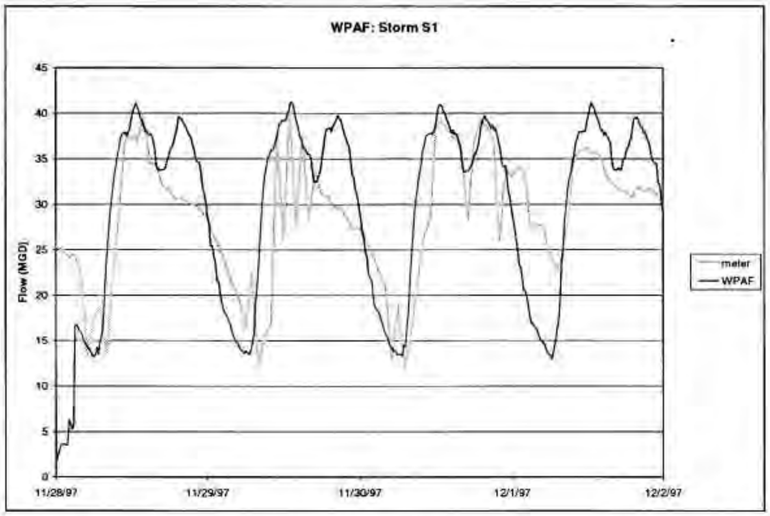



*Figure 50: Comparison of Modeled and Metered Flows at the WPAF for Storm S1*

Figure 51 shows good agreement between the modeled and metered responses from East Haven catchments along Dean Street (NH09 and NH10) that are considered external flows.

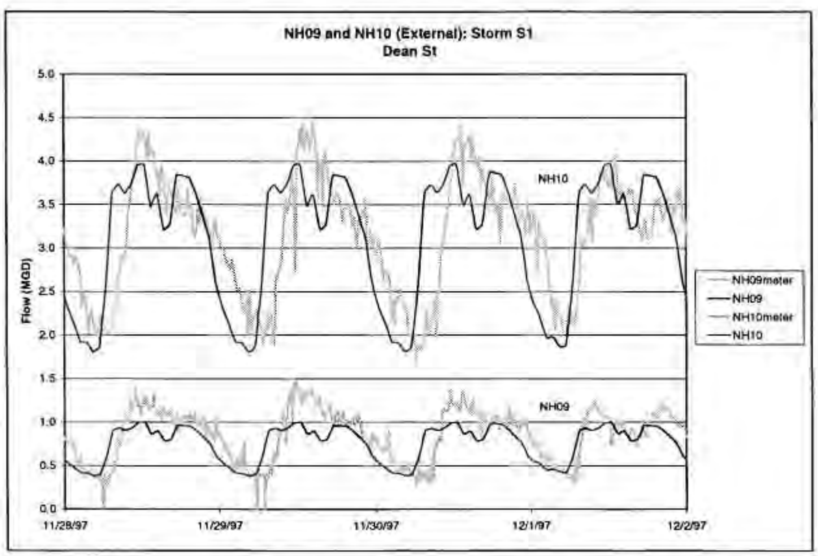



*Figure 51: Comparison of Modeled and Metered Flows at External Areas for System S1*

The flows recorded at the East Shore Pump Station are plotted in Figure 52 with the flows predicted by the model. It can be seen that unlike in the dry weather flow calibration, the modeled and metered flows agree well. This confirmed the belief that the DWF model was simulating flows tributary to the East Shore Pump Station correctly, and that the difference observed previously was a result of the variation in the recycle flows at the WPAF.

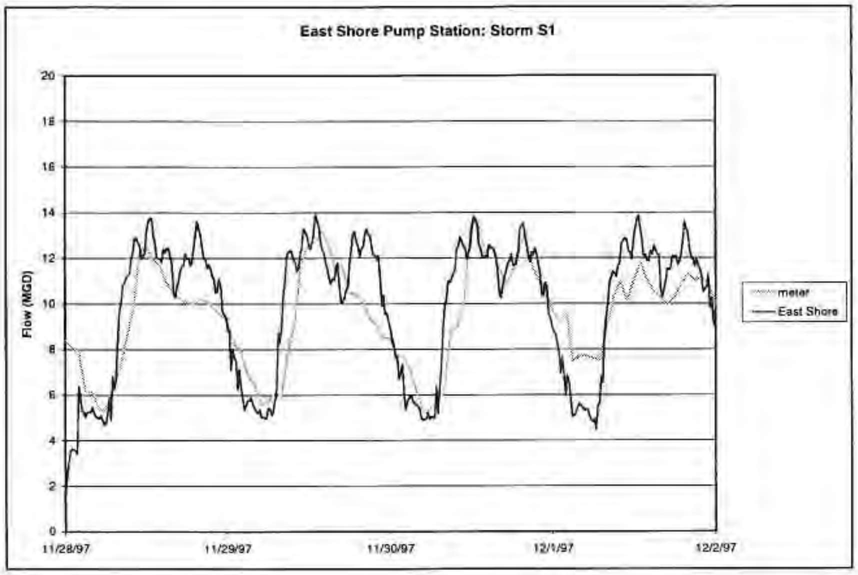



*Figure 52: Comparison of Modeled and Metered Flows at the East Shore Pump Station for Storm S1*

## Storm S2

Storm S2 occurred on September 28-29 1997 (D=0.58", peak $i_{10\,min}$ = 0.48 in/hr). It was the second largest of the storms that was chosen for model calibration. This event was large enough that a wet weather response was observed in some of the hydrographs.
Figure 53 shows good agreement between the modeled and metered flows at the WPAF from Storm S2. It can be seen that the two hydrographs compare favorably with each other, despite the temporal shift in the peak flow. This shift could be caused from an incorrect timestamp in either the flow meter or rainfall data. Because the volume and peak rates predicted by the model match the metered values, this shift will have no affect on the size of CSO control alternatives or pollutant loading calculations.

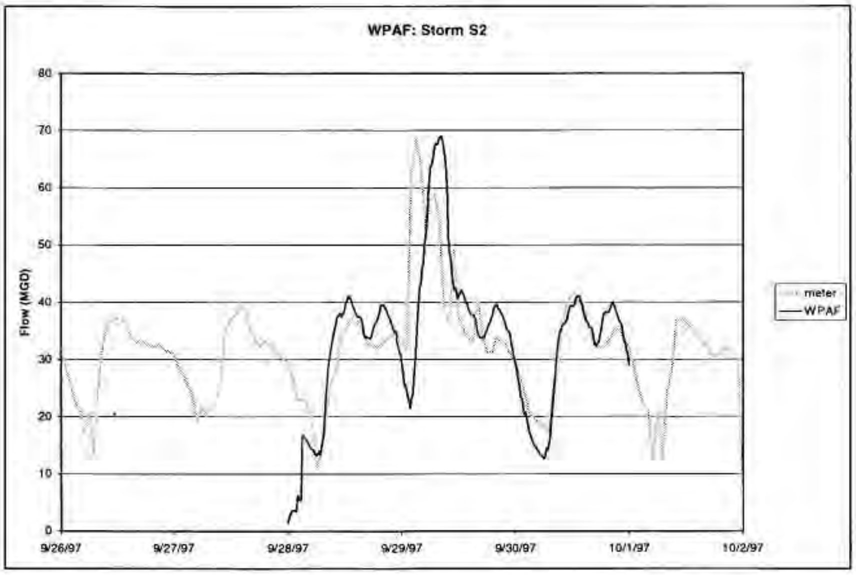



*Figure 53: Comparison of Modeled and Metered Flows at the WPAF for Storm S2*

A similar shift between the modeled and metered flow is evident at the Boulevard Pump Station, as indicated in Figure 54. Again, the volume and peak flow rates compare favorably despite this timing delay.

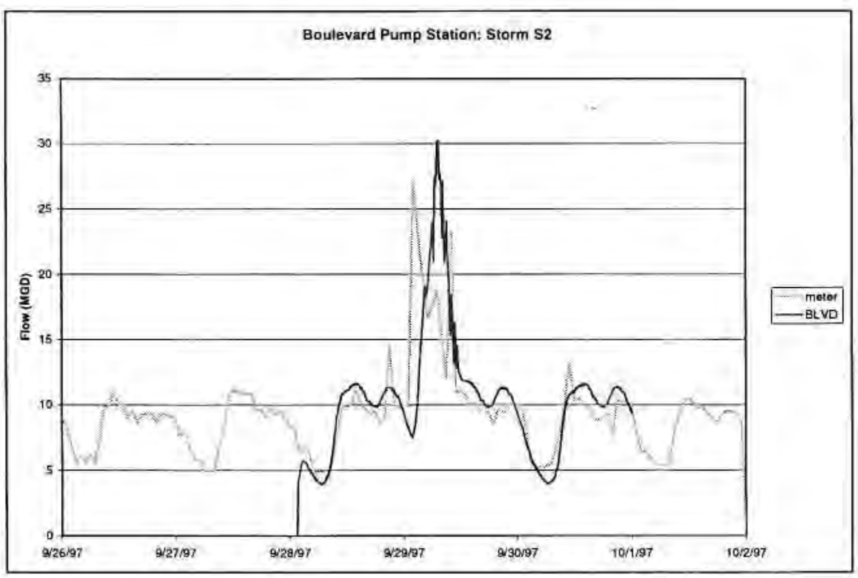



*Figure 54: Comparisons of Modeled and Metered Flows at the Boulevard Pump Station for Storm S2*

Figure 55 presents the flows in the overflow regulator immediately upstream of the Boulevard Pump Station. By comparing the peak flows recorded at this meter to the peak flows reported at the pump station (Figure 54), it is evident that the meter is unreliable at this location. It is believed that the source of error is introduced from the velocity probe that was used to calculate the metered flow rates.

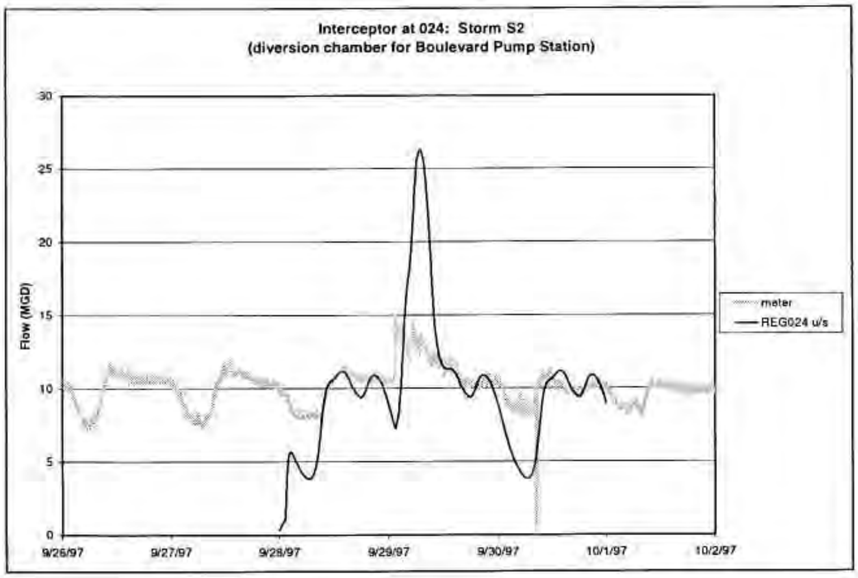



*Figure 55: Comparisons of Modeled and Metered Flows for Storm S2 at Regulator Upstream of the Boulevard Pump Stations*

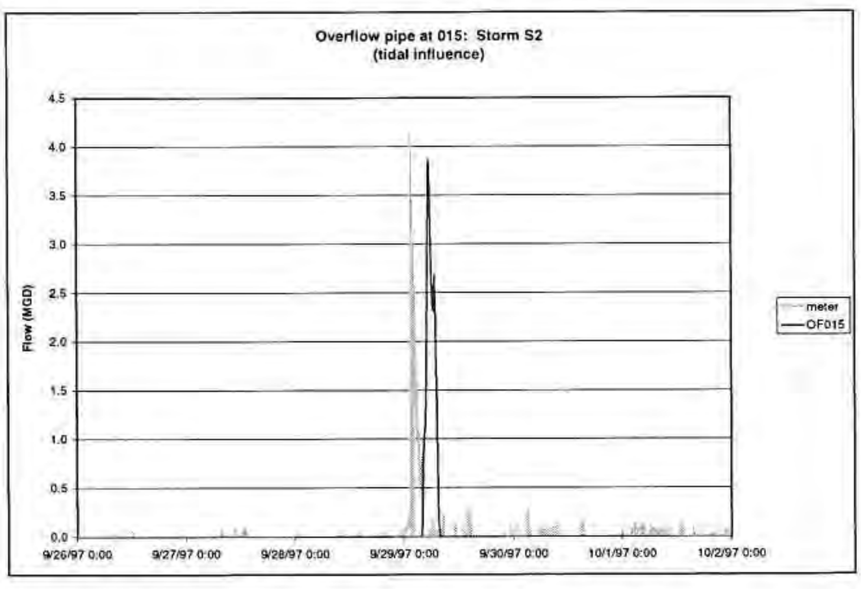



*Figure 56: Comparison of Modeled and Metered Flows at Overflow 015 (James St Siphon) for Storm S2*

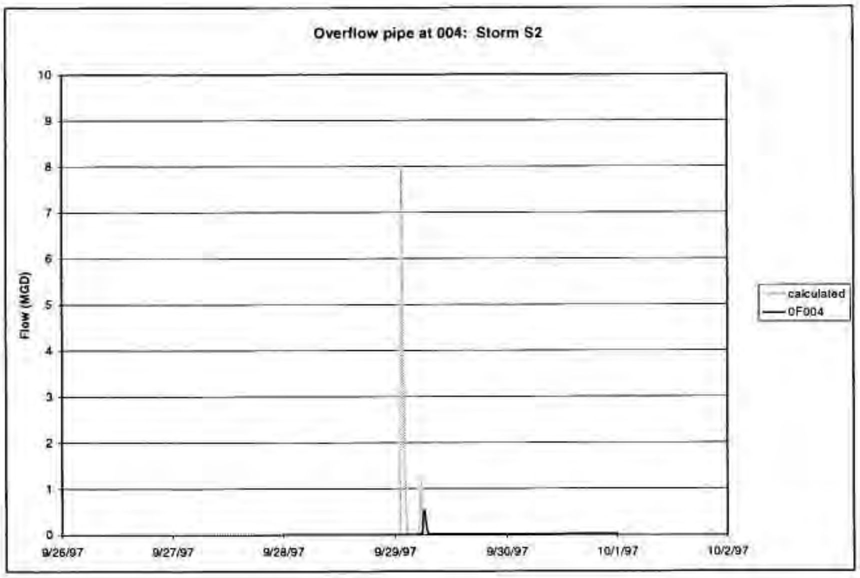



*Figure 57: Comparison of Modeled and Metered Flows at Overflow 004 (Boulevard/Legion) Storm S2*

Meter data reported that only two of the 23 overflows were activated during Storm S2: OF015 (James St Siphon) and OF004 (Boulevard at Legion). The model closely matches the observed flows at OF015 (Figure 56) but it does not predict an overflow at OF004 (Figure 57). The discrepancy at overflow 004 is consistent with other metering and modeling problems previously described for the lower portions of the Boulevard Watershed and along the Boulevard Interceptor. Similar to the discussion of DWFs, it appears that the current conditions may vary significantly from the as-built conditions used to construct the model. Table 28 provides a summary of some possible causes for the discrepancies observed, and analyzes which could be performed to confirm the relative contribution of each. The complete collection of the interceptor and overflow hydrographs simulated and measured for Storm S2 is provided in Appendix E.

**Table 28 Potential Reasons and Investigation Methods for Model/Meter Discrepancies Along Boulevard**

| Possible Cause | Analysis Method |
|---|---|
| Flow metering | Perform additional metering; continue with block testing program |
| Sewer separation performed by DOT that was not included in GIS and model | Add Henry's punchlist of extra items to the GIS and model |
| Seasonally clogged catch basins (leaves) | Run model for storm(s) during seasons other than autumn |
| Street flooding | Perform wet weather street flooding survey |
| Sediment | Perform a detailed sediment survey |
| Unusual field conditions (cave-ins, blockages, cross-connections) | Inspect sewers along Boulevard |
| Exfiltration from the Interceptor | Inspect Boulevard Interceptor |

### Storm S3

Storm S3 generated 2.1" of rain between November 8-9, 1997 at a peak 10-minute intensity of 0.42 in/hr. It was the largest storm that occurred during the 3-month flow monitoring program.

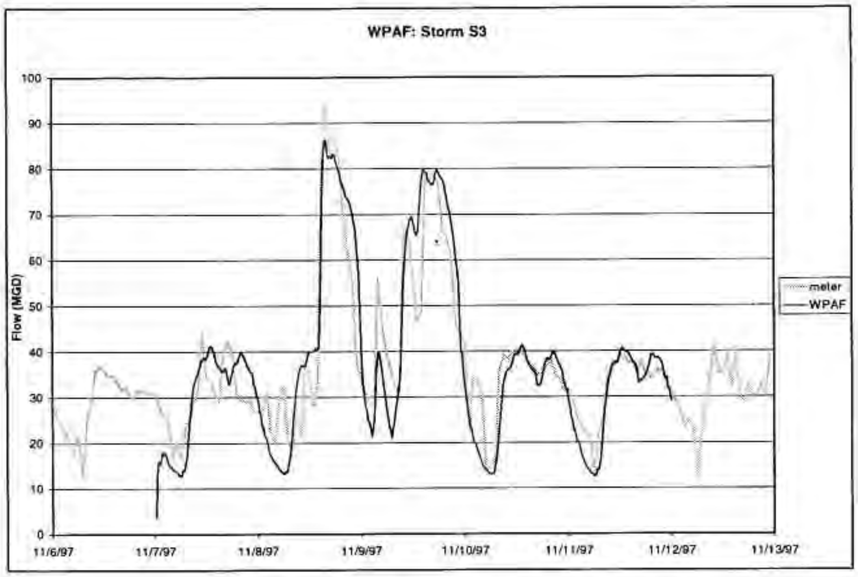



*Figure 58: Comparison of Modeled and Metered Flows at WPAF for Storm S3*

Good agreement between observed and modeled flows at the outlets to each of the major sewersheds (WPAF, Boulevard Pump Station, East Street PS, East Shore Pump Station) can be seen in Figures 58 to 61. Of particular interest are:

- flows reported before and after the storm closely match the modeled flows,
- both modeled and metered flows have similar double-peaked patterns, and
- in general, the model appears to predict system conveyance very well.

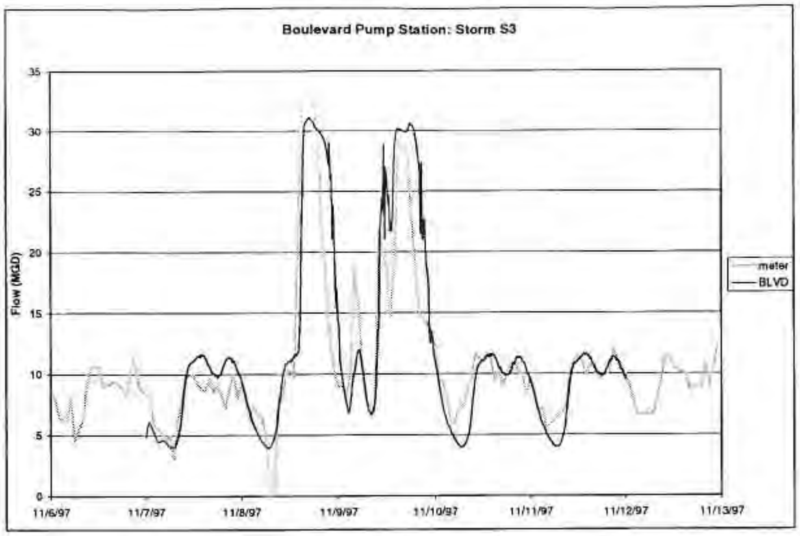



*Figure 59: Comparison of Modeled and Metered Flows at Boulevard Pump Station for Storm S3*

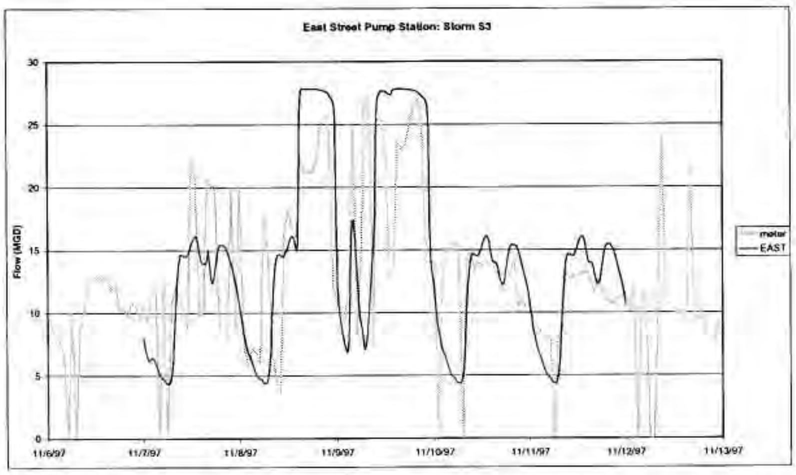



*Figure 60: Comparison of Modeled and Metered Flows at East Street Pump Station for Storm S3*

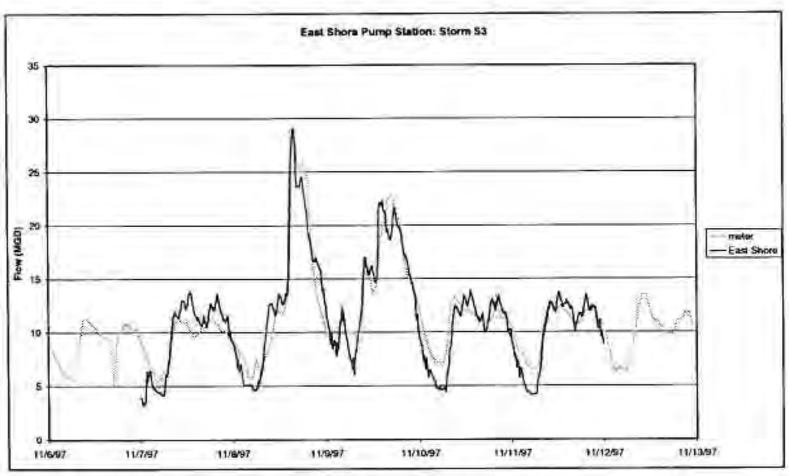



*Figure 61: Comparison of Modeled and Metered Flows at the East Shore Pump Station for Storm S3*

It is evident that the flows measured at the East Street Pump Station fluctuate significantly during this event while Boulevard appears to operate smoothly. Overall, the idealized pump curves in the model simulate the each of these stations well.

Despite its size, monitoring data collected during the event indicate that only 8 of the 20 sites recorded activity, while the model predicted that 14 sites would be active. An example of the model predicting CSOs relatively well is shown in Figure 62 (the James St Siphon). Both the timing of the overflow and its volume agree well between the meter and the model. The CSO at Front/Pine (OF019) shown in Figure 63 is an example of where the model simulates an overflow greater than was observed.

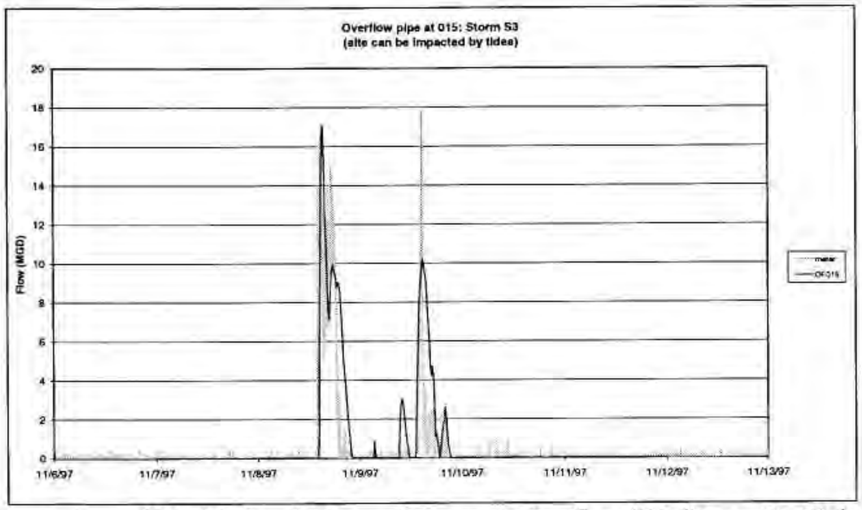



*Figure 62: Comparison of Modeled and Metered Flows at Overflow 015 (James St. Siphon) for Storm S2*

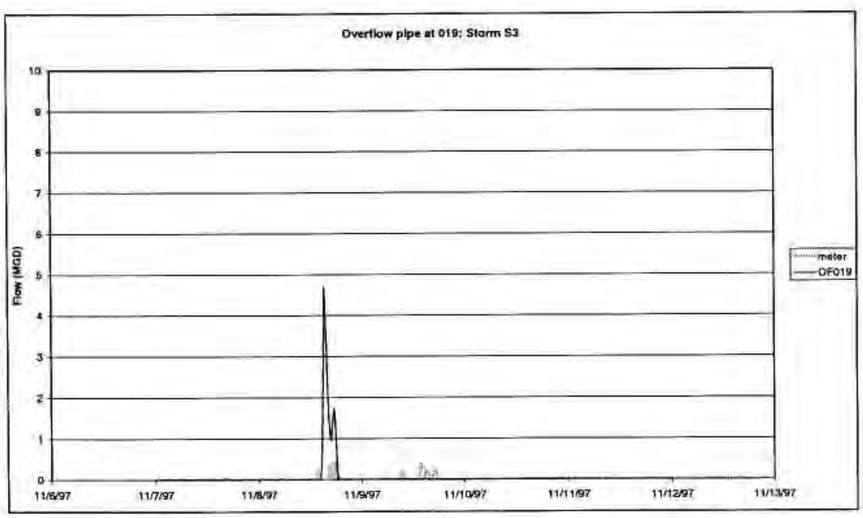



*Figure 63: Comparison of Modeled and Metered Flows at Overflow 019 (Front/Pine) for Storm S3*

The complete collection of the interceptor and overflow hydrographs simulated and measured for Storm S3 is provided in Appendix E.

### Storm S4

Storm S4 occurred during the summer of 1998, and it was the most intense storm event examined in the model. However, many of the flow meters did not reflect the impact of the storm and more rainfall data were sought to confirm the intense pattern recorded at the WPCA. Several data problems occurred during the storm at the various rain gauges around New Haven that prevented their data from being used. The closest rain gauge that could be used for comparison is located at Lake Gaillard, approximately 5 miles northeast of New Haven. The Lake Gaillard data showed significantly lower intensities and total volumes than the WPAF data – a symptom of a spatially variant summer storm. Because of the lack of detailed rain data necessary to model this type of storm, S4 was not used in the calibration.

## Storms S5, S6, and S7

Review of monitoring rain from the WPAF indicate that storms S5, S6, and S7 caused a lengthy response in the sewer system not evident in data collected for the smaller events. This response is shown by the long recession limbs on the hydrographs. Figure 64 shows the metered WPAF hydrograph and the rainfall hyetograph for storm S6 (5.64 inches). It can be seen that the recession limb lingers long after the storm has passed. After much discussion and evaluation, it was hypothesized that this lengthy response is probably due to the contribution from groundwater infiltration or pumpback from sump pumps. Since MOUSE 4.01 is a model that provides a short term response to rainfall, and this effect is not directly due to rainfall, it is not a response that can be simulated in the current model.

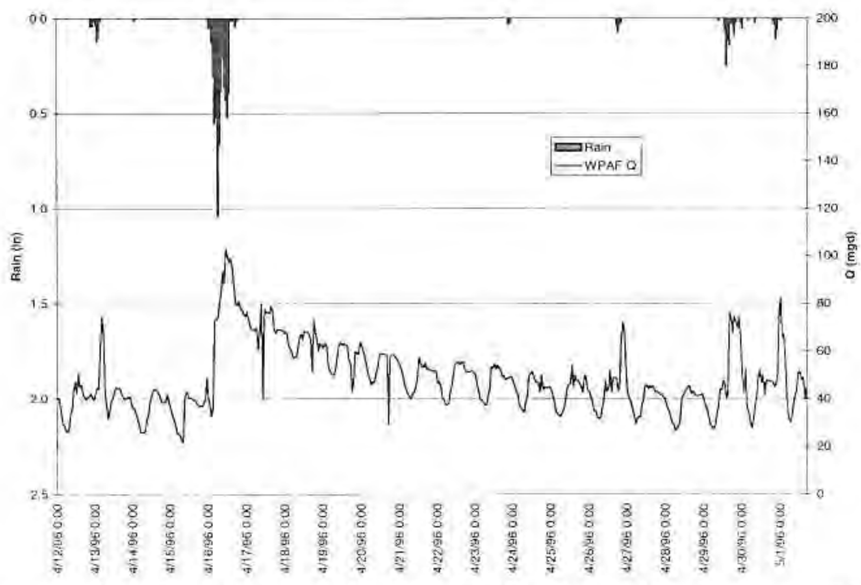



*Figure 64: WPAF hydrograph and rainfall hyetograph during storm S6.*

Review of meter data and model results for Storms S1 through S7 indicates that the model accurately simulates the peak rates and volumes of flow conveyed during the short term response. These results indicate that the model will finally support the evaluation of high rate treatment or conveyance technologies. The same data indicates significant differences in the long term response for storms of 3 inches or larger.

One potential impact of not modeling the lengthy response to larger storms is that pumpback from storage facilities could be impacted. Storage facilities are typically constructed to hold some or all of the flow that would otherwise be discharged as CSOs and then pump it to the WPAF for treatment after the storm has subsided. In reality, pumping from these facilities could be limited by a lack of capacity to accept flow at the treatment plant, while the model would suggest pumping could occur. However, as highlighted in the rainfall section, most of the events in a typical year are small and will be simulated satisfactorily by the model.

Figure 65 shows a comparison of the model results and metered flows at the WPAF during Storm S7. This graph shows the magnitude of the long-term response from the 3.01 inch storm which is not simulated by the model.

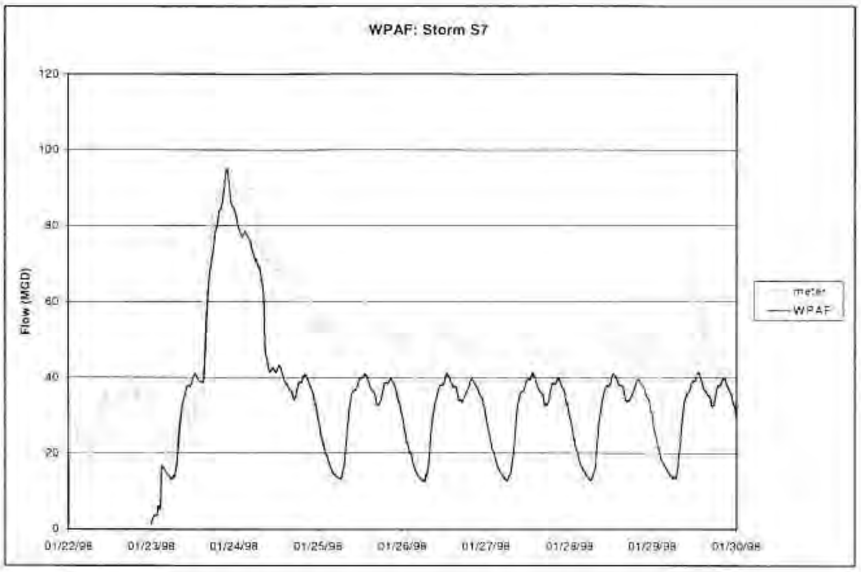



*Figure 65: Comparison of Modeled and Metered Flows at WPAF for Storm S7*

Figure 66 shows a comparison of the model results and metered flows at the Boulevard Pump Station during Storm S7. This graph confirms the model's simulation of peak flows and wet weather flow volumes for a storm which occurred in January 1998 - after the monitoring program was completed. This data could also be cited as evidence that one of the temporary or seasonal issues previously discussed may have restricted flows into the Boulevard system during the monitoring program.

Figure 67 shows a comparison of the model results and metered flows at the East Street Pump Station during Storm S7. This graph shows sustained pumping rates of 50 MGD and, when compared with other events, demonstrates the variability in this facility's operating procedures.

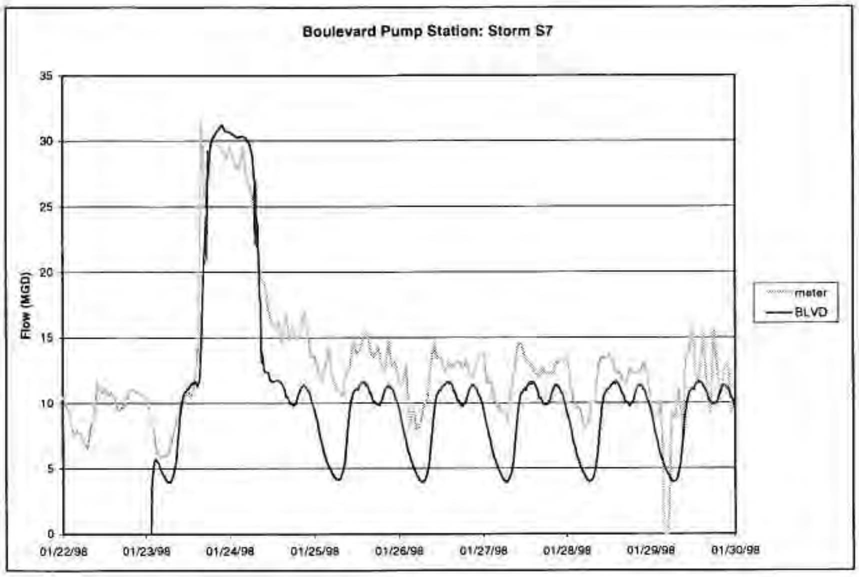



*Figure 66: Comparison of Modeled and Metered Flows at the Boulevard Pump Station for Storm S2*

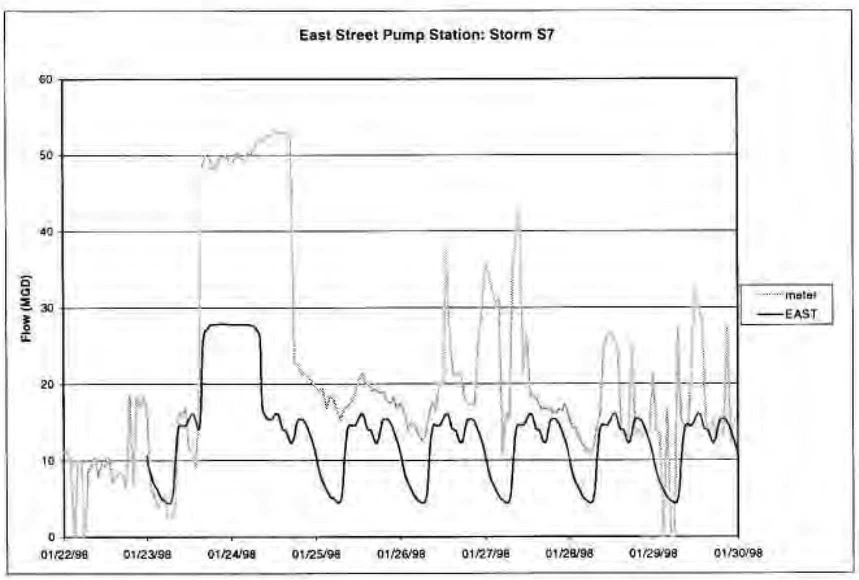



*Figure 67: Comparison of Modeled and Metered Flows at the East St Pump Station for Storm S2*

# Summary and Conclusions

The model development and calibration was completed in reference to several operational, performance, and planning objectives. These objectives were discussed at workshops and were documented in Technical Memorandum #2, *Database Design and System Modeling Approach*. These objectives have been simplified into five general categories as follows:

- computing overflow statistics (volume, frequency) and estimating associated pollutant loads under varying storm conditions,
- identifying system performance problems, such as surcharging, basement flooding, and sediment accumulation,
- estimating how short term controls may improve system performance, such as reducing wet weather surcharging, eliminating dry weather overflows, or maximizing conveyance to the East Shore WPAF,
- estimating the impacts of roof leader connections to the combined and partially separated sewer systems, and identifying a plan for managing roof leader connections and disconnections, and
- evaluating the potential impacts of long term controls on the reduction of overflows and pollutant loads to the receiving waters.

The initial model calibration activities focused on dry weather flows. The model's ability to simulate dry weather flows directly impacts goals related to: identifying system performance problems, sediment accumulation, and plans to disconnect roof leaders. As described in the model development section, the DWF model was created using a combination of flow monitoring data, water consumption data from the RWA, and recorded flows at the WPAF. Although the initial model input parameters from this procedure generally produced good results, four areas did not show good agreement. These areas include:

- the East Shore Pump Station,
- the temporary meter at NPDES Regulator 009 (James Street at Grand Avenue),
- the temporary meter at NPDES Regulator 010 (East Street at I-91), and
- the Boulevard Interceptor.

These areas were investigated and discussed at workshops with the WPCA. For the East Shore Pump Station and temporary meter at Regulator 009, specific reasons for the discrepancies were identified and the model or monitoring data were adjusted to resolve the differences. At the East Shore Pump Station, 4.1 MGD of recycled flows were subtracted from the meter data. The difference at Regulator 009 was resolved once the Welton Street Pump Station was added to the model. At Regulator 010 the differences have been attributed to the flow monitoring data. Within the Boulevard catchment the model's input parameters have been adjusted to reduce base sanitary flows by 18 percent relative to rates predicted with the initial data set. This is the only "calibration" made to the dry weather flow model. A broad range of potential causes for the differences between the measured and predicted flows have been identified in Table 25. Additional field work will be required to assess the relative contributions of each.

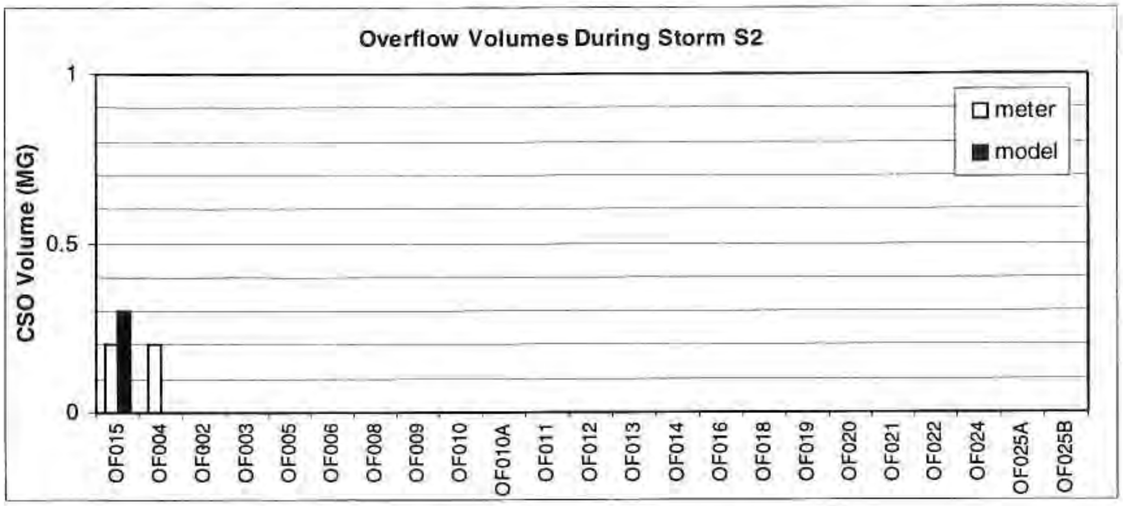
The final dry weather flow model appears to meet each of its initial objectives. The dry weather flow rates measured at 50 locations within the system are compared with flows predicted by the model in Figure 42. This figure shows good agreement between the measured and predicted flows on a system-wide basis. Hydrographs previously presented throughout the model development and calibration sections also indicate good agreement between the diurnal patterns measured in the field and predicted by the model. Both the minimum and peak rates needed for evaluations of scouring, sedimentation, and options for roof leaders are in agreement.

After the dry weather calibration was completed, the wet weather flow and hydraulic models were addressed. The model's ability to simulate the generation and conveyance of wet weather flows directly impacts goals related to: computing pollutant loads from combined sewer overflows, identifying system performance problems, evaluating the potential impacts of short-term control measures, and evaluating the potential impacts of long-term control measures.

As described in the model development section, the model was designed to address the wet weather impacts associated with separated, partially separated, and combined sewer catchments. A systematic approach using Areal Reduction Factors (ARFs) was used to address these conditions as they existed during the monitoring program and to support the evaluation of future sewer separation projects. Figure 49 demonstrates how the ARFs were used to reduce the "effective" area of each type of catchment. Hydrographs presented in the appendices demonstrate how the model matches flows for both large separated areas and combined areas.

The model's ability to predict the wet weather characteristics of the system was compared with three storms which occurred during the monitoring program. Detailed meter data including estimations of overflow volumes were available for these events. Data for Storm S1, the smallest storm, confirmed that the model will not over predict flows during the small and frequent events. No overflows were observed in the field and no overflows were predicted by the model. Significant wet weather flows were observed throughout the system during Storms S2 and S3, and, in general, the model appears to agree with the metered data. The total flows conveyed to the WPAF for these events are shown in Figures 53 and 58. Both of these figures show good agreement between the peak rates and volumes of flows recorded at the plant. The primary exception to the good results was noted along the Boulevard Interceptor. Figures 54 and 55 demonstrate inconsistencies in both the measured flows and the model results. As discussed in previous sections, several possible sources for the disagreement have been identified and additional field work may be required to assess the relative contribution of each.

Figure 68 compares the CSO volumes measured in the field and predicted by the model for Storms S2 and S3. These storms ranged from 0.58 to 2.10 inches. Although only a limited number of overflow sites were activated during these storms, data from the model generally agrees with the sites that did activate and the relative magnitude of the overflows at each site. Additional field data for a larger number of storms and storms with larger volumes and peak intensities would be useful to confirm the models' results. These data could be collected through additional monitoring efforts or through "block tests" as discussed at recent meetings.



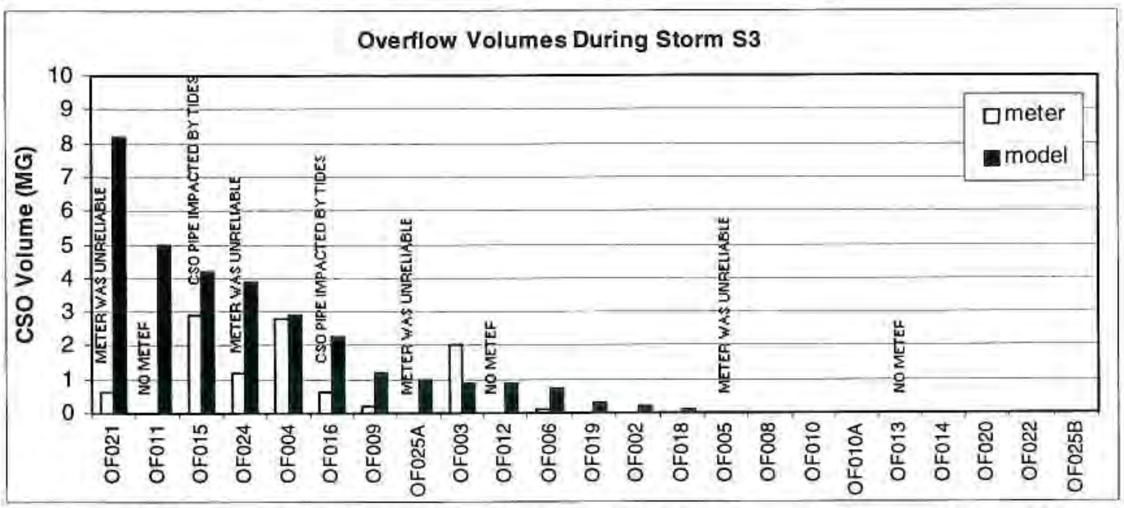




*Figure 68: Comparison of Modeled and Metered CSO Volumes for Storms S2, and S3*

The model was also used to simulate the system's wet weather characteristics for larger storms. These evaluations focused on the system's hydrologic and conveyance characteristics. No overflow data are available for these events. Storms S5, S6, and S7 represent events ranging from 3.01 to 5.64 inches. Model results for these storms continue to match the peak rates and volumes of flow conveyed through the system and to the WPAF. Results for Storm S7 are shown in Figures 65, 66 and 67. Figure 65 may also be cited as evidence that the temporary or seasonal issues discussed in Table 28 may have restricted flows within the Boulevard system during the monitoring program. The results for these events also demonstrated that the model does not simulate the long-term response observed in the system. This response is shown in Figure 64.

Based on the data and analyses presented within this report, it appears that the calibration of the model is adequate for its intended purposes. In general, the observed dry weather flows and model results are in good agreement. These results should fully support each of the project's dry weather flow objectives. In general, the observed wet weather flows and model results are also in good agreement. However, as modeling is an inexact science, this model should be used with knowledge and respect for its limitations as described throughout this report.

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# Verification (Addendum)

Technical Memorandum #3 was submitted in December of 1998. Upon review, it was decided that additional field data should be collected to verify the model's ability to accurately predict CSOs for large storm events. During the project's monitoring program in the fall of 1997, there were only a few large volume storms and none with large intensities. Although CSOs occurred during the period, the number of storms and range of storm sizes were not as extensive as necessary to define the overflow characteristics of all the sites. Many CSOs never activated during the period, and others activated only a small number of times. In order to more thoroughly validate the model, a block test program was initiated in April of 1999. Further, in order to more clearly define the current conditions within the Boulevard Interceptor and associated impacts on CSOs, a sediment survey was completed for portions of this conduit in September of 1999.

This chapter is issued as an addendum to the original document. It summarizes the block testing program, documents information received from the inspection of the Boulevard Interceptor, describes changes that were made to the model as a result of new data, compares metered and modeled data, and reviews the potential impacts from using the current model on the development of a long-term CSO control plan.

## Block-Testing Program

A block-testing program provides a simple way to gather information about the occurrence of CSOs. A block (or another similar indicator) is placed on the weir crest or in another appropriate location so that it is washed away when a CSO occurs. By inspecting the CSO regulators after each storm, a database that shows which storms caused CSOs can be built. After a period of time, the database will begin to show trends, and it will be easy to determine what size or intensity of storm will cause a CSO at a given regulator. The reliability of the individual observations will be reinforced as more and more data are collected. In addition, a block-testing program is a simple way of providing the compliance monitoring specified in the EPA's Nine Minimum Controls (which will be addressed as part of Task 5 of this project). Future data could be used to verify the model, to help determine what size storm will cause each regulator to overflow, and to show the improvements resulting from the application of short and long-term CSO controls.

Each CSO indicator used for this project employed a fishing float tied to a fishing line on a spool. The spool was held by a rod that was wedged in the manhole near the ground surface. The floats were weighted with small pieces of hardware to make it easier to maneuver them and to help keep them in place until the occurrence of a CSO. When possible, the float was placed on the weir crest. The proper location for each float was assessed for each site and installations were checked by CH2M HILL in the field. The installations, maintenance, and inspections were performed by the WPCA.

Figures V-1 and V-2 provide comparisons of the volumes and intensities, respectively, of rainfall events that occurred during the 1997 and 1999 monitoring periods. The events for a year with average rainfall statistics are shown, along with the size of storms in each of the monitoring periods. Storms S1, S2, and S3, from 1997, were used as calibration storms for TM#3 and are indicated in the figures. During the block-testing program, data were collected for one storm with a larger volume and 3 storms with equal or larger intensities than occurred in 1997.

Figure V-3 shows the block testing database that indicates the depth, intensity, and duration of each storm and whether a CSO occurred at each regulator. As with all the previous calibration work, a storm event was defined as one that was separated by at least six dry hours from other wet periods.

As with any data collection effort, uncertainty in the quality of the block testing data exists. It takes time for inspectors to learn what to look for, equipment failures can occur, and observations of the occurrence of a CSO can be complicated by the existence of tidal or storm-related inflows. In addition, the block testing occurred largely during a period of significant drought. Antecedent conditions for some storms were very dry, while for others they were wetter. A database is strengthened by having a large number of observations, so that outliers can easily be spotted. It is expected that there is a trigger rainfall depth and intensity above which CSOs will nearly always occur at a given site. Exceptions may occur for storms that are large in volume and small in intensity, or vice versa, but in general the database should indicate a trend for each site. Figures V-4 and V-5 show the block test database sorted by rainfall depth and intensity, respectively. Observations that are considered to be suspect data based on the failure to maintain a trend are indicated in the figures.

## Inspection of Boulevard Interceptor

Throughout the calibration period, the Boulevard sewershed has proved more difficult to calibrate than the rest of the system. After considerable review of meter data and model results, it was speculated that the current conditions in the interceptor might be significantly different from the as-built conditions used in the GIS and model construction. It was further speculated that these differences might have impacted CSO volumes and frequencies during the monitoring programs. Therefore, portions of the interceptor were inspected by a dive team in September of 1999.

The primary finding in the inspection was the presence of a significant sediment layer, which varied with depths up to 18 inches. Measurements were taken throughout the segments of pipe, providing information needed for including sediment in the model. In addition, a significant amount of debris that could be related to cave-ins that occurred in the summer of 1998 was found in the interceptor near the regulator at Derby Avenue. This debris partially blocks the local inflow from Derby Avenue as well as limiting the capacity of the interceptor. Several obstructions, including pipes, structural supports, and sediment, were also found in the vicinity of the regulator at Orange Avenue. Figure V-6 shows a plan view of the sewers in the area where the inspections occurred.

## Adjustments to Model

Based on the new data acquired and further investigation to resolve discrepancies between measured data and model results, some changes to the model were instituted. These changes included:

## East Shore Sewershed

- **The tide gate at the end of Poplar St (016) was modeled as partially open.** Modeling results did not match meter data very well, and it was hypothesized that the sewer system in this location was impacted by the tidal waters of the Quinnipiac River despite the presence of a tide gate. OMI inspected the tide gate and found it to be stuck partially open. Instead of the tide gate being modeled as a one-way valve as was done previously, it was modeled as an orifice that is smaller than the existing pipe (to simulate the head losses through the partial opening).

- **Changes were made to the way regulator 015 (James St Siphon) was modeled.** Because of the changes at 016 which allowed more tidal water to be in the 016 overflow pipe and simulated a greater head loss at the outfall, less water was overflowed at 016 and more flow was forced to stay in the interceptor system and be conveyed downstream. The orifice that passes flow to the James St Siphon, created by the presence of stop logs over most of the cross-section of the pipe influent to the siphon chamber, had previously been used to calibrate the model at 015. It was opened slightly so that more of the flow would be passed through the siphon instead of being overflowed at 015.

## East Street Sewershed

- **The proposed 42" pipe that runs parallel to Humphrey St between State St and East St was deleted from the model.** The pipe had been added to the model because it was thought the construction had already taken place. However, the project is due to be bid in late 1999, with construction beginning in the summer of 2000. After the pipe was deleted from the model, the overflow at Humphrey/I-91 (011) increased, and others downstream decreased because of the smaller amount of flow that reached the interceptor.

- **A cross-connection at East St/Ives Place was investigated and found to be open, so it was opened in the model.** Model results have indicated that this is a small-volume but active overflow.

- **Changes to the reported CSO volumes from the meter at 021 (East Street Pump Station) were made.** The meter at this site tended to blank out in the peak of overflows. As a result, CSO volumes calculated based on depth of flow over the weir were significantly underreported. Instead, the pump station flow measured by the WPCA was subtracted from the flow measurement taken by ADS upstream of the CSO diversion to arrive at the CSO flow, from which the CSO volume was calculated.

## Boulevard Sewershed

- **The sediment near regulator 006 (Whalley/Fitch) was reduced.** Previous modeling efforts had generalized the depths of sediment near this regulator. However, it appears to be quite sensitive to the depth of sediment, so a more accurate representation was created that allows for a more varied sediment layer.

- **Changes were made to the way regulator 005 (Blvd/Derby) was modeled.** The metering data from the monitoring program had significant data missing during the peaks of storms. Initially, it was thought that the overflows were quite small, and the regulator was modeled in a restrictive manner to limit the amount of overflow. ADS was asked during the verification effort for the raw data for this meter, and they provided the missing data. The new data indicated that overflows were larger in volume than originally thought. The modeling of the regulator was restored to its original dimensions, and was changed to more accurately simulate head losses. In addition, a partial blockage was modeled where the local inflow joins the interceptor because of the 16" sediment layer present in the interceptor.

- **Sediment was added to the Boulevard Interceptor, based on measurements taken in the diving inspection, from Derby Ave (005) downstream to the Boulevard Pump Station.** Previously, because it had been reported that the sediment layer was a transient problem, only a small portion of the interceptor near Orange Avenue (003) was modeled with sediment.
- **An additional constriction was added near regulator 003 (Orange Avenue) to account for head losses due to a pipe crossing the interceptor.**

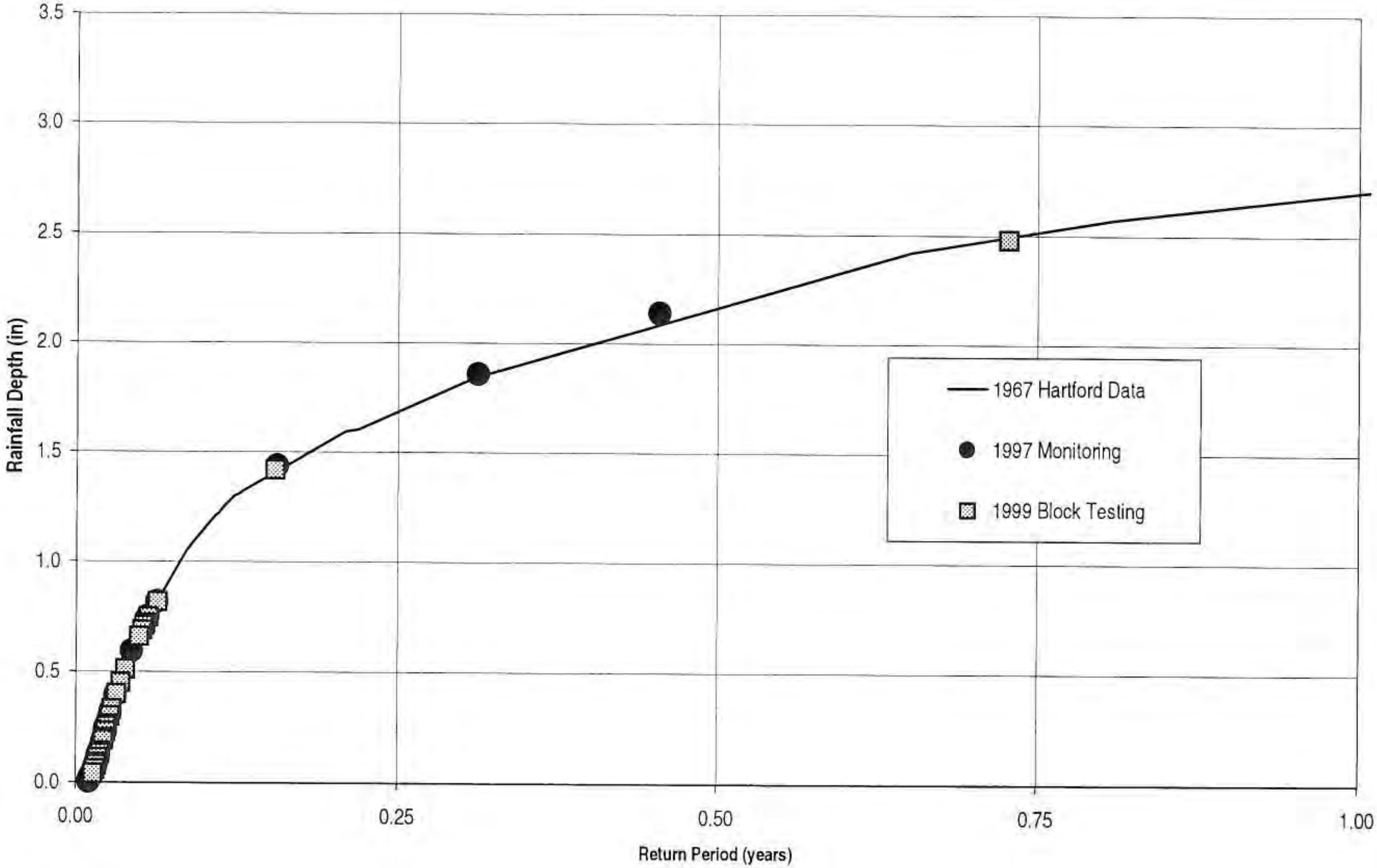
# Results

Because of the many differences between the regulators and the metering conditions at each site, the examination of the model and meter results will be presented on a site-by-site basis.[1] On each page, there is a brief description of observations and the impact of the current calibration status on the development of a CSO control plan. There are also two figures. The first is a graph showing the volumes observed or predicted by the meter/block or model. Where appropriate based on data availability and consistency, linear trends in the 1997 meter data are also graphed. In some cases, outliers were discarded from the dataset so that a trend could be developed. The second figure on each page is a table listing selected storm events from the calibration (1997) and verification (1999) periods with their volumes and intensities, sorted by volume. This table is colored to show agreement and disagreement between the model and meter or block. The following legend is employed:

- BOTH meter/block and model predict CSO
- NEITHER meter/block nor model predicts CSO
- CSO meter/block; NONE model
- NONE meter/block; CSO model
- UNKNOWN meter/block; CSO model
- UNKNOWN meter/block; NONE model

[1] No site sheet is given for site 022 (Allen Place). This site is essentially a stormwater pipe with a small sanitary connection that forces it to be classified as combined. Because the stormwater pipes are not modeled, the model indicates no overflow for the calibration and verification storms, while the meter/block indicates a CSO for nearly every storm. Improvements necessary to eliminate this overflow will be included in the project's Short-Term Control Plan.

## Figure V-1. Comparison of Rainfall Events by Volume

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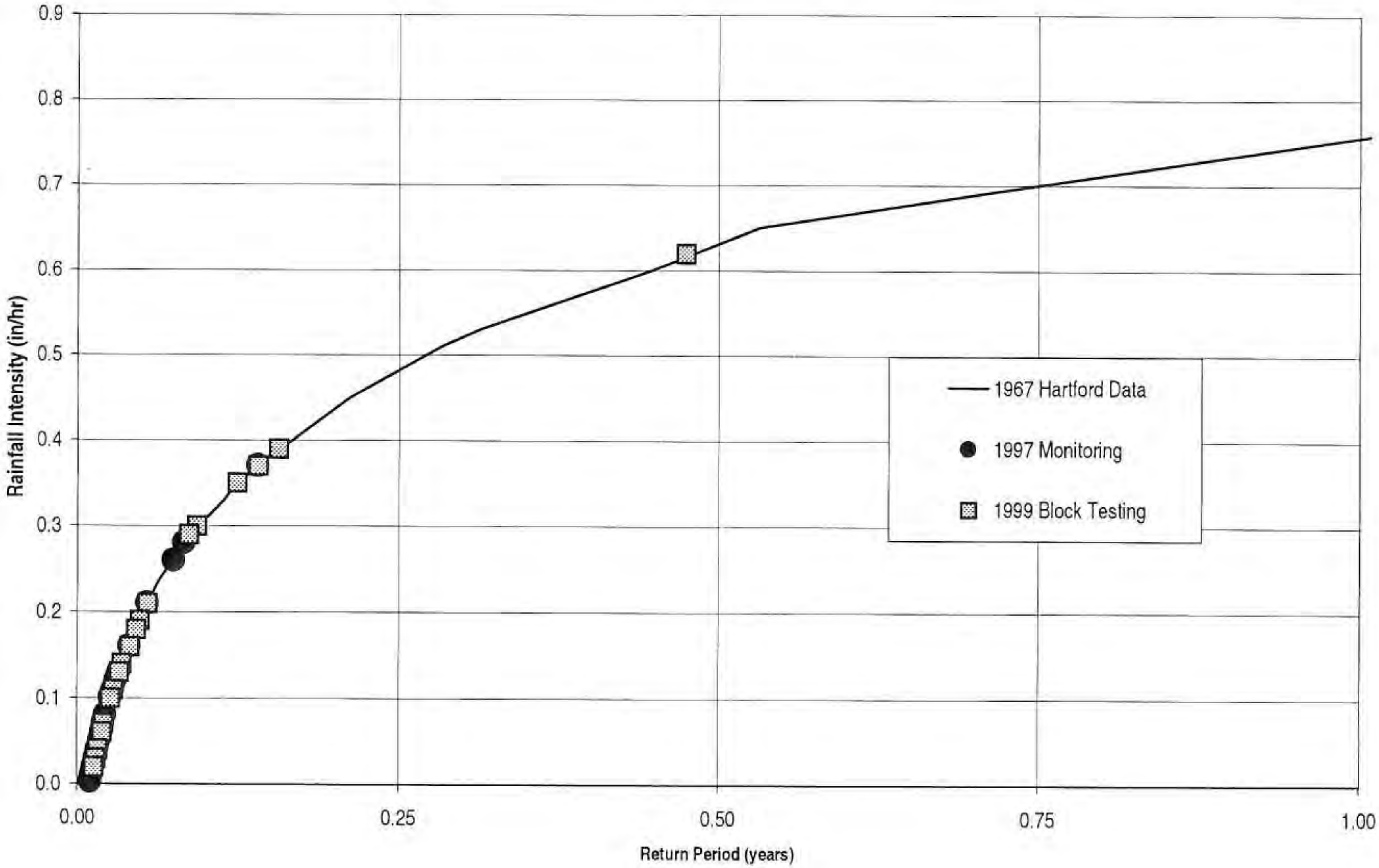
## Figure V-2. Comparison of Rainfall Events by Intensity




figures1-2.xls

# Figure V-3. CSO Block Test Database

| CSO # | Location | 04/09/99 | 04/11/99 | 04/16/99 | 04/20/99 | 04/23/99 | 05/03/99 | 05/08/99 | 05/08/99 | 05/18/99 | 05/19/99 | 05/23/99 | 05/24/99 | 07/01/99 | 07/02/99 | 07/13/99 | 07/19/99 | 07/25/99 | 08/08/99 | 08/11/99 | 08/14/99 | 08/14/99 | 08/20/99 | 08/26/99 | 08/27/99 | 09/07/99 | 09/08/99 | 09/10/99 | 09/15/99 | 09/21/99 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Total rainfall (in) | 0.40 | 0.23 | 0.26 | 0.04 | 0.51 | 0.20 | 0.04 | 0.07 | 0.14 | 0.71 | 0.72 | 0.69 | 0.66 | 0.25 | 0.09 | 0.13 | 0.06 | 0.51 | 0.45 | 0.26 | 0.82 | 0.30 | 0.75 | 0.19 | 0.08 | 0.33 | 1.42 | 2.48 | 0.33 |
| | Max Intensity (in/hr) | 0.14 | 0.11 | 0.16 | 0.02 | 0.14 | 0.06 | 0.03 | 0.04 | 0.06 | 0.29 | 0.19 | 0.30 | 0.62 | 0.19 | 0.03 | 0.13 | 0.06 | 0.35 | 0.16 | 0.18 | 0.62 | 0.11 | 0.21 | 0.16 | 0.07 | 0.14 | 0.37 | 0.39 | 0.10 |
| | Rainfall Duration (hr) | 9.5 | 6.0 | 10.5 | 2.5 | 7.0 | 24.5 | 2.0 | 13.0 | 5.5 | 18.0 | 12.0 | 5.0 | 1.5 | 7.5 | 6.0 | 1.0 | 0.5 | 2.0 | 11.5 | 4.5 | 9.0 | 6.0 | 7.5 | 5.0 | 1.5 | 4.5 | 15.0 | 36.0 | 10.5 |
| 002 | Blvd @ Lamberton | | | | | | | N | | Y | | | | | N | | N | N | N | N | Y | | Y | | | N | | N | Y | Y |
| 003 | Blvd @ Orange | Y | Y | Y | N | Y | Y | N | | Y | | Y | | Y | Y | Y | Y | Y | Y | N | Y | | Y | Y | | Y | | Y | Y | Y |
| 004 | Blvd @ Legion | Y | Y | Y | N | Y | N | N | | Y | | Y | | Y | Y | N | Y | Y | Y | N | Y | | Y | Y | | Y | | Y | Y | Y |
| 005 | Blvd @ Derby | Y | Y | Y | N | Y | Y | N | | Y | | Y | | Y | Y | Y | Y | Y | Y | Y | Y | | Y | | | Y | | Y | Y | Y |
| 006 | Whalley @ Fitch | | | | | | N | N | | Y | | Y | | N | N | N | Y | Y | N | N | Y | | N | N | | Y | | Y | Y | N |
| 008 | Munson @ Orchard | | | | | N | Y | N | | Y | | Y | | N | N | N | N | Y | Y | N | N | | N | Y | | Y | | N | N | N |
| 009 | Grand @ James | N | N | N | N | N | N | N | | Y | | N | | N | N | N | N | N | N | N | N | | N | N | | N | | N | Y | N |
| 010 | East St @ I-91 (upstream weir) | Y | N | N | N | N | N | N | | N | | N | | N | N | N | Y | N | Y | N | Y | | N | N | | N | | Y | Y | N |
| 010 | East St @ I-91 (downstream weir) | | | | | | | N | | N | | N | | N | N | N | N | N | N | N | Y | | N | | | N | | Y | Y | N |
| 011 | Humphrey @ I-91 | | | N | N | Y | Y | N | | Y | | Y | | | N | N | Y | Y | Y | N | Y | | Y | Y | | Y | | Y | Y | Y |
| 012 | Mitchell @ Nicoll | | N | Y | N | Y | Y | N | | N | | Y | | | N | N | Y | Y | Y | N | Y | | N | Y | | Y | | Y | Y | Y |
| 013 | Everit @ East Rock | N | N | N | N | N | N | N | | Y | | Y | | N | N | N | N | N | Y | N | N | | N | N | | N | | N | N | N |
| 014 | Trumbull @ Orange | | | | | Y | Y | N | | Y | | Y | | Y | N | N | N | N | Y | N | Y | | N | N | | Y | | Y | Y | Y |
| 015 | James St Siphon | Y | N | Y | N | Y | Y | N | | Y | | Y | | Y | N | N | Y | Y | Y | N | Y | | N | Y | | Y | | N | Y | Y |
| 016 | River @ Poplar | Y | N | Y | N | Y | Y | N | | Y | | Y | | Y | | N | | Y | Y | | Y | | | Y | | | | Y | Y | |
| 018 | Lombard @ Front | Y | N | Y | N | Y | Y | N | | Y | | Y | | Y | Y | Y | Y | Y | Y | Y | Y | | N | N | | N | | Y | Y | Y |
| 019 | Pine @ Front | | N | N | N | N | Y | N | | Y | | Y | | Y | Y | Y | Y | Y | Y | Y | Y | | Y | Y | | N | | Y | Y | Y |
| 020 | Quinnipiac @ Clifton | N | N | N | N | N | N | N | | N | | N | | N | N | N | N | N | N | N | N | | N | N | | N | | Y | Y | N |
| 021 | East St PS | | | | | | | N | | Y | | Y | | Y | N | N | N | Y | Y | Y | Y | | N | | | Y | | Y | Y | Y |
| 022 | Allen Place | | | | | Y | Y | Y | | Y | | Y | | | Y | Y | Y | Y | Y | Y | Y | | Y | Y | | Y | | Y | Y | Y |
| 024 | Boulevard PS | | | | | Y | N | N | | N | | Y | | | N | N | N | Y | Y | Y | Y | | N | Y | | Y | | Y | Y | N |
| 025 | Union PS | N | Y | Y | N | Y | N | N | | Y | | Y | | | Y | Y | Y | Y | Y | Y | Y | | N | N | | Y | | Y | Y | Y |
| N/A | George @ Temple | | | | | N | N | N | | Y | | Y | | Y | N | N | Y | Y | Y | Y | Y | | Y | Y | | Y | | Y | Y | Y |
| N/A | East @ Ives | | | | | | | | | | | | | | | | | | | | N | | N | N | | N | | N | Y | N |

* Note: blocks were not checked between some of the storms, so results in combined columns are for both storms.

| | |
|---|---|
| Y | Block had been moved from its preset location (probably indicating a CSO occurred) |
| N | Block had NOT been moved from its preset location (no CSO) |
| | No data |

## Figure V-4. Block Test Data Sorted By Storm Volume

| CSO # | Location | 04/20/99 | 05/08/99 | 07/25/99 | 05/08/99 | 09/07/99 | 07/13/99 | 07/19/99 | 05/18/99 | 08/27/99 | 05/03/99 | 04/11/99 | 07/02/99 | 04/16/99 | 08/14/99 | 08/20/99 | 09/08/99 | 09/21/99 | 04/09/99 | 08/11/99 | 04/23/99 | 08/08/99 | 07/01/99 | 05/24/99 | 05/19/99 | 05/23/99 | 08/26/99 | 08/14/99 | 09/10/99 | 09/15/99 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Total rainfall (in) | 0.04 | 0.04 | 0.06 | 0.07 | 0.08 | 0.09 | 0.13 | 0.14 | 0.19 | 0.20 | 0.23 | 0.25 | 0.26 | 0.26 | 0.30 | 0.33 | 0.33 | 0.40 | 0.45 | 0.51 | 0.51 | 0.66 | 0.69 | 0.71 | 0.72 | 0.75 | 0.82 | 1.42 | 2.48 |
| | Max Intensity (in/hr) | 0.02 | 0.03 | 0.06 | 0.04 | 0.07 | 0.03 | 0.13 | 0.06 | 0.16 | 0.06 | 0.11 | 0.19 | 0.16 | 0.18 | 0.11 | 0.14 | 0.10 | 0.14 | 0.16 | 0.14 | 0.35 | 0.62 | 0.30 | 0.29 | 0.19 | 0.21 | 0.62 | 0.37 | 0.39 |
| | Rainfall Duration (hr) | 2.5 | 2.0 | 0.5 | 13.0 | 1.5 | 6.0 | 1.0 | 5.5 | 5.0 | 24.5 | 6.0 | 7.5 | 10.5 | 4.5 | 6.0 | 4.5 | 10.5 | 9.5 | 11.5 | 7.0 | 2.0 | 1.5 | 5.0 | 18.0 | 12.0 | 7.5 | 9.0 | 15.0 | 36.0 |
| 002 | Blvd @ Lamberton | | * | N | N | * | | N | * | * | | | N | | * | Y | N | Y | | N | | N | | | Y | * | | Y | N | Y |
| 003 | Blvd @ Orange | N | * | Y | N | * | Y | Y | * | * | Y | Y | Y | Y | * | Y | Y | Y | Y | N | Y | Y | Y | Y | Y | * | Y | Y | Y | Y |
| 004 | Blvd @ Legion | N | * | Y | N | * | N | Y | * | * | N | Y | Y | Y | * | Y | Y | Y | Y | N | Y | Y | Y | Y | Y | * | Y | Y | Y | Y |
| 005 | Blvd @ Derby | N | * | Y | N | * | Y | Y | * | * | Y | Y | Y | Y | * | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | * | | Y | Y | Y |
| 006 | Whalley @ Fitch | | * | Y | N | * | N | Y | * | * | N | | N | | * | N | Y | N | | N | | N | N | Y | Y | * | N | Y | Y | Y |
| 008 | Munson @ Orchard | | * | Y | N | * | N | N | * | * | Y | | N | | * | N | Y | N | | N | N | Y | N | Y | Y | * | Y | N | N | N |
| 009 | Grand @ James | N | * | N | N | * | N | N | * | * | N | N | N | N | * | N | N | N | N | N | N | N | N | N | Y | * | N | N | N | Y |
| 010 | East St @ I-91 (u/s) | N | * | N | N | * | N | Y | * | * | N | N | N | N | * | N | N | N | Y | N | N | Y | N | N | N | * | N | Y | Y | Y |
| 010 | East St @ I-91 (d/s) | | * | N | N | * | N | N | * | * | | | N | | * | N | N | N | | N | | N | N | N | N | * | | Y | Y | Y |
| 011 | Humphrey @ I-91 | N | * | Y | N | * | N | Y | * | * | Y | | N | N | * | Y | Y | Y | | N | Y | Y | | Y | Y | * | Y | Y | Y | Y |
| 012 | Mitchell @ Nicoll | N | * | Y | N | * | N | Y | * | * | Y | N | N | Y | * | N | Y | Y | | N | Y | Y | | Y | N | * | Y | Y | Y | Y |
| 013 | Everit @ East Rock | N | * | N | N | * | N | N | * | * | N | N | N | N | * | N | N | N | N | N | N | Y | N | Y | Y | * | N | N | N | N |
| 014 | Trumbull @ Orange | | * | N | N | * | N | N | * | * | Y | | N | | * | N | Y | Y | | N | Y | Y | Y | Y | Y | * | N | Y | Y | Y |
| 015 | James St Siphon | N | * | Y | N | * | N | Y | * | * | Y | N | N | Y | * | N | Y | Y | Y | N | Y | Y | Y | Y | Y | * | Y | Y | N | Y |
| 016 | River @ Poplar | N | * | Y | N | * | N | | * | * | Y | N | | Y | * | | | | Y | | Y | Y | Y | Y | Y | * | Y | Y | Y | Y |
| 018 | Lombard @ Front | N | * | Y | N | * | Y | Y | * | * | Y | N | Y | Y | * | N | N | Y | Y | Y | Y | Y | Y | Y | Y | * | N | Y | Y | Y |
| 019 | Pine @ Front | N | * | Y | N | * | Y | Y | * | * | Y | N | Y | N | * | Y | N | Y | | Y | N | Y | Y | Y | Y | * | Y | Y | Y | Y |
| 020 | Quinnipiac @ Clifton | N | * | N | N | * | N | N | * | * | N | N | N | N | * | N | N | N | N | N | N | N | N | N | N | * | N | N | Y | Y |
| 021 | East St PS | | * | Y | N | * | N | N | * | * | | | N | | * | N | Y | Y | | Y | | Y | Y | Y | Y | * | | Y | Y | Y |
| 022 | Allen Place | | * | Y | Y | * | Y | Y | * | * | Y | | Y | | * | Y | Y | Y | | Y | Y | Y | | Y | Y | * | Y | Y | Y | Y |
| 024 | Boulevard PS | | * | Y | N | * | N | N | * | * | N | | N | | * | N | Y | N | | Y | Y | Y | | Y | N | * | Y | Y | Y | Y |
| 025 | Union PS | N | * | Y | N | * | Y | Y | * | * | N | Y | Y | Y | * | N | Y | Y | N | Y | Y | Y | | Y | Y | * | N | Y | Y | Y |
| N/A | George @ Temple | | * | Y | N | * | N | Y | * | * | N | | N | | * | Y | Y | Y | | Y | N | Y | Y | Y | Y | * | Y | Y | Y | Y |
| N/A | East @ Ives | | | | | * | | | | * | | | | | * | N | N | N | | | | | | | | | N | N | N | Y |

| | |
|---|---|
| Y | CSO occurred |
| N | No CSO occurred |
| N | Suspicious data |
| | No data |
| * | Inspection included more than one storm, results are reported for the most likely case |

## Figure V-5. Block Test Data Sorted By Peak Storm Intensity

| CSO # | Location | 04/20/99 | 05/08/99 | 07/13/99 | 05/08/99 | 05/03/99 | 05/18/99 | 07/25/99 | 09/07/99 | 09/21/99 | 04/11/99 | 08/20/99 | 07/19/99 | 04/09/99 | 04/23/99 | 09/08/99 | 04/16/99 | 08/11/99 | 08/27/99 | 08/14/99 | 05/23/99 | 07/02/99 | 08/26/99 | 05/19/99 | 05/24/99 | 08/08/99 | 09/10/99 | 09/15/99 | 07/01/99 | 08/14/99 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Total rainfall (in) | 0.04 | 0.04 | 0.09 | 0.07 | 0.20 | 0.14 | 0.06 | 0.08 | 0.33 | 0.23 | 0.30 | 0.13 | 0.40 | 0.51 | 0.33 | 0.26 | 0.45 | 0.19 | 0.26 | 0.72 | 0.25 | 0.75 | 0.71 | 0.69 | 0.51 | 1.42 | 2.48 | 0.66 | 0.82 |
| | Max Intensity (in/hr) | 0.02 | 0.03 | 0.03 | 0.04 | 0.06 | 0.06 | 0.06 | 0.07 | 0.10 | 0.11 | 0.11 | 0.13 | 0.14 | 0.14 | 0.14 | 0.16 | 0.16 | 0.16 | 0.18 | 0.19 | 0.19 | 0.21 | 0.29 | 0.30 | 0.35 | 0.37 | 0.39 | 0.62 | 0.62 |
| | Rainfall Duration (hr) | 2.5 | 2.0 | 6.0 | 13.0 | 24.5 | 5.5 | 0.5 | 1.5 | 10.5 | 6.0 | 6.0 | 1.0 | 9.5 | 7.0 | 4.5 | 10.5 | 11.5 | 5.0 | 4.5 | 12.0 | 7.5 | 7.5 | 18.0 | 5.0 | 2.0 | 15.0 | 36.0 | 1.5 | 9.0 |
| 002 | Blvd @ Lamberton | | * | | N | | * | N | * | Y | | Y | N | | | N | | N | * | * | * | N | | Y | | N | N | Y | | Y |
| 003 | Blvd @ Orange | N | * | Y | N | Y | * | Y | * | Y | Y | Y | Y | Y | Y | Y | Y | N | * | * | * | Y | Y | Y | Y | Y | Y | Y | Y | Y |
| 004 | Blvd @ Legion | N | * | N | N | N | * | Y | * | Y | Y | Y | Y | Y | Y | Y | Y | N | * | * | * | Y | Y | Y | Y | Y | Y | Y | Y | Y |
| 005 | Blvd @ Derby | N | * | Y | N | Y | * | Y | * | Y | Y | Y | Y | Y | Y | Y | Y | Y | * | * | * | Y | | Y | Y | Y | Y | Y | Y | Y |
| 006 | Whalley @ Fitch | | * | N | N | N | * | Y | * | N | | N | Y | | | Y | | N | * | * | * | N | N | Y | Y | N | Y | Y | N | Y |
| 008 | Munson @ Orchard | | * | N | N | Y | * | Y | * | N | | N | N | | N | Y | | N | * | * | * | N | Y | Y | Y | Y | N | N | N | N |
| 009 | Grand @ James | N | * | N | N | N | * | N | * | N | N | N | N | N | N | N | N | N | * | * | * | N | N | Y | N | N | N | Y | N | N |
| 010 | East St @ I-91 (u/s) | N | * | N | N | N | * | N | * | N | N | N | Y | Y | N | N | N | N | * | * | * | N | N | N | N | Y | Y | Y | N | Y |
| 010 | East St @ I-91 (d/s) | | * | N | N | | * | N | * | N | | N | N | | | N | | N | * | * | * | N | | N | N | N | Y | Y | N | Y |
| 011 | Humphrey @ I-91 | N | * | N | N | Y | * | Y | * | Y | | Y | Y | | Y | Y | N | N | * | * | * | N | Y | Y | Y | Y | Y | Y | | Y |
| 012 | Mitchell @ Nicoll | N | * | N | N | Y | * | Y | * | Y | N | N | Y | | Y | Y | Y | N | * | * | * | N | Y | N | Y | Y | Y | Y | | Y |
| 013 | Everit @ East Rock | N | * | N | N | N | * | N | * | N | N | N | N | N | N | N | N | N | * | * | * | N | N | Y | Y | Y | N | N | N | N |
| 014 | Trumbull @ Orange | | * | N | N | Y | * | N | * | Y | | N | N | | Y | Y | | N | * | * | * | N | N | Y | Y | Y | Y | Y | Y | Y |
| 015 | James St Siphon | N | * | N | N | Y | * | Y | * | Y | N | N | Y | Y | Y | Y | Y | N | * | * | * | N | Y | Y | Y | Y | N | Y | Y | Y |
| 016 | River @ Poplar | N | * | N | N | Y | * | Y | * | | N | | | Y | Y | | Y | | * | * | * | | Y | Y | Y | Y | Y | Y | Y | Y |
| 018 | Lombard @ Front | N | * | Y | N | Y | * | Y | * | Y | N | N | Y | Y | Y | N | Y | Y | * | * | * | Y | N | Y | Y | Y | Y | Y | Y | Y |
| 019 | Pine @ Front | N | * | Y | N | Y | * | Y | * | Y | N | Y | Y | | N | N | N | Y | * | * | * | Y | Y | Y | Y | Y | Y | Y | Y | Y |
| 020 | Quinnipiac @ Clifton | N | * | N | N | N | * | N | * | N | N | N | N | N | N | N | N | N | * | * | * | N | N | N | N | N | Y | Y | N | N |
| 021 | East St PS | | * | N | N | | * | Y | * | Y | | N | N | | | Y | | Y | * | * | * | N | | Y | Y | Y | Y | Y | Y | Y |
| 022 | Allen Place | | * | Y | Y | Y | * | Y | * | Y | | Y | Y | | Y | Y | | Y | * | * | * | Y | Y | Y | Y | Y | Y | Y | | Y |
| 024 | Boulevard PS | | * | N | N | N | * | Y | * | N | | N | N | | Y | Y | | Y | * | * | * | N | Y | N | Y | Y | Y | Y | | Y |
| 025 | Union PS | N | * | Y | N | N | * | Y | * | Y | Y | N | Y | N | Y | Y | Y | Y | * | * | * | Y | N | Y | Y | Y | Y | Y | | Y |
| N/A | George @ Temple | | * | N | N | N | * | Y | * | Y | | Y | Y | | N | Y | | Y | * | * | * | N | Y | Y | Y | Y | Y | Y | Y | Y |
| N/A | East @ Ives | | | | | | | | * | N | | N | | | | N | | | * | * | | | N | | | | N | Y | | N |

| | |
|---|---|
| Y | CSO occurred |
| N | No CSO occurred |
| N (highlighted) | Suspicious data |
| | No data |
| * | Inspection included more than one storm; results are reported for the most likely case |

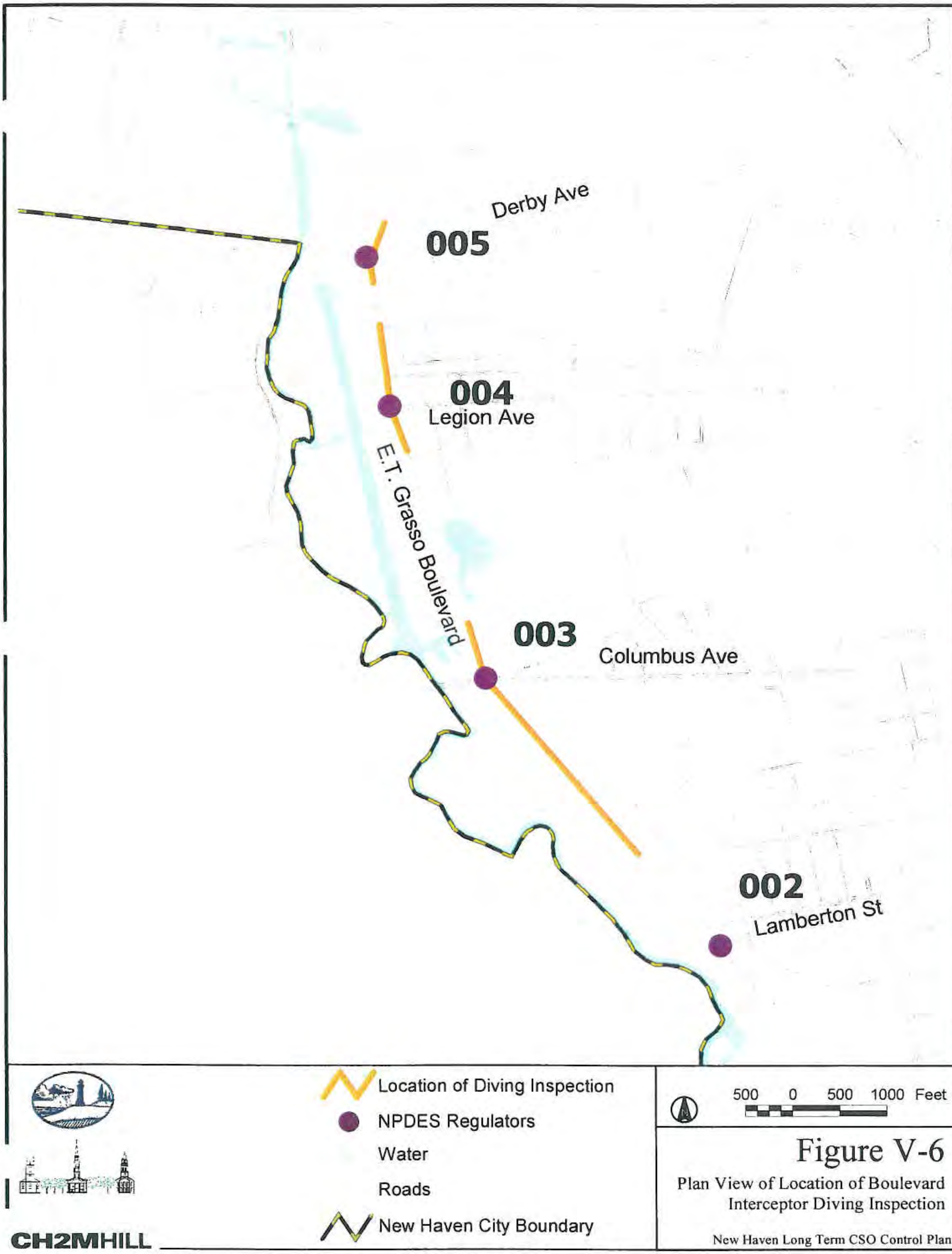



Figure V-6

Plan View of Location of Boulevard Interceptor Diving Inspection

New Haven Long Term CSO Control Plan

# 002 - E.T. Grasso Blvd at Lamberton

## Observations

* CSOs are small in volume and infrequent.
* The condition of the outfall pipe is unknown. If this CSO is blocked in the field, the meter would reflect it but the model would not, because it is modeled as an open regulator.
* A bar rack at the Boulevard Pump Station was broken during one of the storms used for calibration. The resulting backwater affected regulators 024, 002, and 003.
* The model agrees with the meter/block for 75% of the 12 storms that were simulated.

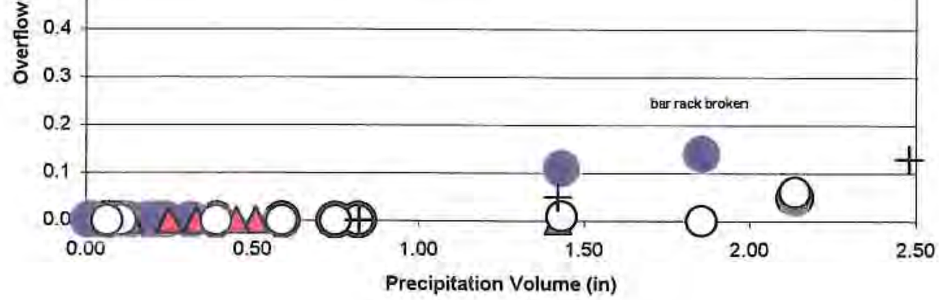
| Storm Date | Vol (in) | Pk Int (in/hr) |
|---|---|---|
| 09/15/99 | 2.48 | 0.39 |
| 11/08/97 | 2.14 | 0.37 |
| 10/31/97 | 1.86 | 0.28 |
| 10/26/97 | 1.43 | 0.26 |
| 09/10/99 | 1.42 | 0.37 |
| 08/14/99 | 0.82 | 0.62 |
| 10/24/97 | 0.82 | 0.12 |
| 11/21/97 | 0.75 | 0.16 |
| 09/28/97 | 0.59 | 0.21 |
| 11/15/97 | 0.39 | 0.11 |
| 11/02/97 | 0.11 | 0.06 |
| 11/13/97 | 0.07 | 0.04 |

## Need for Further Investigation

Verify condition of overflow. Is it partially or fully blocked or is it able to overflow?

## Impact on CSO Control Plan

* If this outfall is currently blocked, it could potentially be eliminated under the Short-Term Control Plan.
* This CSO may be indirectly affected by part of the Kimberly/Columbus separation project that will be included in the baseline model, as the Boulevard Interceptor downstream of Lamberton will gain wet-weather conveyance capacity by the removal of some storm-induced inflow.



# 003 - E.T. Grasso Blvd at Orange Ave

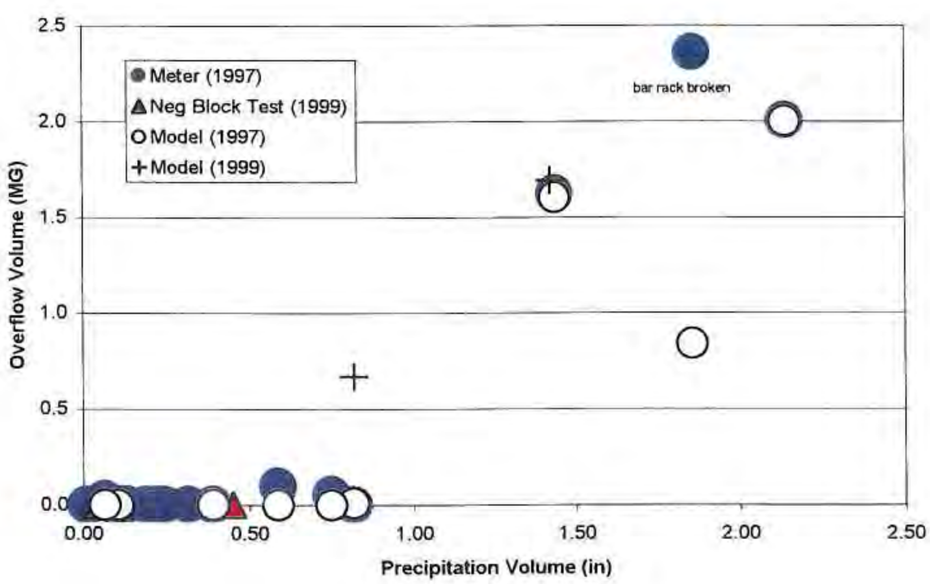
## Observations

* CSOs are large in volume.
* The interceptor near this regulator is modeled with 12" or more of sediment and a constricted cross-section due to a pipe crossing the interceptor.
* A bar rack at the Boulevard Pump Station was broken during one of the storms used for calibration. The resulting backwater affected regulators 024, 002, and 003.
* The model agrees with the meter/block for 83% of the 12 storms that were simulated.

| Storm Date | Vol (in) | Pk Int (in/hr) |
|---|---|---|
| 09/16/99 | 2.48 | 0.38 |
| 11/08/97 | 2.14 | 0.37 |
| 10/31/97 | 1.86 | 0.28 |
| 10/26/97 | 1.43 | 0.26 |
| 09/10/99 | 1.42 | 0.37 |
| 08/14/99 | 0.82 | 0.62 |
| 10/24/97 | 0.82 | 0.12 |
| 11/21/97 | 0.75 | 0.16 |
| 09/28/97 | 0.58 | 0.21 |
| 11/15/97 | 0.39 | 0.11 |
| 11/02/97 | 0.11 | 0.06 |
| 11/13/97 | 0.07 | 0.04 |

## Impact on CSO Control Plan

* The accuracy of the calibration at this site is good and will support development of the LTCP.
* The Long-Term Control Plan (LTCP) may need to address slow velocities and associated sedimentation problems.



# 004 - E.T. Grasso Blvd at Legion Ave

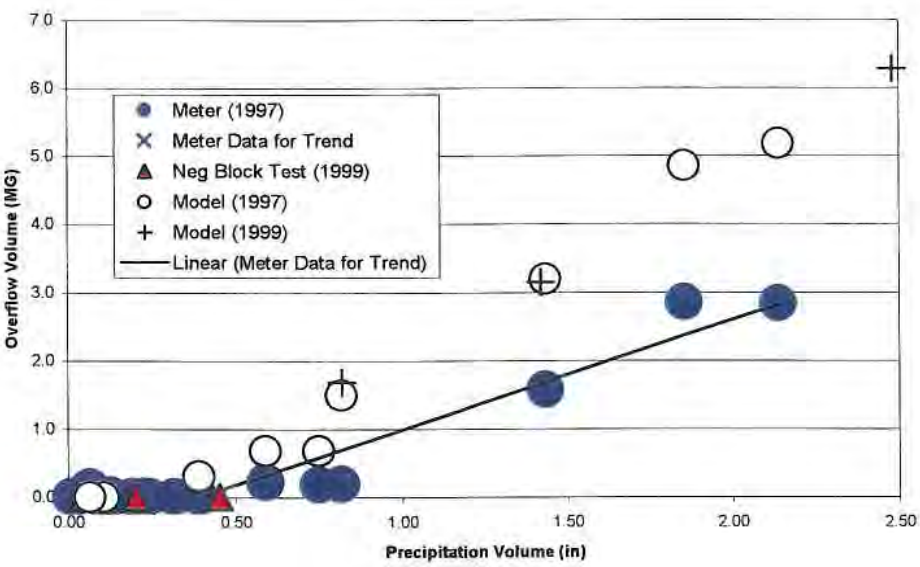
| Storm Date | Vol (in) | Pk Int (in/hr) |
|---|---|---|
| 09/15/99 | 2.48 | 0.39 |
| 11/08/97 | 2.14 | 0.37 |
| 10/31/97 | 1.86 | 0.28 |
| 10/26/97 | 1.43 | 0.26 |
| 08/10/99 | 1.42 | 0.37 |
| 08/14/99 | 0.82 | 0.62 |
| 10/24/97 | 0.82 | 0.12 |
| 11/21/97 | 0.75 | 0.15 |
| 09/28/97 | 0.58 | 0.21 |
| 11/15/97 | 0.39 | 0.11 |
| 11/02/97 | 0.11 | 0.06 |
| 11/13/97 | 0.07 | 0.04 |

## Observations

* CSOs are large in volume.
* The model and meter/block show strong agreement.
* The two lower weirs were raised to the level of the highest weir to address a dry-weather overflow in early 1998, between the two monitoring programs.
* The velocities at this site are higher than those at 002 and 003 and provide some degree of scouring in wet-weather.
* A test model run was made to determine how sensitive this regulator is to the sediment layer in the interceptor. By decreasing the amount of sediment downstream of the regulator, the simulated overflows at regulator 004 decreased, but the flow was conveyed downstream to regulator 003, where it then overflowed.
* The model agrees with the meter/block for 83% of the 12 storms that were simulated.

## Impact on CSO Control Plan

The model's overprediction of overflow volumes in large storms could impact facility sizing during development of the Long-Term Control Plan, if storage facilities are considered a viable option for addressing this overflow.



# 005 - E.T. Grasso Blvd at Derby Ave

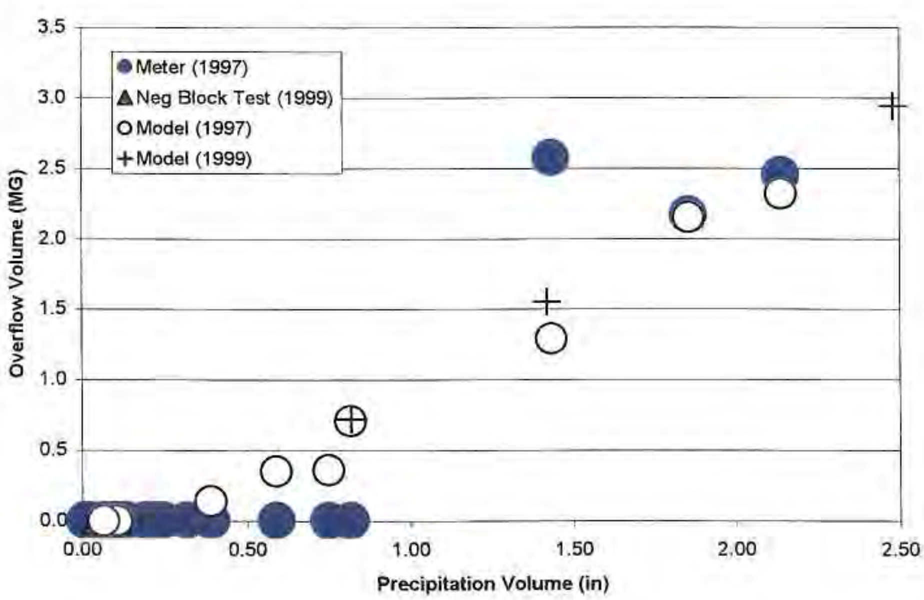
## Observations

| Storm Date | Vol (in) | Pk Int (in/hr) |
|---|---|---|
| 09/15/99 | 2.48 | 0.39 |
| 11/08/97 | 2.14 | 0.37 |
| 10/31/97 | 1.86 | 0.28 |
| 10/26/97 | 1.43 | 0.26 |
| 09/10/99 | 1.42 | 0.37 |
| 08/14/99 | 0.82 | 0.62 |
| 10/24/97 | 0.82 | 0.12 |
| 11/21/97 | 0.75 | 0.16 |
| 09/28/97 | 0.59 | 0.21 |
| 11/15/97 | 0.39 | 0.11 |
| 11/02/97 | 0.11 | 0.06 |
| 11/13/97 | 0.07 | 0.04 |

* CSO volumes are large.
* Metered flows indicate a large volume that is not supported by the model for one calibration storm. There may have been an unusual occurrence during the storm, such as a blockage, that was not a common condition for this site.
* Two collapses occurred in sewers upstream of this regulator during the summer of 1998. In the fall of 1999, an inspection of the interceptor indicated that a significant amount of deposited material (approximately 16") was present in the interceptor near the local inflow connection. The model includes the sediment layer and the resulting partial blockage of the local inflow connection.
* The model tends to overpredict CSO volumes associated with smaller storms.
* The model agrees with the meter/block for 67% of the 12 storms that were simulated.

## Impact on CSO Control Plan

The model's tendency to overpredict volumes for smaller storms should not impact storage facility sizing since facilities will likely be designed to accommodate larger storms. The accuracy of the model calibration for large storms appears good for development of a Long-Term Control Plan.



# 006 - Whalley Ave at Fitch St

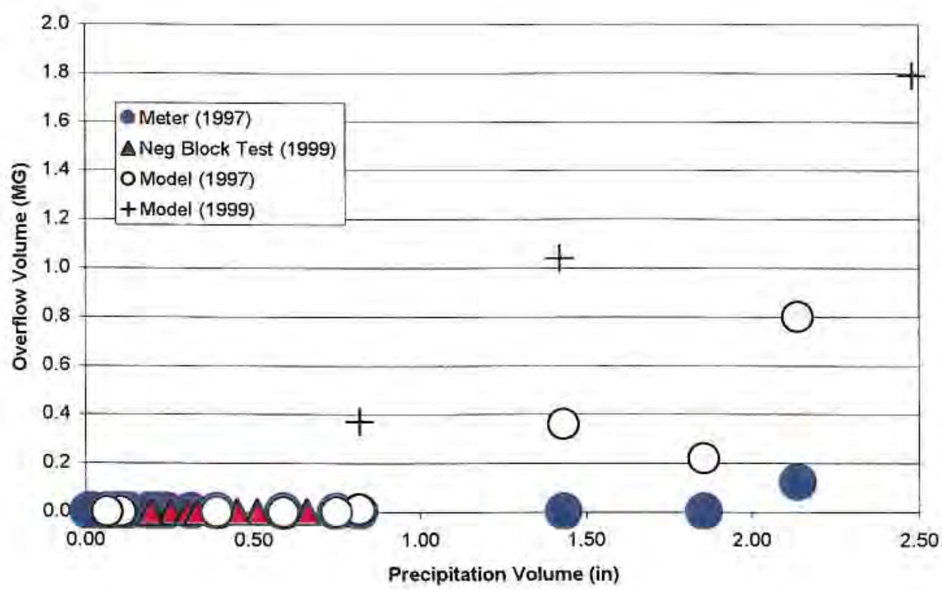
## Observations

* CSOs are relatively small in volume.
* There is backwater from the Boulevard Interceptor that overflows at 006 during wet weather.
* Most of the catchment upstream of this site is already separated.
* There is a significant amount of sediment in the interceptor near this regulator.
* The model tends to overpredict the frequency and volume of CSOs.
* There appear to be different trends in the modeled CSO volumes for calibration (1997) and verification (1999) storms. All of the verification storms had intensities greater than or equal to the maximum intensity of any of the calibration storms. It is possible that the behavior of this regulator is better correlated with rainfall intensity than with rainfall volume.
* The model agrees with the meter/block for 75% of the 12 storms that were simulated.

| Storm Date | Vol (in) | Pk Int (in/hr) |
|---|---|---|
| 09/15/99 | 2.48 | 0.39 |
| 11/08/97 | 2.11 | 0.37 |
| 10/31/97 | 1.86 | 0.28 |
| 10/26/97 | 1.43 | 0.26 |
| 09/10/99 | 1.42 | 0.37 |
| 06/14/99 | 0.82 | 0.62 |
| 10/24/97 | 0.82 | 0.12 |
| 11/21/97 | 0.75 | 0.16 |
| 09/28/97 | 0.59 | 0.21 |
| 11/15/97 | 0.39 | 0.11 |
| 11/02/97 | 0.11 | 0.06 |
| 11/13/97 | 0.07 | 0.04 |

## Impact on CSO Control Plan

The model's overprediction of overflow volumes and frequencies could impact facility sizing during development of the Long-Term Control Plan, if storage facilities are considered a viable option for addressing this overflow.



# 008 - Munson at Orchard

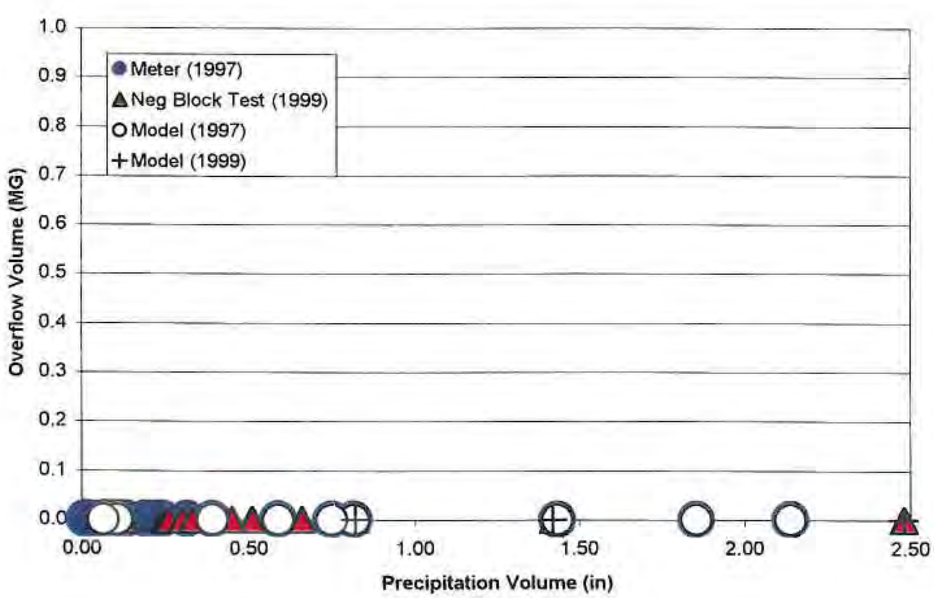
## Observations

* The area tributary to this CSO has been separated.
* The overflow will relieve the combined sewer before it becomes surcharged.
* The model agrees with the meter/block for 100% of the 12 storms that were simulated.

| Storm Date | Vol (in) | Pk Int (in/hr) |
|---|---|---|
| 09/15/99 | 2.48 | 0.39 |
| 11/08/97 | 2.14 | 0.37 |
| 10/31/97 | 1.86 | 0.28 |
| 10/26/97 | 1.43 | 0.26 |
| 09/10/99 | 1.42 | 0.37 |
| 08/14/99 | 0.82 | 0.62 |
| 10/24/97 | 0.82 | 0.12 |
| 11/21/97 | 0.75 | 0.16 |
| 09/28/97 | 0.59 | 0.21 |
| 11/15/97 | 0.39 | 0.11 |
| 11/02/97 | 0.11 | 0.06 |
| 11/13/97 | 0.07 | 0.04 |

## Impact on CSO Control Plan

The LTCP may have to address this regulator since it is not physically blocked, as it may overflow in extreme storm conditions. It is possible that the physical elimination of this overflow could be achieved under the Short-Term Control Plan.



# 009 - James St at Grand Ave

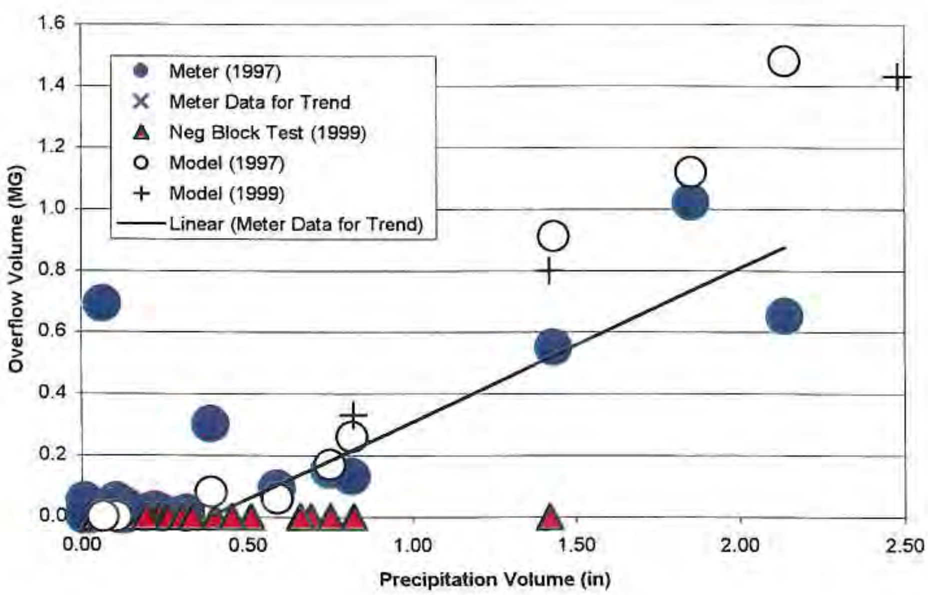
## Observations

* The model and meter/block agree that this site has frequent overflows.
* Overflows occur even for small storms.
* The model overpredicts the volume of CSOs for some larger storms.
* The weir was raised in early 1998 to stop a dry-weather overflow.
* The model agrees with the meter/block for 75% of the 12 storms that were simulated.

## Impact on CSO Control Plan

The accuracy of the model calibration at this site is sufficient for the needs of the LTCP development.

| Storm Date | Vol (in) | Pk Int (in/hr) |
|---|---|---|
| 09/15/99 | 2.48 | 0.39 |
| 11/08/97 | 2.14 | 0.37 |
| 10/31/97 | 1.86 | 0.28 |
| 10/26/97 | 1.43 | 0.26 |
| 09/10/99 | 1.42 | 0.37 |
| 08/14/99 | 0.82 | 0.62 |
| 10/24/97 | 0.82 | 0.12 |
| 11/21/97 | 0.75 | 0.16 |
| 09/28/97 | 0.59 | 0.21 |
| 11/15/97 | 0.39 | 0.11 |
| 11/02/97 | 0.11 | 0.06 |
| 11/13/97 | 0.07 | 0.04 |



# 010 - East St at I-91 (upstream weir)

## Observations

* The model and meter predicted no overflows during the metering period.
* Several block tests have indicated the occurrence of CSOs for storms for which the model predicts no CSO. Given the inconsistency with meter data and model predictions, it is possible that these observations were "false positives" that indicated overflows when none occurred. It is also possible that field conditions changed between the 1997 and 1999 monitoring periods. No sediment is modeled at this site for either period; 4"-6" of sediment would likely be sufficient to cause one or more overflows in the model.
* The model agrees with the meter/block for 75% of the 12 storms that were simulated.

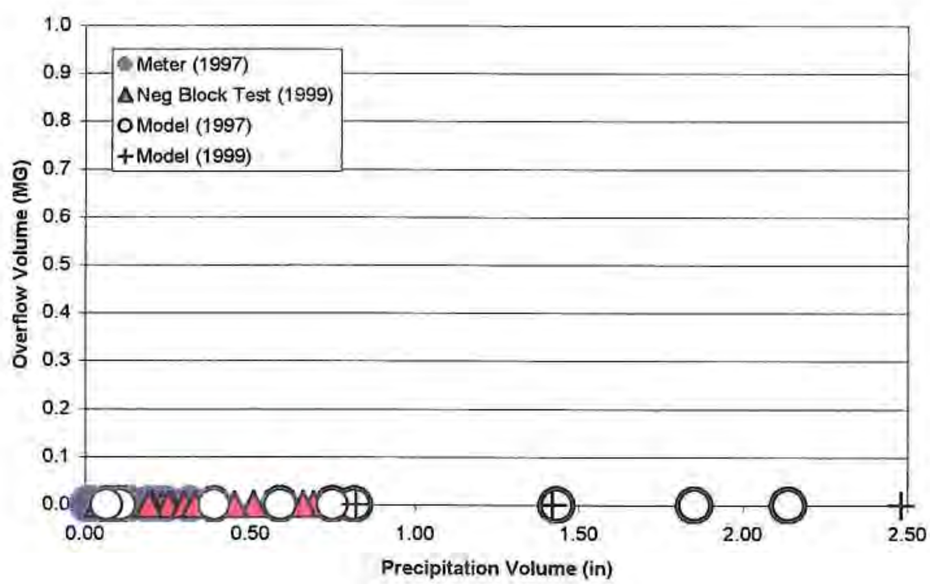
| Storm Date | Vol (in) | Pk Int (in/hr) |
|---|---|---|
| 09/15/99 | 2.48 | 0.39 |
| 11/08/97 | 2.14 | 0.37 |
| 10/31/97 | 1.86 | 0.28 |
| 10/26/97 | 1.43 | 0.26 |
| 09/10/99 | 1.42 | 0.37 |
| 08/14/99 | 0.82 | 0.62 |
| 10/24/97 | 0.82 | 0.12 |
| 11/21/97 | 0.75 | 0.16 |
| 09/28/97 | 0.59 | 0.21 |
| 11/15/97 | 0.39 | 0.11 |
| 11/02/97 | 0.11 | 0.06 |
| 11/13/97 | 0.07 | 0.04 |

## Need for Further Investigation

Inspect the interceptor to assess whether field conditions might promote overflows.

## Impact on CSO Control Plan

The possibility of blocking either this weir or its downstream neighbor should be considered for the Short-Term Control Plan. In addition, the possibility that future sewer separation work (baseline conditions) could be avoided if the flow levels in this sewer have already been sufficiently lowered to prevent CSOs should be investigated.



# 010 - East St at I-91 (downstream weir)

## Observations

* This weir is approximately 8 feet downstream and 8 inches lower than the upstream weir at this site. Therefore, this weir will overflow first.
* The model agrees with the meter/block for 83% of the 12 storms that were simulated.

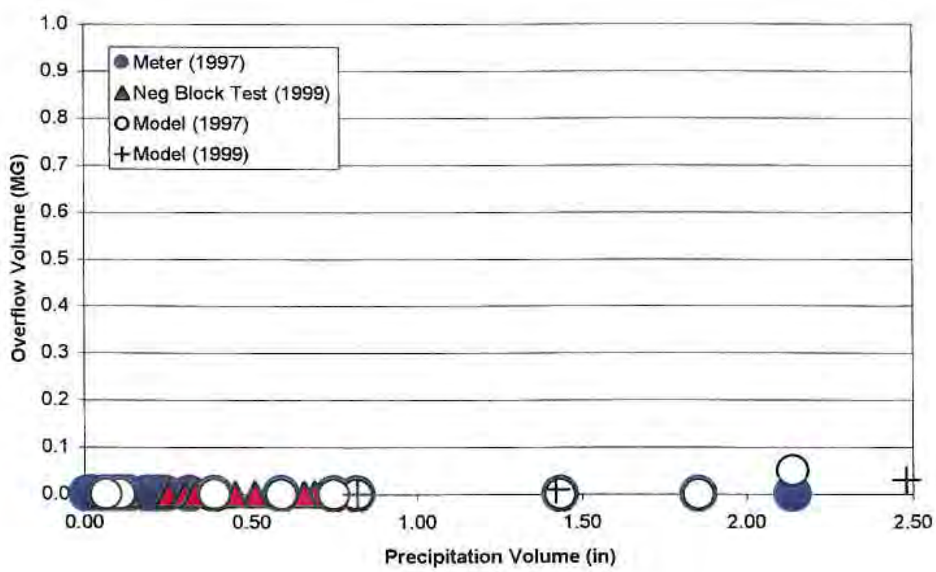
| Storm Date | Vol (in) | Pk Int (in/hr) |
|---|---|---|
| 09/16/99 | 2.48 | 0.39 |
| 11/08/97 | 2.14 | 0.37 |
| 10/31/97 | 1.86 | 0.28 |
| 10/26/97 | 1.43 | 0.26 |
| 09/10/99 | 1.42 | 0.37 |
| 08/14/99 | 0.82 | 0.62 |
| 10/24/97 | 0.82 | 0.12 |
| 11/21/97 | 0.75 | 0.16 |
| 09/28/97 | 0.59 | 0.21 |
| 11/15/97 | 0.39 | 0.11 |
| 11/02/97 | 0.11 | 0.06 |
| 11/13/97 | 0.07 | 0.04 |

## Need for Further Investigation

Inspect the interceptor to assess whether field conditions might promote overflows.

## Impact on CSO Control Plan

The possibility of blocking either this weir or its upstream neighbor should be considered for the Short-Term Control Plan. In addition, the possibility that future sewer separation work (baseline conditions) could be avoided if the flow levels in this sewer have already been sufficiently lowered to prevent CSOs should be investigated.



# 011 - Humphrey St at I-91

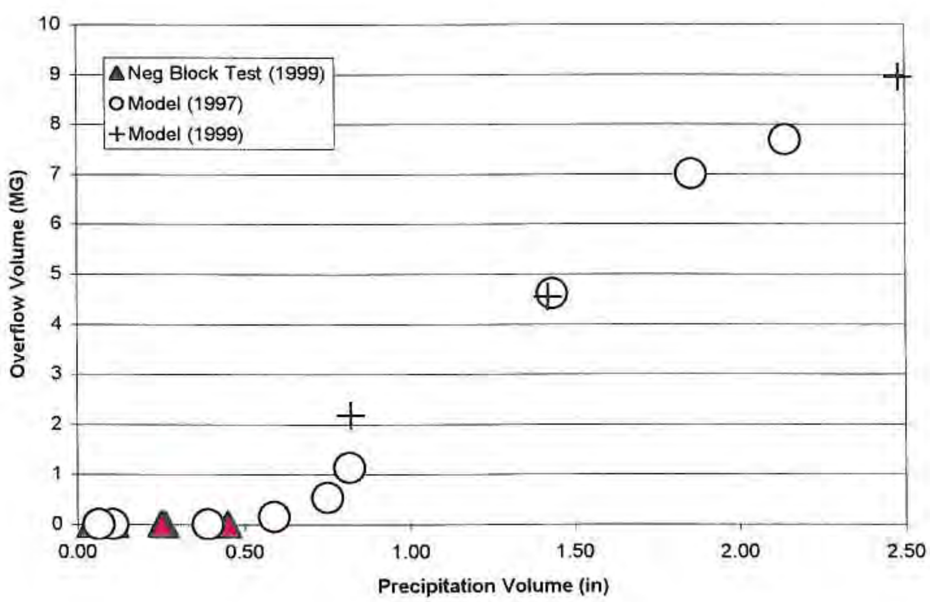
## Observations

* Due to significant future impacts at this site from planned sewer separation projects, no meter was installed during the monitoring program.
* The model shows this regulator to have some of the largest volume CSOs in the system.
* The model agrees with the block for 100% of the 3 verification storms that were simulated.

## Impact on CSO Control Plan

This CSO will be addressed by sewer separation (baseline conditions).

| Storm Date | Vol (in) | Pk Int (in/hr) |
|---|---|---|
| 09/15/99 | 2.48 | 0.39 |
| 11/08/97 | 2.14 | 0.37 |
| 10/31/97 | 1.86 | 0.29 |
| 10/25/97 | 1.41 | 0.95 |
| 09/10/99 | 1.42 | 0.37 |
| 09/14/99 | 0.82 | 0.62 |
| 10/24/97 | 0.82 | 0.17 |
| 11/21/97 | 0.75 | 0.11 |
| 09/28/97 | 0.59 | 0.21 |
| 11/15/97 | 0.39 | 0.11 |
| 11/02/97 | 0.11 | 0.06 |
| 11/13/97 | 0.07 | 0.04 |



# 012 - Mitchell Dr east of Nicoll

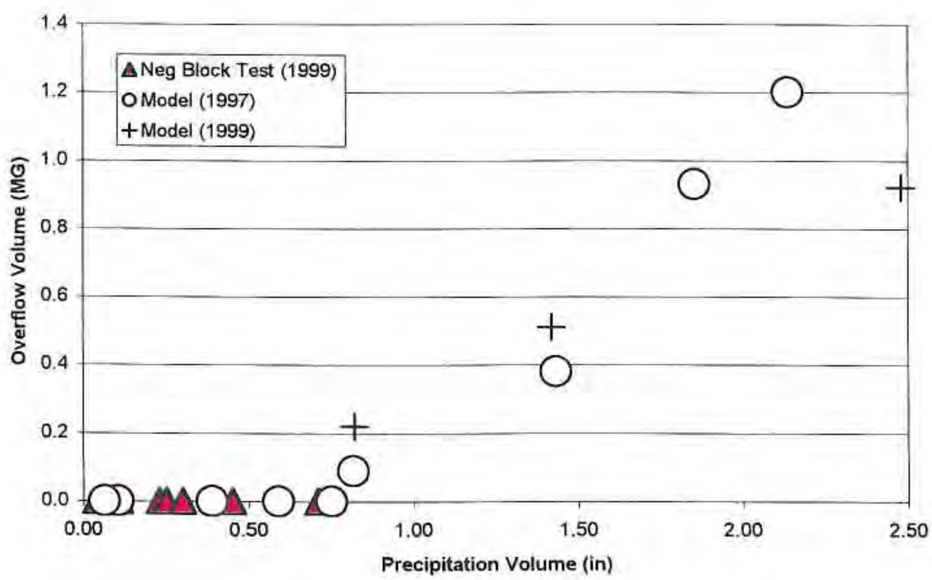
## Observations

* Due to significant future impacts at this site from planned sewer separation projects, no meter was installed during the monitoring program.
* The model indicates that CSO volumes are relatively small.
* The model agrees with the block for 100% of the 3 verification storms that were simulated.

| Storm Date | Vol (in) | Pk Int (in/hr) |
|---|---|---|
| 09/15/99 | 2.48 | 0.39 |
| 11/08/97 | 2.14 | 0.37 |
| 10/31/97 | 1.86 | 0.28 |
| 10/25/97 | 1.43 | 0.26 |
| 09/10/99 | 1.42 | 0.37 |
| 08/14/99 | 0.82 | 0.62 |
| 10/24/97 | 0.83 | 0.13 |
| 11/21/97 | 0.75 | 0.16 |
| 09/28/97 | 0.59 | 0.21 |
| 11/15/97 | 0.39 | 0.11 |
| 11/02/97 | 0.11 | 0.06 |
| 11/13/97 | 0.07 | 0.04 |

## Impact on CSO Control Plan

This CSO will be addressed by sewer separation (baseline conditions).



# 013 - East Rock Rd

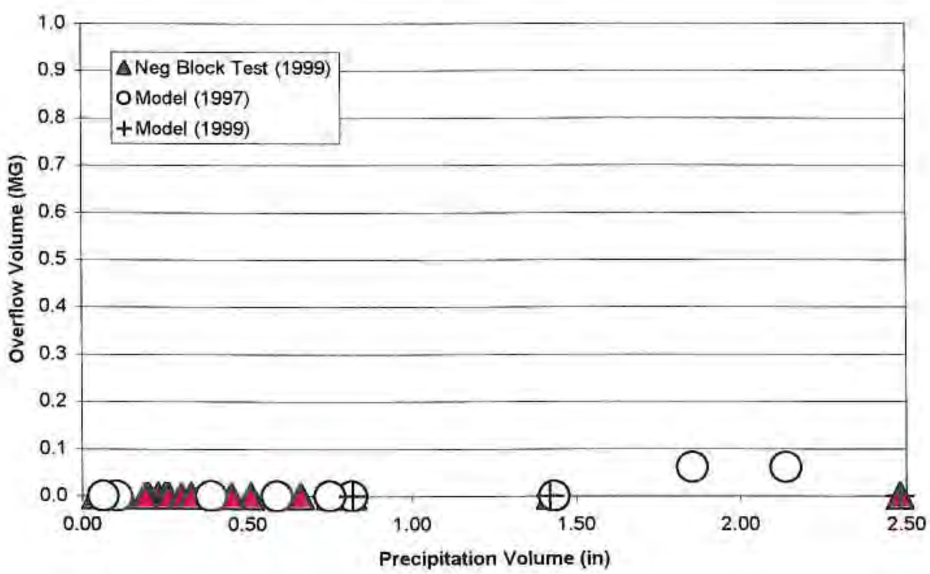
## Observations

* Due to significant future impacts at this site from planned sewer separation projects, no meter was installed during the monitoring program.
* The model indicates that this is not a very active CSO.
* The weir was raised 6" in early 1998 to stop dry-weather overflows that occurred during the morning peak flow hours.
* The Livingston Phase I Sewer Separation Project was completed between the 1997 and 1999 monitoring periods.
* The model agrees with the meter/block for 100% of the 3 verification storms that were simulated.

| Storm Date | Vol (in) | Pk Int (in/hr) |
|---|---|---|
| 09/15/99 | 2.48 | 0.39 |
| [illegible] | [illegible] | [illegible] |
| [illegible] | [illegible] | [illegible] |
| [illegible] | [illegible] | [illegible] |
| 09/10/99 | 1.42 | 0.37 |
| 08/14/99 | 0.82 | 0.62 |
| 10/24/97 | 0.82 | 0.12 |
| 11/21/97 | 0.75 | 0.16 |
| 09/28/97 | 0.59 | 0.21 |
| 11/15/97 | 0.39 | 0.11 |
| 11/02/97 | 0.11 | 0.06 |
| 11/13/97 | 0.07 | 0.04 |

## Impact on CSO Control Plan

* This CSO will be addressed by sewer separation (baseline conditions).



# 014 - Trumbull St at Orange St

## Observations

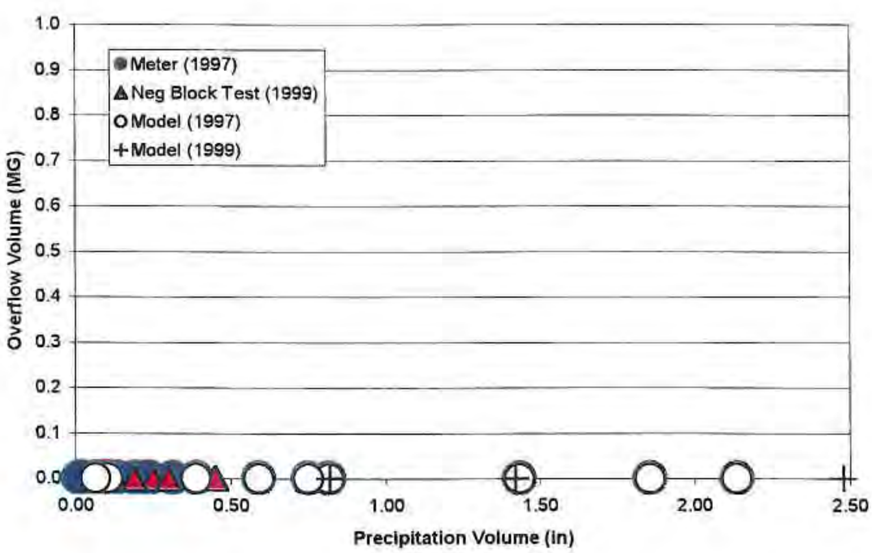
* The meter and model agree that there were no overflows during the 1997 monitoring period.
* There were a number of block tests that seemed to indicate overflows. However, because flow from the storm sewer can flow back over the weir into the combined sewer, these observations are believed to be false positives.
* The model agrees with the meter/block for 75% of the 12 storms that were simulated.

| Storm Date | Vol (in) | Pk Int (in/hr) | |
|---|---|---|---|
| 09/15/99 | 2.48 | 0.39 | * |
| 11/08/97 | 2.14 | 0.37 | |
| 10/31/97 | 1.86 | 0.28 | |
| 10/26/97 | 1.43 | 0.26 | |
| 09/10/99 | 1.42 | 0.37 | * |
| 08/14/99 | 0.82 | 0.62 | * |
| 10/24/97 | 0.82 | 0.12 | |
| 11/21/97 | 0.75 | 0.16 | |
| 09/28/97 | 0.59 | 0.21 | |
| 11/15/97 | 0.39 | 0.11 | |
| 11/02/97 | 0.11 | 0.06 | |
| 11/13/97 | 0.07 | 0.04 | |

* Suspected to be a false positive

## Impact on CSO Control Plan

The possibility of blocking this weir should be considered for the Short-Term Control Plan. In addition, the possibility that future sewer separation work (baseline conditions) could be avoided if the flow levels in this sewer have already been sufficiently lowered to prevent CSOs should be investigated.



# 015 - James St Siphon

## Observations

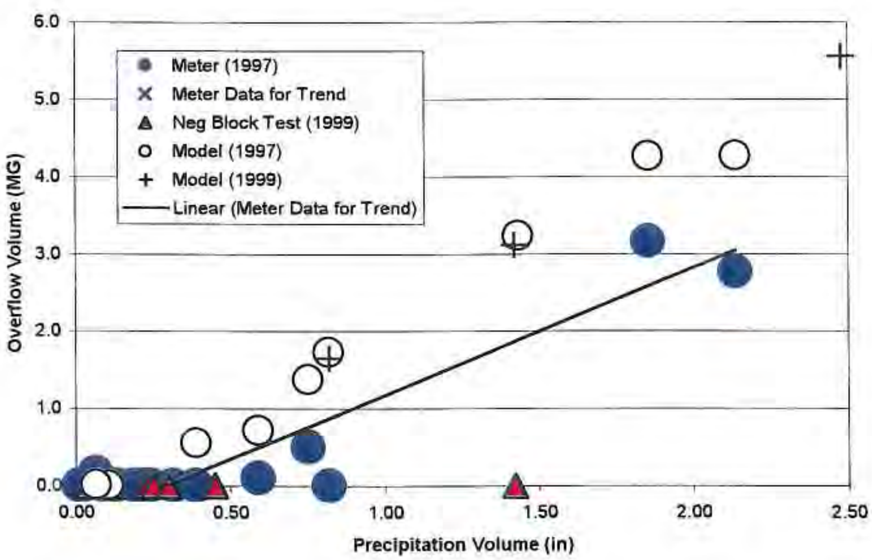
* CSOs are large in volume and occur frequently.
* Overflows occur even for small storms.
* The model indicates that the site begins to overflow at a smaller depth of rainfall than the meter and block suggest.
* A negative block test logged on 9/10/99 is inconsistent with the previously observed behavior of this regulator (metered and modeled) and is believed to be a false negative.
* A bar rack leading to the siphon broke during October of 1997, causing a significant backup. The meter data for a storm during this period is therefore not provided.
* The model agrees with the meter/block for 70% of the 10 storms simulated for which data were available.

| Storm Date | Vol (in) | Pk Int (in/hr) | |
|---|---|---|---|
| 09/15/99 | 2.48 | 0.39 | |
| 11/08/97 | 2.14 | 0.37 | |
| 10/31/97 | 1.86 | 0.28 | |
| [illegible] | 1.43 | 0.25 | |
| 09/10/99 | 1.42 | 0.37 | * |
| 08/14/99 | 0.82 | 0.62 | |
| [illegible] | [illegible] | 0.12 | |
| 11/21/97 | 0.75 | 0.16 | |
| 09/28/97 | 0.69 | 0.21 | |
| 11/15/97 | 0.39 | 0.11 | |
| 11/02/97 | 0.11 | 0.06 | |
| 11/13/97 | 0.07 | 0.04 | |

* Suspected to be a false negative

## Impact on CSO Control Plan

The model's overprediction of overflow volumes could impact facility sizing during development of the Long-Term Control Plan, if storage facilities are considered a viable option for addressing this overflow.



# 016 - River St at Poplar St

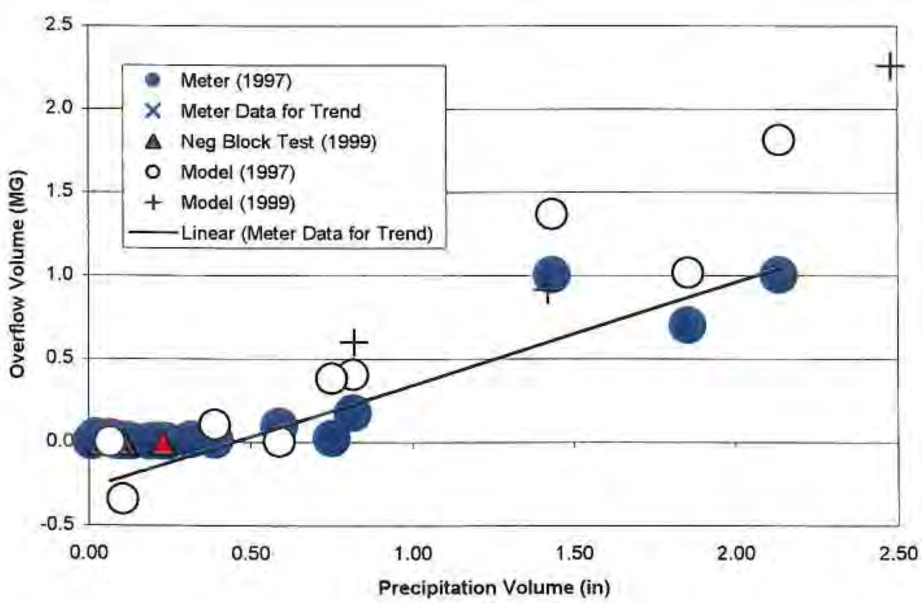
## Observations

* CSOs are large in volume and occur frequently.
* The meter was significantly influenced by the tide on a daily basis.
* Based on field observations, the tide gate was modeled as blocked partially open.
* During some storms, the amount of inflow is enough to offset the overflow for a CSO event, resulting in a net inflow (negative volume in the chart below).
* The model and meter/block show strong agreement for rainfall depths of 0.39 inches and above.
* The model overpredicts the CSO volume in larger storms.
* The model agrees with the meter/block for 83% of the 12 storms that were simulated.

| Storm Date | Vol (in) | Pk Int (in/hr) |
|---|---|---|
| 09/15/99 | 2.48 | 0.39 |
| 11/08/97 | 2.14 | 0.37 |
| 10/31/97 | 1.86 | 0.28 |
| 10/26/97 | 1.43 | 0.26 |
| 09/10/99 | 1.42 | 0.37 |
| 08/14/99 | 0.82 | 0.62 |
| 10/24/97 | 0.82 | 0.12 |
| 11/21/97 | 0.75 | 0.16 |
| 09/28/97 | 0.59 | 0.21 |
| 11/15/97 | 0.39 | 0.11 |
| 11/02/97 | 0.11 | 0.06 |
| 11/13/97 | 0.07 | 0.04 |

## Impact on CSO Control Plan

The model's overprediction of overflow volumes could impact facility sizing during development of the Long-Term Control Plan, if storage facilities are considered a viable option for addressing this overflow.



# 018 - Lombard St near Front St

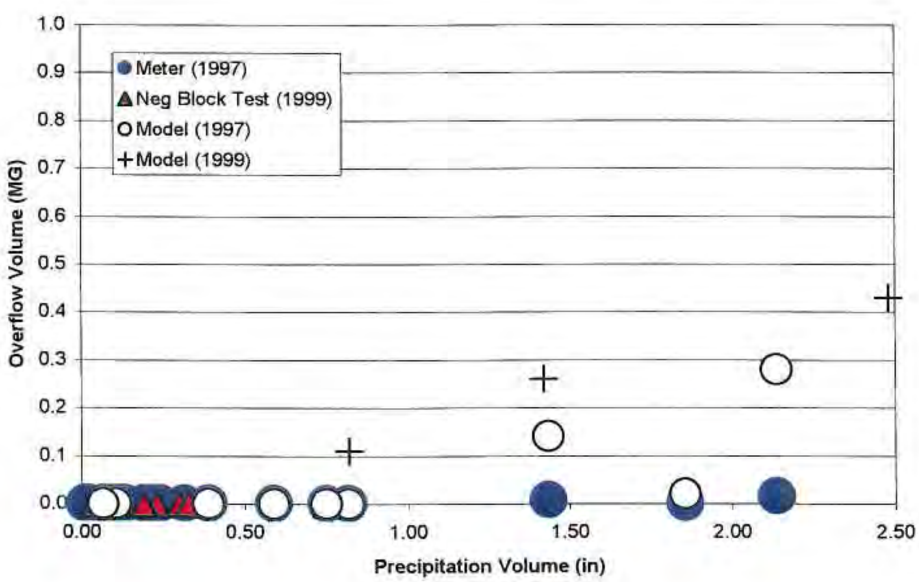
## Observations

* CSOs are small in volume and occur infrequently.
* The model slightly overpredicts the CSO volume in larger storms.
* The model agrees with the meter/block for 92% of the 12 storms that were simulated.

## Impact on CSO Control Plan

This CSO will be addressed by sewer separation (baseline conditions).

| Storm Date | Vol (in) | Pk Int (in/hr) |
|---|---|---|
| 09/15/99 | 2.48 | 0.39 |
| 11/08/97 | 2.14 | 0.37 |
| 10/31/97 | 1.96 | 0.28 |
| 10/26/97 | 1.43 | 0.26 |
| 09/10/99 | 1.42 | 0.37 |
| 08/14/99 | 0.82 | 0.62 |
| 10/24/97 | 0.82 | 0.12 |
| 11/21/97 | 0.75 | 0.16 |
| 09/28/97 | 0.59 | 0.21 |
| 11/15/97 | 0.39 | 0.11 |
| 11/02/97 | 0.11 | 0.06 |
| 11/13/97 | 0.07 | 0.04 |



# 019 - Front St at Pine St

## Observations

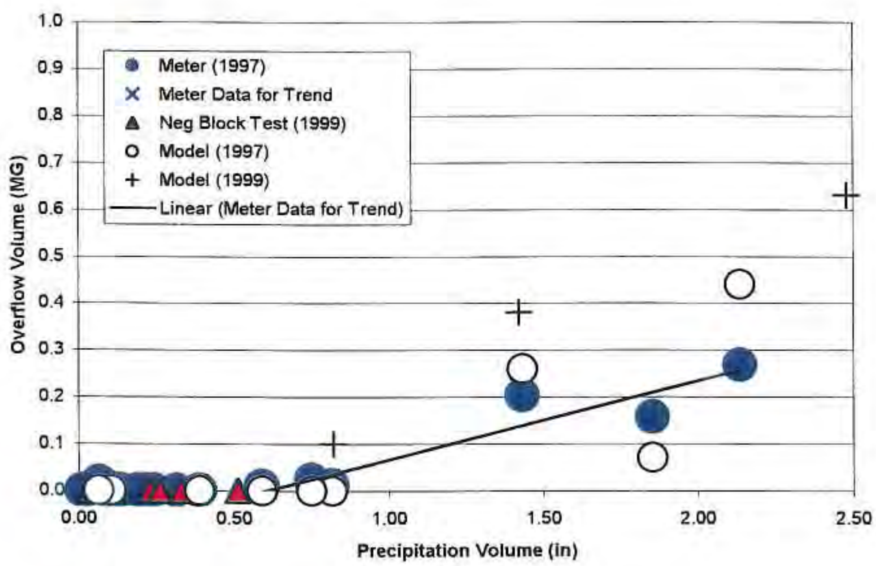
* CSOs are small in volume.
* There are several extremely small CSOs indicated by the meter.
* The model agrees with the meter/block for 58% of the 12 storms that were simulated.

## Impact on CSO Control Plan

The accuracy of the model calibration at this site is sufficient for developing a control plan.

| Storm Date | Vol (in) | Pk Int (in/hr) | |
|---|---|---|---|
| 09/15/99 | 2.48 | 0.39 | |
| 11/08/97 | 2.14 | 0.37 | |
| 10/31/97 | 1.86 | 0.28 | |
| 10/28/97 | 1.43 | 0.26 | |
| 08/10/99 | 1.42 | 0.37 | |
| 08/14/99 | 0.82 | 0.82 | |
| 10/24/97 | 0.82 | 0.12 | * |
| 11/21/97 | 0.75 | 0.16 | |
| 09/28/97 | 0.59 | 0.21 | * |
| 11/15/97 | 0.39 | 0.11 | * |
| 11/02/97 | 0.11 | 0.05 | * |
| 11/13/97 | 0.07 | 0.04 | * |

* Meter indicates overflow with extremely small volume



# 020 - Quinnipiac Ave at Clifton St

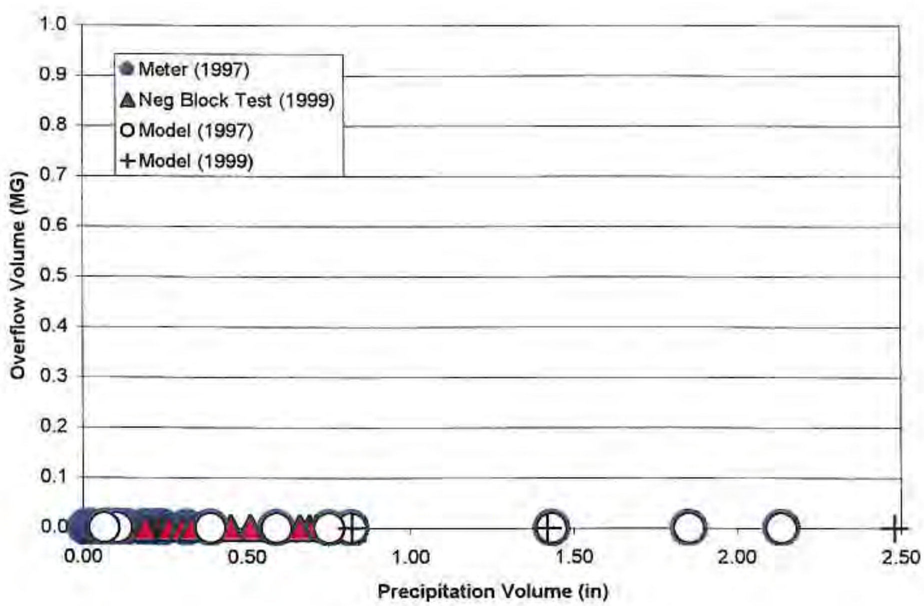
## Observations

* The meter and model agree that there were no overflows during the 1997 monitoring period. Two block tests indicate overflows during the 1999 period that were not predicted by the model.
* Verbal reports to the City have indicated that this CSO is active for larger storms.
* The model agrees with the meter/block for 83% of the 12 storms that were simulated.

| Storm Date | Vol (in) | Pk Int (in/hr) |
|---|---|---|
| 09/15/99 | 2.48 | [illegible] |
| 11/08/97 | 2.14 | 0.37 |
| 10/31/97 | 1.86 | 0.28 |
| 10/26/97 | 1.43 | 0.26 |
| 09/10/99 | 1.42 | 0.37 |
| 08/14/99 | 0.82 | 0.62 |
| 10/24/97 | 0.82 | 0.12 |
| 11/21/97 | 0.75 | 0.16 |
| 09/28/97 | 0.59 | 0.21 |
| 11/15/97 | 0.39 | 0.11 |
| 11/02/97 | 0.11 | 0.06 |
| 11/13/97 | 0.07 | 0.04 |

## Impact on CSO Control Plan

The City has indicated its intention to install an interceptor parallel to the existing one under Quinnipiac Avenue to eliminate this CSO. The sewer system was not designed to accept flows from outside communities. When flows from East Haven were first accepted, the Quinnipiac Pump Station and its forcemain were upgraded to handle the additional flow. However, the interceptor into which the forcemain flows was not upgraded and does not have sufficient capacity to handle extreme wet weather flows without surcharging. The invert of the overflow pipe is approximately 6 inches above the crown of the interceptor. This plan to eliminate the regulator will be added to the Short-Term Control Plan.



# 021 - East St Pump Station

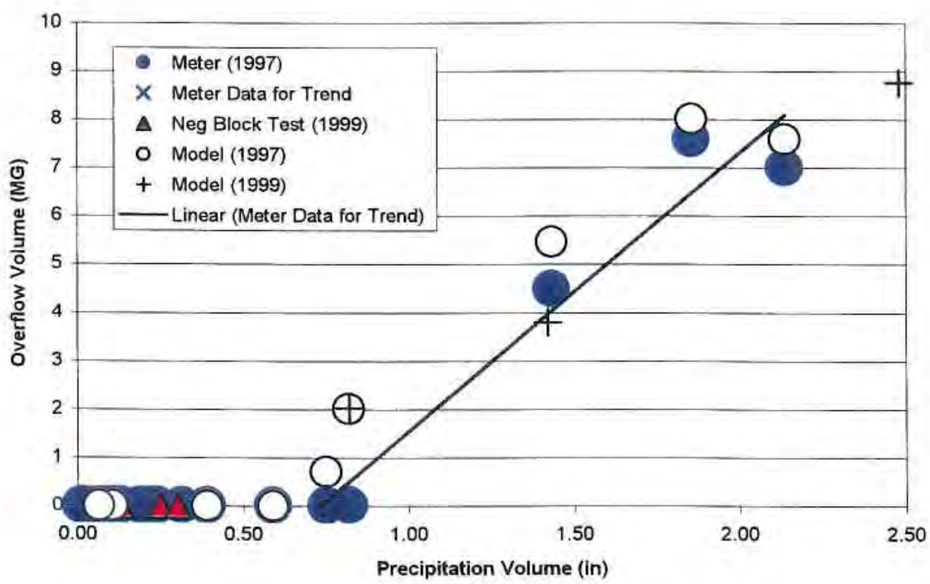
## Observations

* This site exhibits some of the largest volume CSOs in the system.
* The size and occurrence of CSOs at this site are highly influenced by the way the East Street Pump Station is operated.
* The model agrees with the meter/block for 92% of the 12 storms that were simulated.

| Storm Date | Vol (in) | Pk Int (in/hr) |
|---|---|---|
| 09/15/99 | 2.48 | 0.39 |
| 11/08/97 | 2.14 | 0.37 |
| 10/31/97 | 1.86 | 0.28 |
| 10/28/97 | 1.43 | 0.26 |
| 09/10/99 | 1.42 | 0.37 |
| 08/14/99 | 0.82 | 0.62 |
| 10/24/97 | 0.82 | 0.12 |
| 11/21/97 | 0.75 | 0.16 |
| 09/28/97 | 0.59 | 0.21 |
| 11/15/97 | 0.39 | 0.11 |
| 11/02/97 | 0.11 | 0.06 |
| 11/13/97 | 0.07 | 0.04 |

## Impact on CSO Control Plan

The accuracy of the calibration at this site is excellent and will support development of the LTCP.



# 024 - Boulevard Pump Station

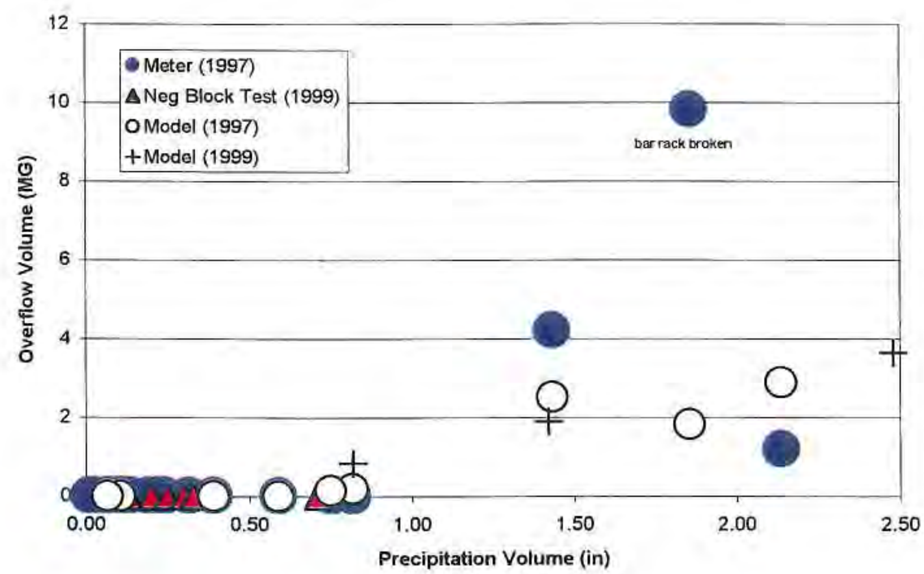
| Storm Date | Vol (in) | Pk Int (in/hr) |
|---|---|---|
| 09/15/99 | 2.48 | 0.39 |
| 11/08/97 | 2.14 | 0.37 |
| 10/31/97 | 1.86 | 0.28 |
| 10/26/97 | 1.43 | 0.26 |
| 09/10/99 | 1.42 | 0.37 |
| 08/14/99 | 0.82 | 0.62 |
| 10/24/97 | 0.82 | 0.12 |
| 11/21/97 | 0.75 | 0.16 |
| 09/28/97 | 0.59 | 0.21 |
| 11/15/97 | 0.39 | 0.11 |
| 11/02/97 | 0.11 | 0.06 |
| 11/13/97 | 0.07 | 0.04 |

## Observations

* CSOs are large in volume and occur frequently.
* The size and occurrence of CSOs at this site are highly influenced by the way the Boulevard Pump Station is operated.
* This site, being the most downstream CSO on the Boulevard Interceptor, is also affected by the conditions of the interceptor. If the significant amount of sediment found in the interceptor upstream were to be removed, more flow would be conveyed downstream, possibly increasing the volume of CSOs at this location.
* For one of the largest storms (10/31/97), a bar rack broke in the pump station, causing a very large overflow. The resulting backwater affected regulators 024, 002, and 003. The model did not simulate this condition, and hence it predicts a much smaller overflow for that storm.
* The model agrees with the meter/block for 83% of the 12 storms that were simulated.

## Impact on CSO Control Plan

The accuracy of the model calibration at this site is sufficient for development of a LTCP.



# 025 - Union/State Pump Station

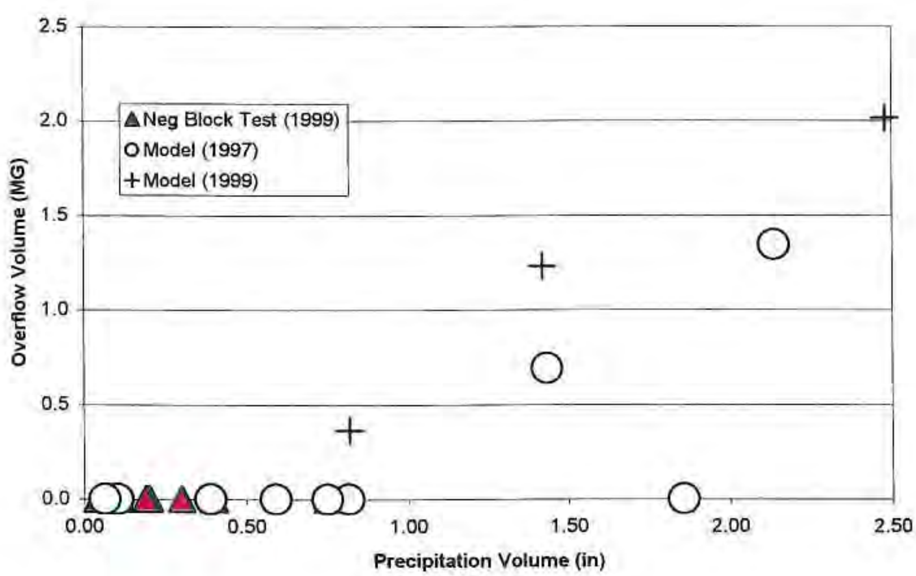
## Observations

* The observance of CSOs at this site is complicated by low elevations that allow seawater due to high tides and stormwater from large storms to flow back over the weir and under the weir through weep holes, and then into the pump station.
* The meter at this site during the 1997 monitoring period was installed in a manner which precludes the estimation of overflows during the period. Instead, it provides a measure of the inflow at this site.
* The size and occurrence of CSOs at this site are influenced by the way the Union Pump Station is operated.
* The model agrees with the block for 100% of the 3 verification storms that were simulated.

| Storm Date | Vol (in) | Pk Int (in/hr) |
|---|---|---|
| [illegible] | 2.48 | 0.39 |
| [illegible] | [illegible] | [illegible] |
| 10/31/97 | 1,86 | 0.28 |
| [illegible] | [illegible] | [illegible] |
| [illegible] | 1.43 | 0.37 |
| [illegible] | [illegible] | [illegible] |
| 10/24/97 | 0.82 | 0.12 |
| 11/21/97 | 0.75 | 0.16 |
| 09/28/97 | 0.59 | 0.21 |
| 11/15/97 | 0.39 | 0.11 |
| 11/02/97 | 0.11 | 0.06 |
| 11/13/97 | 0.07 | 0.04 |

## Impact on CSO Control Plan

* The LTCP needs to address the significant amount of seawater and stormwater inflow believed to be entering the sewer system at this site. It is understood that there is a plan to install a tide gate or gates in association with one of the baseline sewer separation projects currently planned.
* The accuracy of the calibration at this site cannot be assessed with the small amount of data available.



# George at Temple

## Observations

* Due to the steep slope of the pipe influent to the regulator chamber and the flat slope in the chamber, a hydraulic jump forms in the chamber. This results in significant turbulence in the flow and greater flow depths downstream of the jump. The ultrasonic depth sensor installed in the regulator chamber suggested that some depths during wet weather exceeded the height of the weir, causing overflows. However, the model and calculations based on depths reported by a pressure depth sensor installed in the influent pipe are consistent in indicating that flow depths did ***not*** exceed the elevation of the weir crest at any time during the monitoring program of 1997. Photographs of the regulator chamber also show water lines below the weir. However, several block tests have been logged as positive, indicating occurrence of a CSO. It is not known to what extent other influences, such as the turbulence in the chamber or extreme storm flows on the downstream side of the weir, might be affecting the block test results. Based on the consistency found between the model, hand calculations with pressure sensor data, and photographs, the model is considered to be calibrated. It is recommended, however, that wet-weather field observations of this regulator be made.
* The model agrees with the meter/block for 75% of the 12 storms that were simulated.

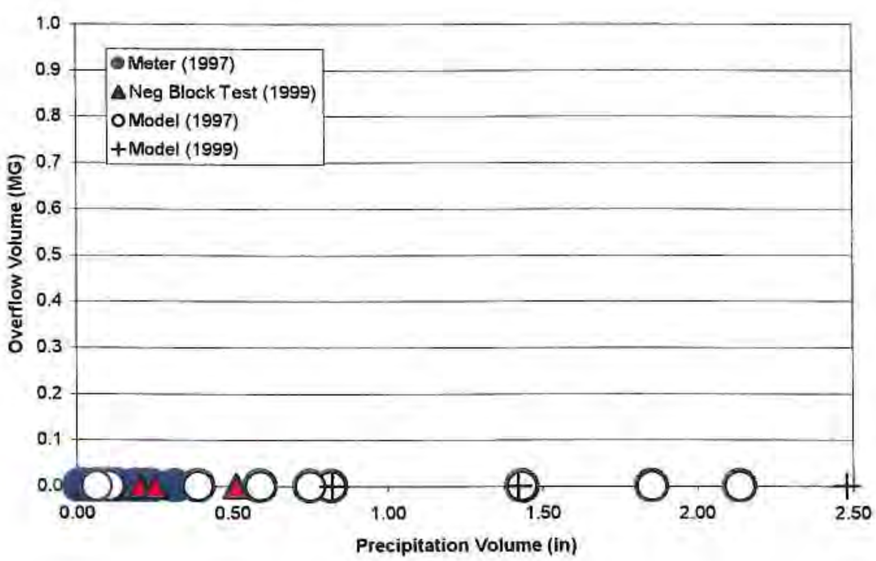
| Storm Date | Vol (in) | Pk Int (in/hr) | |
|---|---|---|---|
| 09/15/99 | 2.48 | 0.39 | ** |
| 11/08/97 | 2.14 | 0.37 | * |
| 10/31/97 | 1.86 | 0.28 | * |
| 10/26/97 | 1.43 | 0.26 | * |
| 09/10/99 | 1.42 | 0.37 | ** |
| 08/14/99 | 0.62 | 0.62 | ** |
| 10/24/97 | 0.82 | 0.12 | * |
| 11/21/97 | 0.75 | 0.16 | * |
| 09/28/97 | 0.59 | 0.21 | * |
| 11/15/97 | 0.39 | 0.11 | |
| 11/02/97 | 0.11 | 0.06 | |
| 11/13/97 | 0.07 | 0.04 | |

* Ultrasonic meter indicates chamber depth sufficient to cause overflow; model and calculations based on depth from upstream pressure sensor do not.

** Suspected to be a false positive

## Impact on CSO Control Plan

Field observations should be made to confirm the assessment of the flow conditions at this site. It is possible that wet-weather conditions that would cause an overflow at this site could occur. The potential for eliminating this CSO in the Short-Term Control Plan by raising or blocking the weir should be investigated.



# East at Ives

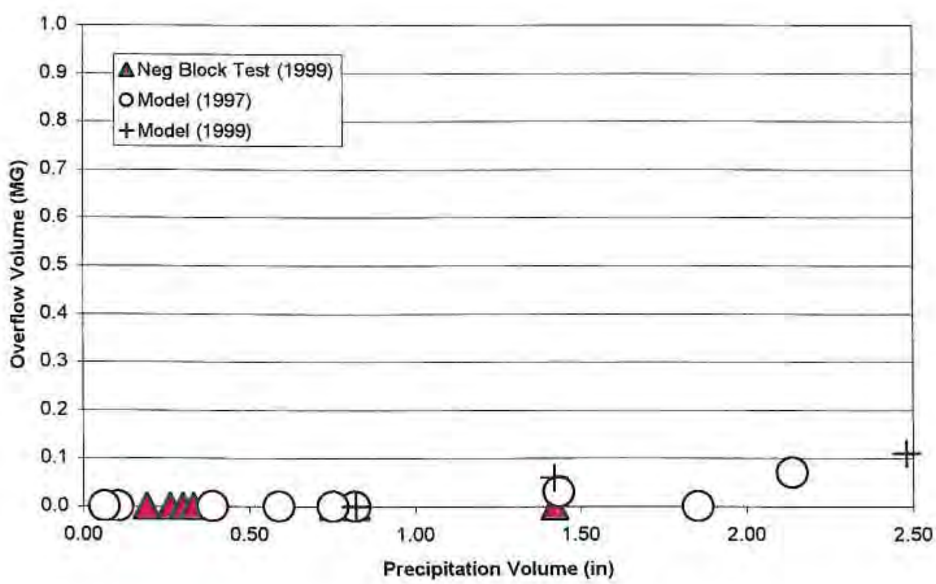
## Observations

* No meter was installed at this site.
* The model indicates that CSOs are small in volume and infrequent.
* The model agrees with the block for 67% of the 3 verification storms that were simulated.

## Impact on CSO Control Plan

The accuracy of the calibration at this site cannot be assessed with the limited amount of data available.

| Storm Date | Vol (in) | Pk Int (in/hr) |
|---|---|---|
| 09/15/99 | 2.48 | 0.39 |
| [illegible] | [illegible] | [illegible] |
| 10/31/97 | 1.86 | 0.28 |
| [illegible] | [illegible] | [illegible] |
| 09/10/99 | 1.42 | 0.37 |
| 08/14/99 | 0.82 | 0.62 |
| 10/24/97 | 0.82 | 0.12 |
| 11/21/97 | 0.75 | 0.16 |
| 09/28/97 | 0.59 | 0.21 |
| 11/15/97 | 0.39 | 0.11 |
| 11/02/97 | 0.11 | 0.06 |
| 11/13/97 | 0.07 | 0.04 |



# Appendix A
# Plots of GIS Coverages

The nine figures in this appendix illustrate the system inventory created as part of Task 2. Each figure highlights the extent of the data available, and illustrates the flexibility of the GIS in displaying the coverages.

Figure A-1: New Haven, Connecticut

- The basemap of the project area, including the boundary, major water bodies and the streets of New Haven.

Figure A-2: 1"=40' Mylar Planimetric Map Grid

- The layout of the 1"40' mylar planimetric maps used in the data transfer process.

Figure A-3: 1"=100' Mylar Planimetric Map Grid

- The layout of the 1"=100' mylar planimetric maps scanned as a temporary basemap.

Figure A-4: Sanitary Sewer Facilities

- The extent of the combined/sanitary sewers contained in the GIS. A close-up view illustrates the position of the sewers and manholes with respect to pavement edges.

Figure A-5: Storm Sewer Facilities

- The extent of the storm sewers contained in the GIS. A close-up view illustrates the position of the sewers and manholes with respect to pavement edges.

Figure A-6: Catchbasins and Catchbasin Laterals

- The extent of the catchbasins contained in the GIS. A close-up view illustrates the position of the facilities with respect to pavement edges, and the laterals connecting them to individual sewers.

Figure A-7: Degree of Sewer Separation (Fall 1997)

- Modeling subcatchment by degree of sewer separation.

Figure A-8: Impervious Cover

- Polygons developed to estimate the percent impervious model parameter.

Figure A-9: Regional Water Authority Water Consumption Records

- Water consumption data obtained from the Regional Water Authority used to determine BSF parameters.

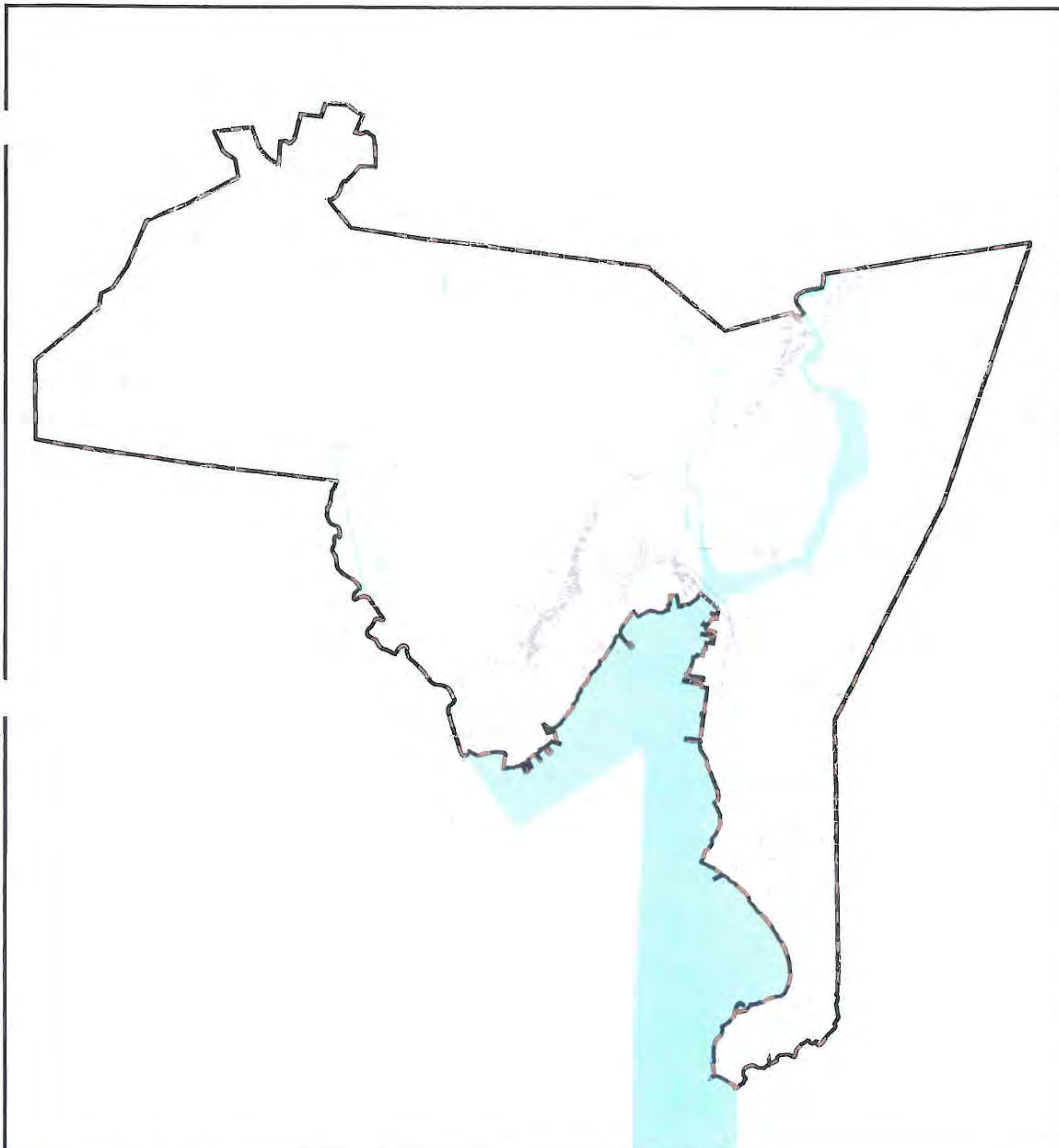
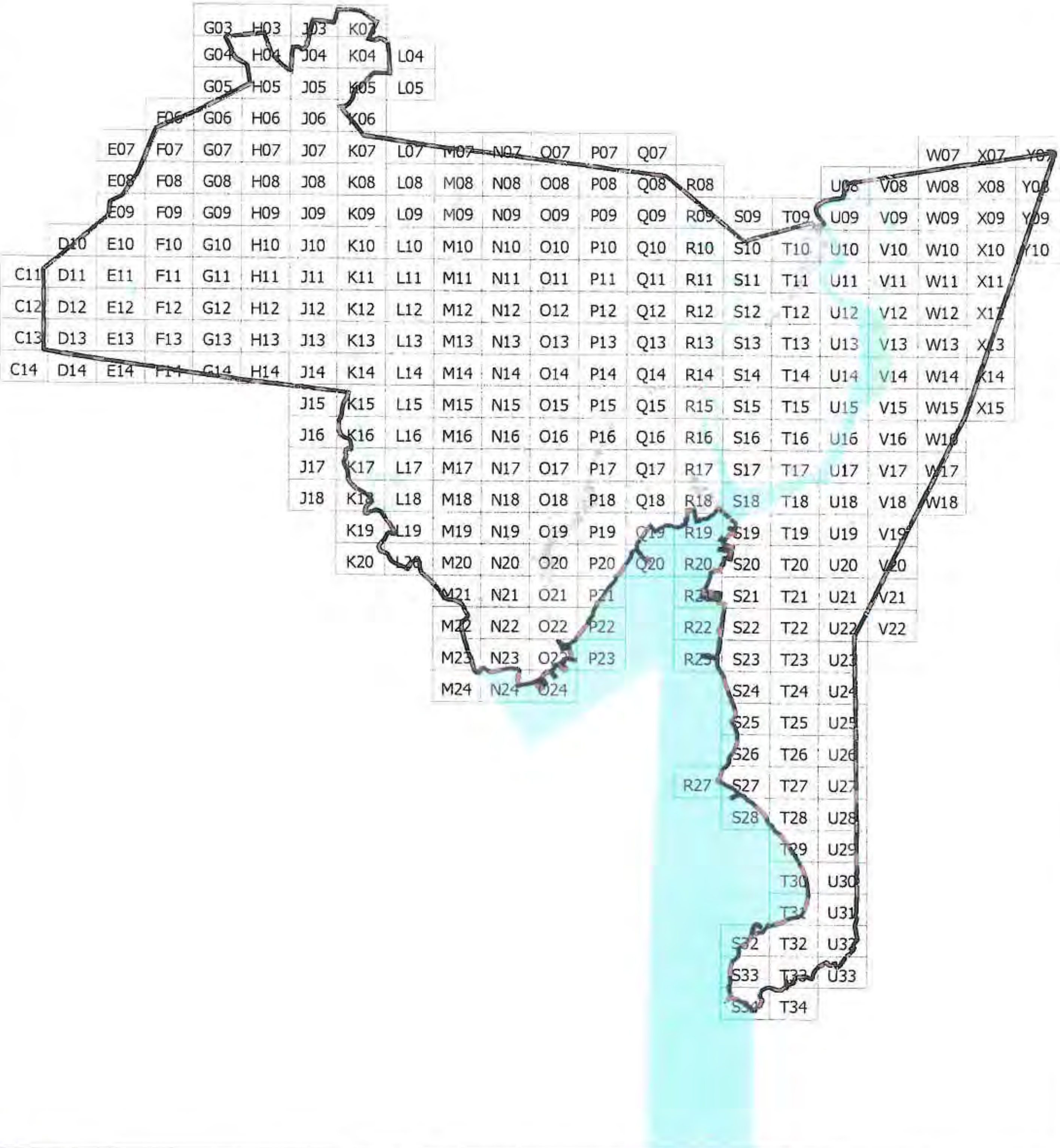



Figure A-1

New Haven, Connecticut

CH2MHILL

New Haven Long Term CSO Control Plan




New Haven City Boundary
Road
Railroad
1"=40' Mylar Planimetric Grid

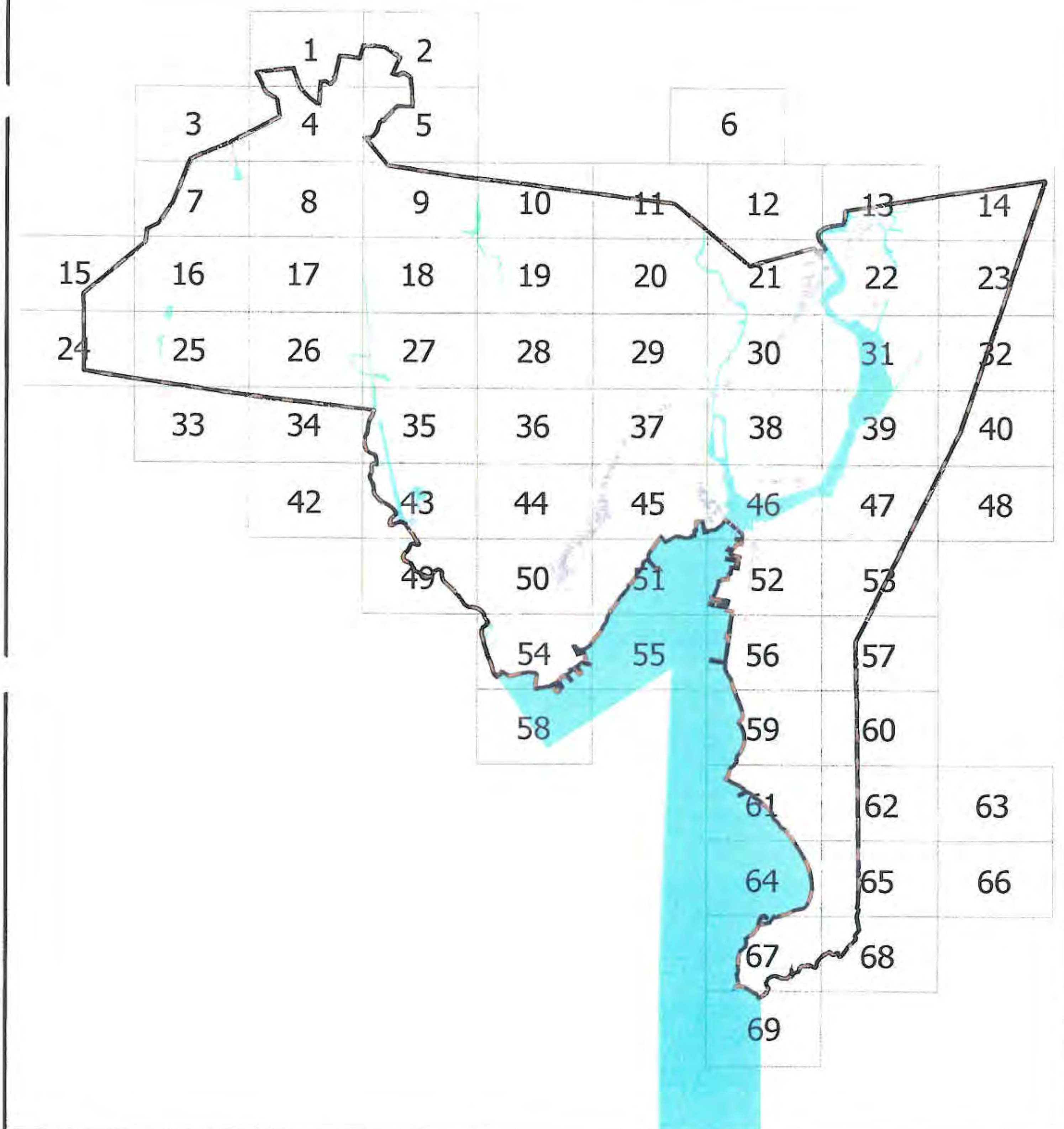
2000 0 2000 4000 Feet

# Figure A-2

## 1"=40' Mylar Planimetric Map Grid

New Haven Long Term CSO Control Plan

CH2MHILL




# Figure A-3
1"=100' Mylar Planimetric Map Grid

New Haven Long Term CSO Control Plan

CH2MHILL

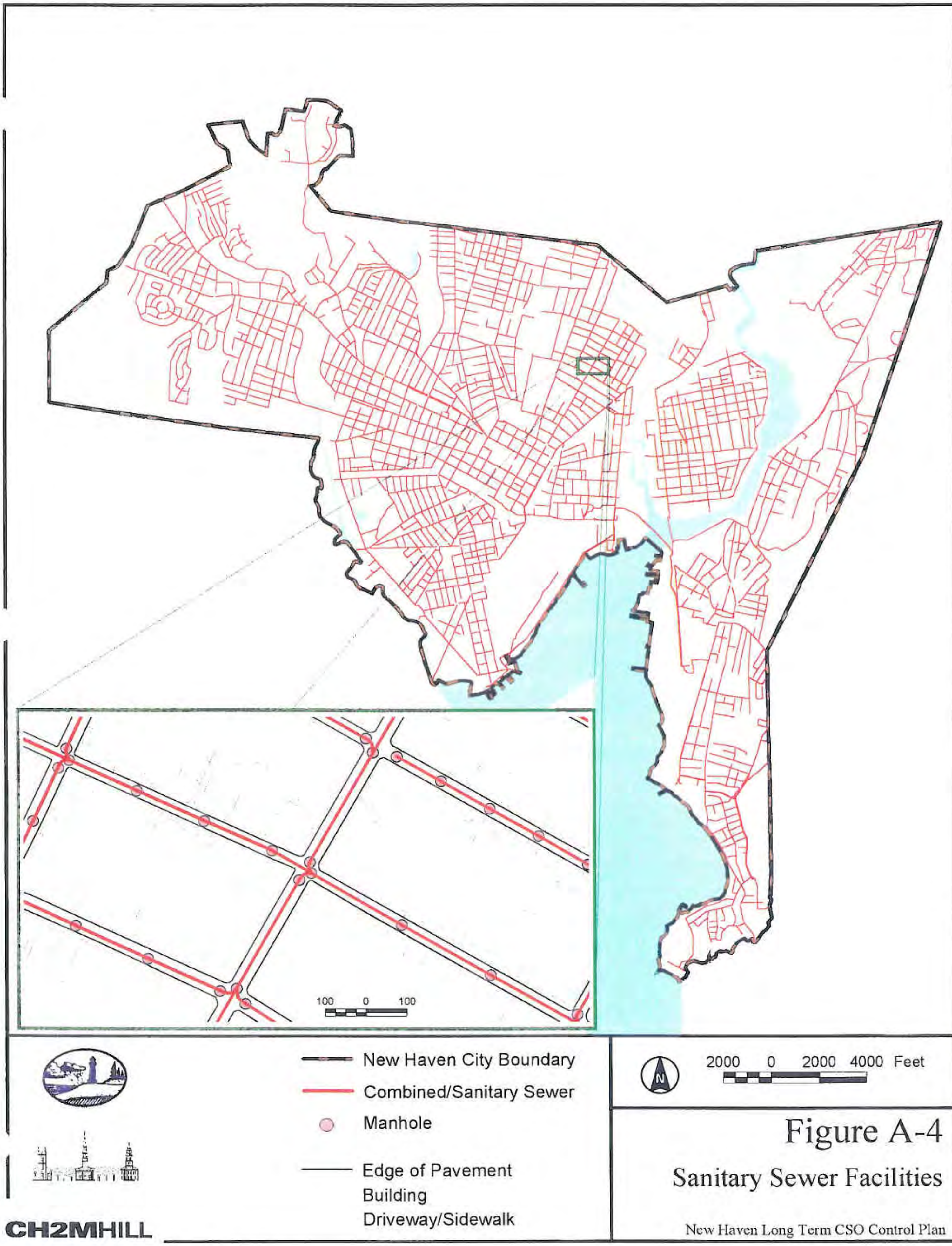
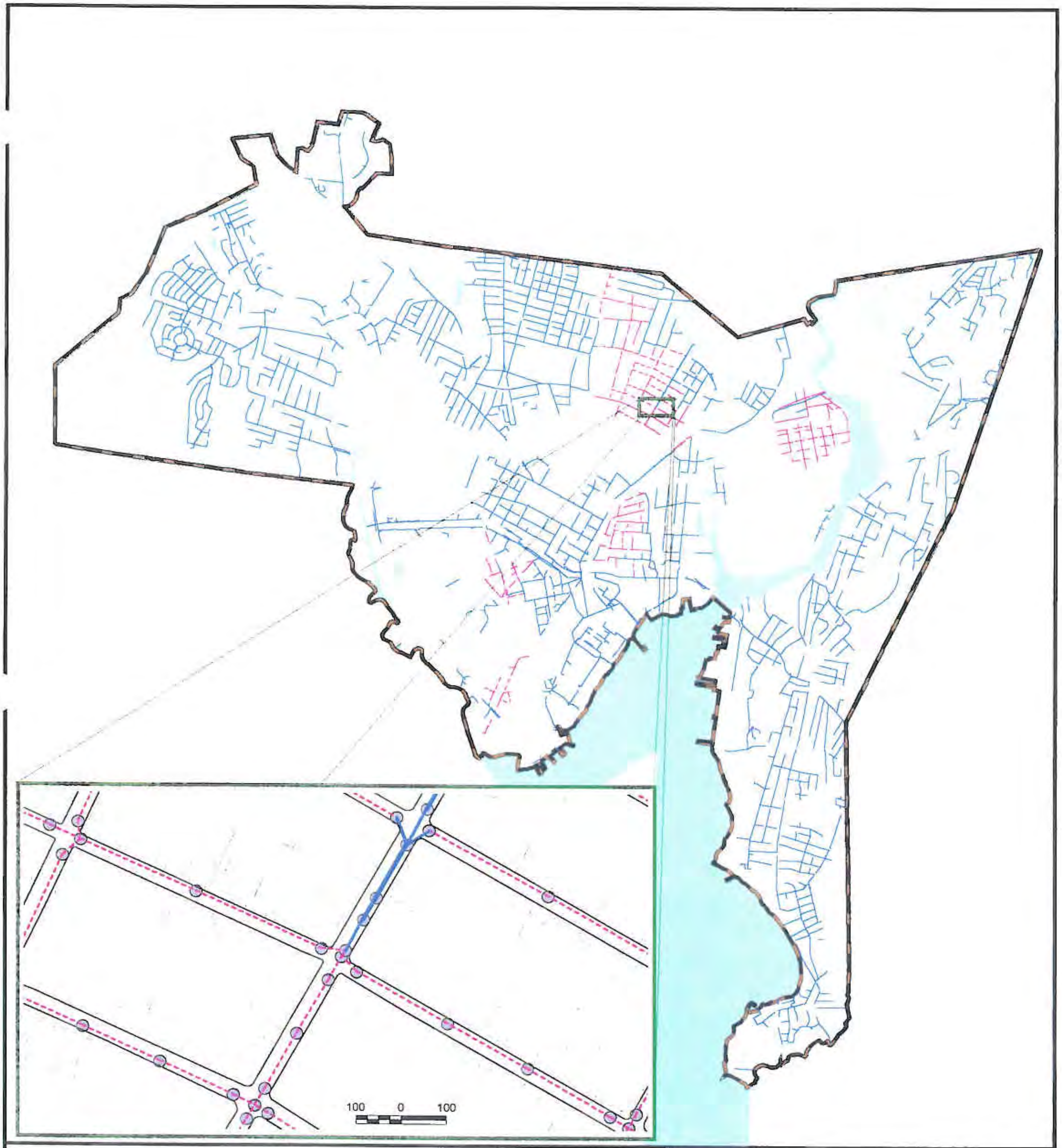



Figure A-4

Sanitary Sewer Facilities

New Haven Long Term CSO Control Plan




New Haven City Boundary

Storm Sewer, Existing

Storm Sewer, Proposed

Manhole

Edge of Pavement

Building

Driveway/Sidewalk

CH2MHILL

2000 0 2000 4000 Feet

# Figure A-5

## Storm Sewer Facilities (Fall, 1997)

New Haven Long Term CSO Control Plan

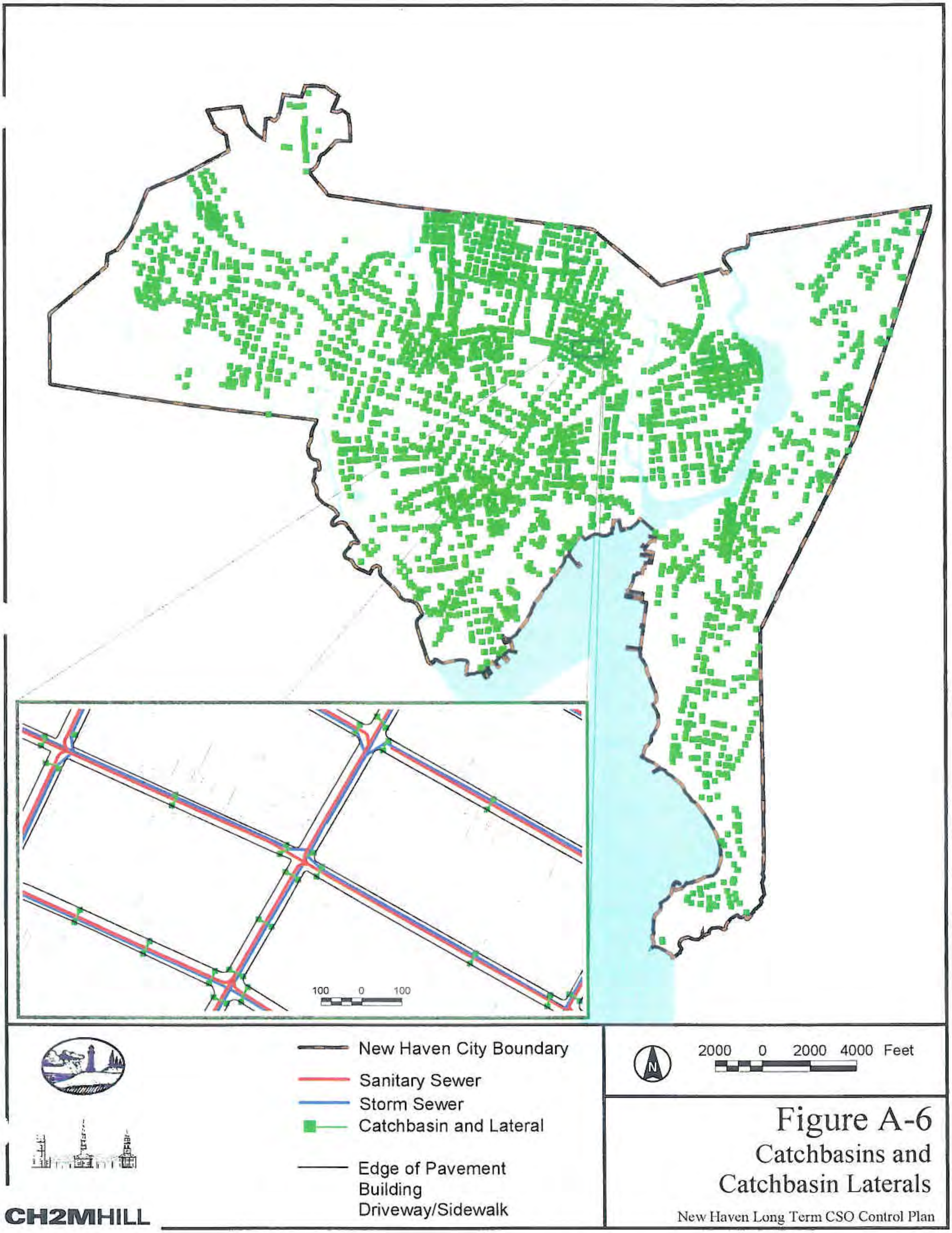
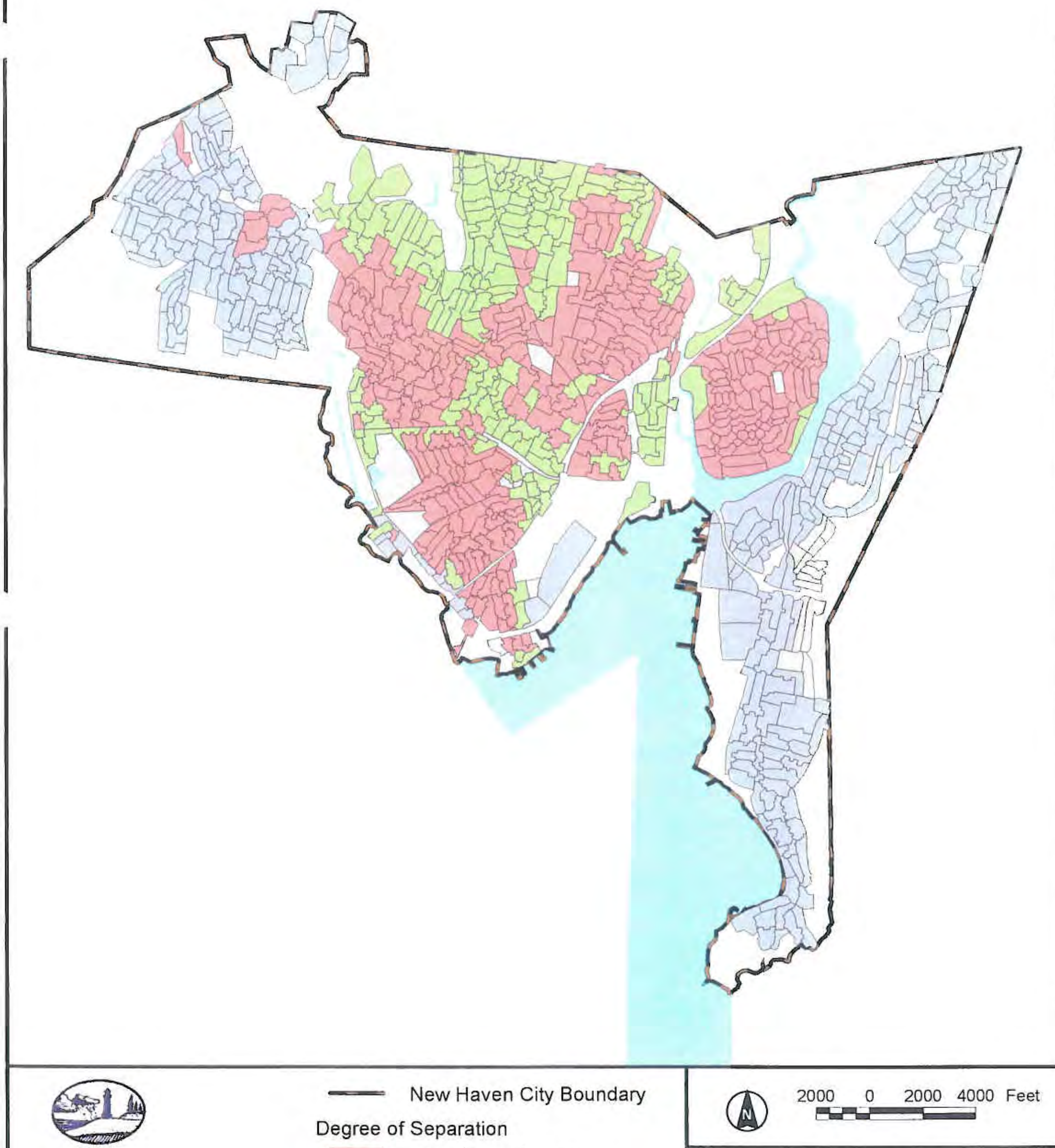



Figure A-6
Catchbasins and Catchbasin Laterals

New Haven Long Term CSO Control Plan



New Haven City Boundary

Degree of Separation

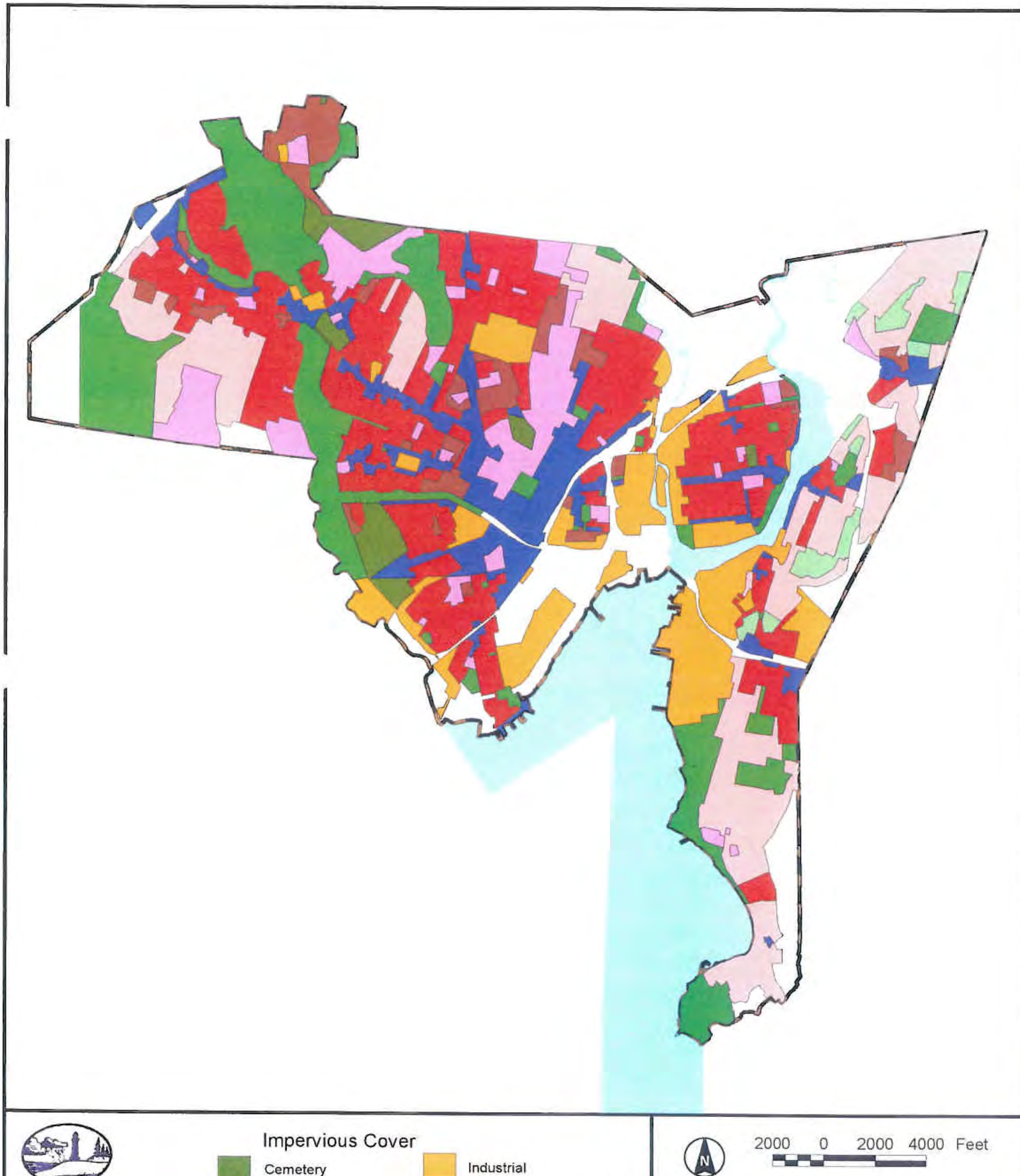
- Combined Sewers
- Partially Separated Sewers
- Separated Sewers
- Not Sewered

CH2MHILL

N

2000 0 2000 4000 Feet

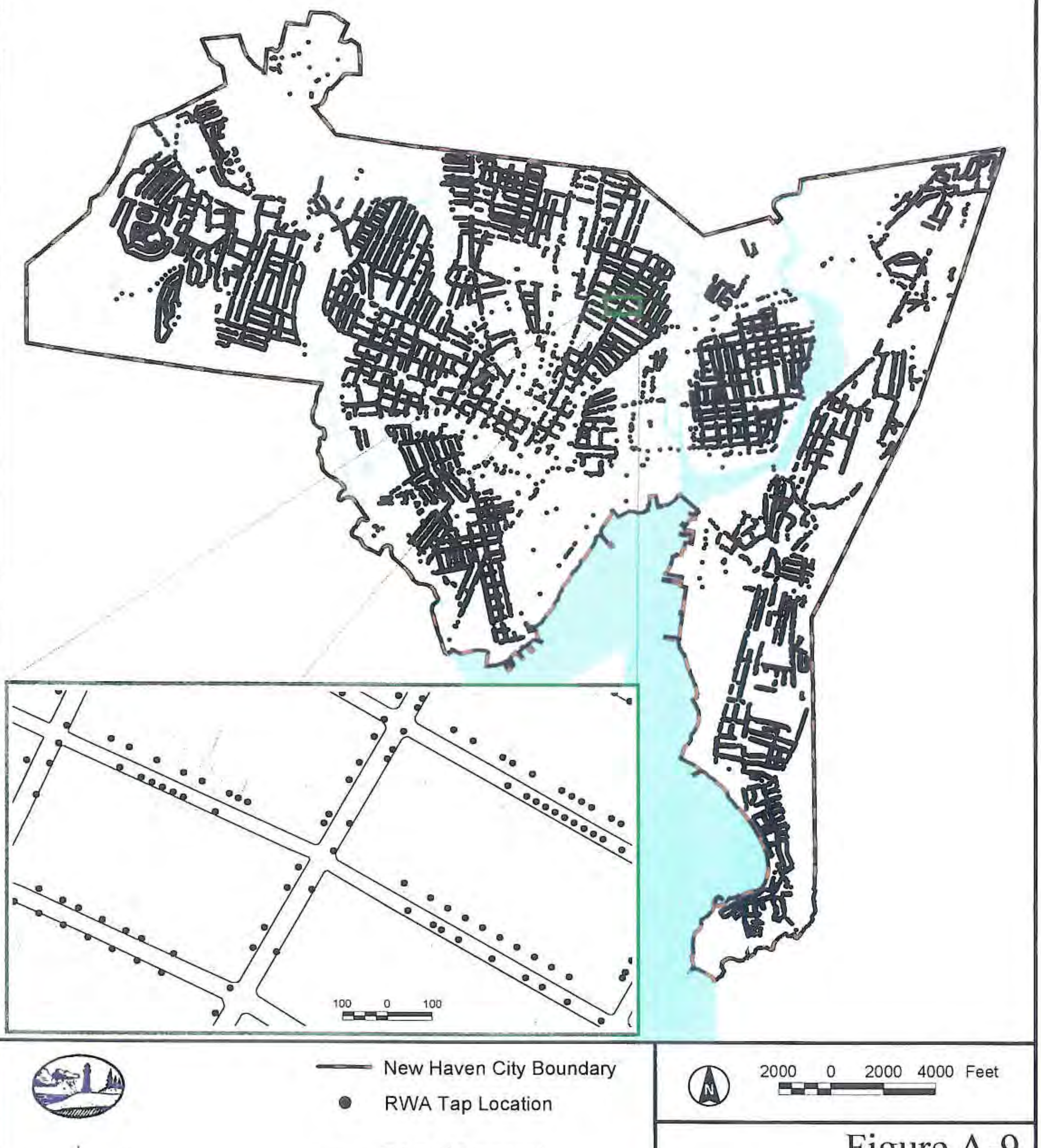
# Figure A-7
## Degree of Sewer Separation (Fall 1997)




CH2MHILL

# Figure A-8
## Impervious Cover

New Haven Long Term CSO Control Plan




# Figure A-9

## Regional Water Authority Water Consumption Records

New Haven Long Term CSO Control Plan

CH2MHILL

# Appendix B
# ARC/INFO Coverages

This CD contains the ARC/INFO coverages created for Task 2. The data contained in these coverages reflects the system information that has been obtained as of December 17, 1998. At the time of publication, City staff was still collecting storm system data, and therefore, the STMLINK and STMNODE coverages will need to be updated.

The coverages are available in two formats: as ARC/INFO export files (*.e00) and as readable ARC/INFO coverages. Figure B-1 shows the data structure provided on the CD.

To expand the export files, the IMPORT utility provided with ArcView or ARC/INFO must be used.


*Figure B-1: ARC/INFO Coverages on CD*

**** CD not included with this copy of the report. ****

# Appendix C

# Data Dictionary and Sample Data Contained in GIS Coverages

This appendix contains tables describing the database field definitions and showing sample data for the following coverages and relational databases:

- SANNODE coverage
- SANLINK coverage
- STMNODE coverage
- STMLINK coverage
- NHSUB coverage
- IMPCOV coverage
- PUMP relational database
- WEIR relational database

## Table C-1a. SANNODE Coverage Data Field Definitions

Manhole Coverage: SANNODE

nitions for data fields

| Field Name | Used in MOUSE Model | Description | Units | Format | Comment | Sample Data |
|---|---|---|---|---|---|---|
| AREA | N | | | | ARC/INFO Field | |
| PERIMETER | N | | | | ARC/INFO Field | |
| SANNODE_ | N | | | | ARC/INFO Field | |
| SANNODE_ID | N | | | | ARC/INFO Field | |
| MSLINK | N | Key | | Integer | Integer index field (used for digitizing) | 2802 |
| **SAN_NAME** | Y | Node name | | Character | | T13N060 |
| **SAN_XPOS** | Y | X-coordinate | NAD 83 | Real | | 560760.436 |
| **SAN_YPOS** | Y | Y-coordinate | NAD 83 | Real | | 176283.45 |
| SAN_CLASS | N | **DU** = Dummy<br>**IN** = Inlet<br>**MB** = Catchbasin<br>**MC** = Chamber<br>**MH** = Manhole<br>**OF** = Outlet<br>**PM** = Proposed MH<br>**PS** = Pump Station<br>**RG** = Regulator<br>**SI** = Siphon | | Character | | MH |
| **SAN_ZBTTM** | Y | Invert elevation | CGS | Real | | 25.76 |
| **SAN_ZGRND** | Y | Ground elevation or Water Surface Elevation for Outfalls used in models | CGS | Real | | 38.76 |
| SAN_QUAD | N | Name of 1"=40' Quad sheet | | Character | | T13 |
| SOURCE | N | **0** or **blank** = from Original transfer<br>**1** = Survey<br>**2** = Interpolated<br>**3** = Records<br>**4** = Paved Over<br>**5** = Assumed<br>**3** = Records<br>**4** = Paved Over<br><br>**9** = not being modeled | | Character | Source of data | 2, 3 |
| **OUTLET_INT** | Y | **0** = Artificial<br>**1** = Round<br>**2** = Sharp<br>**3** = Orifice | | Integer | Description of outlet shape | 2 |
| Include_model | N | **0** = Not Modeled<br>**1** = Modeled | | Integer | Whether or not to model manhole | 1 |
| **Diameter** | Y | Cross-sectional Area of Node | ft2 | Real | Assumed for nodes; measured for Pump Stations | 10 |
| incl_SYS | N | **0** = Not Modeled<br>**1** = Modeled | | Integer | Whether or not to model sewer segment in SYSTEM model | 1 |
| incl_INTR | N | **0** = Not Modeled<br>**1** = Modeled | | Integer | Whether or not to model sewer segment in INTERCEPTOR model | 1 |
| REALGROUND | N | Ground elevation or Water Surface Elevation for Outfalls | CGS | Real | | 38.76 |

## Table C-1b. Sample Data for SANNODE Coverage

| AREA | PERIMETER | SANNODE# | SANNODE-ID | MSLINK | SAN_NAME | SAN_XPOS | SAN_YPOS | SAN_CLASS | SAN_ZBTTM | SAN_ZGRD | SAN_QUAD | SOURCE | OUTLET_INT | INCL_MODEL | DIAMETER | INCL_SYS | INCL_INTR | REALGROUND |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 0 | 1 | 1 | 118 | N11N330 | 948412.34 | 678455.66 | MH | 30.02 | 38.10 | N11 | | 1 | 1 | 10 | 1 | 1 | 38.10 |
| 0 | 0 | 2 | 2 | 218 | M11N010 | 948305.01 | 677865.66 | MH | 29.89 | 43.50 | M11 | | 1 | 1 | 10 | 1 | 1 | 43.50 |
| 0 | 0 | 3 | 3 | 230 | N12N010 | 948490.17 | 677815.45 | MH | 32.71 | 46.40 | N12 | | 1 | 1 | 10 | 1 | 0 | 46.40 |
| 0 | 0 | 4 | 4 | 243 | N12N040 | 948351.57 | 677331.50 | MH | 28.60 | 39.00 | N12 | | 1 | 1 | 10 | 1 | 0 | 39.00 |
| 0 | 0 | 5 | 5 | 245 | M12N010 | 948301.21 | 677169.29 | MH | 27.76 | 37.80 | M12 | | 1 | 1 | 10 | 1 | 0 | 37.80 |
| 0 | 0 | 6 | 6 | 257 | N13N390 | 948389.80 | 676616.92 | MH | 25.61 | 38.50 | N13 | | 1 | 1 | 10 | 1 | 1 | 38.50 |
| 0 | 0 | 7 | 7 | 376 | N13N010 | 948400.22 | 676563.62 | MH | 27.61 | 39.80 | N13 | | 1 | 1 | 10 | 1 | 1 | 39.80 |
| 0 | 0 | 8 | 8 | 472 | N13N240 | 948353.71 | 675996.51 | MH | 35.57 | 48.00 | N13 | | 1 | 1 | 10 | 1 | 0 | 48.00 |
| 0 | 0 | 9 | 9 | 503 | S13N310 | 948421.22 | 675585.21 | MH | 36.87 | 47.30 | N13 | | 1 | 1 | 10 | 1 | 0 | 47.30 |
| 0 | 0 | 10 | 10 | 572 | N13N640 | 948332.06 | 675569.08 | MH | 36.98 | 47.60 | N13 | 1 | 1 | 1 | 10 | 1 | 0 | 47.60 |
| 0 | 0 | 11 | 11 | 635 | N14N280 | 948397.20 | 674976.15 | MH | 35.30 | 41.80 | N14 | | 1 | 1 | 10 | 1 | 0 | 41.80 |
| 0 | 0 | 12 | 12 | 712 | M14N660 | 948324.27 | 674359.74 | MH | 32.36 | 43.20 | M14 | | 1 | 1 | 10 | 1 | 1 | 43.20 |
| 0 | 0 | 13 | 13 | 710 | N14D010 | 948339.45 | 674362.96 | DU | 32.40 | 43.30 | N14 | 2 | 1 | 1 | 10 | 1 | 1 | 43.30 |
| 0 | 0 | 14 | 14 | 1219 | S14N010 | 957668.08 | 675423.44 | MH | 7.41 | 12.41 | S14 | | 1 | 1 | 10 | 1 | 1 | 12.41 |
| 0 | 0 | 15 | 15 | 1221 | S14N020 | 957693.54 | 675194.33 | MH | 6.49 | 13.45 | S14 | | 1 | 1 | 10 | 1 | 1 | 13.45 |
| 0 | 0 | 16 | 16 | 1223 | S14N030 | 957714.40 | 675214.78 | MH | 7.89 | 13.49 | S14 | | 1 | 1 | 10 | 1 | 1 | 13.49 |
| 0 | 0 | 17 | 17 | 1226 | S14N040 | 957721.31 | 674941.08 | MH | 6.11 | 14.61 | S14 | | 1 | 1 | 10 | 1 | 0 | 14.61 |
| 0 | 0 | 18 | 18 | 1228 | S14N050 | 957748.69 | 674687.62 | MH | 5.76 | 16.36 | S14 | | 1 | 1 | 10 | 1 | 1 | 16.36 |
| 0 | 0 | 19 | 19 | 1230 | S14N060 | 957774.47 | 674707.06 | MH | 7.73 | 17.03 | S14 | | 1 | 1 | 10 | 1 | 0 | 17.03 |
| 0 | 0 | 20 | 20 | 1234 | S14N070 | 957781.09 | 674406.53 | MH | 5.36 | 18.36 | S14 | | 1 | 1 | 10 | 1 | 1 | 18.36 |
| 0 | 0 | 21 | 21 | 1236 | S14N080 | 957797.48 | 674246.53 | MH | 4.92 | 19.42 | S14 | | 1 | 1 | 10 | 1 | 1 | 19.42 |
| 0 | 0 | 22 | 22 | 1238 | S14N090 | 958049.38 | 674288.83 | MH | 11.51 | 27.04 | S14 | | 1 | 1 | 10 | 1 | 0 | 27.04 |
| 0 | 0 | 23 | 23 | 1240 | S14N100 | 958035.78 | 674425.29 | MH | 10.87 | 21.97 | S14 | | 1 | 1 | 10 | 1 | 0 | 21.97 |
| 0 | 0 | 24 | 24 | 1242 | S14N110 | 958016.96 | 674448.12 | MH | 10.46 | 21.66 | S14 | | 1 | 1 | 10 | 1 | 0 | 21.66 |
| 0 | 0 | 25 | 25 | 1247 | S14N130 | 958031.05 | 674475.68 | MH | 11.05 | 21.85 | S14 | | 1 | 1 | 10 | 1 | 0 | 21.85 |

(25 of 8782 records shown)

# Table C-2a. SANLINK Coverage Data Field Definitions

| Pipe Coverage: SANLINK | | | | | | |
|---|---|---|---|---|---|---|
| ...nitions for data fields | | | | | | |
| **Field Name** | **Used in MOUSE Model** | **Description** | **Units** | **Format** | **Comment** | **Sample Data** |
| FNODE_ | N | | | | ARC/INFO Field | |
| TNODE_ | N | | | | ARC/INFO Field | |
| LPOLY_ | N | | | | ARC/INFO Field | |
| RPOLY_ | N | | | | ARC/INFO Field | |
| LENGTH | N | | | | ARC/INFO Field | |
| SANLINK_ | N | | | | ARC/INFO Field | |
| SANLINK_ID | N | | | | ARC/INFO Field | |
| MSLINK | N | Key | | Integer | Integer index field (used for digitizing) | 2802 |
| SAN_NAME | N | Feature name | | Character | | 2802 |
| PIPE_CLASS | N | **PI** = pipe<br>**PP** = proposed pipe<br>**PU** = pump<br>**FM** = forcemain<br>**WR** = weir<br>**OR** = orifice<br>**SC** = screens at East PS | | Character | | PI |
| CONSYEAR | N | Year of construction | | Integer | | 1903 |
| SAN_QUAD | N | Name of 1"=40' Quad sheet | | Character | | U13 |
| **US_NODE** | Y | US Node name | | Character | | U13N220 |
| **US_INV** | Y | US invert elevation | CGS | Real | | 11.38 |
| **DS_NODE** | Y | DS Node name | | Character | | U13N230 |
| **DS_INV** | Y | DS invert elevation | CGS | Real | | 9.51 |
| **MOUSE_MAT** | Y | **2** = Cement<br>**4** = Plastic<br>**5** = Iron<br>**7** = Brick<br>**8** = Tile<br><br>**-1** = Dummy Pipe | | Integer | | 7 |
| **MOUSE_SHP** | Y | **0** = User defined<br>**1** = Circular<br>**3** = Egg | | Integer | | 0 |
| **MOUSE_DB** | Y | User-defined sections<br>**NewHaven**<br><br>MOUSE-defined sections<br>**Standard**<br><br>dummy link: **not used** | | Character | Name database contained defined cross-sections | NewHaven |

## Table C-2a. SANLINK Coverage Data Field Definitions

Pipe Coverage: SANLINK

itions for data fields

| Field Name | Used in MOUSE Model | Description | Units | Format | Comment | Sample Data |
|---|---|---|---|---|---|---|
| | | User-defined Shapes<br>**BLV1S FRNT1**<br>**BLVD1 FRNT2**<br>**BLVD2 GRND1**<br>**BLVD3 JMS1S**<br>**BLVD4 JMS2S**<br>**BLVD5 LEGN1**<br>**BLVD6 PPLR1**<br>**BLVD7 PPLR1**<br>**BLVD8 RVR1S**<br>**BLVD9 RVR2S**<br>**BLVD10 RVR3S**<br>**EAST1 RVR4S**<br>**FRN1S STAT1**<br>**FRN2S STAT2**<br>**FRN3S WHL1S**<br>**FRN4S WHL2S**<br>**FRN5S WHL3S**<br>**FRN6S WHLY1**<br><br>**ELLIP1 RECT3**<br>**RECT1 RECT4**<br>**RECT2 RECT5**<br><br>MOUSE-defined Shapes<br>**circular**<br>**egg** | | | | |
| **MOUSE_XSEC** | Y | **not used** | | Character | Name of X-section | PPLR1 |
| Material | N | Mouse Material | | Character | | Tile |
| WIDTH | N | Width of pipe | feet | Real | | 4.5 |
| **HEIGHT** | Y | Pipe size | feet | Real | Characteristic dimension used in model.<br>Circular & Square are WIDTH(=HEIGHT).<br>Eggs are HEIGHT.<br>User defined are scaler values. | 3 |
| SOURCE | N | **0** or **blank** = from Original transfer<br>**1** = Survey<br>**2** = Interpolated<br>**3** = Records<br>**4** = Paved Over<br>**5** = Assumed<br>**3** = Records<br>**4** = Paved Over<br>**9** = not being modeled | | | Source of data | 3,5 |
| SHAPE_COMM | N | | | Character | Comments | and River |
| Include_model | N | **0** = Not Modeled<br>**1** = Modeled | | Integer | Whether or not to model sewer segment | 1 |
| LENGTH_ft | N | Pipe length | | Real | Usually calculated by MOUSE - not used | 140.29 |
| incl_SYS | N | **0** = Not Modeled<br>**1** = Modeled | | Integer | Whether or not to model sewer segment in SYSTEM model | 1 |
| !TR | N | **0** = Not Modeled<br>**1** = Modeled | | Integer | Whether or not to model sewer segment in INTERCEPTOR model | 1 |
| MAT | N | Construction Material | | Character | From Mylar or Assumption | A_RCP |
| Size Label | N | Pipe Size Label | | Character | | 15_INCH |

## Table C-2b. Sample Data for SANLINK Coverage

| FNODE_ | TNODE_ | LPOLY_ | RPOLY_ | LENGTH | SANLINK_ | SANLINK_ID | MSLINK | SAN_NAME | PIPE_CLASS | CONSYEAR | SAN_QUAD | US_NODE | US_INV | DS_NODE | DS_INV | MOUSE_MAT | MOUSE_SHP | MOUSE_DB | MOUSE_XSEC | MATERIAL | WIDTH | HEIGHT | SOURCE | SHAPE_COMM | INCL_MODEL | INCL_SYS | INCL_INTR | LENGTH_FT | CONSMAT | SIZELABEL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 0 | 0 | 0 | 191.868 | 1 | 1 | 219 | 219 | PI | 1916 | N12 | N12N010 | 32.71 | M11N010 | 29.89 | 8 | 1 | Standard | Circular | Tile | 1.25 | 1.25 | | tile <=24" in diameter, tagged as Circ | 1 | 1 | 0 | 191.85 | A_TILE | 15_INCH |
| 0 | 0 | 0 | 0 | 169.831 | 2 | 2 | 244 | 244 | PI | 1914 | N12 | N12N040 | 28.60 | M12N010 | 27.76 | 8 | 1 | Standard | Circular | Tile | 1.25 | 1.25 | | tile <=24" in diameter, tagged as Circ | 1 | 1 | 0 | 169.85 | A_TILE | 15_INCH |
| 0 | 0 | 0 | 0 | 230.540 | 3 | 3 | 1220 | 1220 | PI | 1892 | S14 | S14N010 | 7.41 | S14N020 | 6.49 | 7 | 3 | Standard | Egg | Brick | 2.08 | 3.08 | | 30" egg:37"x25" | 1 | 1 | 1 | 230.52 | A_BRK | >19_INCH |
| 0 | 0 | 0 | 0 | 30.806 | 4 | 4 | 1224 | 1224 | PI | 1892 | S14 | S14N030 | 8.19 | S14N020 | 7.15 | 7 | 3 | Standard | Egg | Brick | 1.67 | 2.50 | | 24" brick egg:30X20 | 1 | 1 | 1 | 30.84 | A_BRK | >19_INCH |
| 0 | 0 | 0 | 0 | 254.766 | 5 | 5 | 1225 | 1225 | PI | 1892 | S14 | S14N020 | 6.49 | S14N040 | 6.11 | 7 | 3 | Standard | Egg | Brick | 2.92 | 4.33 | | 42" egg: 52"x35" | 1 | 1 | 1 | 254.75 | A_BRK | >19_INCH |
| 0 | 0 | 0 | 0 | 254.912 | 6 | 6 | 1227 | 1227 | PI | 1892 | S14 | S14N040 | 6.11 | S14N050 | 5.76 | 7 | 3 | Standard | Egg | Brick | 2.92 | 4.33 | | 42" egg: 52"x35" | 1 | 1 | 1 | 254.93 | A_BRK | >19_INCH |
| 0 | 0 | 0 | 0 | 34.887 | 7 | 7 | 1232 | 1232 | PI | 1908 | S14 | S14N060 | 7.73 | S14N050 | 7.34 | 8 | 1 | Standard | Circular | Tile | 1.25 | 1.25 | | tile <=24" in diameter, tagged as Circ | 1 | 1 | 0 | 35.11 | A_TILE | 15_INCH |
| 0 | 0 | 0 | 0 | 282.983 | 8 | 8 | 1233 | 1233 | PI | 1892 | S14 | S14N050 | 5.76 | S14N070 | 5.36 | 7 | 3 | Standard | Egg | Brick | 2.92 | 4.33 | | 42" egg: 52"x35" | 1 | 1 | 1 | 282.95 | A_BRK | >19_INCH |
| 0 | 0 | 0 | 0 | 160.780 | 9 | 9 | 1235 | 1235 | PI | 1892 | S14 | S14N070 | 5.36 | S14N080 | 4.92 | 7 | 3 | Standard | Egg | Brick | 2.92 | 4.33 | | 42" egg: 52"x35" | 1 | 1 | 1 | 160.83 | A_BRK | >19_INCH |
| 0 | 0 | 0 | 0 | 137.178 | 10 | 10 | 1239 | 1239 | PI | 1911 | S14 | S14N090 | 11.51 | S14N100 | 10.87 | 8 | 1 | Standard | Circular | Tile | 1.00 | 1.00 | | tile <=24" in diameter, tagged as Circ | 1 | 1 | 0 | 137.13 | A_TILE | 10-12_INCH |
| 0 | 0 | 0 | 0 | 31.568 | 11 | 11 | 1241 | 1241 | PI | 1911 | S14 | S14N100 | 10.87 | S14N110 | 10.55 | 8 | 1 | Standard | Circular | Tile | 1.00 | 1.00 | | tile <=24" in diameter, tagged as Circ | 1 | 1 | 0 | 31.56 | A_TILE | 10-12_INCH |
| 0 | 0 | 0 | 0 | 33.032 | 12 | 12 | 1248 | 1248 | PI | 1908 | S14 | S14N130 | 11.05 | S14N110 | 10.72 | 8 | 1 | Standard | Circular | Tile | 1.00 | 1.00 | | tile <=24" in diameter, tagged as Circ | 1 | 1 | 0 | 33.01 | A_TILE | 10-12_INCH |
| 0 | 0 | 0 | 0 | 210.650 | 13 | 13 | 1249 | 1249 | PI | 1906 | S14 | S14N110 | 10.46 | S14N140 | 7.51 | 8 | 1 | Standard | Circular | Tile | 1.25 | 1.25 | | tile <=24" in diameter, tagged as Circ | 1 | 1 | 0 | 210.67 | A_TILE | 15_INCH |
| 0 | 0 | 0 | 0 | 35.814 | 14 | 14 | 1252 | 1252 | PI | 1908 | S14 | S14N140 | 7.43 | S14N070 | 6.99 | 8 | 1 | Standard | Circular | Tile | 1.25 | 1.25 | | tile <=24" in diameter, tagged as Circ | 1 | 1 | 0 | 35.79 | A_TILE | 15_INCH |
| 0 | 0 | 0 | 0 | 158.318 | 15 | 15 | 1255 | 1255 | PI | 1906 | S14 | S14N150 | 14.35 | S14N110 | 10.46 | 8 | 1 | Standard | Circular | Tile | 1.00 | 1.00 | | tile <=24" in diameter, tagged as Circ | 1 | 1 | 0 | 158.28 | A_TILE | 10-12_INCH |
| 0 | 0 | 0 | 0 | 154.669 | 16 | 16 | 1258 | 1258 | PI | 1906 | S14 | S14N160 | 22.24 | S14N170 | 18.37 | 8 | 1 | Standard | Circular | Tile | 1.00 | 1.00 | | tile <=24" in diameter, tagged as Circ | 1 | 1 | 0 | 154.69 | A_TILE | 10-12_INCH |
| 0 | 0 | 0 | 0 | 160.911 | 17 | 17 | 1260 | 1260 | PI | 1906 | S14 | S14N170 | 18.37 | S14N150 | 14.35 | 8 | 1 | Standard | Circular | Tile | 1.00 | 1.00 | | tile <=24" in diameter, tagged as Circ | 1 | 1 | 0 | 160.92 | A_TILE | 10-12_INCH |
| 0 | 0 | 0 | 0 | 223.729 | 18 | 18 | 1263 | 1263 | PI | 1908 | S14 | S14N180 | 23.00 | S14N190 | 21.89 | 8 | 1 | Standard | Circular | Tile | 1.00 | 1.00 | | tile <=24" in diameter, tagged as Circ | 1 | 1 | 0 | 223.75 | A_TILE | 10-12_INCH |
| 0 | 0 | 0 | 0 | 174.105 | 19 | 19 | 1265 | 1265 | PI | 1908 | S14 | S14N190 | 21.89 | S14N200 | 21.01 | 8 | 1 | Standard | Circular | Tile | 1.00 | 1.00 | | tile <=24" in diameter, tagged as Circ | 1 | 1 | 0 | 174.10 | A_TILE | 10-12_INCH |
| 0 | 0 | 0 | 0 | 200.509 | 20 | 20 | 1269 | 1269 | PI | 1905 | S14 | S14N210 | 20.76 | S14N220 | 15.71 | 8 | 1 | Standard | Circular | Tile | 1.00 | 1.00 | | tile <=24" in diameter, tagged as Circ | 1 | 1 | 0 | 200.49 | A_TILE | 10-12_INCH |
| 0 | 0 | 0 | 0 | 31.539 | 21 | 21 | 1273 | 1273 | PI | 1906 | S14 | S14N230 | 15.64 | S14N220 | 15.48 | 8 | 1 | Standard | Circular | Tile | 1.25 | 1.25 | | tile <=24" in diameter, tagged as Circ | 1 | 1 | 0 | 31.54 | A_TILE | 15_INCH |
| 0 | 0 | 0 | 0 | 165.761 | 22 | 22 | 1276 | 1276 | PI | 1906 | S14 | S14N240 | 16.19 | S14N230 | 15.71 | 8 | 1 | Standard | Circular | Tile | 1.25 | 1.25 | | tile <=24" in diameter, tagged as Circ | 1 | 1 | 0 | 165.87 | A_TILE | 15_INCH |
| 0 | 0 | 0 | 0 | 292.003 | 23 | 23 | 1277 | 1277 | PI | 1903 | S14 | S14N220 | 15.48 | S14N250 | 14.10 | 8 | 1 | Standard | Circular | Tile | 1.50 | 1.50 | | tile <=24" in diameter, tagged as Circ | 1 | 1 | 1 | 292.00 | A_TILE | 16-18_INCH |
| 0 | 0 | 0 | 0 | 32.556 | 24 | 24 | 1282 | 1282 | PI | 1903 | S14 | S14N260 | 14.82 | S14N250 | 14.51 | 8 | 1 | Standard | Circular | Tile | 1.50 | 1.50 | | tile <=24" in diameter, tagged as Circ | 1 | 1 | 1 | 32.58 | A_TILE | 16-18_INCH |
| 0 | 0 | 0 | 0 | 172.954 | 25 | 25 | 1285 | 1285 | PI | 1903 | S14 | S14N270 | 16.19 | S14N260 | 15.03 | 8 | 1 | Standard | Circular | Tile | 1.25 | 1.25 | | tile <=24" in diameter, tagged as Circ | 1 | 1 | 0 | 172.91 | A_TILE | 15_INCH |

(25 of 8855 records shown)

## Table C-3a. STMNODE Coverage Data Field Definitions

| Manhole Coverage: STMNODE | | | | | |
|---|---|---|---|---|---|
| efinitions for data fields | | | | | |
| **Field Name** | **Description** | **Units** | **Format** | **Comment** | **Sample Data** |
| AREA | | | | ARC/INFO Field | |
| PERIMETER | | | | ARC/INFO Field | |
| STMNODE# | | | | ARC/INFO Field | |
| STMNODE-ID | | | | ARC/INFO Field | |
| MSLINK | Key | | Integer | Integer index field (used for digitizing) | 1178 |
| STM_NAME | Node name | | Character | | O11N315 |
| STM_XPOS | X-coordinate | NAD 83 | Real | | 950398.3 |
| STM_YPOS | Y-coordinate | NAD 83 | Real | | 677893.2 |
| STM_CLASS | **DU** = Dummy<br>**IN** = Inlet<br>**MB** = Catchbasin<br>**MC** = Chamber<br>**MH** = Manhole<br>**OF** = Outlet<br>**PC** = Proposed Catchbasin<br>**PD** = Proposed Dummy<br>**PM** = Proposed MH<br>**PO** = Proposed Outfall | | Character | | MH |
| STM_ZBTTM | Invert elevation | CGS | Real | | 33.91 |
| STM_ZGRND | Ground elevation | CGS | Real | | 42.9 |
| STM_QUAD | Name of 1"=40' Quad sheet | | Character | | O11 |
| SOURCE | **0** or **blank** = from Original transfer<br>**1** = Survey<br>**2** = Interpolated<br>**3** = Records<br>**4** = Paved Over<br>**5** = Assumed<br>**3** = Records<br>**4** = Paved Over<br><br>**9** = not being modeled | | Character | Source of data | 3 |
| IGDS_LAYER | CHAMBERS<br>DUMMY<br>INLETS<br>MANHOLE_CATCHBAS<br>MANHOLES<br>OUTFALLS<br>PROPOSED_DUMMY<br>PROPOSED_MANHOLE<br>PROPOSED_OUTFALL | | Character | | MANHOLES |
| QUESTIONS | | | Character | | Sanitary connection |

## Table C-3b. Sample Data for STMNODE Coverage

| AREA | PERIMETER | STMNODE# | STMNODE-ID | MSLINK | STM_NAME | STM_XPOS | STM_YPOS | STM_CLASS | STM_ZBTTM | STM_ZGRD | STM_QUAD | SOURCE | IGDS_LAYER | QUESTIONS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 0 | 1 | 1 | 116.000 | N11N015 | 948609.588 | 678940.533 | MH | 31.8 | 41.2 | N11 | | MANHOLES | |
| 0 | 0 | 2 | 2 | 121.000 | N11N025 | 948584.003 | 678923.353 | MH | 19.5 | 40.0 | N11 | | MANHOLES | |
| 0 | 0 | 3 | 3 | 127.000 | N11O005 | 948453.103 | 679034.412 | OF | 19.3 | 29.0 | N11 | 3 | OUTFALLS | |
| 0 | 0 | 4 | 4 | 134.000 | N11N045 | 948539.910 | 678790.965 | MH | 19.9 | 41.0 | N11 | | MANHOLES | |
| 0 | 0 | 5 | 5 | 138.000 | N11N055 | 948583.259 | 678754.961 | MH | 31.3 | 40.6 | N11 | | MANHOLES | |
| 0 | 0 | 6 | 6 | 143.000 | N11N065 | 948391.313 | 678498.482 | MC | 20.2 | 38.5 | N11 | | CHAMBERS | |
| 0 | 0 | 7 | 7 | 151.000 | N11N075 | 948456.961 | 678456.936 | MH | 26.9 | 38.8 | N11 | | MANHOLES | |
| 0 | 0 | 8 | 8 | 212.000 | M11N015 | 948311.339 | 677868.019 | MH | 36.5 | 44.0 | M11 | | MANHOLES | |
| 0 | 0 | 9 | 9 | 335.000 | N12N005 | 949508.911 | 677716.739 | MH | 43.5 | 49.8 | N12 | | MANHOLES | |
| 0 | 0 | 10 | 10 | 337.000 | N12N015 | 949634.011 | 677741.827 | MH | 42.6 | 49.5 | N12 | | MANHOLES | |
| 0 | 0 | 11 | 11 | 339.000 | N12N025 | 949896.244 | 677794.638 | MH | 41.2 | 48.0 | N12 | | MANHOLES | |
| 0 | 0 | 12 | 12 | 355.000 | N12N045 | 948950.515 | 677713.012 | MH | 43.7 | 51.7 | N12 | | MANHOLES | |
| 0 | 0 | 13 | 13 | 357.000 | N12N055 | 949097.805 | 677705.383 | MH | 42.9 | 51.0 | N12 | | MANHOLES | |
| 0 | 0 | 14 | 14 | 359.000 | N12N035 | 949296.107 | 677695.884 | MH | 41.8 | 50.9 | N12 | | MANHOLES | |
| 0 | 0 | 15 | 15 | 361.000 | N12N065 | 949381.972 | 677699.966 | MH | 41.4 | 50.8 | N12 | | MANHOLES | |
| 0 | 0 | 16 | 16 | 363.000 | N12N085 | 949430.993 | 677710.069 | MH | 25.9 | 51.0 | N12 | | MANHOLES | |
| 0 | 0 | 17 | 17 | 609.000 | N12N575 | 948358.987 | 677332.948 | MH | 33.0 | 39.0 | N12 | | MANHOLES | |
| 0 | 0 | 18 | 18 | 644.000 | N12N635 | 948798.843 | 677739.823 | MH | 44.8 | 51.3 | N12 | | MANHOLES | |
| 0 | 0 | 19 | 19 | 647.000 | N12N645 | 948532.116 | 677810.277 | MH | 42.2 | 48.0 | N12 | | MANHOLES | |
| 0 | 0 | 20 | 20 | 1178.000 | O11N315 | 950398.270 | 677893.176 | MH | 33.9 | 42.9 | O11 | | MANHOLES | |
| 0 | 0 | 21 | 21 | 341.000 | O11N115 | 950138.222 | 677844.924 | MH | 39.3 | 45.8 | O11 | | MANHOLES | |
| 0 | 0 | 22 | 22 | 1181.000 | O11N325 | 950354.884 | 677889.335 | MH | 37.0 | 43.2 | O11 | | MANHOLES | |
| 0 | 0 | 23 | 23 | 683.000 | O11N085 | 950397.450 | 677904.546 | MC | 28.9 | 42.9 | O11 | | CHAMBERS | |
| 0 | 0 | 24 | 24 | 1175.000 | O11N095 | 950449.021 | 677914.146 | MC | 29.0 | 42.0 | O11 | | CHAMBERS | |
| 0 | 0 | 25 | 25 | 1752.000 | S11N005 | 958768.283 | 677985.891 | MH | 47.3 | 54.4 | S11 | | MANHOLES | |

(25 of 6256 records shown)

# Table C-4a. STMLINK Coverage Data Field Definitions

| Pipe Coverage: STMLINK | | | | | |
|---|---|---|---|---|---|
| Definitions for data fields | | | | | |
| **Field Name** | **Description** | **Units** | **Format** | **Comment** | **Sample Data** |
| FNODE# | | | | ARC/INFO Field | |
| TNODE# | | | | ARC/INFO Field | |
| LPOLY# | | | | ARC/INFO Field | |
| RPOLY# | | | | ARC/INFO Field | |
| LENGTH | | | | ARC/INFO Field | |
| STMLINK# | | | | ARC/INFO Field | |
| STMLINK-ID | | | | ARC/INFO Field | |
| MSLINK | Key | | Integer | Integer index field (used for digitizing) | 1182 |
| STM_NAME | Feature name | | Integer | | 1182 |
| STM_USNODE | US Node name | | Character | | O11N325 |
| STM_ZUS | US invert elevation | CGS | Real | | 36.98 |
| STM_DSNODE | DS Node name | | Character | | O11N315 |
| STM_ZDS | DS invert elevation | CGS | Real | | 33.91 |
| STM_CLASS | **PI** = pipe<br>**PP** = proposed pipe | | Character | | PI |
| STM_HEIGHT | Pipe height | feet | Real | | 1.5 |
| STM_WIDTH | Pipe width | feet | Real | | 1.5 |
| STM_CONSYE | Year of construction | | Integer | | 1993 |
| STM_QUAD | Name of 1"=40' Quad sheet | | Character | | O11 |
| STM_LENGTH | Pipe length | | Real | | 43.56 |
| SOURCE | **0** or **blank** = from Original transfer<br>**1** = Survey<br>**2** = Interpolated<br>**3** = Records<br>**4** = Paved Over<br>**5** = Assumed<br>**9** = not being modeled | | Character | Source of data | 3 |
| PIPE_SHAPE | **CIRC** = circular<br>**EGG** = standard egg<br>**ELLIP** = elliptical<br>**HELLIP** = horizontal elliptical<br>**RECT** = rectangular | | Character | | CIRC |
| MATERIAL | Aluminum<br>Brick<br>Cast iron<br>Cement<br>Corrugated metal<br>Corrugated plastic<br>Corrugated steel<br>Ductile iron<br>Metal<br>Polyvinyl chloride<br>RCP slotted<br>Reinforced concrete<br>Unknown<br>Vitrified clay<br>Wood | | Character | Construction material | reinforced concrete |

# Table C-4a. STMLINK Coverage Data Field Definitions

Pipe Coverage: STMLINK

Definitions for data fields

| Field Name | Description | Units | Format | Comment | Sample Data |
|---|---|---|---|---|---|
| CONSMAT | A_BRK = assumed brick<br>A_RCP = assumed RCP<br>A_TILE = assumed tile<br>ACC = corrugated metal<br>ALU = aluminum<br>BOX = box<br>BRK = brick<br>CB = cement box<br>CCM = corrugated metal<br>CIP = cast iron<br>CMP = corrugated metal<br>CON = concrete<br>CP = corrugated plastic<br>CSP = corrugated steel<br>CUL = culvert<br>DIP = ductile iron<br>MET = metal<br>PVC = polyvinyl chloride<br>RCP = reinforced concrete<br>RCS = RCP slotted<br>TIL = tile<br>VP = vitrified clay<br>VT = vitrified tile<br>WOD = wood<br>XX = unknown | | Character | Field provides further information about specific materials, some shapes, and assumptions. | A_RCP |
| SIZELABEL | Pipe size label | | Character | | 16-18_INCH |

## Table C-4b. Sample Data for STMLINK Coverage

| FNODE# | TNODE# | LPOLY# | RPOLY# | LENGTH | STMLINK# | STMLINK-ID | MSLINK | STM_NAME | STM_USNODE | STM_ZUS | STM_DSNODE | STM_ZDS | STM_CLASS | STM_HEIGHT | STM_WIDTH | STM_CONSYE | STM_QUAD | STM_LENGTH | SOURCE | PIPE_SHAPE | MATERIAL | CONSMAT | SIZELABEL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 0 | 0 | 0 | 30.803 | 1 | 1 | 120 | 120 | N11N015 | 31.77 | N11N025 | 31.70 | PI | 0 | 2.00 | 1993 | N11 | 30.82 | | CIRC | reinforced concrete | A_RCP | >19_INCH |
| 0 | 0 | 0 | 0 | 171.648 | 2 | 2 | 122 | 122 | N11N025 | 19.51 | N11O005 | 19.28 | PI | 0 | 8.50 | 1976 | N11 | 171.66 | 3 | CIRC | reinforced concrete | A_RCP | >19_INCH |
| 0 | 0 | 0 | 0 | 143.627 | 3 | 3 | 133 | 133 | N11N045 | 19.88 | N11N025 | 19.51 | PI | 0 | 8.50 | 1976 | N11 | 143.55 | | CIRC | reinforced concrete | A_RCP | >19_INCH |
| 0 | 0 | 0 | 0 | 56.320 | 4 | 4 | 141 | 141 | N11N055 | 31.31 | N11N045 | 30.10 | PI | 0 | 1.25 | 1976 | N11 | 56.35 | | CIRC | reinforced concrete | A_RCP | 15_INCH |
| 0 | 0 | 0 | 0 | 328.674 | 5 | 5 | 142 | 142 | N11N065 | 20.24 | N11N045 | 19.88 | PI | 0 | 8.50 | 1976 | N11 | 328.71 | | CIRC | reinforced concrete | A_RCP | >19_INCH |
| 0 | 0 | 0 | 0 | 77.680 | 6 | 6 | 152 | 152 | N11N075 | 26.89 | N11N065 | 26.74 | PI | 0 | 4.50 | 1919 | N11 | 77.69 | | CIRC | brick | A_BRK | >19_INCH |
| 0 | 0 | 0 | 0 | 127.549 | 7 | 7 | 336 | 336 | N12N005 | 43.49 | N12N015 | 42.55 | PI | 0 | 1.25 | 1993 | N12 | 127.59 | | CIRC | reinforced concrete | A_RCP | 15_INCH |
| 0 | 0 | 0 | 0 | 267.515 | 8 | 8 | 338 | 338 | N12N015 | 42.55 | N12N025 | 41.23 | PI | 0 | 1.25 | 1993 | N12 | 267.50 | | CIRC | reinforced concrete | A_RCP | 15_INCH |
| 0 | 0 | 0 | 0 | 247.175 | 9 | 9 | 340 | 340 | N12N025 | 41.23 | O11N115 | 39.31 | PI | 0 | 1.50 | 1993 | N12 | 247.15 | | CIRC | reinforced concrete | A_RCP | 16-18_INCH |
| 0 | 0 | 0 | 0 | 147.510 | 10 | 10 | 356 | 356 | N12N045 | 43.72 | N12N055 | 42.85 | PI | 0 | 1.25 | 1993 | N12 | 147.49 | | CIRC | reinforced concrete | A_RCP | 15_INCH |
| 0 | 0 | 0 | 0 | 198.540 | 11 | 11 | 358 | 358 | N12N055 | 42.85 | N12N035 | 41.82 | PI | 0 | 1.25 | 1993 | N12 | 198.53 | | CIRC | reinforced concrete | A_RCP | 15_INCH |
| 0 | 0 | 0 | 0 | 85.971 | 12 | 12 | 360 | 360 | N12N035 | 41.82 | N12N065 | 41.39 | PI | 0 | 1.25 | 1993 | N12 | 85.96 | | CIRC | reinforced concrete | A_RCP | 15_INCH |
| 0 | 0 | 0 | 0 | 50.035 | 13 | 13 | 362 | 362 | N12N065 | 41.39 | N12N085 | 41.14 | PI | 0 | 1.25 | 1993 | N12 | 50.05 | | CIRC | reinforced concrete | A_RCP | 15_INCH |
| 0 | 0 | 0 | 0 | 275.833 | 14 | 14 | 646 | 646 | N12N635 | 44.80 | N12N645 | 42.24 | PI | 0 | 1.25 | 1993 | N12 | 275.87 | | CIRC | reinforced concrete | A_RCP | 15_INCH |
| 0 | 0 | 0 | 0 | 52.442 | 15 | 15 | 1176 | 1176 | O11N095 | 29.03 | O11N085 | 28.88 | PI | 0 | 6.00 | 1993 | O11 | 52.46 | | CIRC | reinforced concrete | A_RCP | >19_INCH |
| 0 | 0 | 0 | 0 | 11.404 | 16 | 16 | 1179 | 1179 | O11N315 | 34.05 | O11N085 | 28.88 | PI | 0 | 2.50 | 1993 | O11 | 11.40 | | CIRC | reinforced concrete | A_RCP | >19_INCH |
| 0 | 0 | 0 | 0 | 221.123 | 17 | 17 | 1180 | 1180 | O11N115 | 39.31 | O11N325 | 36.98 | PI | 0 | 1.50 | 1993 | O11 | 221.17 | | CIRC | reinforced concrete | A_RCP | 16-18_INCH |
| 0 | 0 | 0 | 0 | 43.548 | 18 | 18 | 1182 | 1182 | O11N325 | 36.98 | O11N315 | 33.91 | PI | 0 | 1.50 | 1993 | O11 | 43.56 | | CIRC | reinforced concrete | A_RCP | 16-18_INCH |
| 0 | 0 | 0 | 0 | 228.239 | 19 | 19 | 648 | 648 | N12N645 | 42.24 | M11N015 | 36.51 | PI | 0 | 1.25 | 1993 | N12 | 228.20 | | CIRC | reinforced concrete | A_RCP | 15_INCH |
| 0 | 0 | 0 | 0 | 53.797 | 20 | 20 | 1753 | 1753 | S11N005 | 47.27 | S11N115 | 45.90 | PI | 0 | 1.25 | 1992 | S11 | 53.85 | | CIRC | reinforced concrete | RCP | 15_INCH |
| 0 | 0 | 0 | 0 | 44.242 | 21 | 21 | 1757 | 1757 | S11N015 | 46.80 | S11N115 | 45.90 | PI | 0 | 1.25 | 1992 | S11 | 44.24 | | CIRC | reinforced concrete | RCP | 15_INCH |
| 0 | 0 | 0 | 0 | 204.045 | 22 | 22 | 1760 | 1760 | S12N315 | 62.82 | S11N015 | 49.64 | PI | 0 | 1.25 | 1992 | S12 | 204.05 | | CIRC | reinforced concrete | RCP | 15_INCH |
| 0 | 0 | 0 | 0 | 115.138 | 23 | 23 | 1761 | 1761 | S11N115 | 45.90 | S11N025 | 43.06 | PI | 0 | 1.50 | 1992 | S11 | 115.10 | | CIRC | reinforced concrete | RCP | 16-18_INCH |
| 0 | 0 | 0 | 0 | 194.964 | 24 | 24 | 1763 | 1763 | S11N025 | 43.06 | S12N005 | 40.47 | PI | 0 | 1.50 | 1992 | S11 | 194.99 | | CIRC | reinforced concrete | RCP | 16-18_INCH |
| 0 | 0 | 0 | 0 | 33.776 | 25 | 25 | 1765 | 1765 | S12N005 | 40.47 | S12N015 | 40.02 | PI | 0 | 1.50 | 1992 | S12 | 33.72 | | CIRC | reinforced concrete | RCP | 16-18_INCH |

(25 of 6168 records shown)

## Table C-5a. NHSUB Coverage Data Field Definitions

| ıtchment Coverage: NHSUB | | | | | | |
|---|---|---|---|---|---|---|
| ‿efinitions for data fields | | | | | | |
| | | | | | | |
| **Field Name** | **Used in MOUSE Model** | **Description** | **Units** | **Format** | **Comment** | **Sample Data** |
| AREA | N | | | | ARC/INFO Field | |
| PERIMETER | N | | | | ARC/INFO Field | |
| NHSUB_ | N | | | | ARC/INFO Field | |
| NHSUB_ID | N | | | | ARC/INFO Field | |
| Basin_ID | N | Basin number | | Integer | | 346 |
| Basin_Type | N | **S** = Separated<br>**P** = Partially Separated<br>**C** = Combined<br>**NS** = non-sewered area<br>**EH** = flows to East Haven | | Character | Degree of sewer separation, baseline | S |
| **Node_ID** | Y | Inlet node name | | Character | | T13N470 |
| Model_Status | N | **0** = not included in model<br>**1** = modeled | | Integer | | 1 |
| **Area_acre** | Y | Area | ac | Real | | 7.706517447 |
| **Slope_pct** | Y | Basin slope | $^{o}/_{oo}$ | Integer | | 1 |
| **Length_ft** | Y | Hydraulic length | ft | Integer | | 869 |
| **LU_Type** | Y | **1** = Green Area<br>**2** = Detached Houses<br>**3** = Town Houses<br>**4** = Semi-detached<br>**5** = City<br>**6** = Traffic Area<br>**7** = Industrial | | Integer | | 4 |
| **PE_acre** | Y | Population per Acre | PE/Acre | Integer | | 30 |
| **ɟdtl_flow** | Y | Additional flow | cfs | Real | | 0 |
| .prvs_pct | N | Impervious cover | Percent | Integer | | 40 |
| RWA_rt_cfs | N | RWA consumption rate | cfs | Real | | 0.026754847 |
| **inlet_SYS** | Y | Inlet node name for SYSTEM model | | Character | | T13N470 |
| **inlet_INTR** | Y | Inlet node name for INTERCEPTOR model | | Character | "actual" inlet may not exist in INTERCEPTOR model | T13N470 |
| Sewershed | N | B = Boulevard<br>ESH = East Shore<br>EST = East Street<br>FH = Fair Haven<br>O = other | | Character | Other is used for basins from which flow goes to East Haven or Hamden | B |
| **PCT_MOD** | Y | Impervious cover | Percent | Integer | "effective" imperviousness by basin type | 4 |
| Calibstatus | N | **S** = Separated<br>**P** = Partially Separated<br>**C** = Combined<br>**NS** = non-sewered area<br>**EH** = flows to East Haven<br>**FP**=proposed separation | | Character | Degree of sewer separation, calibration | S |

## Table C-5b. Sample Data for NHSUB Coverage

| AREA | PERIMETER | NHSUBS2# | NHSUBS2-ID | AREA__AC_ | ID | BASIN_TYPE | MODEL_STAT | SLOPE_PCT | LU_TYPE | ADDTL_FLOW | IMPRVS_PCT | RWA_RT_CFS | PE_ACRE | LENGTH_FT | INLET_SYS | INLET_INTR | SEWERSHED | PCT_MOD |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 336486.63 | 2460.35 | 2 | 1 | 7.725 | 991 | S | 1 | 17 | 3 | 0.005 | 65 | 0.000 | 11 | 1160 | K03N050 | K06N010 | B | 65 |
| 442062.84 | 2770.95 | 3 | 2 | 10.148 | 1 | S | 1 | 2 | 3 | 0.007 | 65 | 0.000 | 1 | 1330 | K03N020 | K06N010 | B | 65 |
| 604308.00 | 2990.06 | 4 | 3 | 13.873 | 2 | S | 1 | 7 | 3 | 0.009 | 65 | 0.044 | 16 | 1555 | J03N050 | K06N010 | B | 65 |
| 568488.25 | 3010.56 | 5 | 4 | 13.051 | 3 | S | 1 | 7 | 3 | 0.009 | 65 | 0.000 | 1 | 1508 | K04N020 | K06N010 | B | 65 |
| 2124045.25 | 6624.50 | 6 | 5 | 48.761 | 4 | S | 1 | 25 | 3 | 0.032 | 55 | 0.044 | 5 | 2915 | J04N060 | K06N010 | B | 55 |
| 687060.13 | 3560.54 | 7 | 6 | 15.773 | 5 | S | 1 | 3 | 3 | 0.010 | 65 | 0.245 | 81 | 1658 | K04N170 | K06N010 | B | 65 |
| 835783.19 | 4137.97 | 8 | 7 | 19.187 | 992 | S | 1 | 38 | 3 | 0.013 | 65 | 0.140 | 38 | 1828 | J04N050 | K06N010 | B | 65 |
| 690162.00 | 3407.91 | 9 | 8 | 15.844 | 6 | S | 1 | 19 | 4 | 0.010 | 61 | 0.041 | 14 | 1662 | G06N440 | G06N190 | B | 61 |
| 572825.44 | 3992.32 | 10 | 9 | 13.150 | 7 | S | 1 | 19 | 4 | 0.009 | 64 | 0.014 | 6 | 1514 | G06N150 | G06N190 | B | 64 |
| 271567.03 | 2636.11 | 11 | 10 | 6.234 | 8 | S | 1 | 35 | 4 | 0.004 | 50 | 0.009 | 7 | 1042 | G06N550 | G06N190 | B | 50 |
| 476054.56 | 3645.59 | 12 | 11 | 10.929 | 9 | S | 1 | 64 | 4 | 0.007 | 50 | 0.022 | 10 | 1380 | G06N600 | G06N190 | B | 50 |
| 525492.50 | 4350.54 | 13 | 12 | 12.064 | 10 | C | 1 | 5 | 7 | 0.008 | 69 | 0.029 | 12 | 1450 | G07N190 | G07N190 | B | 69 |
| 588103.94 | 5181.51 | 14 | 13 | 13.501 | 11 | NS | 0 | 0 | 1 | 0.000 | 13 | 0.000 | 0 | 1534 | WATER | WATER | B | 13 |
| 292100.25 | 3268.89 | 15 | 14 | 6.706 | 12 | S | 1 | 20 | 4 | 0.004 | 50 | 0.042 | 33 | 1081 | G07N300 | G06N190 | B | 50 |
| 283976.56 | 2507.52 | 16 | 15 | 6.519 | 13 | S | 1 | 29 | 4 | 0.004 | 48 | 0.010 | 8 | 1066 | H07N040 | J09N110 | B | 48 |
| 491690.25 | 3791.13 | 17 | 16 | 11.288 | 14 | S | 1 | 4 | 4 | 0.007 | 49 | 0.000 | 1 | 1402 | G07N380 | G08N270 | B | 49 |
| 610309.44 | 3912.63 | 18 | 17 | 14.011 | 15 | S | 1 | 3 | 7 | 0.009 | 72 | 0.049 | 18 | 1562 | F07N050 | G07N010 | B | 72 |
| 277242.53 | 2916.36 | 19 | 18 | 6.365 | 16 | S | 1 | 6 | 4 | 0.004 | 50 | 0.000 | 1 | 1053 | G07N330 | G08N270 | B | 50 |
| 193496.66 | 2533.45 | 20 | 19 | 4.442 | 17 | S | 1 | 10 | 4 | 0.003 | 50 | 0.000 | 1 | 880 | G07N410 | G08N270 | B | 50 |
| 1559099.63 | 5538.93 | 21 | 20 | 35.792 | 18 | P | 1 | 9 | 6 | 0.024 | 23 | 0.002 | 1 | 2497 | L08N020 | K09N120 | B | 23 |
| 347556.00 | 3057.53 | 22 | 21 | 7.979 | 19 | S | 1 | 34 | 4 | 0.005 | 50 | 0.014 | 9 | 1179 | H07N120 | J09N110 | B | 50 |
| 722148.00 | 4430.74 | 23 | 22 | 16.578 | 20 | S | 1 | 53 | 2 | 0.011 | 35 | 0.021 | 7 | 1700 | Y08N050 | W08N040 | ESH | 35 |
| 239982.61 | 2125.11 | 24 | 23 | 5.509 | 21 | S | 1 | 30 | 4 | 0.004 | 50 | 0.023 | 22 | 980 | G07N250 | J09N110 | B | 50 |
| 579961.88 | 6682.34 | 25 | 24 | 13.314 | 22 | P | 1 | 7 | 4 | 0.009 | 37 | 0.051 | 20 | 1523 | N08N070 | N08N070 | B | 37 |
| 159721.41 | 1714.53 | 26 | 25 | 3.667 | 23 | S | 1 | 53 | 2 | 0.002 | 35 | 0.004 | 6 | 799 | Y07N100 | W08N040 | ESH | 35 |

(25 of 810 records shown)

## Table C-6a. IMPCOV Coverage Data Field Definitions

| 'mpervious Cover Coverage: IMPCOV | | | | | |
|---|---|---|---|---|---|
| ,efinitions for data fields | | | | | |
| | | | | | |
| **Field Name** | **Description** | **Units** | **Format** | **Comment** | **Sample Data** |
| AREA | | | | ARC/INFO Field | |
| PERIMETER | | | | ARC/INFO Field | |
| LANDUSE# | | | | ARC/INFO Field | |
| LANDUSE-ID | | | | ARC/INFO Field | |
| LANDUSE | **CEM** = cemetery<br>**COM** = commercial<br>**HDH** = high-density housing<br>**IND** = industry<br>**LDH** = low-density housing<br>**MDH** = middle-density housing<br>**O/U** = open or undeveloped<br>**PRK** = park<br>**SCH** = school | | Character | | COM |

## Table C-6b. Sample Data for IMPCOV Coverage

| AREA | PERIMETER | LANDUSE# | LANDUSE-ID | LANDUSE |
|---|---|---|---|---|
| 6434719.23 | 19828.52 | 2 | 1 | HDH |
| 62510.23 | 981.46 | 3 | 2 | CEM |
| 17440226.00 | 35622.73 | 4 | 3 | PRK |
| 1594240.62 | 7761.36 | 5 | 4 | PRK |
| 812105.53 | 3691.30 | 6 | 5 | SCH |
| 257899.30 | 2156.38 | 7 | 6 | IND |
| 2871761.32 | 21125.52 | 8 | 7 | COM |
| 5451115.30 | 12044.02 | 9 | 8 | MDH |
| 3485024.72 | 11165.81 | 10 | 9 | CEM |
| 582163.79 | 3061.21 | 11 | 10 | COM |
| 5280567.19 | 15641.90 | 12 | 11 | SCH |
| 11050922.91 | 26067.25 | 13 | 12 | LDH |
| 2045613.60 | 8199.07 | 14 | 13 | MDH |
| 12628397.60 | 31751.72 | 15 | 14 | MDH |
| 315344.08 | 2943.76 | 16 | 15 | HDH |
| 596403.03 | 5029.23 | 17 | 17 | COM |
| 15810621.50 | 37182.26 | 18 | 18 | LDH |
| 16075917.13 | 42295.48 | 19 | 19 | MDH |
| 2050280.40 | 7639.12 | 20 | 20 | SCH |
| 6661735.79 | 15534.97 | 21 | 21 | LDH |
| 403418.23 | 2773.41 | 22 | 22 | PRK |
| 54122.68 | 954.89 | 23 | 23 | SCH |
| 1731.30 | 179.19 | 24 | 24 | SCH |
| 1293285.45 | 6877.96 | 25 | 25 | MDH |
| 112315.95 | 1360.90 | 26 | 26 | LDH |

(25 of 226 records shown)

# Table C-7a. PUMP Relational Database Data Field Definitions

| ʾump Relational Database | | | | | | |
|---|---|---|---|---|---|---|
| ˌDefinitions for data fields | | | | | | |
| | | | | | | |
| **Field Name** | **Used in MOUSE Model** | **Description** | **Units** | **Format** | **Comment** | **Sample Data** |
| ID# | N | | | Integer | | 1 |
| Location | N | Pump Station name per 1/30/96 list | | Character | | Boulevard |
| Location | N | Pump Station name per 8/7/98 list | | Character | | Boulevard |
| Pump-Link | N | ID of "PU" link in GIS | | Character | | 15622 |
| **PSNode** | Y | NODE ID | | Character | ("PS") | O23P010 |
| **DischargeTo** | Y | Dishcarge to | | Character | forcemain | O23D080 |
| WetWellInvert | N | Invert of wetwell | ft | Real | Defined in SANNODE coverage | -21.5 |
| Xsectional Area | N | Cross-sectional area of wet well | ft2 | Real | Defined in SANNODE coverage | 448 |
| **Relation** | Y | 1 = Q/H<br>2 = Q/dH | | Integer | Defines Pump Relationship | 1 |
| **NPump** | Y | Number of pumps | | Integer | | 3 |
| **Start1** | Y | Pump#1 Start | ft | Real | | -8 |
| **Stop1** | Y | Pump#1 Stop | ft | Real | | -10.3 |
| **NPts1** | Y | Number of points describing Pump#1 discharge curve | | Integer | | 2 |
| **H11** | Y | Set points for Pump#1 curve | ft | Real | | -50 |
| **Q11** | Y | Flowrates for Pump#1 curve | cfs | Real | | 17 |
| **H12** | Y | Set points for Pump#1 curve | ft | Real | | 50 |
| **Q12** | Y | Flowrates for Pump#1 curve | cfs | Real | | 17 |
| **H13** | Y | Set points for Pump#1 curve | ft | Real | | -7 |
| **Q13** | Y | Flowrates for Pump#1 curve | cfs | Real | | 16 |
| **H14** | Y | Set points for Pump#1 curve | ft | Real | | -6 |
| **14** | Y | Flowrates for Pump#1 curve | cfs | Real | | 24 |
| **.tart2** | Y | Pump#2 Start | ft | Real | | -5.8 |
| **Stop2** | Y | Pump#2 Stop | ft | Real | | -8.7 |
| **NPts2** | Y | Number of points describing Pump#2 discharge curve | | Integer | | 2 |
| **H21** | Y | Set points for Pump#2 curve | ft | Real | | -50 |
| **Q21** | Y | Flowrates for Pump#2 curve | cfs | Real | Net flowrate (P#1+P#2) | 35 |
| **H22** | Y | Set points for Pump#2 curve | ft | Real | | 50 |
| **Q22** | Y | Flowrates for Pump#2 curve | cfs | Real | Net flowrate (P#1+P#2) | 35 |
| **H23** | Y | Set points for Pump#2 curve | ft | Real | | -4.4 |
| **Q23** | Y | Flowrates for Pump#2 curve | cfs | Real | Net flowrate (P#1+P#2) | 34.5 |
| **H24** | Y | Set points for Pump#2 curve | ft | Real | | -4 |
| **Q24** | Y | Flowrates for Pump#2 curve | cfs | Real | Net flowrate (P#1+P#2) | 38 |
| **Start3** | Y | Pump#3 Start | ft | Real | | -2.8 |
| **Stop3** | Y | Pump#3 Stop | ft | Real | | -7 |
| **NPts3** | Y | Number of points describing Pump#3 discharge curve | | Integer | | 2 |
| **H31** | Y | Set points for Pump#3 curve | ft | Real | | -50 |
| **Q31** | Y | Flowrates for Pump#3 curve | cfs | Real | Net flowrate (P#1+P#2+P#3) | 53 |
| **H32** | Y | Set points for Pump#3 curve | ft | Real | | 50 |
| **Q32** | Y | Flowrates for Pump#3 curve | cfs | Real | Net flowrate (P#1+P#2+P#3) | 53 |
| **H33** | Y | Set points for Pump#3 curve | ft | Real | | -3 |
| **Q33** | Y | Flowrates for Pump#3 curve | cfs | Real | Net flowrate (P#1+P#2+P#3) | 52 |
| **H34** | Y | Set points for Pump#3 curve | ft | Real | | 10 |
| **Q34** | Y | Flowrates for Pump#3 curve | cfs | Real | Net flowrate (P#1+P#2+P#3) | 52 |

## Table C-7b. Data for PUMP Relational Database

| | LOCATION | PSNODE | DISCHARGETO | RELATION | NPUMP | START1 | STOP1 | NPTS1 | H11 | Q11 | H12 | Q12 | H13 | Q13 | H14 | Q14 | START2 | STOP2 | NPTS2 | H21 | Q21 | H22 | Q22 | H23 | Q23 | H24 | Q24 | START3 | STOP3 | NPTS3 | H31 | Q31 | H32 | Q32 | H33 | Q33 | H34 | Q34 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Boulevard | O23P010 | O23D080 | 1 | 3 | -9.000 | -10.300 | 4 | -12.000 | 2.000 | -8.500 | 9.000 | -7.000 | 16.000 | -6 | 24 | -4.800 | -5.000 | 4 | -5.000 | 27.500 | -4.600 | 30.000 | -4.4 | 34.5 | -4 | 38 | -3.400 | -3.500 | 4 | -3.5 | 41.500 | -3.200 | 52.000 | -3.000 | 52.000 | 10.000 | 52.000 |
| 2 | East Street | R19P010 | R19D040 | 1 | 2 | -7.880 | -11.680 | 4 | -14.000 | 2.000 | -9.700 | 10.500 | -8.200 | 19.000 | -6.88 | 27.75 | -6.200 | -6.500 | 4 | -6.500 | 27.800 | -5.900 | 32.400 | -5.1 | 38.7 | 10 | 44.11 | | | | | | | | | | | |
| 3 | Union/State | P17P010 | P18D040 | 1 | 2 | -5.600 | -7.000 | 2 | -50.000 | 10.667 | 50.000 | 10.667 | | | | | -4.300 | -7.000 | 2 | -50.000 | 29.111 | 50.000 | 29.111 | | | | | | | | | | | | | | | |
| 4 | Dean Street | U31P010 | U31D020 | 1 | 3 | -13.280 | -15.370 | 2 | -50.000 | 5.748 | 50.000 | 5.748 | | | | | -12.030 | -14.120 | 2 | -50.000 | 11.496 | 50.000 | 11.496 | | | | | -11.200 | -13.280 | 2 | -50.000 | 22.334 | 50.000 | 22.334 | | | | |
| 5 | Quinnipiac | W13P120 | W13D010 | 1 | 2 | -4.390 | -5.760 | 2 | -50.000 | 4.723 | 50.000 | 4.723 | | | | | -3.570 | -4.950 | 2 | -50.000 | 8.065 | 50.000 | 8.065 | | | | | | | | | | | | | | | |
| 6 | Barnes | W10P010 | W10D010 | 1 | 2 | -4.800 | -8.800 | 2 | -50.000 | 1.560 | 50.000 | 1.560 | | | | | -4.300 | -8.800 | 2 | -50.000 | 3.119 | 50.000 | 3.119 | | | | | | | | | | | | | | | |
| 7 | Grand/East | R15P020 | R15D020 | 1 | 2 | 2.430 | 1.020 | 2 | -50.000 | 0.223 | 50.000 | 0.223 | | | | | 2.970 | 1.020 | 2 | -50.000 | 0.446 | 50.000 | 0.446 | | | | | | | | | | | | | | | |
| 8 | Grand/Haven | S15P400 | S15D010 | 1 | 2 | -2.700 | -7.700 | 2 | -50.000 | 1.449 | 50.000 | 1.449 | | | | | -0.700 | -7.700 | 2 | -50.000 | 2.897 | 50.000 | 2.897 | | | | | | | | | | | | | | | |
| 9 | Long Wharf | O23P020 | O23D020 | 1 | 2 | -12.000 | -17.500 | 2 | -50.000 | 0.780 | 50.000 | 0.780 | | | | | -11.000 | -16.500 | 2 | -50.000 | 1.560 | 50.000 | 1.560 | | | | | | | | | | | | | | | |
| 10 | Mill River | R14P010 | R14D070 | 1 | 2 | -2.300 | -3.400 | 2 | -50.000 | 0.390 | 50.000 | 0.390 | | | | | -1.400 | -3.400 | 2 | -50.000 | 0.780 | 50.000 | 0.780 | | | | | | | | | | | | | | | |
| 11 | Mitchell | R11P010 | R11D040 | 1 | 2 | -2.500 | -4.200 | 2 | -50.000 | 0.892 | 50.000 | 0.892 | | | | | -0.500 | -4.200 | 2 | -50.000 | 1.783 | 50.000 | 1.783 | | | | | | | | | | | | | | | |
| 12 | Stone | J09P005 | J09D020 | 1 | 2 | 4.400 | 3.200 | 2 | -50.000 | 0.402 | 50.000 | 0.402 | | | | | 5.300 | 3.200 | 2 | -50.000 | 0.803 | 50.000 | 0.803 | | | | | | | | | | | | | | | |
| 13 | West Rock | J10P010 | J10D010 | 1 | 2 | 0.500 | -0.800 | 2 | -50.000 | 0.335 | 50.000 | 0.335 | | | | | 1.000 | -0.800 | 2 | -50.000 | 0.669 | 50.000 | 0.669 | | | | | | | | | | | | | | | |
| 14 | Woodward | S27P010 | S27D020 | 1 | 2 | 4.400 | 3.400 | 2 | -50.000 | 0.669 | 50.000 | 0.669 | | | | | 5.200 | 3.400 | 2 | -50.000 | 1.337 | 50.000 | 1.337 | | | | | | | | | | | | | | | |
| 15 | JW Murphy | R15P010 | R15D010 | 1 | 2 | -4.640 | -5.340 | 2 | -50.000 | 0.357 | 50.000 | 0.357 | | | | | -3.240 | -5.340 | 2 | -50.000 | 0.713 | 50.000 | 0.713 | | | | | | | | | | | | | | | |
| 16 | Lighthouse | S34P010 | S34D030 | 1 | 2 | -1.650 | -2.750 | 2 | -50.000 | 0.557 | 50.000 | 0.557 | | | | | -1.000 | -2.750 | 2 | -50.000 | 1.114 | 50.000 | 1.114 | | | | | | | | | | | | | | | |

## Table C-8a. WEIR Relational Database Data Field Definitions

| Weir Relational Database | | | | | |
|---|---|---|---|---|---|
| Definitions for data fields | | | | | |
| | | | | | |
| **Field Name** | **Used in MOUSE Model** | **Description** | **Units** | **Format** | **Comment** |
| NPDES | N | NPDES permit number | | Character | |
| **US_Node** | Y | Node name | | Character | |
| **DS_Node** | Y | Node name | | Character | |
| **Elevation_cgs** | Y | Crest elevation | CGS | | From regulator sketches |
| Depth_in | N | Height of weir | inches | | From regulator sketches |
| **Method** | Y | **1** = constant flow<br>**2** = weir formula<br>**3** = H/Q relationship | | Integer | |
| **Constant_flow** | Y | blank | cfs | Real | Requested by model but not really used |
| **Type** | Y | **1** = side weir<br>**2** = transverse weir<br>**3** = other | | Integer | |
| Weir_type | N | | | Character | text description of weir type |
| **Width_ft** | Y | Effective weir width | ft | Real | From regulator sketches |
| **Crest** | Y | **1** = sharp<br>**2** = broad | | Integer | |
| Crest shape | N | | | Character | Text description of weir shape |
| **No_of_values** | Y | blank | | Integer | Only used for method = 3 |
| Crest_thick_in | N | Thickness of weir | inches | Real | Used to determine "Crest" |
| Material | N | | | Character | Description of construction material |
| Notes | N | | | Character | Comments |

## Table C-8b. Data for WEIR Relational Database

| NPDES | US_NODE | DS_NODE | ELEVATION_CGS | DEPTH_IN | METHOD | CONSTANT_FLOW | TYPE | WEIR_TYPE | WIDTH_FT | CREST | CREST SHAPE | NO_OF_VALUES |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 002 | M21R002 | M21D010 | 6.1 | 60.6 | 2 | 0 | 1 | Side | 3.87 | 1 | sharp | |
| 003 | L19R003 | L19D040 | 6.35 | 46.8 | 2 | 0 | 1 | Side | 8 | 2 | broad | |
| 004 | K16R004 | K16N170 | 6.61 | 30.6 | 2 | 0 | 1 | Side | 2 | 2 | broad | |
| 004 | K16R004 | K16N170 | 6.71 | 31.8 | 2 | 0 | 1 | Side | 2 | 2 | broad | |
| 004 | K16R004 | K16N170 | 7.21 | 37.8 | 2 | 0 | 1 | Side | 2 | 2 | broad | |
| 009 | S15R009 | S15N360 | 5.2 | 19 | 2 | 0 | 1 | Side | 5.5 | 2 | broad | |
| 010 | R14R010 | R14D050 | 13 | 55.68 | 2 | 0 | 1 | Side | 3.8 | 2 | broad | |
| 010a | R14R10A | R14D040 | 13.67 | 62.4 | 2 | 0 | 1 | Side | 9.5 | 2 | broad | |
| 011 | R14R011 | R14D010 | 11.7 | 36 | 2 | 0 | 2 | Transverse | 6 | 2 | broad | |
| 013 | R09R013 | R09D010 | 21.7 | 19.2 | 2 | 0 | 2 | Transverse | 2.1 | 2 | broad | |
| 014 | P14R014 | P14D070 | 17 | 55.2 | 2 | 0 | 1 | Side | 3.7 | 2 | broad | |
| 015 | S18R015 | S18D020 | 2.1 | 37.92 | 2 | 0 | 2 | Transverse | 3.75 | 2 | broad | |
| 016 | T17R016 | T17D010 | 3.4 | 30 | 2 | 0 | 1 | Side | 3.8 | 2 | broad | |
| 018 | U13R018 | U13D010 | 8.5 | 15.6 | 2 | 0 | 2 | Transverse | 2.3 | 2 | broad | |
| 021 | R19R021 | R19D050 | 6.34 | 90 | 2 | 0 | 1 | Side | 13.6 | 1 | sharp | |
| 022 | T21R022 | T21D010 | 14.8 | 4.2 | 2 | 0 | 2 | Transverse | 2 | 2 | broad | |
| 024 | O23R024 | O23D030 | 3.6 | 60 | 2 | 0 | 2 | Transverse | 13.5 | 2 | broad | |
| 025 | P18R25A | P18D030 | 4.2 | 18 | 2 | 0 | 2 | Transverse | 4 | 2 | broad | |
| 025b | O17R25B | O17D010 | 12.7 | 36 | 2 | 0 | 1 | Side | 6.6 | 2 | broad | |

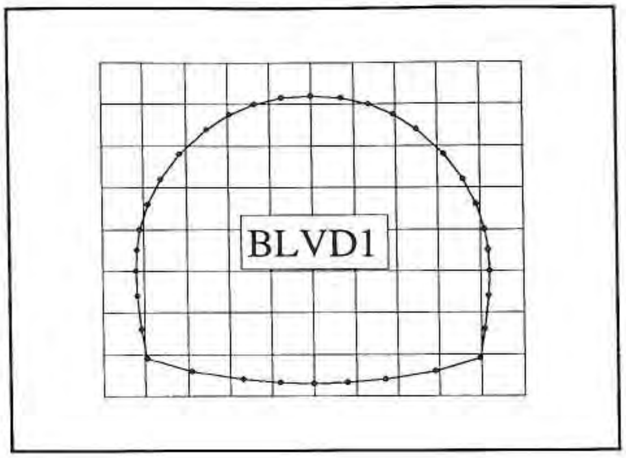
# Appendix D
# Coded Cross Sections in Mouse

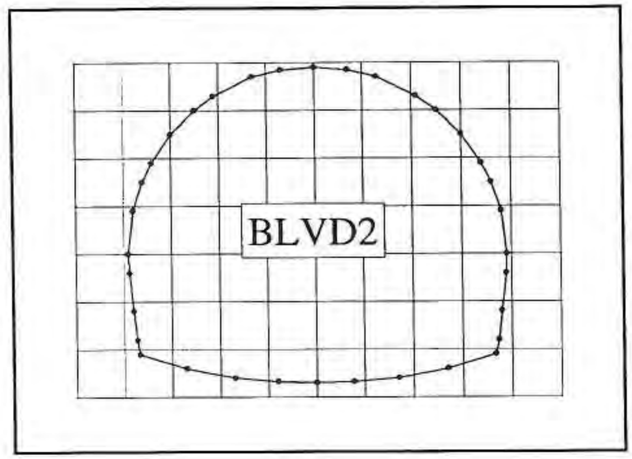
Various cross sections were defined for the sewers in New Haven. Table D-1 lists the location of the 22 special shapes that were defined in the MOUSE hydraulic model. Table D-2 lists the location and depth of sediment that was used to define sewers with sediment deposited in their invert. Plots of each section are provided at the end of this Appendix.

## Special Cross Sections

**Table D-1. Special Cross Sections Used in the New Haven Model**

| Name | Location | Shape | Size | Comment |
|---|---|---|---|---|
| BLVD1 | Boulevard - outfall/Hallock | horseshoe | 84"W x 69"H | |
| BLVD2 | Boulevard - Greenwich/Kimberly | horseshoe | 78"W x 66"H | |
| BLVD3 | Boulevard - Kimberly/Lamberton | horseshoe | 78"W x 64"H | |
| BLVD4 | Boulevard - Lamberton/Washington | ellipse | 102"W x 62"H | |
| BLVD5 | Boulevard - Washington/Legion | horseshoe | 72"W x 64"H | |
| BLVD7 | Boulevard - Legion/Derby | horseshoe | 63"W x 60"H | |
| BLVD8 | Boulevard - Edgewood/Whalley | horseshoe | 66"W x 63"H | |
| BLVD9 | Boulevard - Hallock/Greenwich | horseshoe | 78"W x 69"H | |
| BLVD10 | Boulevard - Derby/Edgewood | horseshoe | 60"W x 57"H | same as WHLY1 |
| EAST1 | East St | arch | 60"W x 60"H | |
| ELLIP | Blake | ellipse | 45"W x29"H | |
| FRNT1 | Front St – River/Pine | box | 52"W x (17.5") 30"H | |
| FRNT2 | Front St – Pine/Middletown | box | 48"W x (17.5") 28"H | |
| LEGN1 | Boulevard/Legion overflow | box | 60"W x 36"H | |
| PPLR1 | Poplar St | horseshoe | 60"W x 48"H | |
| RECT1 | Whalley/Fitch overflow | rectangle | 35"W x 30"H | |
| RECT2 | Boulevard/Lamberton overflow | rectangle | 54"W x 30"H | |
| RECT3 | Siphon under sewers | rectangle | 45"W x29"H | |
| RECT4 | Siphon under sewers | rectangle | 23"W x 14"H | |
| STAT1 | State St overflows | box | 72"W x 48"H | |
| STAT2 | Union/State overflow | arch | 48"W x 60"H | |
| WHLY1 | Whalley – Boulevard /Fitch | horseshoe | 60"W x 57"H | same as BLVD10 |


BLVD1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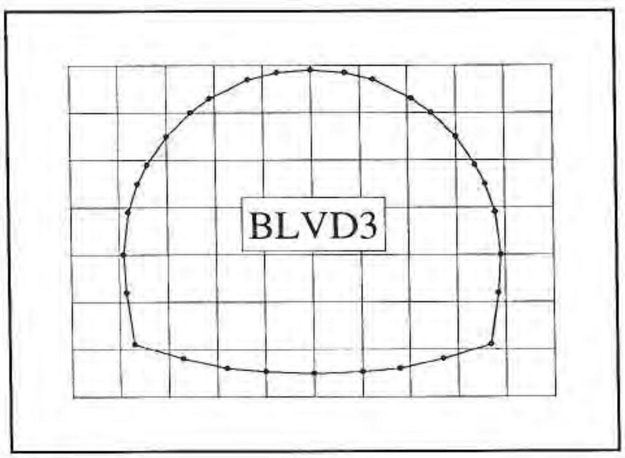
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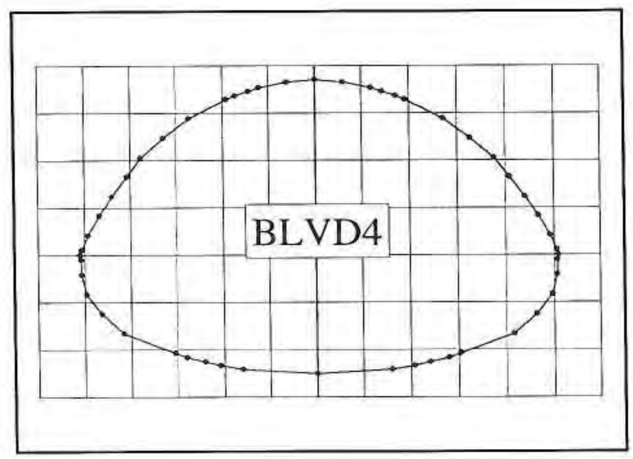
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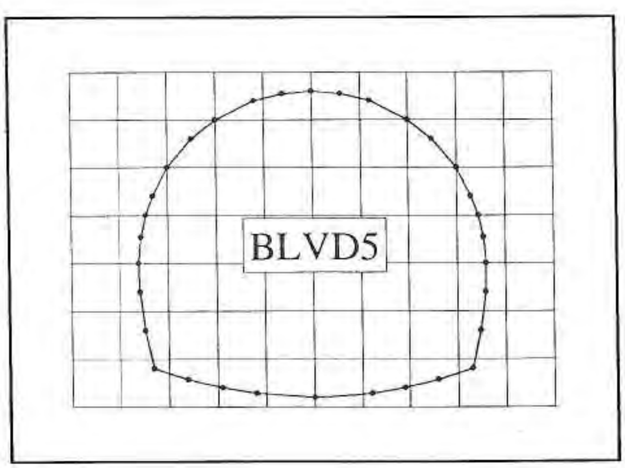
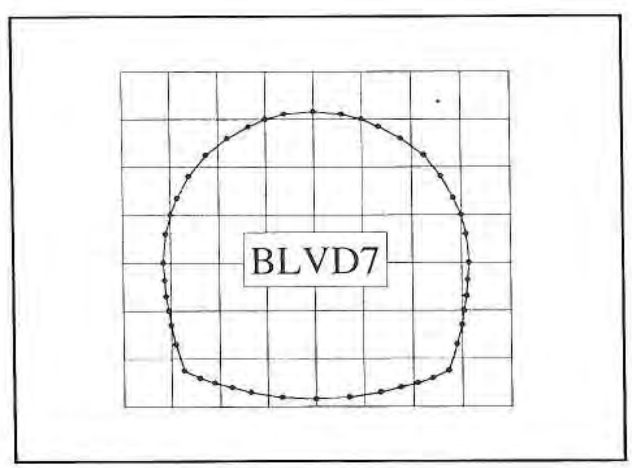

BLVD5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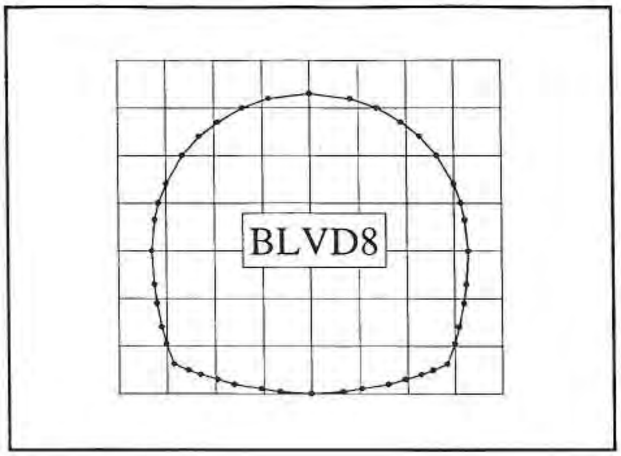
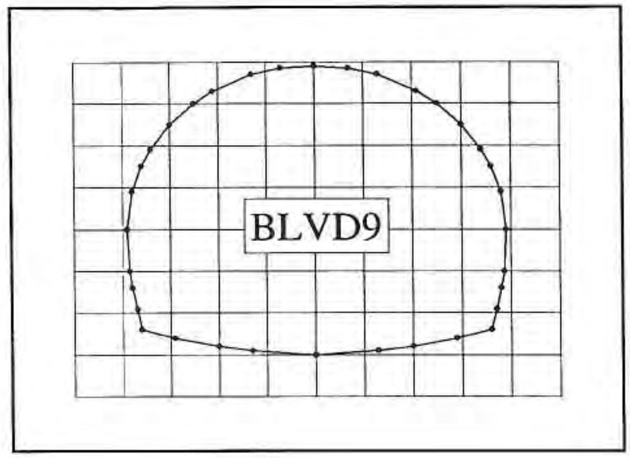
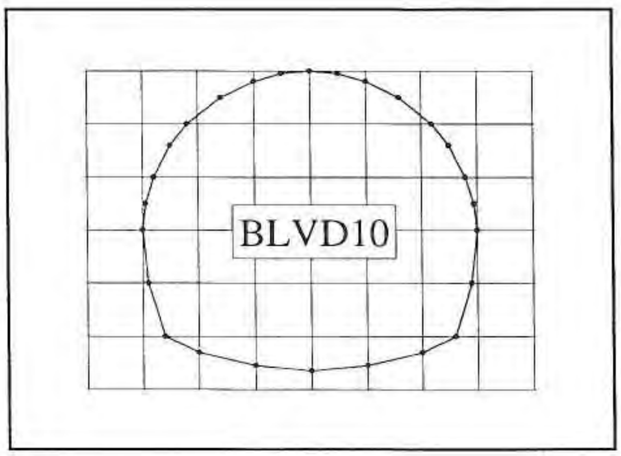
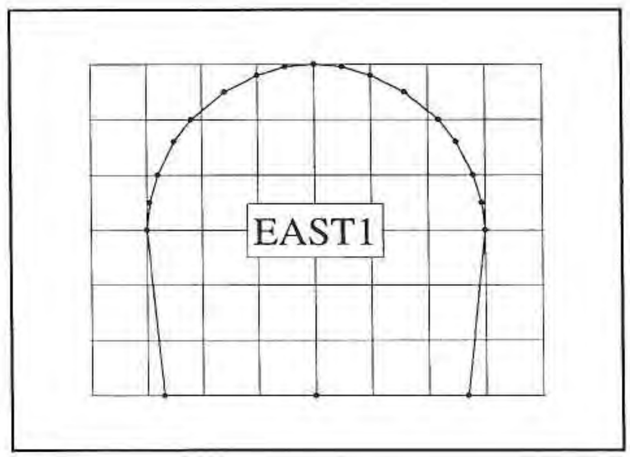
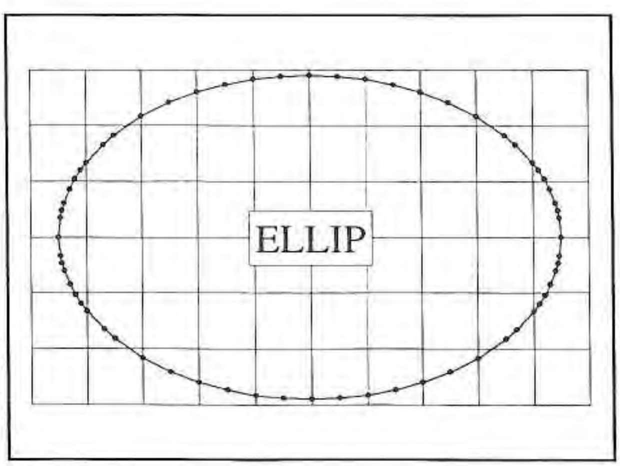
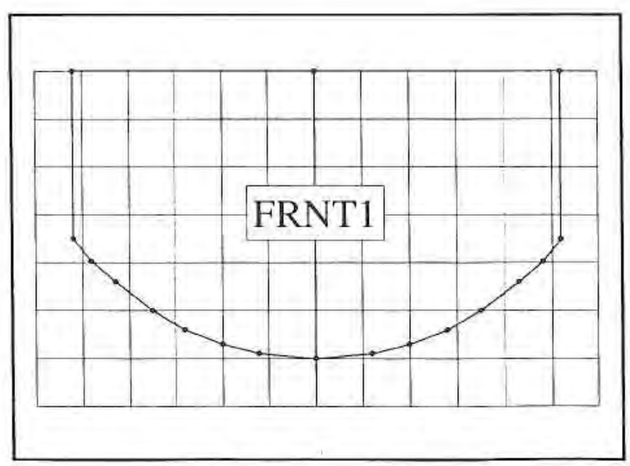
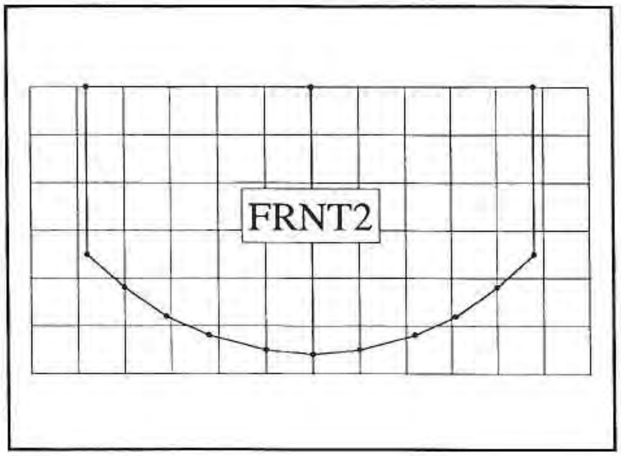
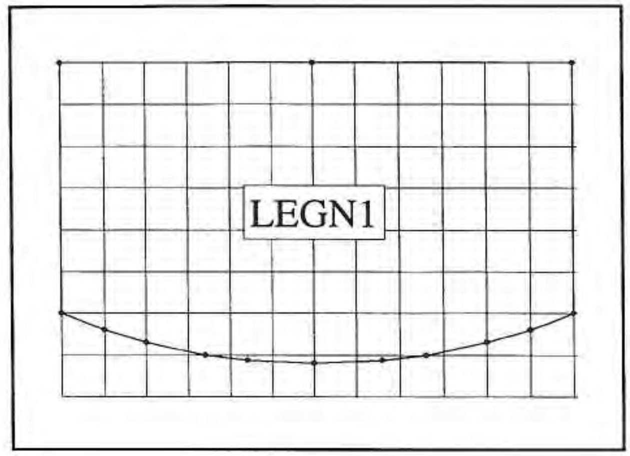
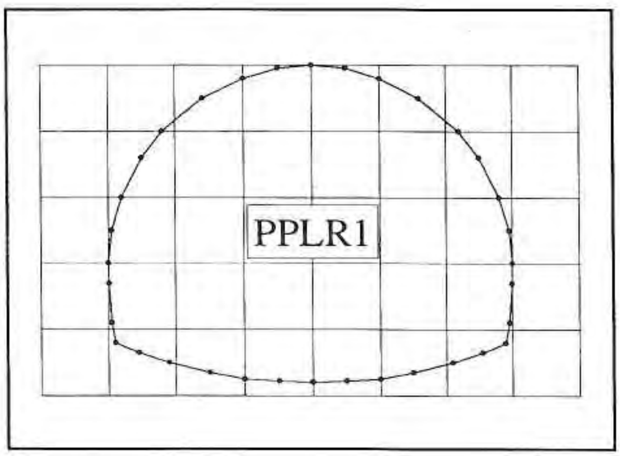
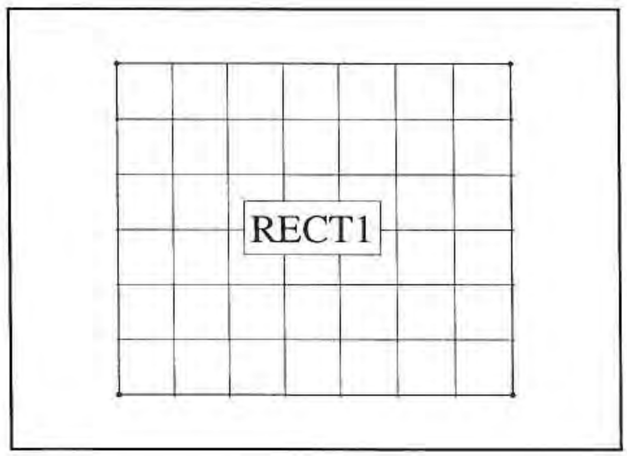
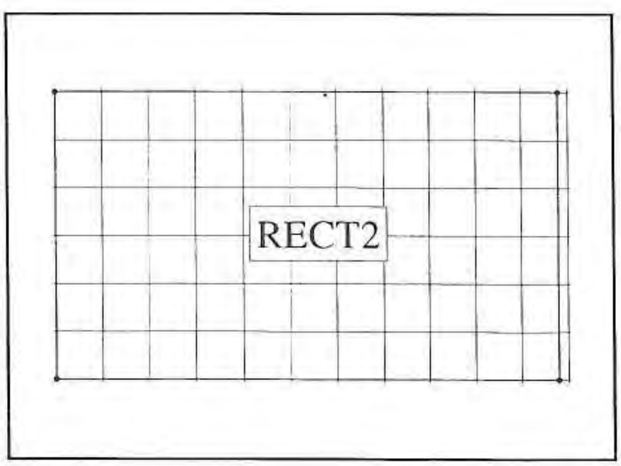

BLVD8

BLVD9

BLVD10

EAST1

ELLIP

FRNT1

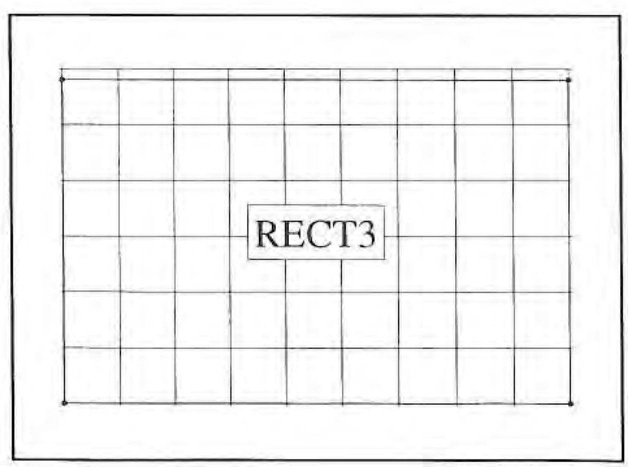

FRNT2


LEGN1


PPLR1


RECT1


RECT2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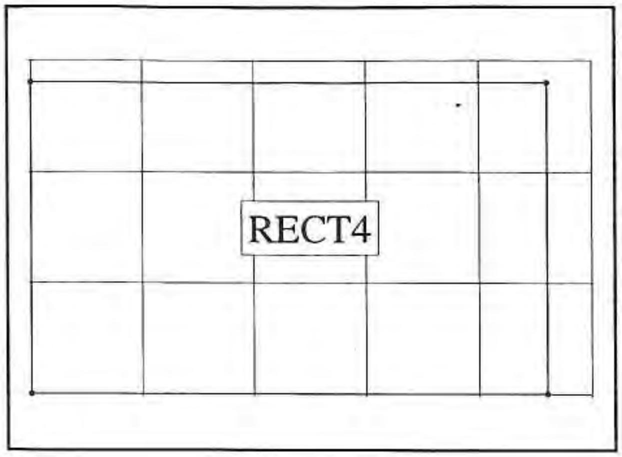
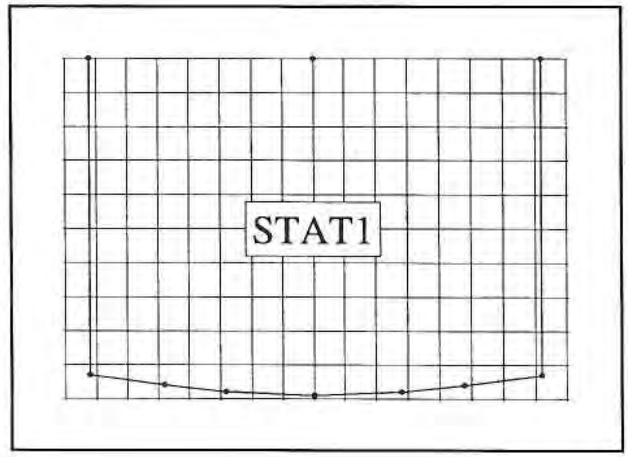
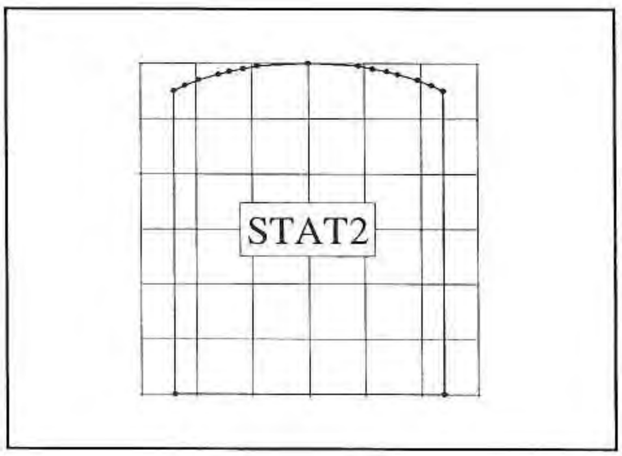
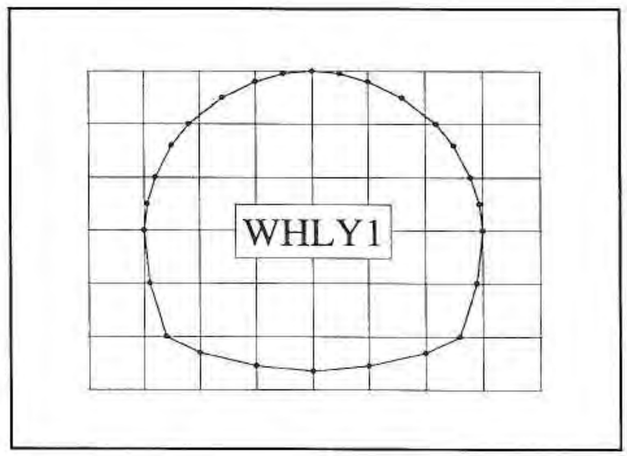

RECT4


STAT1

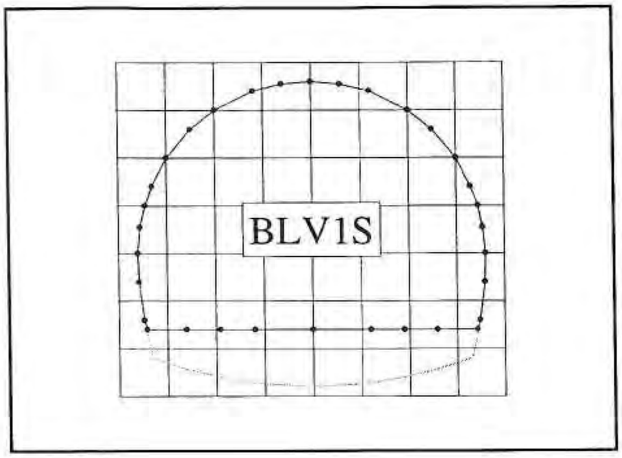

STAT2

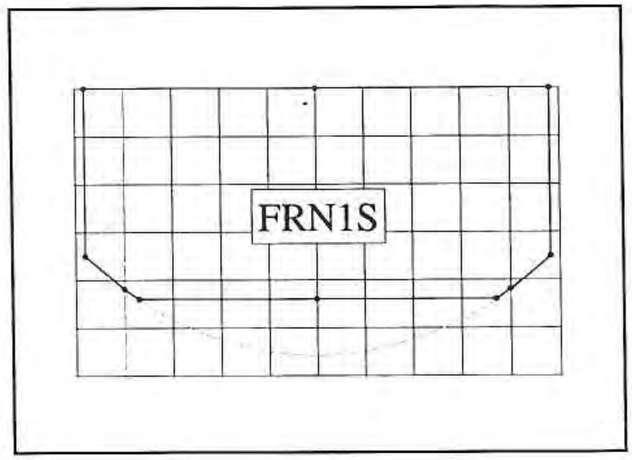

WHLY1

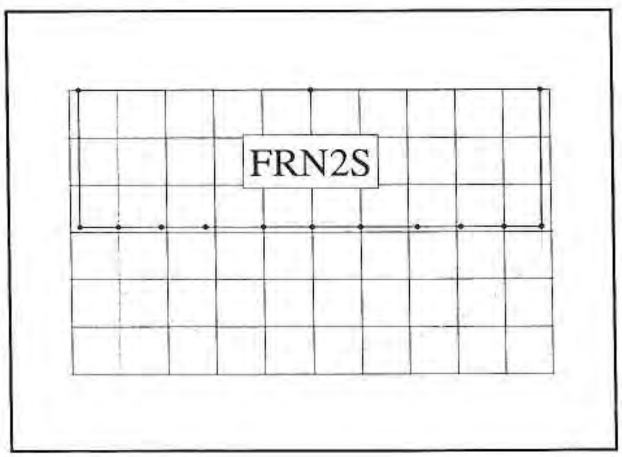
# Modified Cross Sections with Sediment Deposition

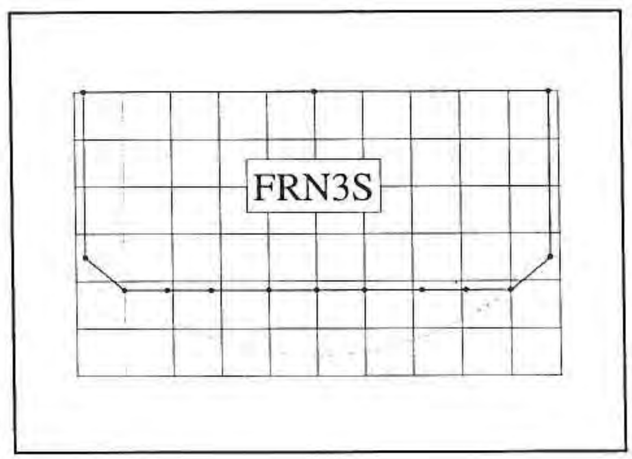
**Table D-2. Sediment Depths Included in the New Haven Model**

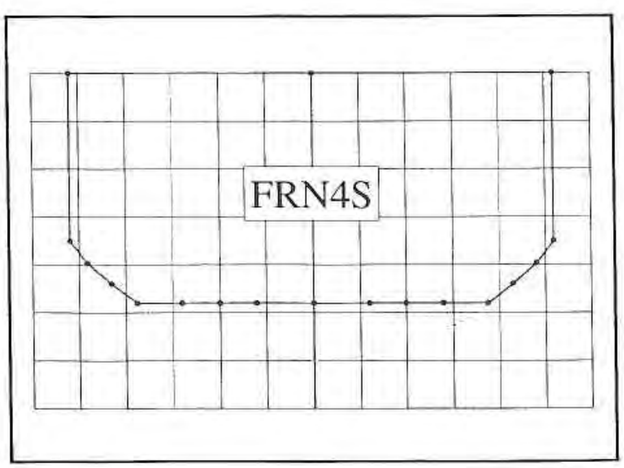
| Name | Location | Pipe Size and Shape | Sediment Depth |
|---|---|---|---|
| BLV1S | Boulevard – from cemetery inflow to next downstream manhole (near Orange Ave) | 5.3'H x 6'W modified horseshoe | 12" |
| FRN1S | Front St – near Dover Dr and near Pine St | 2.3'H x 4.0'W modified box | 6" |
| FRN2S | Front St – near Lombard St | 2.3'H x 4.0'W modified box | 13.5" |
| FRN3S | Front St – near Chatham St | 2.3'H x 4.0'W modified box | 7" |
| FRN4S | Front St – near Pine St and near Grand Ave | 2.5'H x 4.3'W modified box | 6" |
| FRN5S | Front St – near Lewis St | 2.5'H x 4.3'W modified box | 8.5" |
| FRN6S | Front St – near River St | 2.5'H x 4.3'W modified box | 12" |
| JMS1S | James St – Chapel St to River St | 4.3'H x 2.9'W egg | 12" |
| RVR1S | River St – between Front St and Poplar St | 4.3'H x 2.9' W egg | 11" |
| RVR2S | River St – at Poplar St | 42" round | 11" |
| RVR3S | River St – from Poplar St to between Blatchley Ave and Lloyd St | 54" round | 13" |
| RVR4S | River St – from between Blatchley Ave and Lloyd St to James St | 60" round | 18" |
| WHL1S | Whalley Ave – West Rock Ave to West River | 3.1'H x 2.1'W egg | 4" |
| WHL2S | Whalley Ave – West River to Fitch St | 36" round | 8" |
| WHL3S | Whalley Ave – Fitch St to Osborn Ave | 4.75'H x 5'W modified horseshoe | 12" |

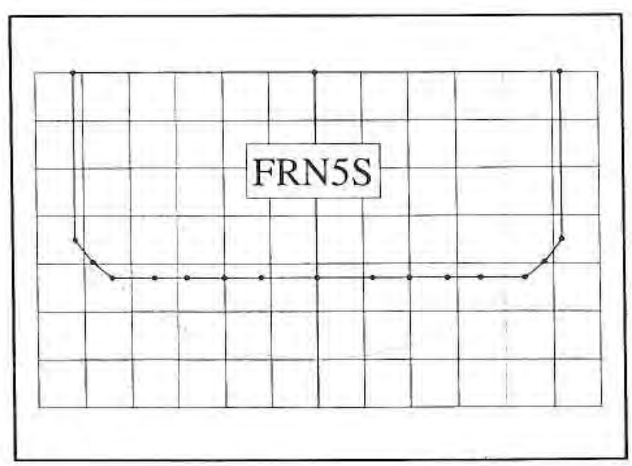

BLV1S

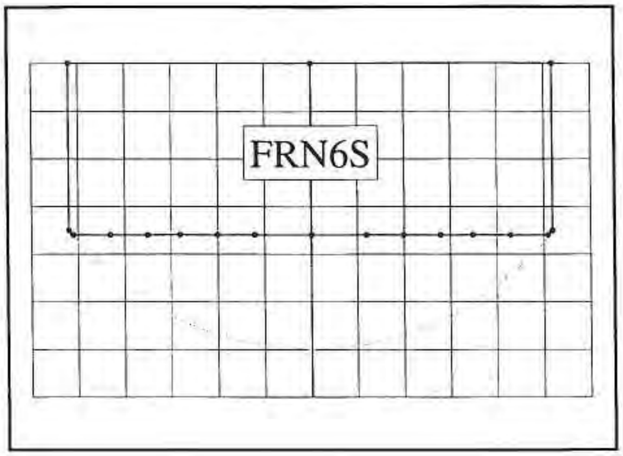

FRN1S

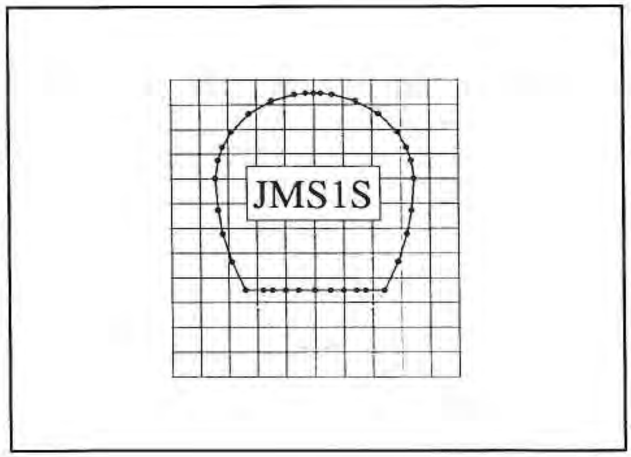

FRN2S

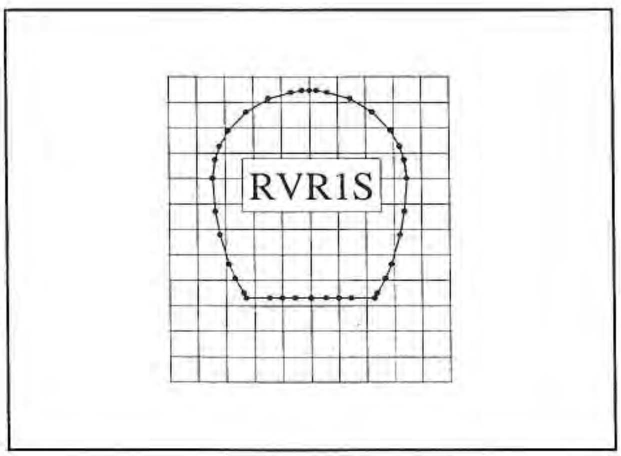

FRN3S

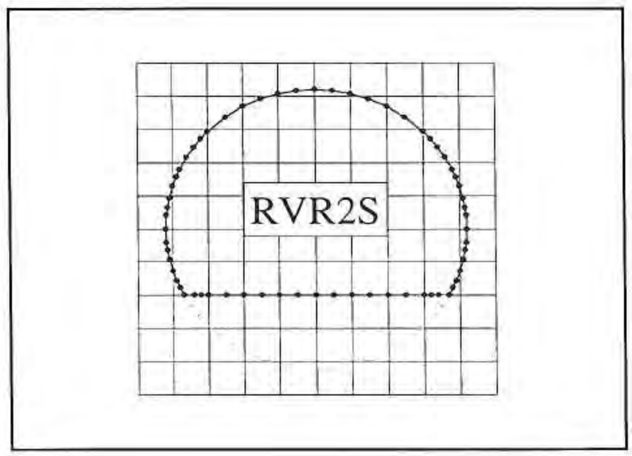

FRN4S

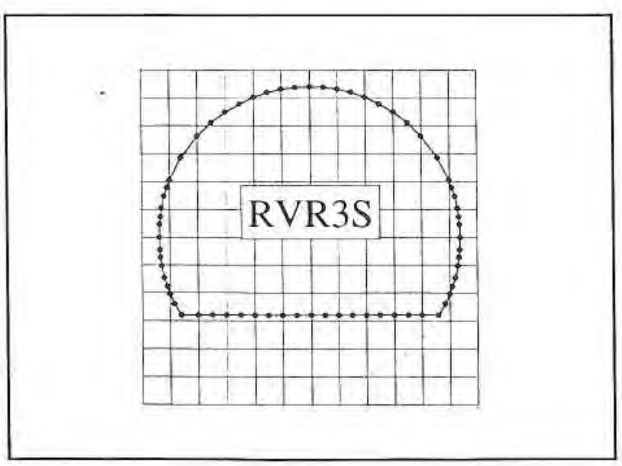

FRN5S

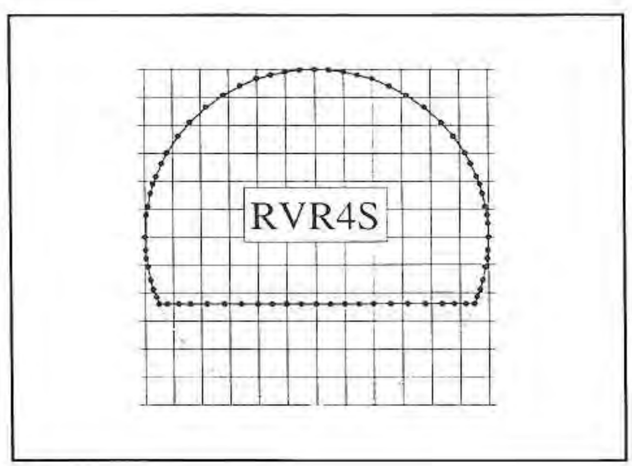

FRN6S

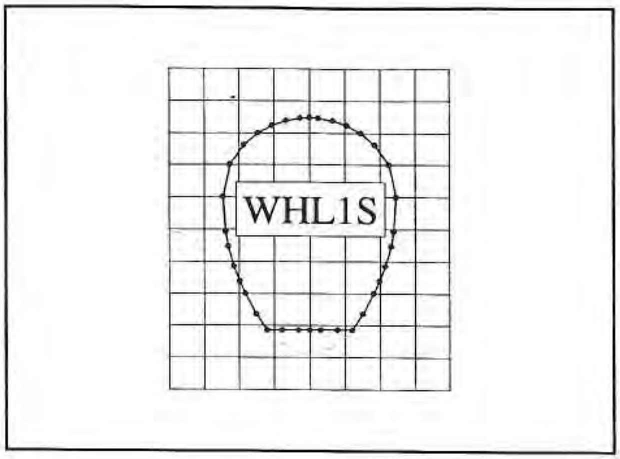

JMS1S

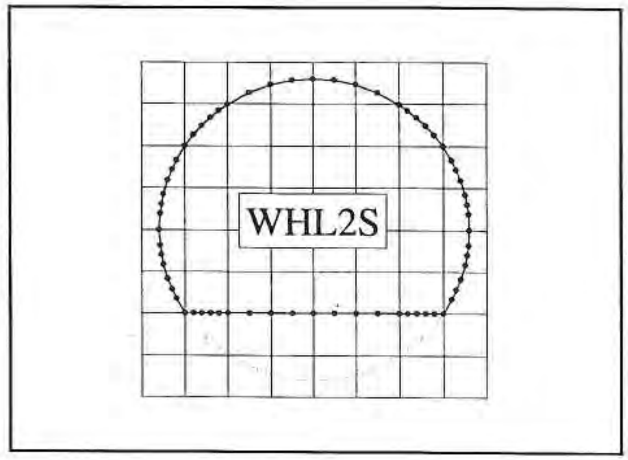

RVR1S

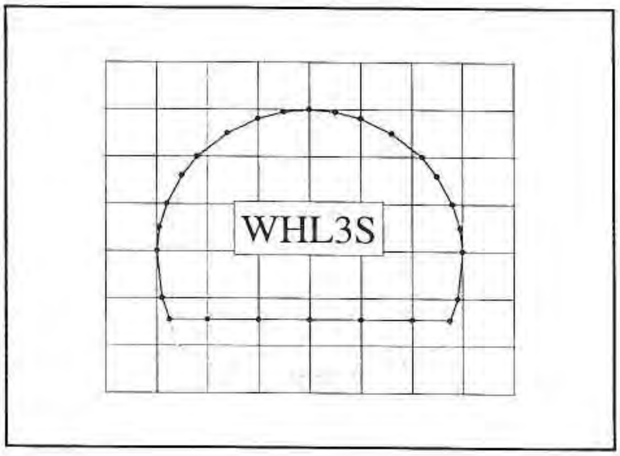

RVR2S


RVR3S


RVR4S


WHL1S


WHL2S


WHL3S

# Appendix E
# Calibration Hydrographs

Calibration hydrographs comparing modeled and metered flows for dry weather and each calibration storm are presented in this appendix. The individual simulations are separated by blue sheets. Within each simulation, the graphs are generally presented in order from the outlet of the three major sewersheds moving upstream. Where applicable, both interceptor and overflow hydrographs are presented. For the dry-weather flow simulation, no overflow plots are presented. Figure E-1 shows a schematic of the system, and the following list indicates the order:

- WPAF

**BOULEVARD SEWERSHED**

- Boulevard Pump Station
- 024 – interceptor and overflow
- 002 – interceptor and overflow
- 003 – interceptor and overflow
- 004 – interceptor and overflow
- 005 – interceptor and overflow
- 006 – interceptor and overflow
- NH01 (Fountain St)
- NH02 (Route 15)
- NH12 (Brookside Ave)
- 008 – interceptor and overflow
- NH03 (Dixwell Ave)

**EAST STREET SEWERSHED**

- East Street Pump Station
- 021 – interceptor and overflow
- 025 – overflow
- George/Temple – interceptor and overflow
- 011 – overflow
- 014 – interceptor and overflow
- NH04 (Winchester Ave)
- 010 – interceptor and two overflows
- 012 – overflow
- 013 – overflow
- NH05 (Whitney Ave)
- NH11 (East Rock Rd)

**EAST SHORE SEWERSHED**

- East Shore Pump Station
- 015 – interceptor and overflow
- 016 – overflow
- 019 – interceptor and overflow
- 018 – interceptor and overflow
- 009 – interceptor and overflow
- 020 – interceptor and overflow
- NH07 (Eastern St)
- NH06 (Old Foxon Rd)
- 022 – interceptor and overflow
- NH09 and NH10 (Dean St)

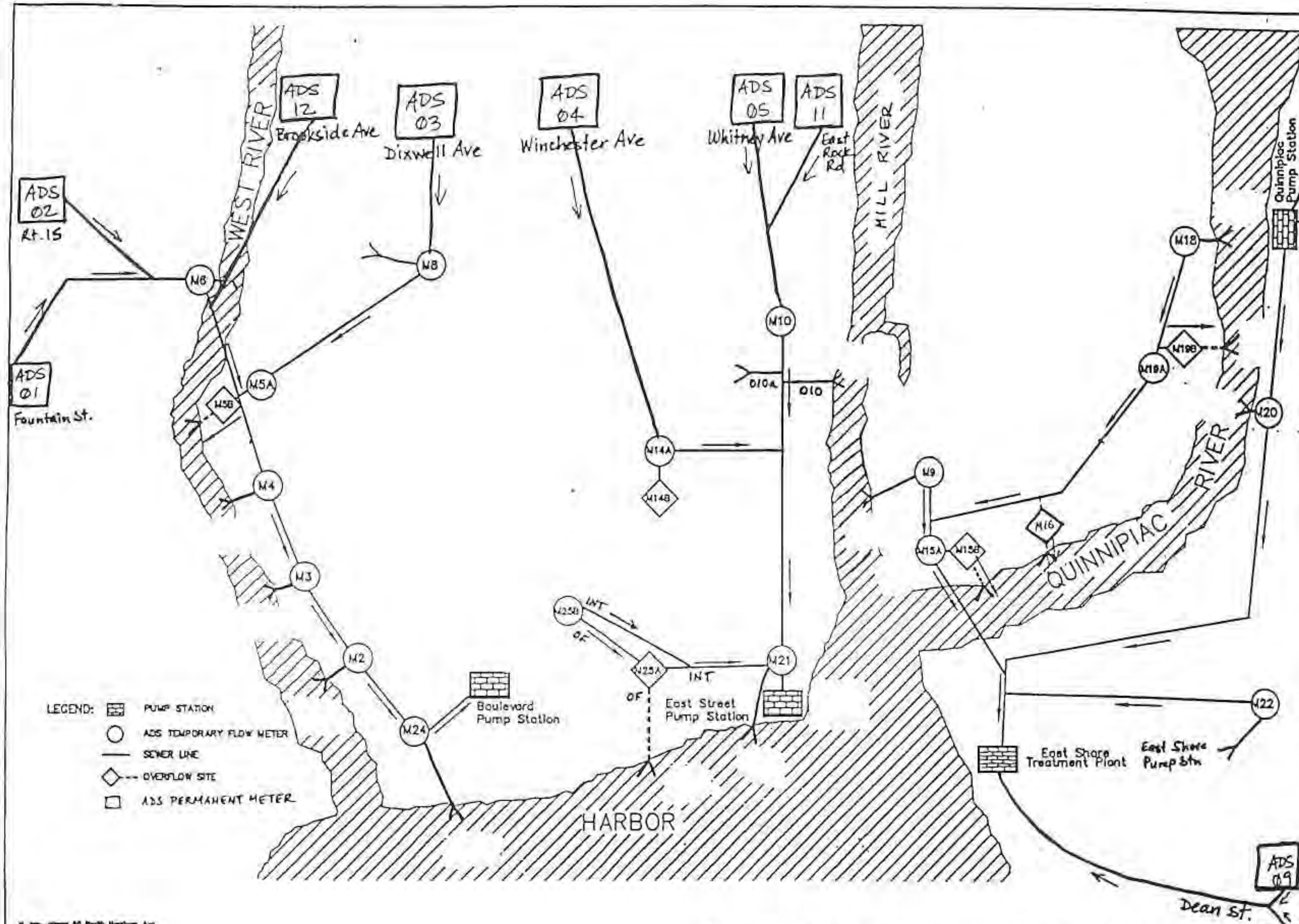
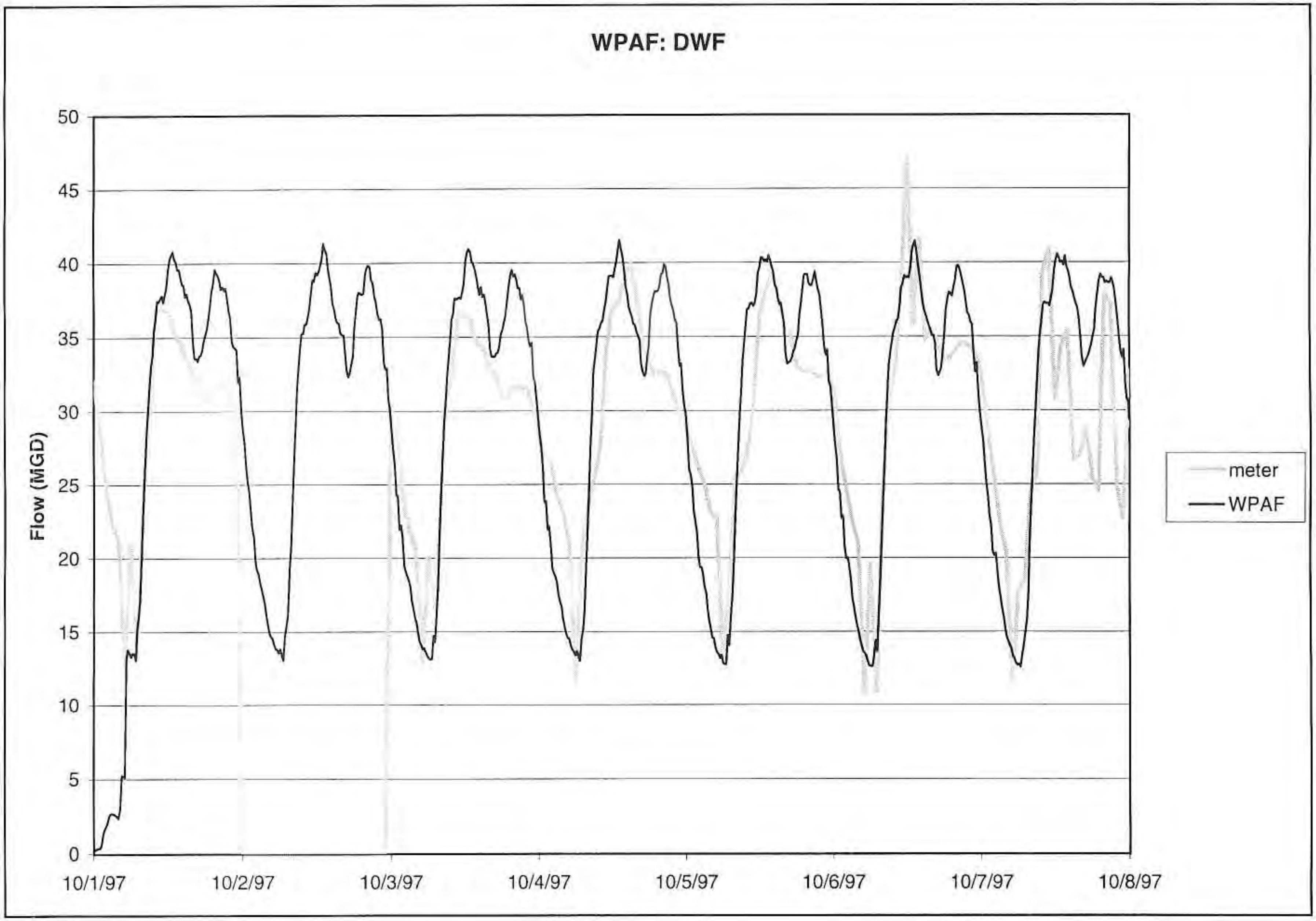
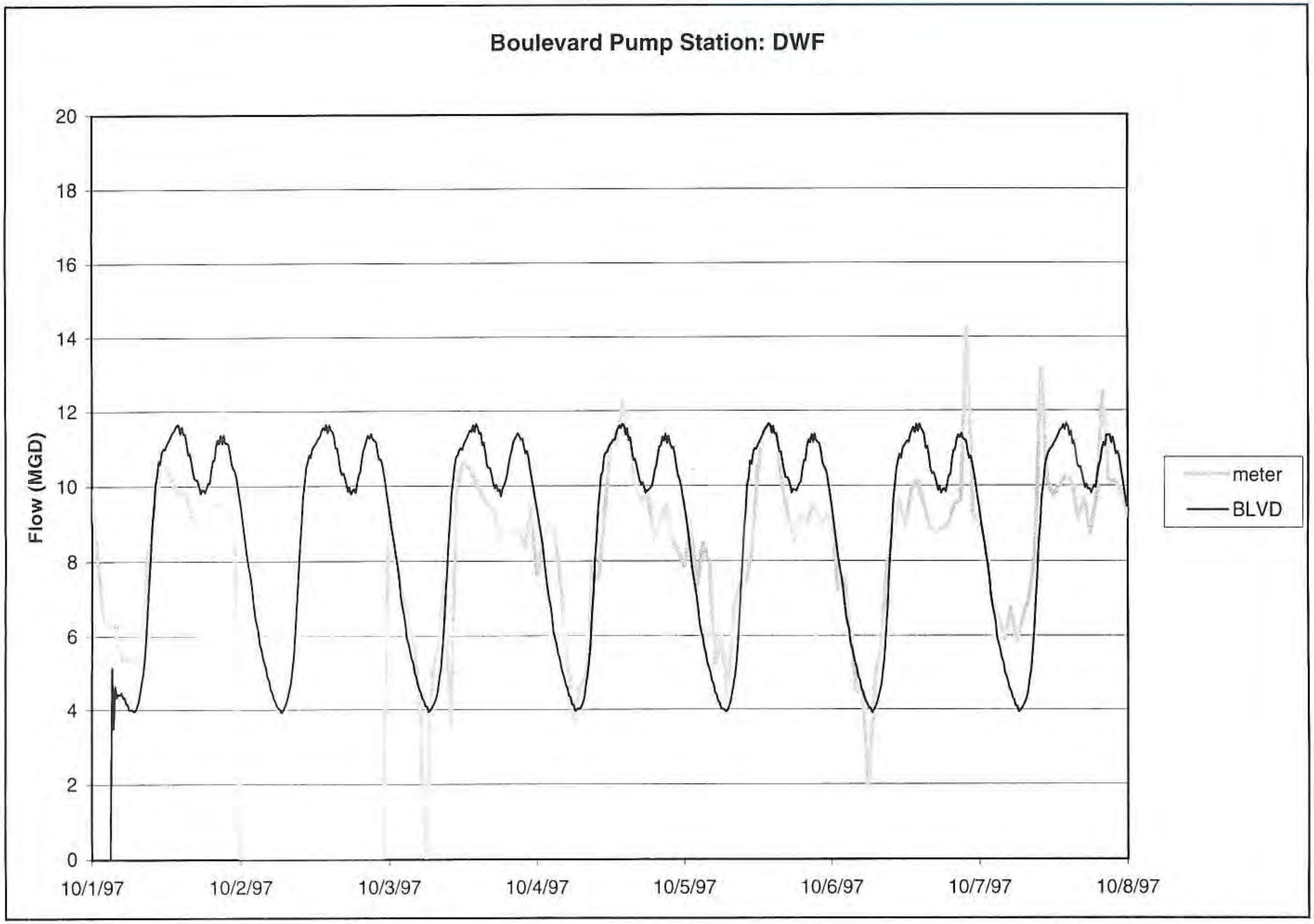



*Figure E-1* Flow Monitoring Network Schematic

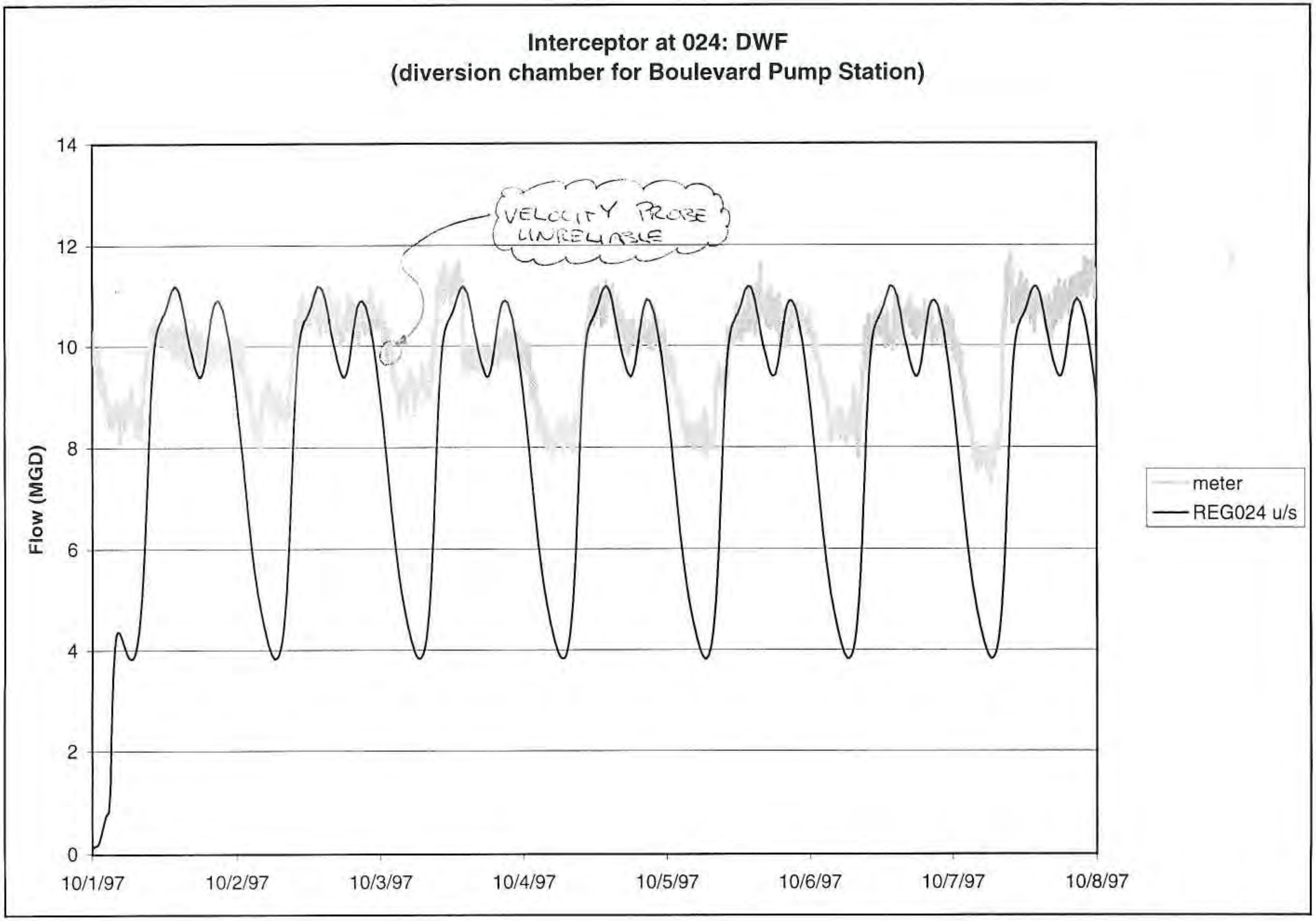
CH2MHILL

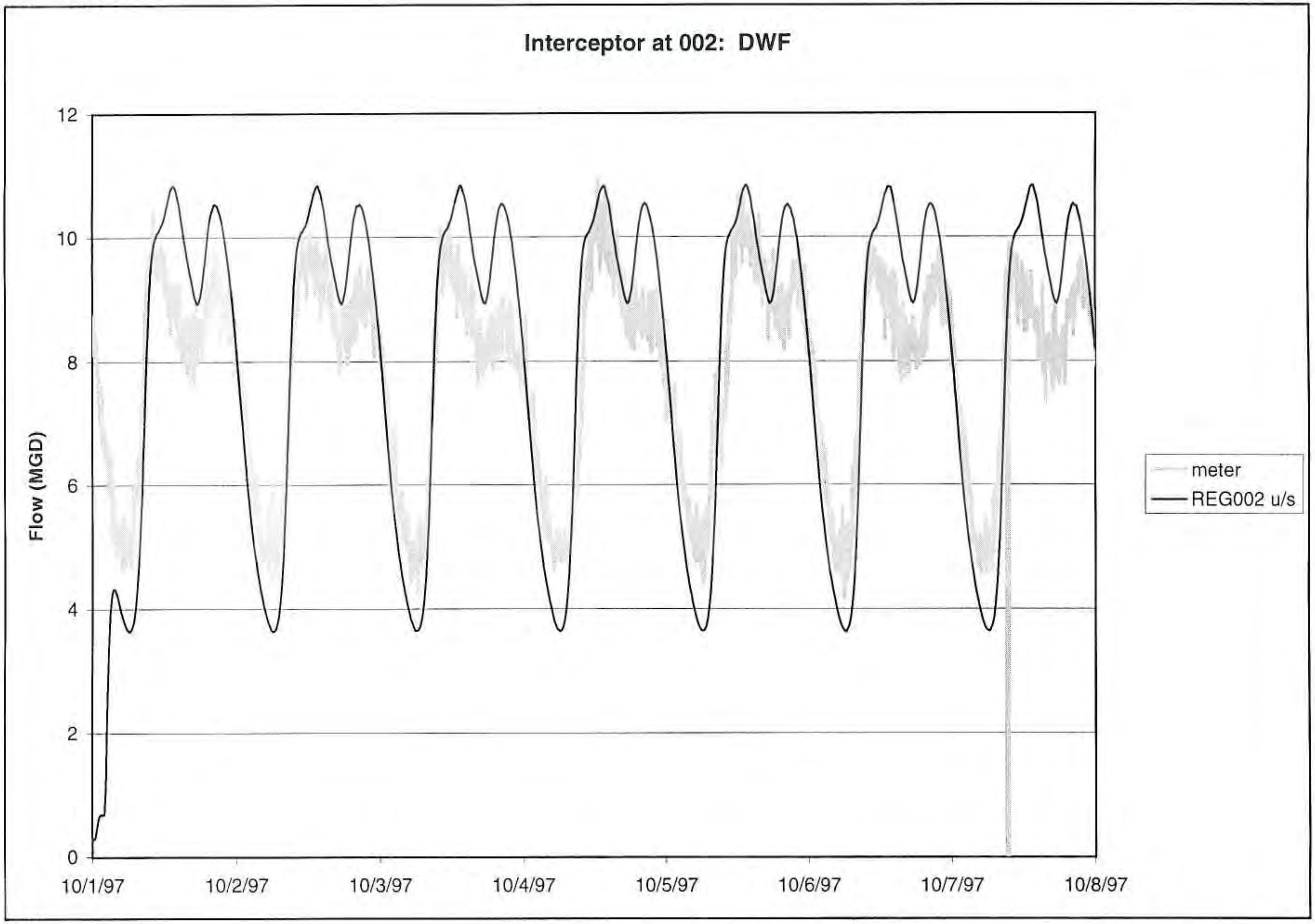
# Dry Weather Flow

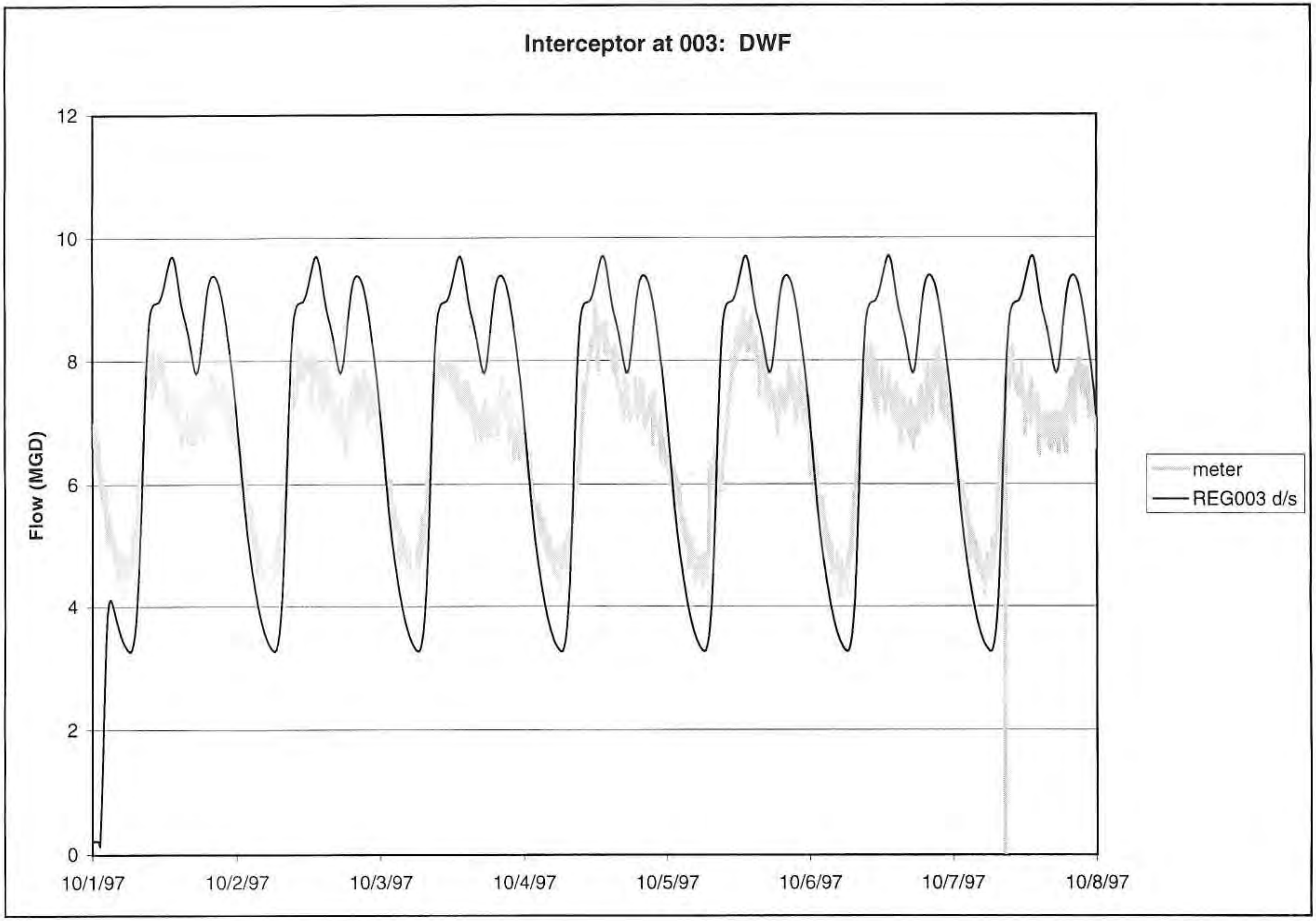

WPAF: DWF
Flow (MGD)
50
45
40
35
30
25
20
15
10
5
0
10/1/97
10/2/97
10/3/97
10/4/97
10/5/97
10/6/97
10/7/97
10/8/97
meter
WPAF



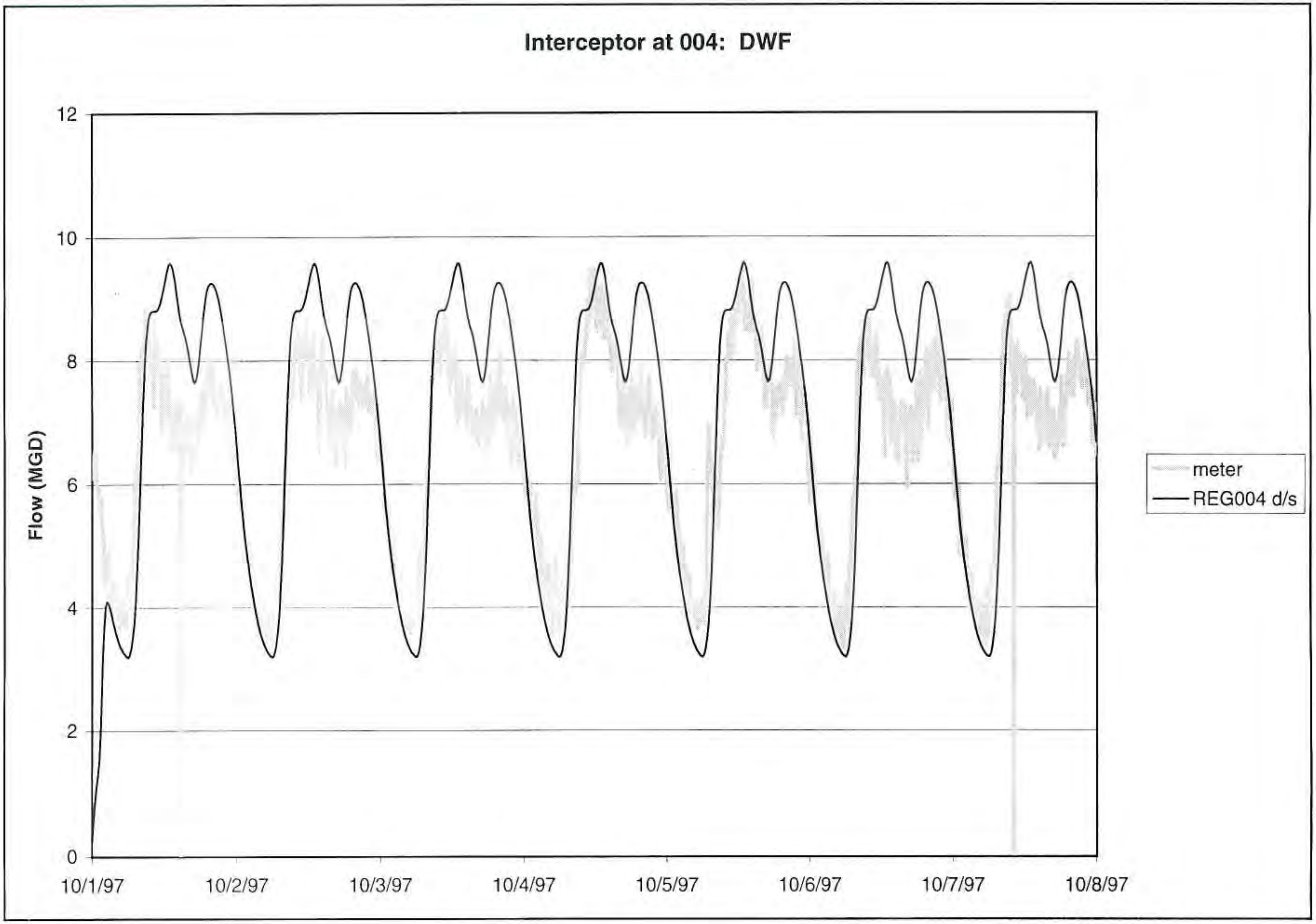
Boulevard Pump Station: DWF
Flow (MGD)
20
18
16
14
12
10
8
6
4
2
0
10/1/97
10/2/97
10/3/97
10/4/97
10/5/97
10/6/97
10/7/97
10/8/97
meter
BLVD

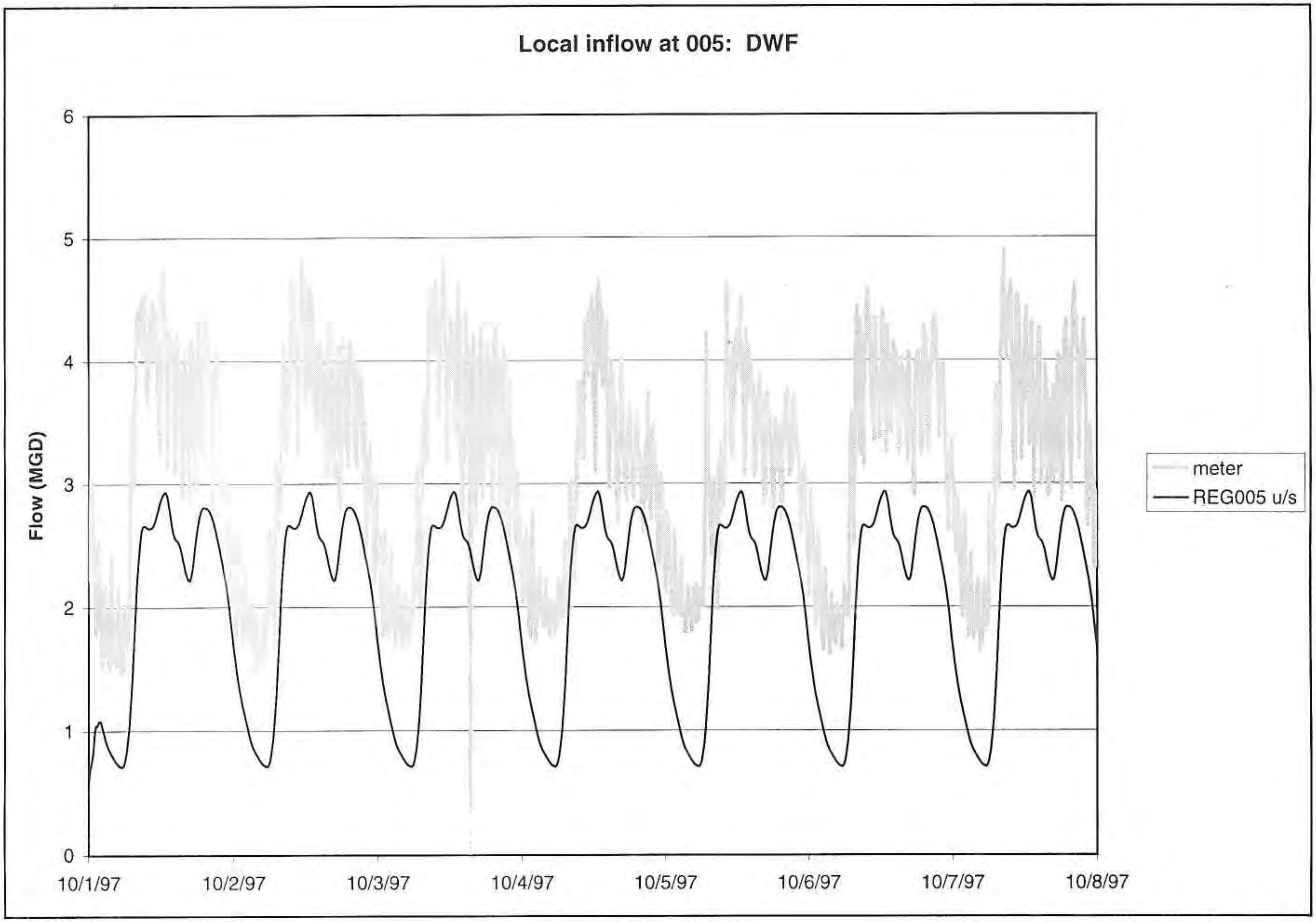

Interceptor at 024: DWF
(diversion chamber for Boulevard Pump Station)
VELOCITY PROBE UNRELIABLE
Flow (MGD)
14
12
10
8
6
4
2
0
10/1/97
10/2/97
10/3/97
10/4/97
10/5/97
10/6/97
10/7/97
10/8/97
meter
REG024 u/s


Interceptor at 002: DWF
Flow (MGD)
12
10
8
6
4
2
0
10/1/97
10/2/97
10/3/97
10/4/97
10/5/97
10/6/97
10/7/97
10/8/97
meter
REG002 u/s

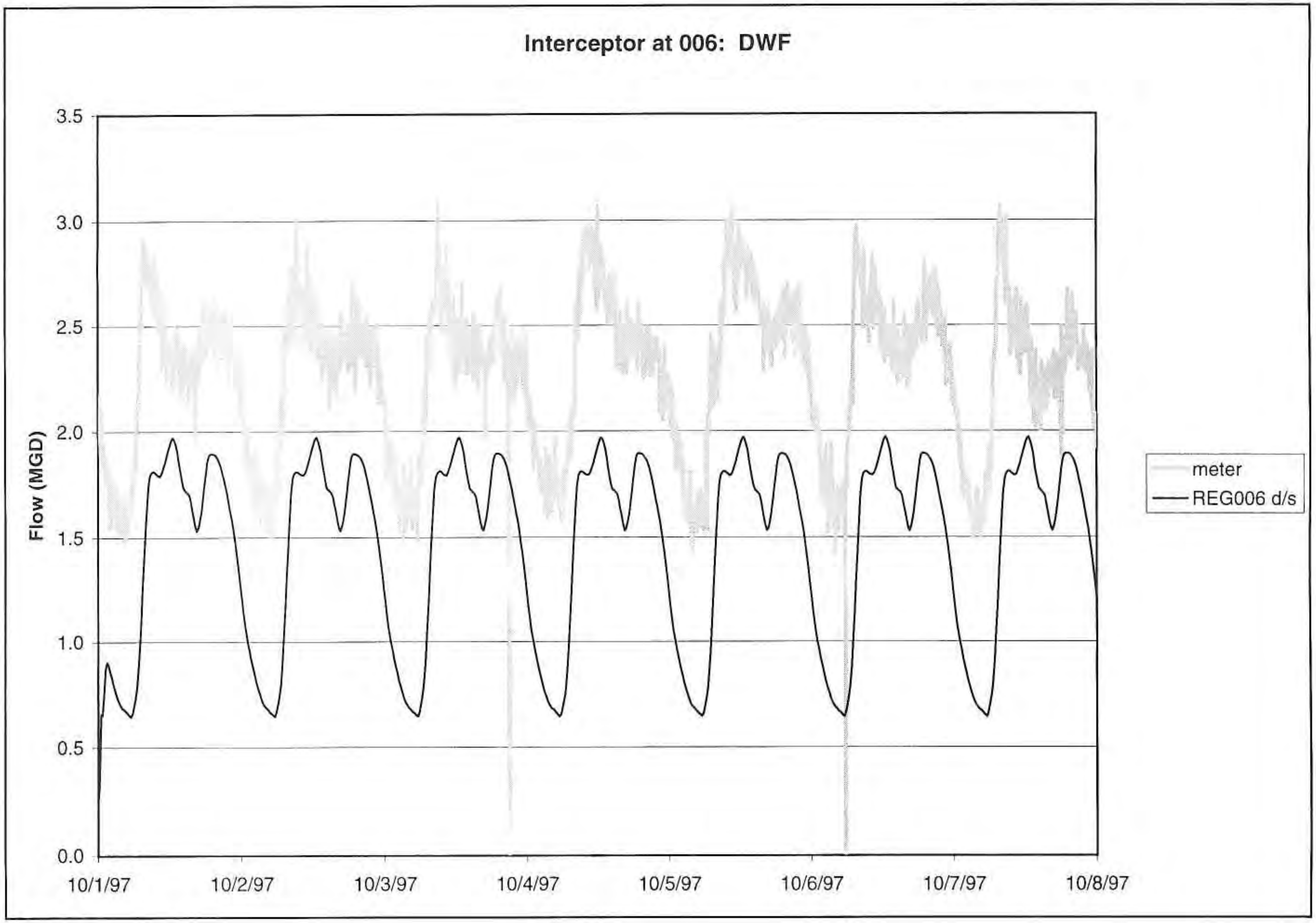


Interceptor at 003: DWF
Flow (MGD)
12
10
8
6
4
2
0
10/1/97
10/2/97
10/3/97
10/4/97
10/5/97
10/6/97
10/7/97
10/8/97
meter
REG003 d/s

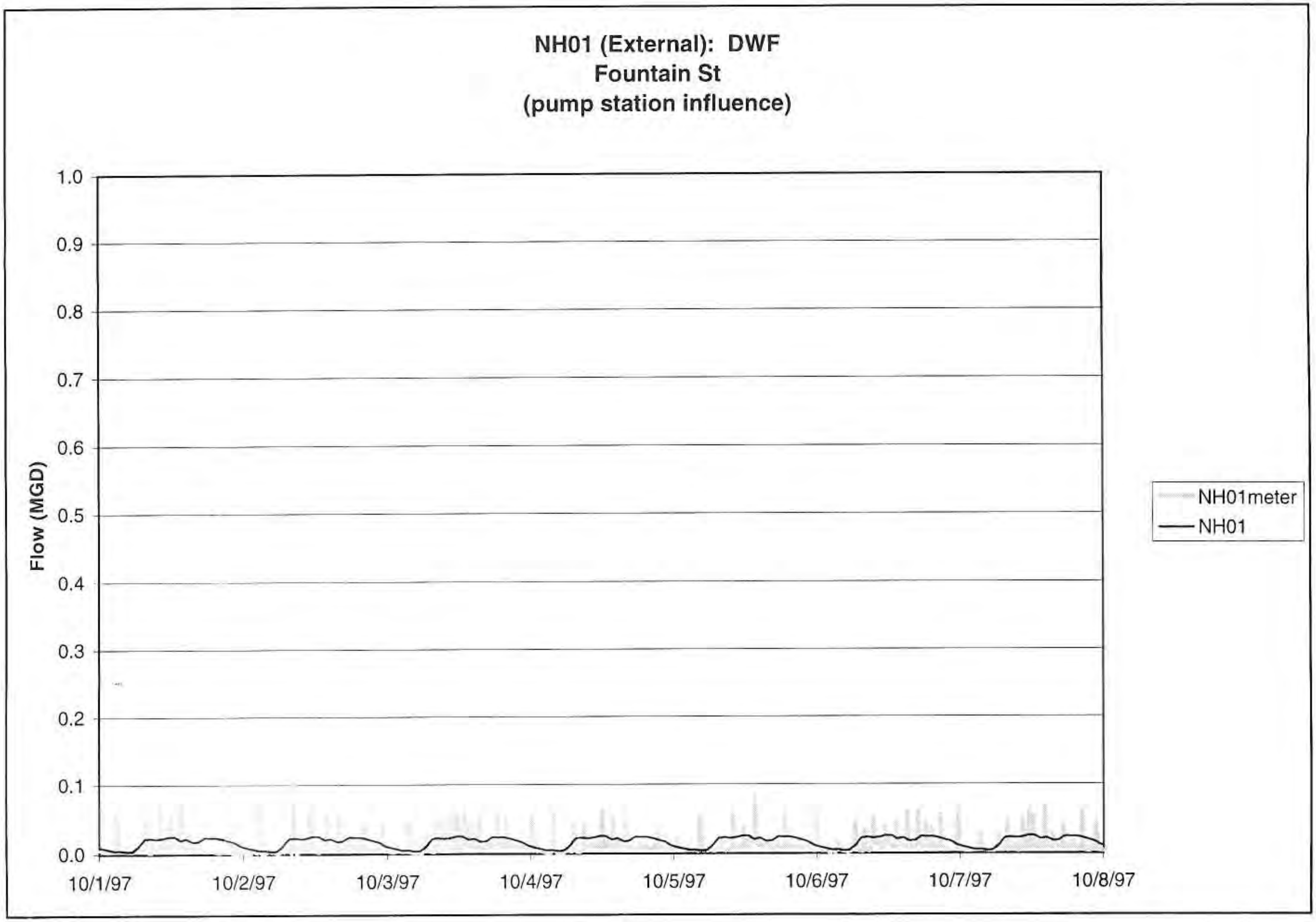

Interceptor at 004: DWF
Flow (MGD)
12
10
8
6
4
2
0
10/1/97
10/2/97
10/3/97
10/4/97
10/5/97
10/6/97
10/7/97
10/8/97
meter
REG004 d/s



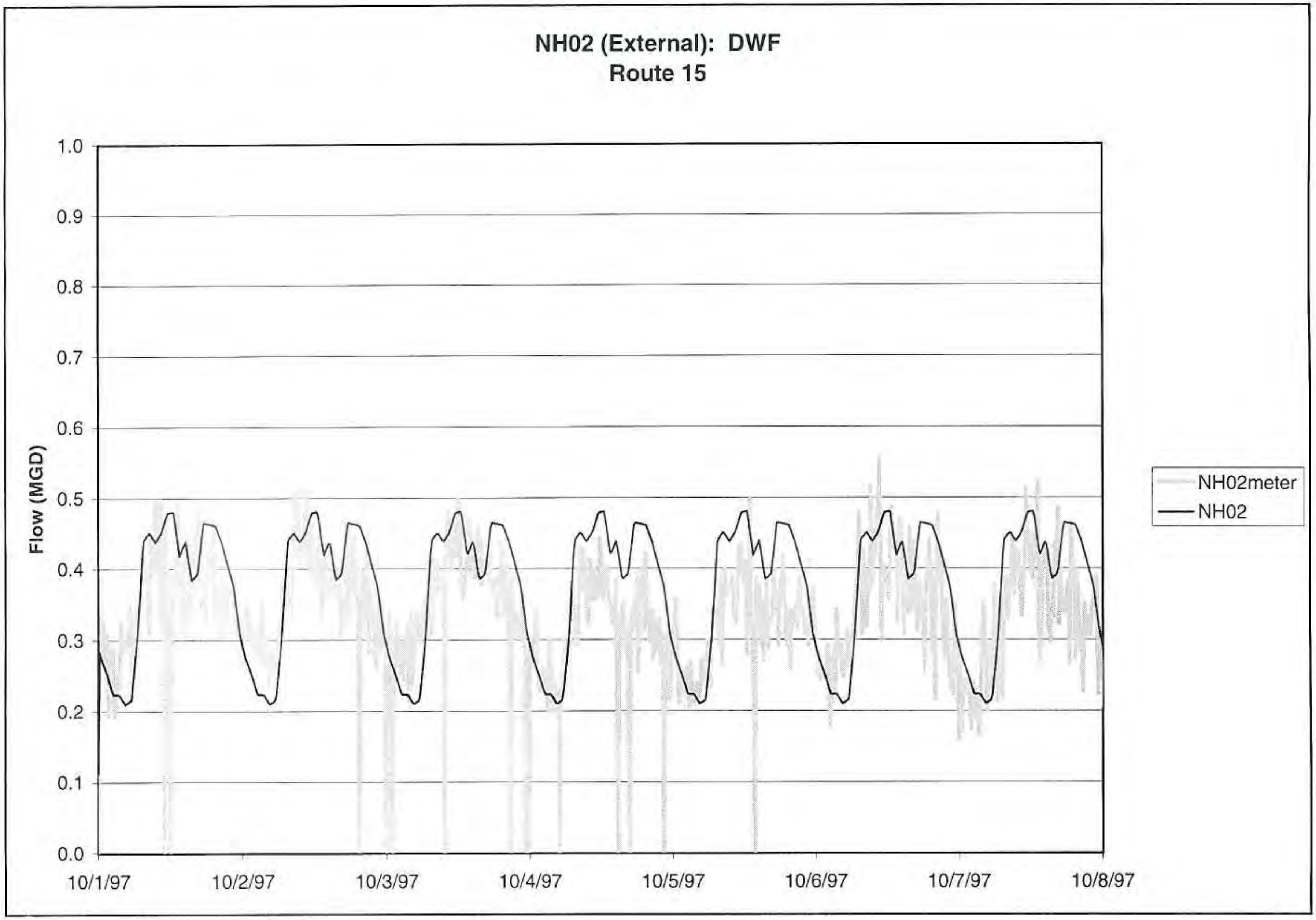
Local inflow at 005: DWF
Flow (MGD)
0
1
2
3
4
5
6
10/1/97
10/2/97
10/3/97
10/4/97
10/5/97
10/6/97
10/7/97
10/8/97
meter
REG005 u/s

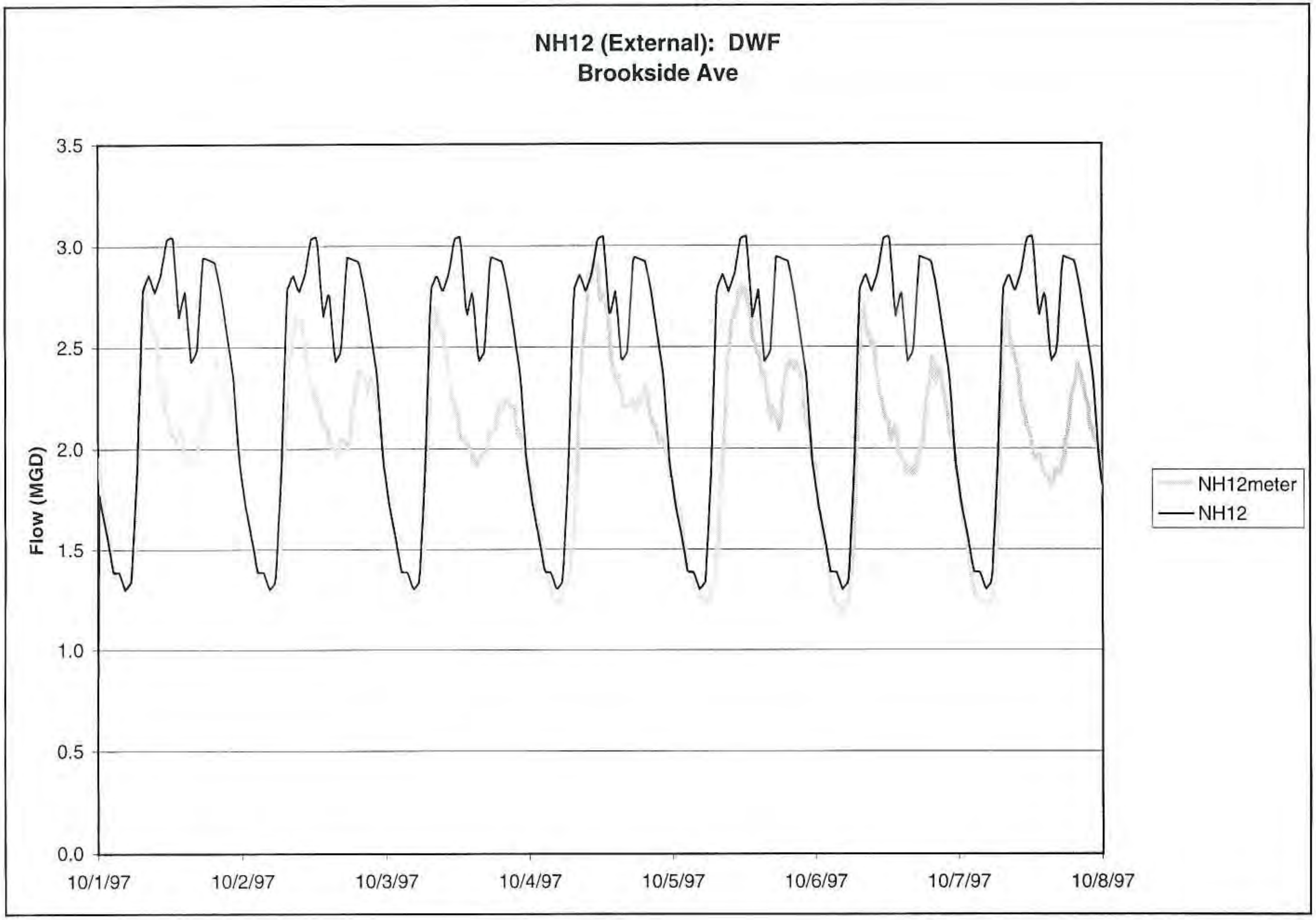


Interceptor at 006: DWF
Flow (MGD)
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
10/1/97
10/2/97
10/3/97
10/4/97
10/5/97
10/6/97
10/7/97
10/8/97
meter
REG006 d/s

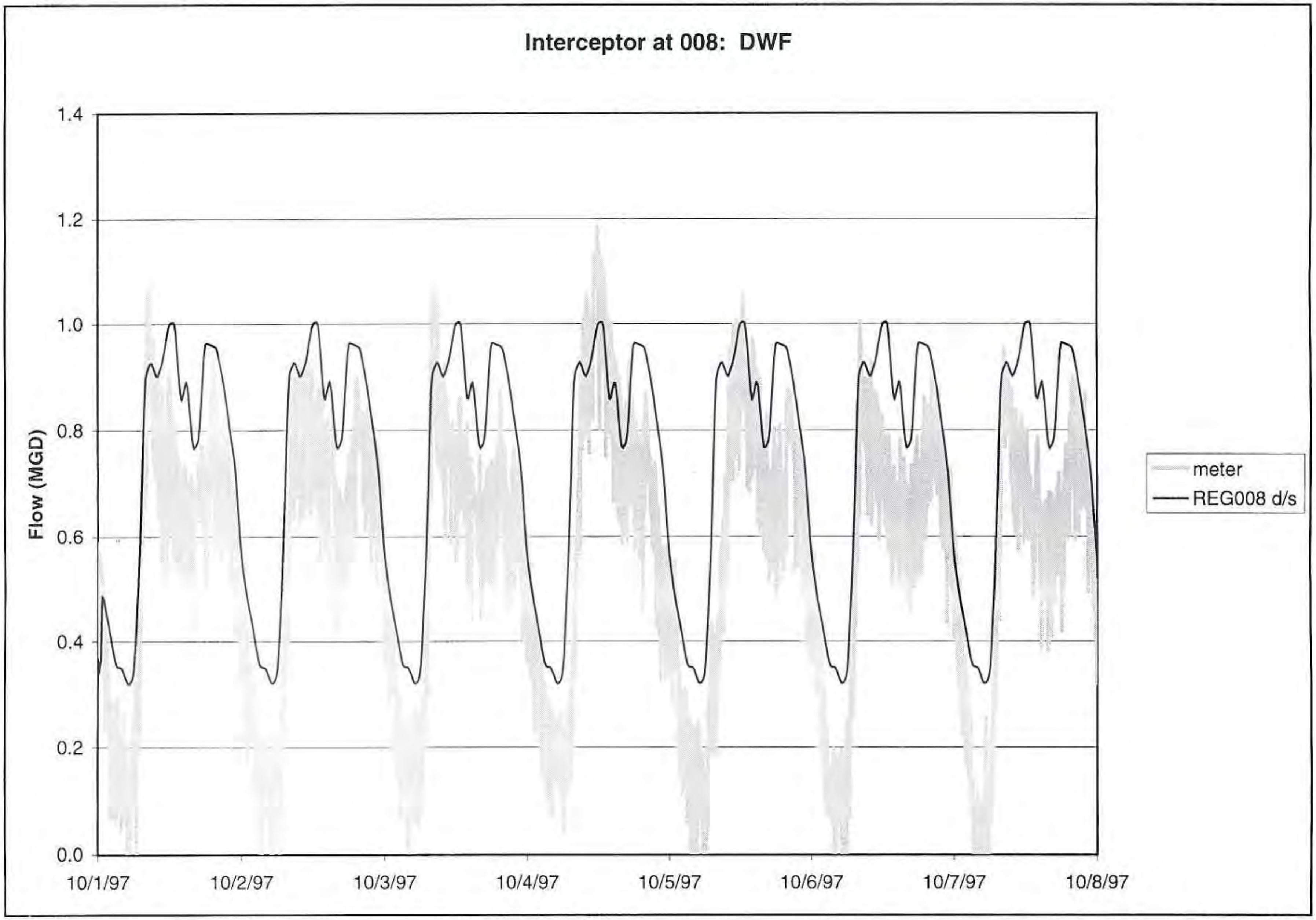


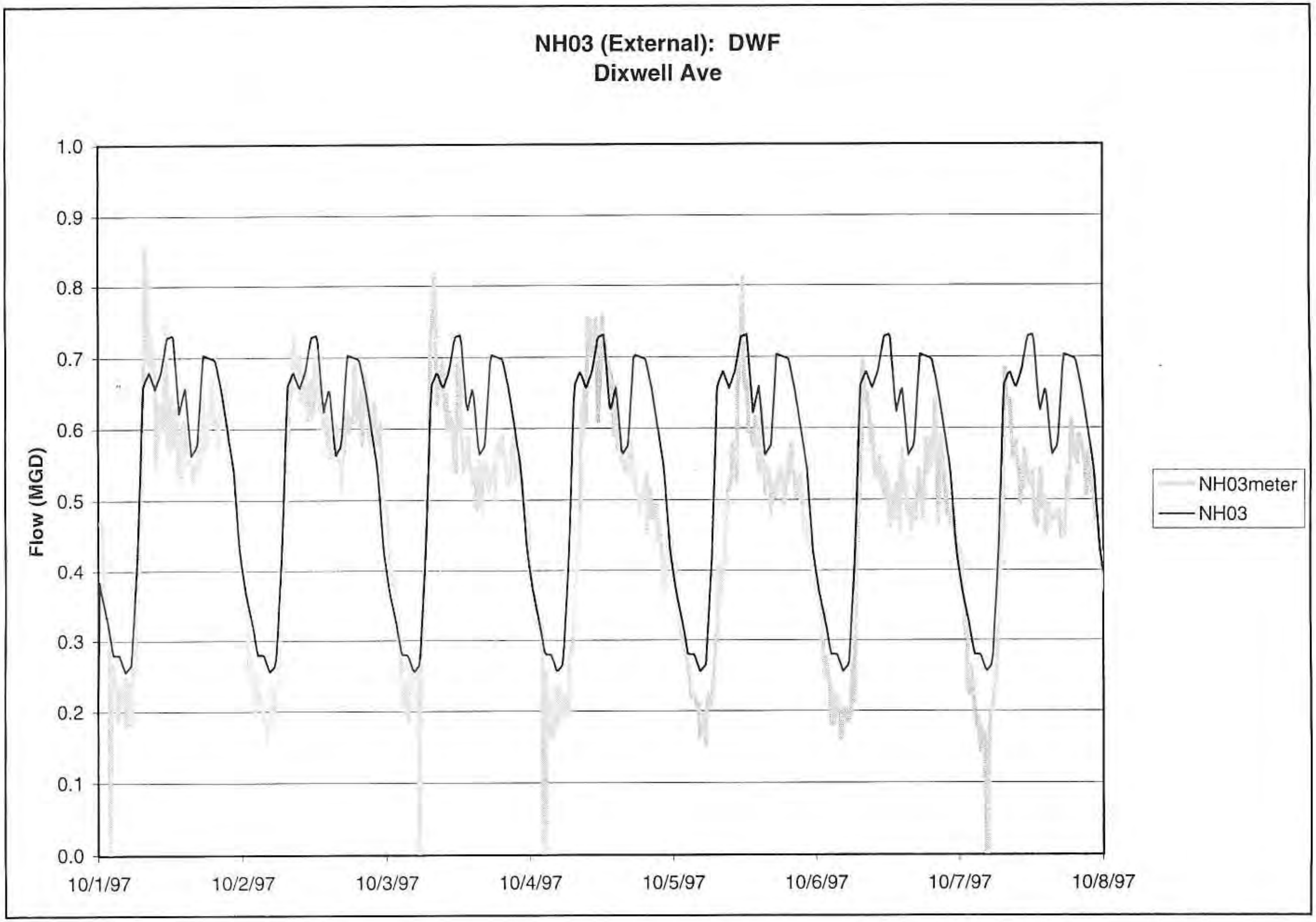
NH01 (External): DWF
Fountain St
(pump station influence)
Flow (MGD)
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
10/1/97
10/2/97
10/3/97
10/4/97
10/5/97
10/6/97
10/7/97
10/8/97
NH01meter
NH01


NH02 (External): DWF
Route 15
Flow (MGD)
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
10/1/97
10/2/97
10/3/97
10/4/97
10/5/97
10/6/97
10/7/97
10/8/97
NH02meter
NH02

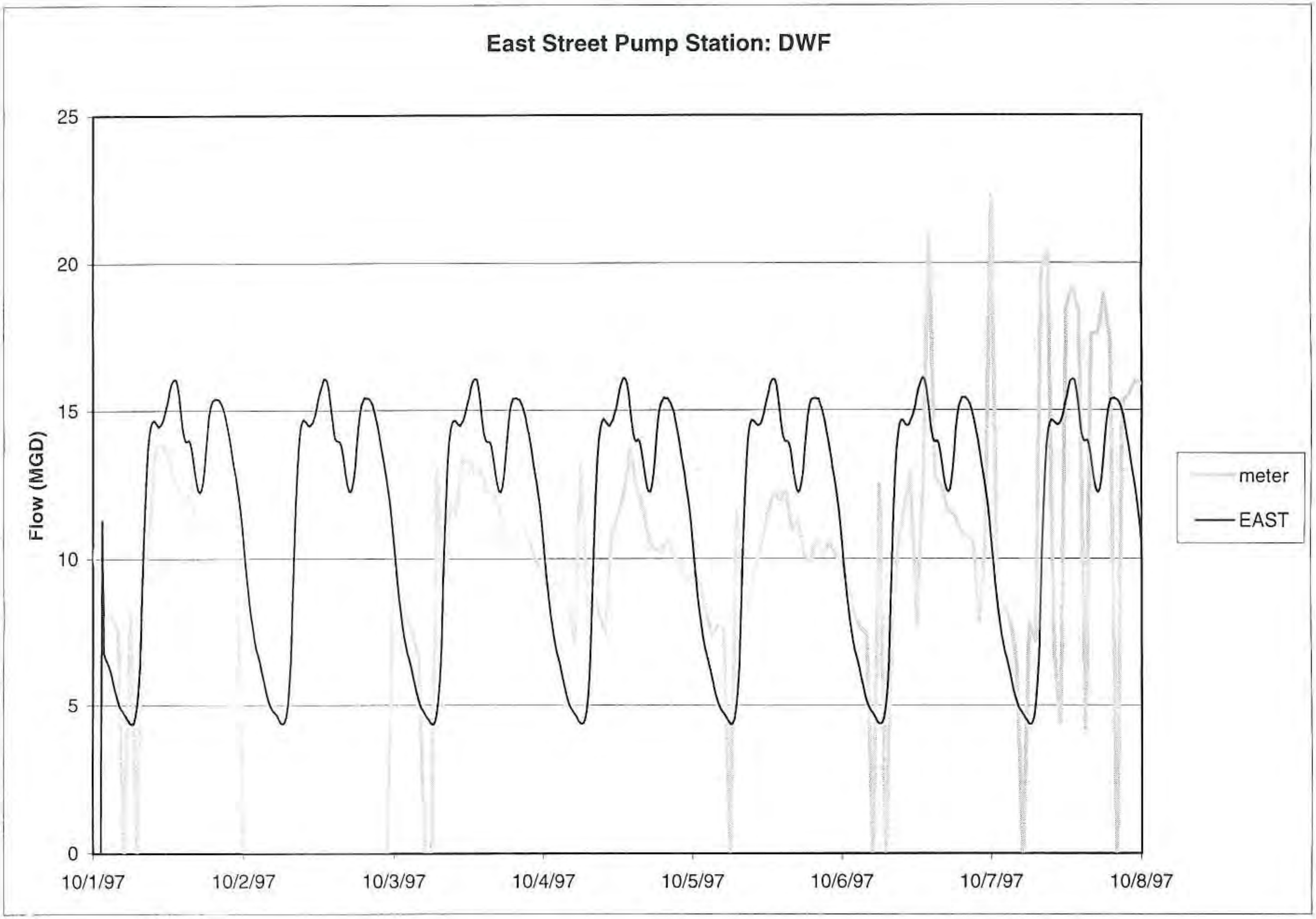


NH12 (External): DWF
Brookside Ave
Flow (MGD)
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
10/1/97
10/2/97
10/3/97
10/4/97
10/5/97
10/6/97
10/7/97
10/8/97
NH12meter
NH12

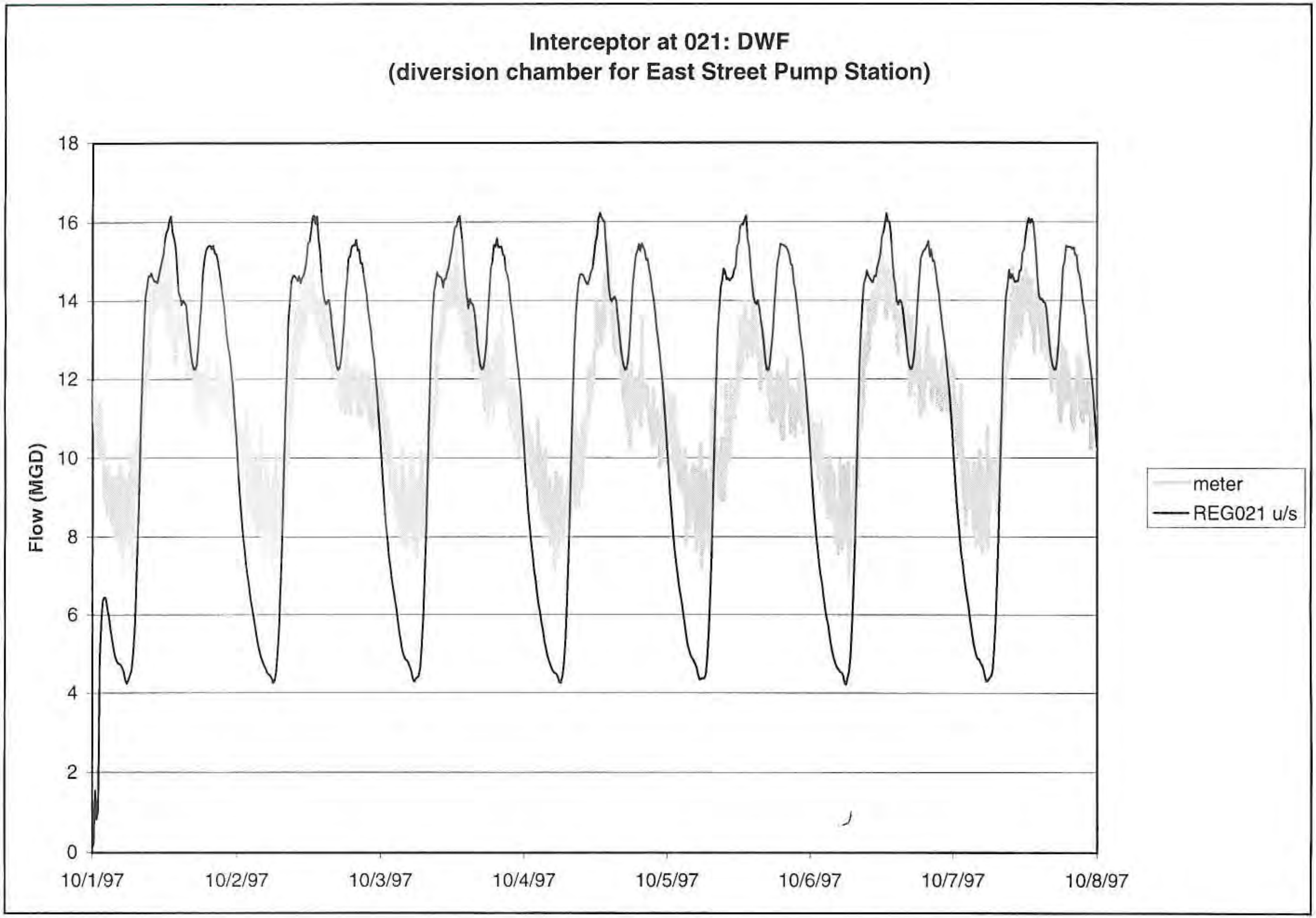

Interceptor at 008: DWF
Flow (MGD)
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
10/1/97
10/2/97
10/3/97
10/4/97
10/5/97
10/6/97
10/7/97
10/8/97
meter
REG008 d/s



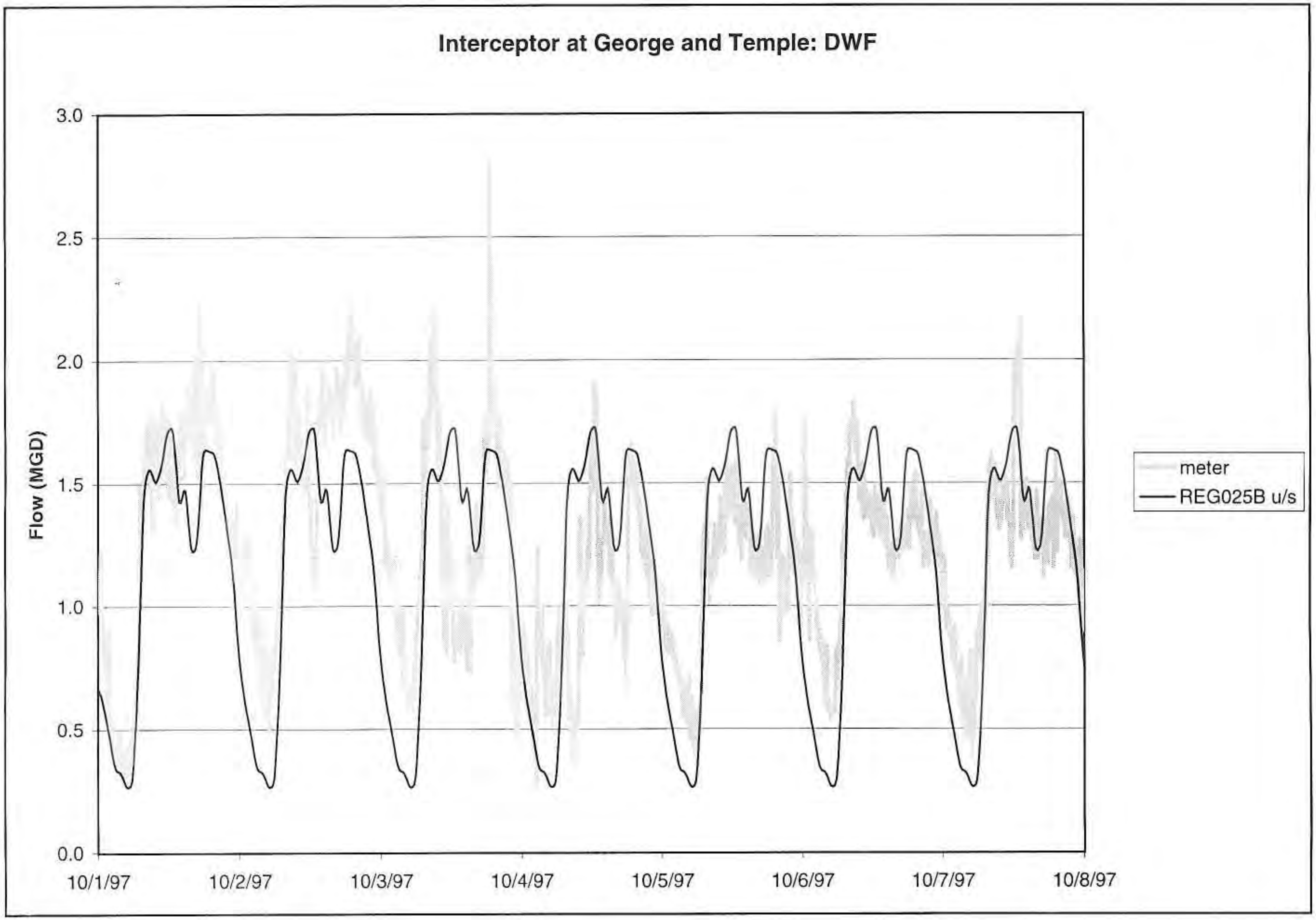
NH03 (External): DWF
Dixwell Ave
Flow (MGD)
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
10/1/97
10/2/97
10/3/97
10/4/97
10/5/97
10/6/97
10/7/97
10/8/97
NH03meter
NH03

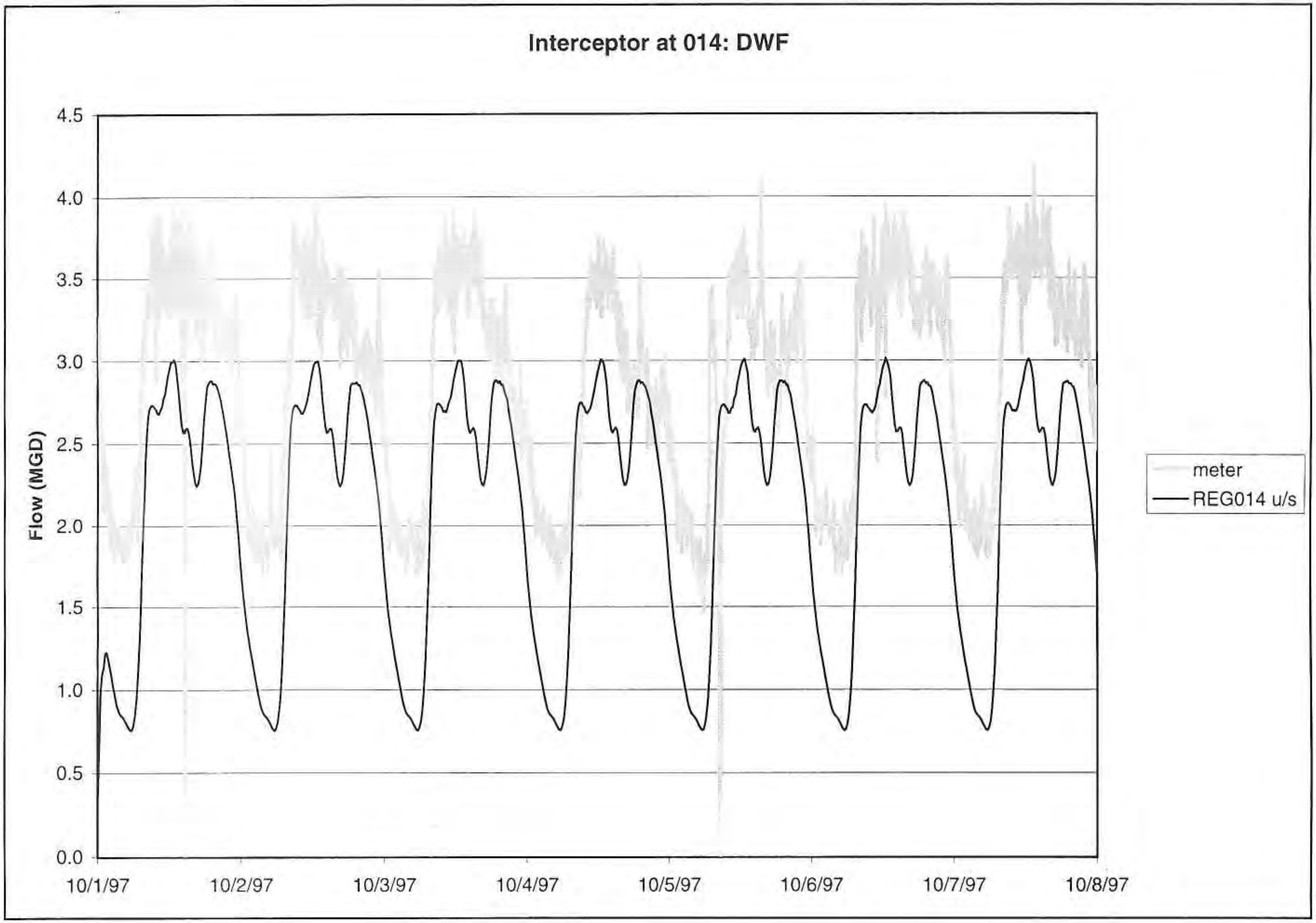


East Street Pump Station: DWF
Flow (MGD)
25
20
15
10
5
0
10/1/97
10/2/97
10/3/97
10/4/97
10/5/97
10/6/97
10/7/97
10/8/97
meter
EAST

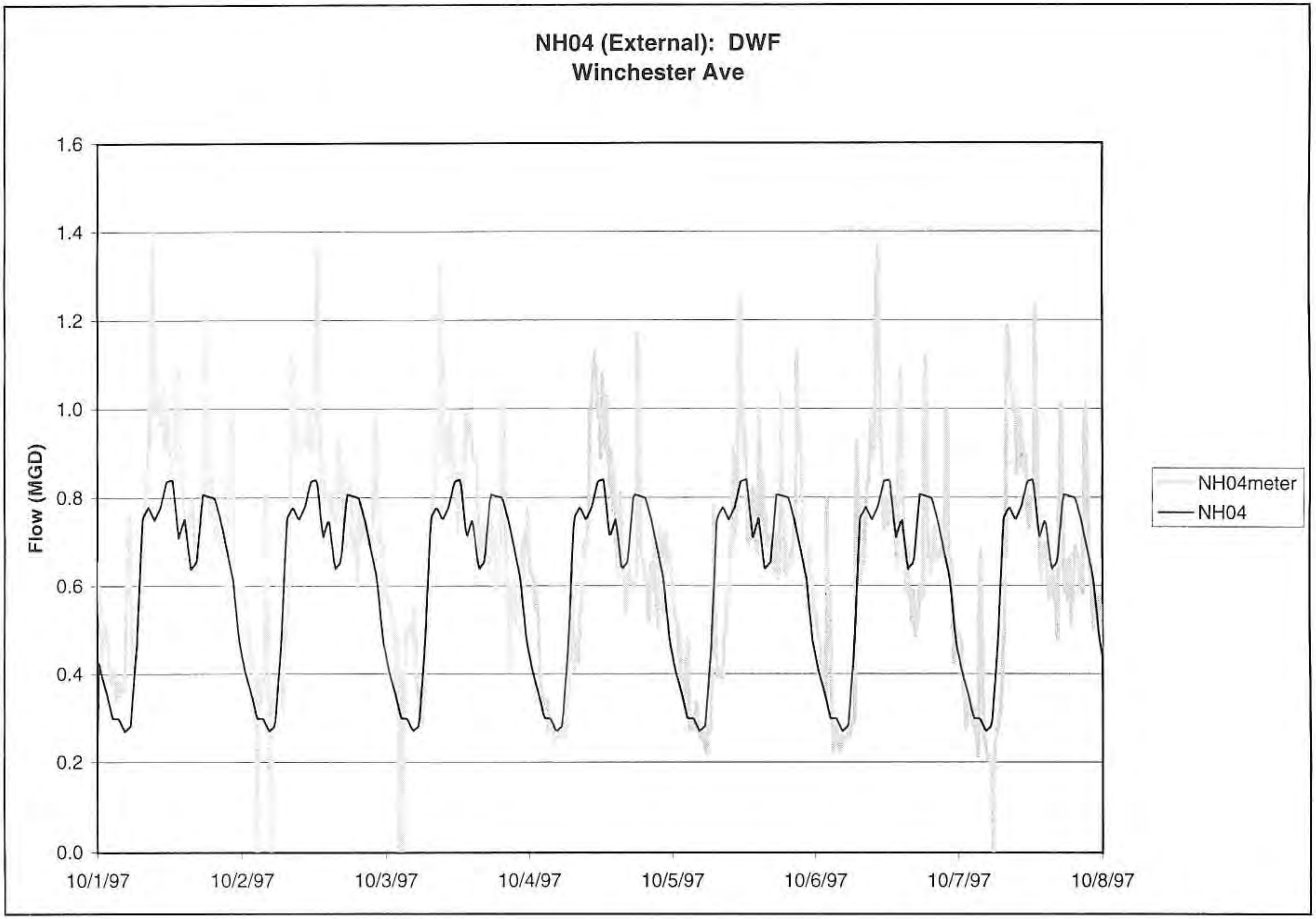


Interceptor at 021: DWF
(diversion chamber for East Street Pump Station)
Flow (MGD)
0
2
4
6
8
10
12
14
16
18
10/1/97
10/2/97
10/3/97
10/4/97
10/5/97
10/6/97
10/7/97
10/8/97
meter
REG021 u/s

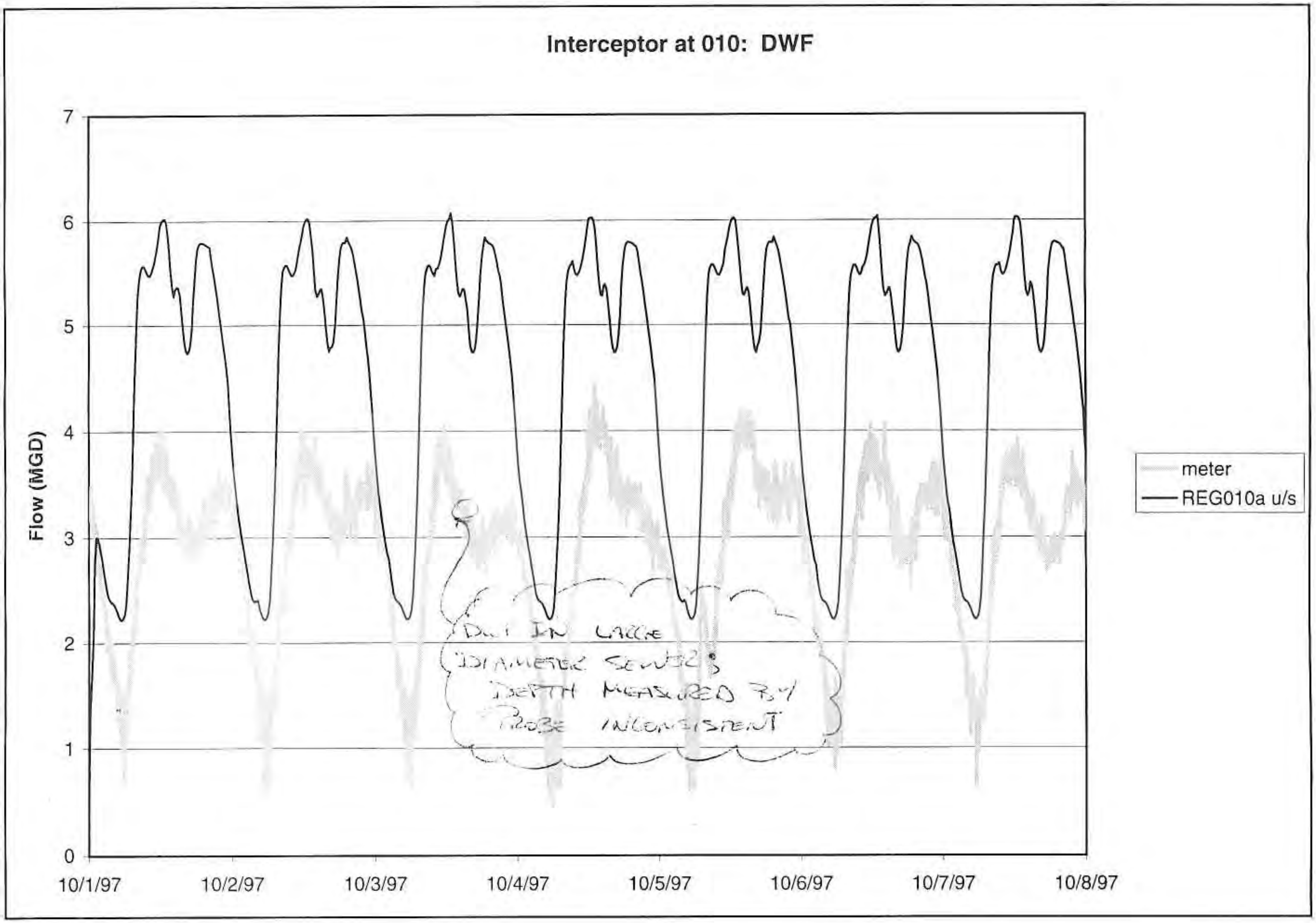

Interceptor at George and Temple: DWF
Flow (MGD)
3.0
2.5
2.0
1.5
1.0
0.5
0.0
10/1/97
10/2/97
10/3/97
10/4/97
10/5/97
10/6/97
10/7/97
10/8/97
meter
REG025B u/s



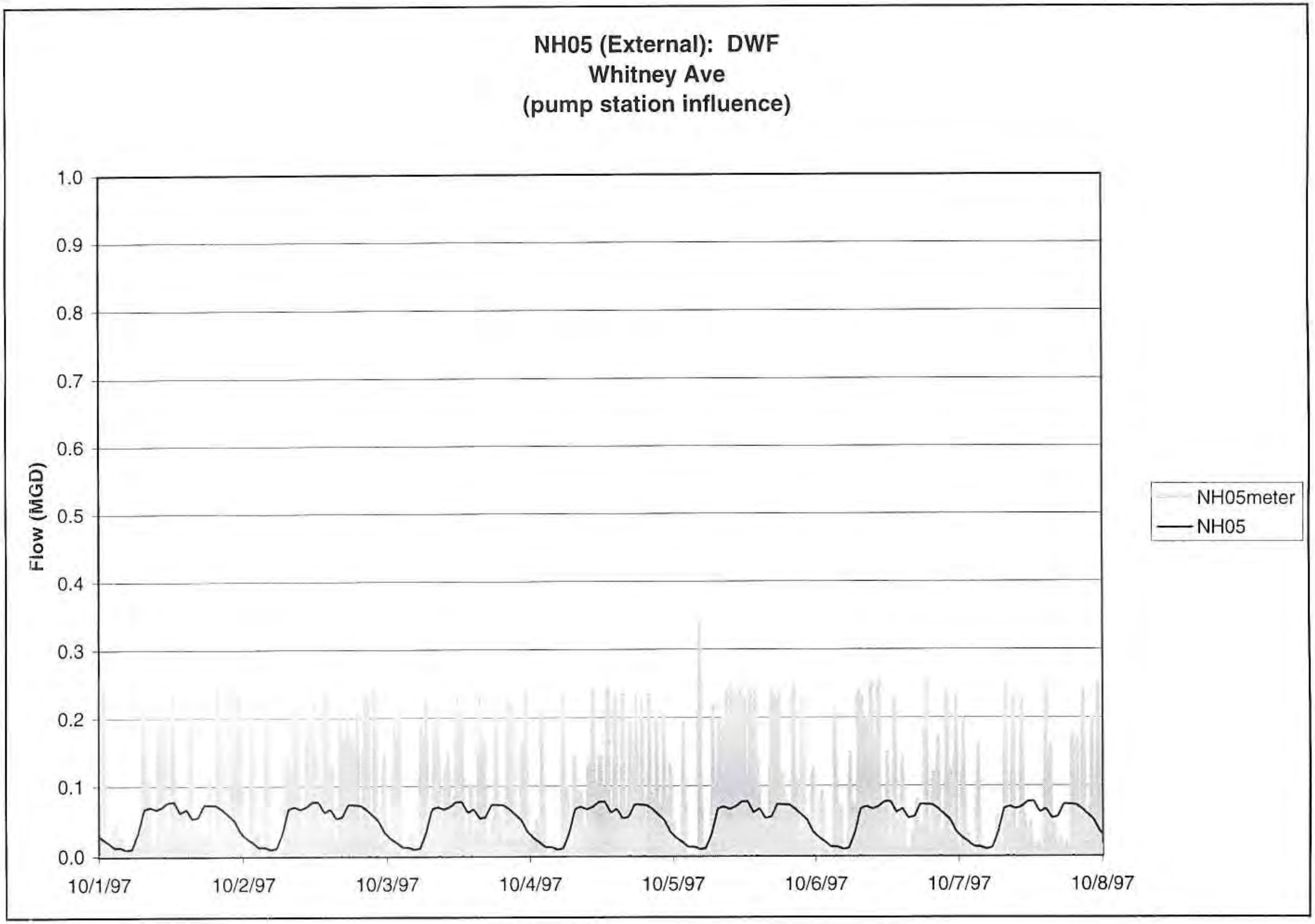
Interceptor at 014: DWF
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
Flow (MGD)
10/1/97
10/2/97
10/3/97
10/4/97
10/5/97
10/6/97
10/7/97
10/8/97
meter
REG014 u/s



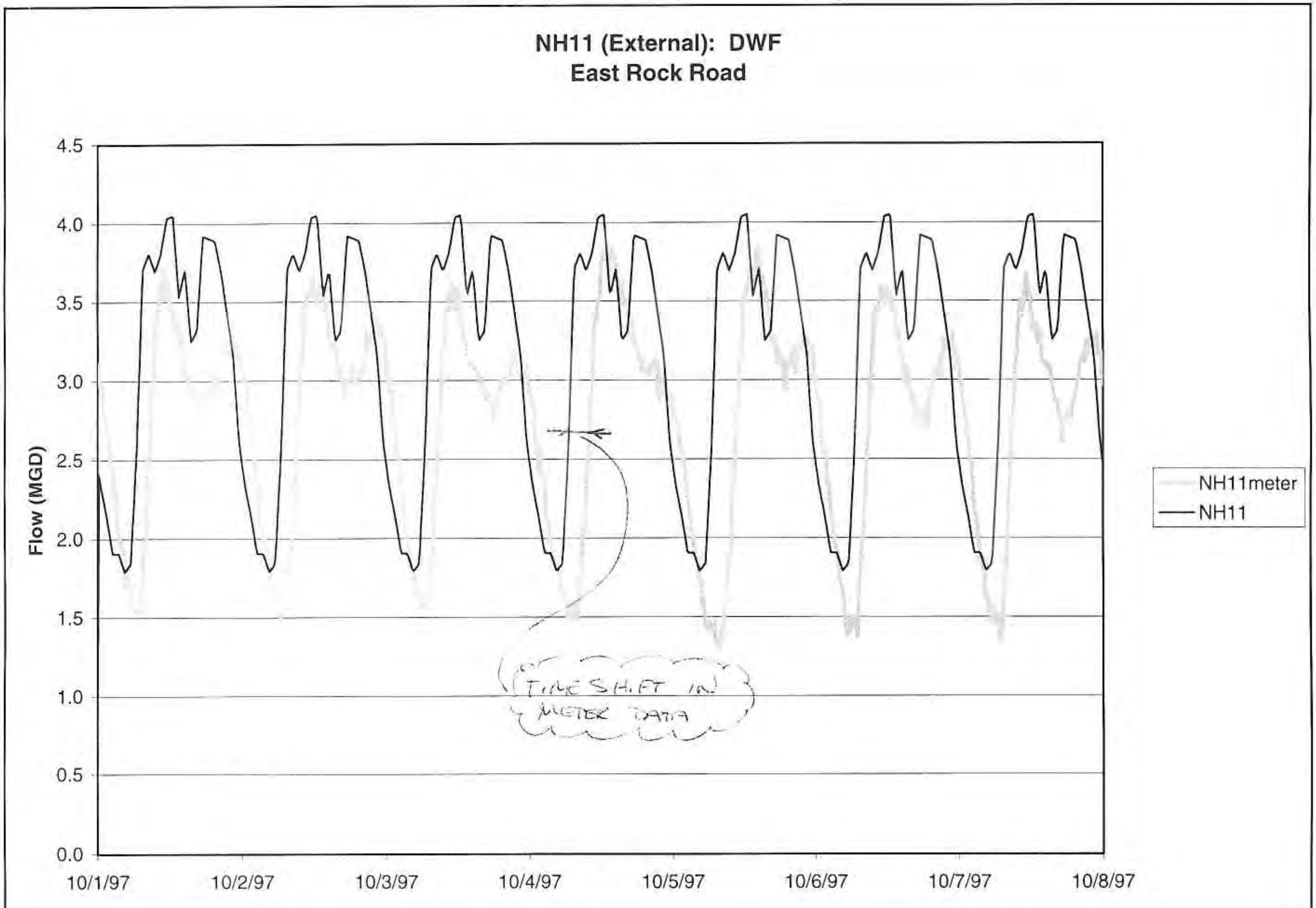
NH04 (External): DWF
Winchester Ave
Flow (MGD)
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
10/1/97
10/2/97
10/3/97
10/4/97
10/5/97
10/6/97
10/7/97
10/8/97
NH04meter
NH04

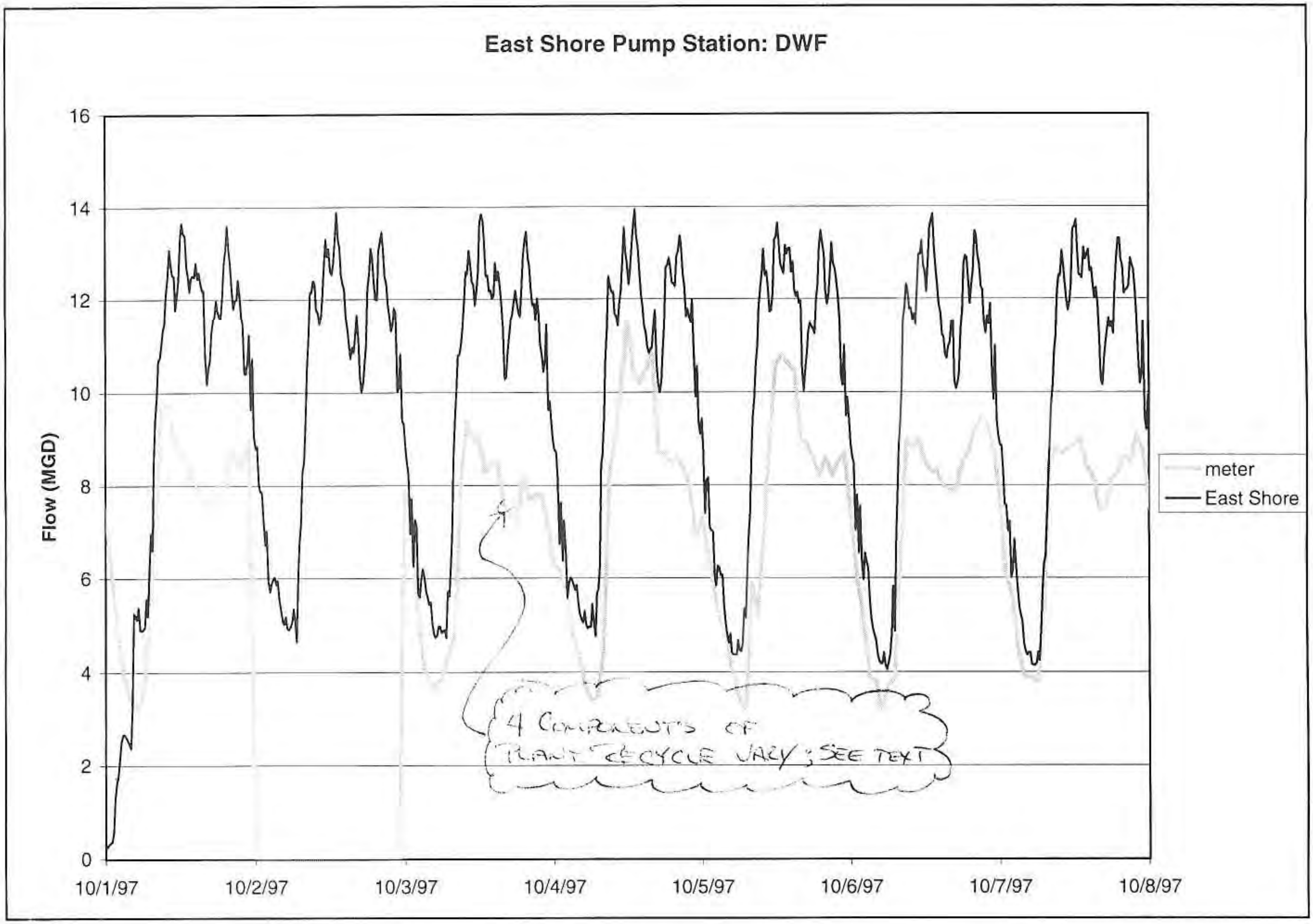


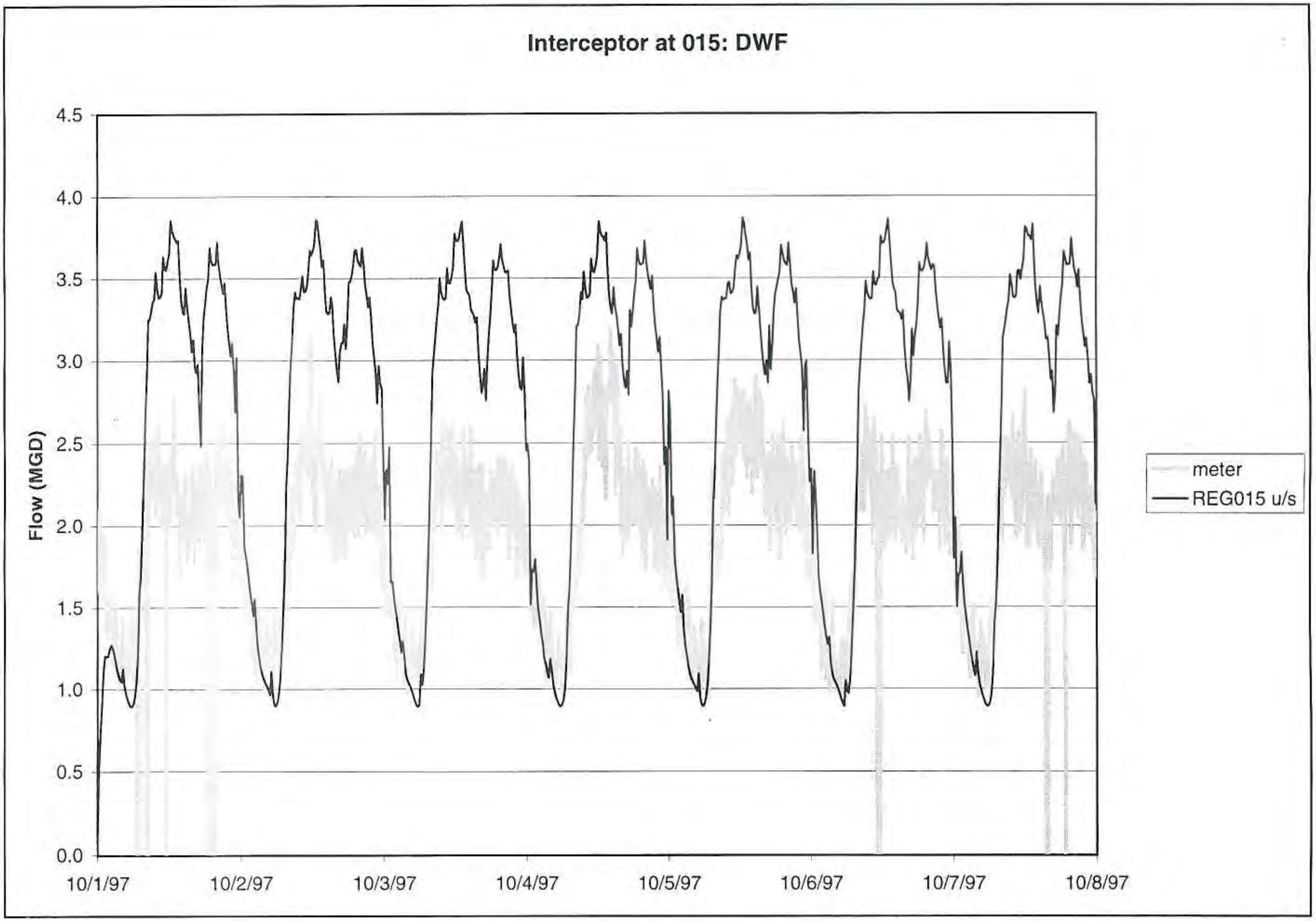
Interceptor at 010: DWF
Flow (MGD)
0
1
2
3
4
5
6
7
10/1/97
10/2/97
10/3/97
10/4/97
10/5/97
10/6/97
10/7/97
10/8/97
meter
REG010a u/s
DWF IN LARGE DIAMETER SEWERS; DEPTH MEASURED BY PROBE INCONSISTENT



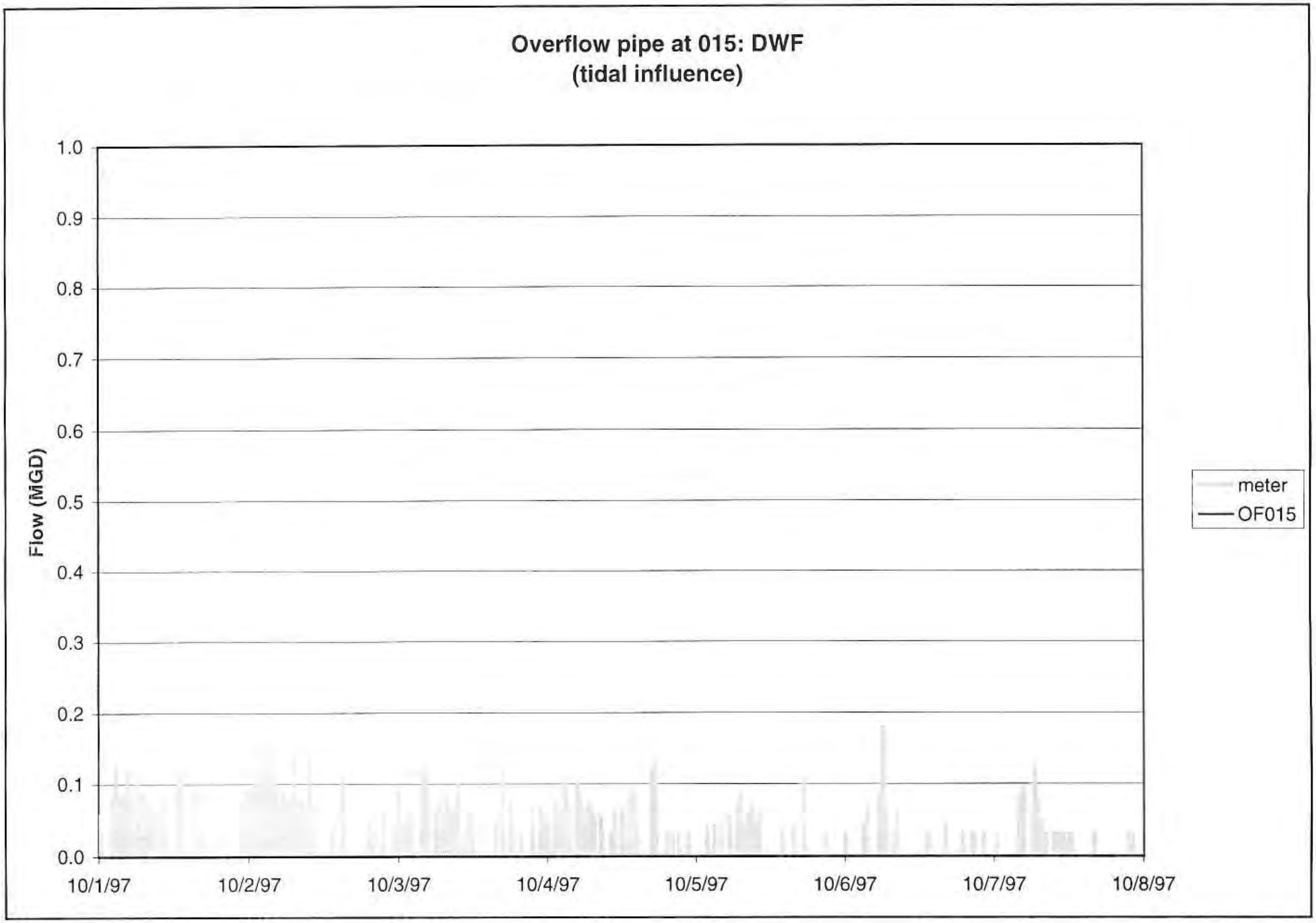
NH05 (External): DWF
Whitney Ave
(pump station influence)
Flow (MGD)
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
10/1/97
10/2/97
10/3/97
10/4/97
10/5/97
10/6/97
10/7/97
10/8/97
NH05meter
NH05


NH11 (External): DWF
East Rock Road
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
Flow (MGD)
10/1/97
10/2/97
10/3/97
10/4/97
10/5/97
10/6/97
10/7/97
10/8/97
NH11meter
NH11
TIME SHIFT IN METER DATA

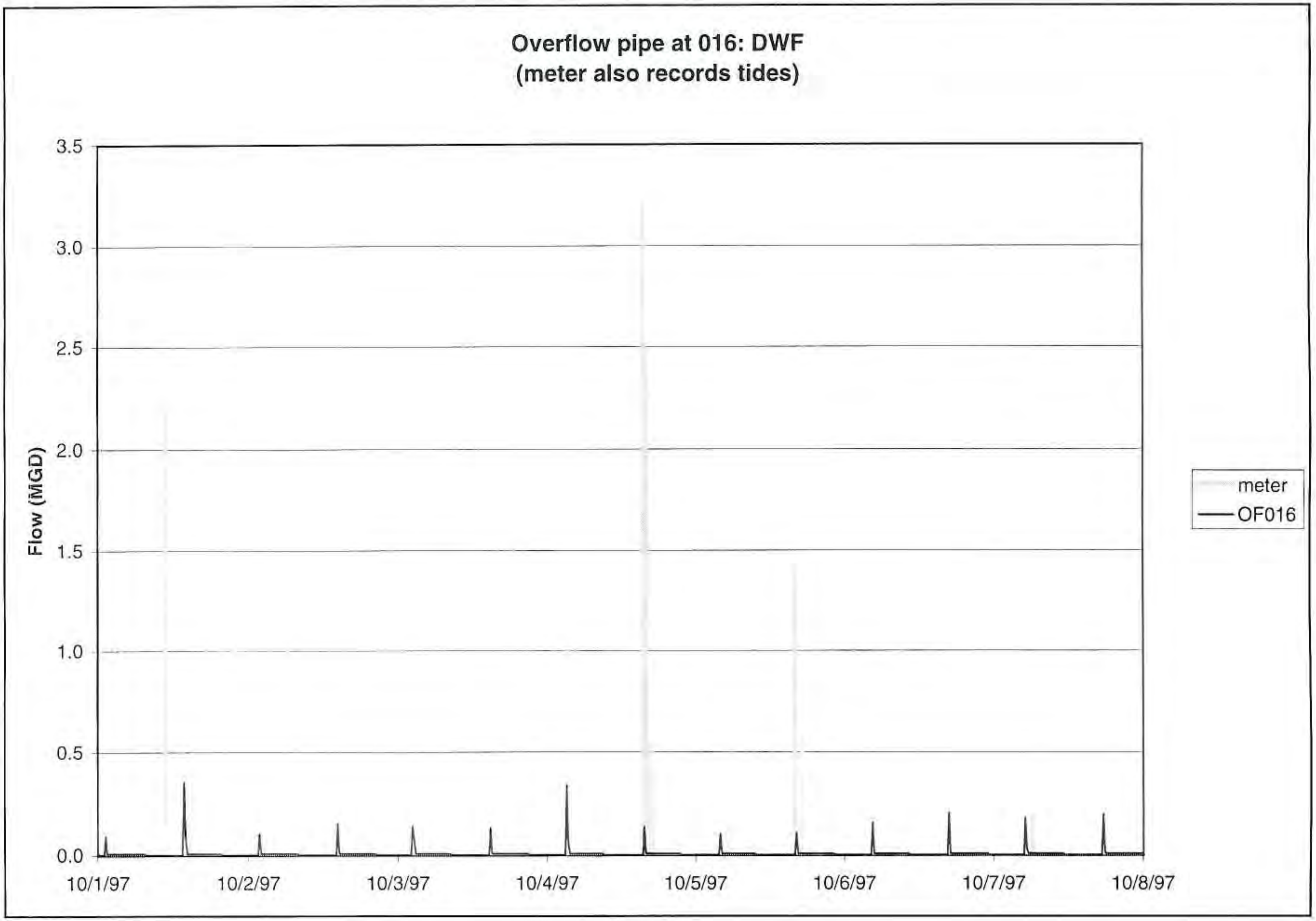

East Shore Pump Station: DWF
Flow (MGD)
0
2
4
6
8
10
12
14
16
10/1/97
10/2/97
10/3/97
10/4/97
10/5/97
10/6/97
10/7/97
10/8/97
meter
East Shore
4 COMPONENTS OF PLANT RECYCLE VARY; SEE TEXT

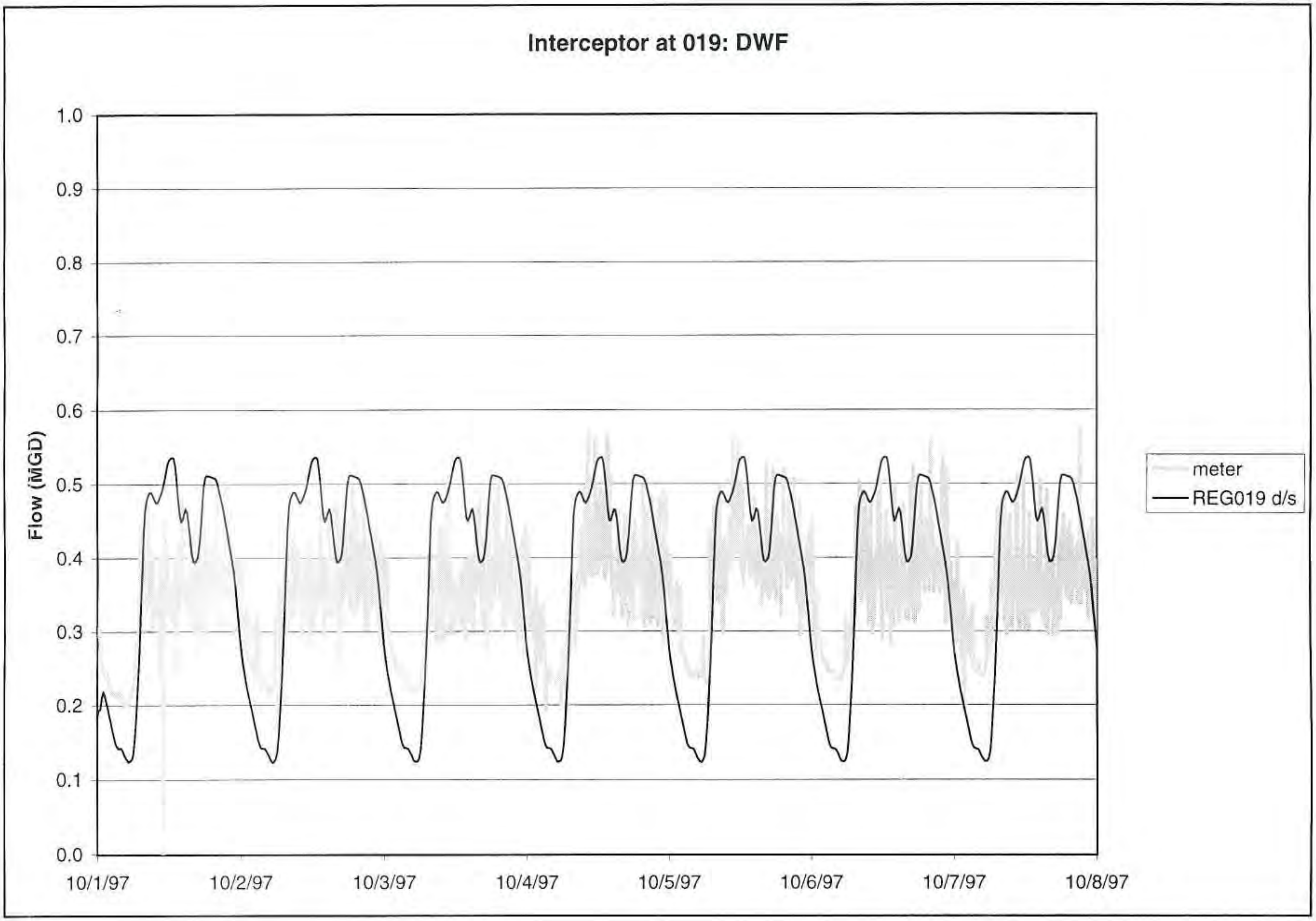


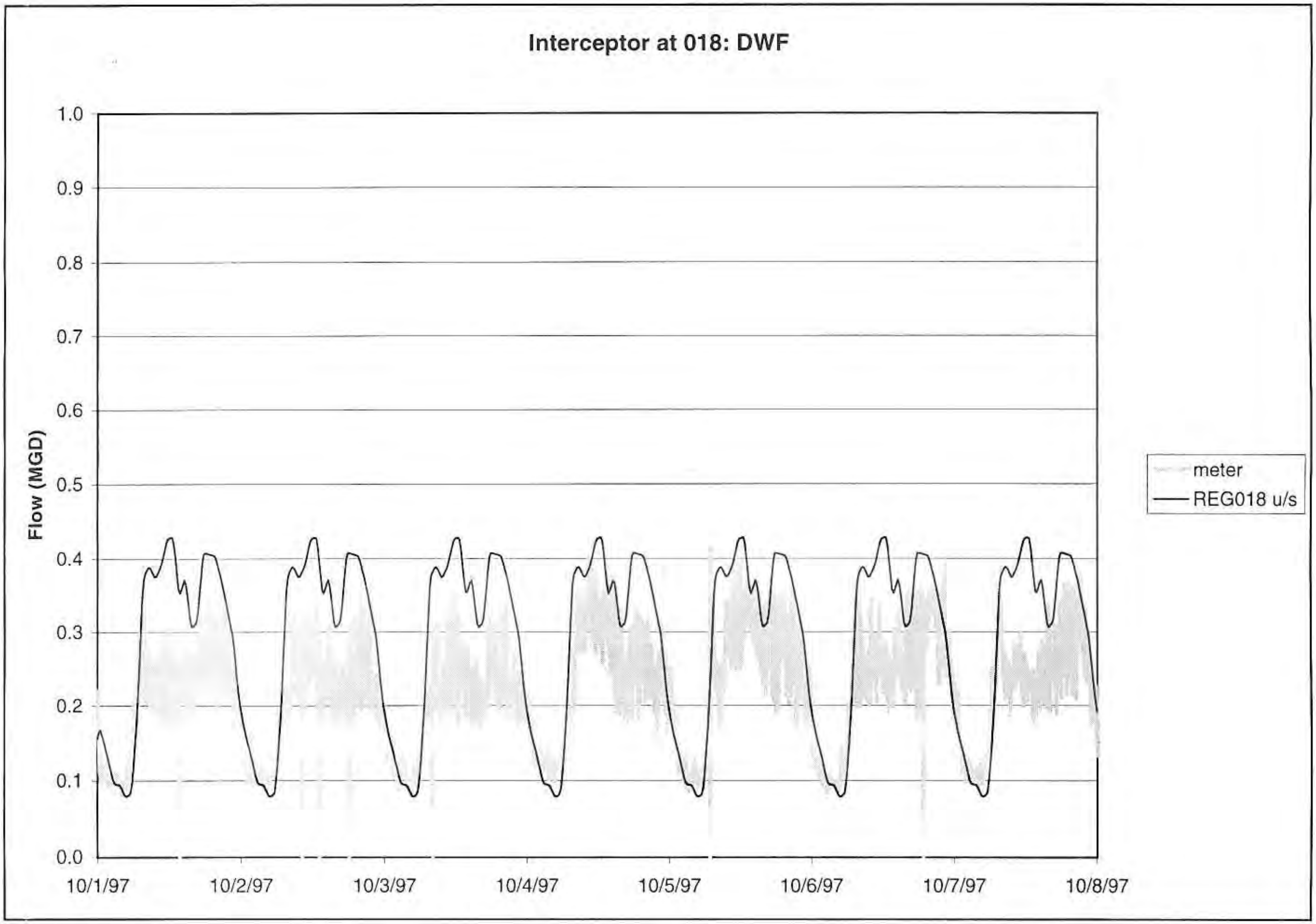
Interceptor at 015: DWF
Flow (MGD)
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
10/1/97
10/2/97
10/3/97
10/4/97
10/5/97
10/6/97
10/7/97
10/8/97
meter
REG015 u/s



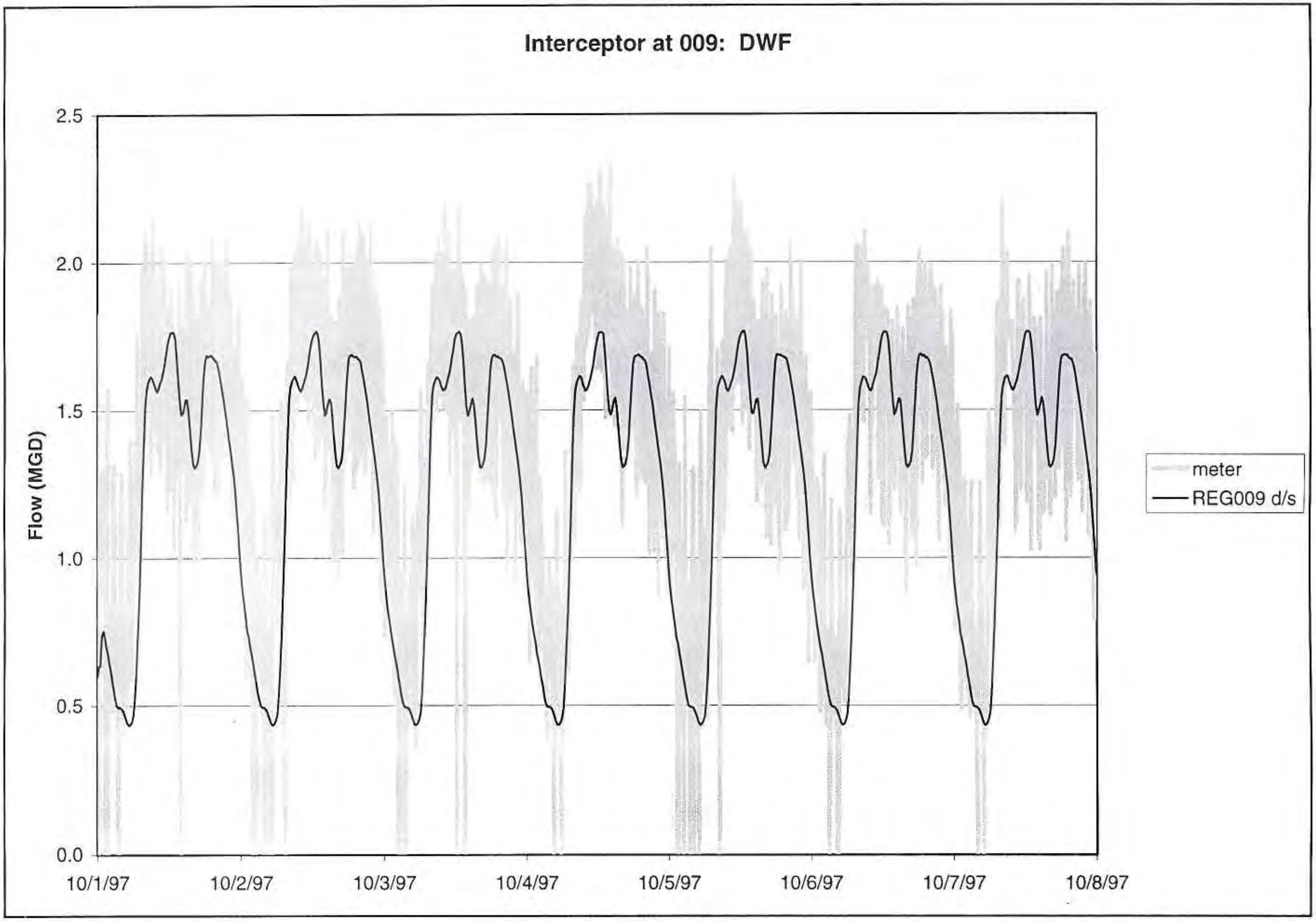
Overflow pipe at 015: DWF
(tidal influence)
Flow (MGD)
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
10/1/97
10/2/97
10/3/97
10/4/97
10/5/97
10/6/97
10/7/97
10/8/97
meter
OF015


Overflow pipe at 016: DWF
(meter also records tides)
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
Flow (MGD)
10/1/97
10/2/97
10/3/97
10/4/97
10/5/97
10/6/97
10/7/97
10/8/97
meter
OF016

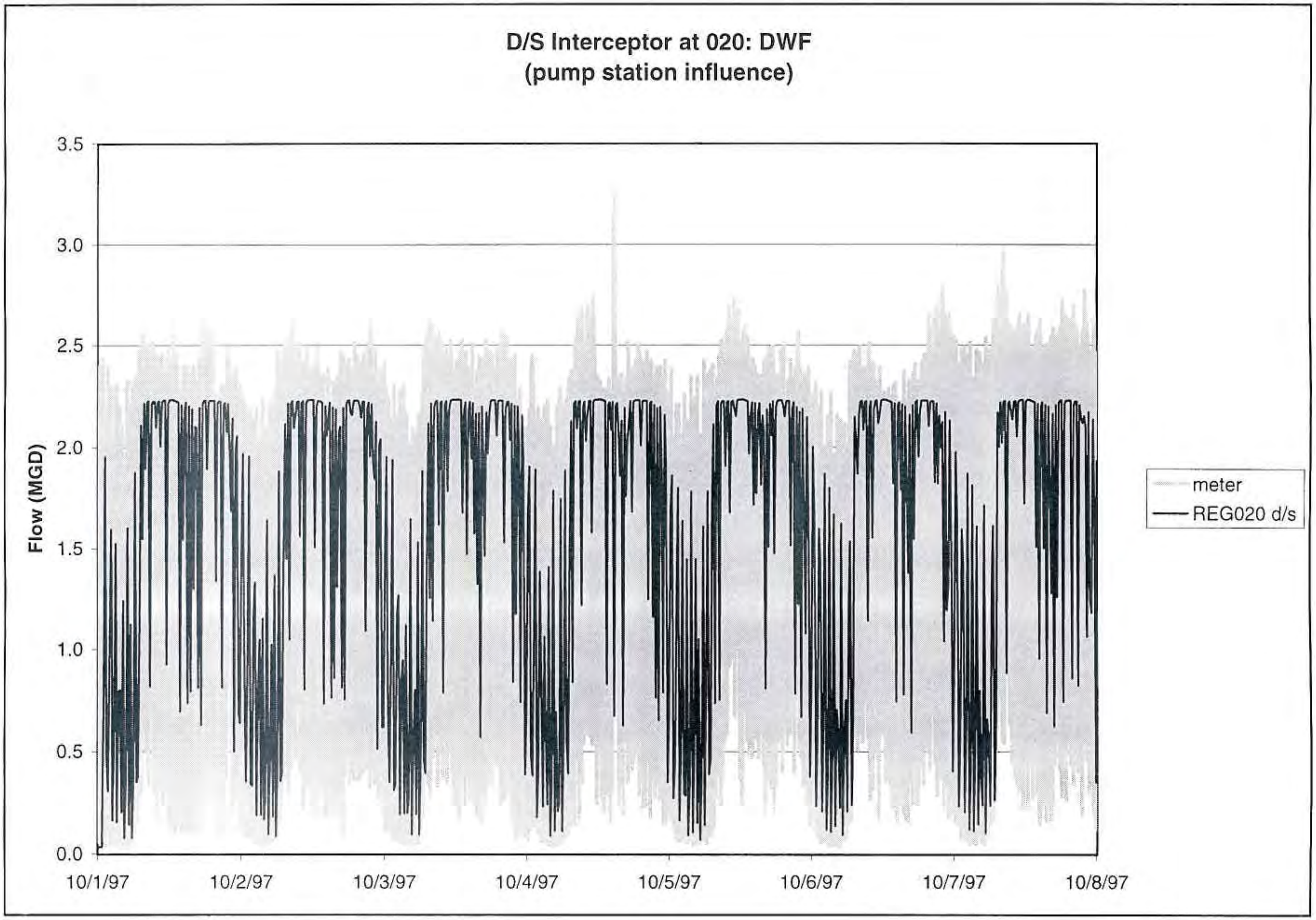

Interceptor at 019: DWF
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
Flow (MGD)
10/1/97
10/2/97
10/3/97
10/4/97
10/5/97
10/6/97
10/7/97
10/8/97
meter
REG019 d/s

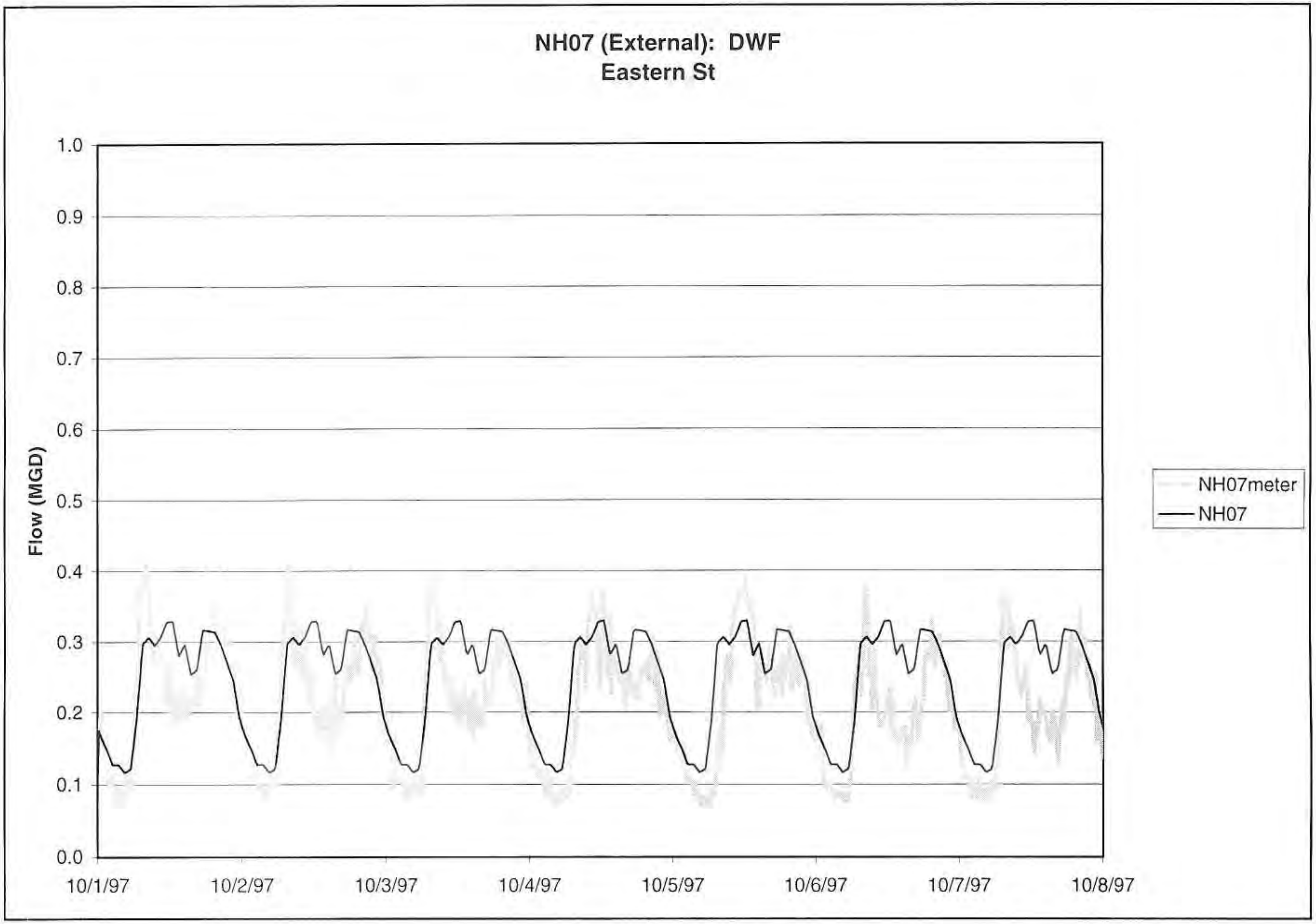


Interceptor at 018: DWF
Flow (MGD)
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
10/1/97
10/2/97
10/3/97
10/4/97
10/5/97
10/6/97
10/7/97
10/8/97
meter
REG018 u/s

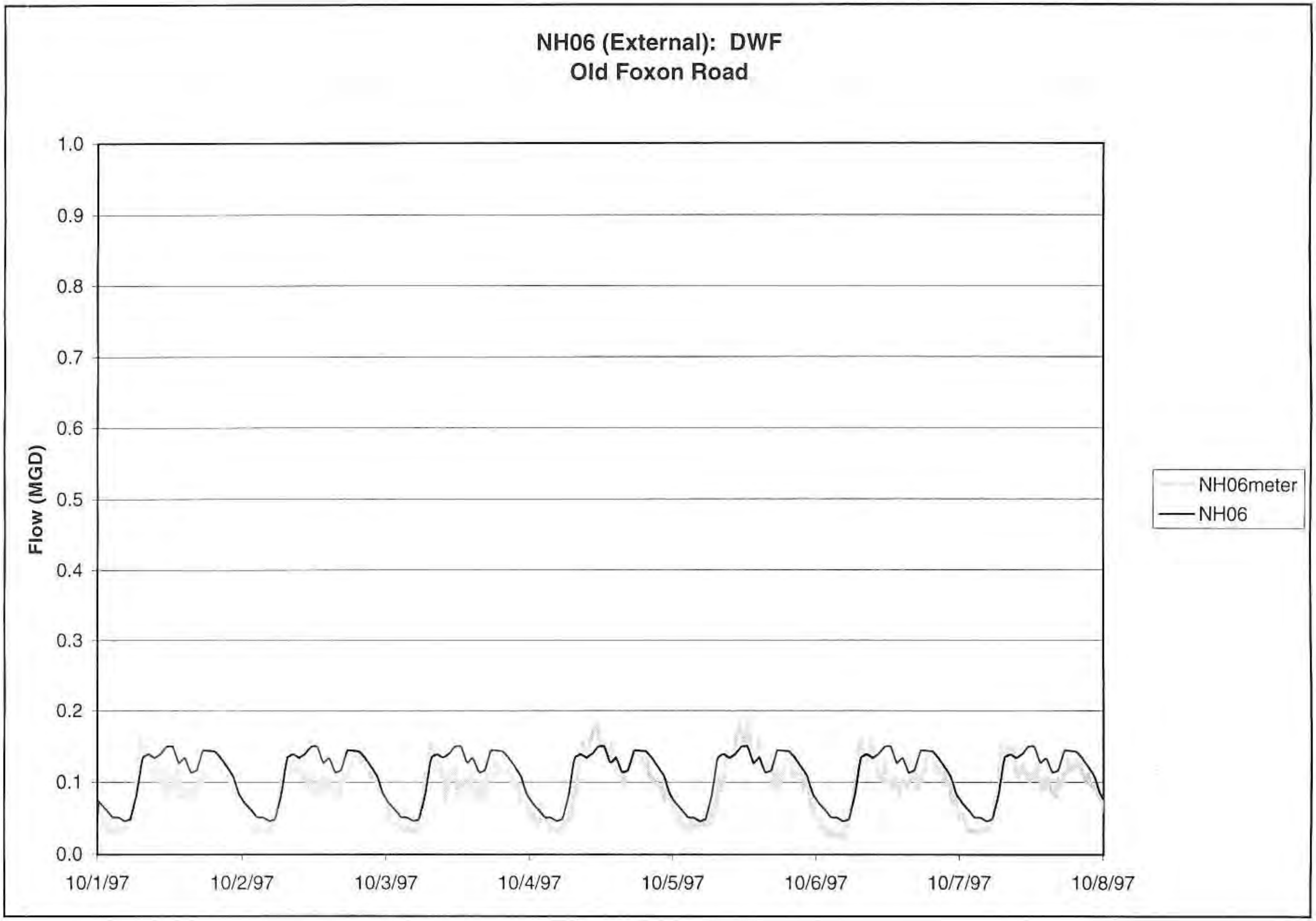


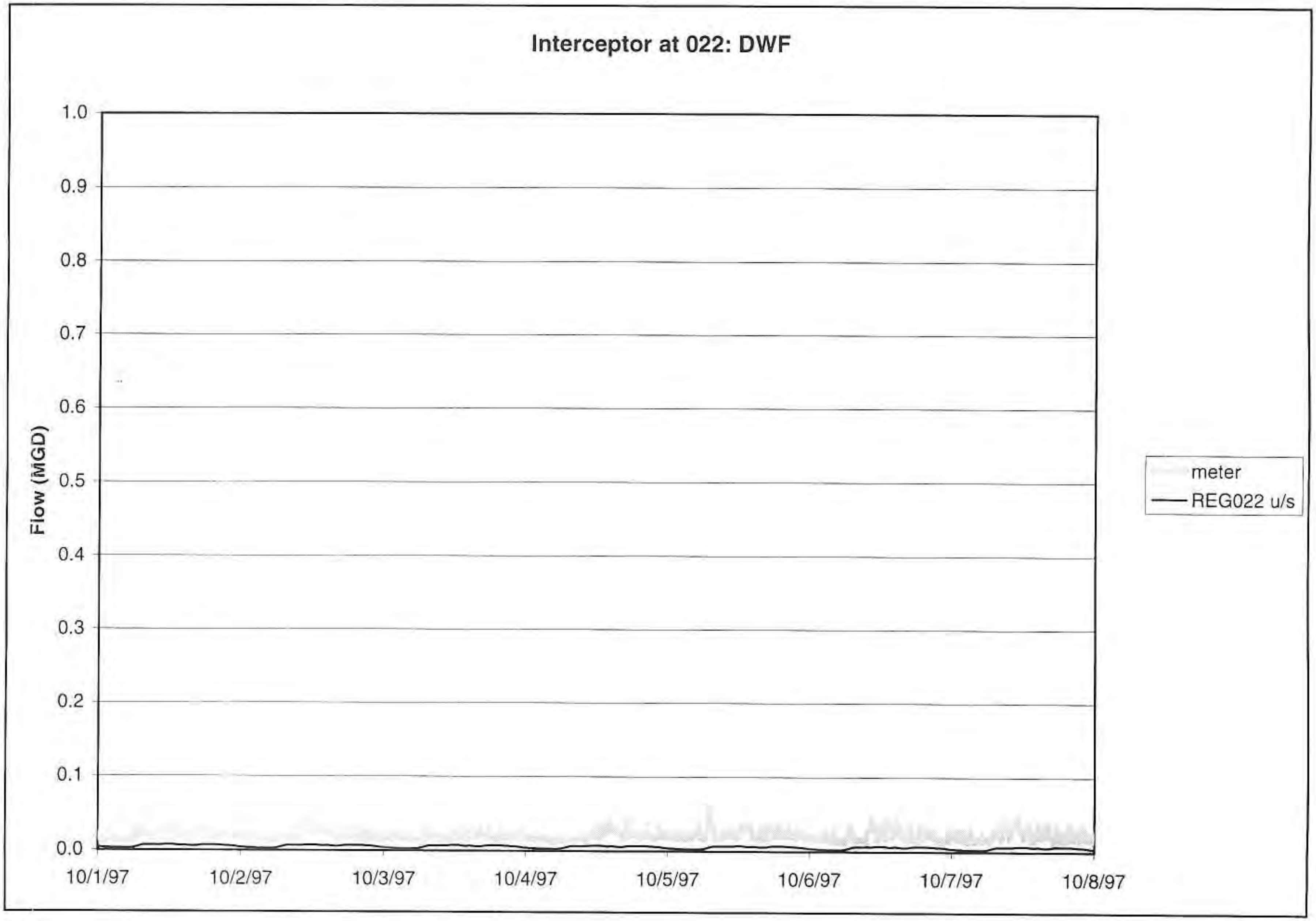
Interceptor at 009: DWF
2.5
2.0
1.5
1.0
0.5
0.0
Flow (MGD)
10/1/97
10/2/97
10/3/97
10/4/97
10/5/97
10/6/97
10/7/97
10/8/97
meter
REG009 d/s


D/S Interceptor at 020: DWF
(pump station influence)
Flow (MGD)
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
10/1/97
10/2/97
10/3/97
10/4/97
10/5/97
10/6/97
10/7/97
10/8/97
meter
REG020 d/s

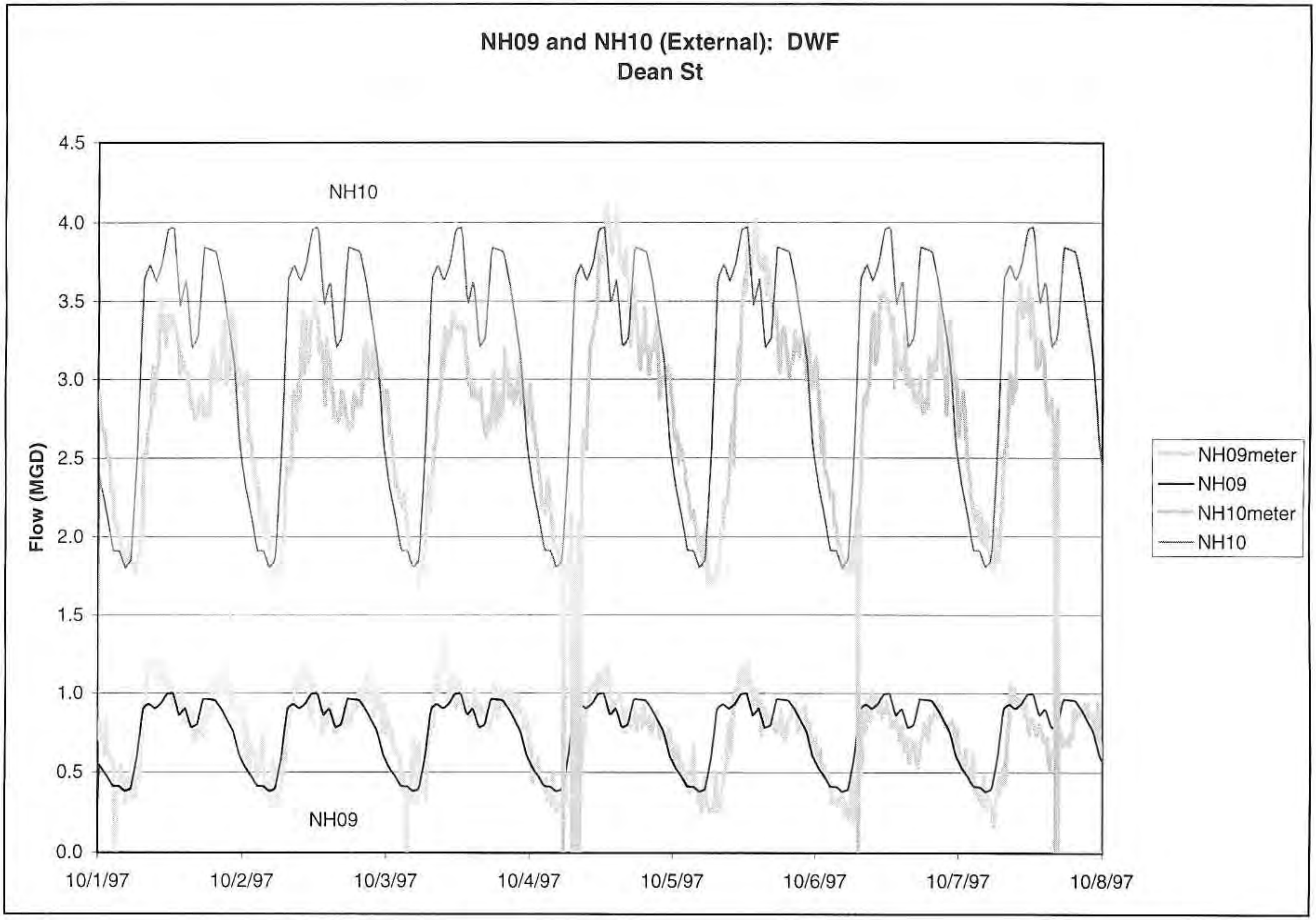


NH07 (External): DWF
Eastern St
Flow (MGD)
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
10/1/97
10/2/97
10/3/97
10/4/97
10/5/97
10/6/97
10/7/97
10/8/97
NH07meter
NH07


NH06 (External): DWF
Old Foxon Road
Flow (MGD)
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
10/1/97
10/2/97
10/3/97
10/4/97
10/5/97
10/6/97
10/7/97
10/8/97
NH06meter
NH06



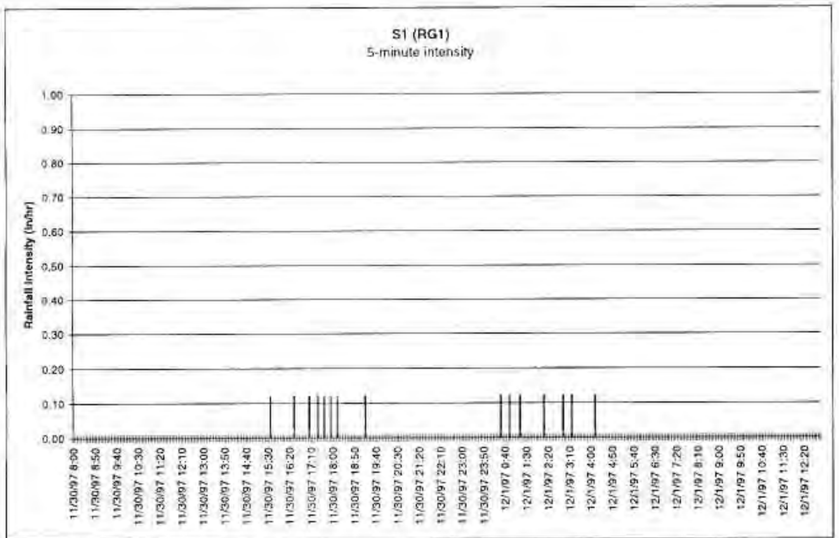
Interceptor at 022: DWF
Flow (MGD)
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
10/1/97
10/2/97
10/3/97
10/4/97
10/5/97
10/6/97
10/7/97
10/8/97
meter
REG022 u/s

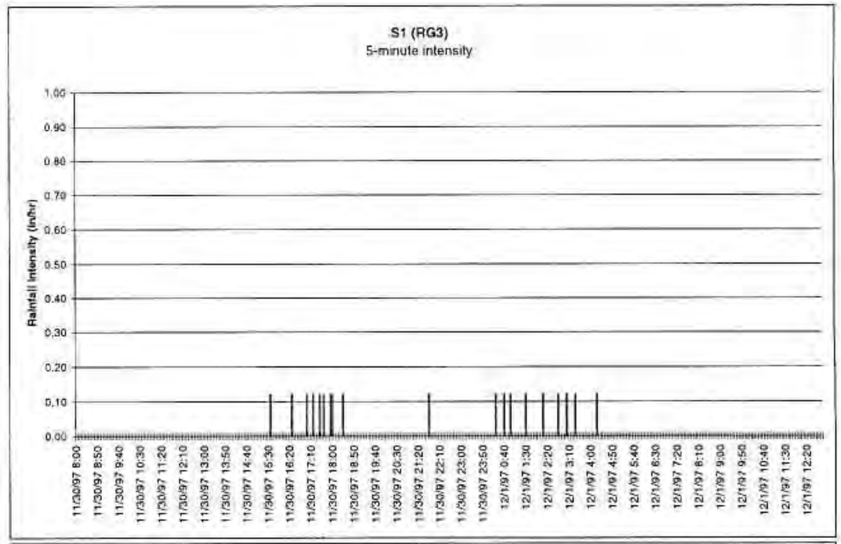


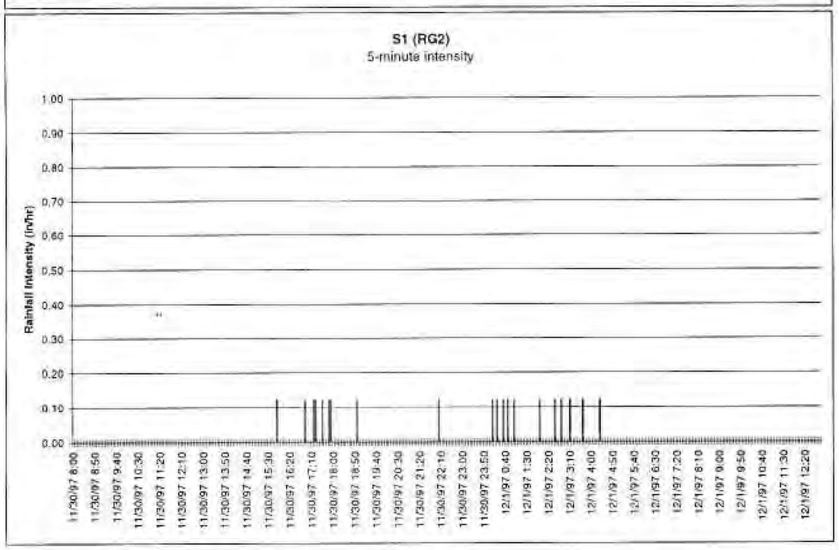
NH09 and NH10 (External): DWF
Dean St
Flow (MGD)
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
NH10
NH09
10/1/97
10/2/97
10/3/97
10/4/97
10/5/97
10/6/97
10/7/97
10/8/97
NH09meter
NH09
NH10meter
NH10

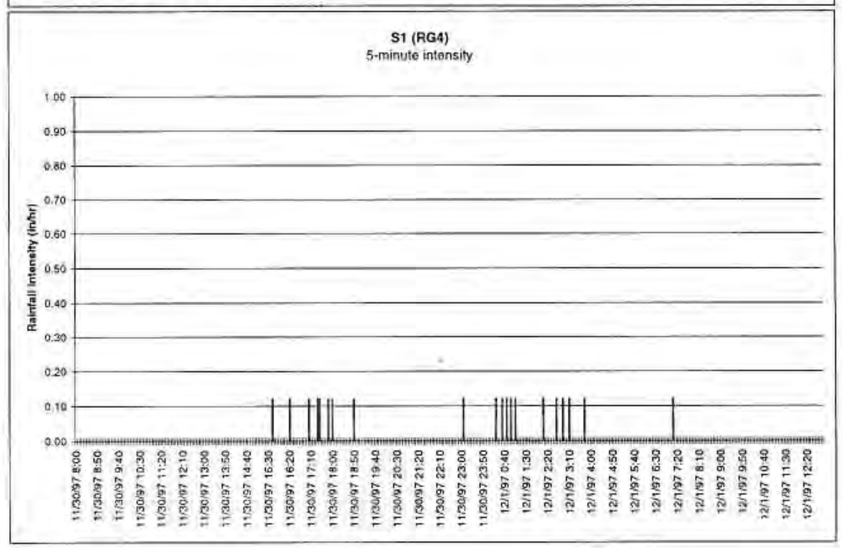
## Storm S1

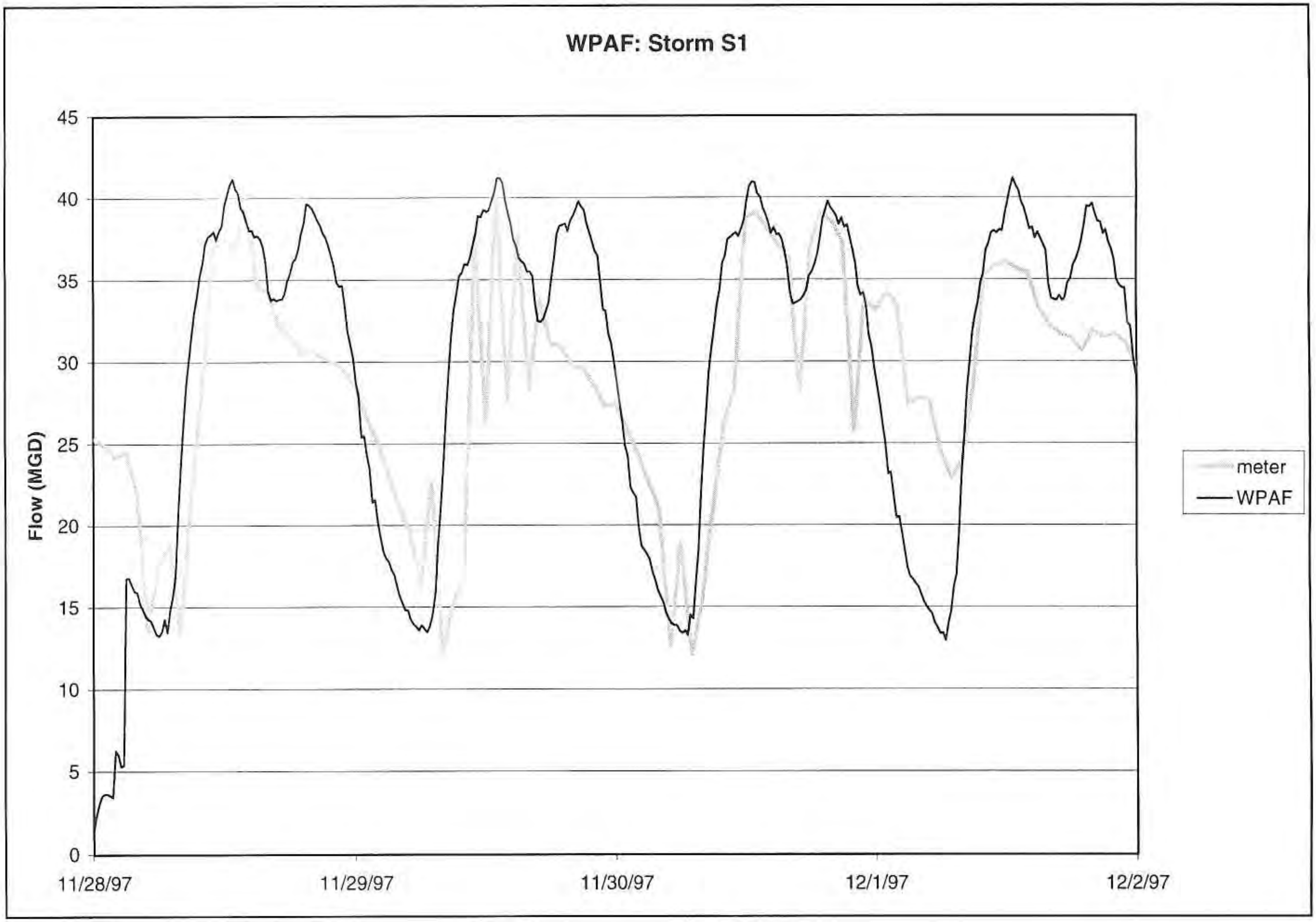
# Rainfall: Storm S1



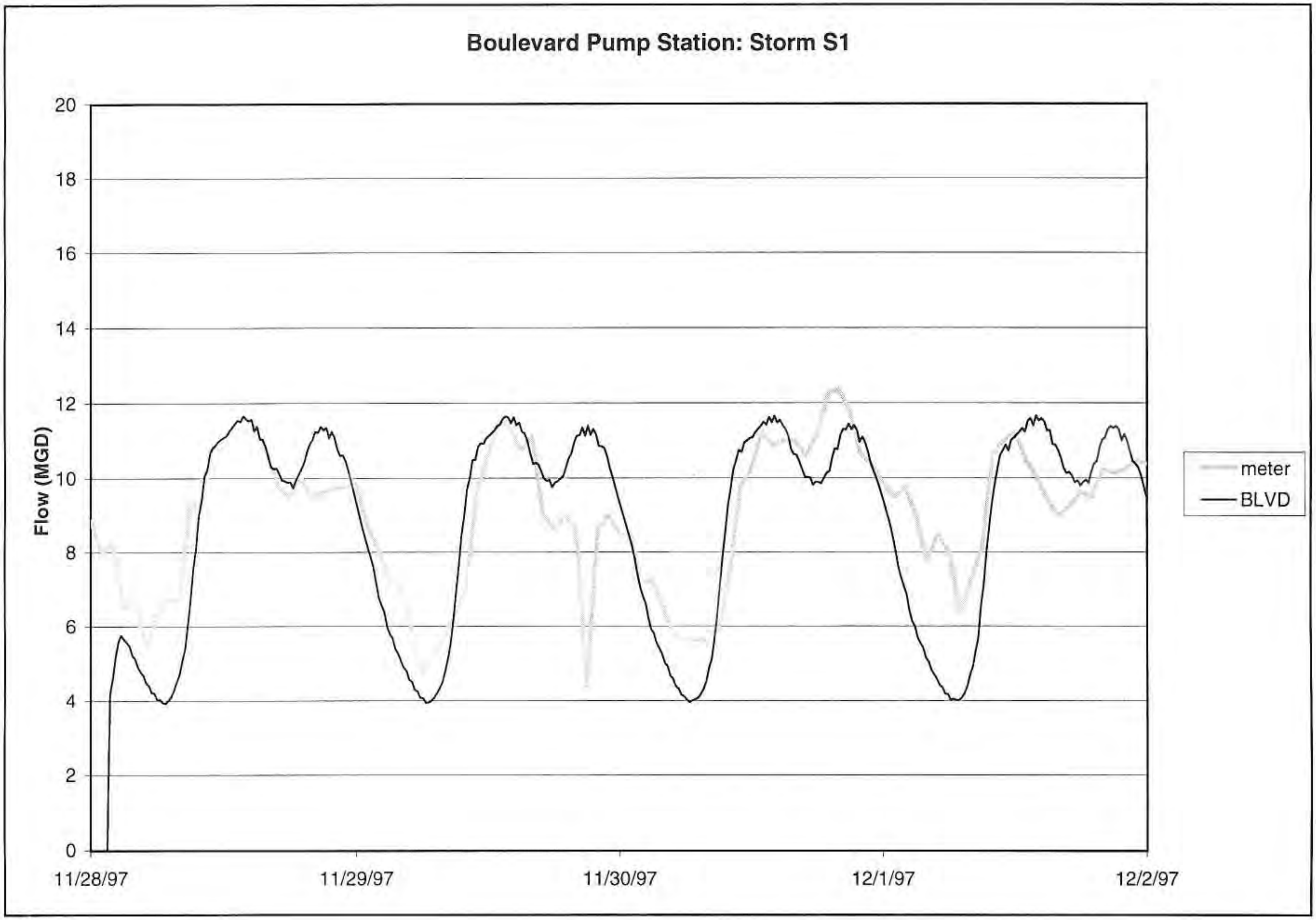



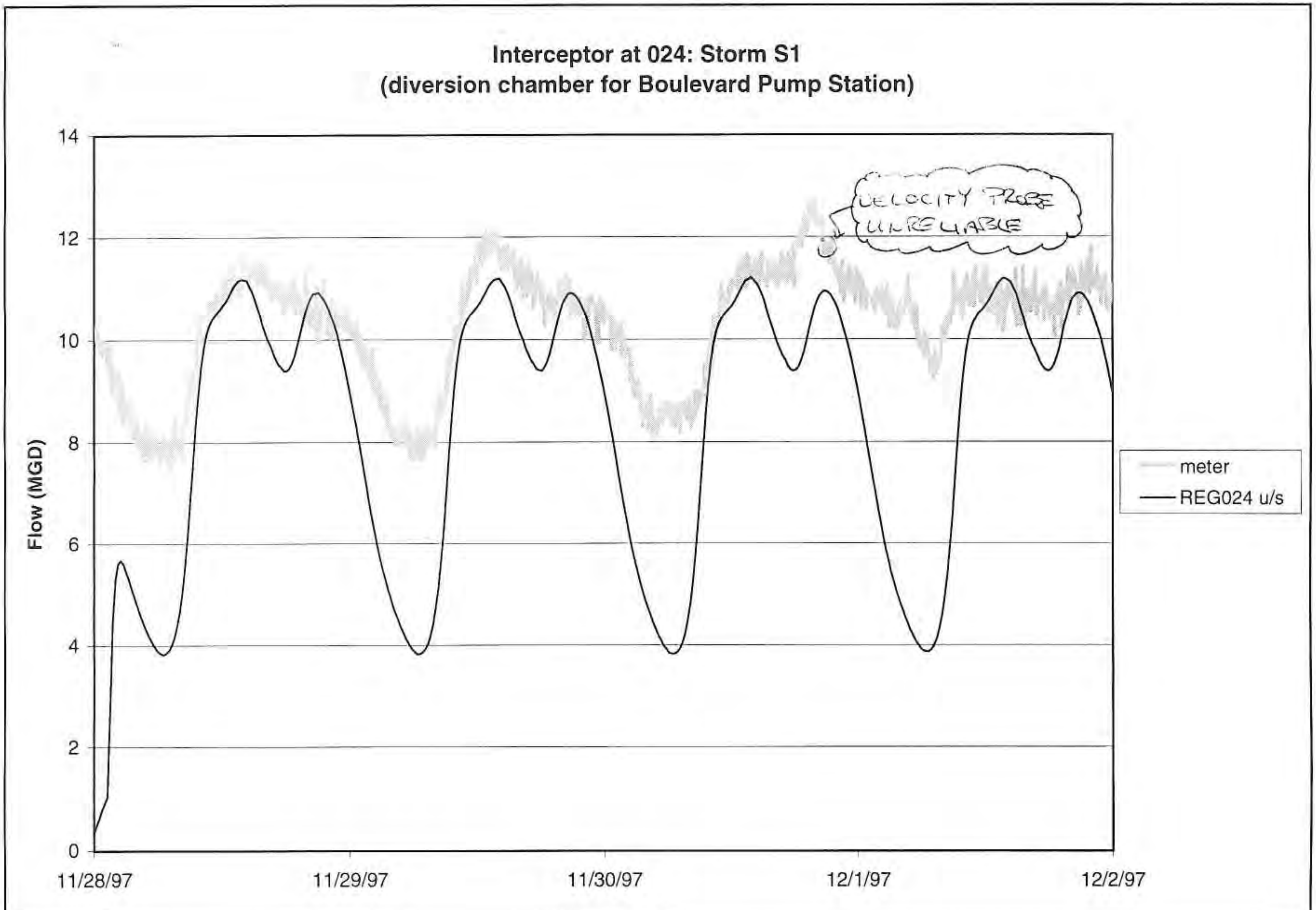





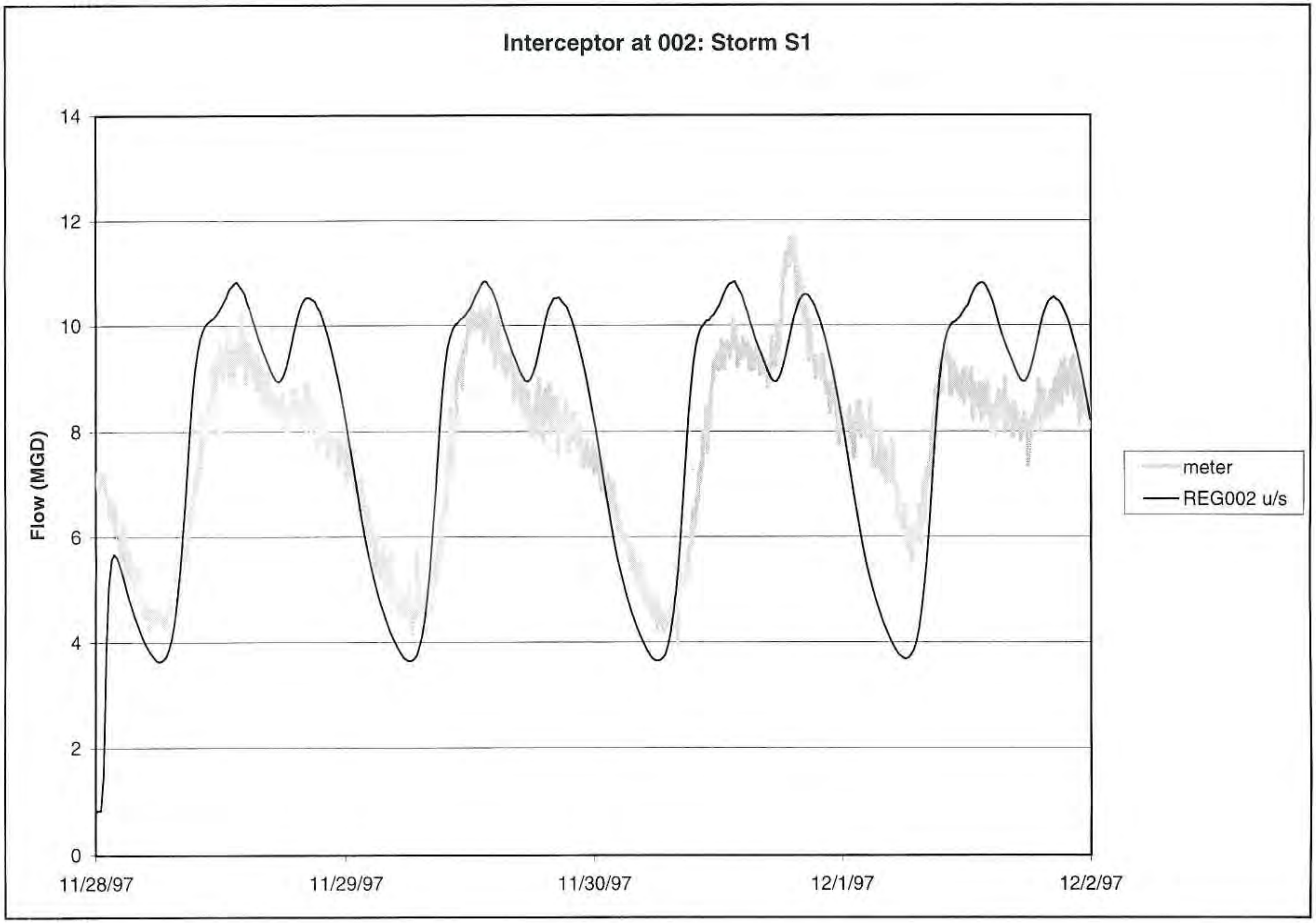
WPAF: Storm S1
45
40
35
30
25
20
15
10
5
0
Flow (MGD)
11/28/97
11/29/97
11/30/97
12/1/97
12/2/97
meter
WPAF



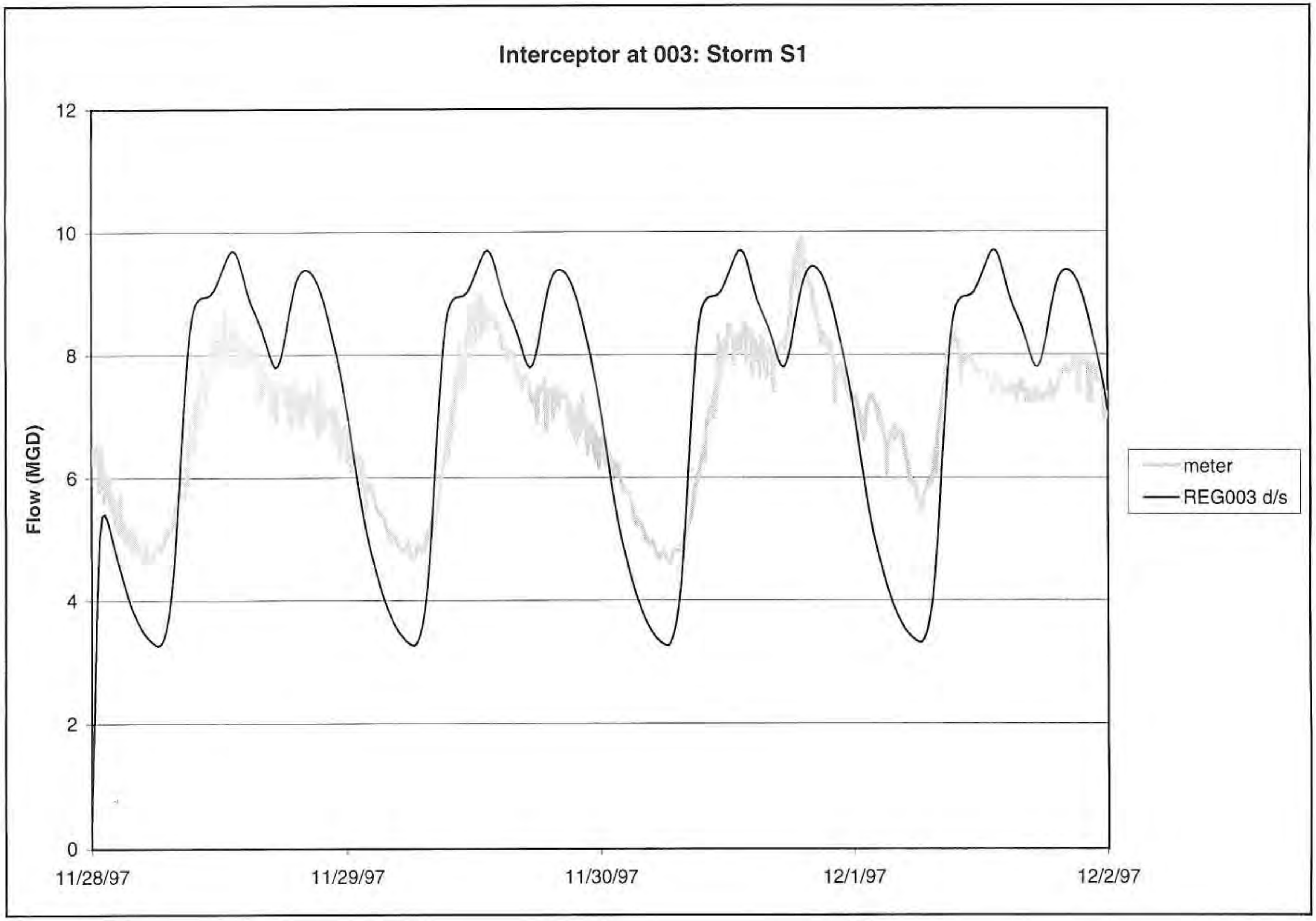
Boulevard Pump Station: Storm S1
Flow (MGD)
20
18
16
14
12
10
8
6
4
2
0
11/28/97
11/29/97
11/30/97
12/1/97
12/2/97
meter
BLVD



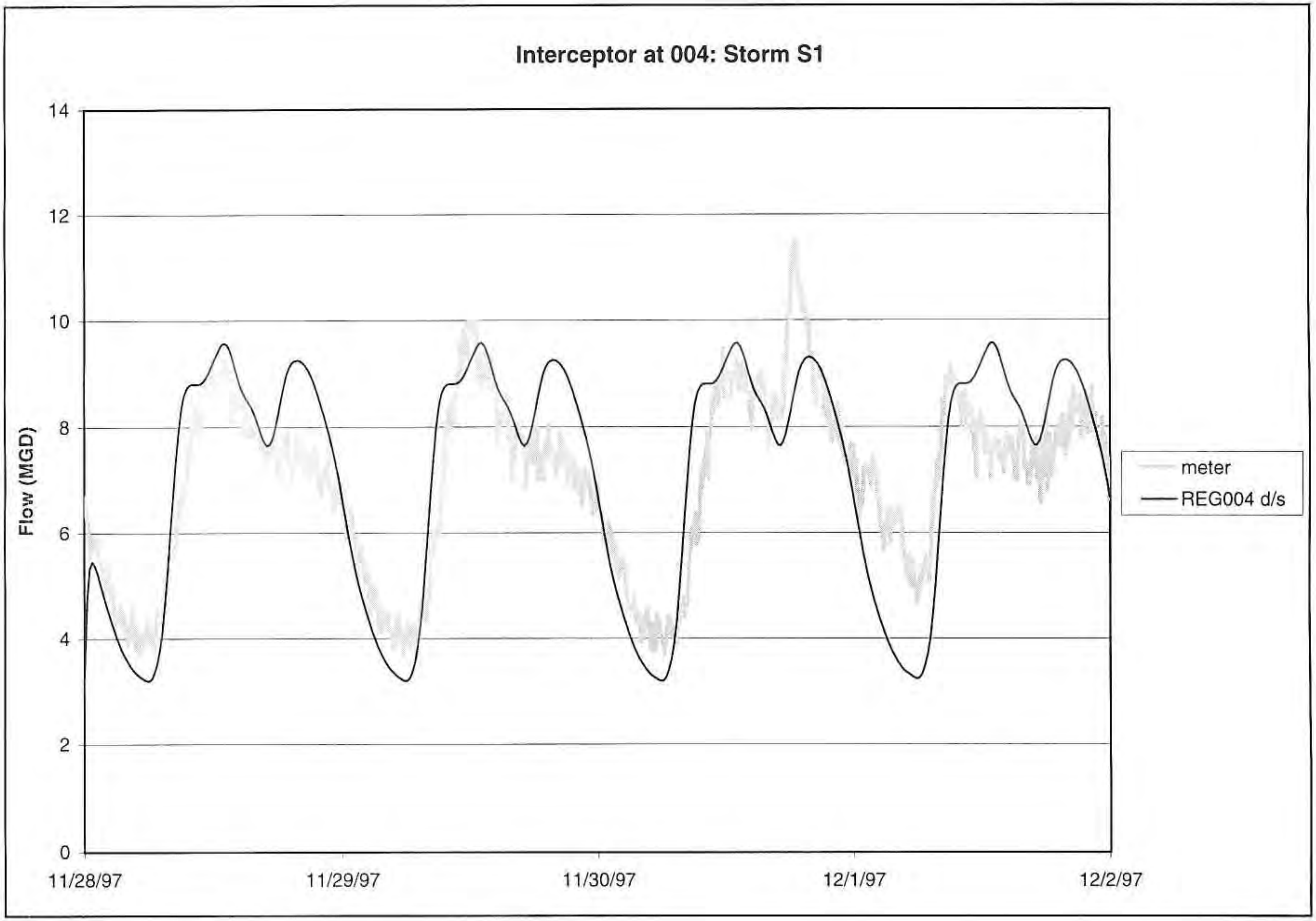
Interceptor at 024: Storm S1
(diversion chamber for Boulevard Pump Station)
Flow (MGD)
14
12
10
8
6
4
2
0
11/28/97
11/29/97
11/30/97
12/1/97
12/2/97
meter
REG024 u/s
VELOCITY PROBE UNRELIABLE



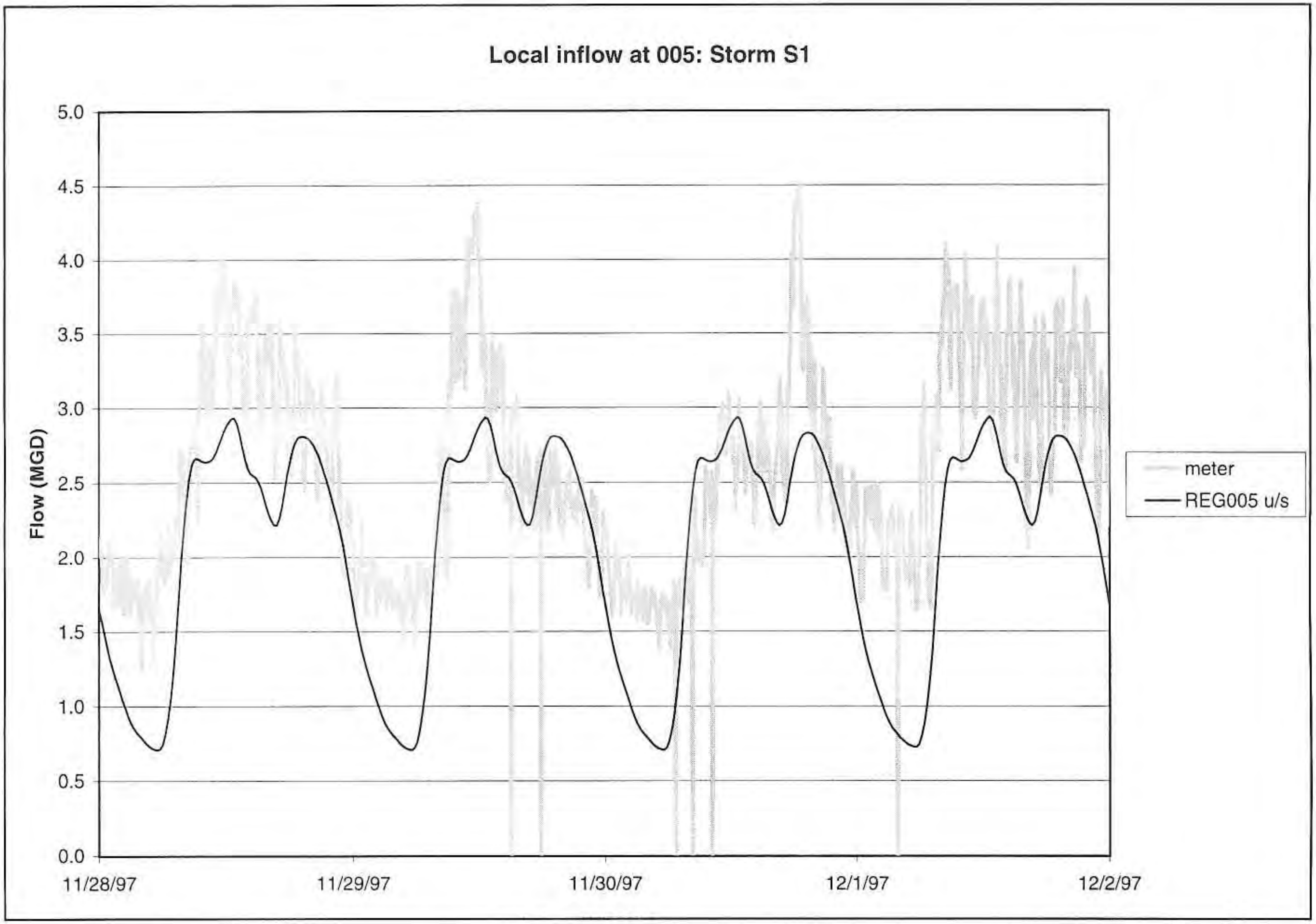
Interceptor at 002: Storm S1
14
12
10
8
6
4
2
0
Flow (MGD)
11/28/97
11/29/97
11/30/97
12/1/97
12/2/97
meter
REG002 u/s

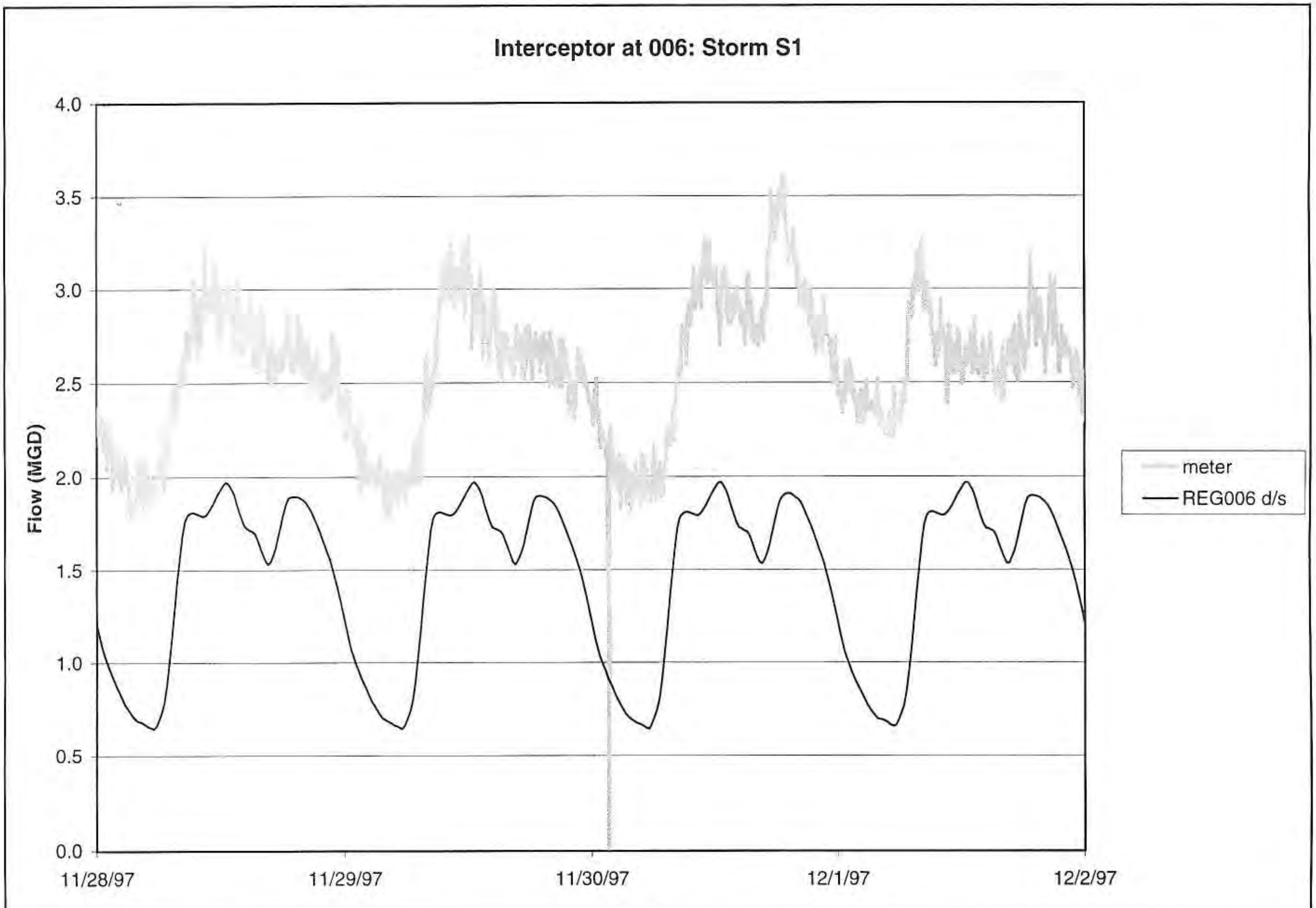


Interceptor at 003: Storm S1
Flow (MGD)
0
2
4
6
8
10
12
11/28/97
11/29/97
11/30/97
12/1/97
12/2/97
meter
REG003 d/s

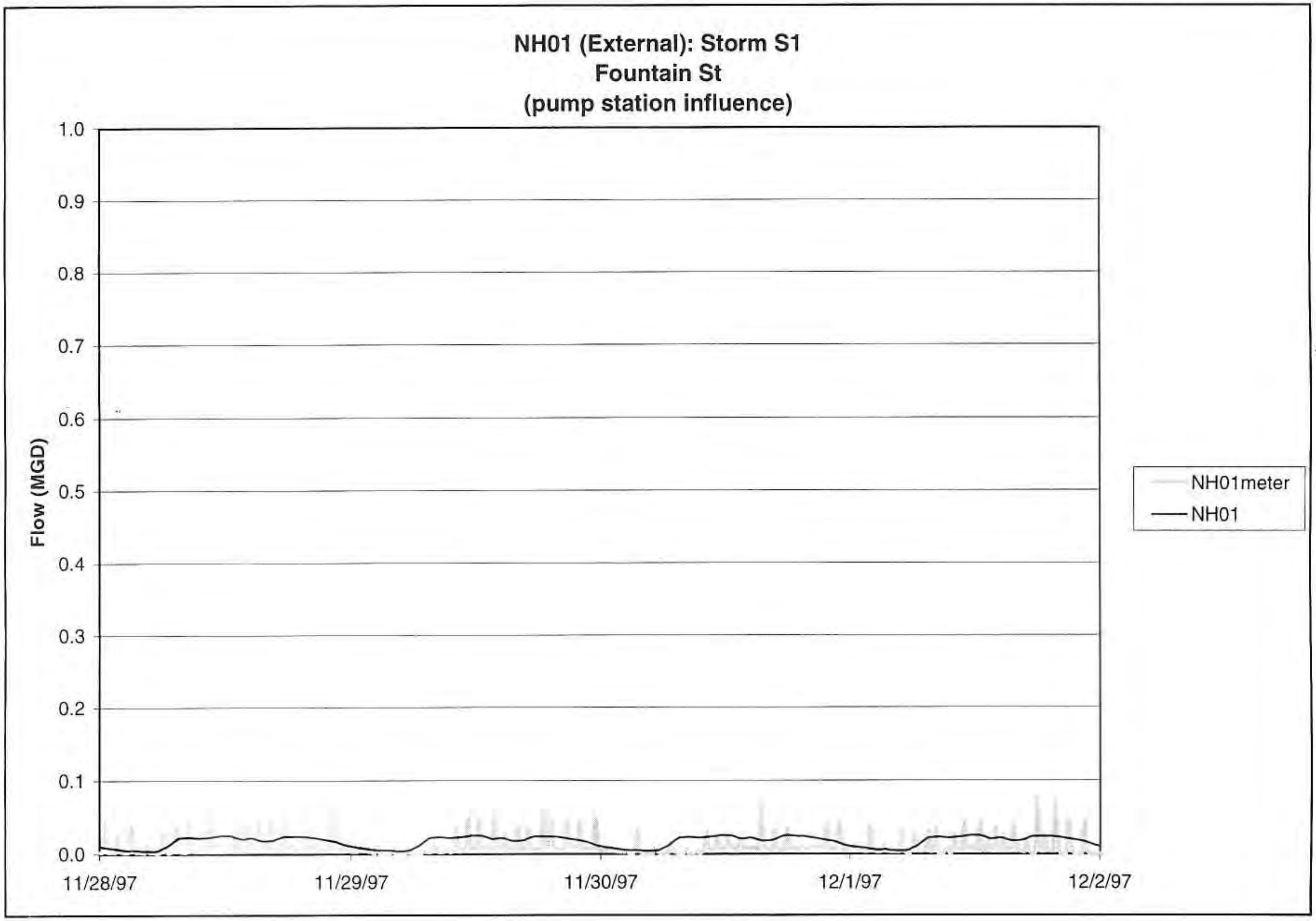


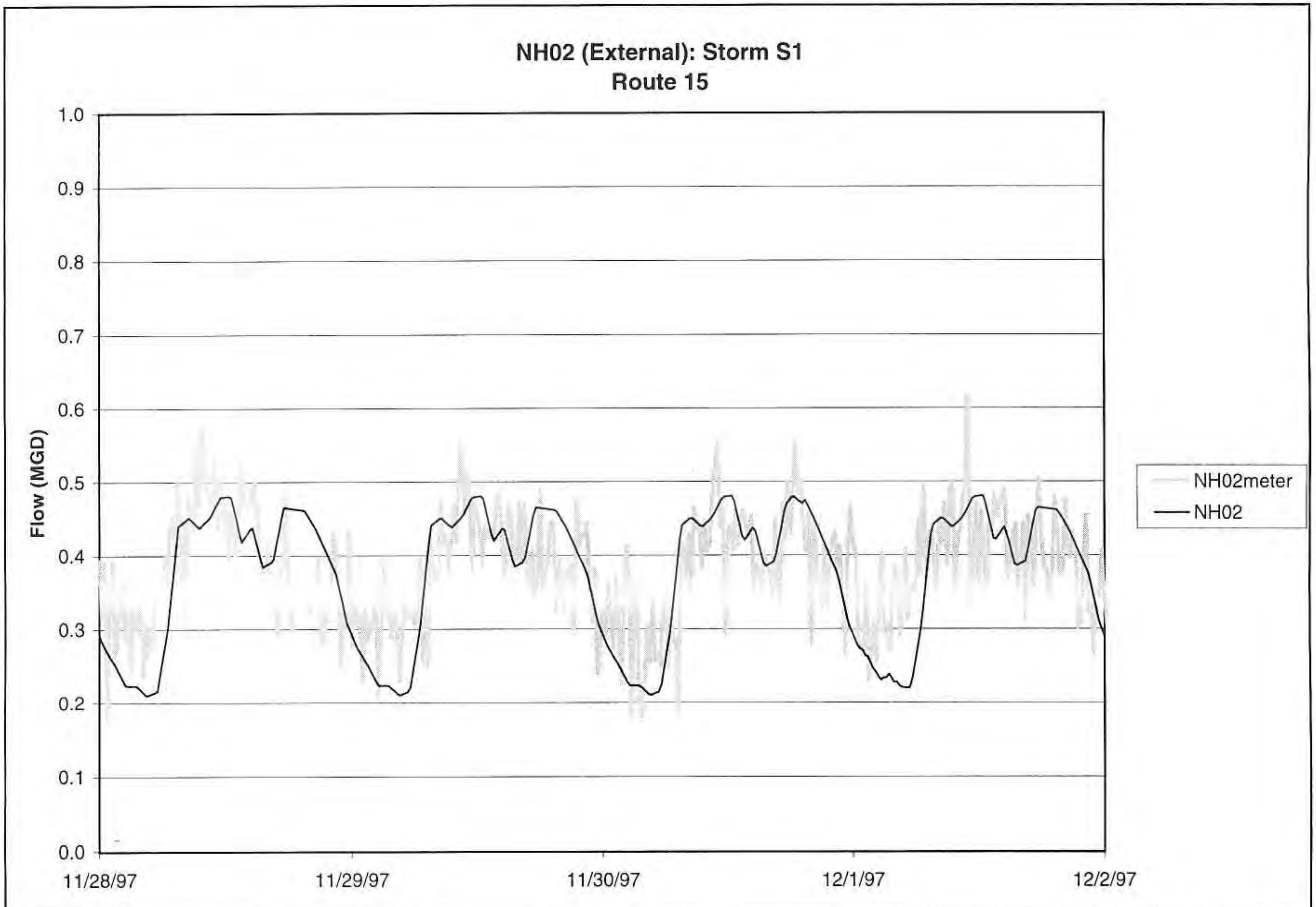
Interceptor at 004: Storm S1
Flow (MGD)
14
12
10
8
6
4
2
0
11/28/97
11/29/97
11/30/97
12/1/97
12/2/97
meter
REG004 d/s

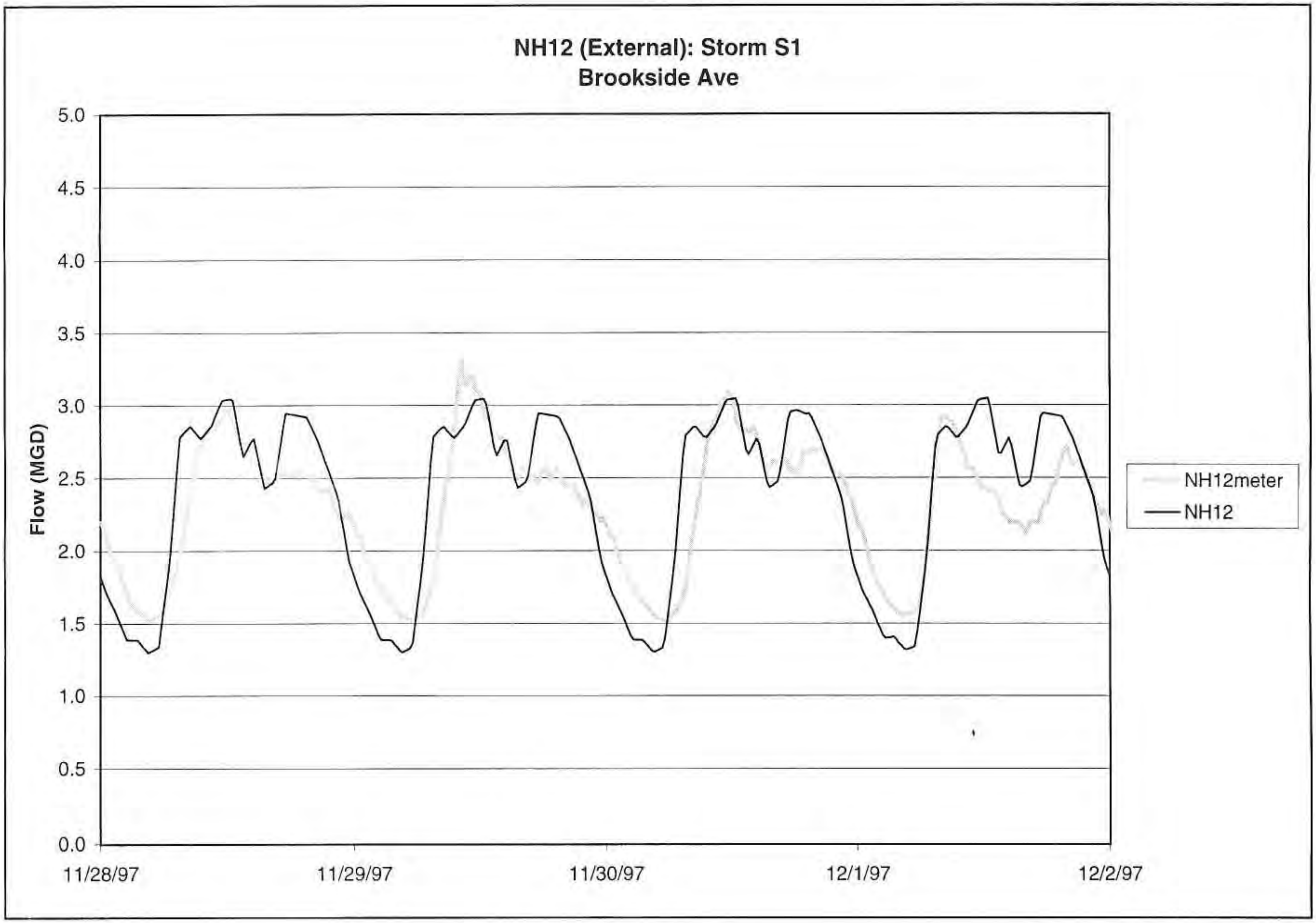

Local inflow at 005: Storm S1
Flow (MGD)
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
11/28/97
11/29/97
11/30/97
12/1/97
12/2/97
meter
REG005 u/s

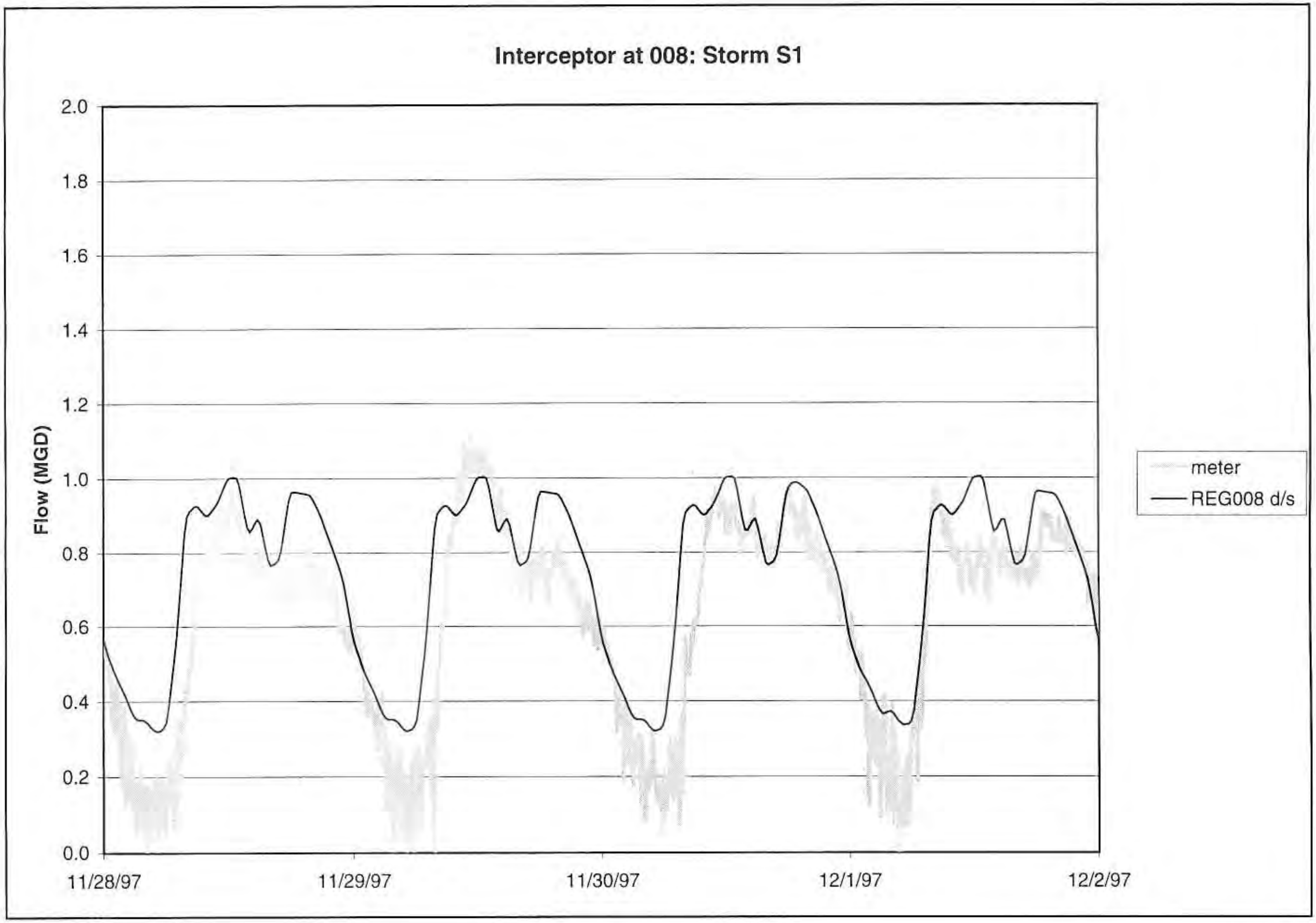


Interceptor at 006: Storm S1
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
Flow (MGD)
11/28/97
11/29/97
11/30/97
12/1/97
12/2/97
meter
REG006 d/s

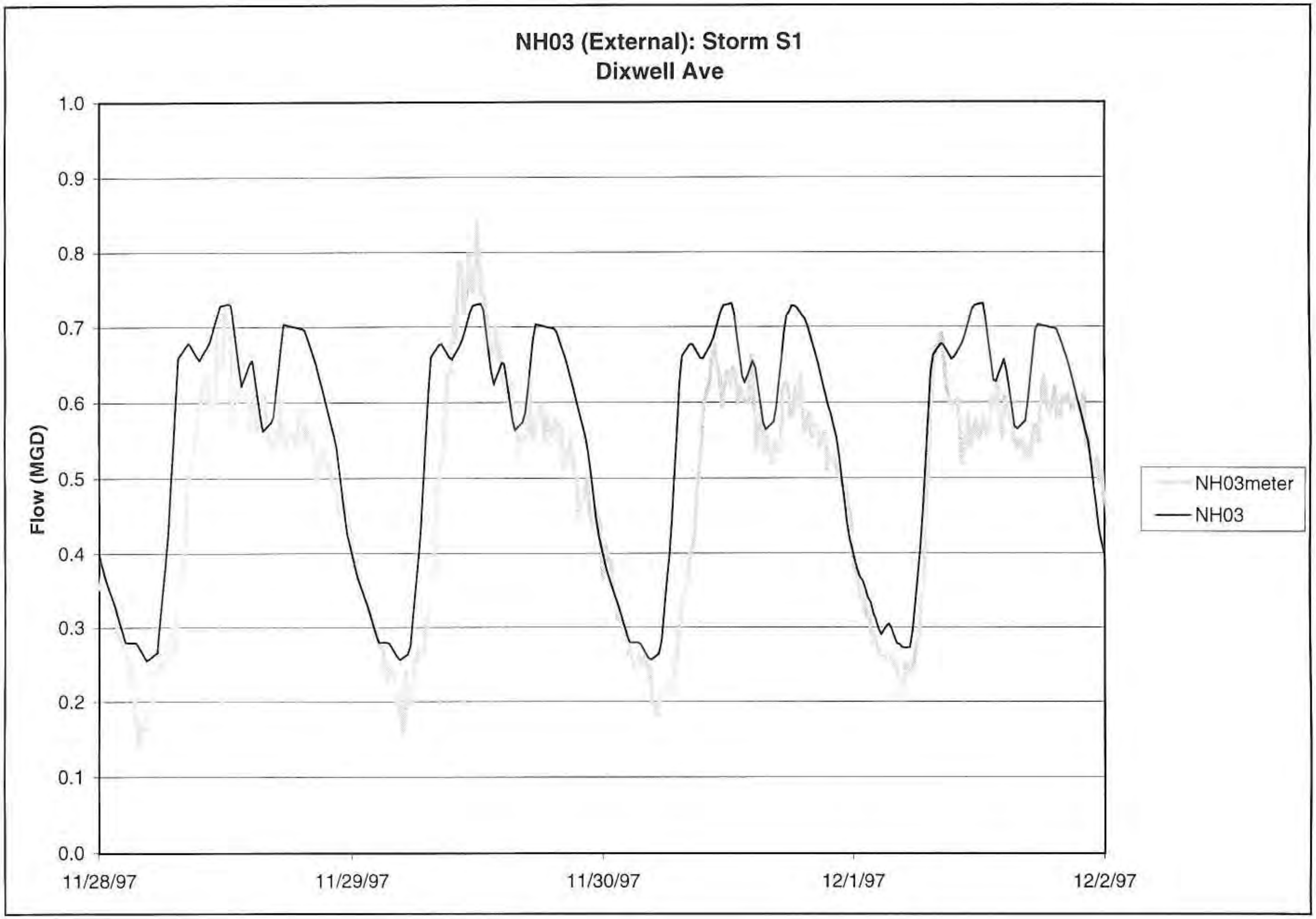

NH01 (External): Storm S1
Fountain St
(pump station influence)
Flow (MGD)
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
11/28/97
11/29/97
11/30/97
12/1/97
12/2/97
NH01meter
NH01


NH02 (External): Storm S1
Route 15
Flow (MGD)
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
11/28/97
11/29/97
11/30/97
12/1/97
12/2/97
NH02meter
NH02

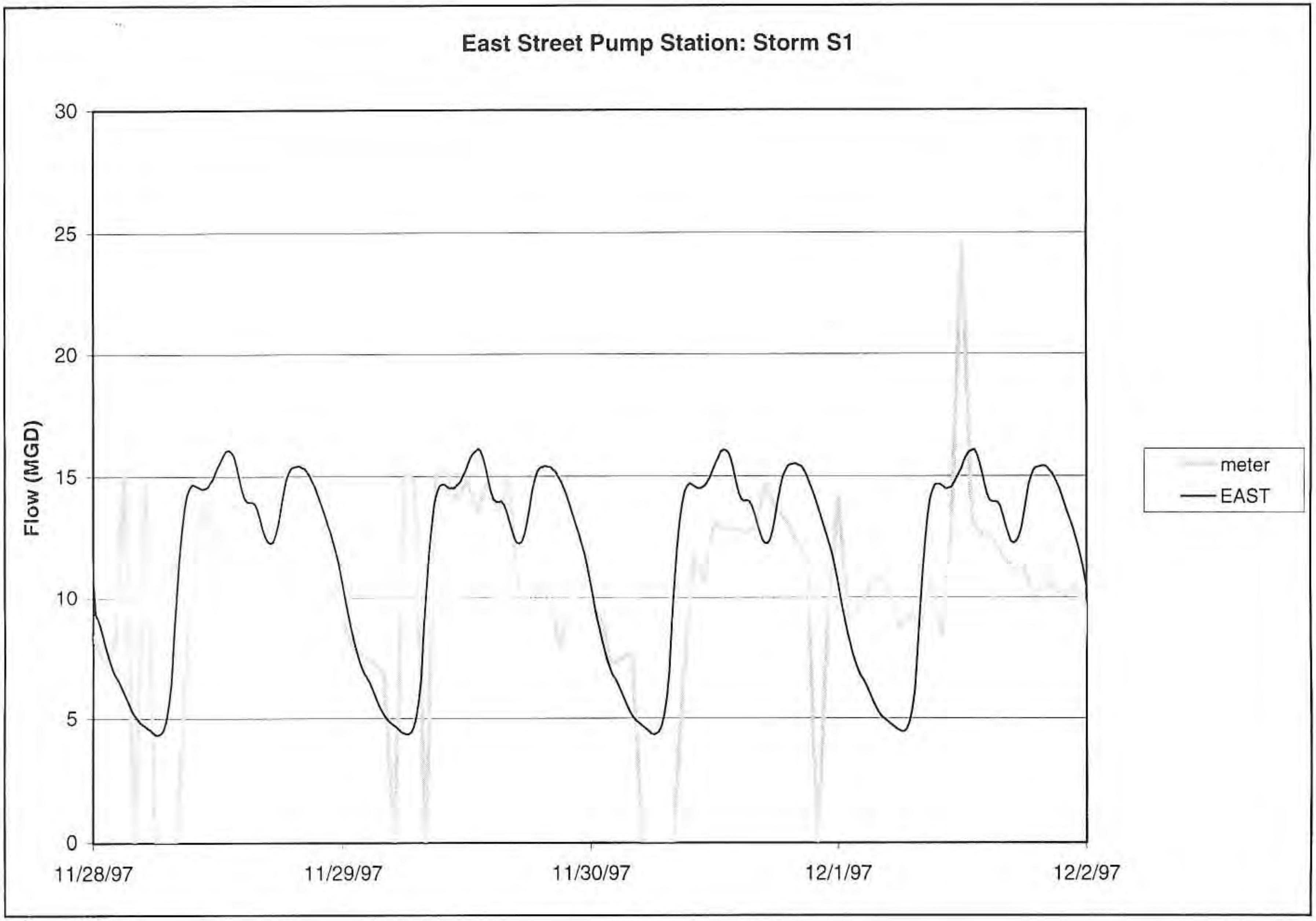

NH12 (External): Storm S1
Brookside Ave
Flow (MGD)
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
11/28/97
11/29/97
11/30/97
12/1/97
12/2/97
NH12meter
NH12

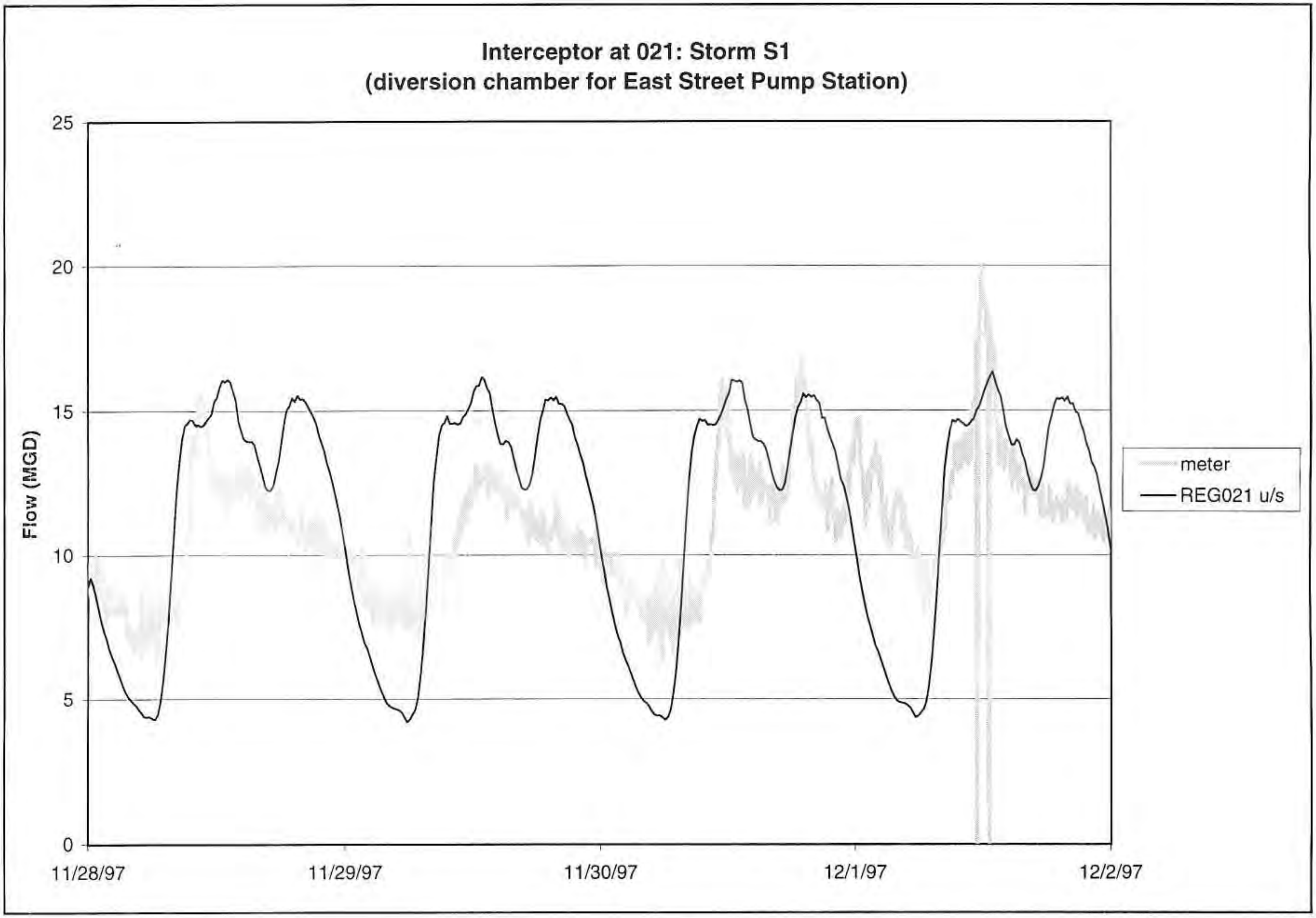


Interceptor at 008: Storm S1
Flow (MGD)
2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
11/28/97
11/29/97
11/30/97
12/1/97
12/2/97
meter
REG008 d/s

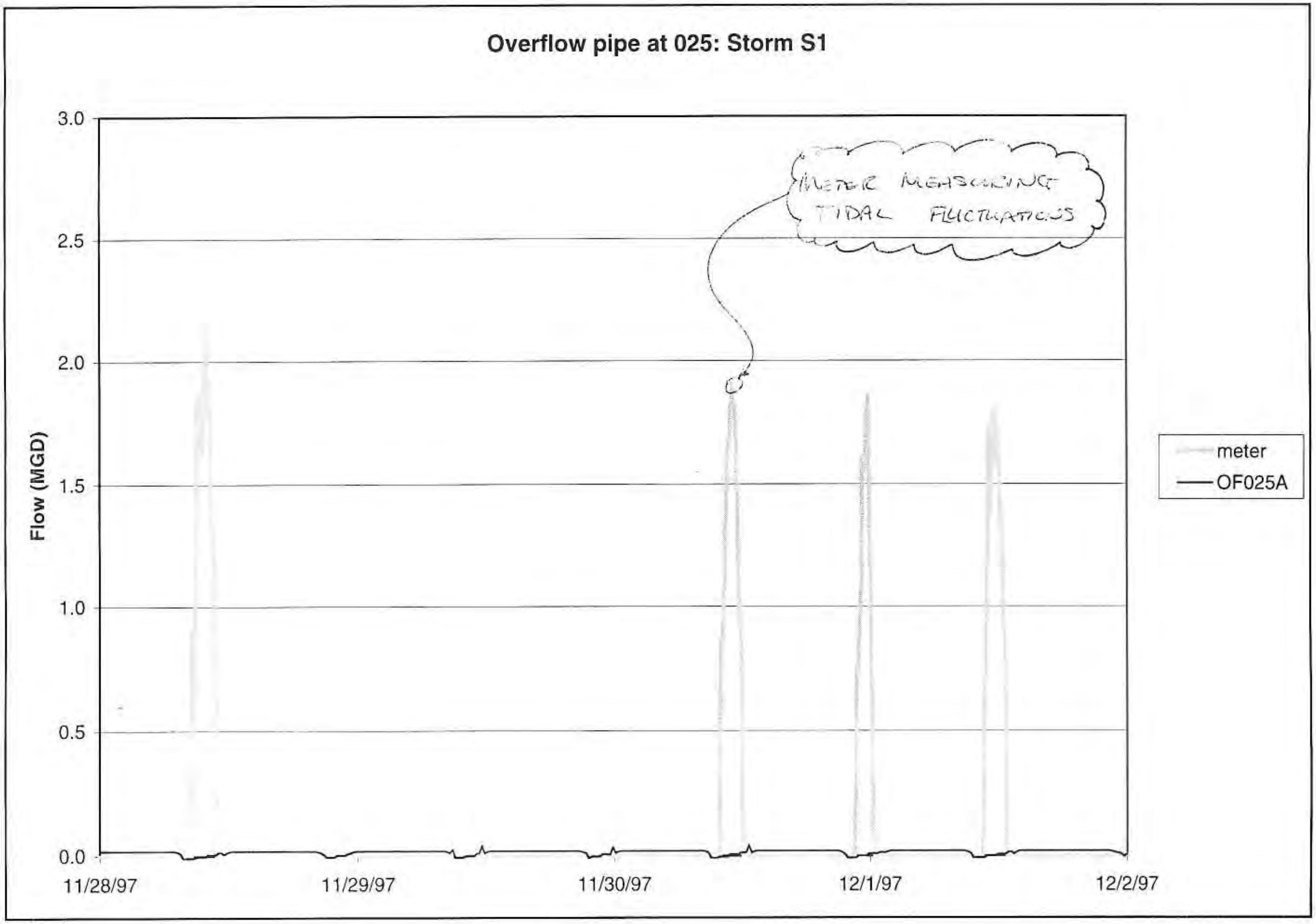


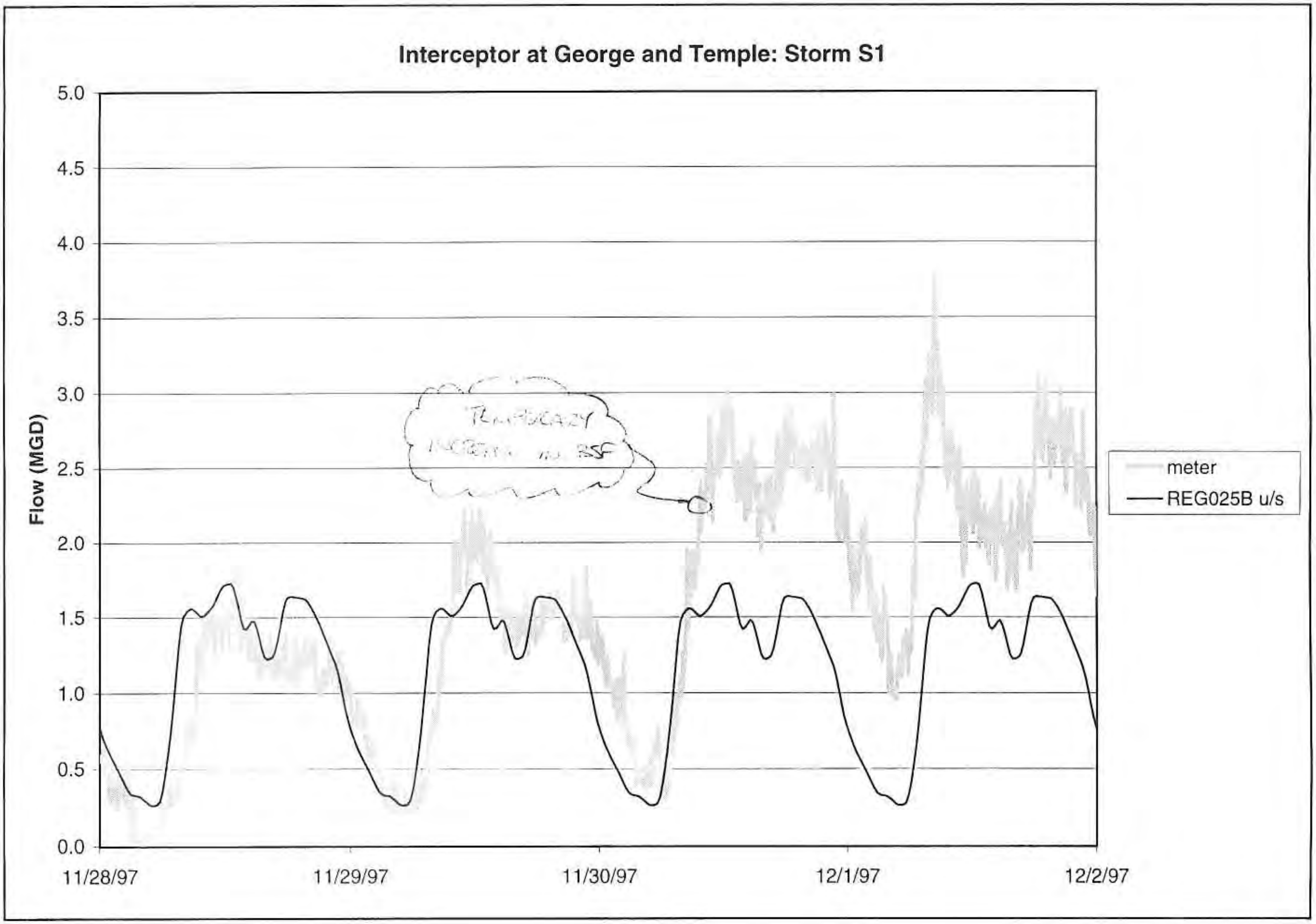
NH03 (External): Storm S1
Dixwell Ave
Flow (MGD)
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
11/28/97
11/29/97
11/30/97
12/1/97
12/2/97
NH03meter
NH03

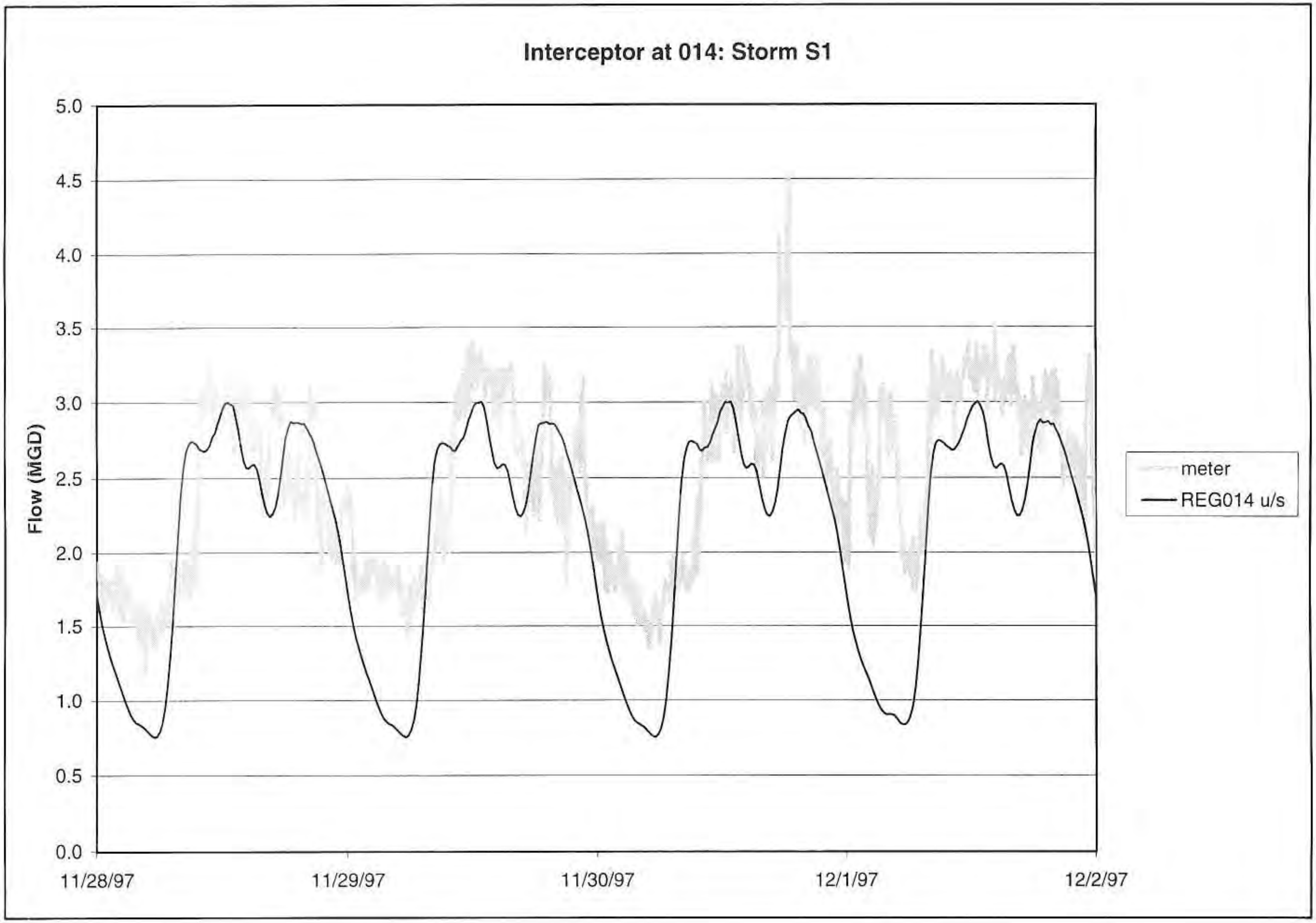

East Street Pump Station: Storm S1
30
25
20
15
10
5
0
Flow (MGD)
11/28/97
11/29/97
11/30/97
12/1/97
12/2/97
meter
EAST



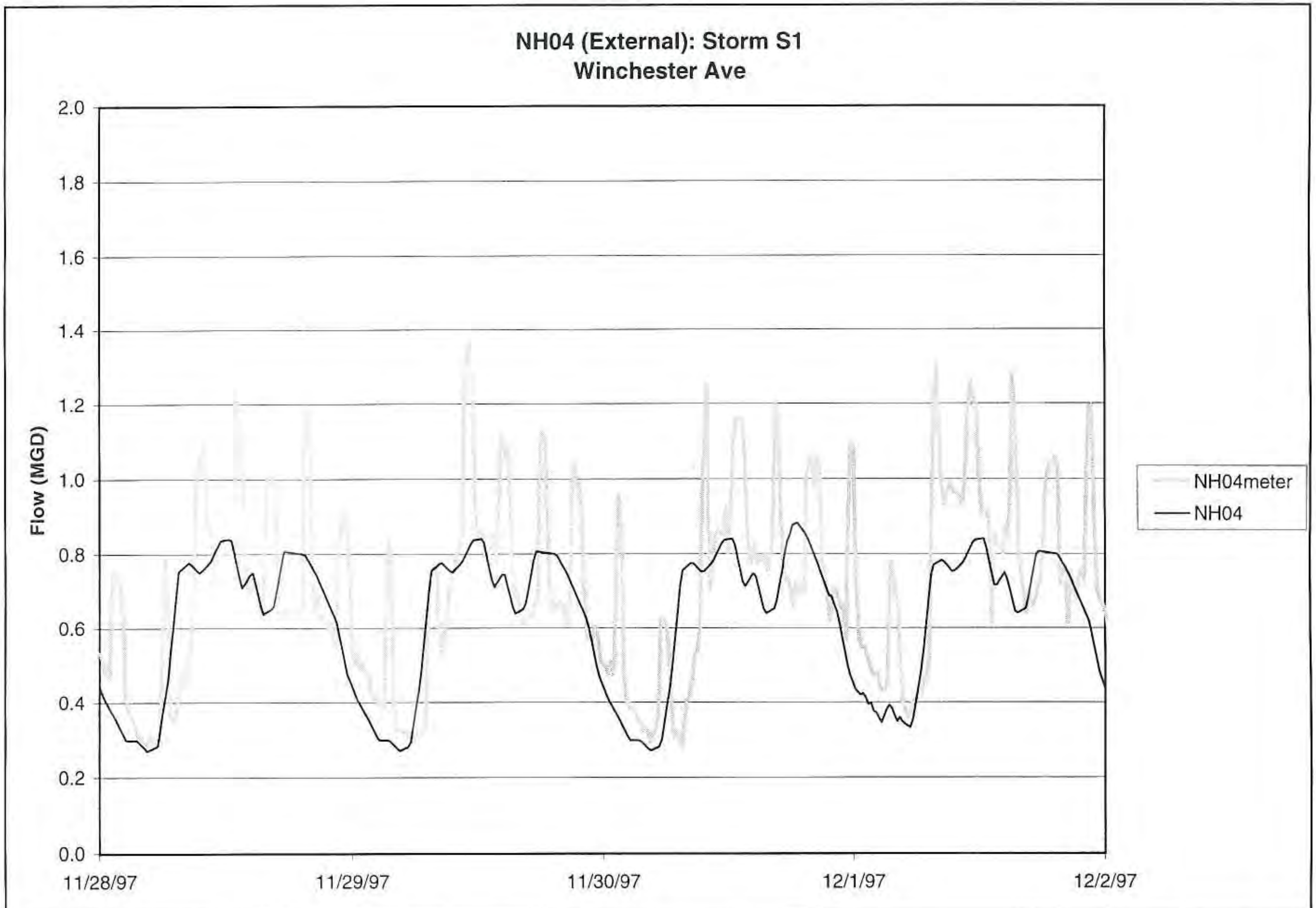
Interceptor at 021: Storm S1
(diversion chamber for East Street Pump Station)
Flow (MGD)
25
20
15
10
5
0
11/28/97
11/29/97
11/30/97
12/1/97
12/2/97
meter
REG021 u/s

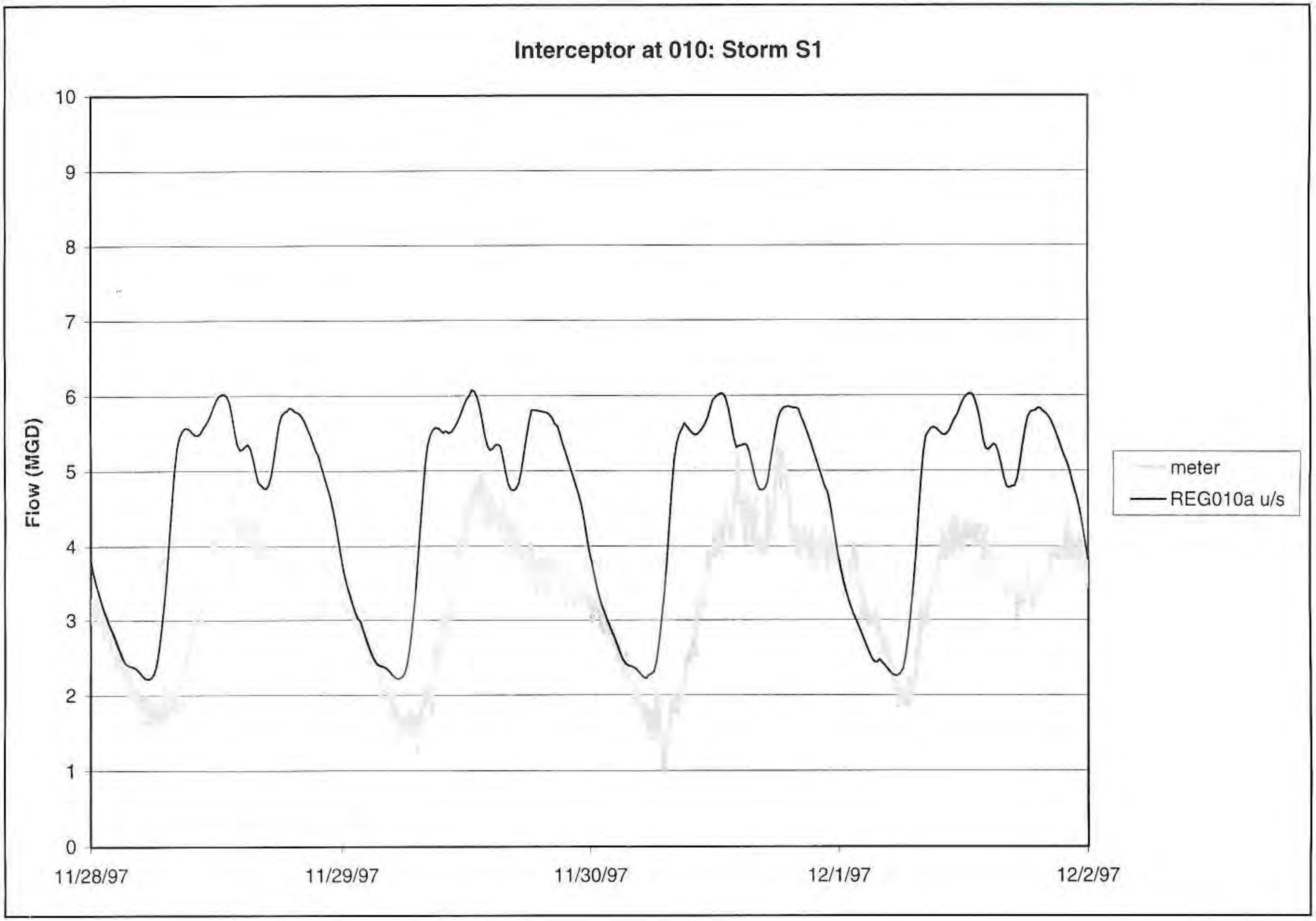

Overflow pipe at 025: Storm S1
3.0
2.5
2.0
1.5
1.0
0.5
0.0
Flow (MGD)
11/28/97
11/29/97
11/30/97
12/1/97
12/2/97
meter
OF025A
METER MEASURING TIDAL FLUCTUATIONS

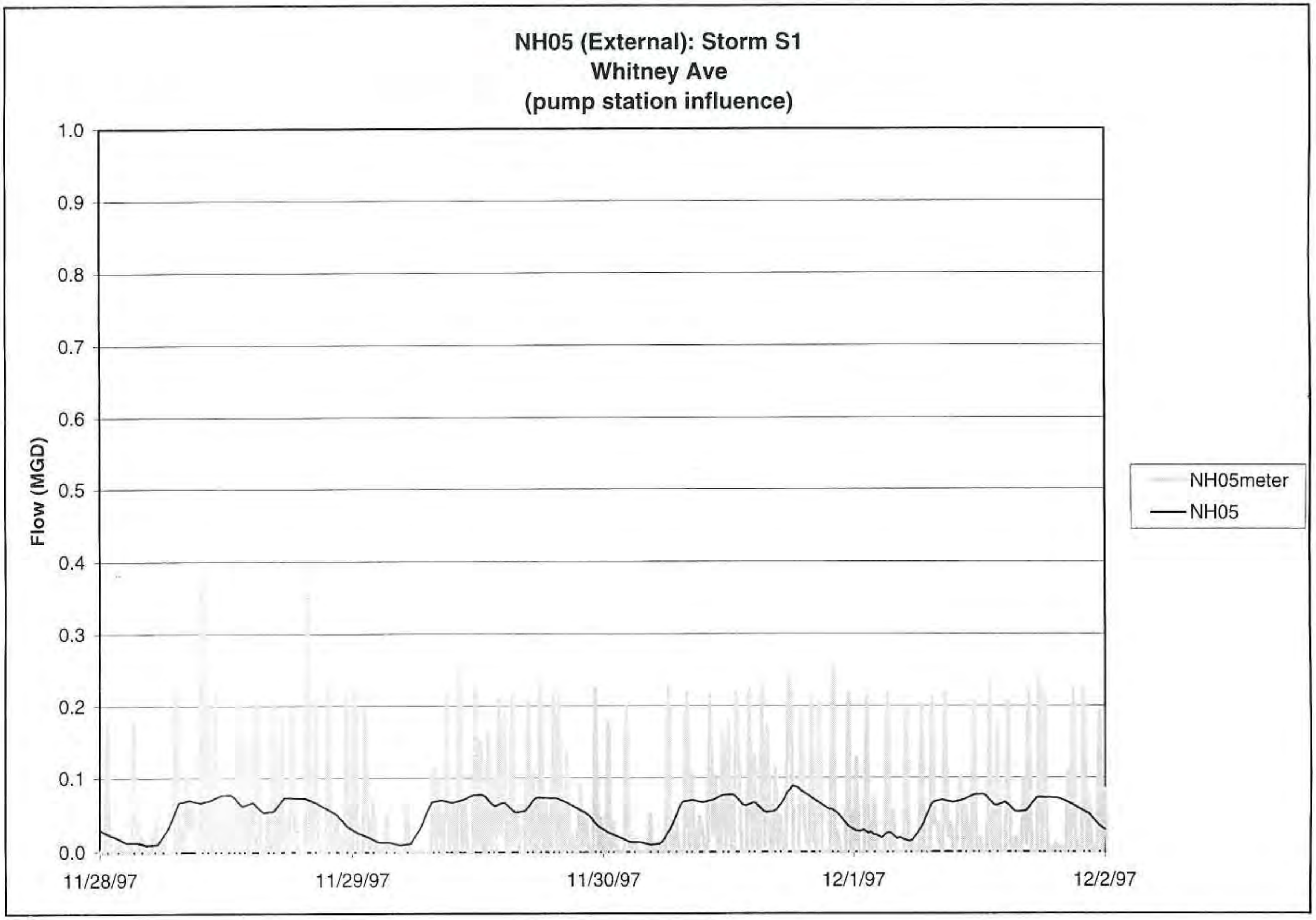

Interceptor at George and Temple: Storm S1
Flow (MGD)
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
11/28/97
11/29/97
11/30/97
12/1/97
12/2/97
meter
REG025B u/s

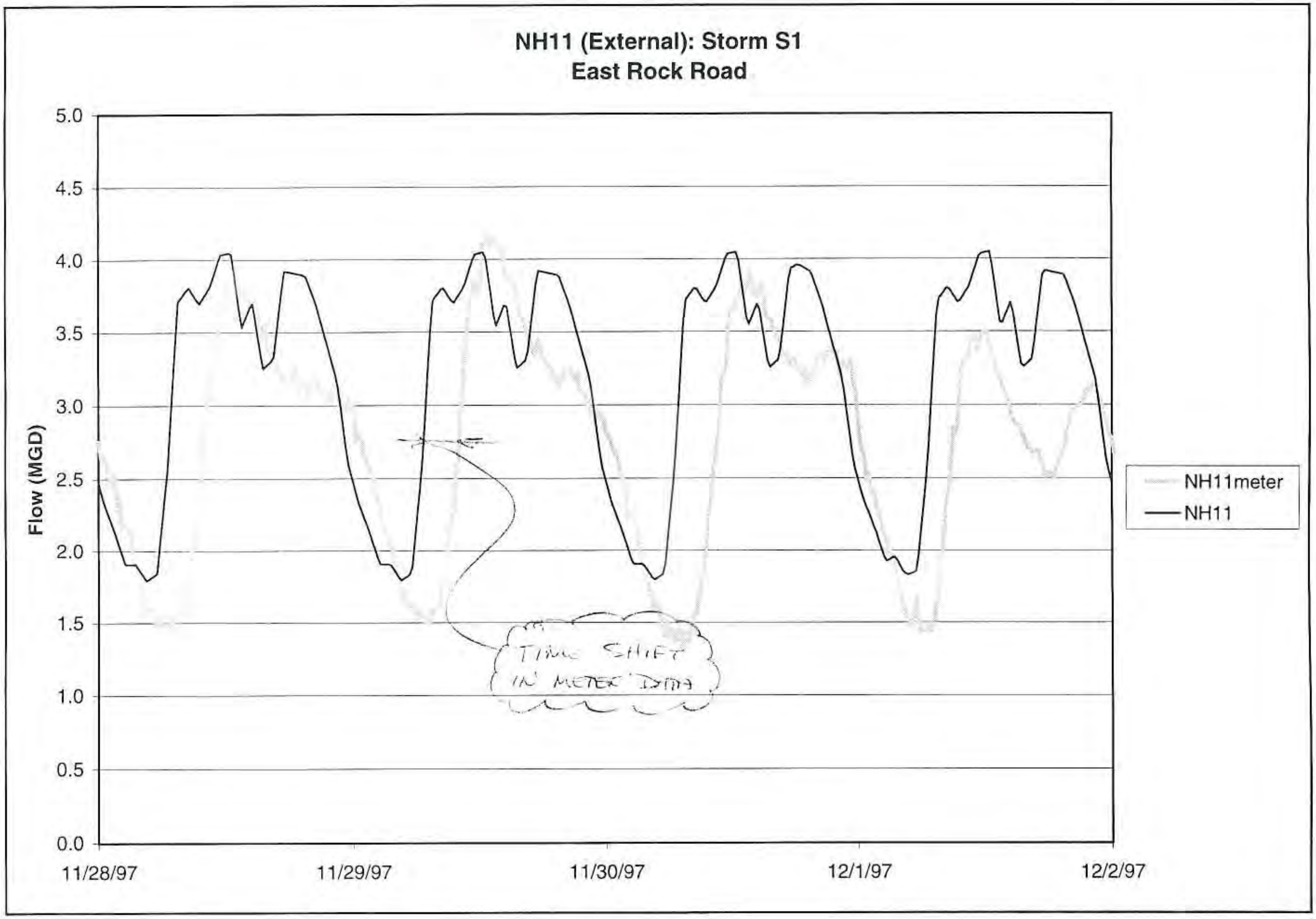


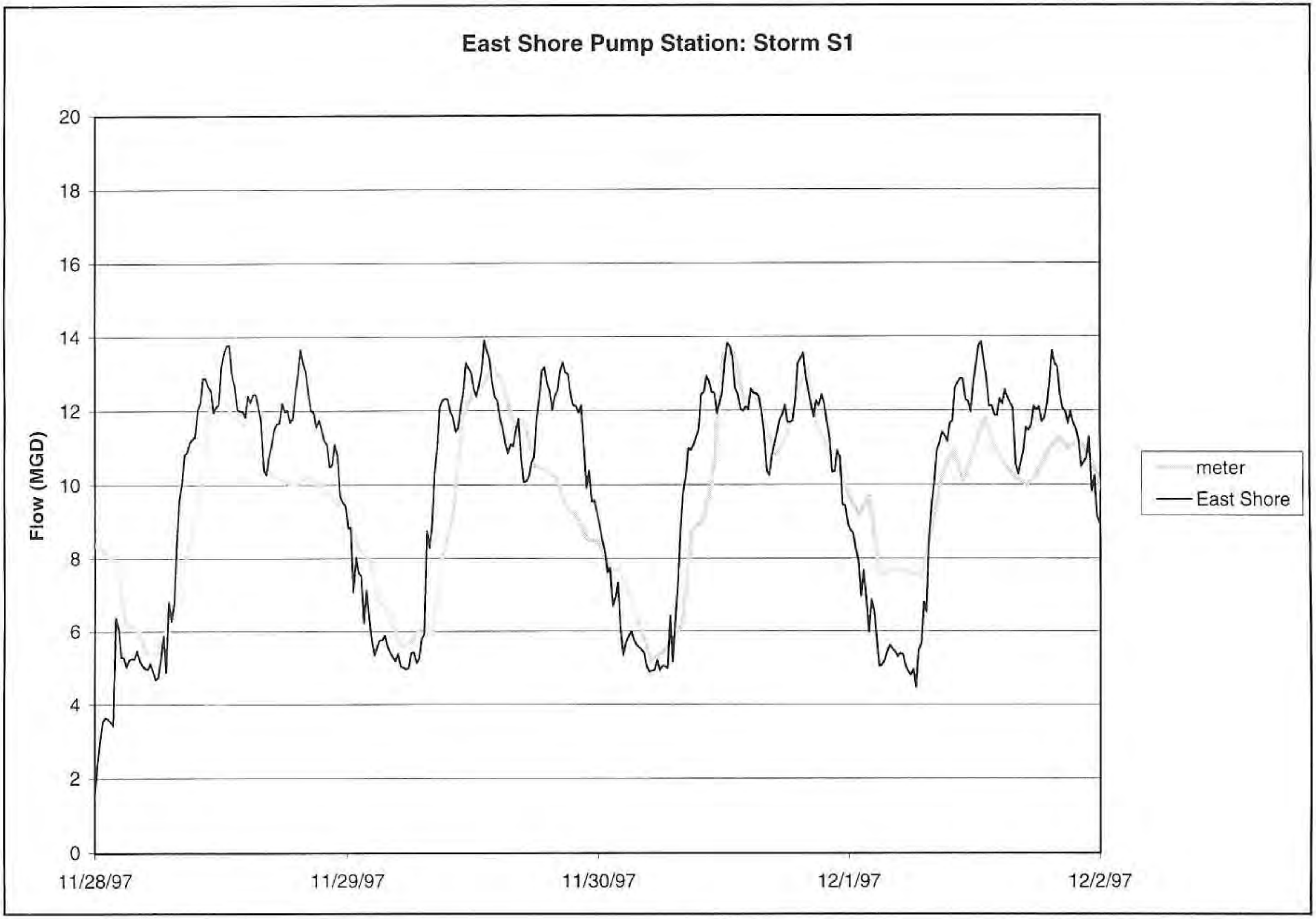
Interceptor at 014: Storm S1
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
Flow (MGD)
11/28/97
11/29/97
11/30/97
12/1/97
12/2/97
meter
REG014 u/s

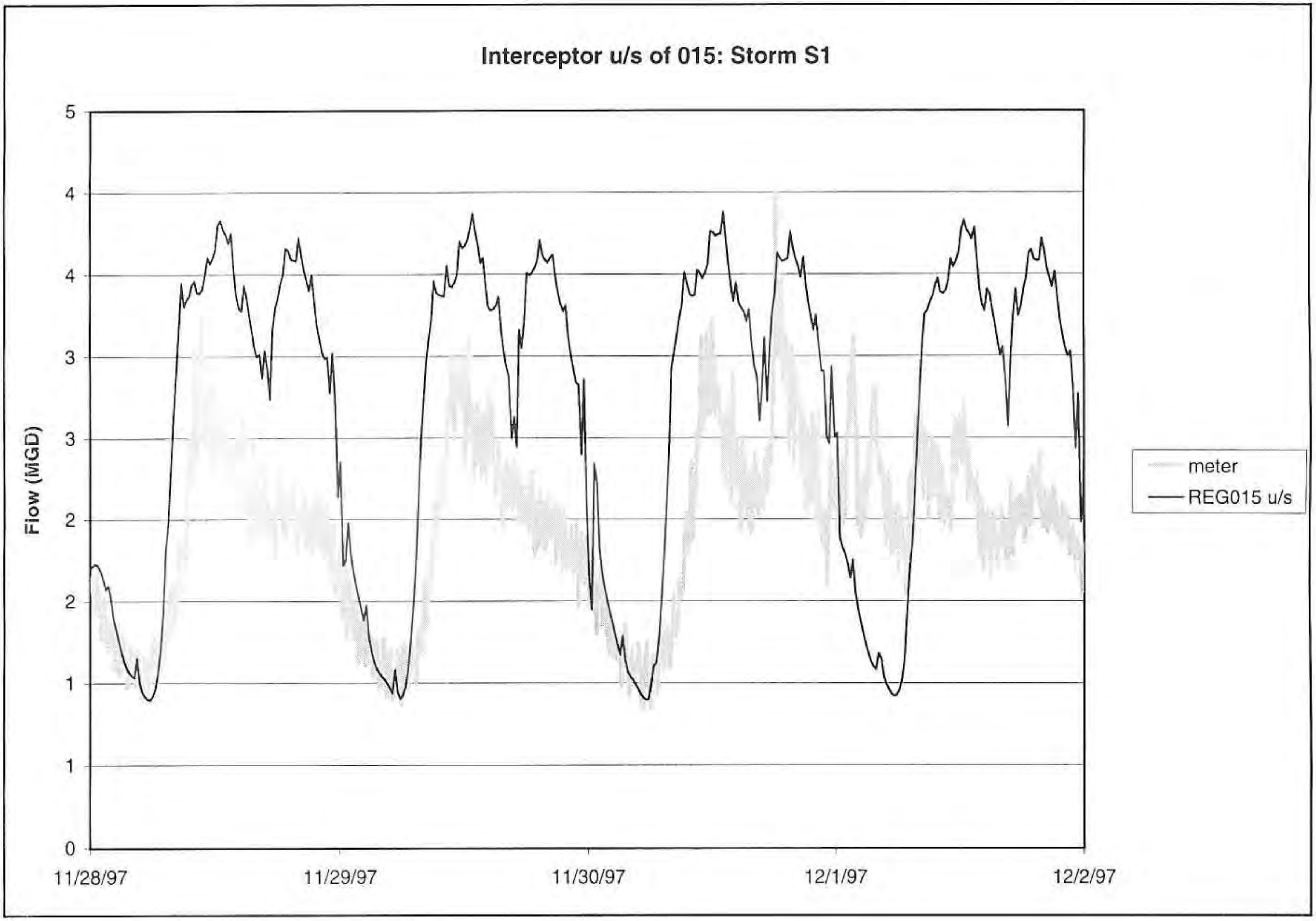

NH04 (External): Storm S1
Winchester Ave
Flow (MGD)
2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
11/28/97
11/29/97
11/30/97
12/1/97
12/2/97
NH04meter
NH04

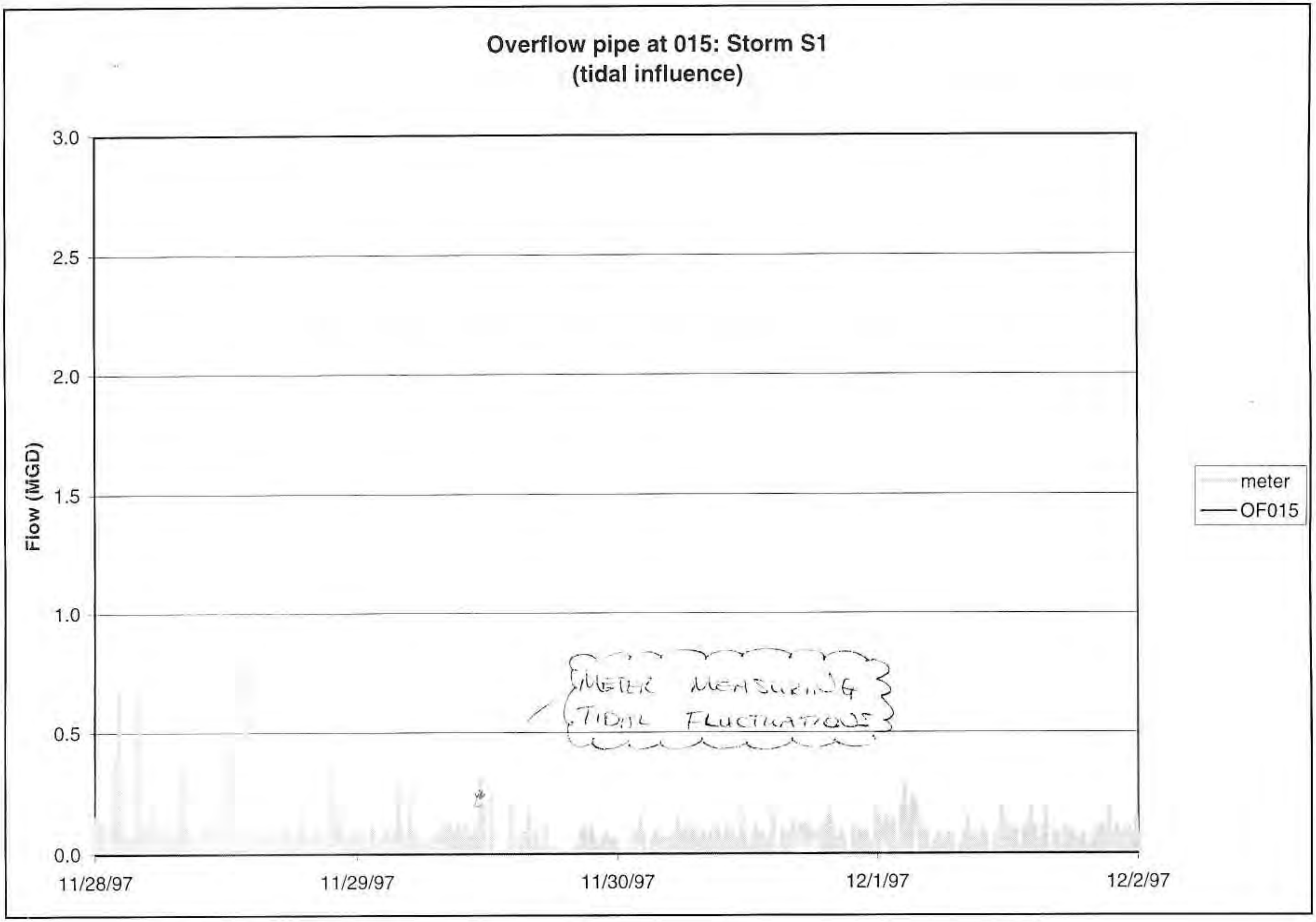

Interceptor at 010: Storm S1
Flow (MGD)
10
9
8
7
6
5
4
3
2
1
0
11/28/97
11/29/97
11/30/97
12/1/97
12/2/97
meter
REG010a u/s


NH05 (External): Storm S1
Whitney Ave
(pump station influence)
Flow (MGD)
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
11/28/97
11/29/97
11/30/97
12/1/97
12/2/97
NH05meter
NH05

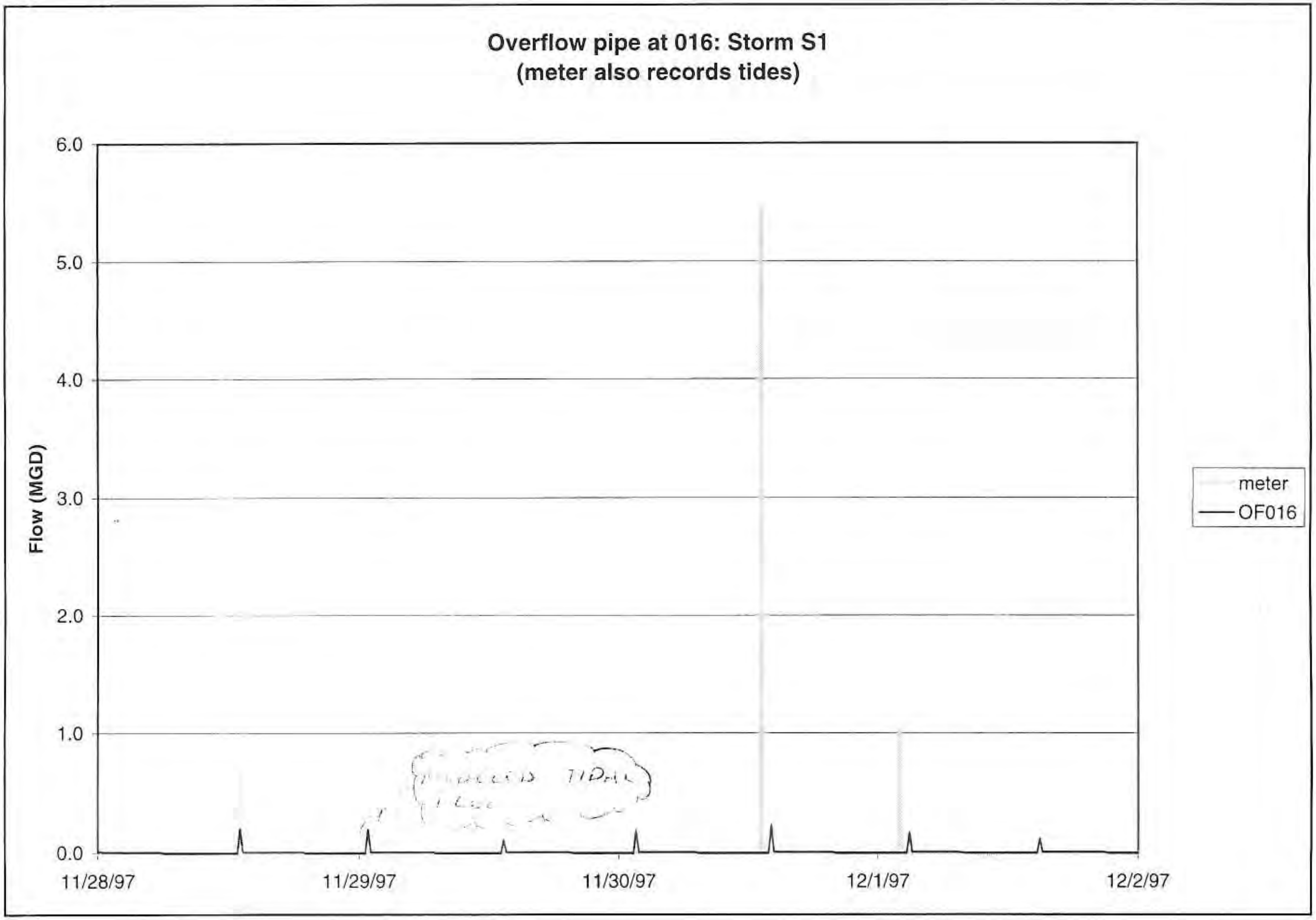

NH11 (External): Storm S1
East Rock Road
Flow (MGD)
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
11/28/97
11/29/97
11/30/97
12/1/97
12/2/97
NH11meter
NH11
TIME SHIFT
IN METER DATA

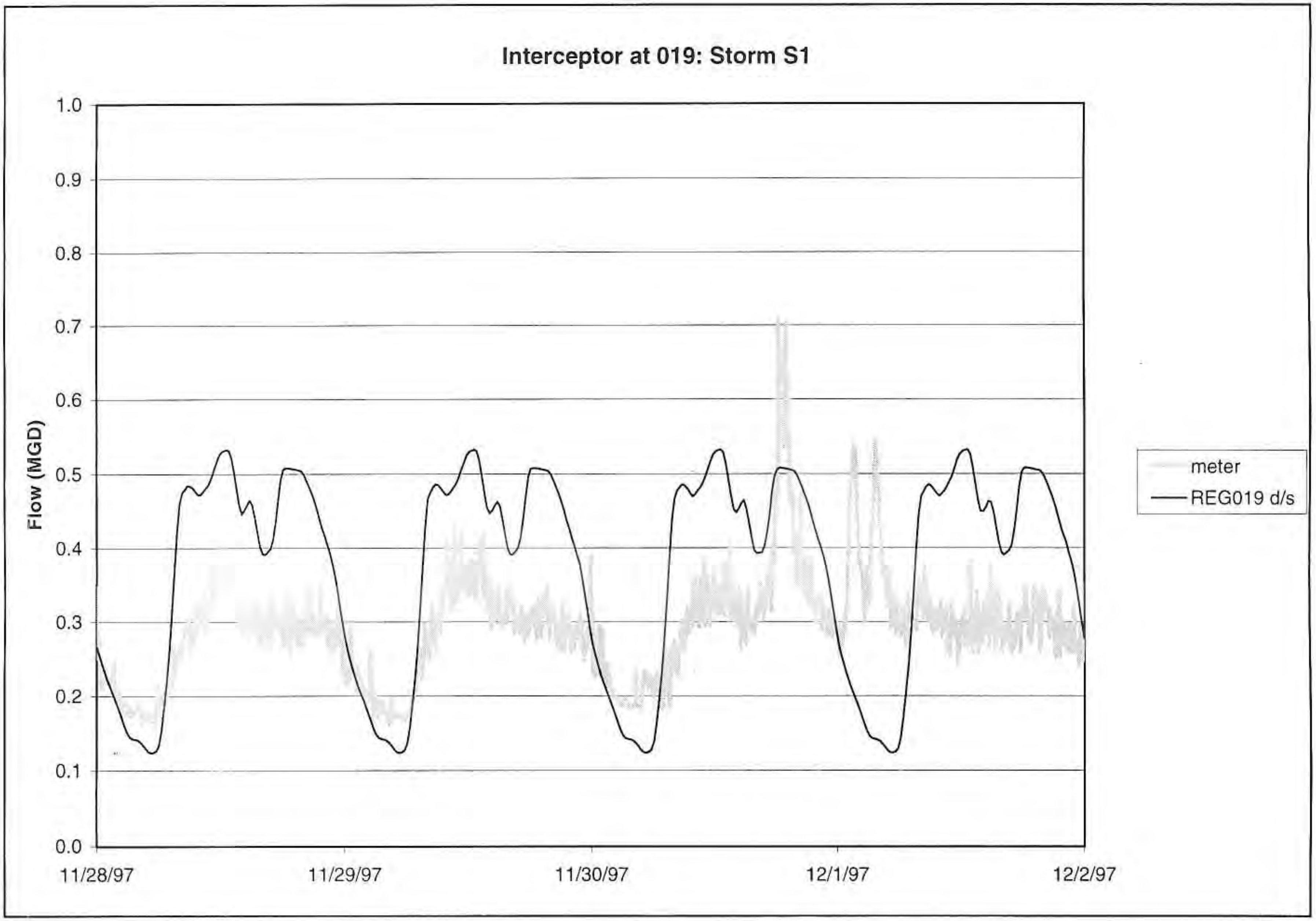

East Shore Pump Station: Storm S1
Flow (MGD)
20
18
16
14
12
10
8
6
4
2
0
11/28/97
11/29/97
11/30/97
12/1/97
12/2/97
meter
East Shore


Interceptor u/s of 015: Storm S1
Flow (MGD)
5
4
4
3
3
2
2
1
1
0
11/28/97
11/29/97
11/30/97
12/1/97
12/2/97
meter
REG015 u/s

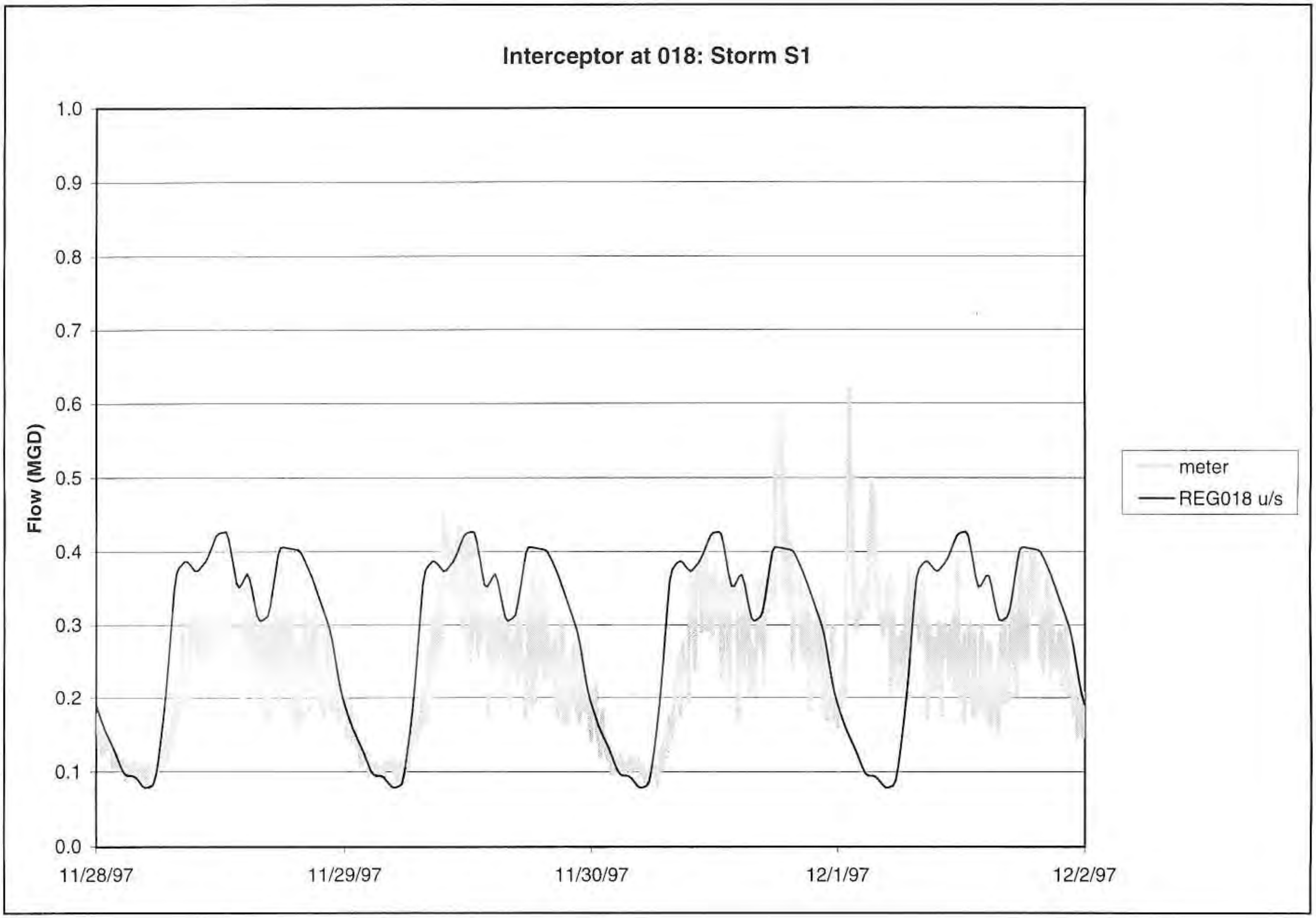


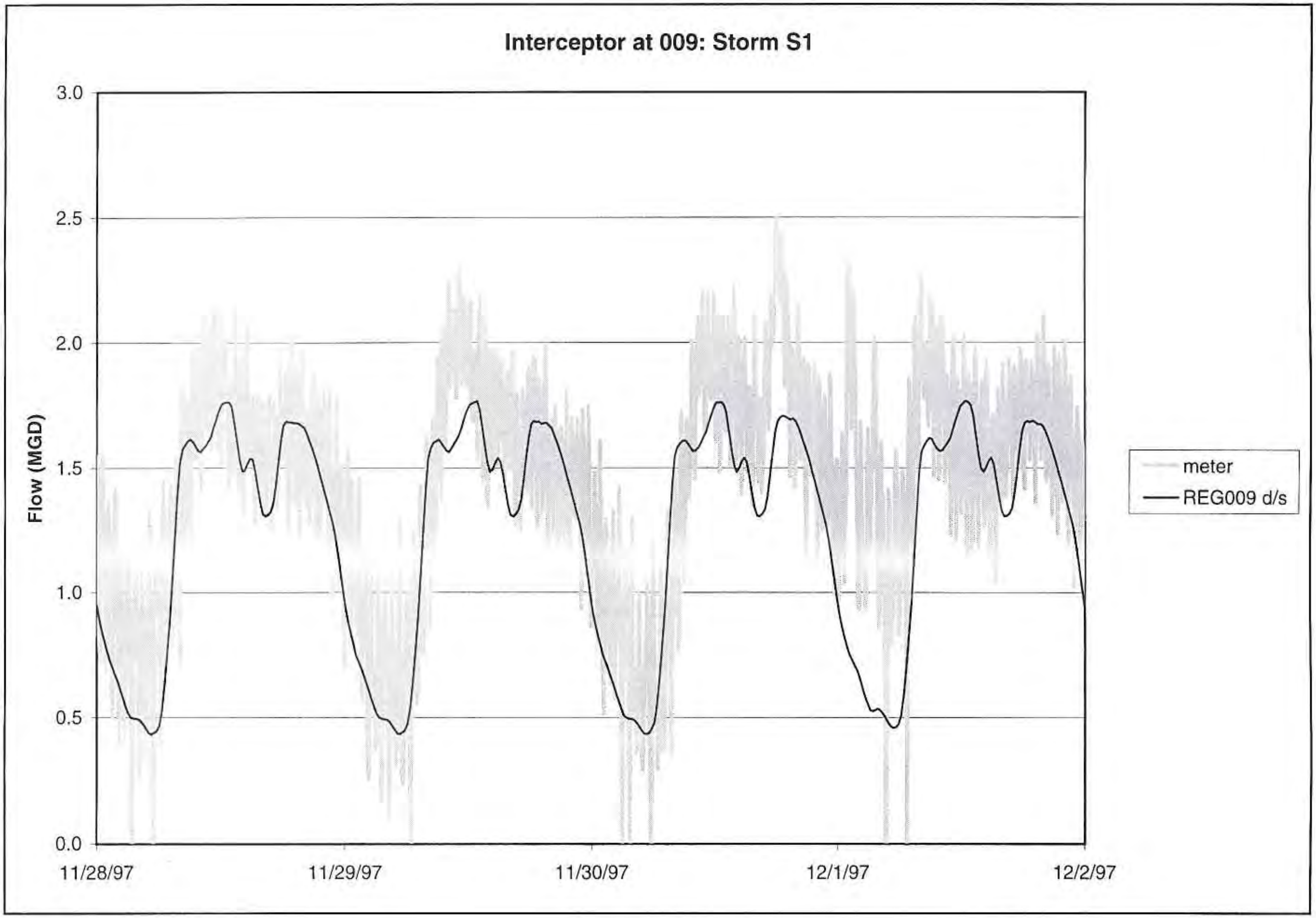
Overflow pipe at 015: Storm S1
(tidal influence)
Flow (MGD)
3.0
2.5
2.0
1.5
1.0
0.5
0.0
11/28/97
11/29/97
11/30/97
12/1/97
12/2/97
meter
OF015
METER MEASURING TIDAL FLUCTUATIONS


Overflow pipe at 016: Storm S1
(meter also records tides)
Flow (MGD)
6.0
5.0
4.0
3.0
2.0
1.0
0.0
11/28/97
11/29/97
11/30/97
12/1/97
12/2/97
meter
OF016

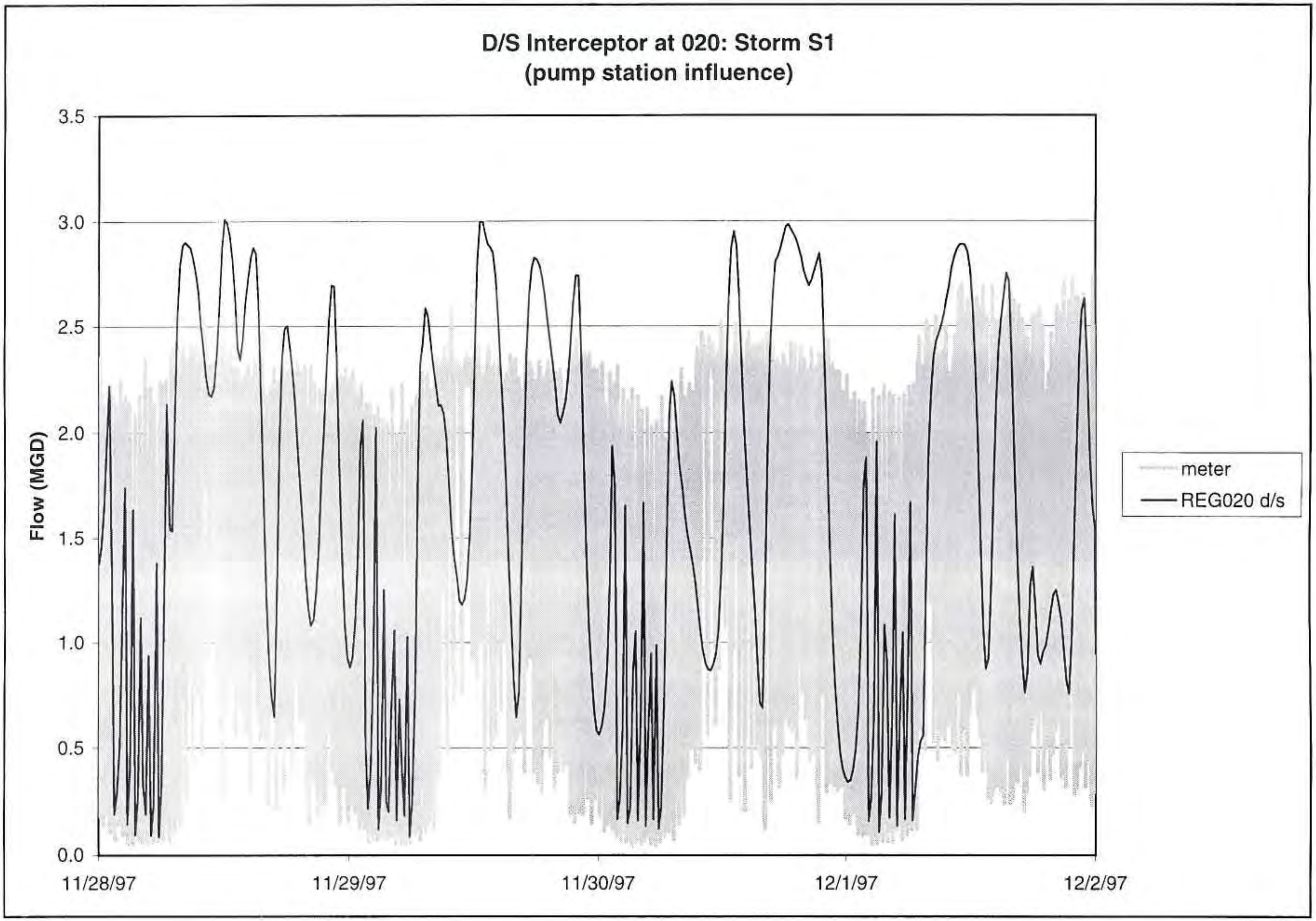


Interceptor at 019: Storm S1
Flow (MGD)
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
11/28/97
11/29/97
11/30/97
12/1/97
12/2/97
meter
REG019 d/s

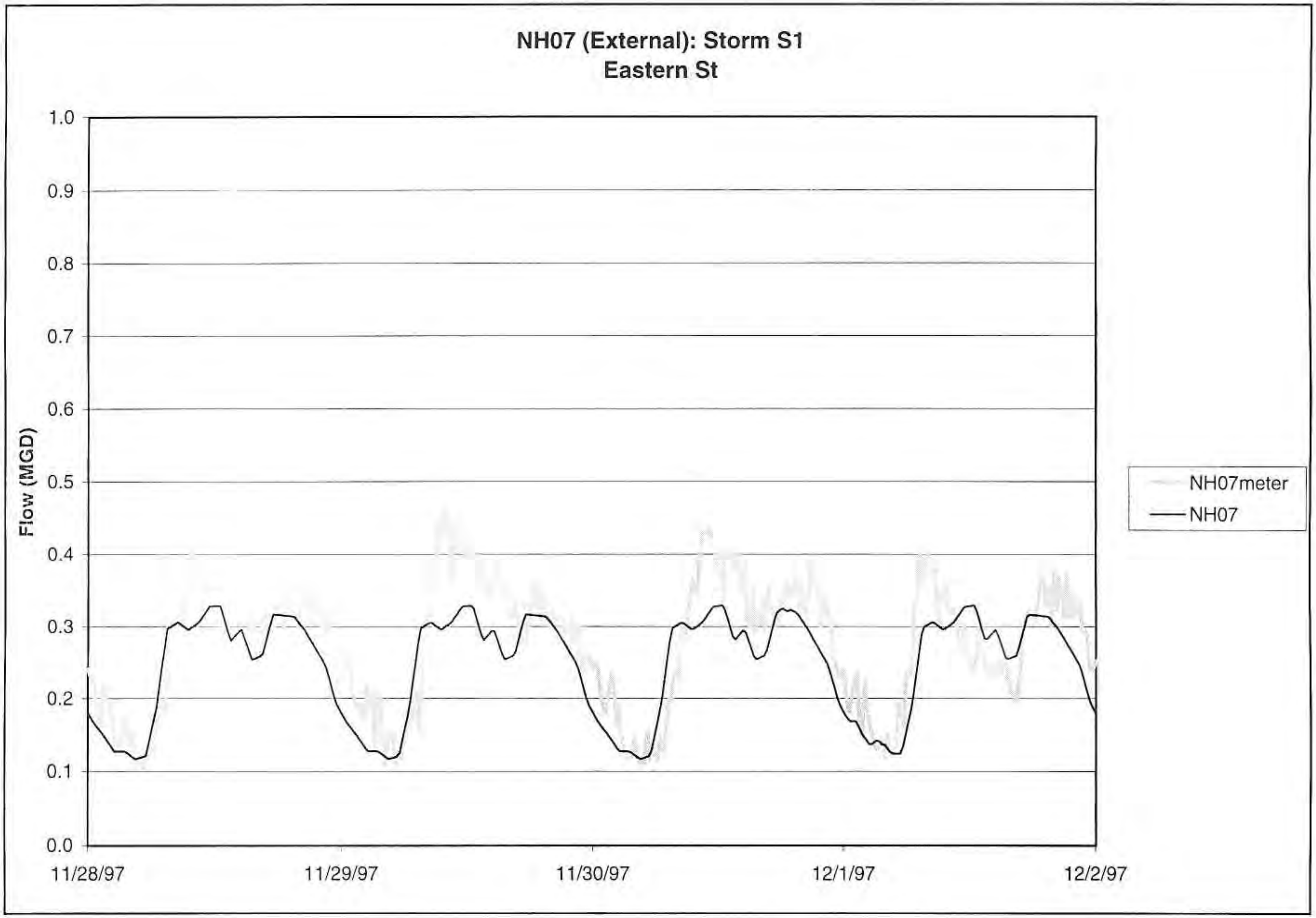

Interceptor at 018: Storm S1
Flow (MGD)
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
11/28/97
11/29/97
11/30/97
12/1/97
12/2/97
meter
REG018 u/s



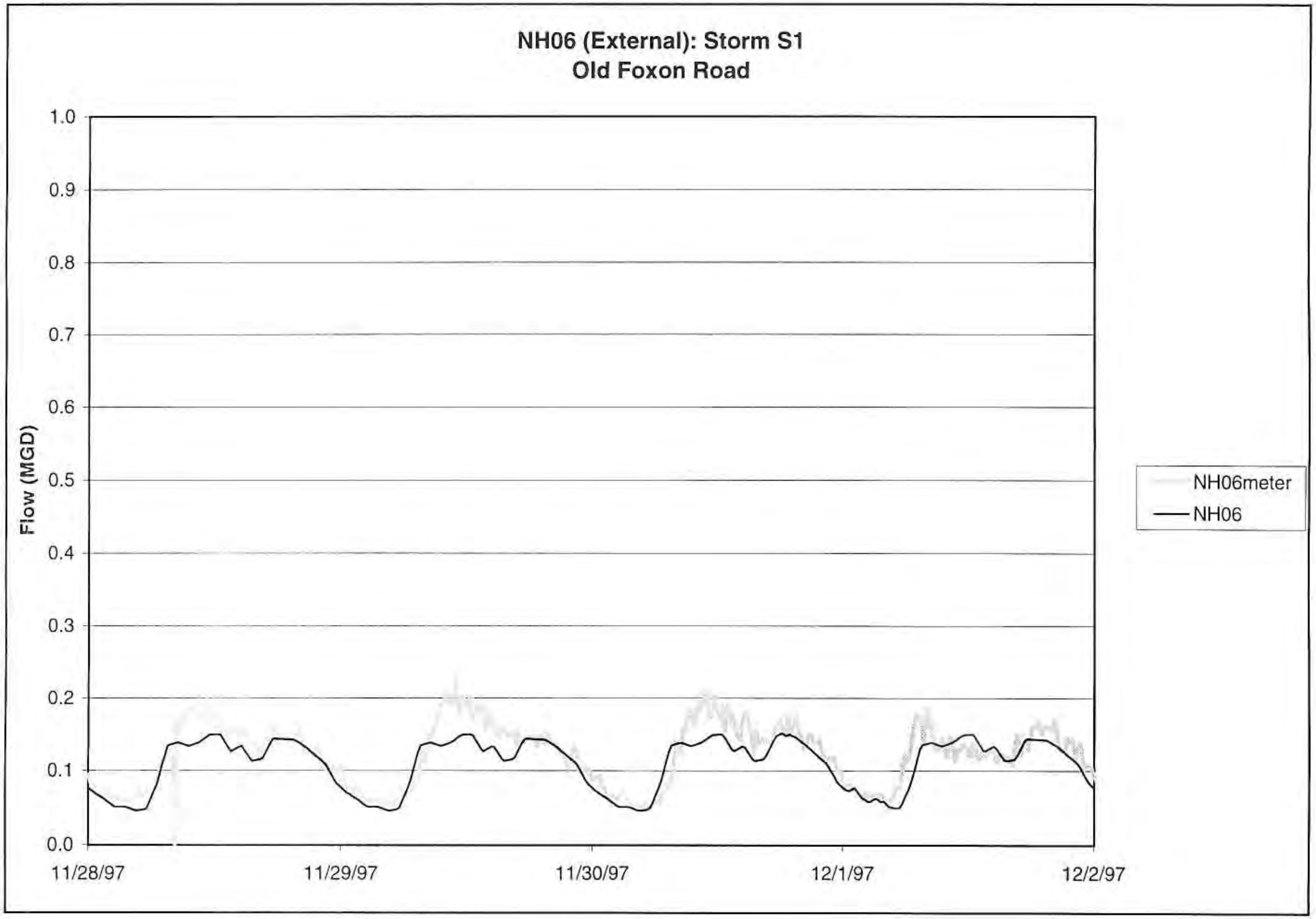
Interceptor at 009: Storm S1
3.0
2.5
2.0
1.5
1.0
0.5
0.0
Flow (MGD)
11/28/97
11/29/97
11/30/97
12/1/97
12/2/97
meter
REG009 d/s

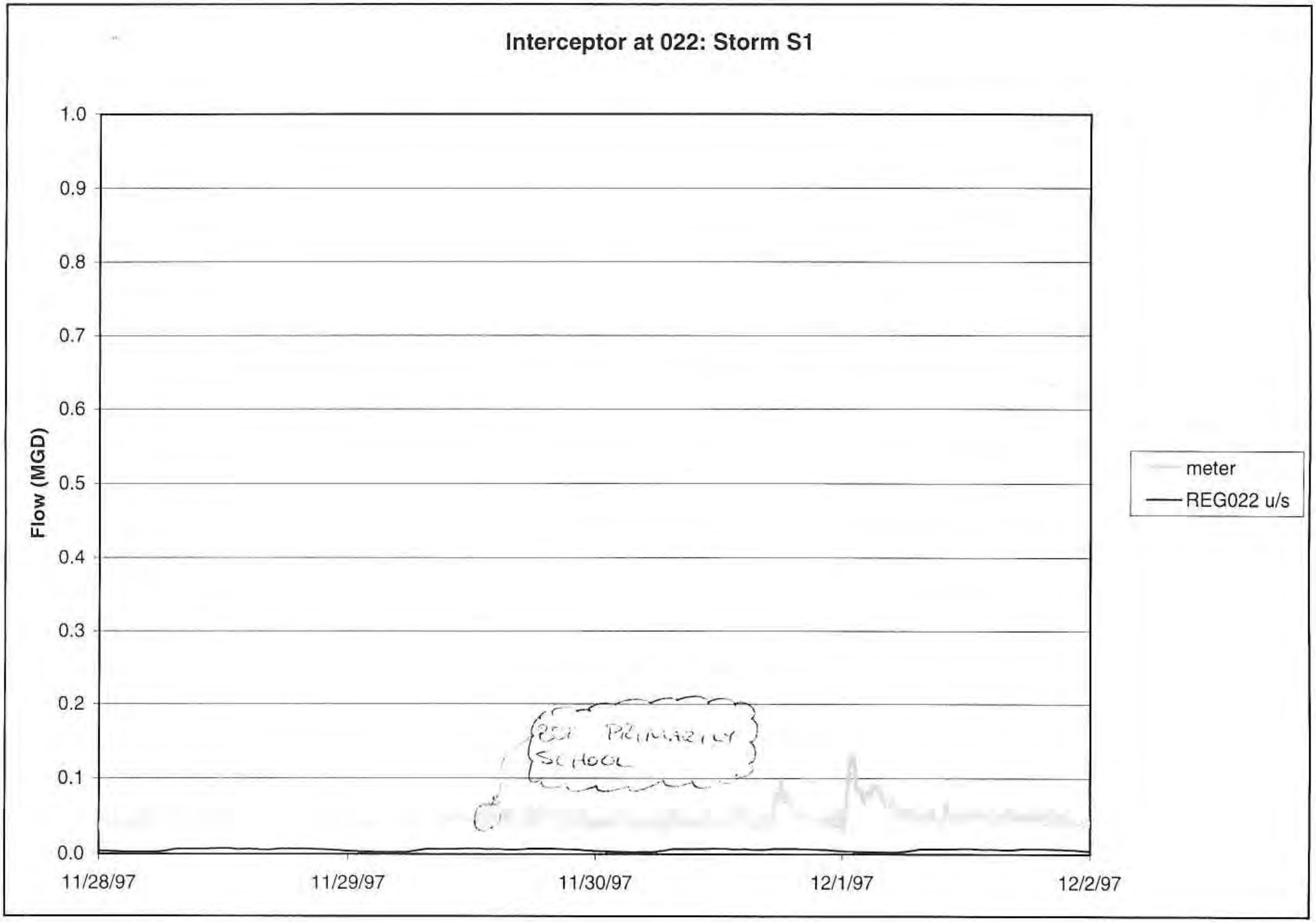


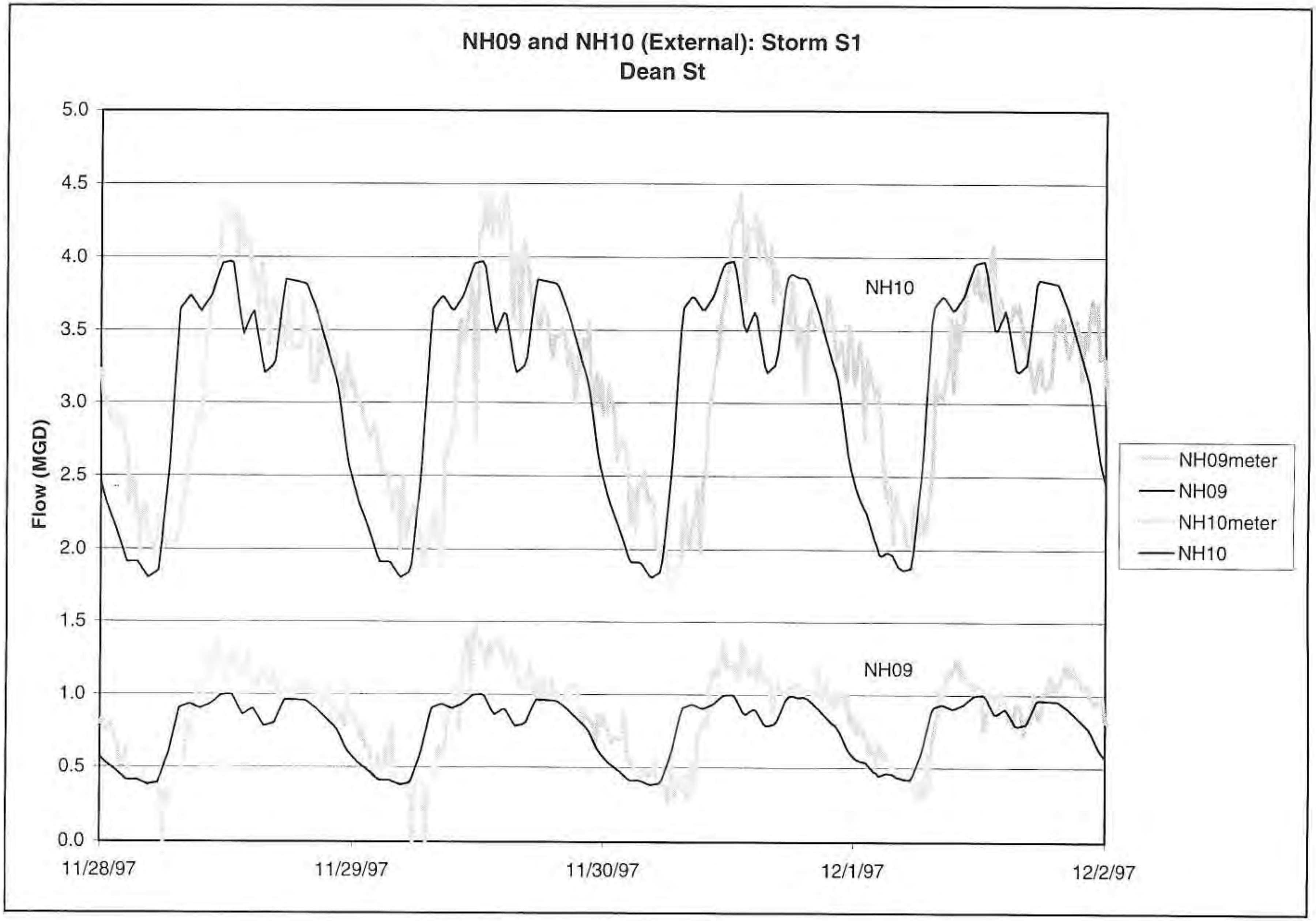
D/S Interceptor at 020: Storm S1
(pump station influence)
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
Flow (MGD)
11/28/97
11/29/97
11/30/97
12/1/97
12/2/97
meter
REG020 d/s



NH07 (External): Storm S1
Eastern St
Flow (MGD)
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
11/28/97
11/29/97
11/30/97
12/1/97
12/2/97
NH07meter
NH07


NH06 (External): Storm S1
Old Foxon Road
Flow (MGD)
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
11/28/97
11/29/97
11/30/97
12/1/97
12/2/97
NH06meter
NH06

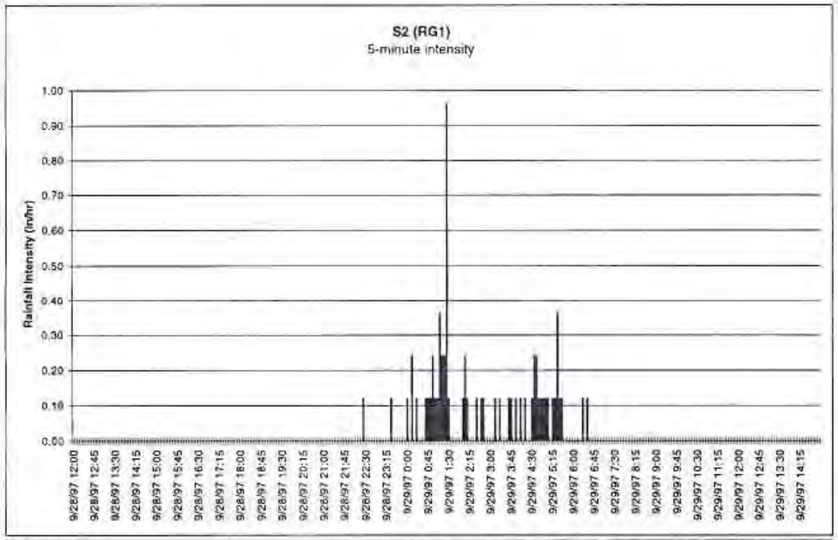

Interceptor at 022: Storm S1
Flow (MGD)
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
11/28/97
11/29/97
11/30/97
12/1/97
12/2/97
meter
REG022 u/s
PRIMARILY
SCHOOL

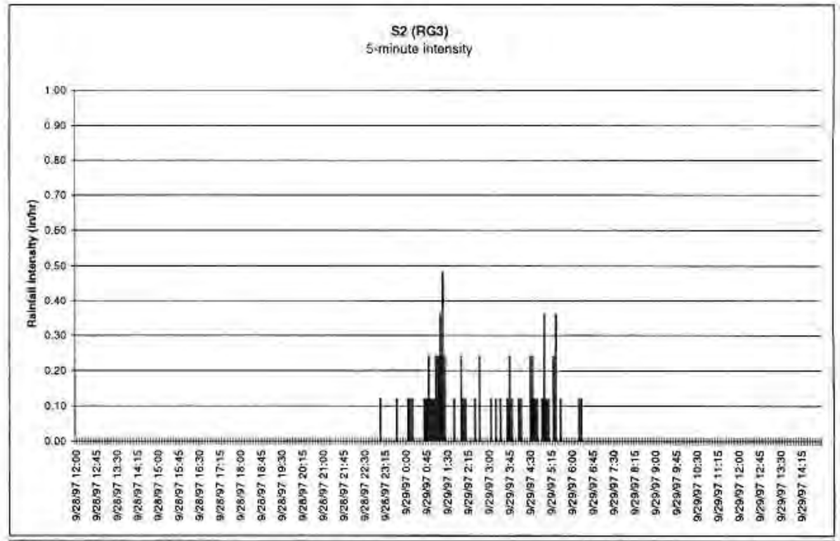


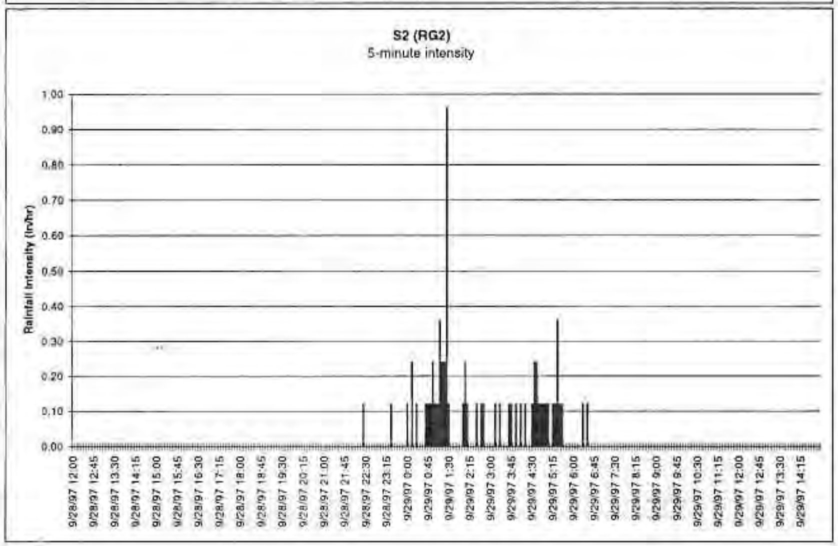
NH09 and NH10 (External): Storm S1
Dean St
Flow (MGD)
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
11/28/97
11/29/97
11/30/97
12/1/97
12/2/97
NH10
NH09
NH09meter
NH09
NH10meter
NH10

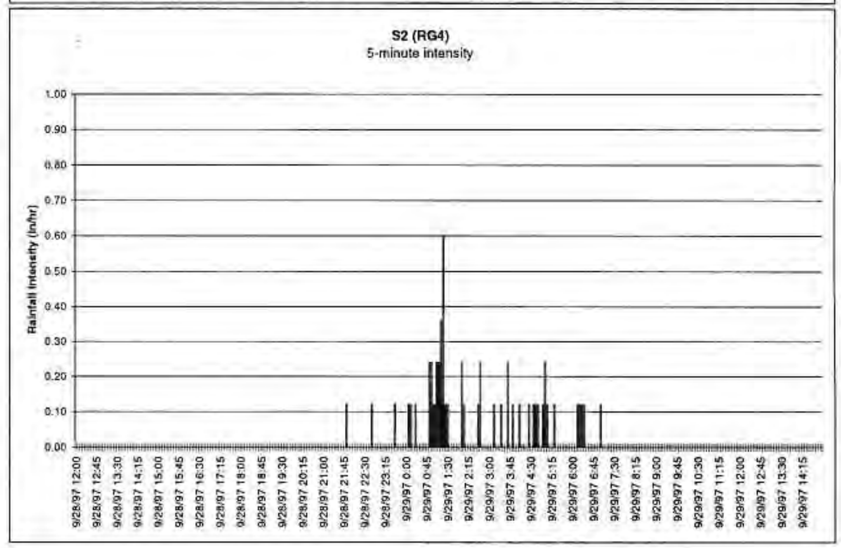
Storm S2

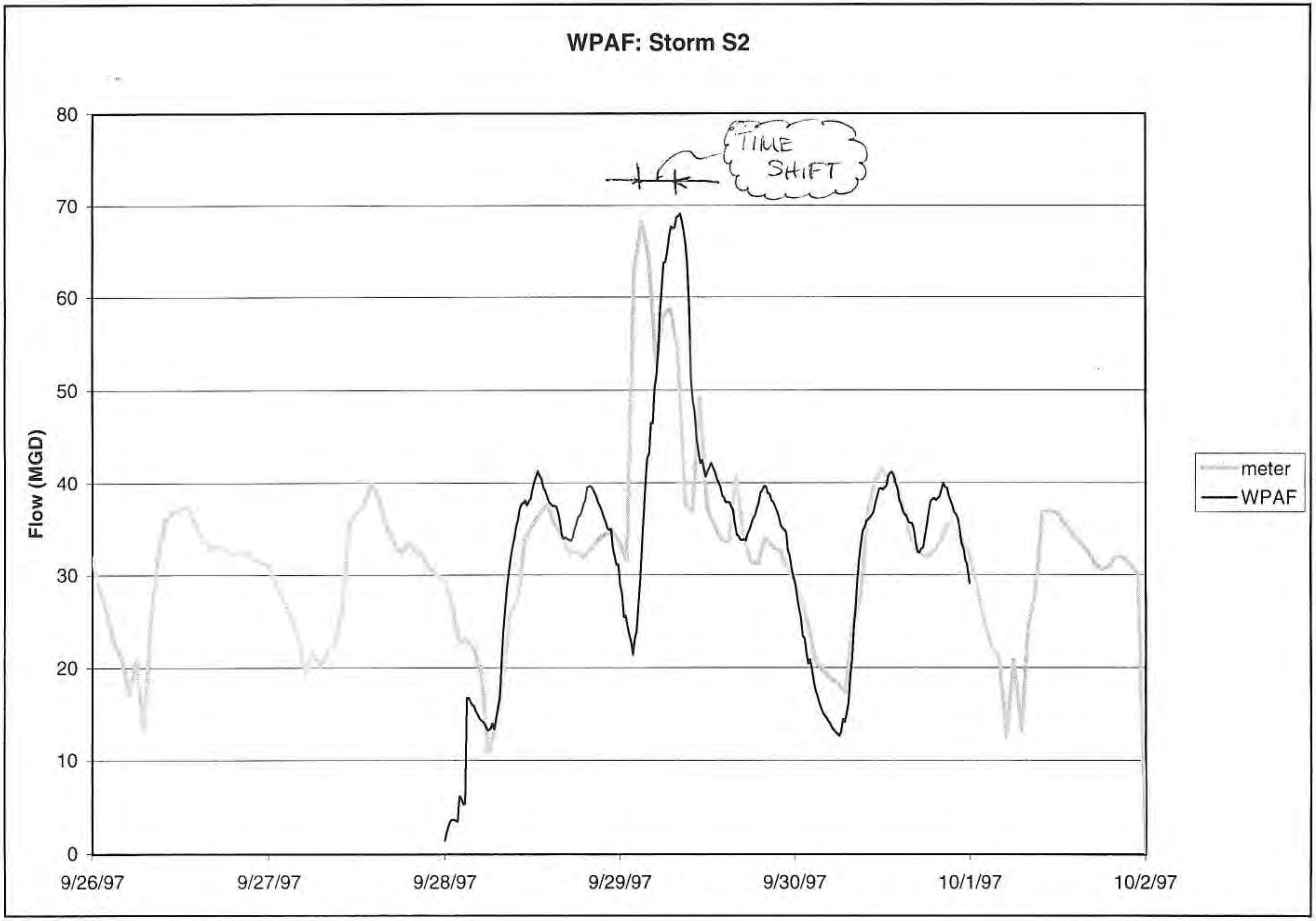
Rainfall: ...m S2



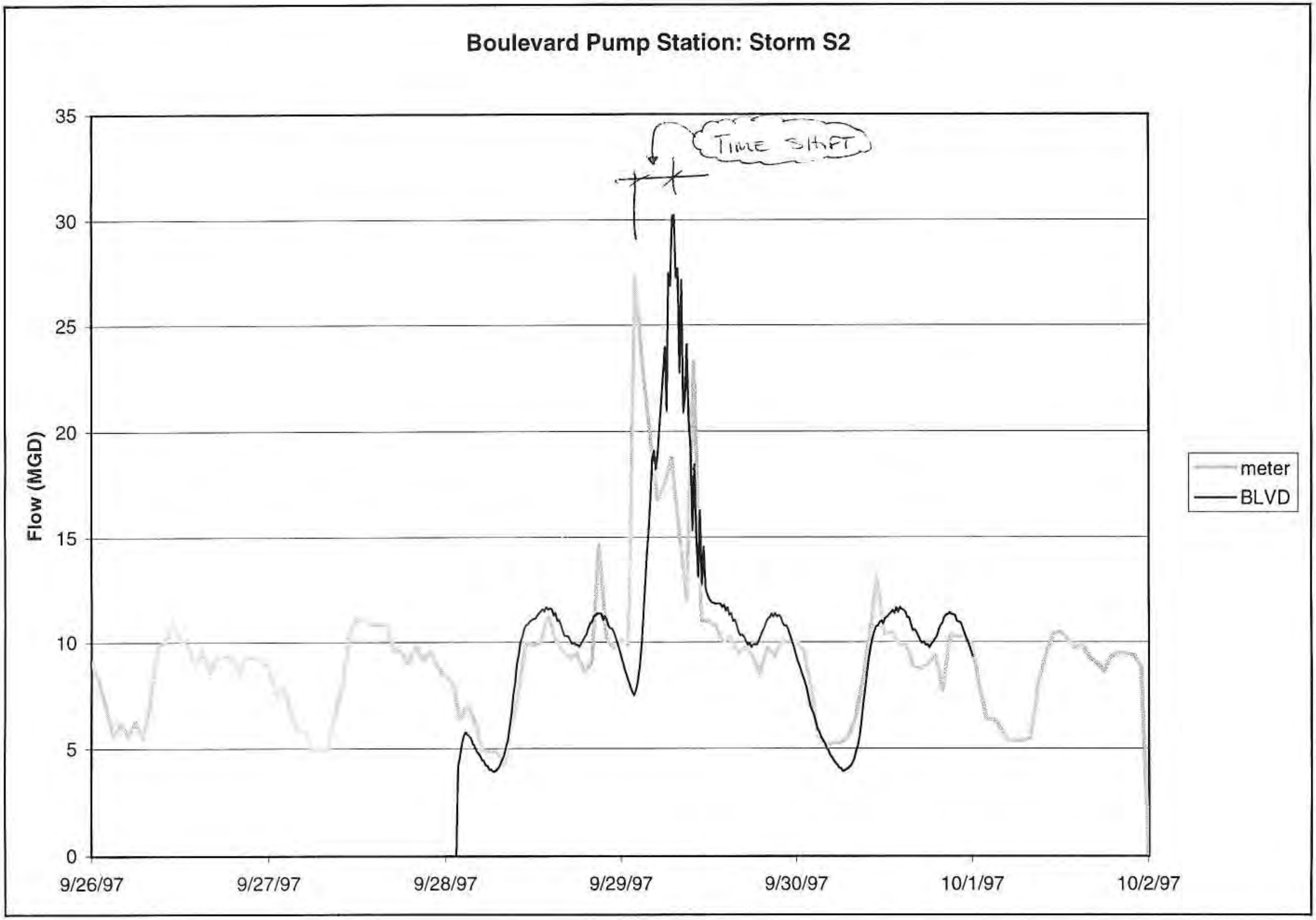



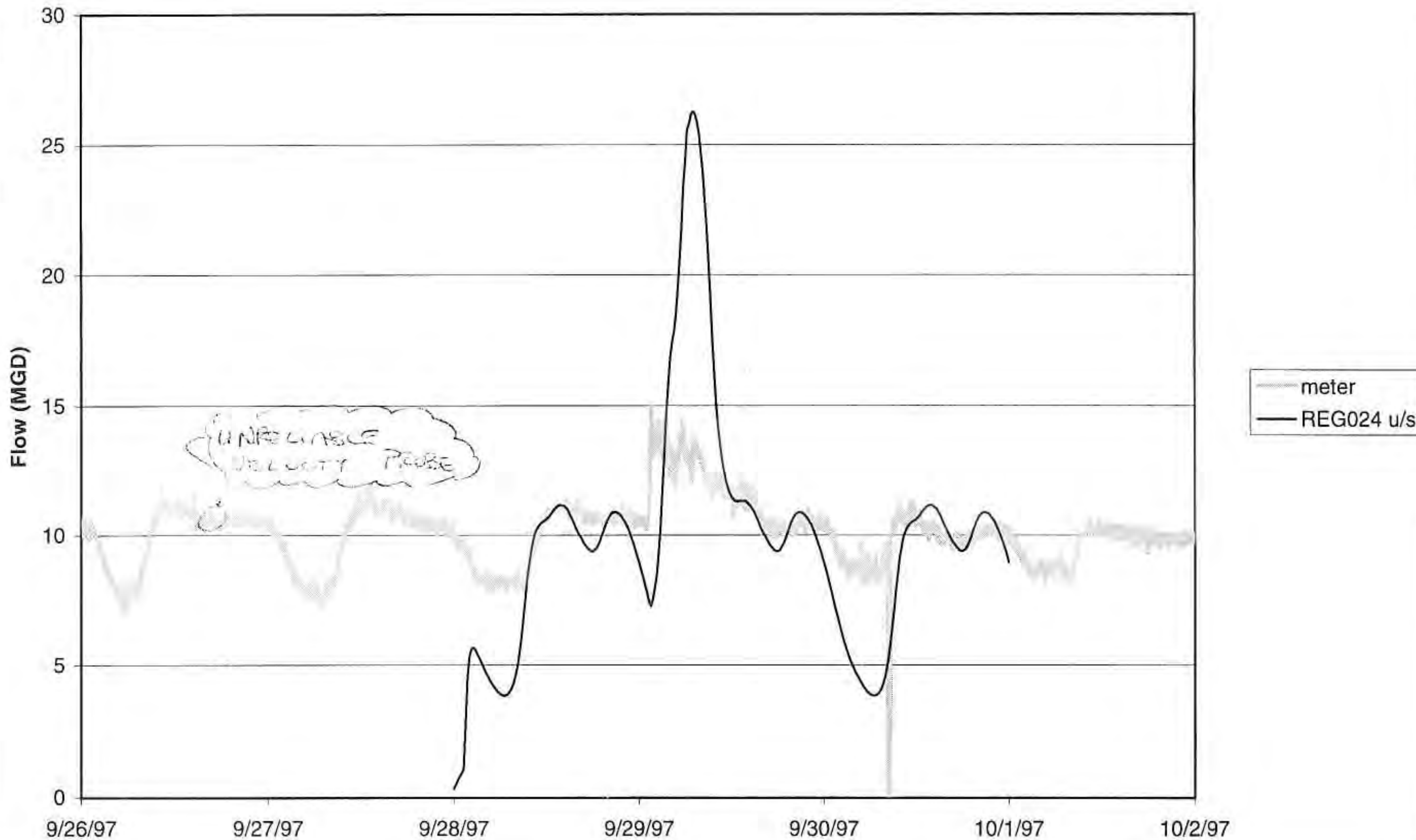



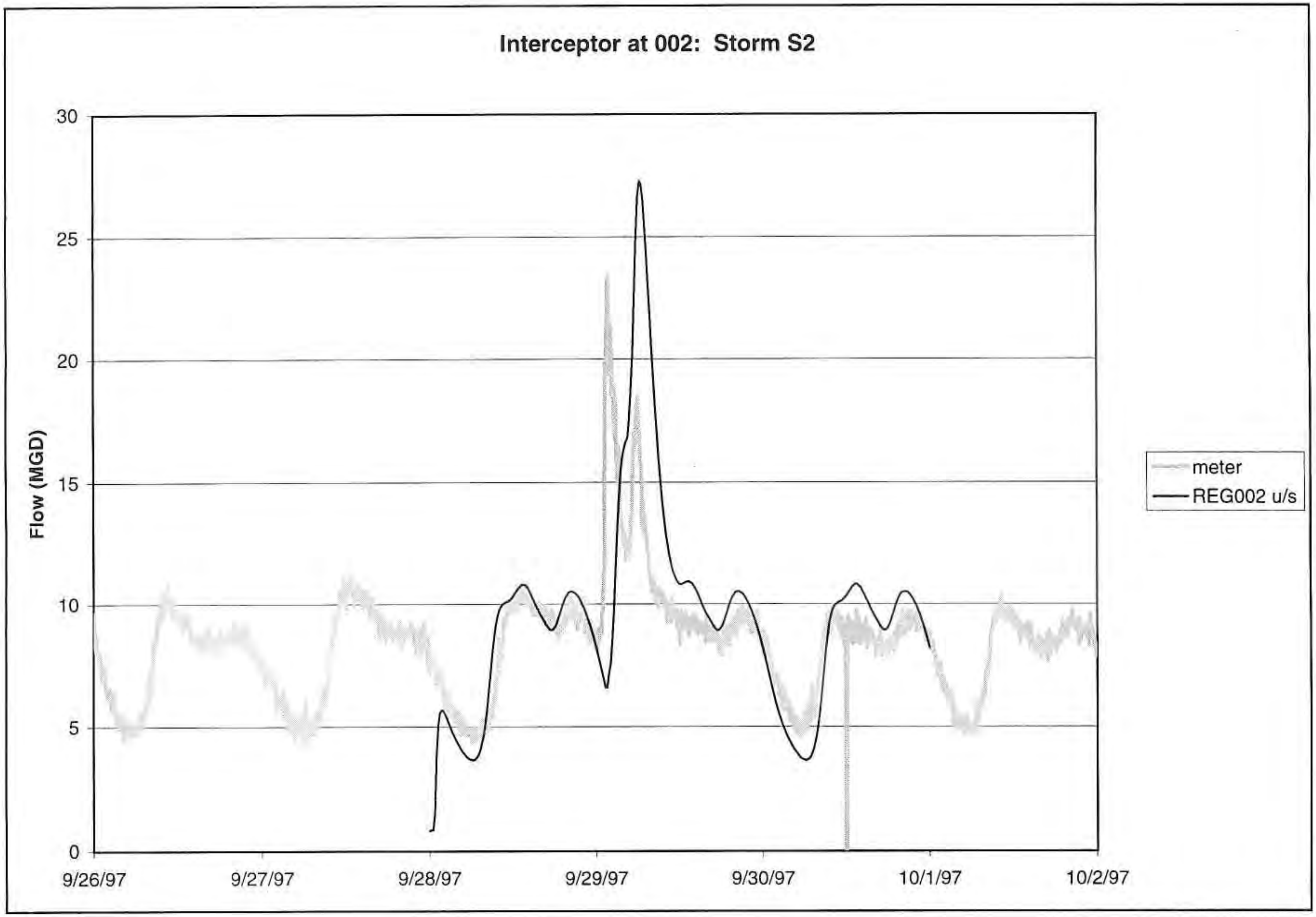


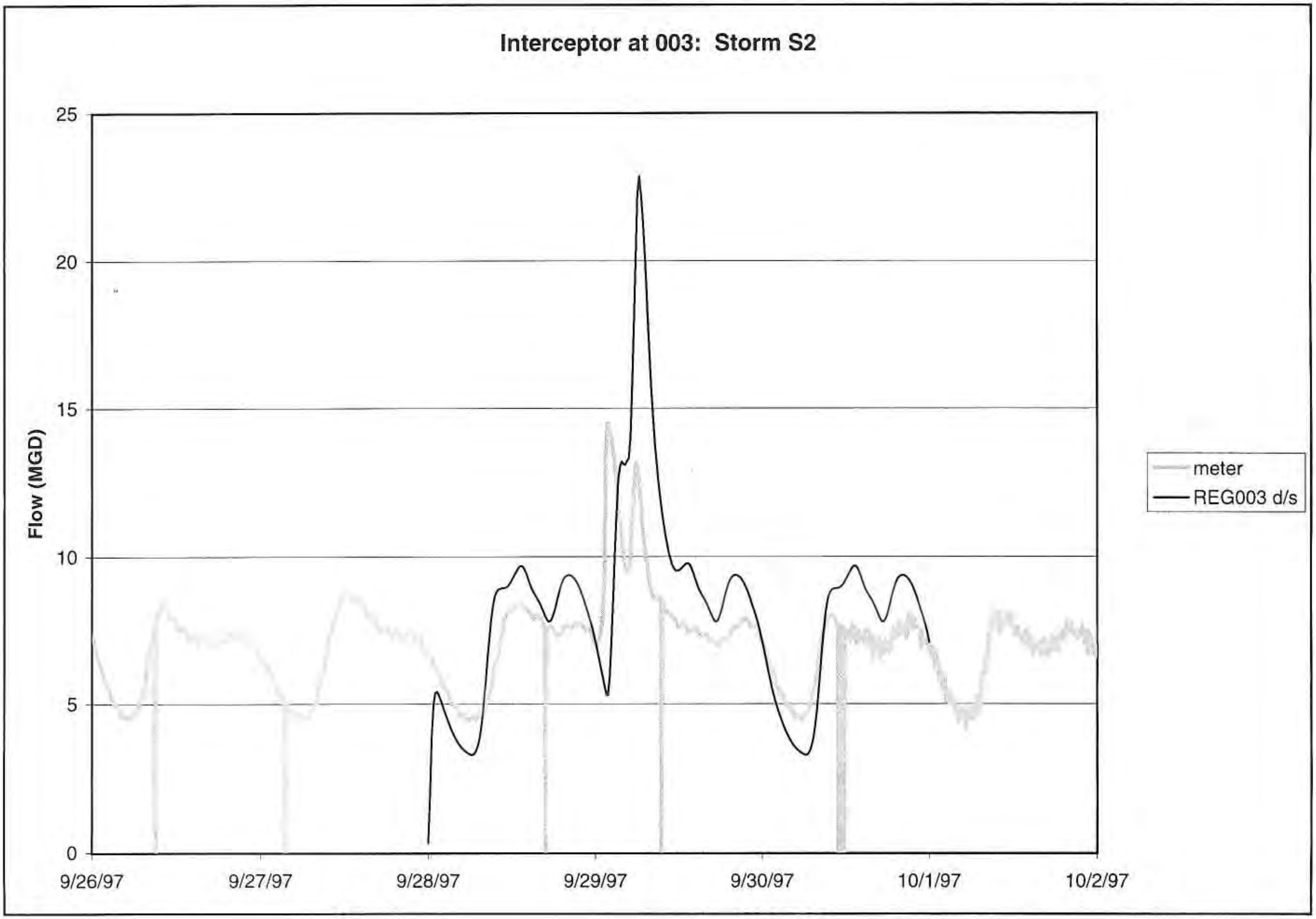
WPAF: Storm S2
TIME SHIFT
Flow (MGD)
80
70
60
50
40
30
20
10
0
9/26/97
9/27/97
9/28/97
9/29/97
9/30/97
10/1/97
10/2/97
meter
WPAF


Boulevard Pump Station: Storm S2
Flow (MGD)
35
30
25
20
15
10
5
0
9/26/97
9/27/97
9/28/97
9/29/97
9/30/97
10/1/97
10/2/97
meter
BLVD
TIME SHIFT

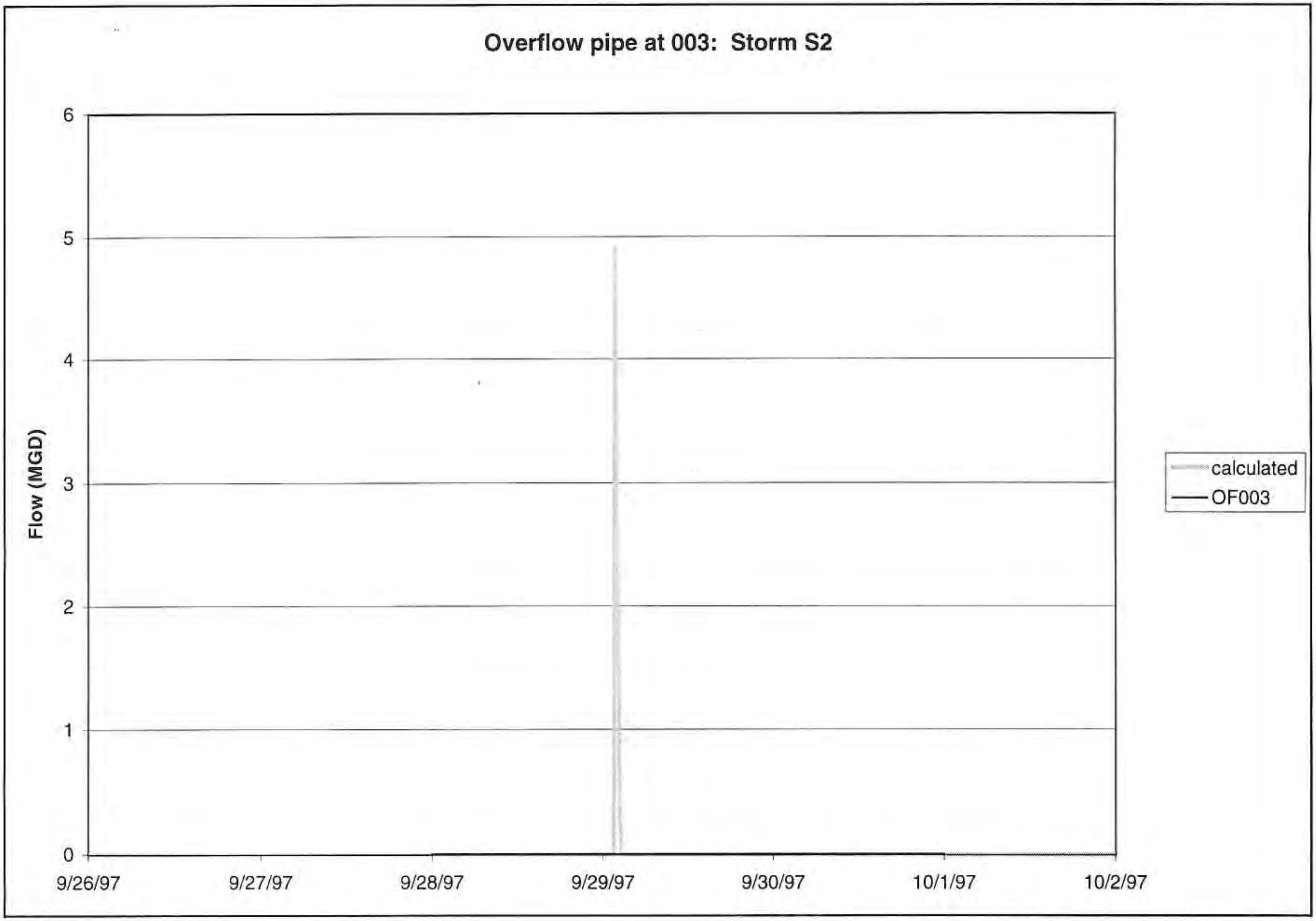
**Interceptor at 024: Storm S2**
**(diversion chamber for Boulevard Pump Station)**



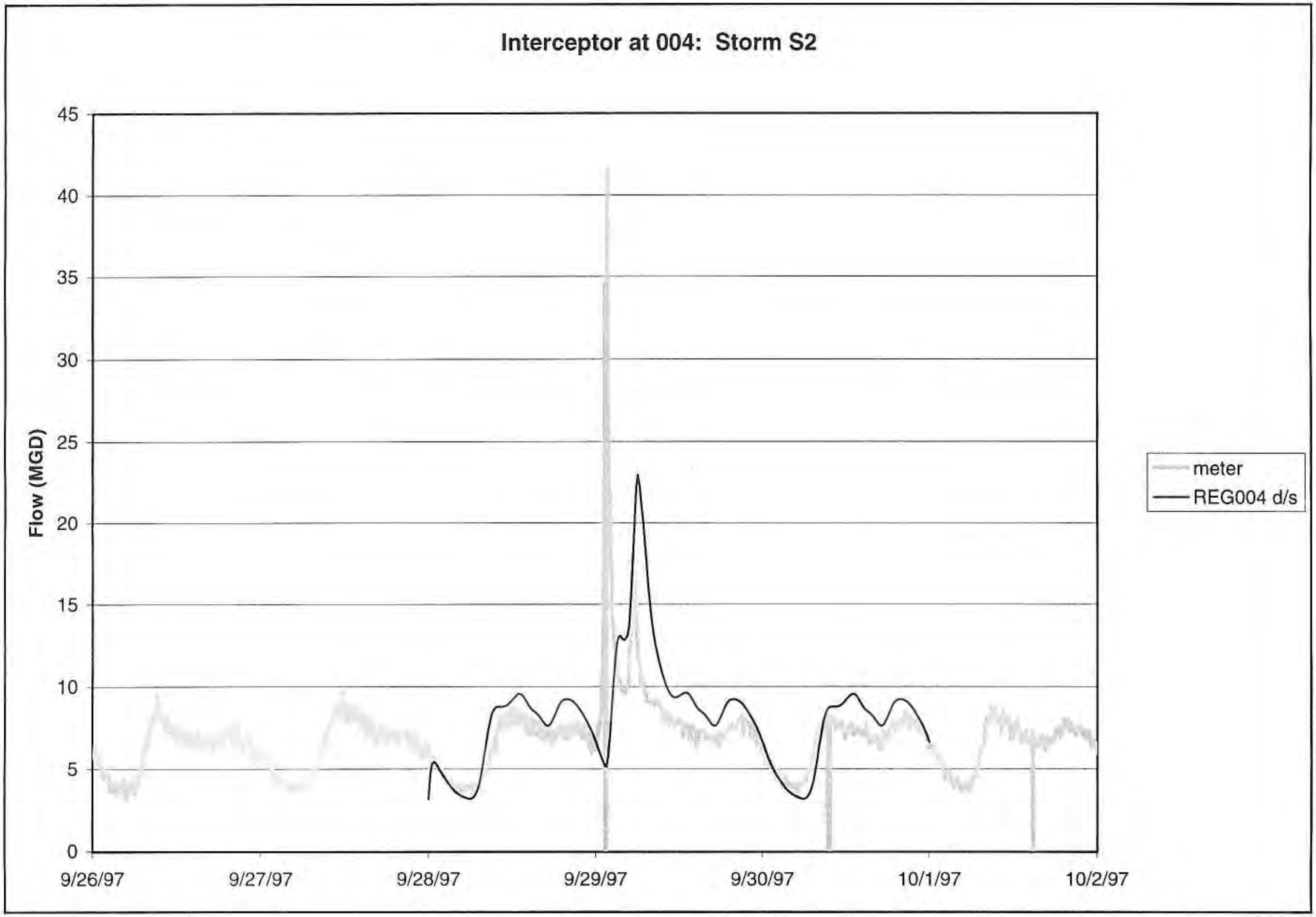

Interceptor at 002: Storm S2
Flow (MGD)
30
25
20
15
10
5
0
9/26/97
9/27/97
9/28/97
9/29/97
9/30/97
10/1/97
10/2/97
meter
REG002 u/s

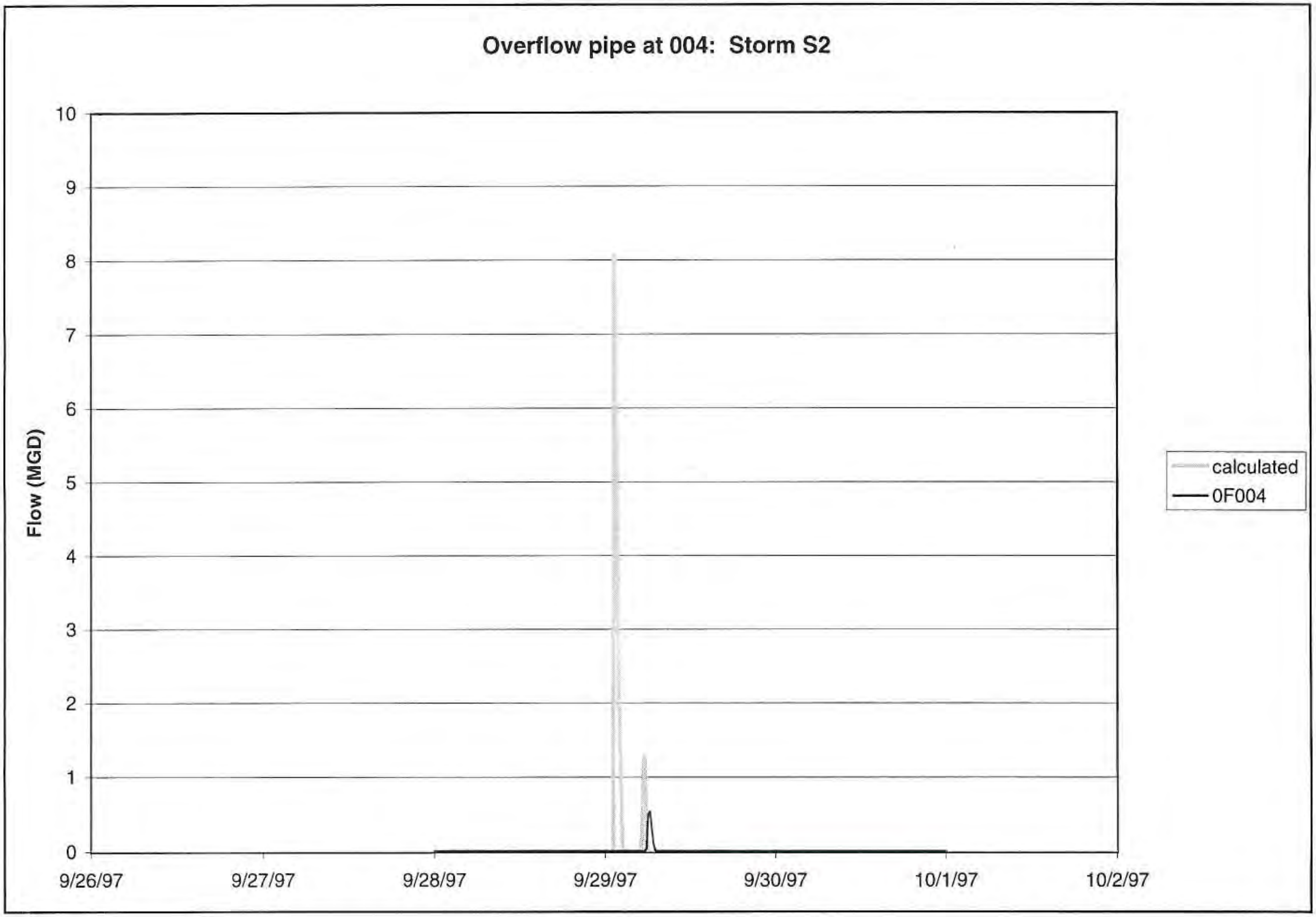


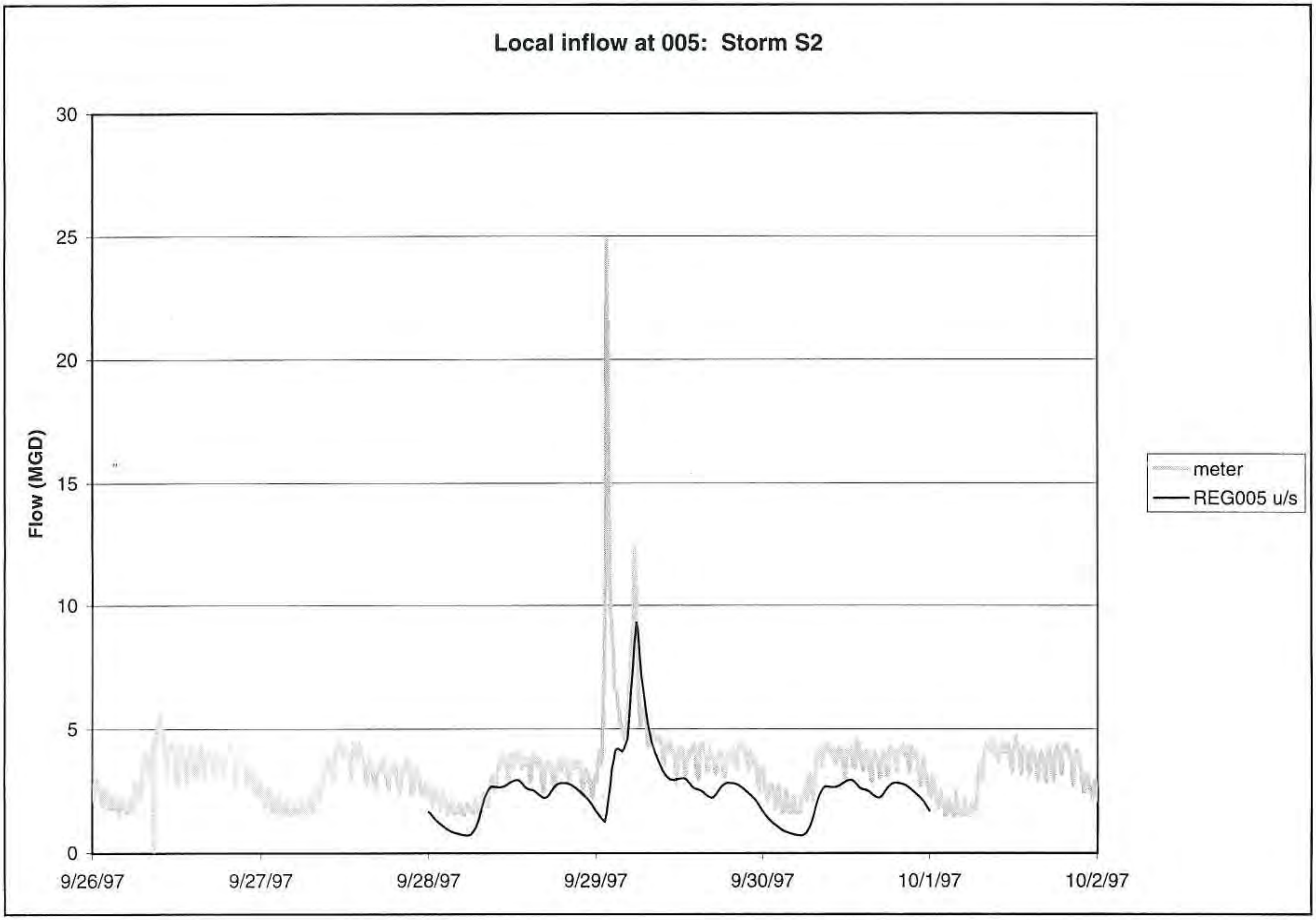
Interceptor at 003: Storm S2
Flow (MGD)
25
20
15
10
5
0
9/26/97
9/27/97
9/28/97
9/29/97
9/30/97
10/1/97
10/2/97
meter
REG003 d/s



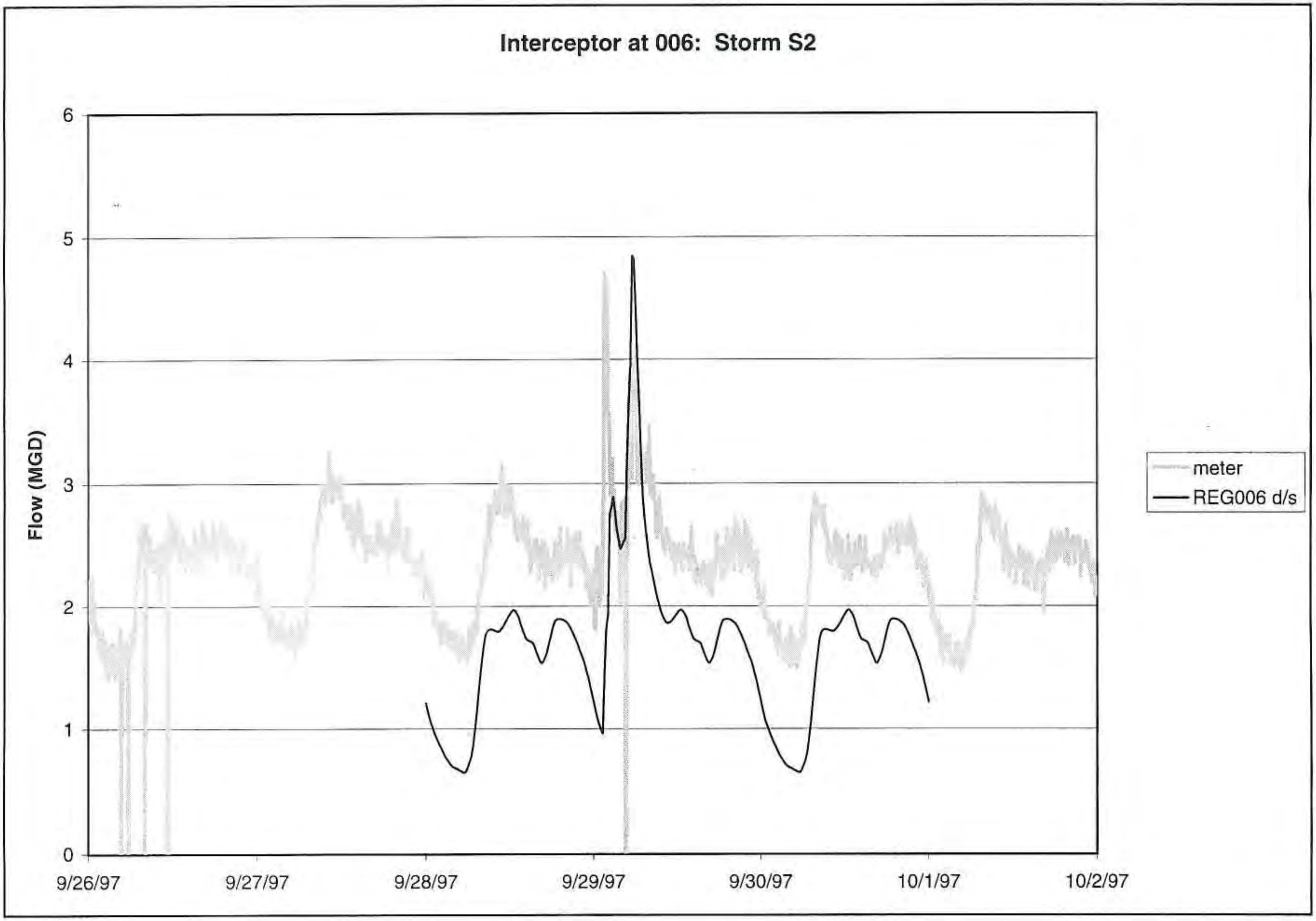
Overflow pipe at 003: Storm S2
Flow (MGD)
6
5
4
3
2
1
0
9/26/97
9/27/97
9/28/97
9/29/97
9/30/97
10/1/97
10/2/97
calculated
OF003


Interceptor at 004: Storm S2
45
40
35
30
25
20
15
10
5
0
Flow (MGD)
9/26/97
9/27/97
9/28/97
9/29/97
9/30/97
10/1/97
10/2/97
meter
REG004 d/s

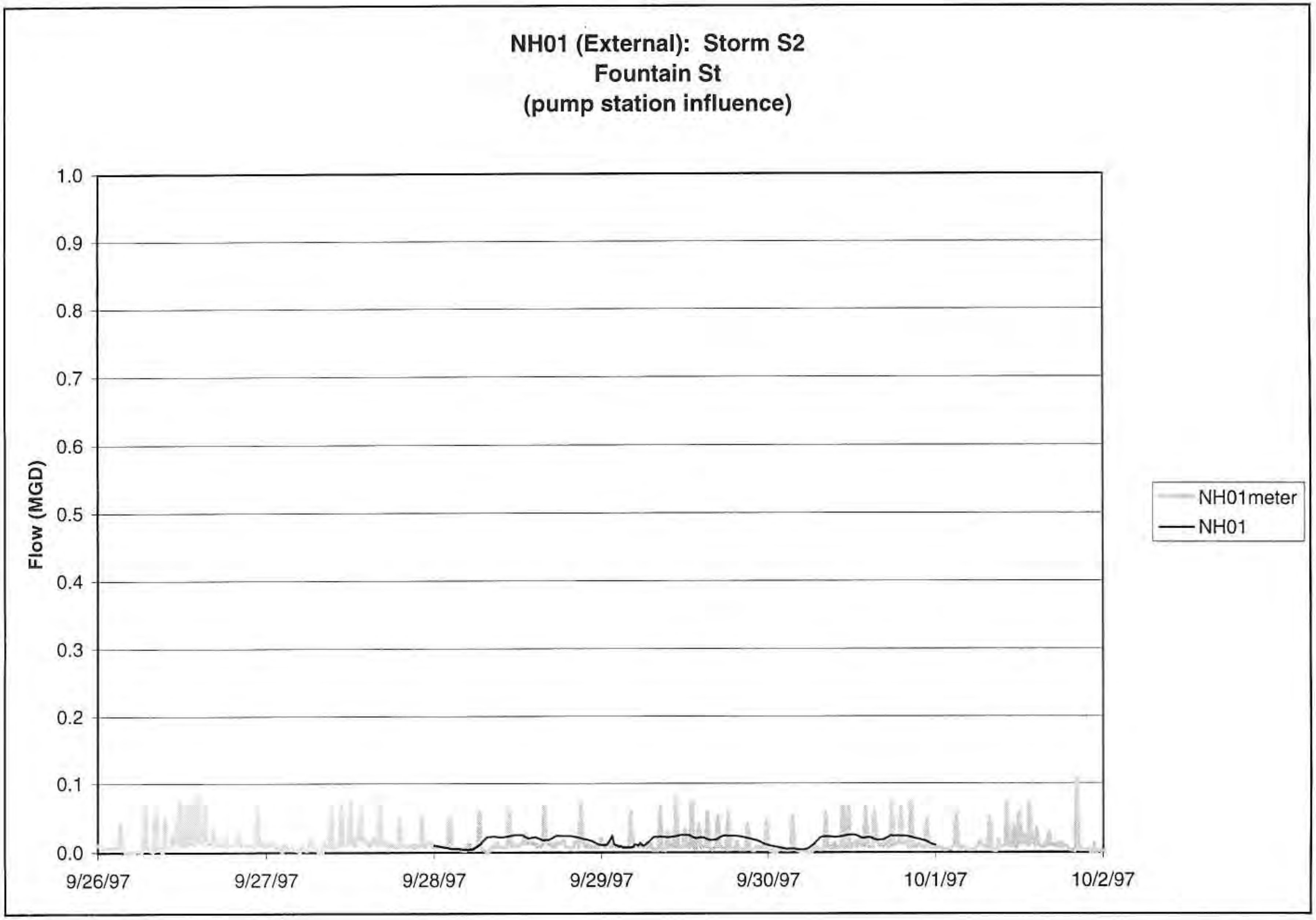

Overflow pipe at 004: Storm S2
Flow (MGD)
10
9
8
7
6
5
4
3
2
1
0
9/26/97
9/27/97
9/28/97
9/29/97
9/30/97
10/1/97
10/2/97
calculated
0F004



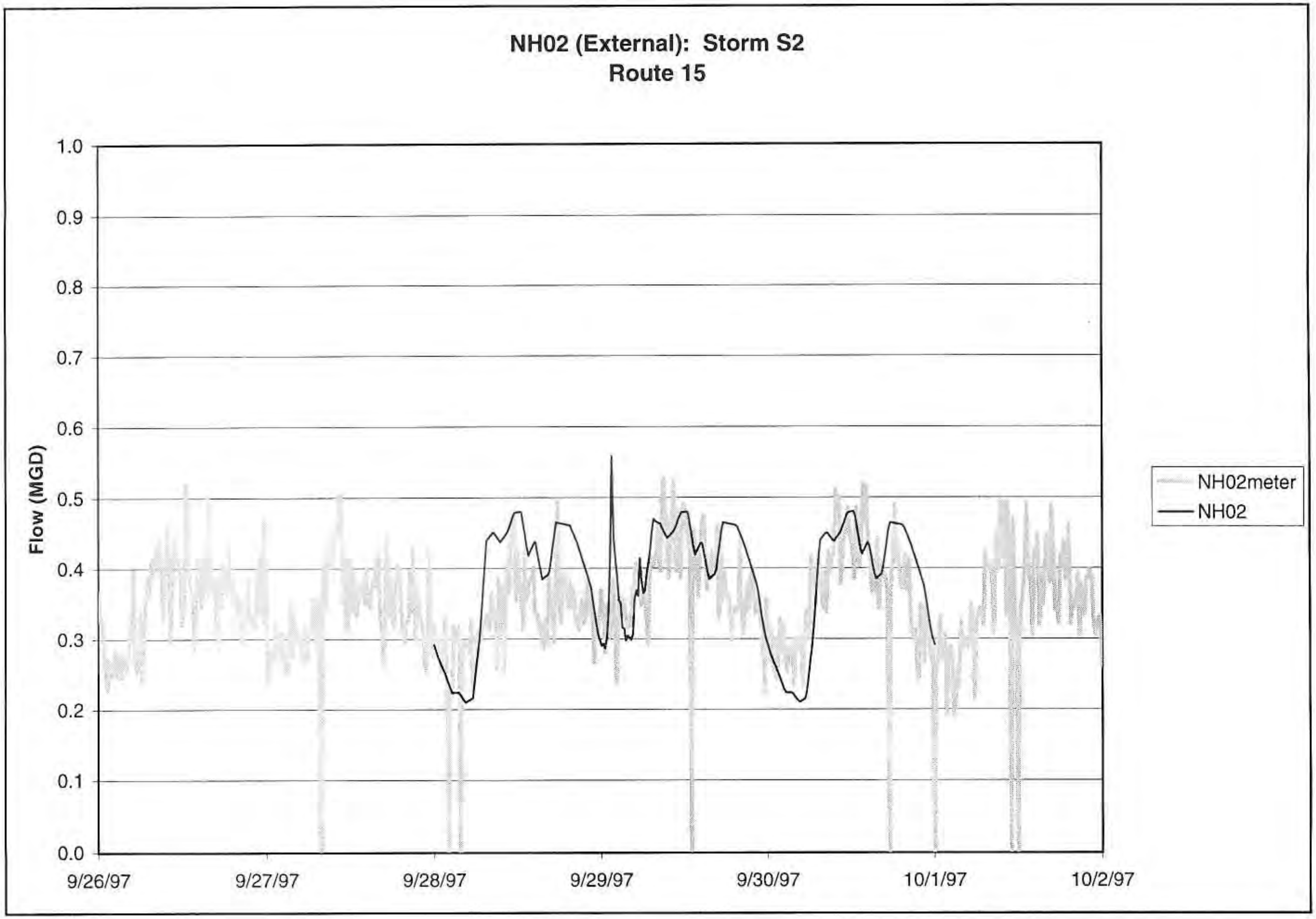
Local inflow at 005: Storm S2
Flow (MGD)
30
25
20
15
10
5
0
9/26/97
9/27/97
9/28/97
9/29/97
9/30/97
10/1/97
10/2/97
meter
REG005 u/s



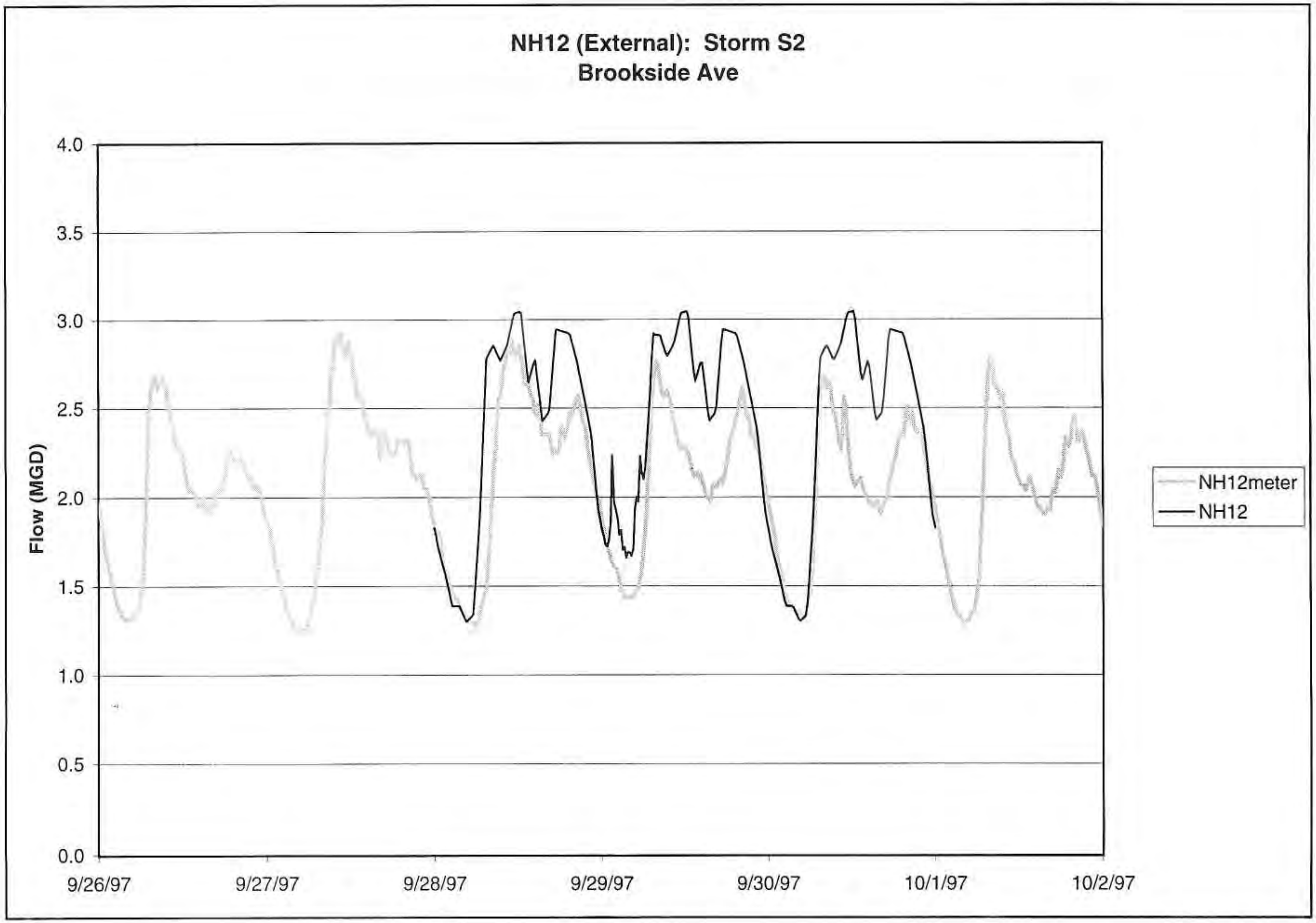
Interceptor at 006: Storm S2
Flow (MGD)
6
5
4
3
2
1
0
9/26/97
9/27/97
9/28/97
9/29/97
9/30/97
10/1/97
10/2/97
meter
REG006 d/s

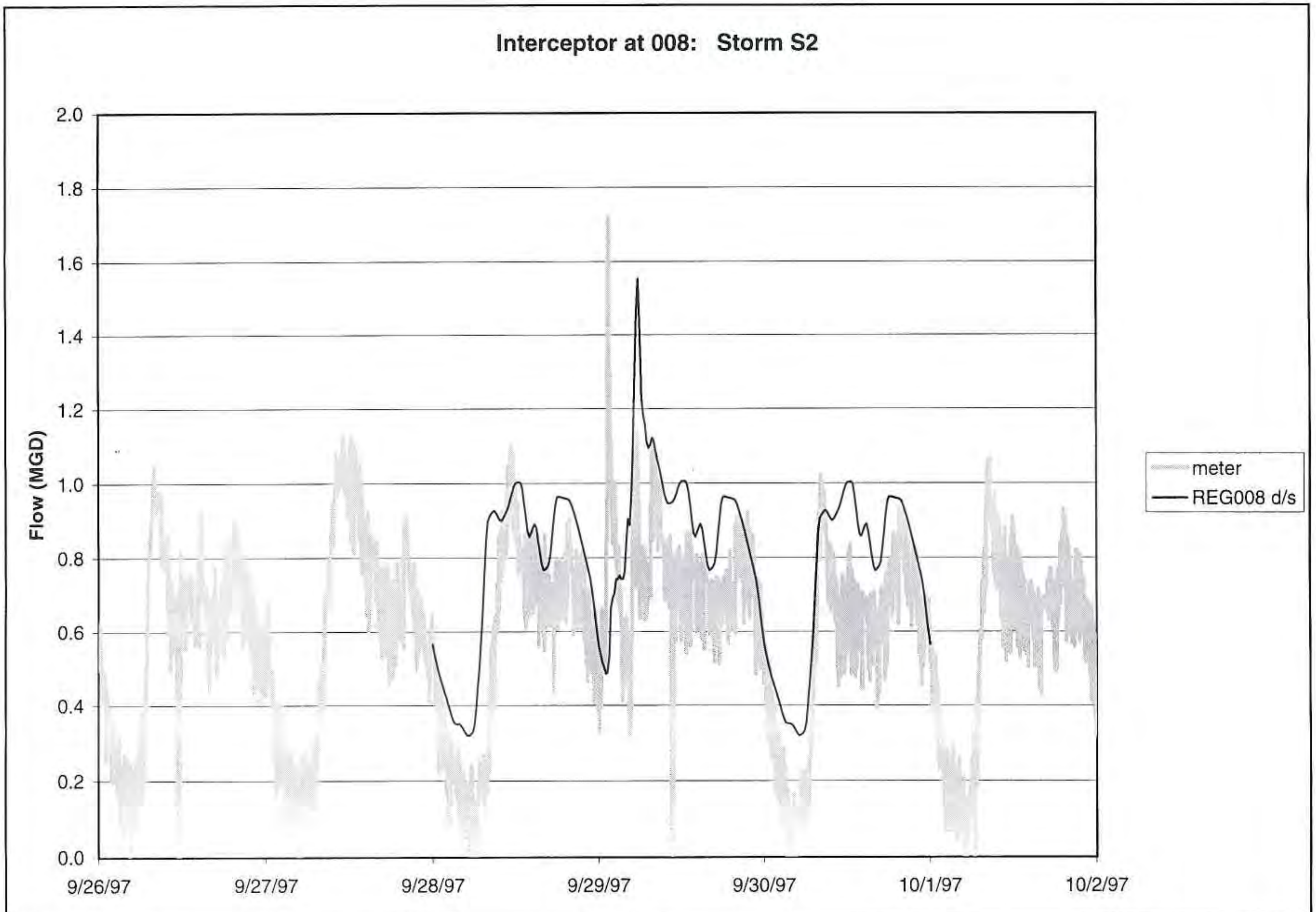


NH01 (External): Storm S2
Fountain St
(pump station influence)
Flow (MGD)
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
9/26/97
9/27/97
9/28/97
9/29/97
9/30/97
10/1/97
10/2/97
NH01meter
NH01

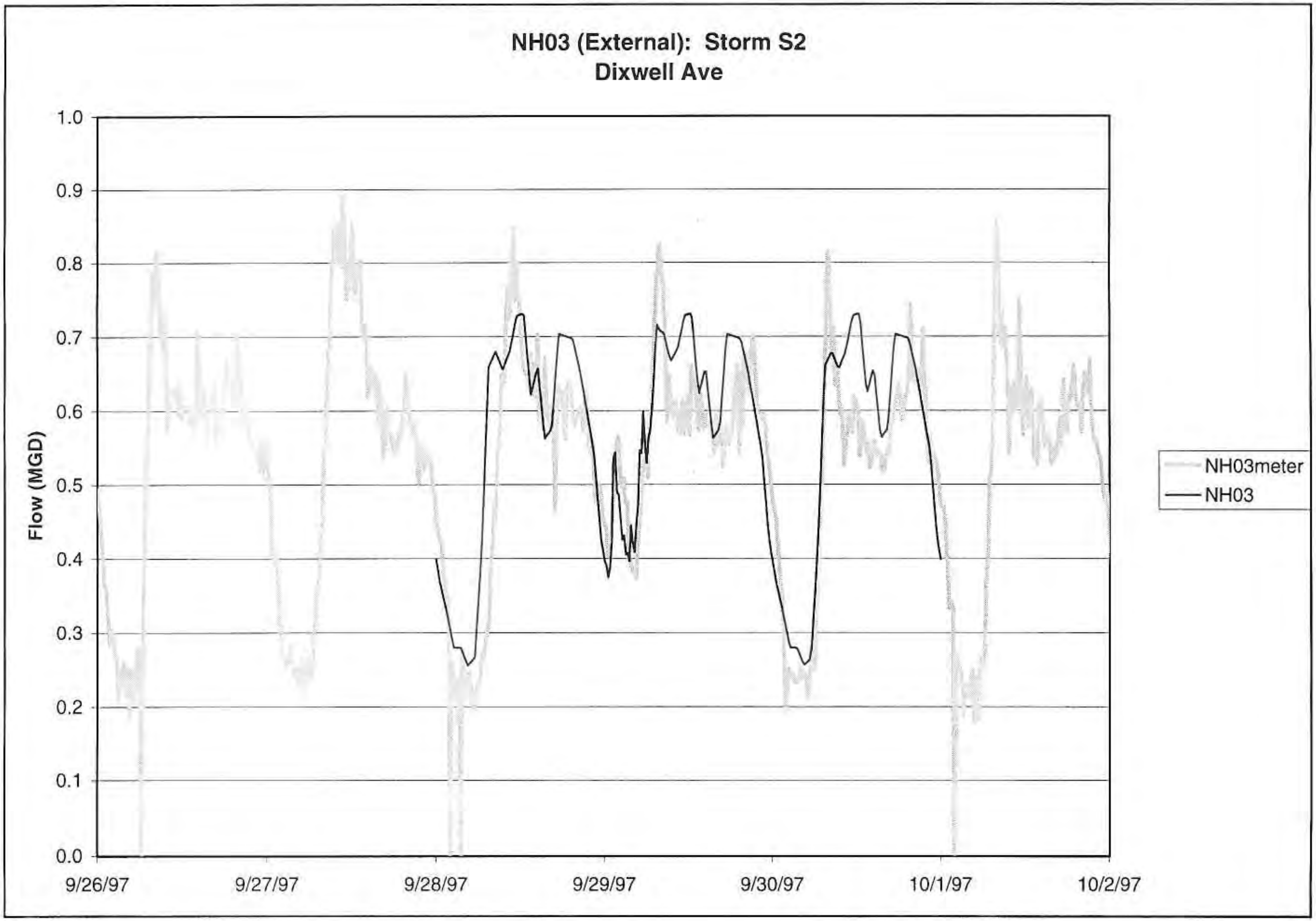


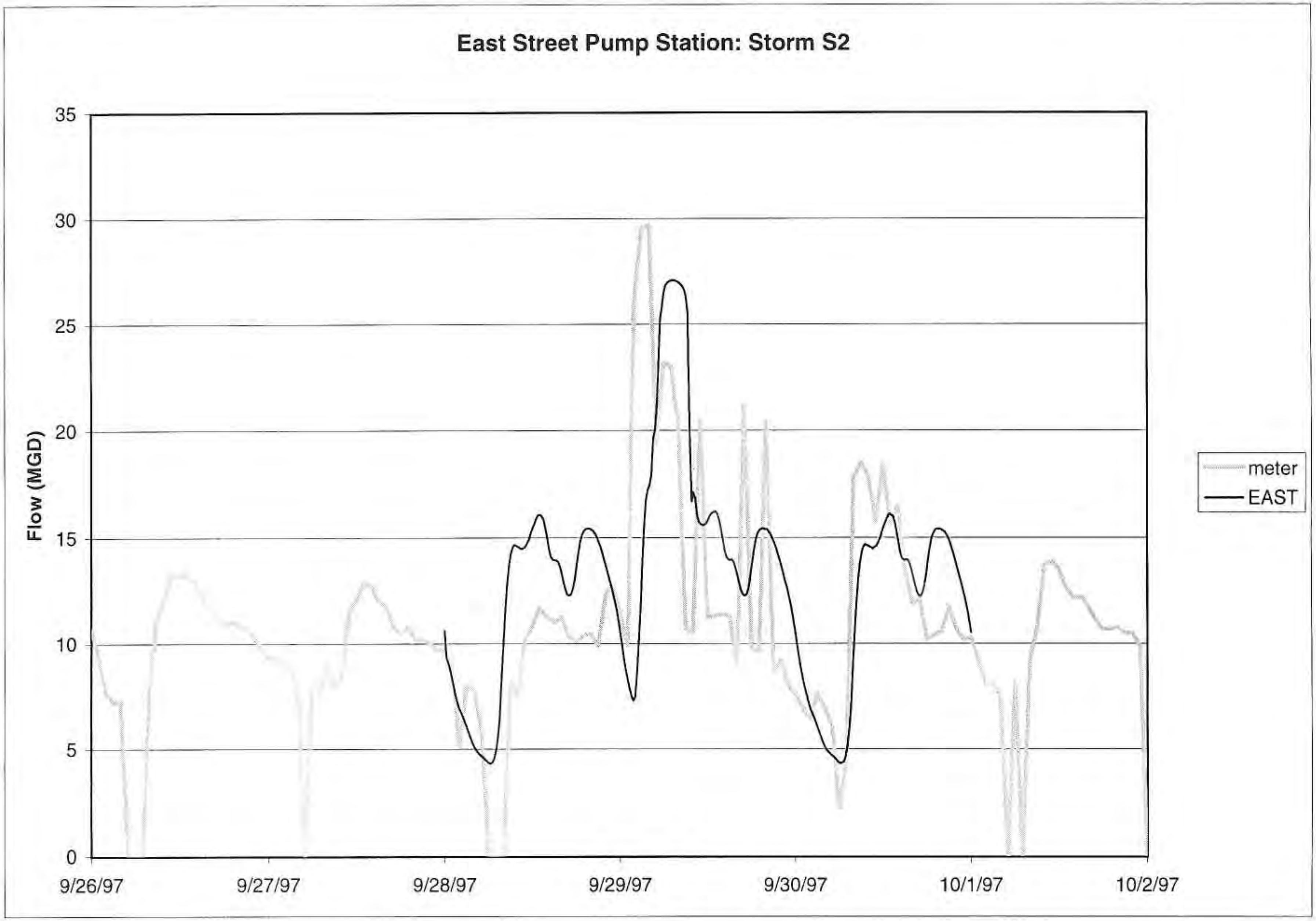
NH02 (External): Storm S2
Route 15
Flow (MGD)
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
9/26/97
9/27/97
9/28/97
9/29/97
9/30/97
10/1/97
10/2/97
NH02meter
NH02


NH12 (External): Storm S2
Brookside Ave
Flow (MGD)
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
9/26/97
9/27/97
9/28/97
9/29/97
9/30/97
10/1/97
10/2/97
NH12meter
NH12

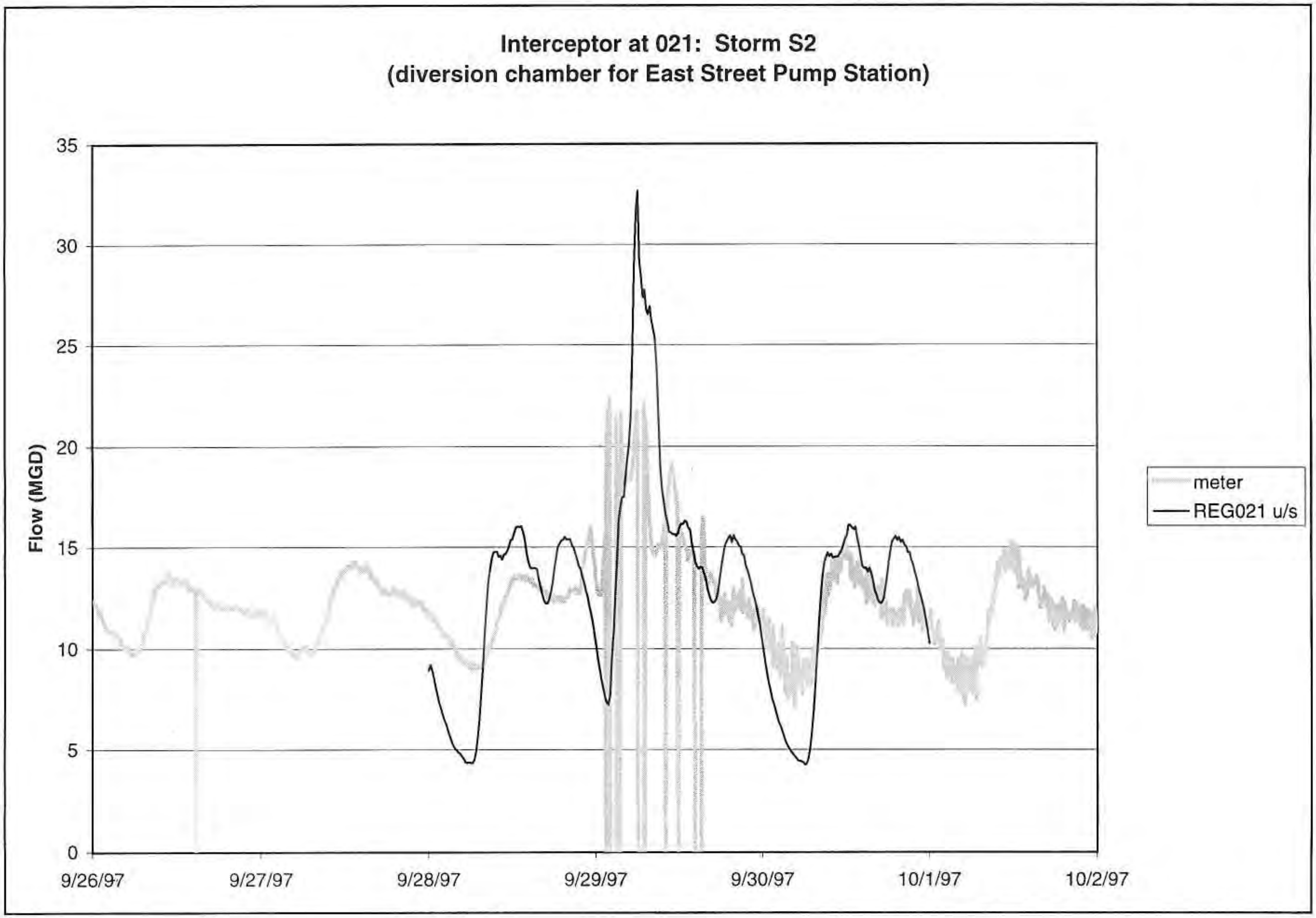


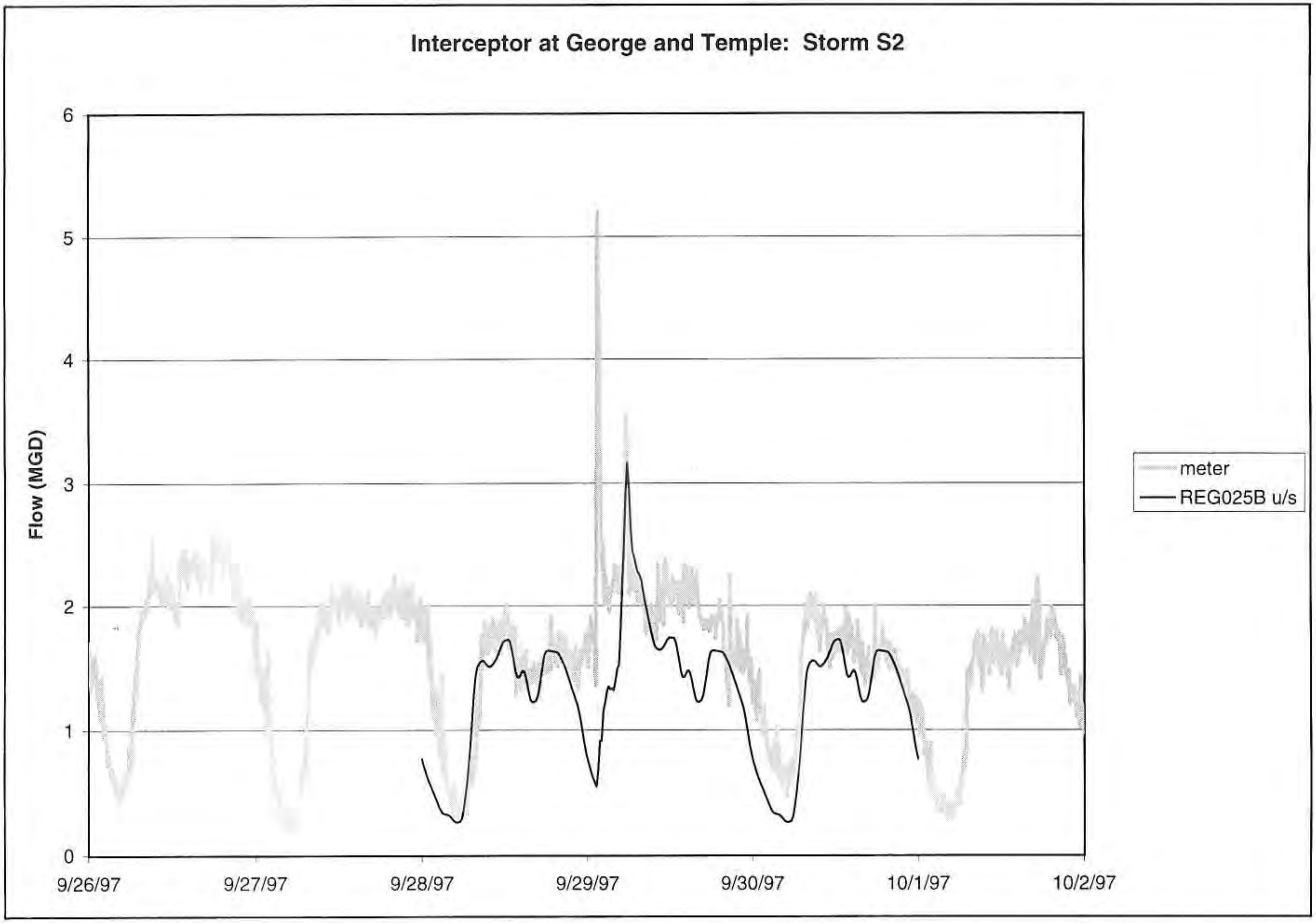
Interceptor at 008: Storm S2
Flow (MGD)
2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
9/26/97
9/27/97
9/28/97
9/29/97
9/30/97
10/1/97
10/2/97
meter
REG008 d/s


NH03 (External): Storm S2
Dixwell Ave
Flow (MGD)
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
9/26/97
9/27/97
9/28/97
9/29/97
9/30/97
10/1/97
10/2/97
NH03meter
NH03

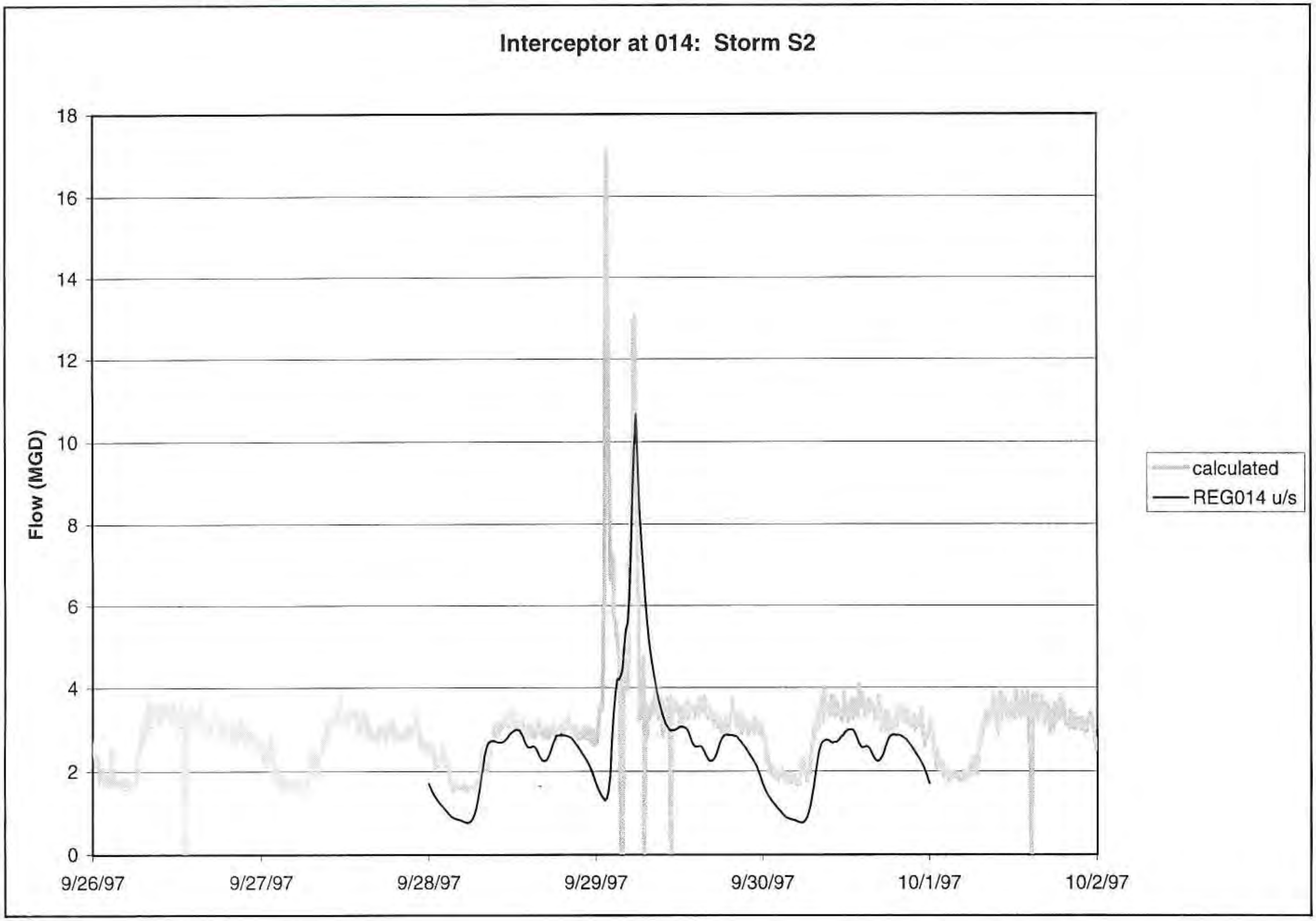


East Street Pump Station: Storm S2
Flow (MGD)
35
30
25
20
15
10
5
0
9/26/97
9/27/97
9/28/97
9/29/97
9/30/97
10/1/97
10/2/97
meter
EAST

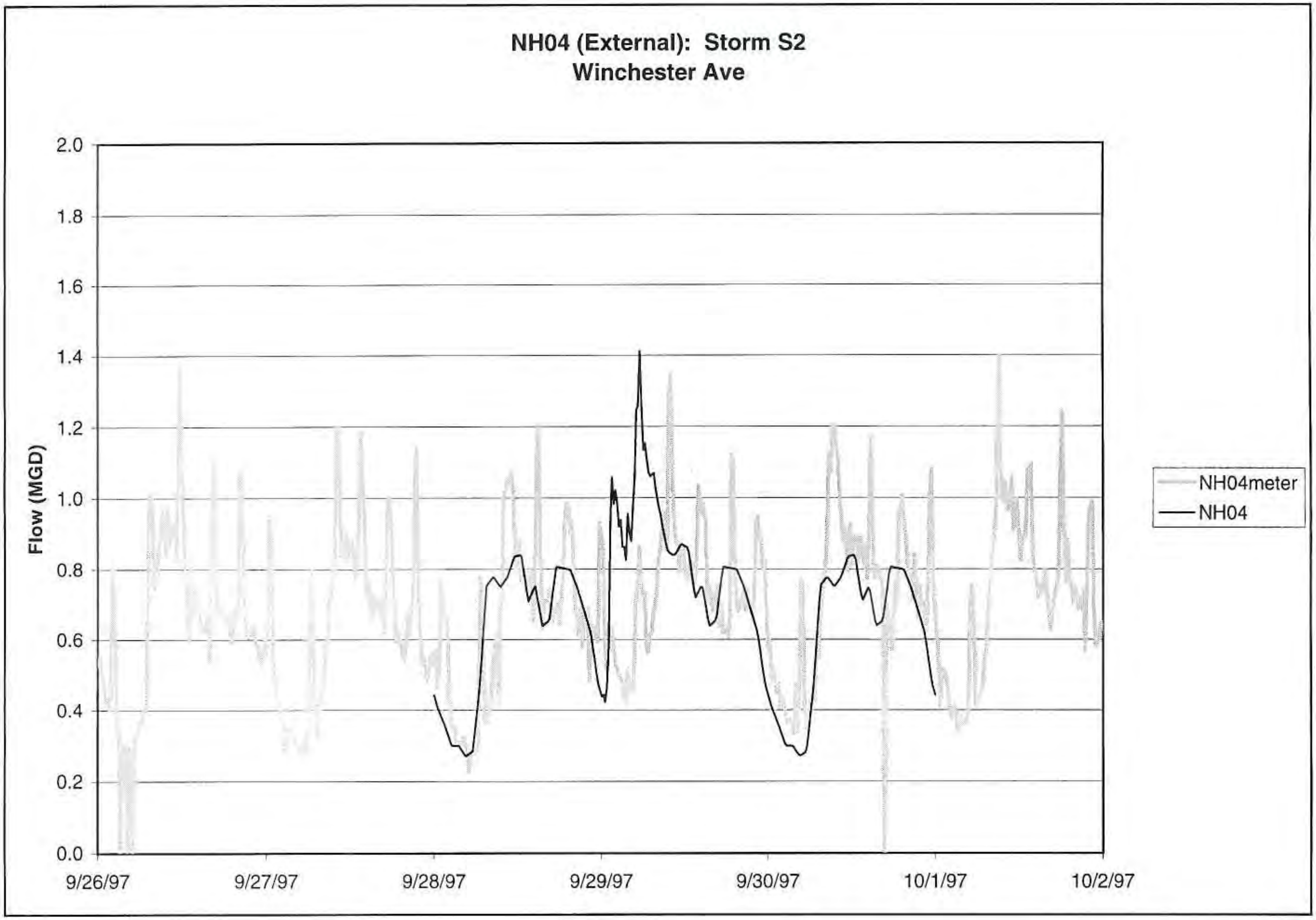

Interceptor at 021: Storm S2
(diversion chamber for East Street Pump Station)
Flow (MGD)
35
30
25
20
15
10
5
0
9/26/97
9/27/97
9/28/97
9/29/97
9/30/97
10/1/97
10/2/97
meter
REG021 u/s

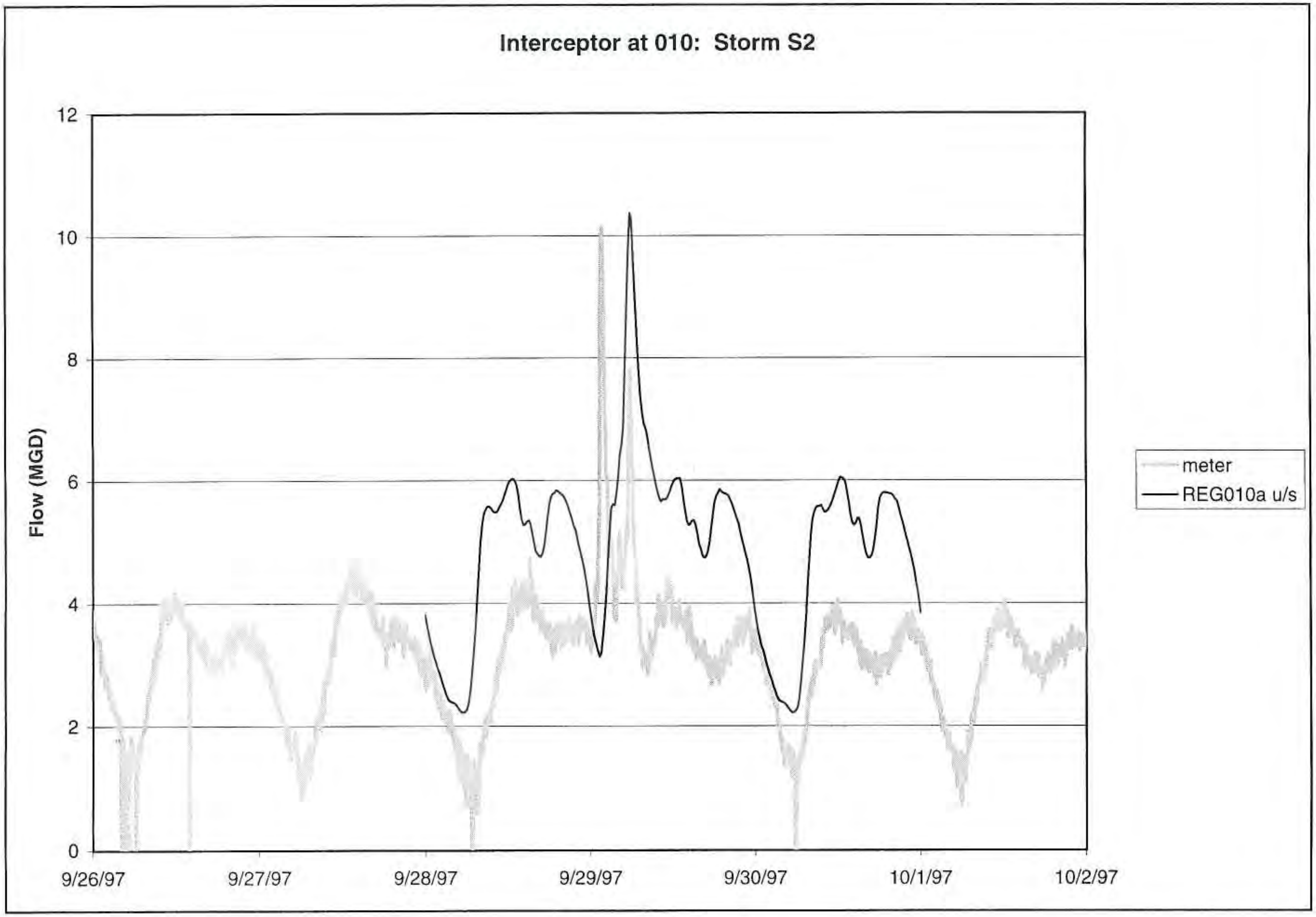


Interceptor at George and Temple: Storm S2
Flow (MGD)
0
1
2
3
4
5
6
9/26/97
9/27/97
9/28/97
9/29/97
9/30/97
10/1/97
10/2/97
meter
REG025B u/s

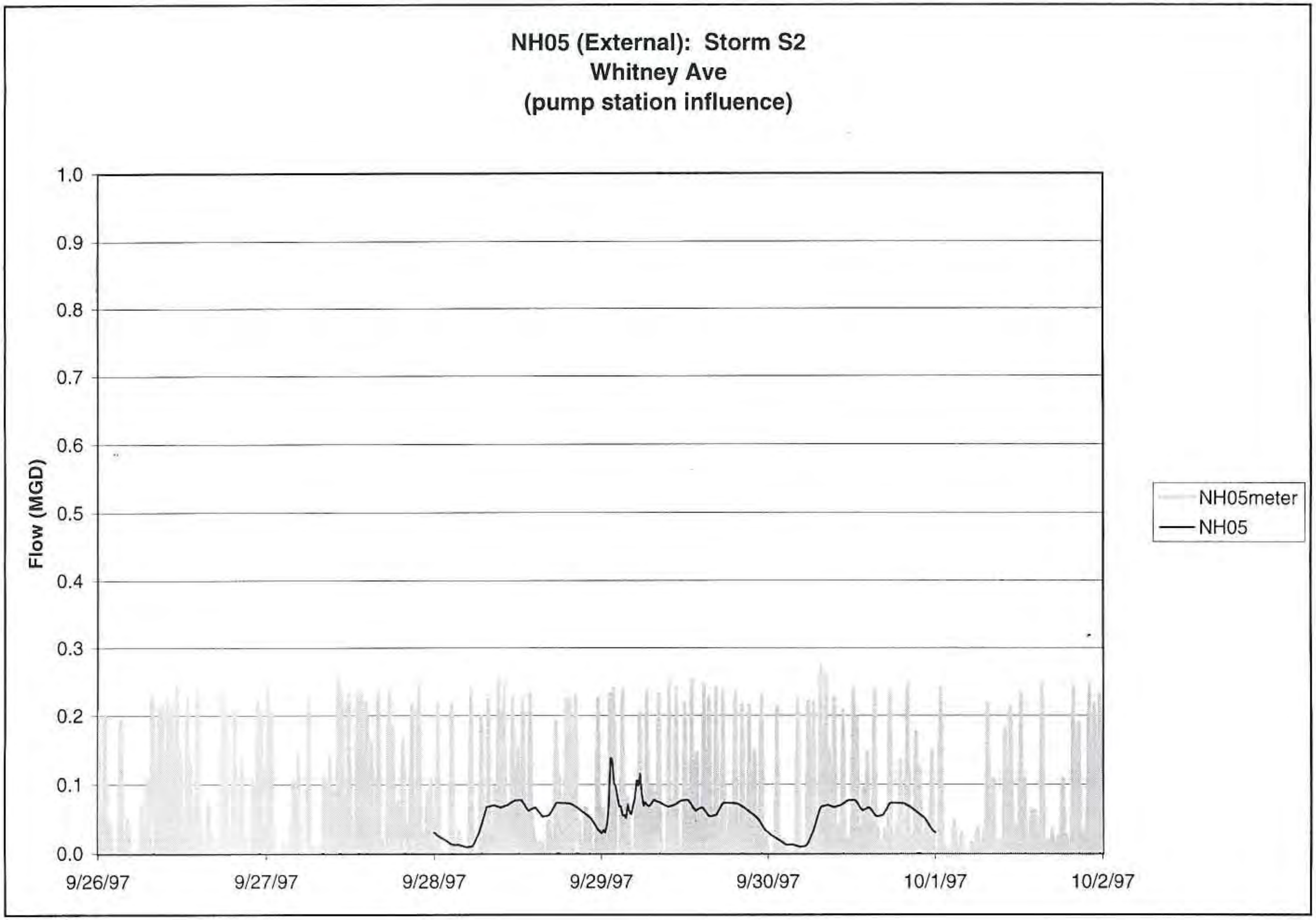


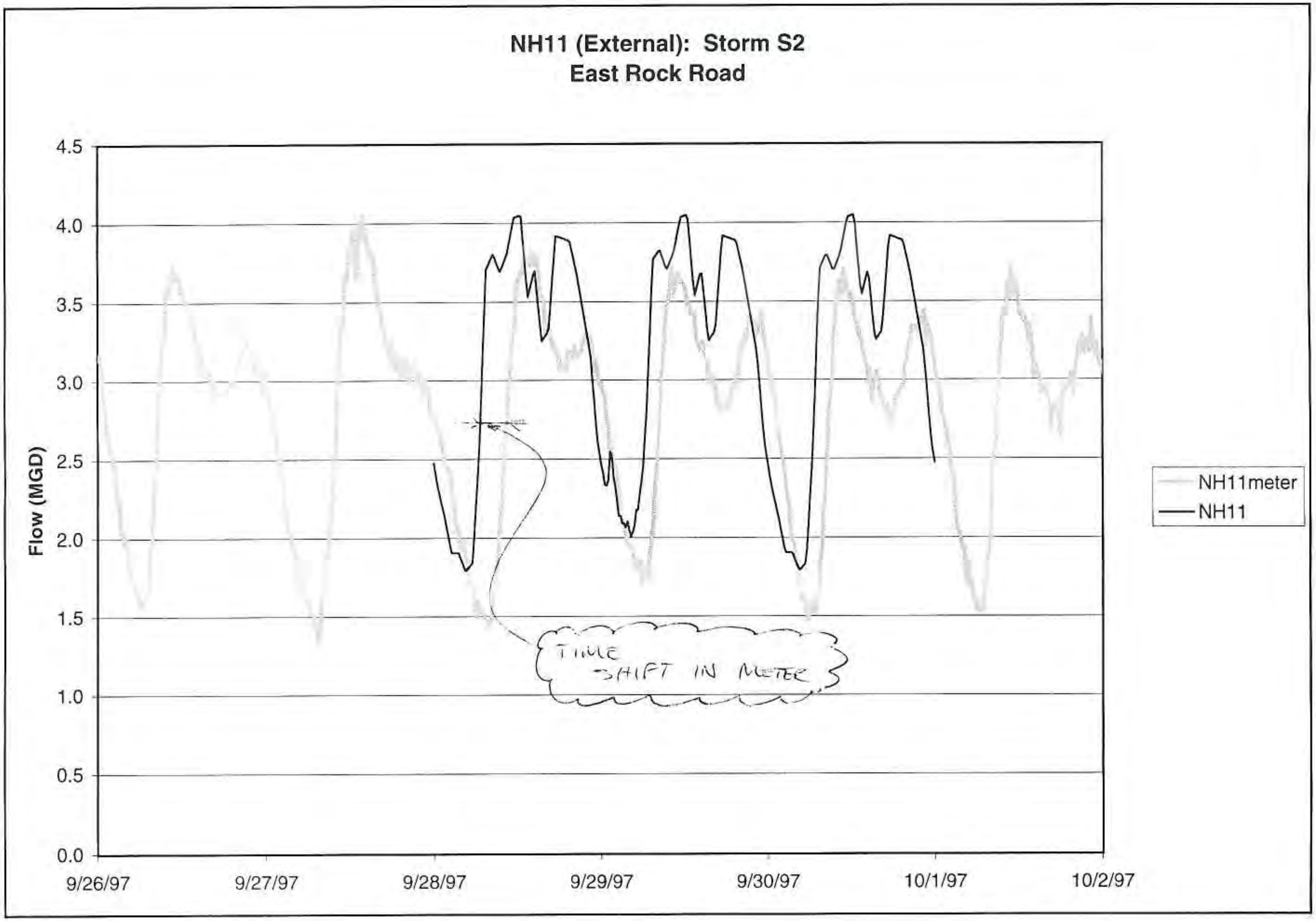
Interceptor at 014: Storm S2
Flow (MGD)
18
16
14
12
10
8
6
4
2
0
9/26/97
9/27/97
9/28/97
9/29/97
9/30/97
10/1/97
10/2/97
calculated
REG014 u/s


NH04 (External): Storm S2
Winchester Ave
Flow (MGD)
2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
9/26/97
9/27/97
9/28/97
9/29/97
9/30/97
10/1/97
10/2/97
NH04meter
NH04

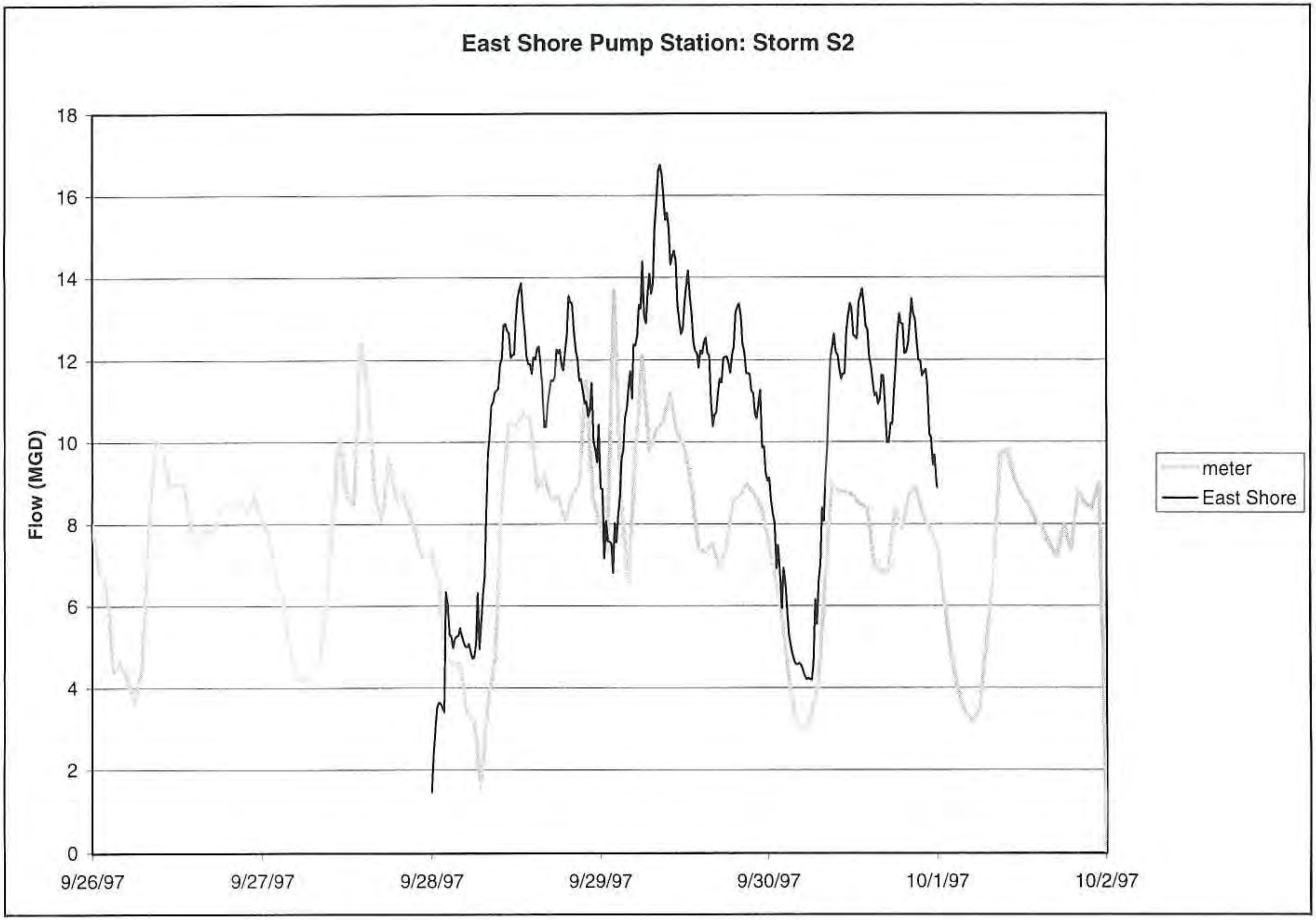


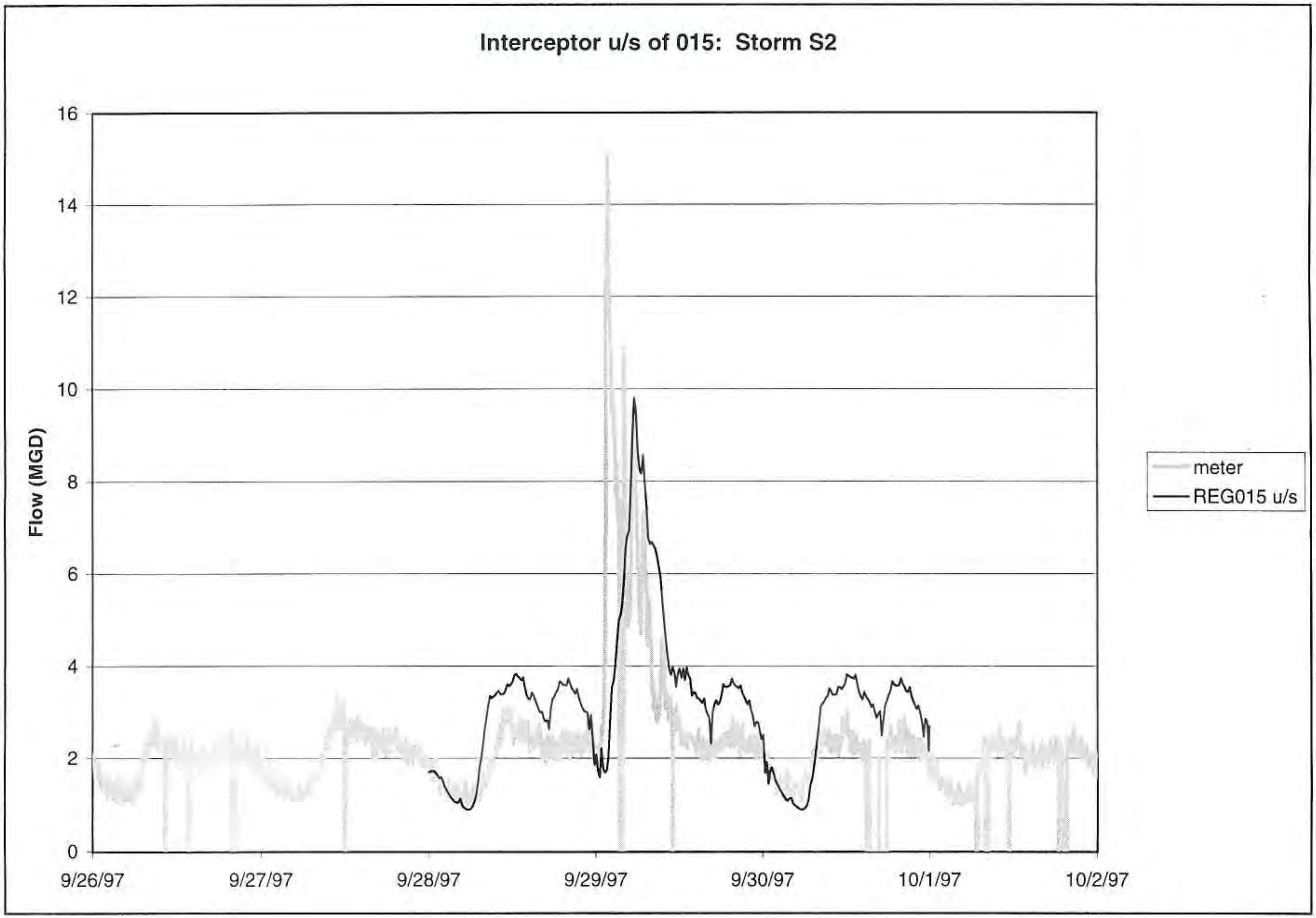
Interceptor at 010: Storm S2
Flow (MGD)
12
10
8
6
4
2
0
9/26/97
9/27/97
9/28/97
9/29/97
9/30/97
10/1/97
10/2/97
meter
REG010a u/s


NH05 (External): Storm S2
Whitney Ave
(pump station influence)
Flow (MGD)
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
9/26/97
9/27/97
9/28/97
9/29/97
9/30/97
10/1/97
10/2/97
NH05meter
NH05

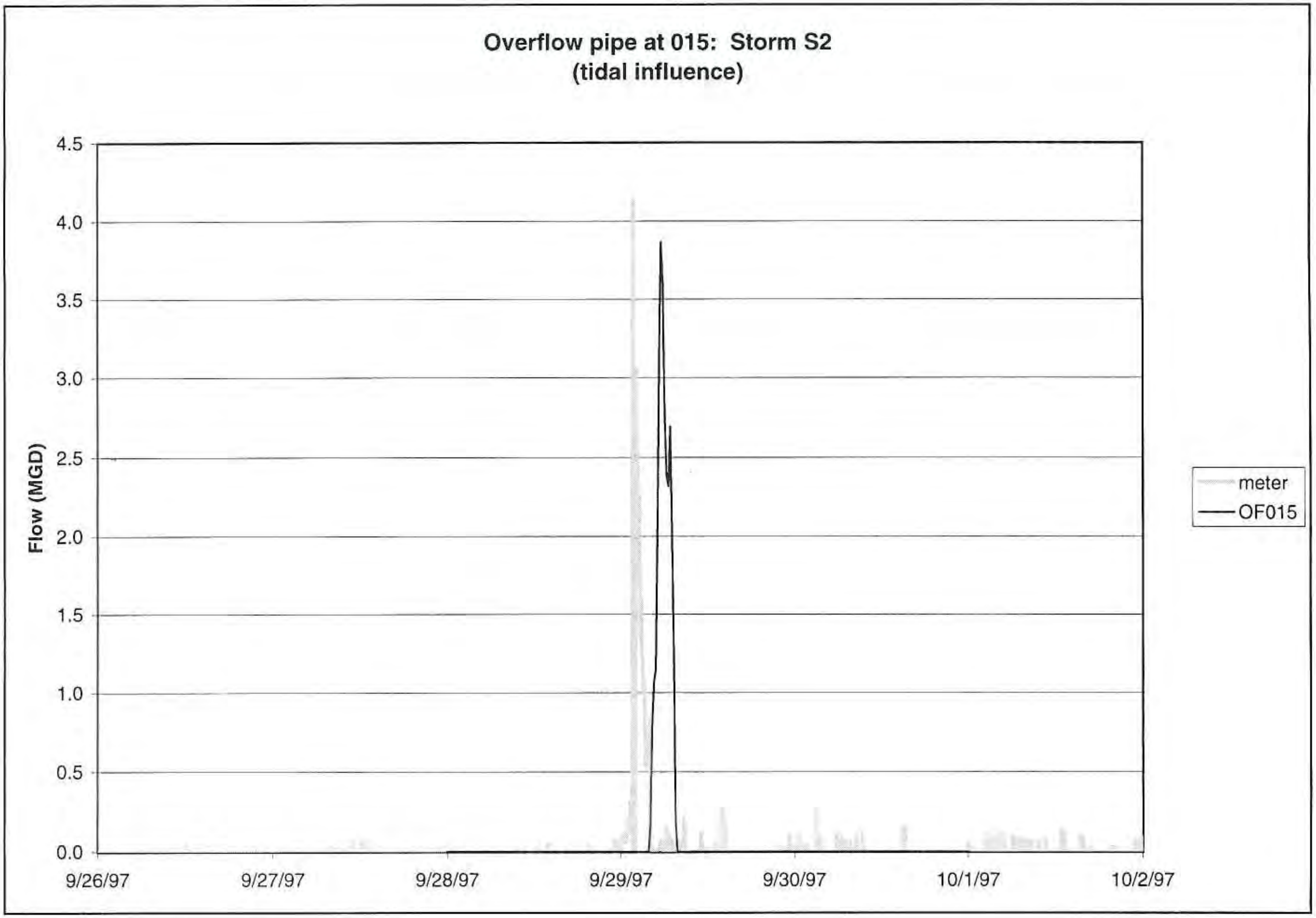


NH11 (External): Storm S2
East Rock Road
Flow (MGD)
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
9/26/97
9/27/97
9/28/97
9/29/97
9/30/97
10/1/97
10/2/97
NH11meter
NH11
TIME SHIFT IN METER

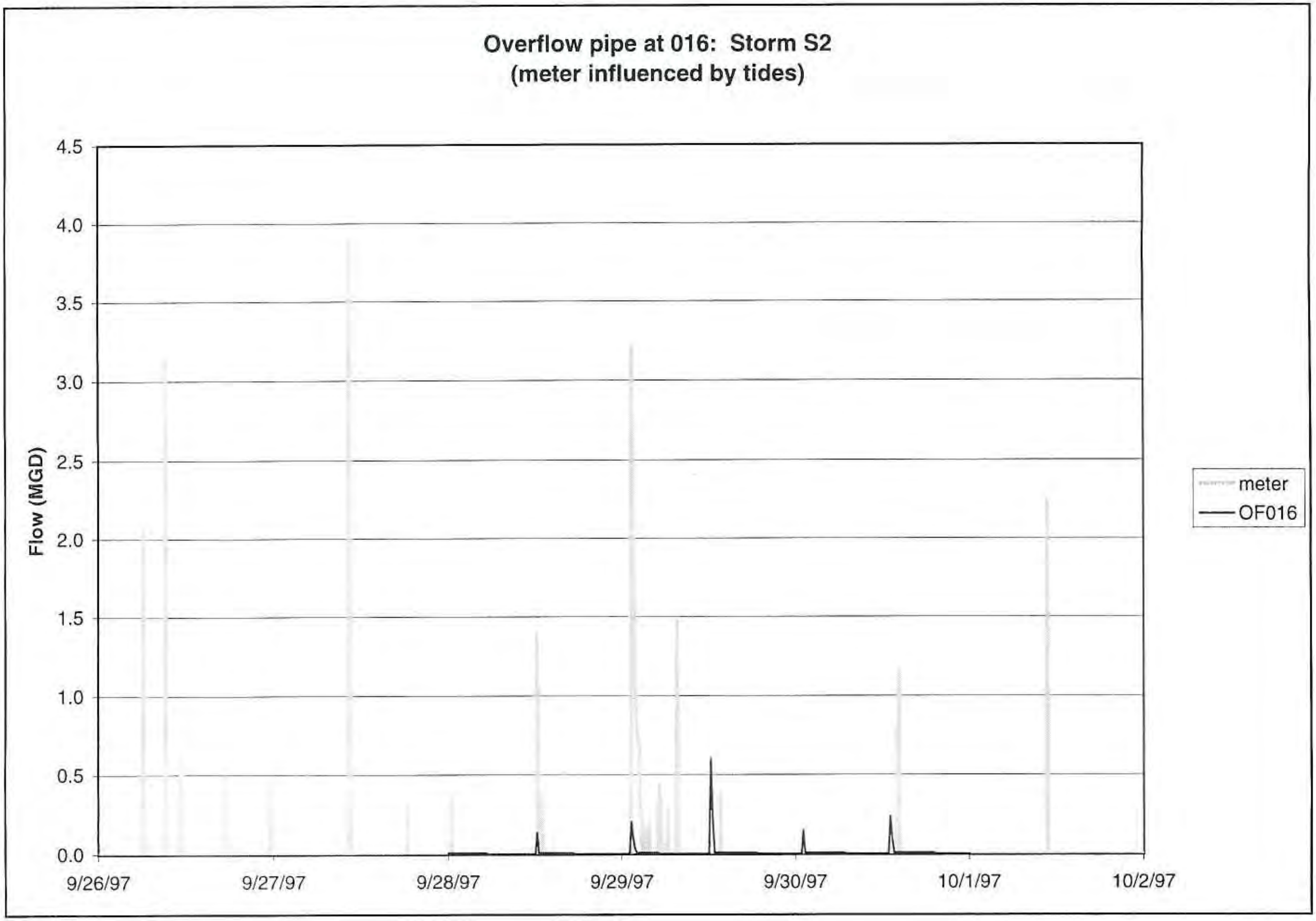

East Shore Pump Station: Storm S2
Flow (MGD)
18
16
14
12
10
8
6
4
2
0
9/26/97
9/27/97
9/28/97
9/29/97
9/30/97
10/1/97
10/2/97
meter
East Shore



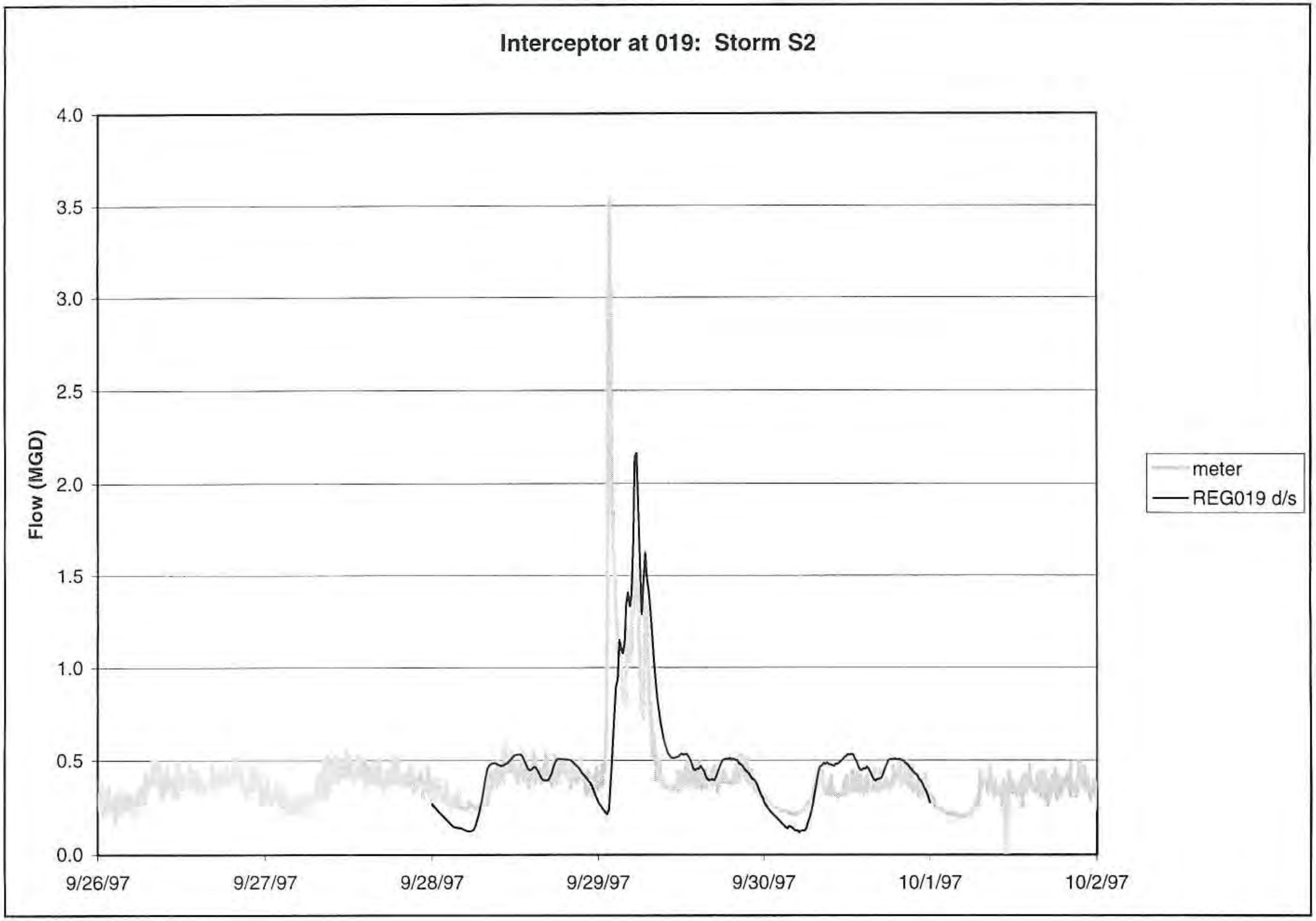
Interceptor u/s of 015: Storm S2
Flow (MGD)
16
14
12
10
8
6
4
2
0
9/26/97
9/27/97
9/28/97
9/29/97
9/30/97
10/1/97
10/2/97
meter
REG015 u/s

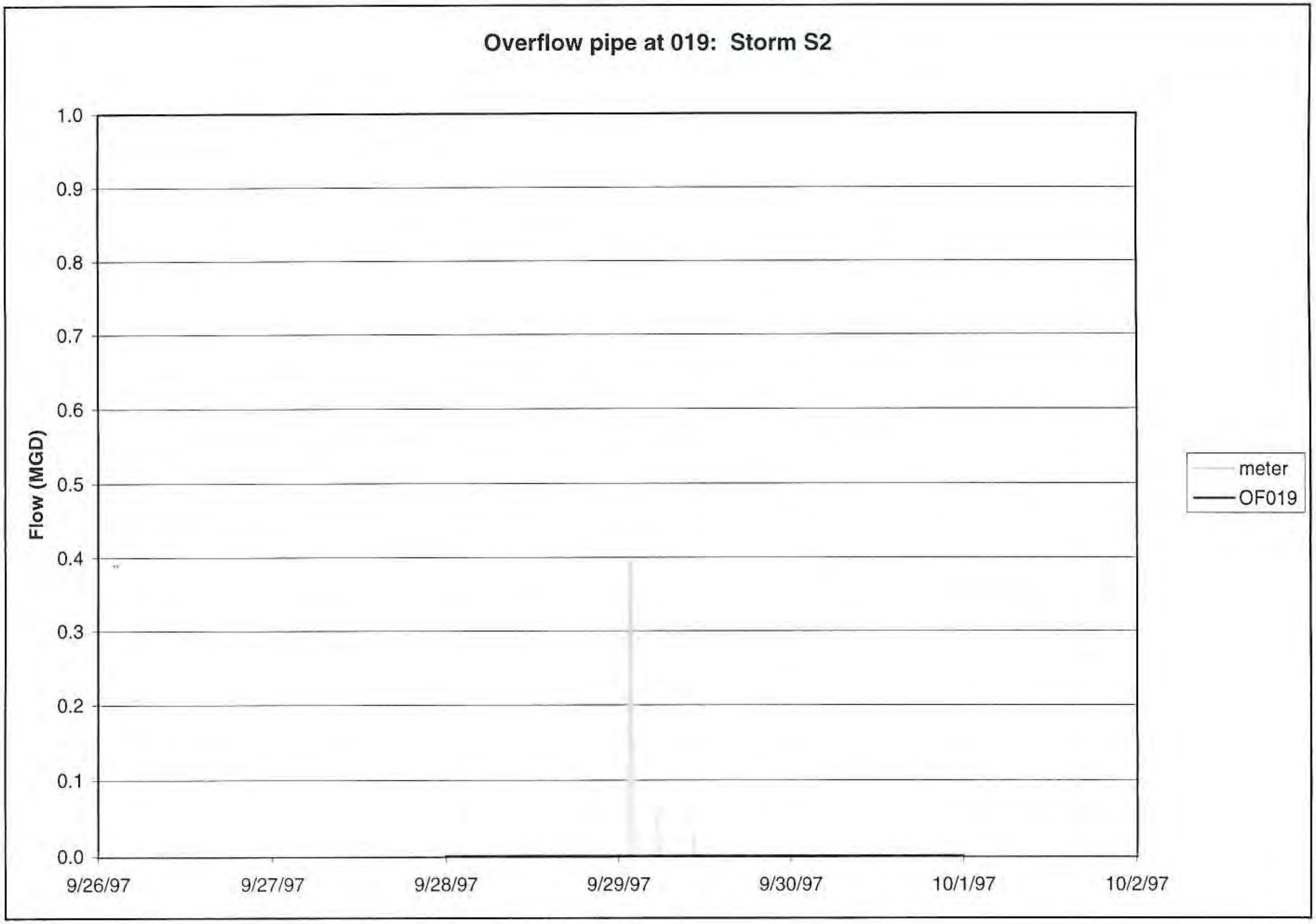


Overflow pipe at 015: Storm S2
(tidal influence)
Flow (MGD)
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
9/26/97
9/27/97
9/28/97
9/29/97
9/30/97
10/1/97
10/2/97
meter
OF015

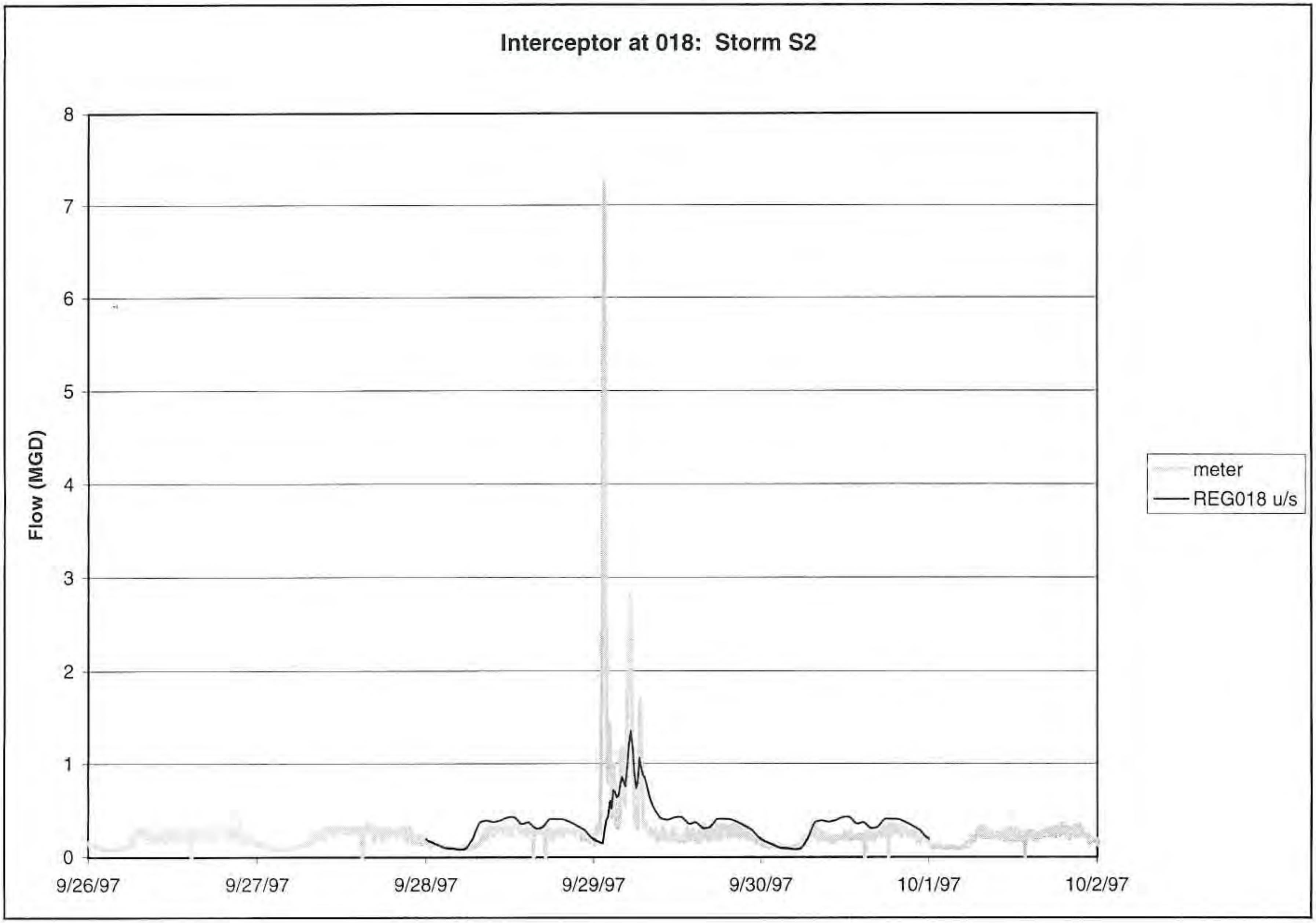


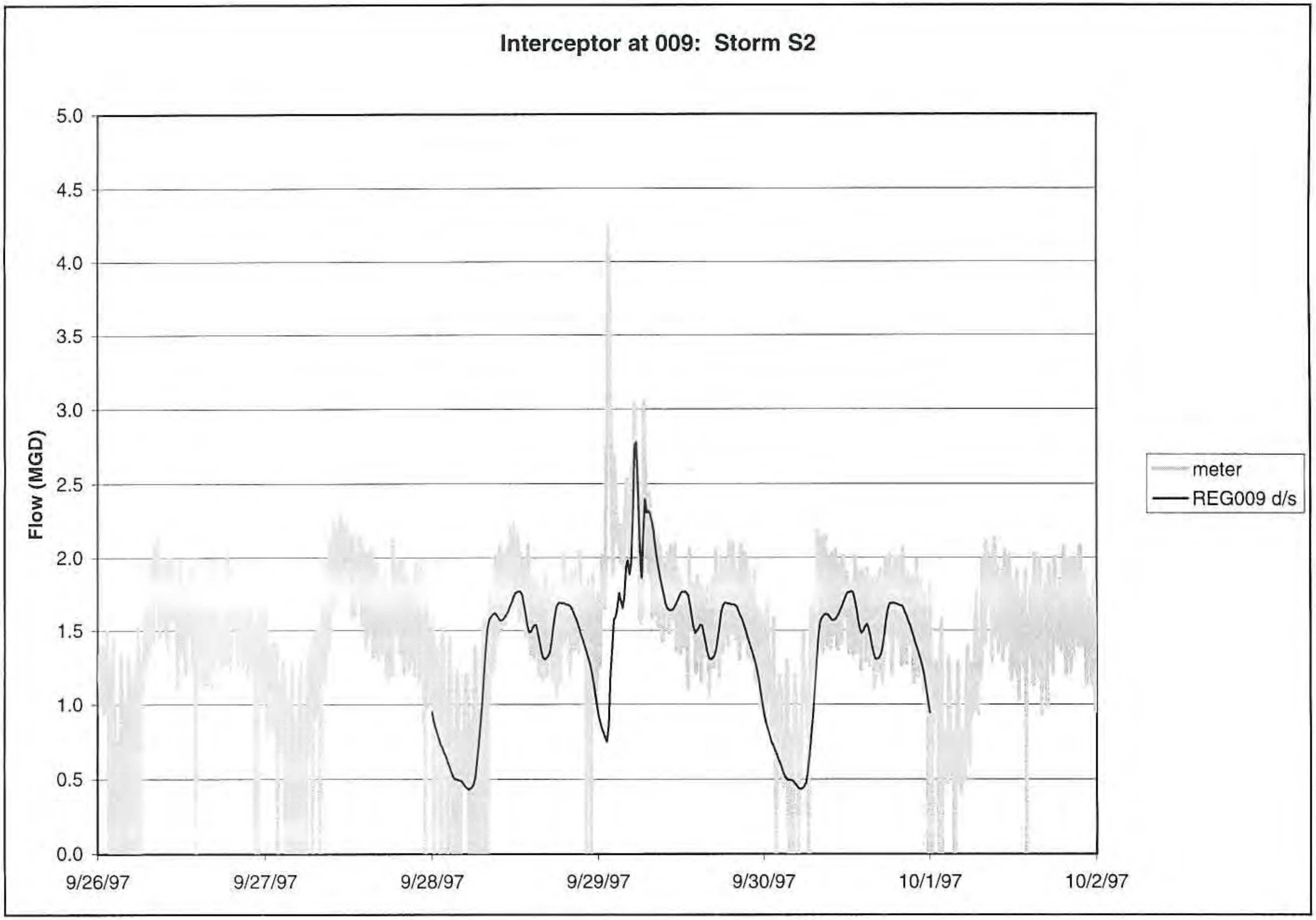
Overflow pipe at 016: Storm S2
(meter influenced by tides)
Flow (MGD)
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
9/26/97
9/27/97
9/28/97
9/29/97
9/30/97
10/1/97
10/2/97
meter
OF016

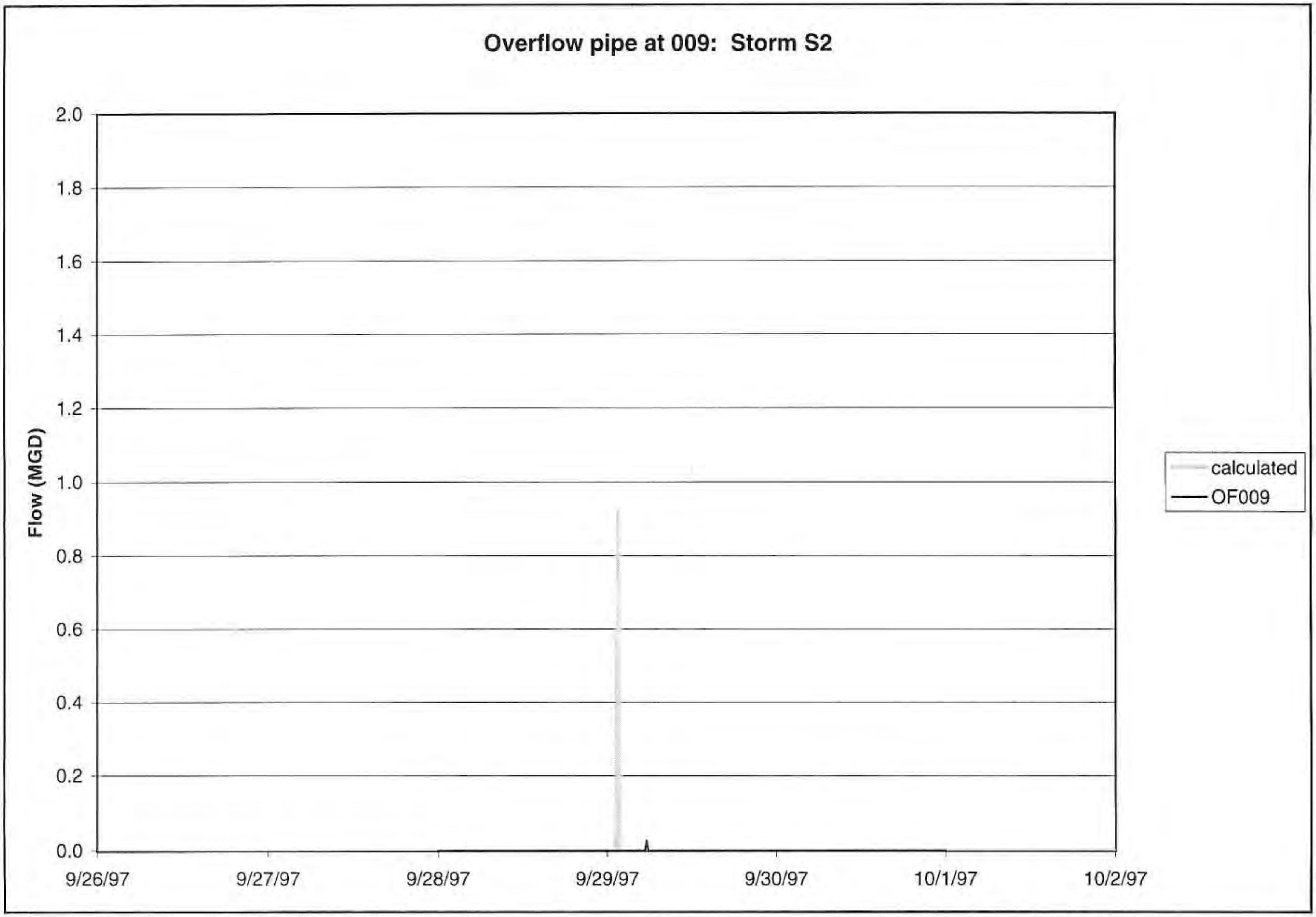

Interceptor at 019: Storm S2
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
Flow (MGD)
9/26/97
9/27/97
9/28/97
9/29/97
9/30/97
10/1/97
10/2/97
meter
REG019 d/s



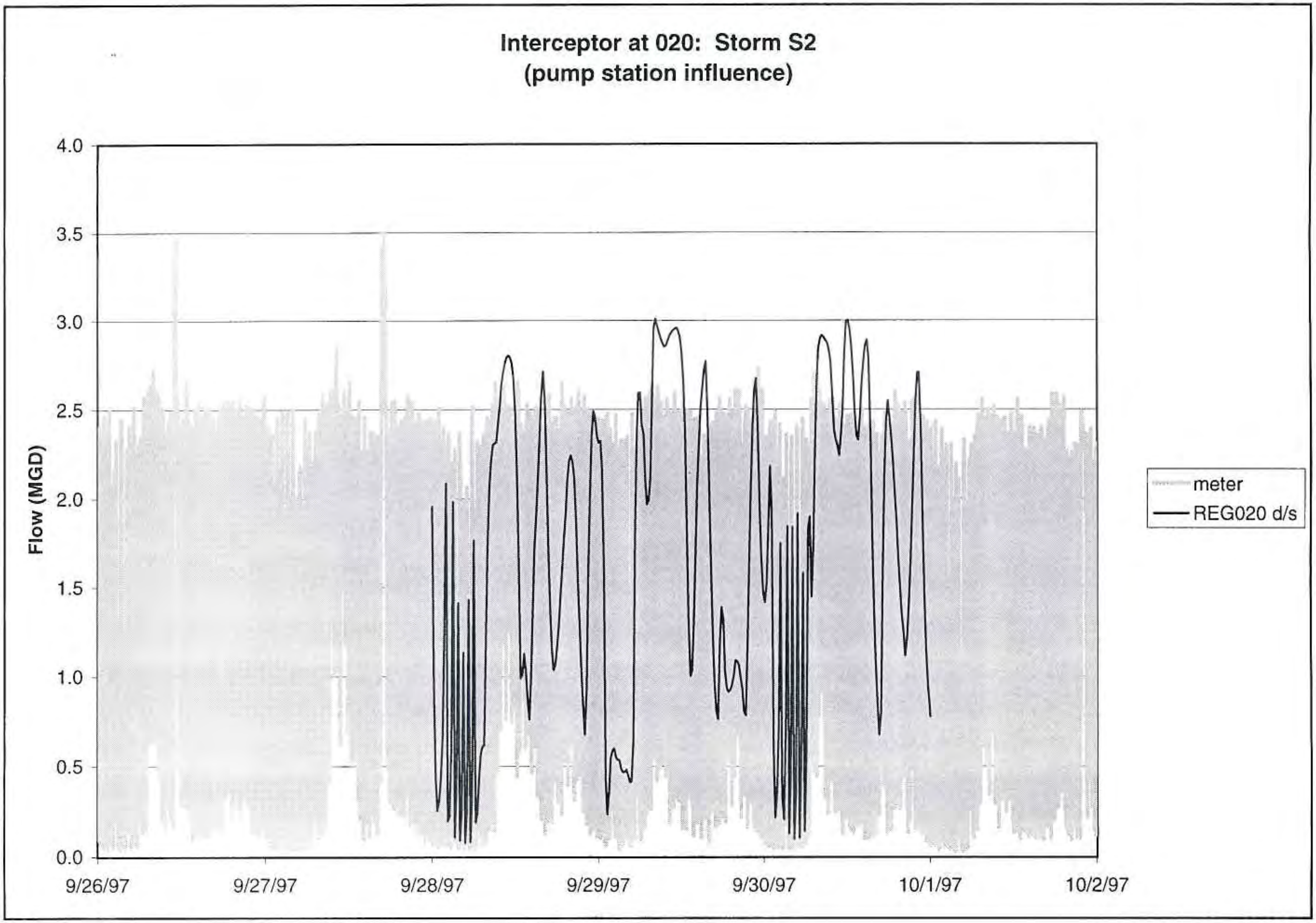
Overflow pipe at 019: Storm S2
Flow (MGD)
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
9/26/97
9/27/97
9/28/97
9/29/97
9/30/97
10/1/97
10/2/97
meter
OF019


Interceptor at 018: Storm S2
Flow (MGD)
0
1
2
3
4
5
6
7
8
9/26/97
9/27/97
9/28/97
9/29/97
9/30/97
10/1/97
10/2/97
meter
REG018 u/s

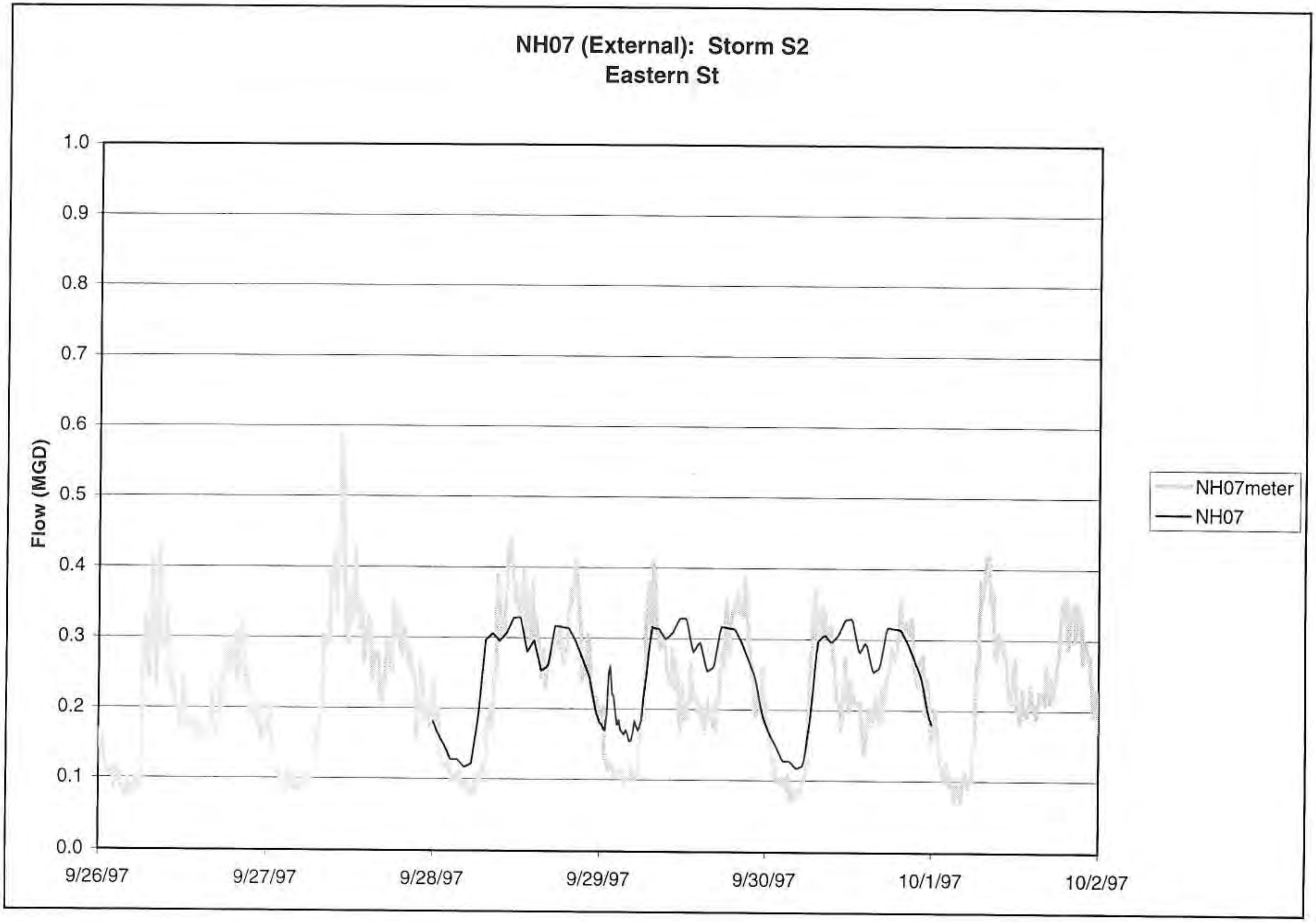

Interceptor at 009: Storm S2
Flow (MGD)
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
9/26/97
9/27/97
9/28/97
9/29/97
9/30/97
10/1/97
10/2/97
meter
REG009 d/s

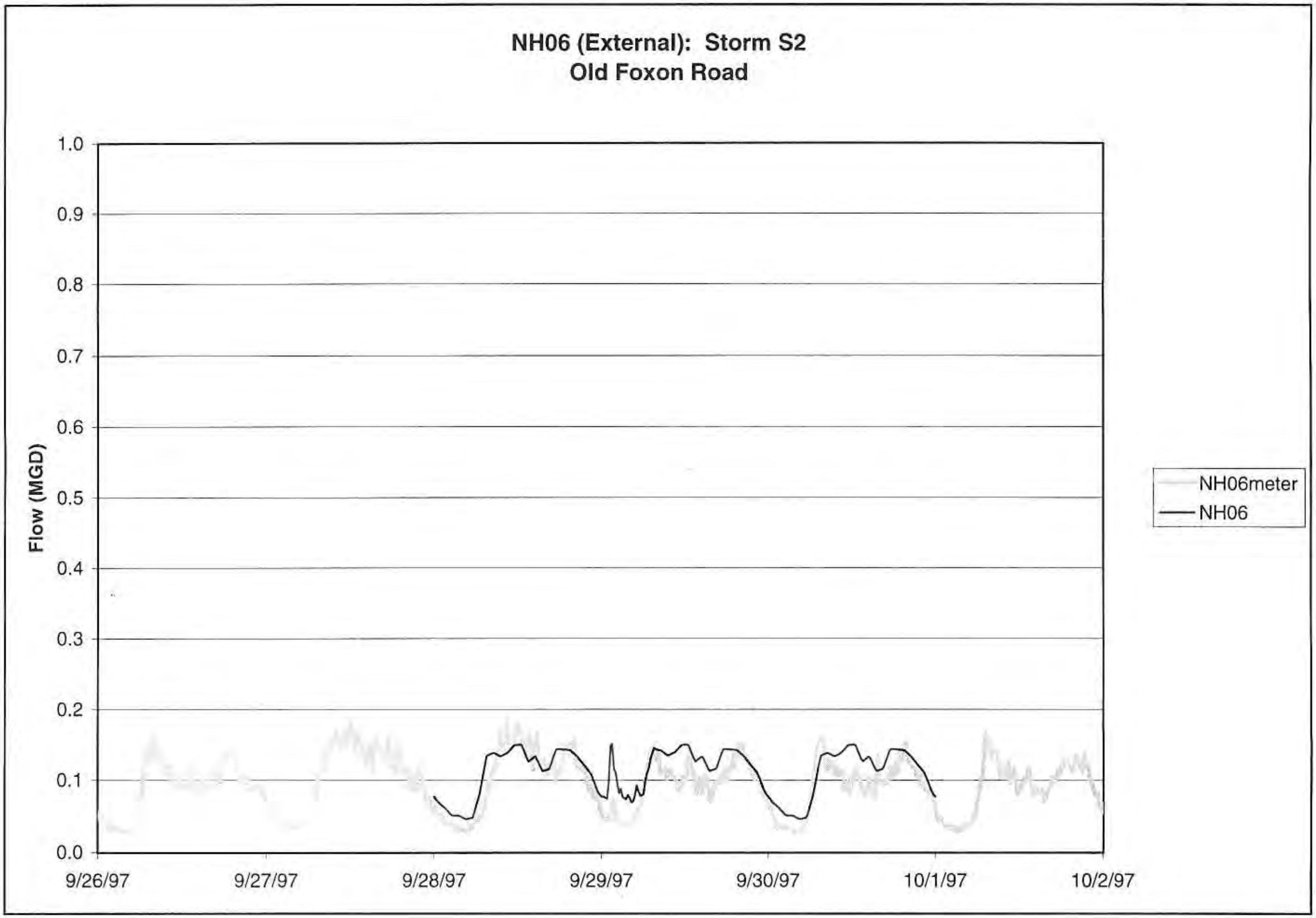


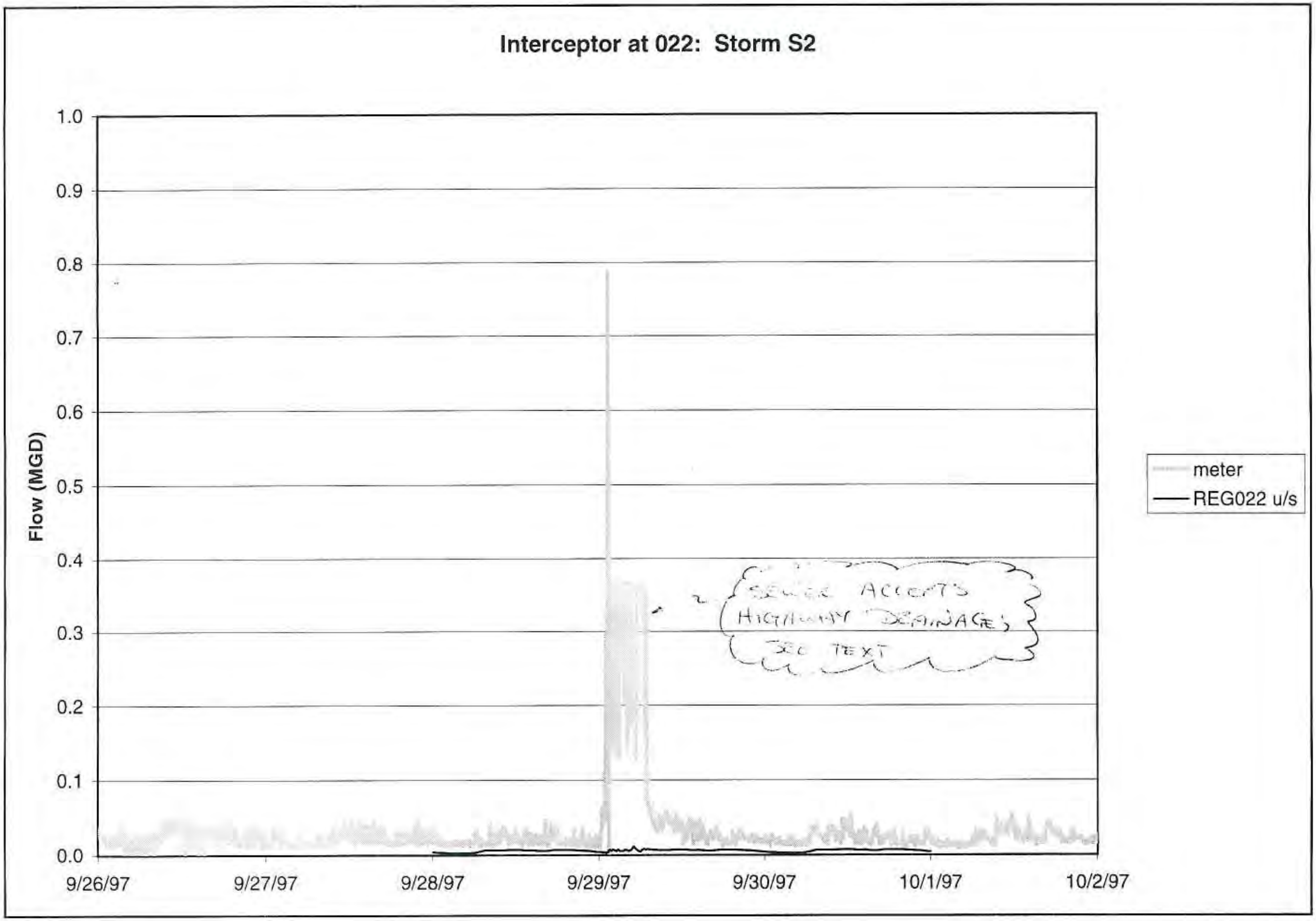
Overflow pipe at 009: Storm S2
Flow (MGD)
2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
9/26/97
9/27/97
9/28/97
9/29/97
9/30/97
10/1/97
10/2/97
calculated
OF009

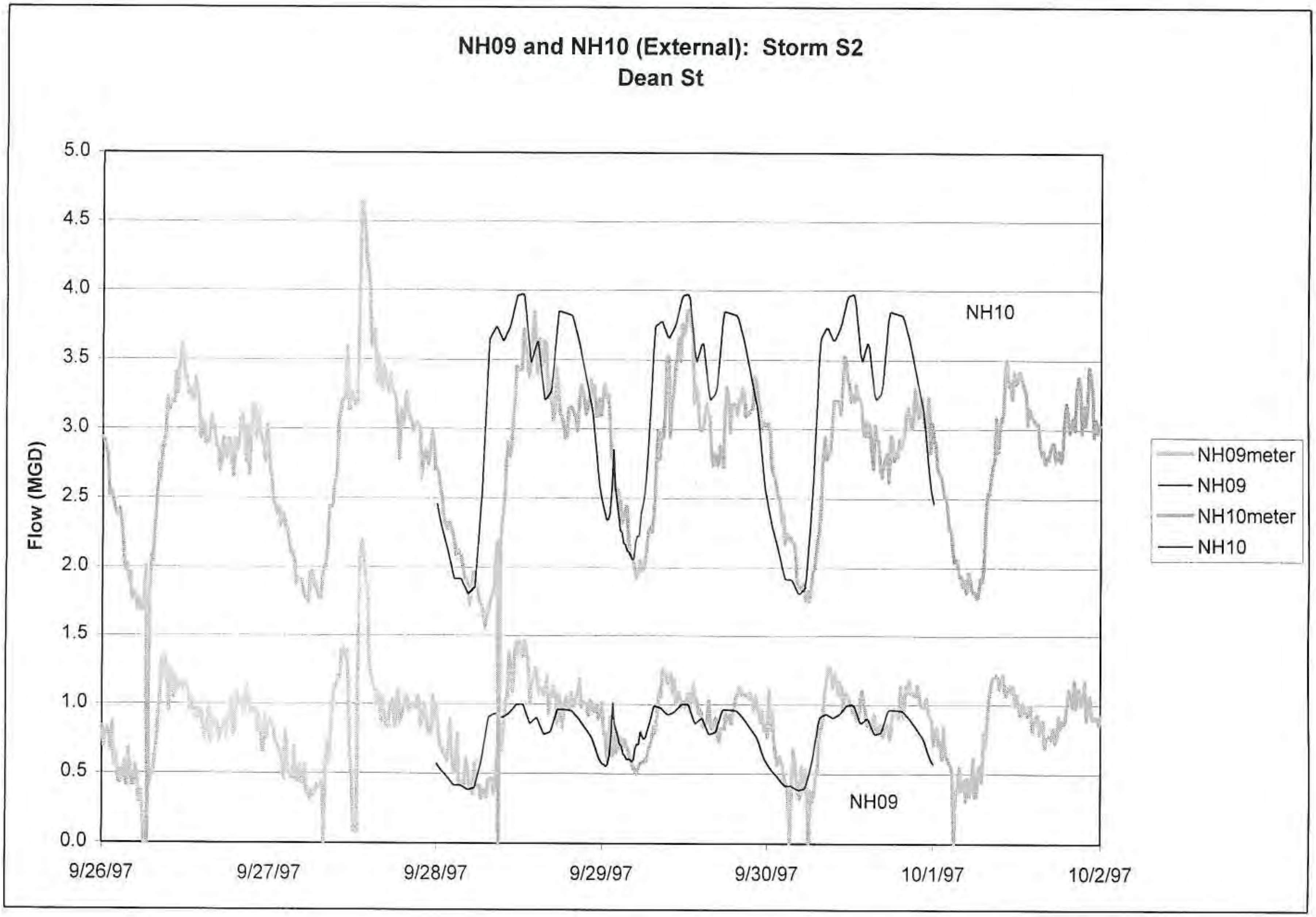


Interceptor at 020: Storm S2
(pump station influence)
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
Flow (MGD)
9/26/97
9/27/97
9/28/97
9/29/97
9/30/97
10/1/97
10/2/97
meter
REG020 d/s


NH07 (External): Storm S2
Eastern St
Flow (MGD)
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
9/26/97
9/27/97
9/28/97
9/29/97
9/30/97
10/1/97
10/2/97
NH07meter
NH07


NH06 (External): Storm S2
Old Foxon Road
Flow (MGD)
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
9/26/97
9/27/97
9/28/97
9/29/97
9/30/97
10/1/97
10/2/97
NH06meter
NH06

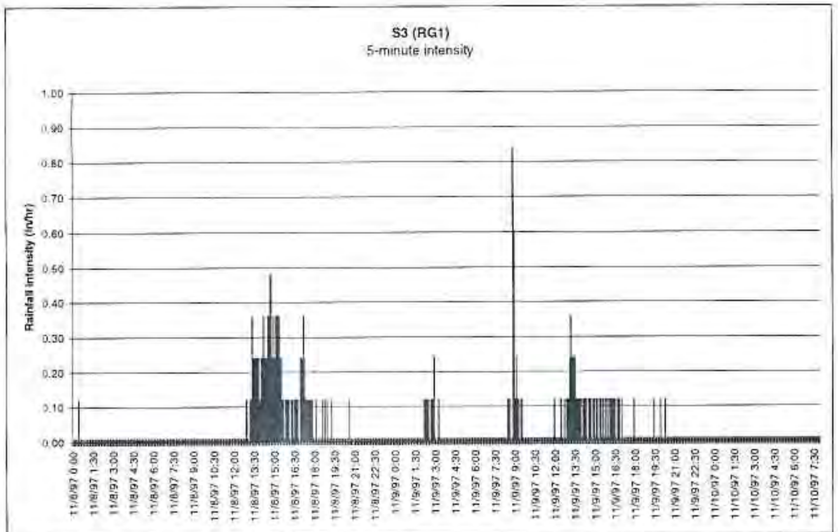

Interceptor at 022: Storm S2
Flow (MGD)
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
9/26/97
9/27/97
9/28/97
9/29/97
9/30/97
10/1/97
10/2/97
meter
REG022 u/s
SEWER ACCEPTS HIGHWAY DRAINAGE; SEE TEXT

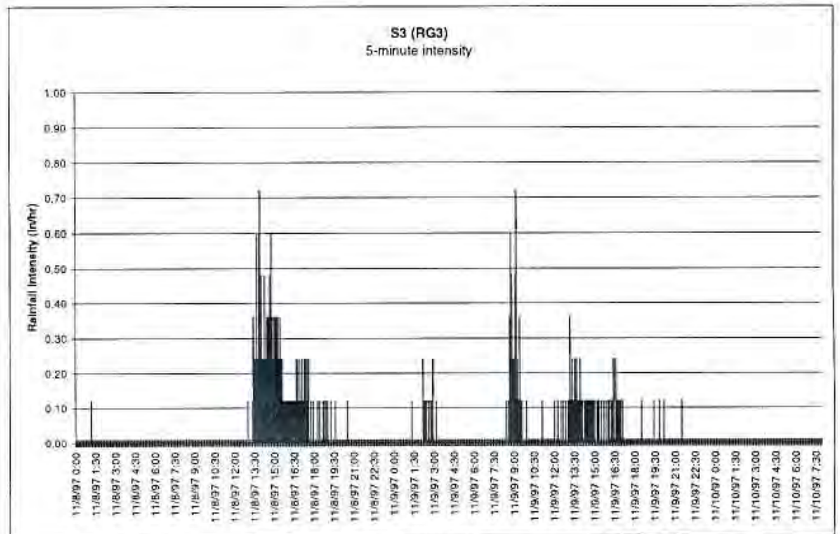


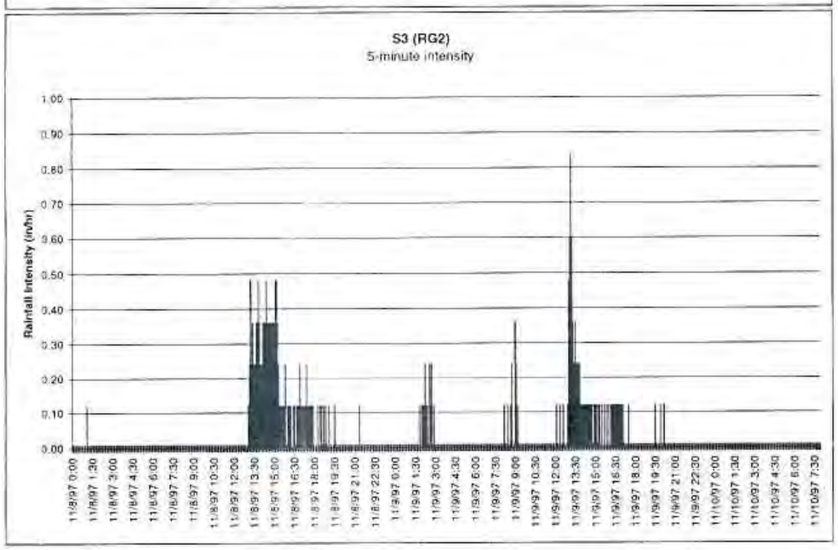
NH09 and NH10 (External): Storm S2
Dean St
Flow (MGD)
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
9/26/97
9/27/97
9/28/97
9/29/97
9/30/97
10/1/97
10/2/97
NH10
NH09
NH09meter
NH09
NH10meter
NH10

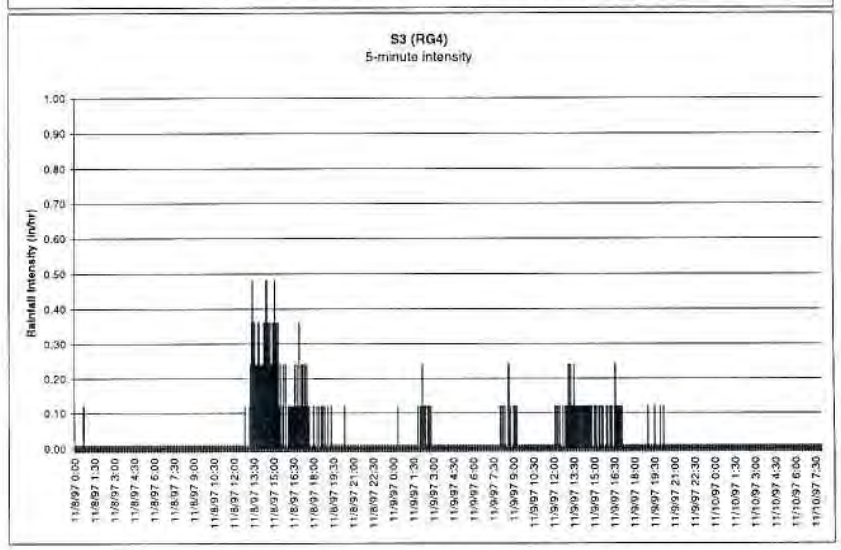
Storm S3

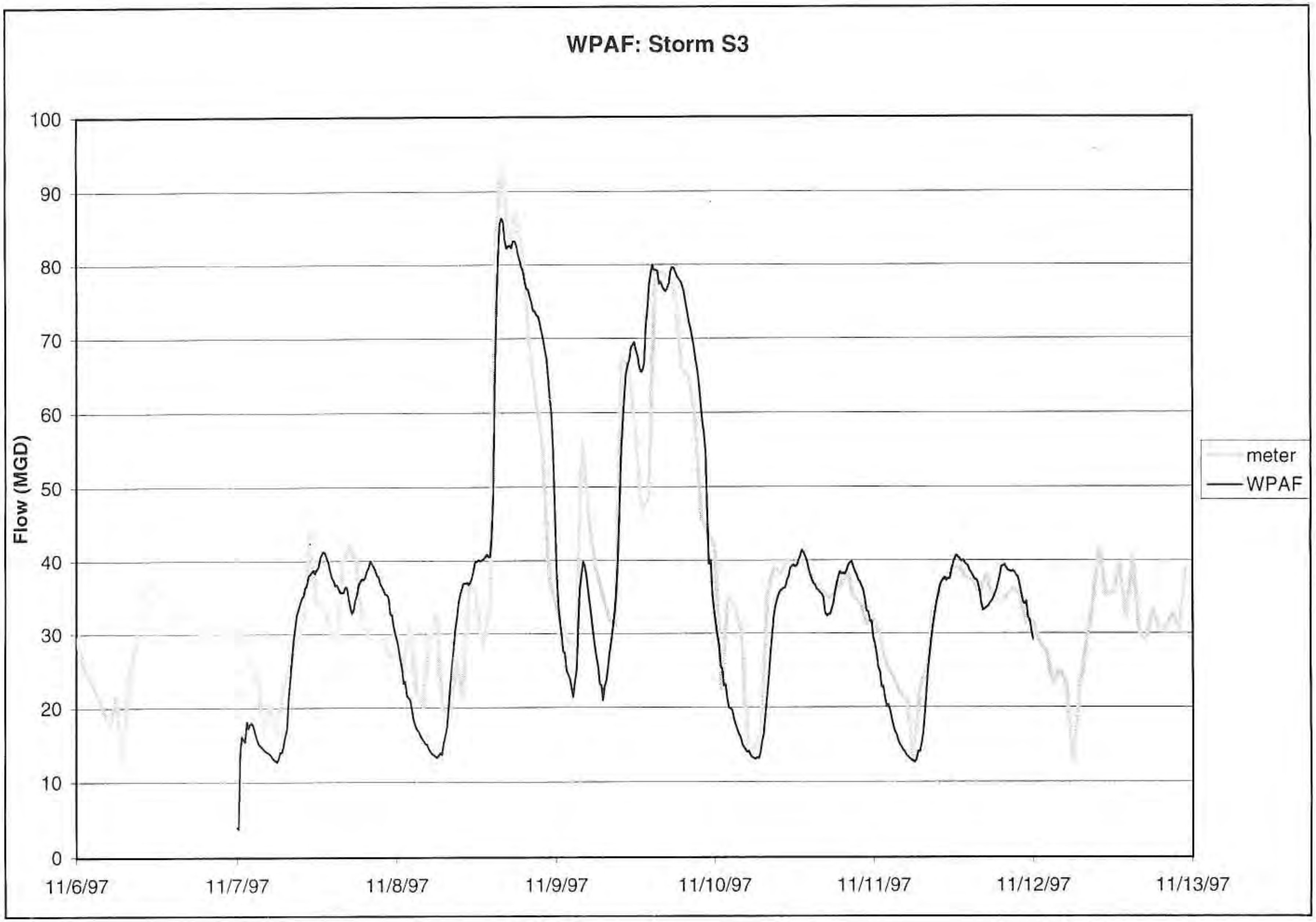
# Rainfall: Storm S3



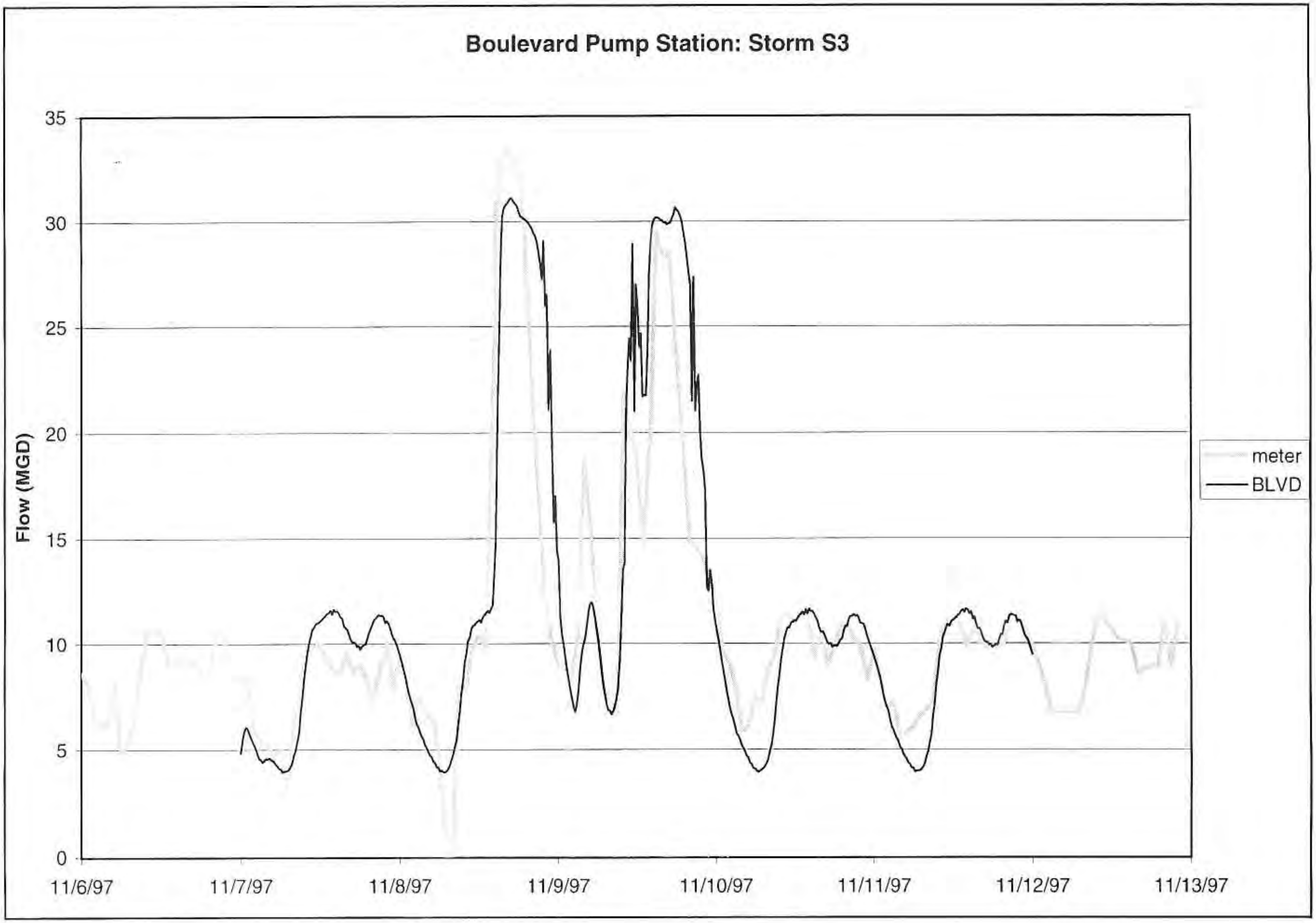



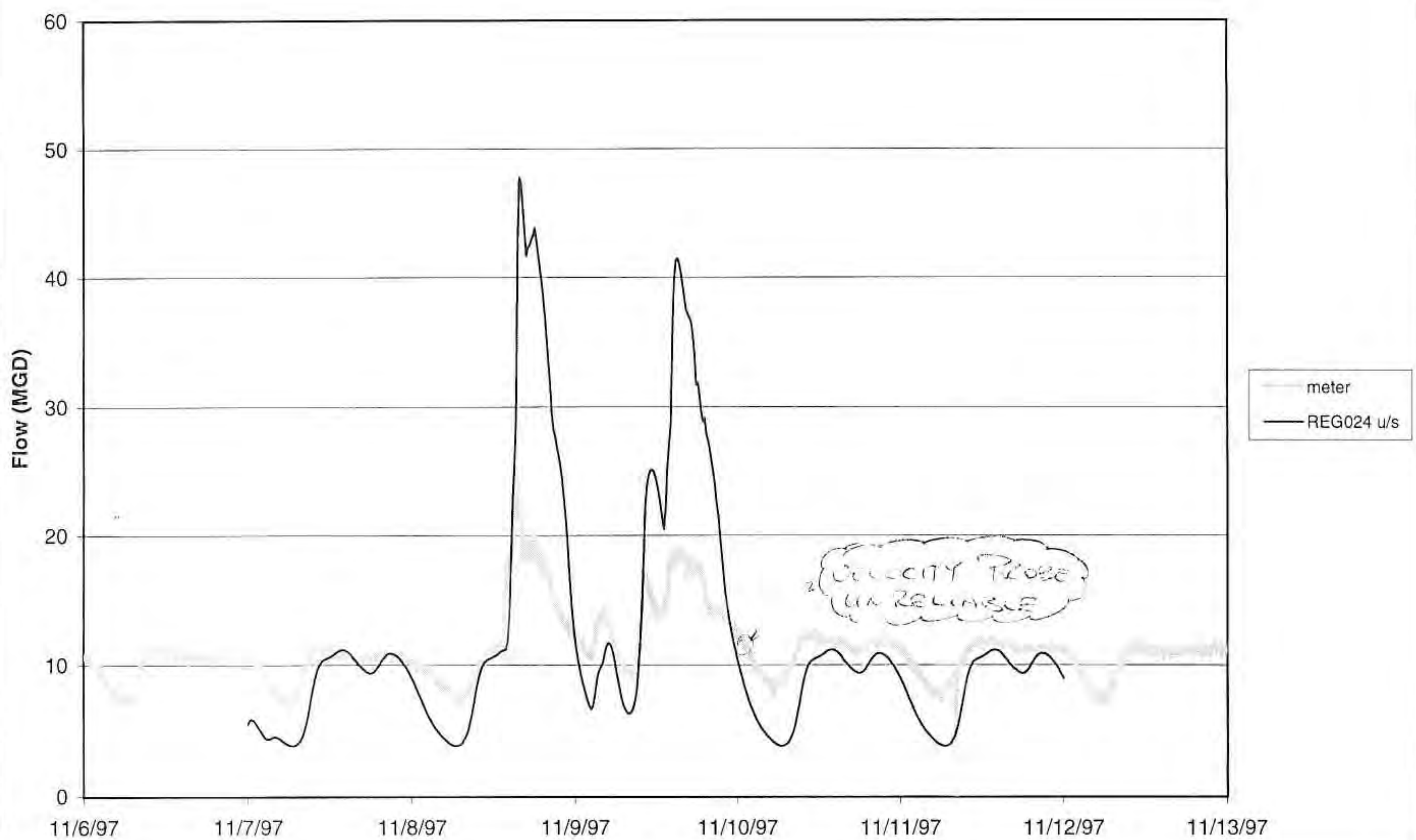


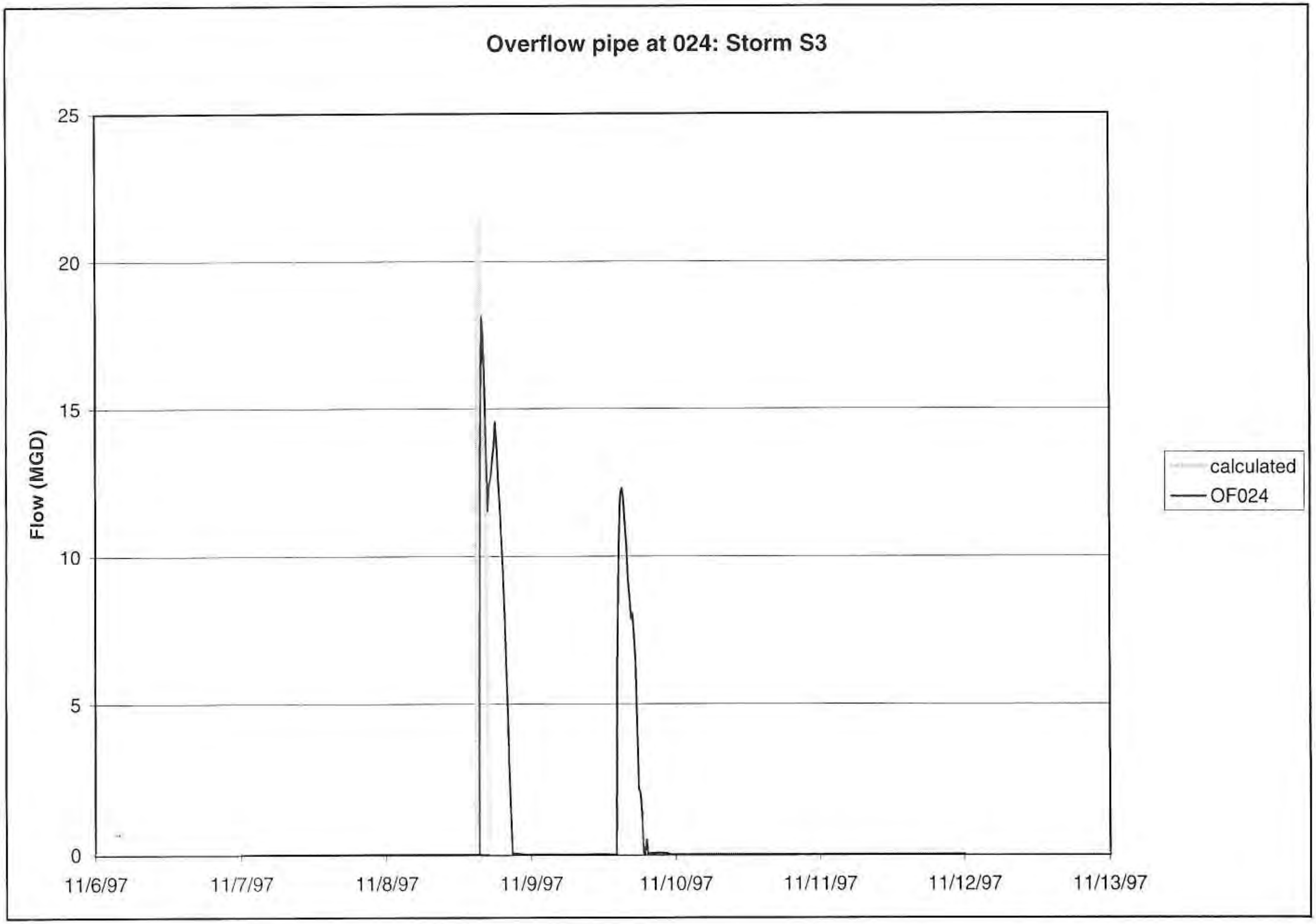
WPAF: Storm S3
Flow (MGD)
100
90
80
70
60
50
40
30
20
10
0
11/6/97
11/7/97
11/8/97
11/9/97
11/10/97
11/11/97
11/12/97
11/13/97
meter
WPAF

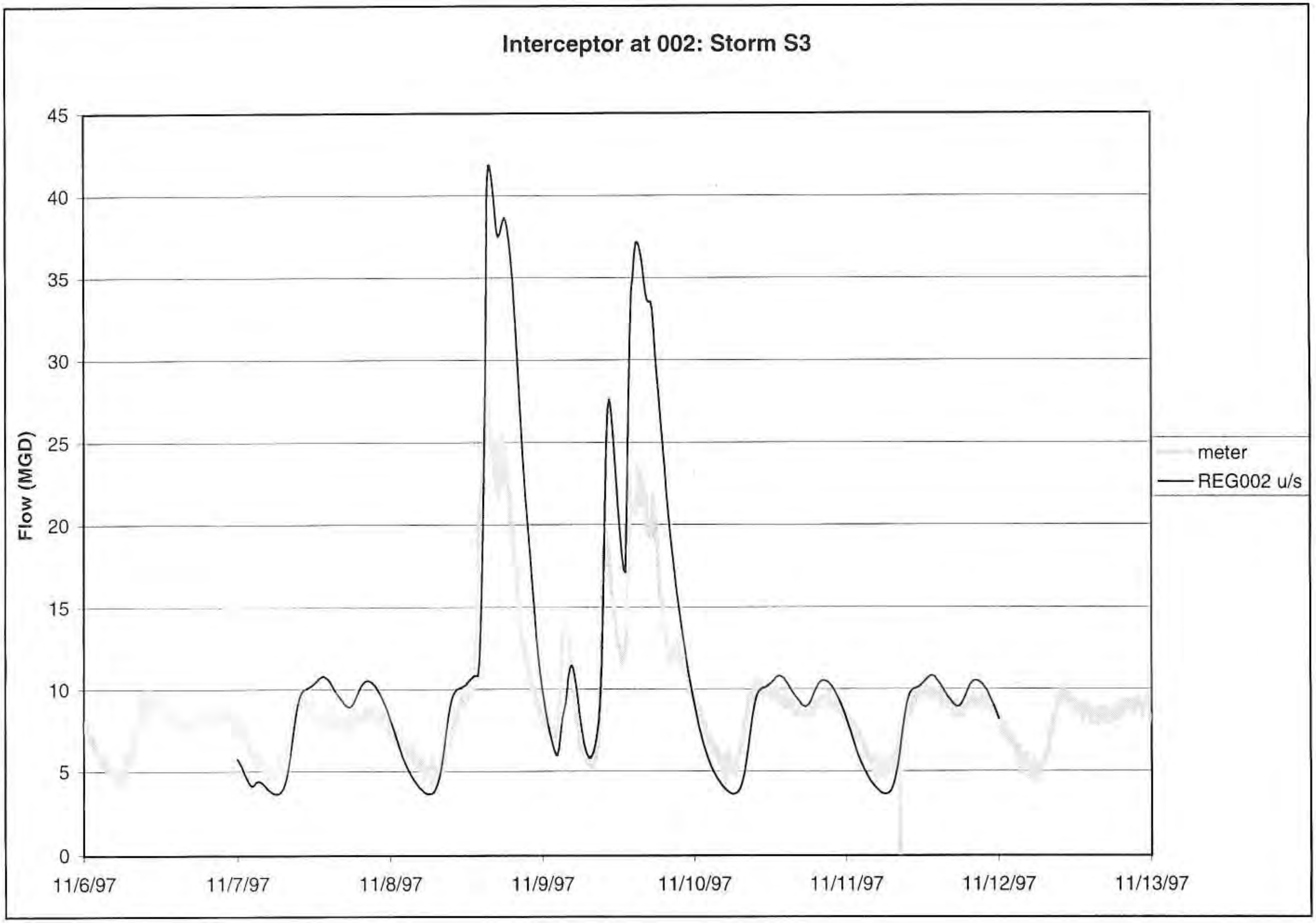


Boulevard Pump Station: Storm S3
Flow (MGD)
35
30
25
20
15
10
5
0
11/6/97
11/7/97
11/8/97
11/9/97
11/10/97
11/11/97
11/12/97
11/13/97
meter
BLVD

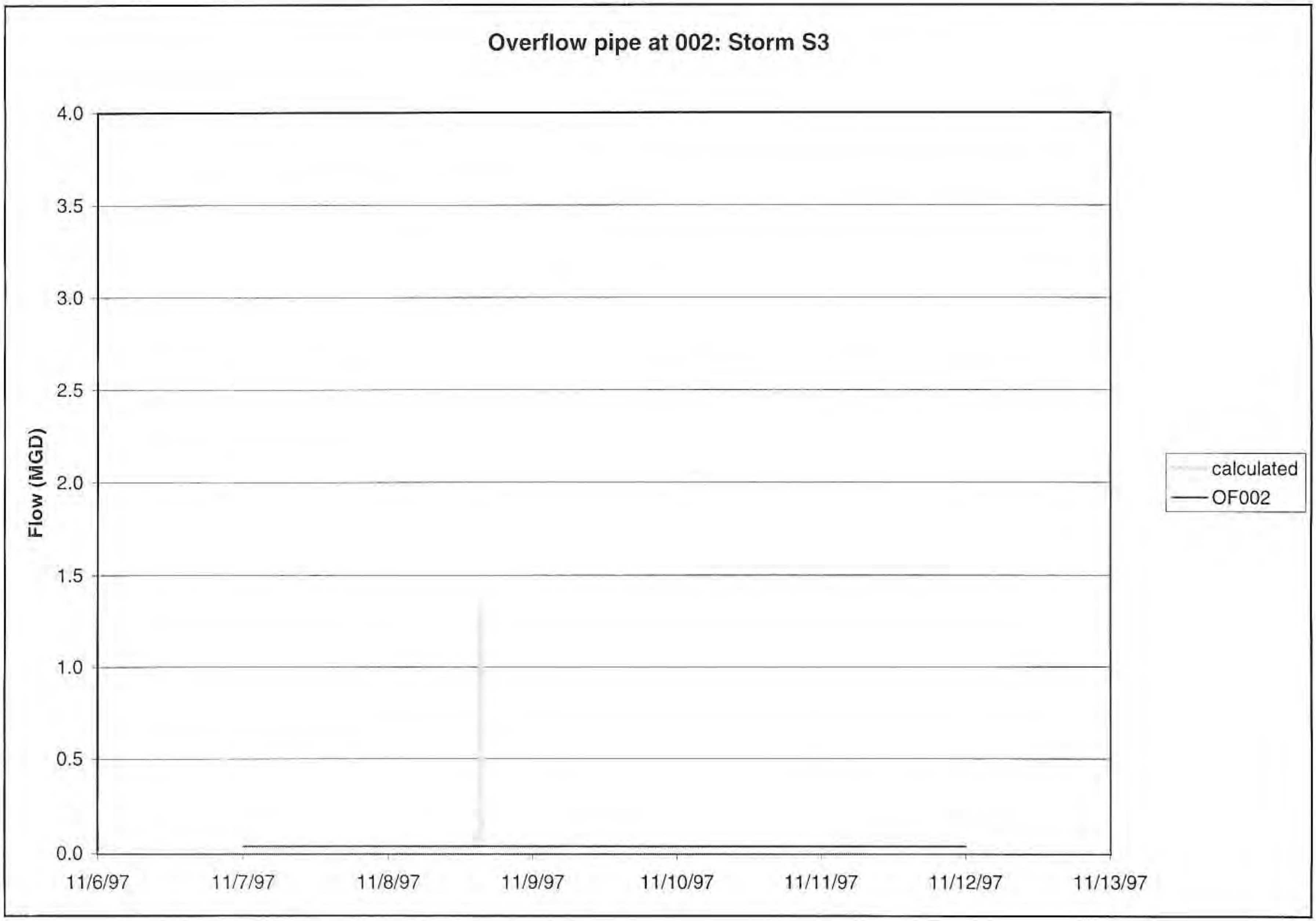
## Interceptor at 024: Storm S3
## (diversion chamber for Boulevard Pump Station)

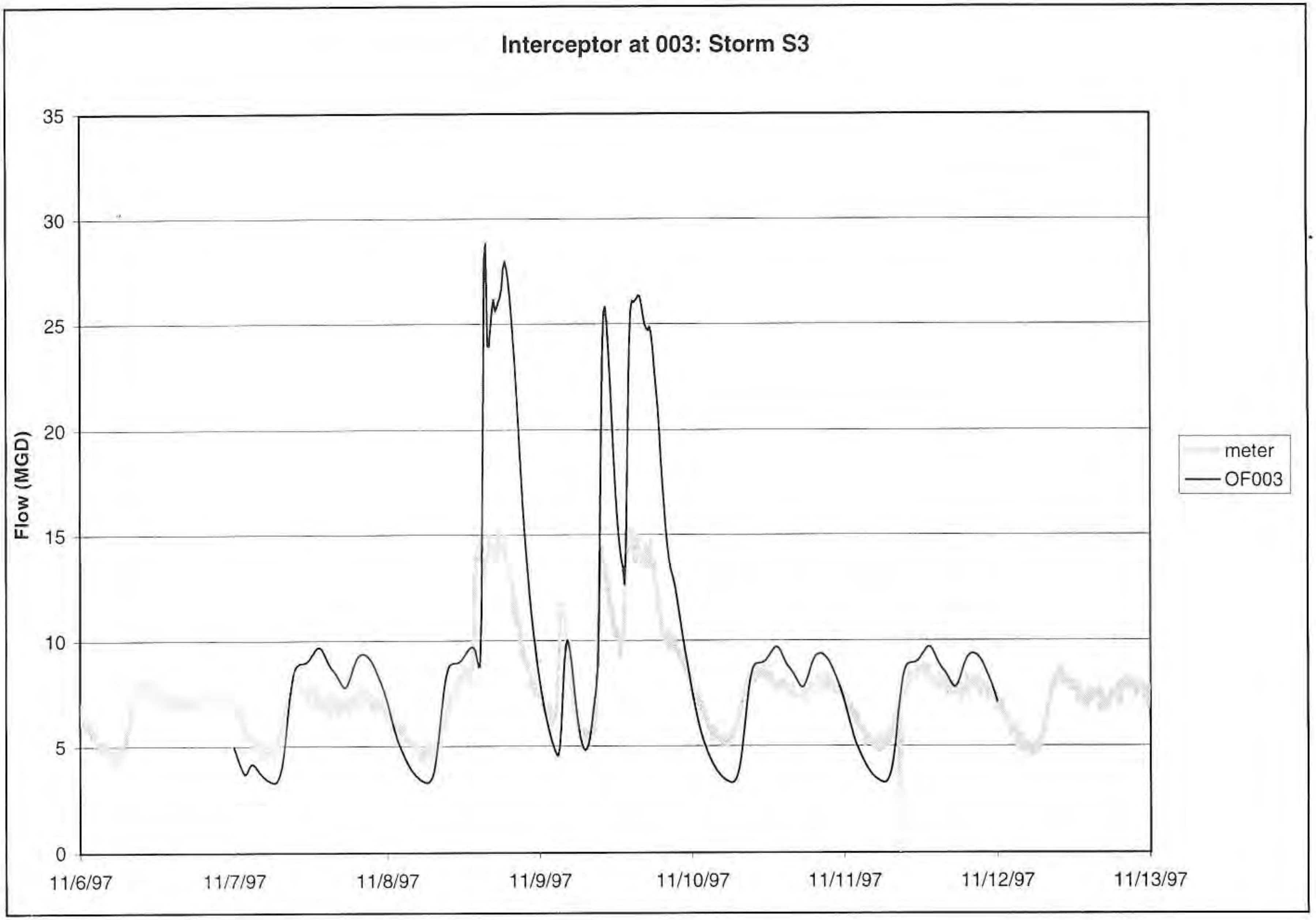


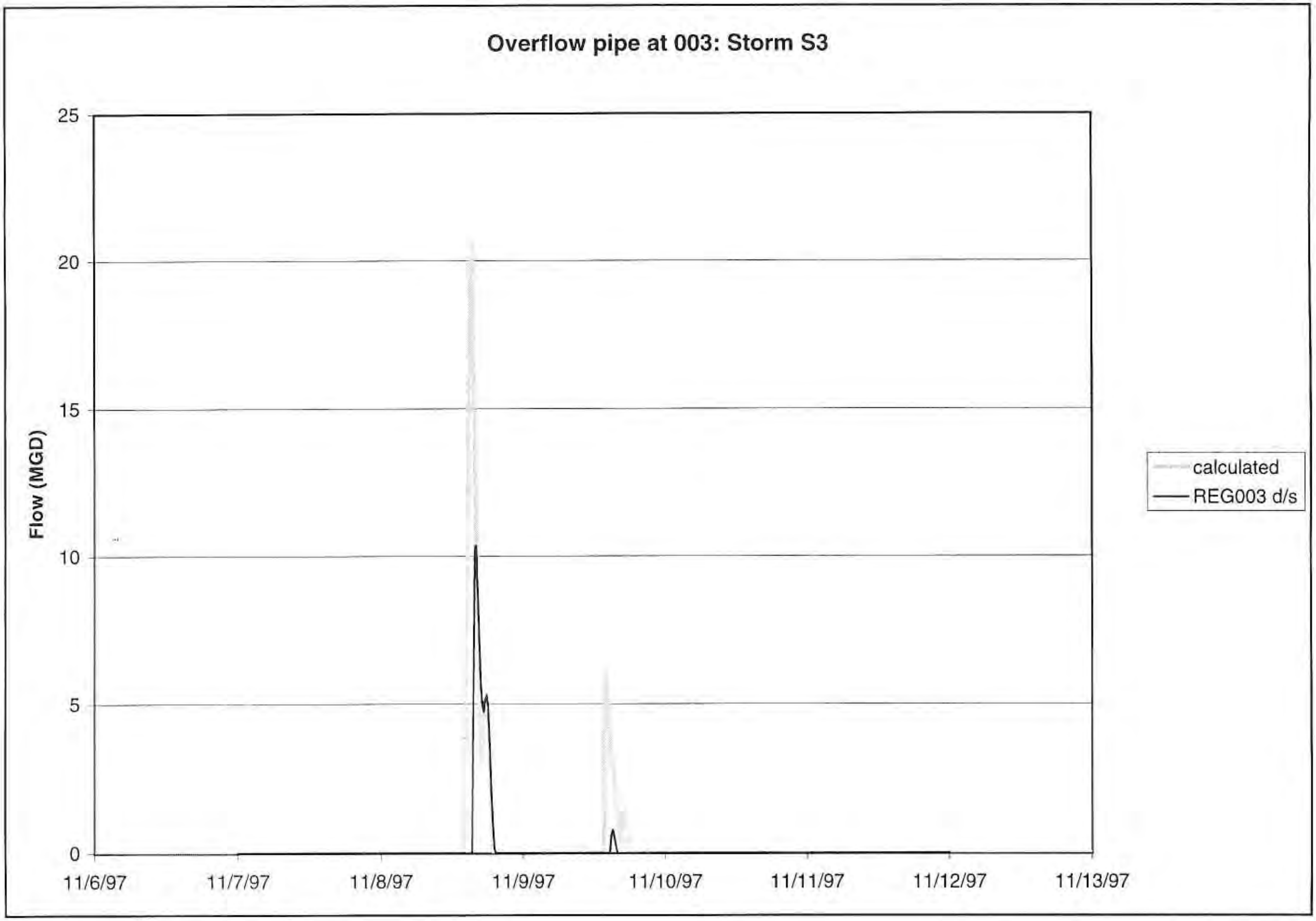

Overflow pipe at 024: Storm S3
Flow (MGD)
25
20
15
10
5
0
11/6/97
11/7/97
11/8/97
11/9/97
11/10/97
11/11/97
11/12/97
11/13/97
calculated
OF024



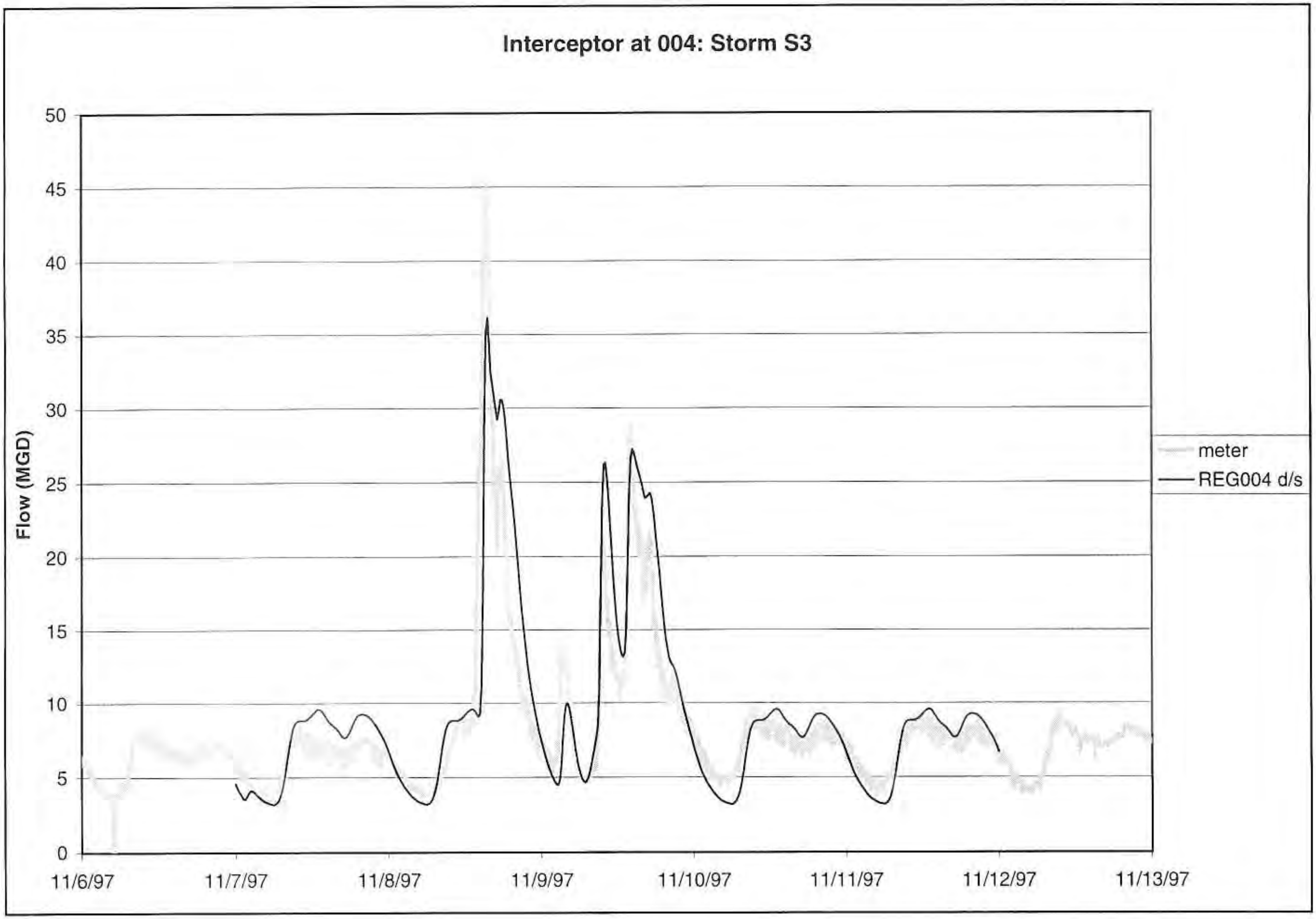
Interceptor at 002: Storm S3
Flow (MGD)
45
40
35
30
25
20
15
10
5
0
11/6/97
11/7/97
11/8/97
11/9/97
11/10/97
11/11/97
11/12/97
11/13/97
meter
REG002 u/s


Overflow pipe at 002: Storm S3
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
Flow (MGD)
11/6/97
11/7/97
11/8/97
11/9/97
11/10/97
11/11/97
11/12/97
11/13/97
calculated
OF002

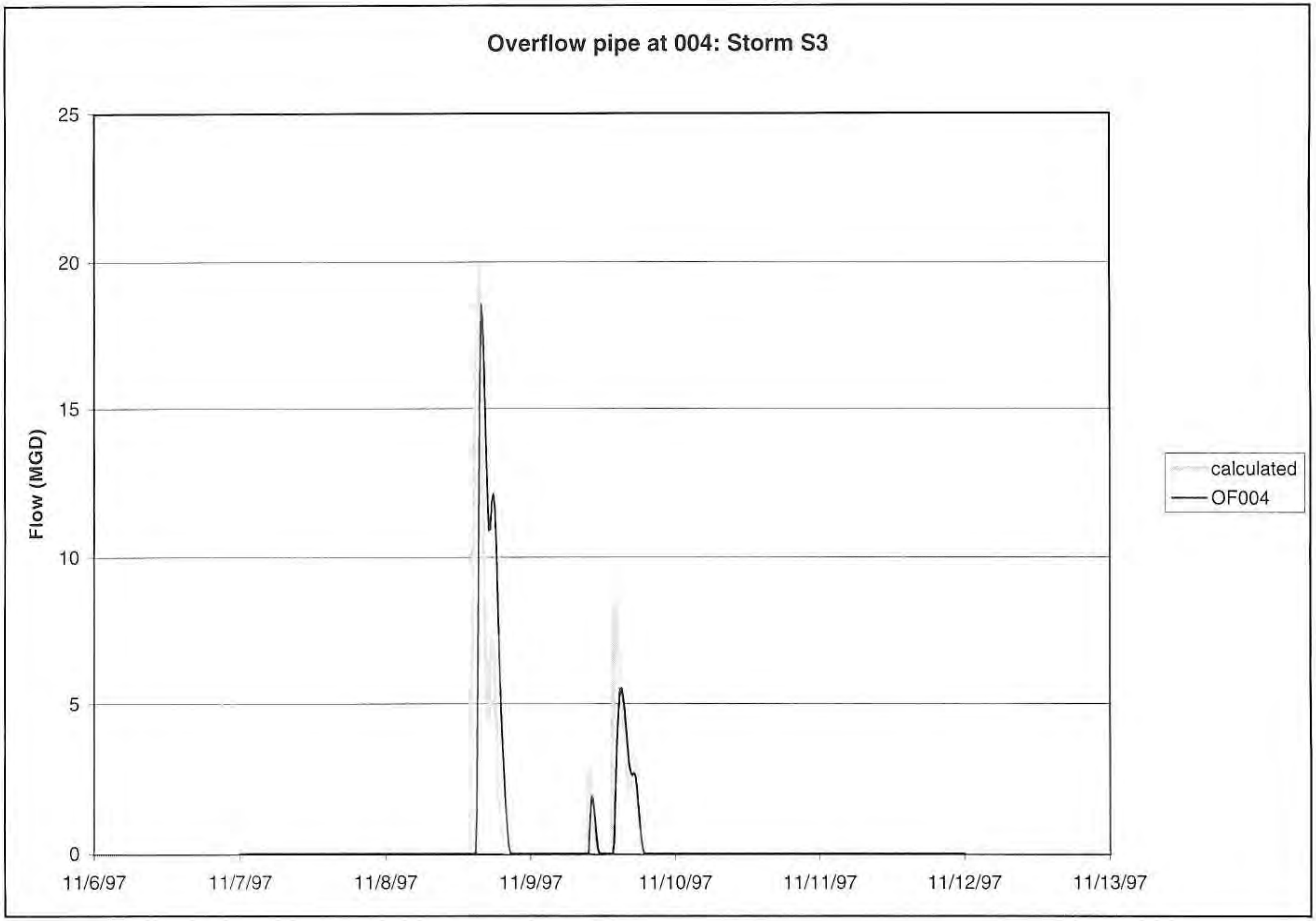

Interceptor at 003: Storm S3
Flow (MGD)
35
30
25
20
15
10
5
0
11/6/97
11/7/97
11/8/97
11/9/97
11/10/97
11/11/97
11/12/97
11/13/97
meter
OF003

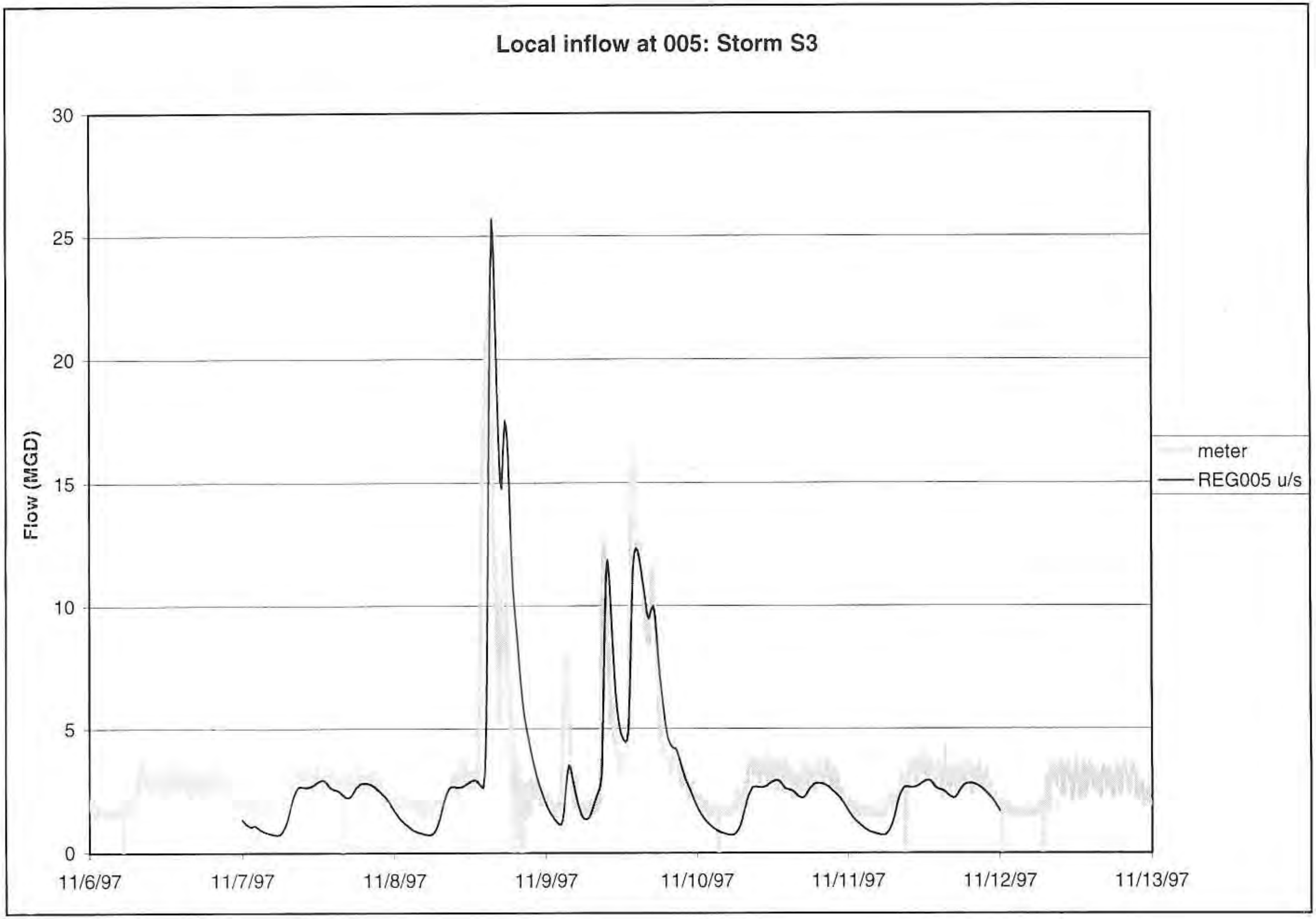


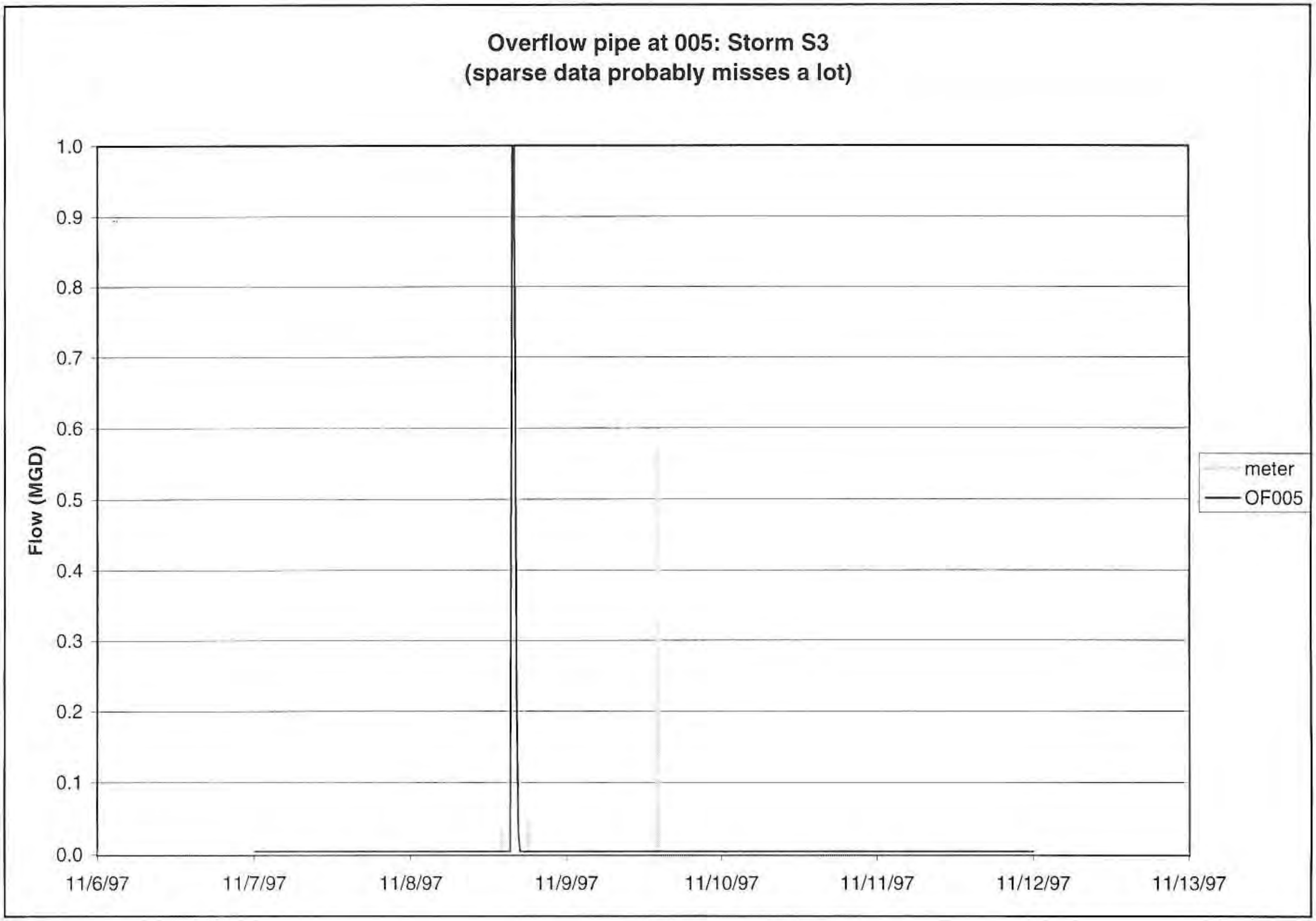
Overflow pipe at 003: Storm S3
25
20
15
10
5
0
Flow (MGD)
11/6/97
11/7/97
11/8/97
11/9/97
11/10/97
11/11/97
11/12/97
11/13/97
calculated
REG003 d/s

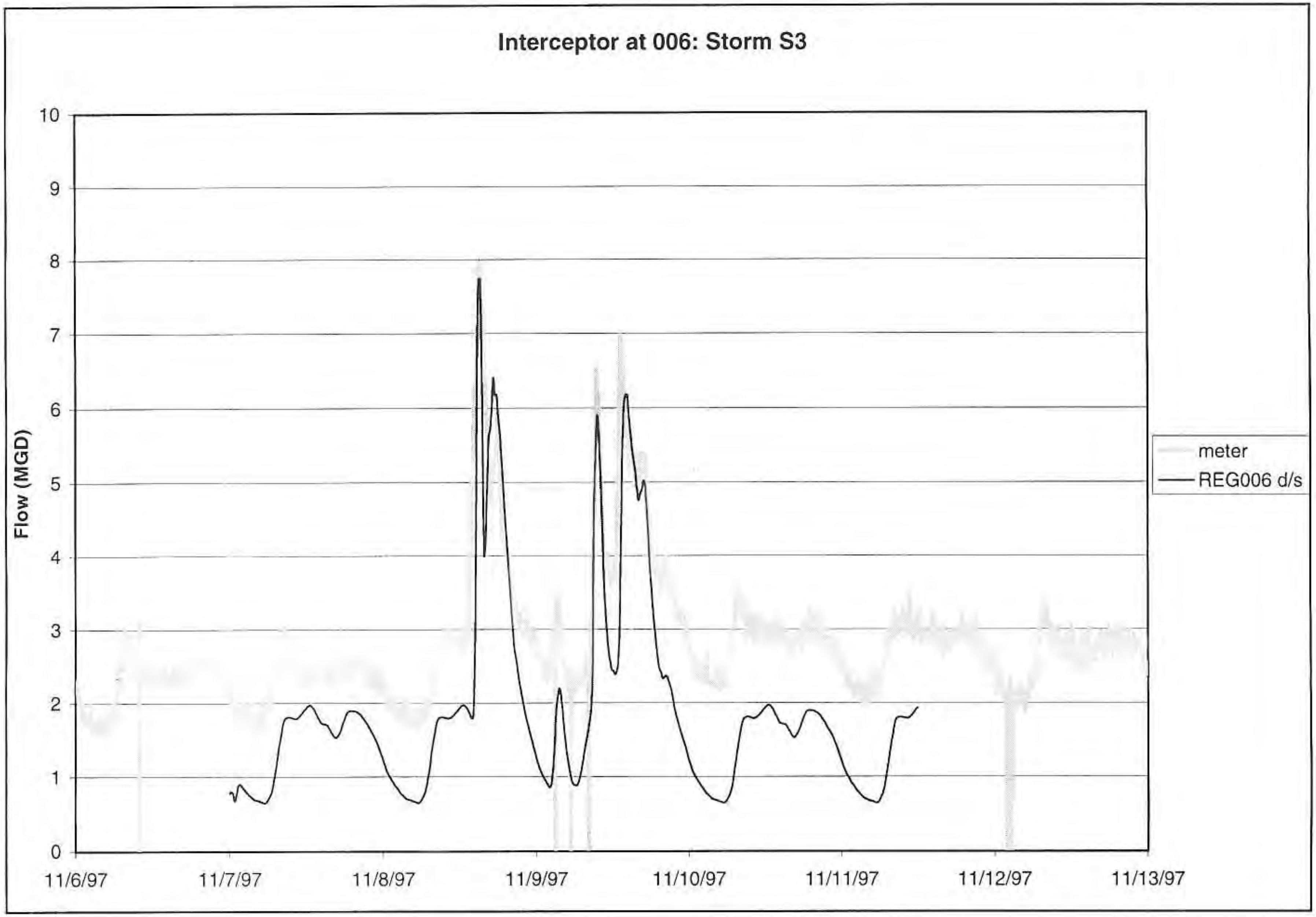


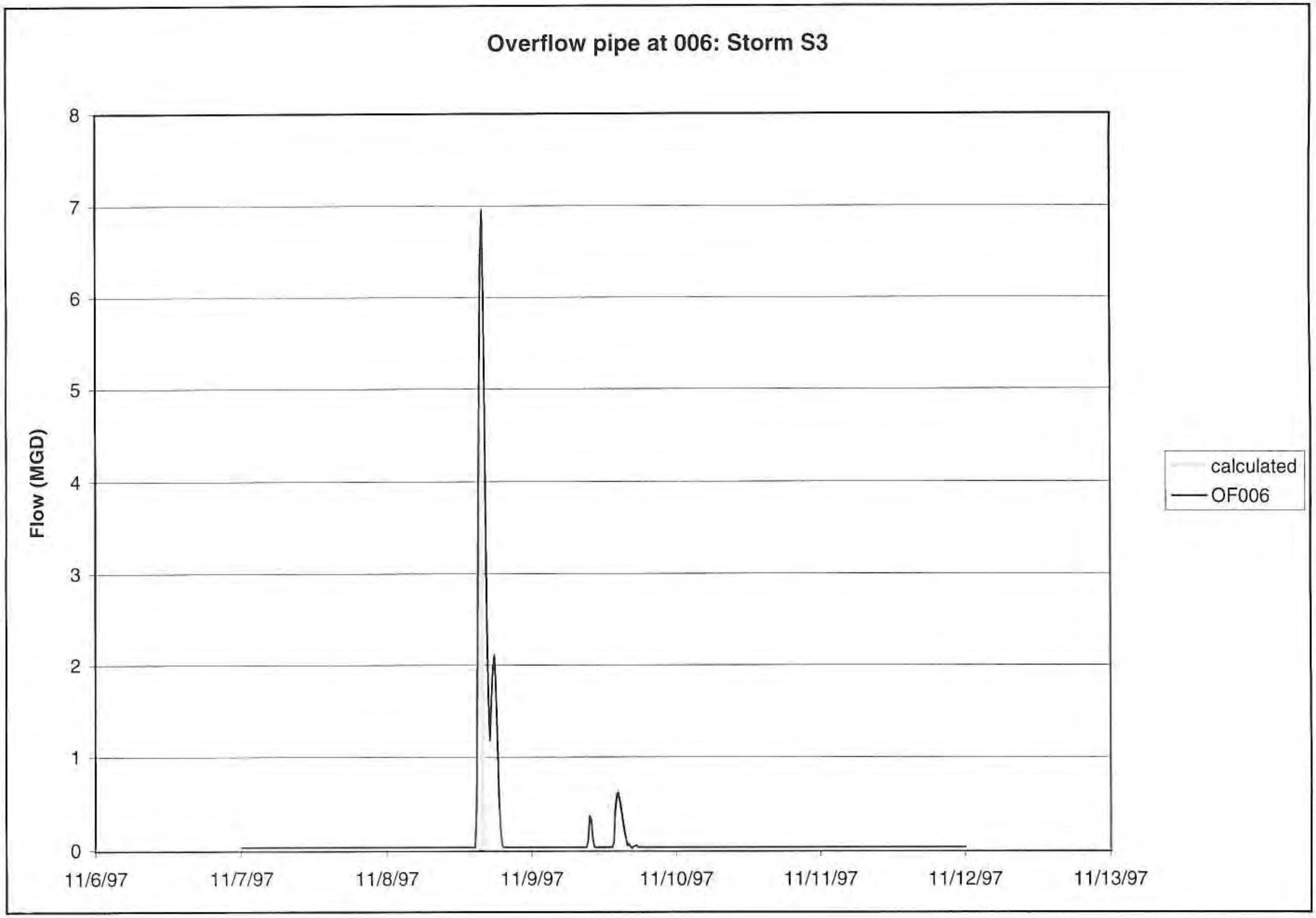
Interceptor at 004: Storm S3
Flow (MGD)
50
45
40
35
30
25
20
15
10
5
0
11/6/97
11/7/97
11/8/97
11/9/97
11/10/97
11/11/97
11/12/97
11/13/97
meter
REG004 d/s


Overflow pipe at 004: Storm S3
Flow (MGD)
25
20
15
10
5
0
11/6/97
11/7/97
11/8/97
11/9/97
11/10/97
11/11/97
11/12/97
11/13/97
calculated
OF004

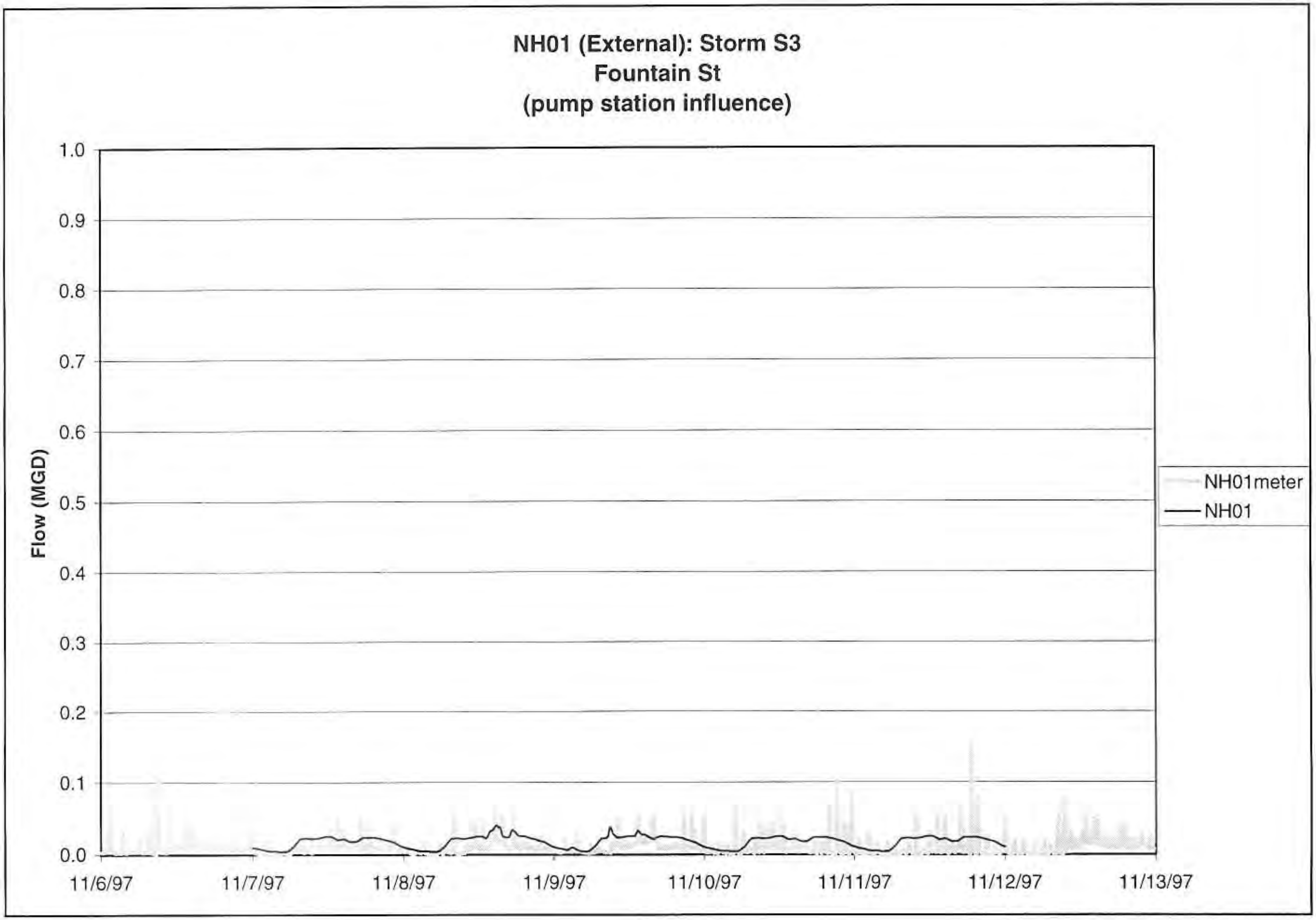

Local inflow at 005: Storm S3
Flow (MGD)
30
25
20
15
10
5
0
11/6/97
11/7/97
11/8/97
11/9/97
11/10/97
11/11/97
11/12/97
11/13/97
meter
REG005 u/s

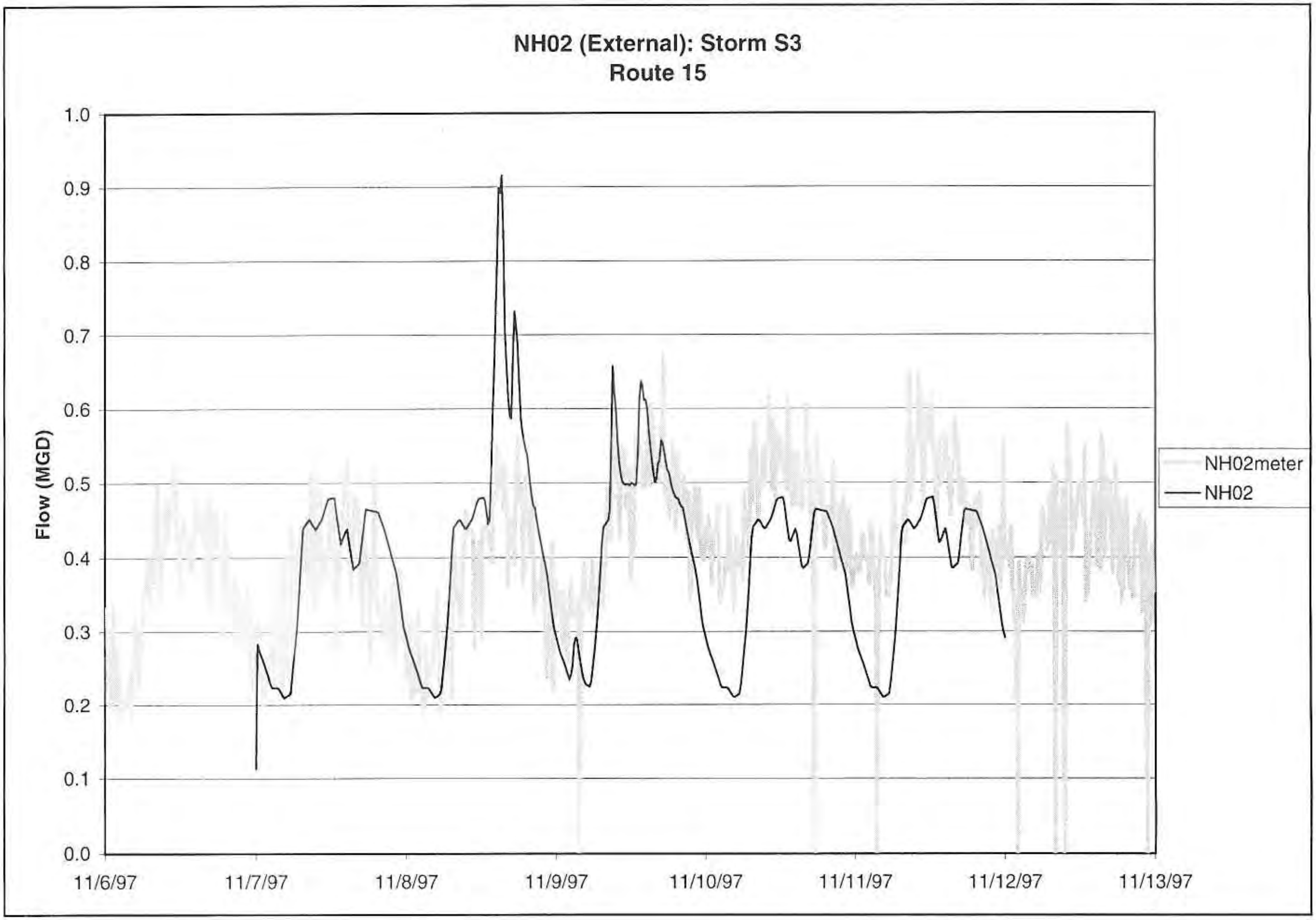

Overflow pipe at 005: Storm S3
(sparse data probably misses a lot)
Flow (MGD)
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
11/6/97
11/7/97
11/8/97
11/9/97
11/10/97
11/11/97
11/12/97
11/13/97
meter
OF005

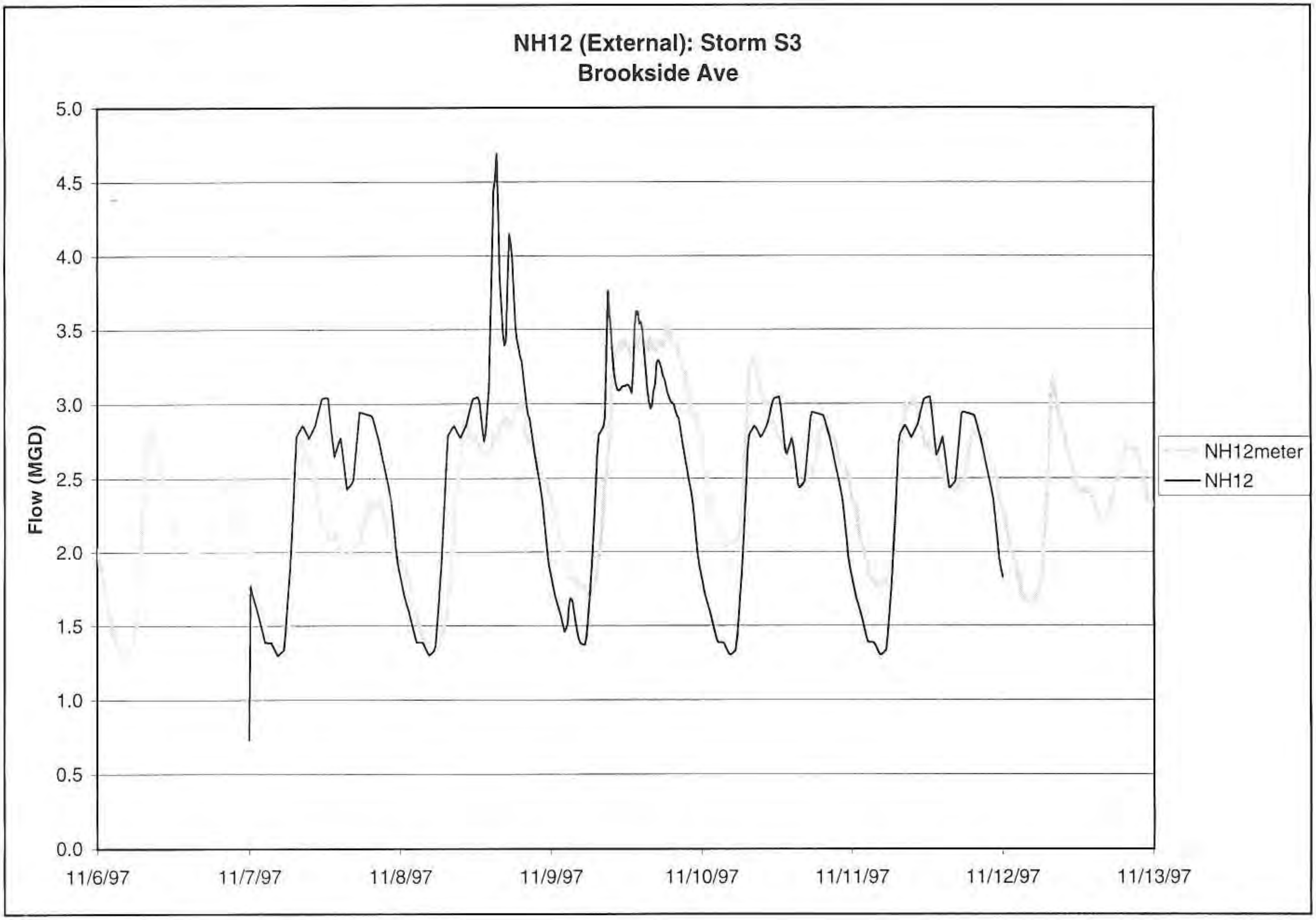

Interceptor at 006: Storm S3
Flow (MGD)
10
9
8
7
6
5
4
3
2
1
0
11/6/97
11/7/97
11/8/97
11/9/97
11/10/97
11/11/97
11/12/97
11/13/97
meter
REG006 d/s



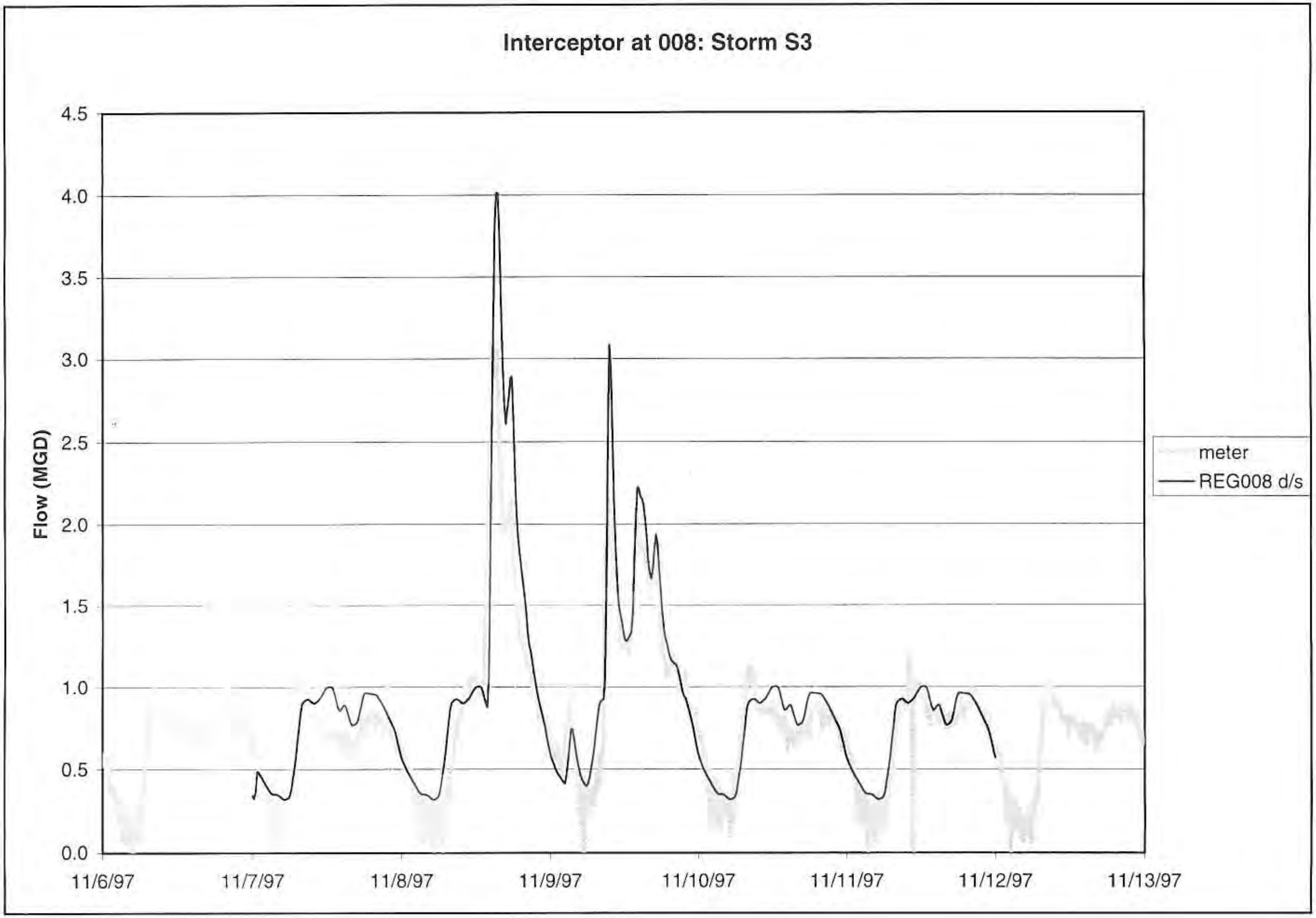
Overflow pipe at 006: Storm S3
Flow (MGD)
8
7
6
5
4
3
2
1
0
11/6/97
11/7/97
11/8/97
11/9/97
11/10/97
11/11/97
11/12/97
11/13/97
calculated
OF006


NH01 (External): Storm S3
Fountain St
(pump station influence)
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
Flow (MGD)
11/6/97
11/7/97
11/8/97
11/9/97
11/10/97
11/11/97
11/12/97
11/13/97
NH01meter
NH01

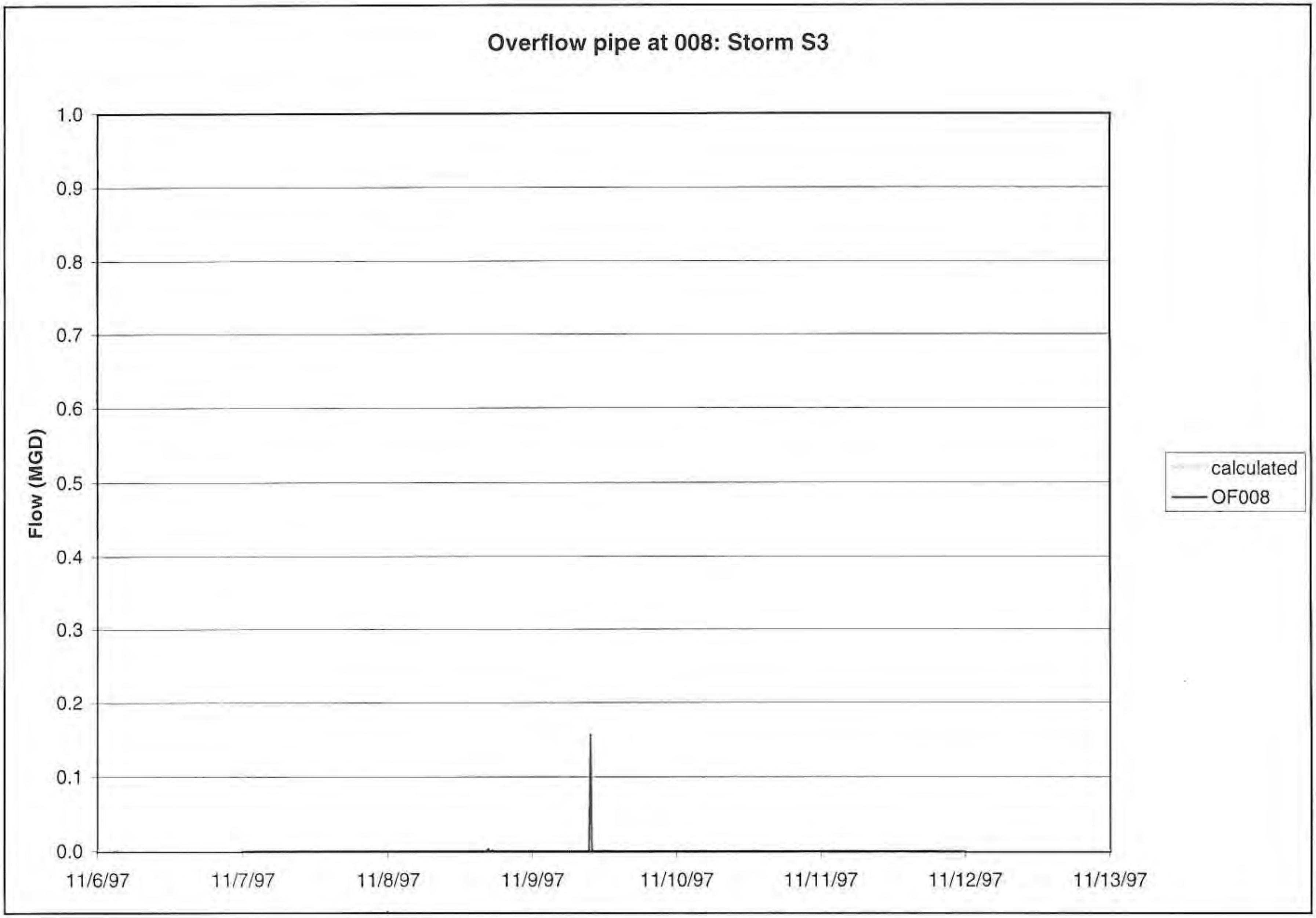

NH02 (External): Storm S3
Route 15
Flow (MGD)
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
11/6/97
11/7/97
11/8/97
11/9/97
11/10/97
11/11/97
11/12/97
11/13/97
NH02meter
NH02



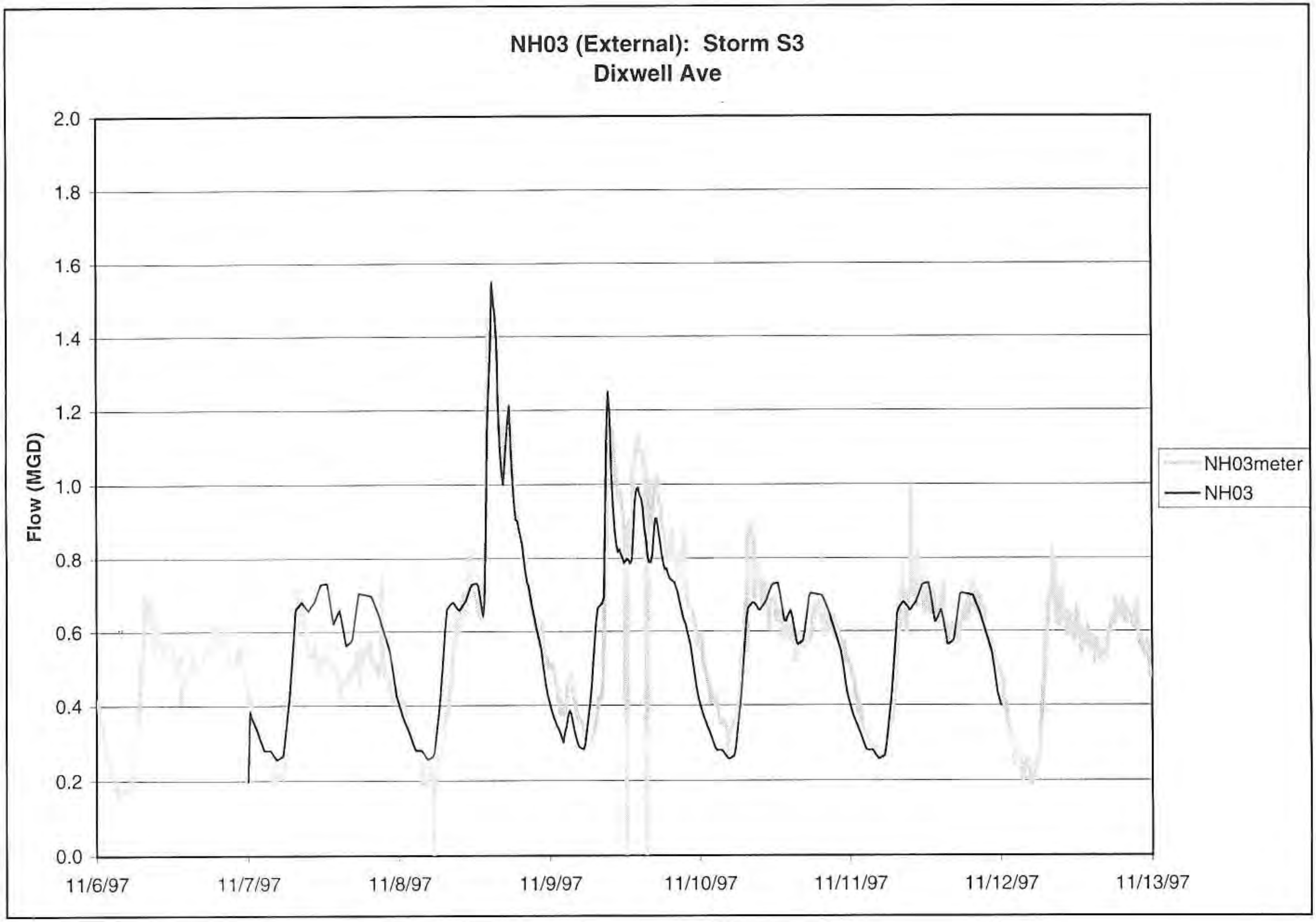
NH12 (External): Storm S3
Brookside Ave
Flow (MGD)
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
11/6/97
11/7/97
11/8/97
11/9/97
11/10/97
11/11/97
11/12/97
11/13/97
NH12meter
NH12

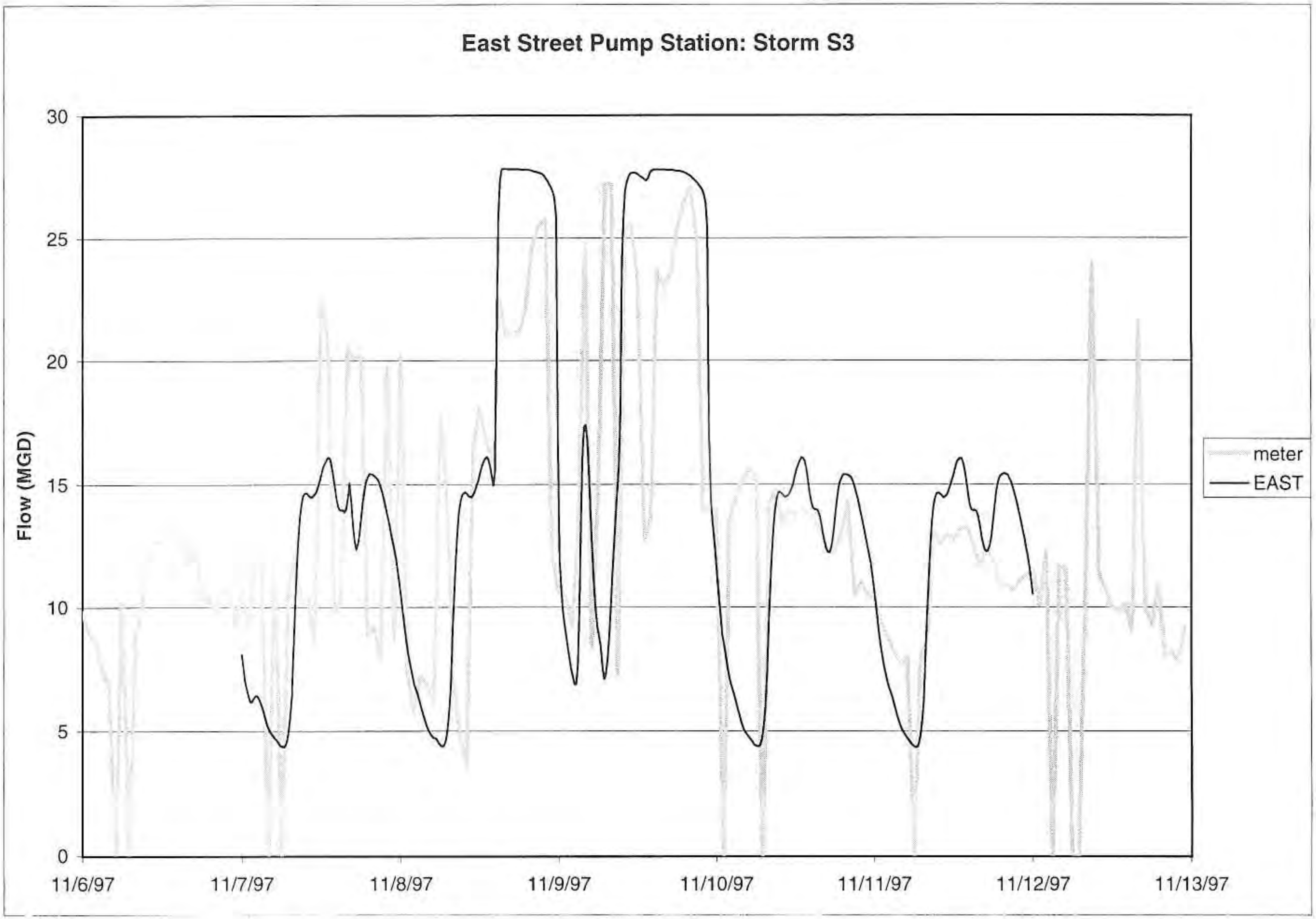


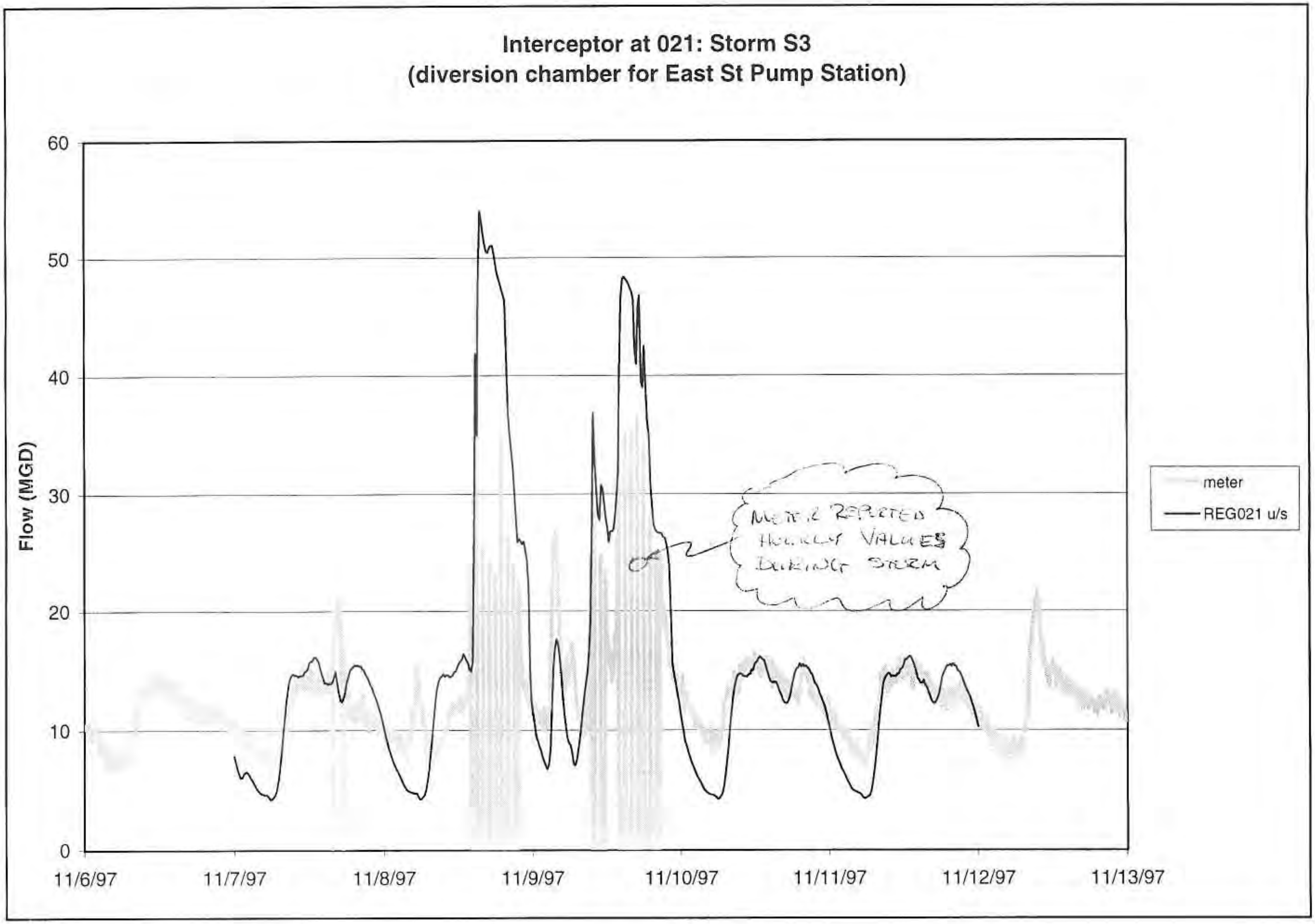
Interceptor at 008: Storm S3
Flow (MGD)
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
11/6/97
11/7/97
11/8/97
11/9/97
11/10/97
11/11/97
11/12/97
11/13/97
meter
REG008 d/s

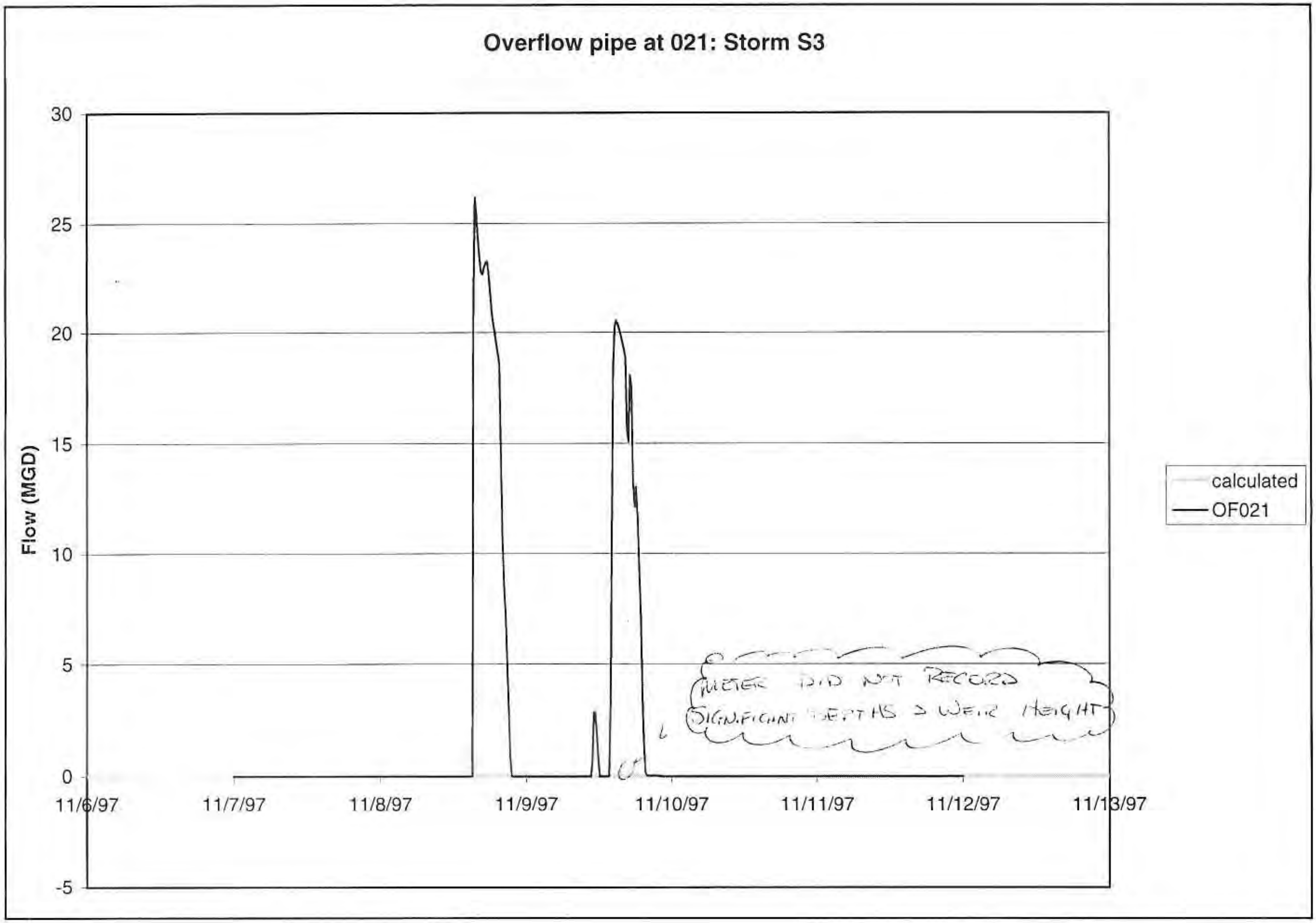


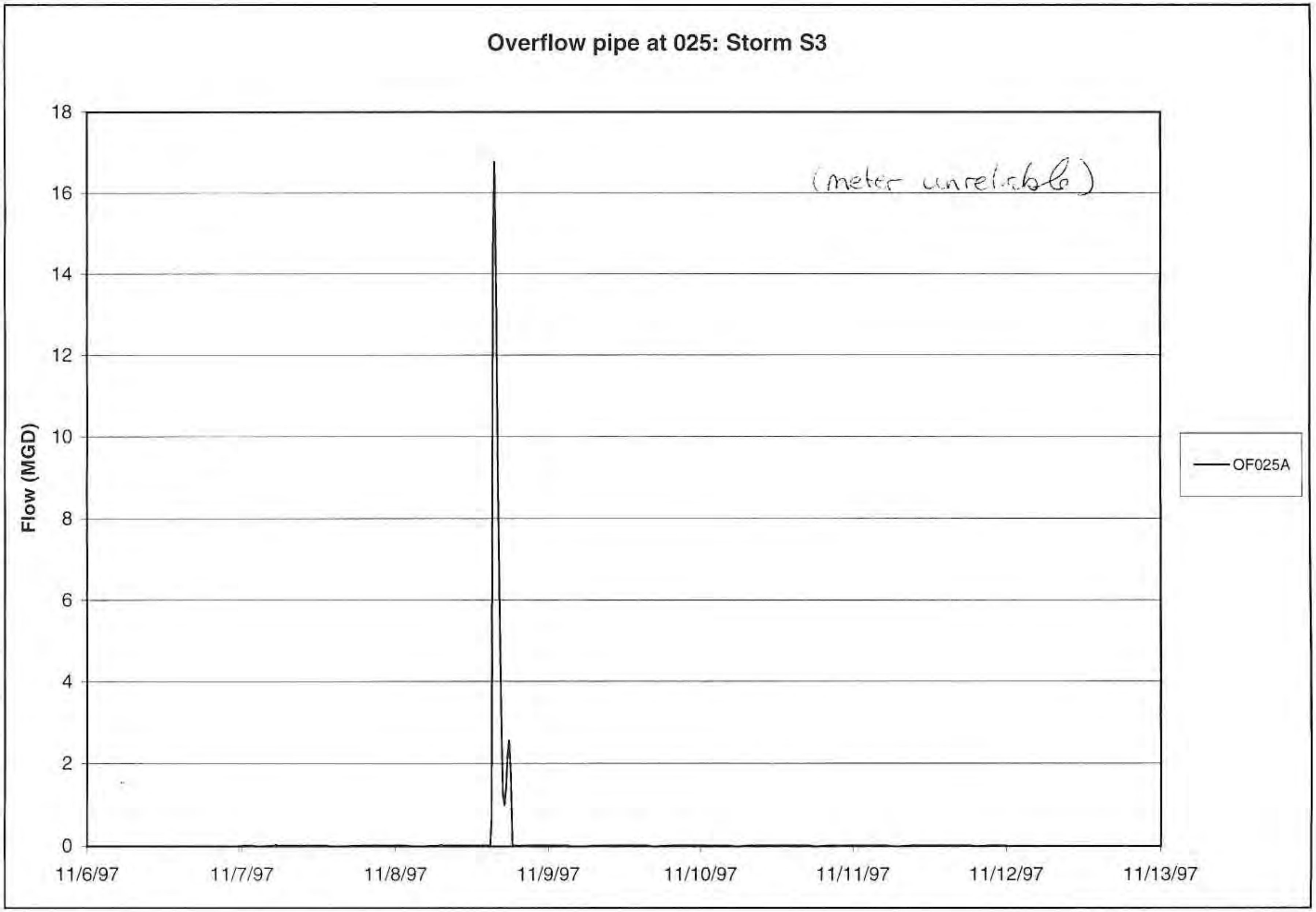
Overflow pipe at 008: Storm S3
Flow (MGD)
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
11/6/97
11/7/97
11/8/97
11/9/97
11/10/97
11/11/97
11/12/97
11/13/97
calculated
OF008


NH03 (External): Storm S3
Dixwell Ave
Flow (MGD)
2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
11/6/97
11/7/97
11/8/97
11/9/97
11/10/97
11/11/97
11/12/97
11/13/97
NH03meter
NH03

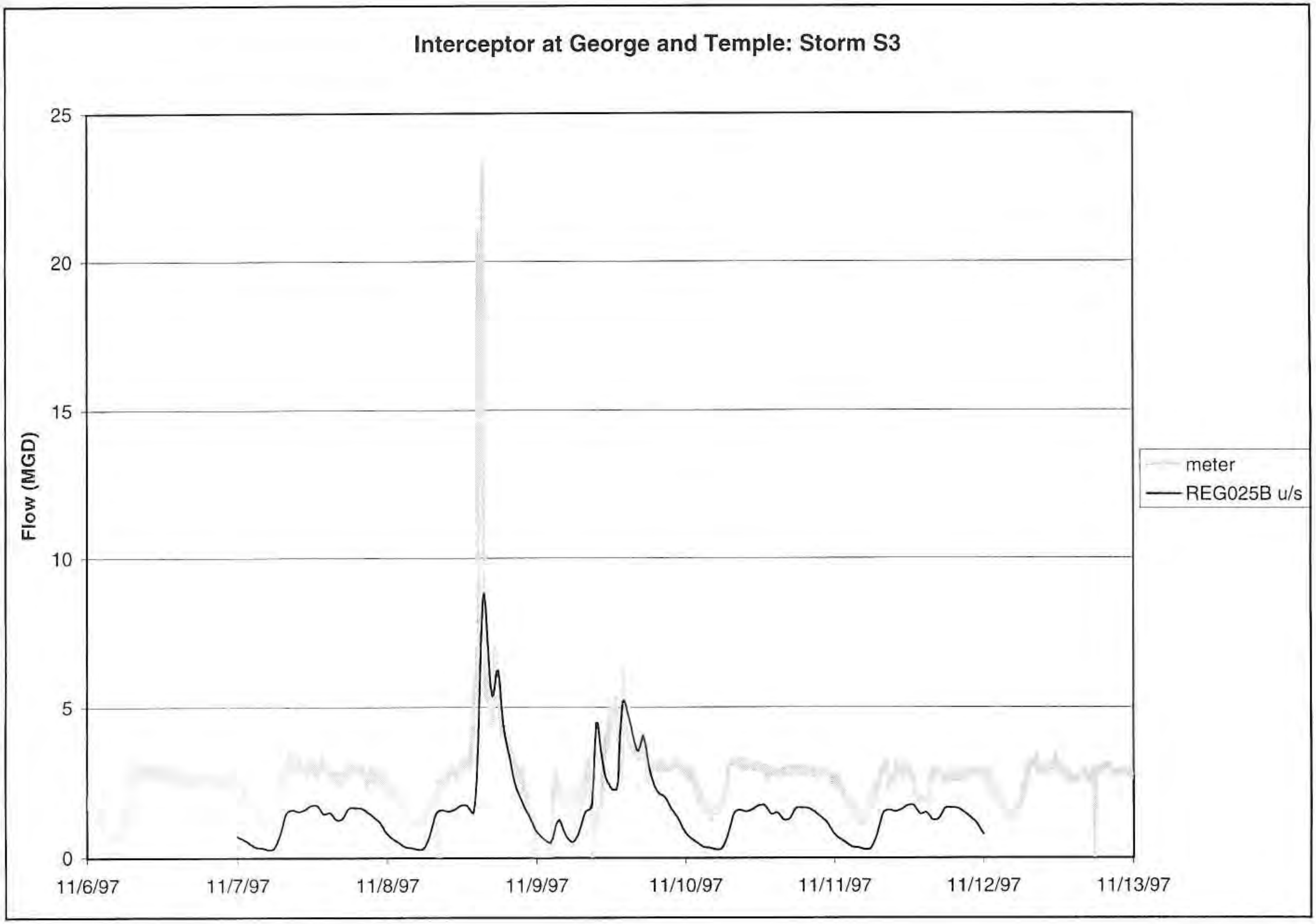

East Street Pump Station: Storm S3
Flow (MGD)
30
25
20
15
10
5
0
11/6/97
11/7/97
11/8/97
11/9/97
11/10/97
11/11/97
11/12/97
11/13/97
meter
EAST


Interceptor at 021: Storm S3
(diversion chamber for East St Pump Station)
Flow (MGD)
60
50
40
30
20
10
0
11/6/97
11/7/97
11/8/97
11/9/97
11/10/97
11/11/97
11/12/97
11/13/97
meter
REG021 u/s
METER REPORTED HOURLY VALUES DURING STORM

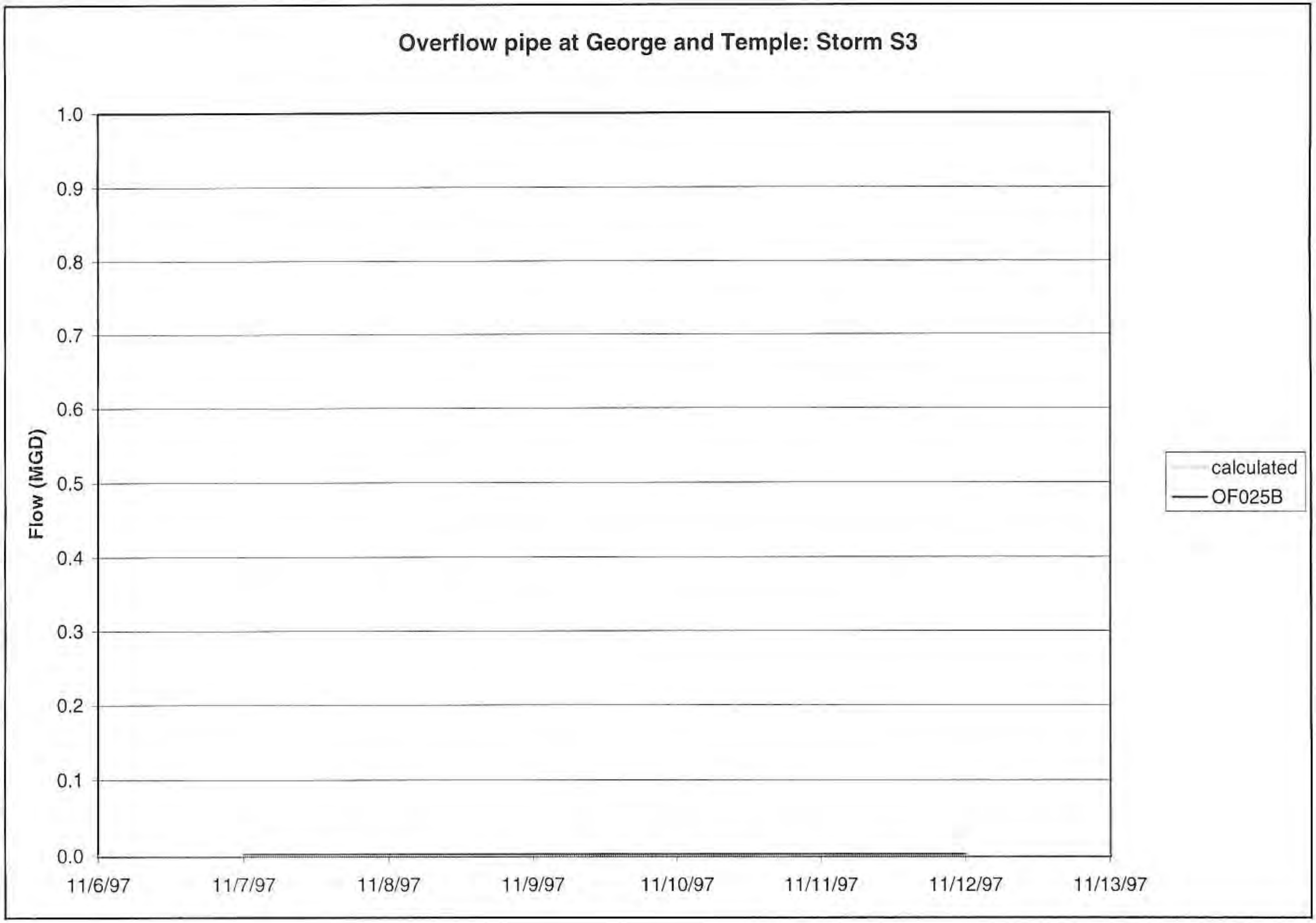

Overflow pipe at 021: Storm S3
Flow (MGD)
30
25
20
15
10
5
0
-5
11/6/97
11/7/97
11/8/97
11/9/97
11/10/97
11/11/97
11/12/97
11/13/97
calculated
OF021
METER DID NOT RECORD
SIGNIFICANT DEPTHS > WEIR HEIGHT

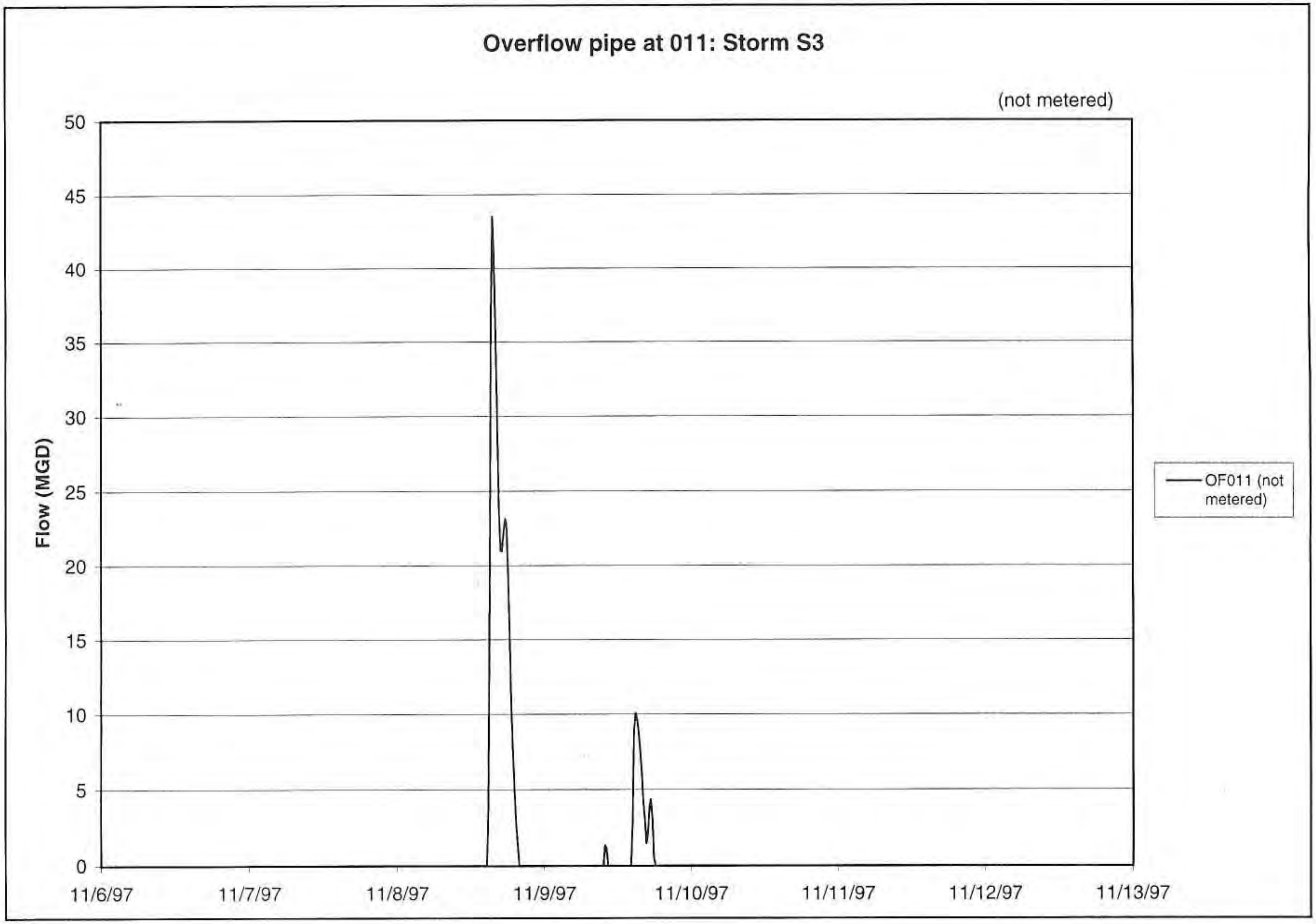


Overflow pipe at 025: Storm S3
(meter unreliable)
18
16
14
12
10
8
6
4
2
0
Flow (MGD)
11/6/97
11/7/97
11/8/97
11/9/97
11/10/97
11/11/97
11/12/97
11/13/97
OF025A

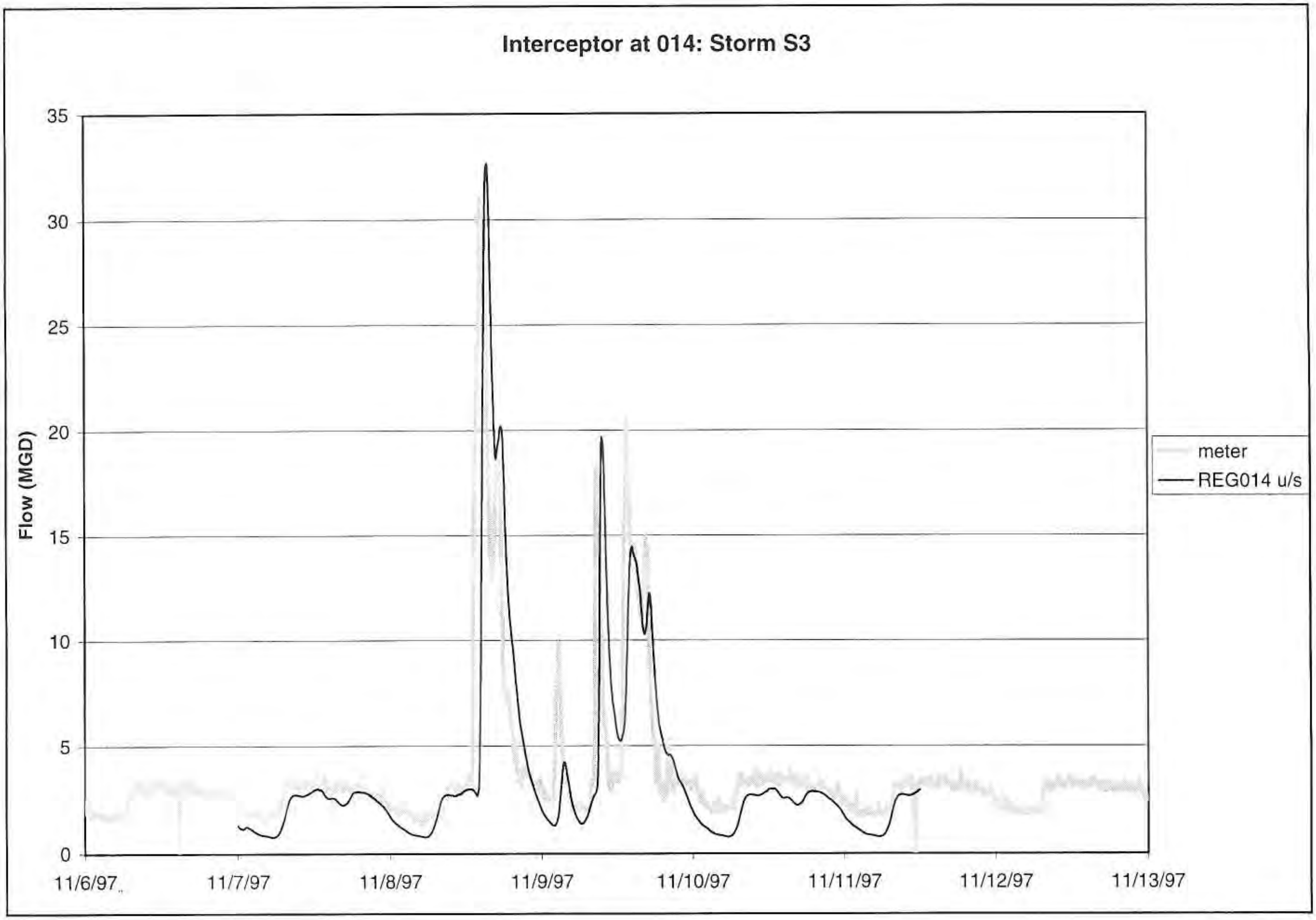


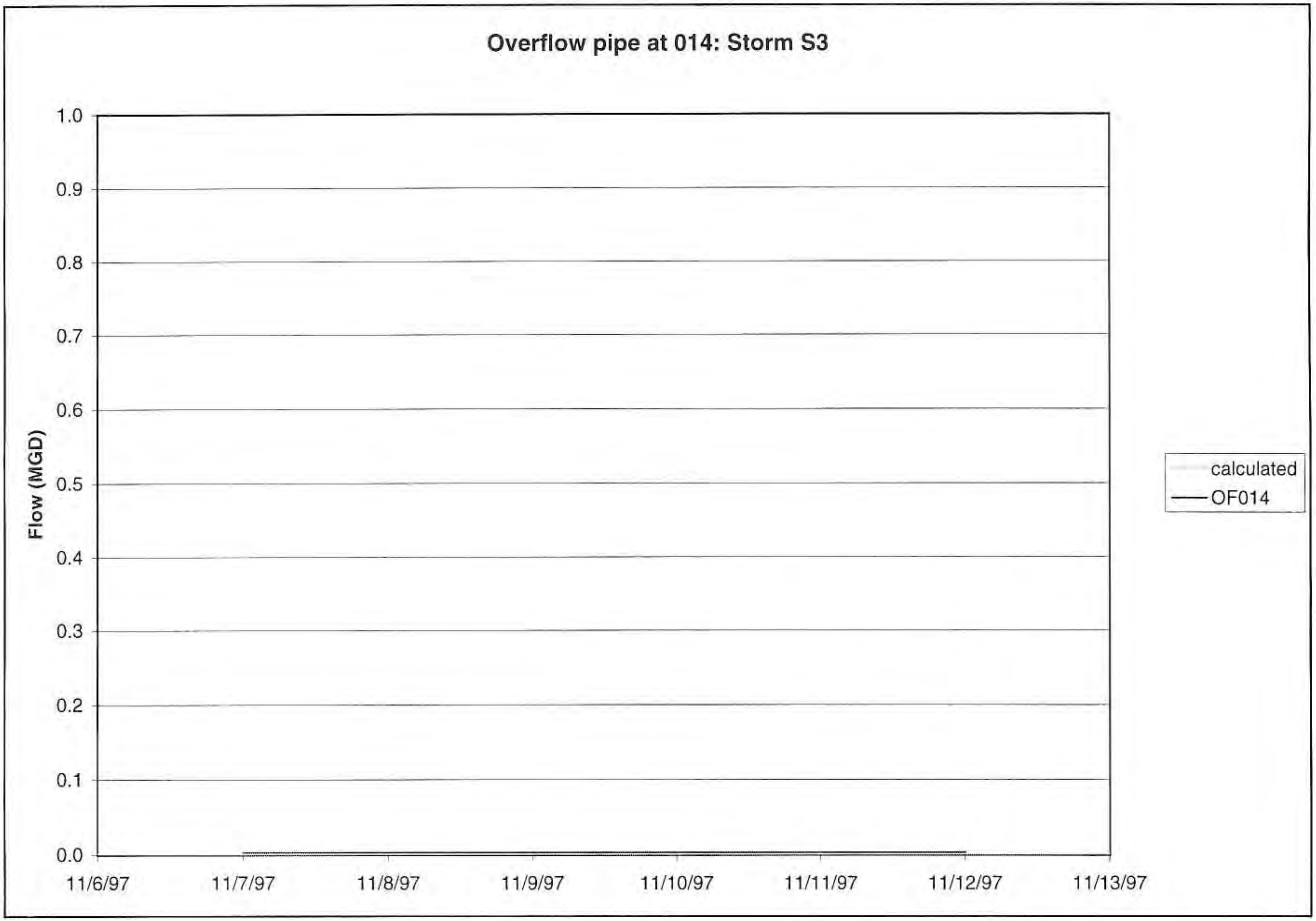
Interceptor at George and Temple: Storm S3
Flow (MGD)
25
20
15
10
5
0
11/6/97
11/7/97
11/8/97
11/9/97
11/10/97
11/11/97
11/12/97
11/13/97
meter
REG025B u/s


Overflow pipe at George and Temple: Storm S3
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
Flow (MGD)
11/6/97
11/7/97
11/8/97
11/9/97
11/10/97
11/11/97
11/12/97
11/13/97
calculated
OF025B

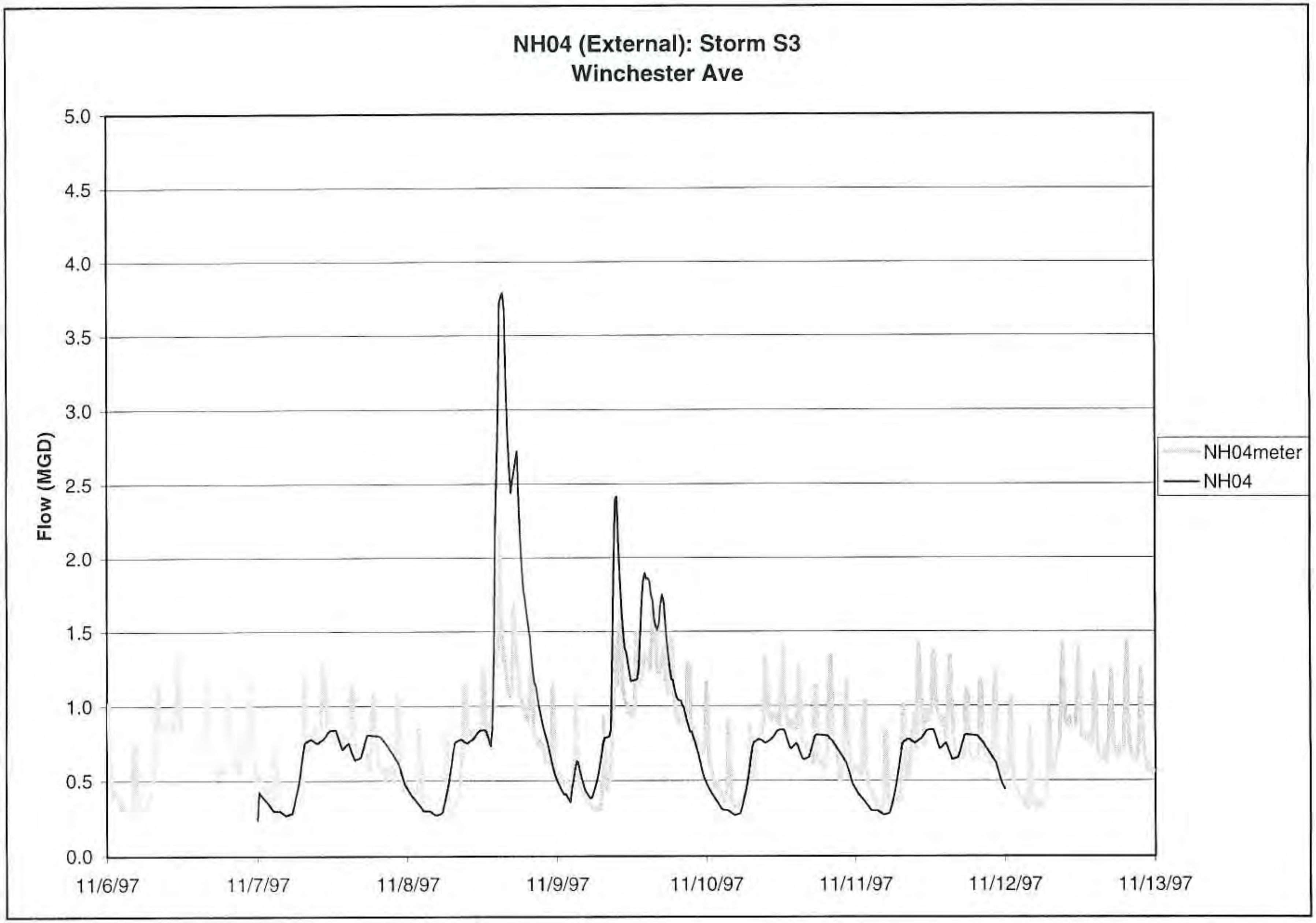


Overflow pipe at 011: Storm S3
(not metered)
Flow (MGD)
50
45
40
35
30
25
20
15
10
5
0
11/6/97
11/7/97
11/8/97
11/9/97
11/10/97
11/11/97
11/12/97
11/13/97
OF011 (not metered)

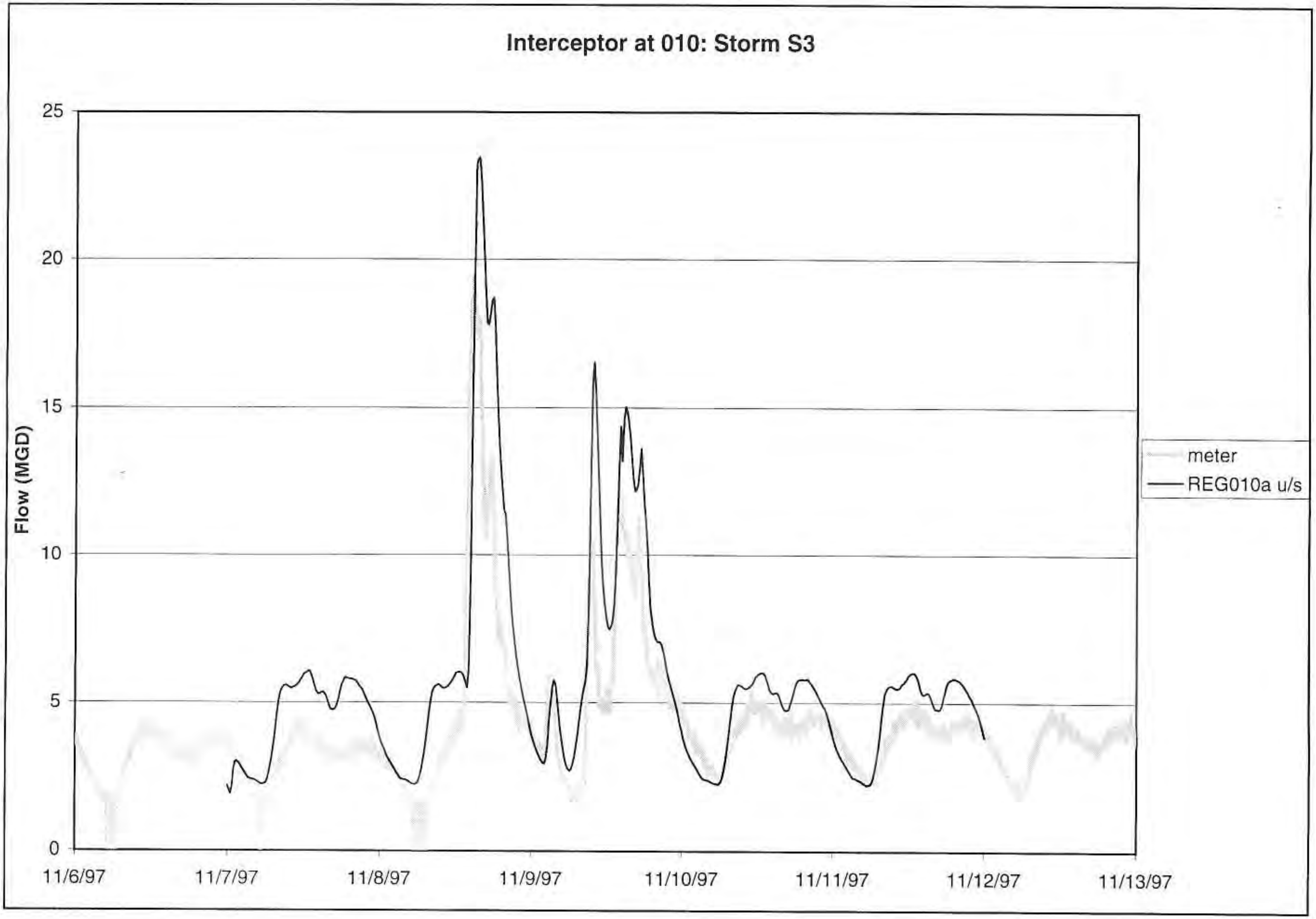

Interceptor at 014: Storm S3
35
30
25
20
15
10
5
0
Flow (MGD)
11/6/97
11/7/97
11/8/97
11/9/97
11/10/97
11/11/97
11/12/97
11/13/97
meter
REG014 u/s



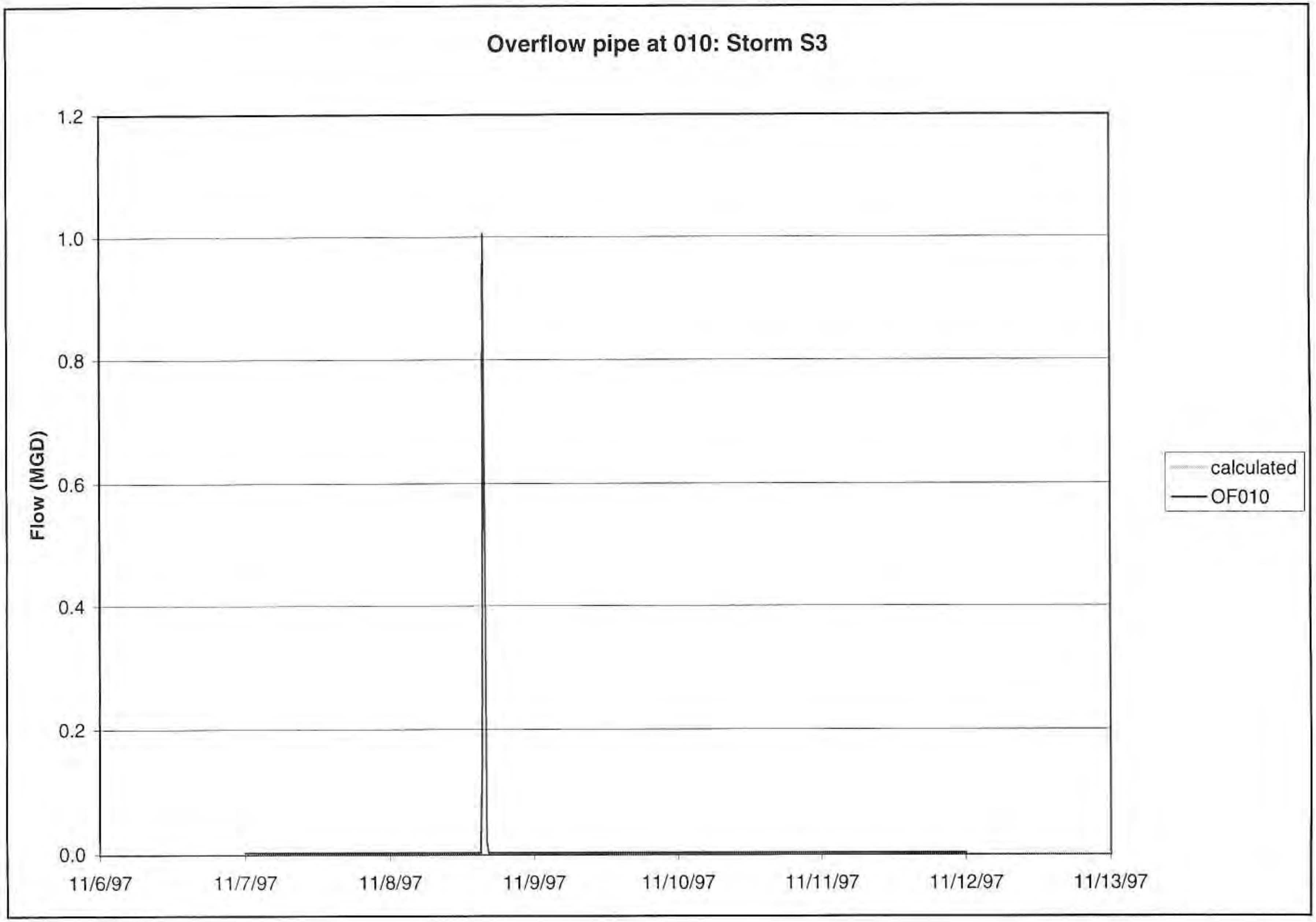
Overflow pipe at 014: Storm S3
Flow (MGD)
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
11/6/97
11/7/97
11/8/97
11/9/97
11/10/97
11/11/97
11/12/97
11/13/97
calculated
OF014

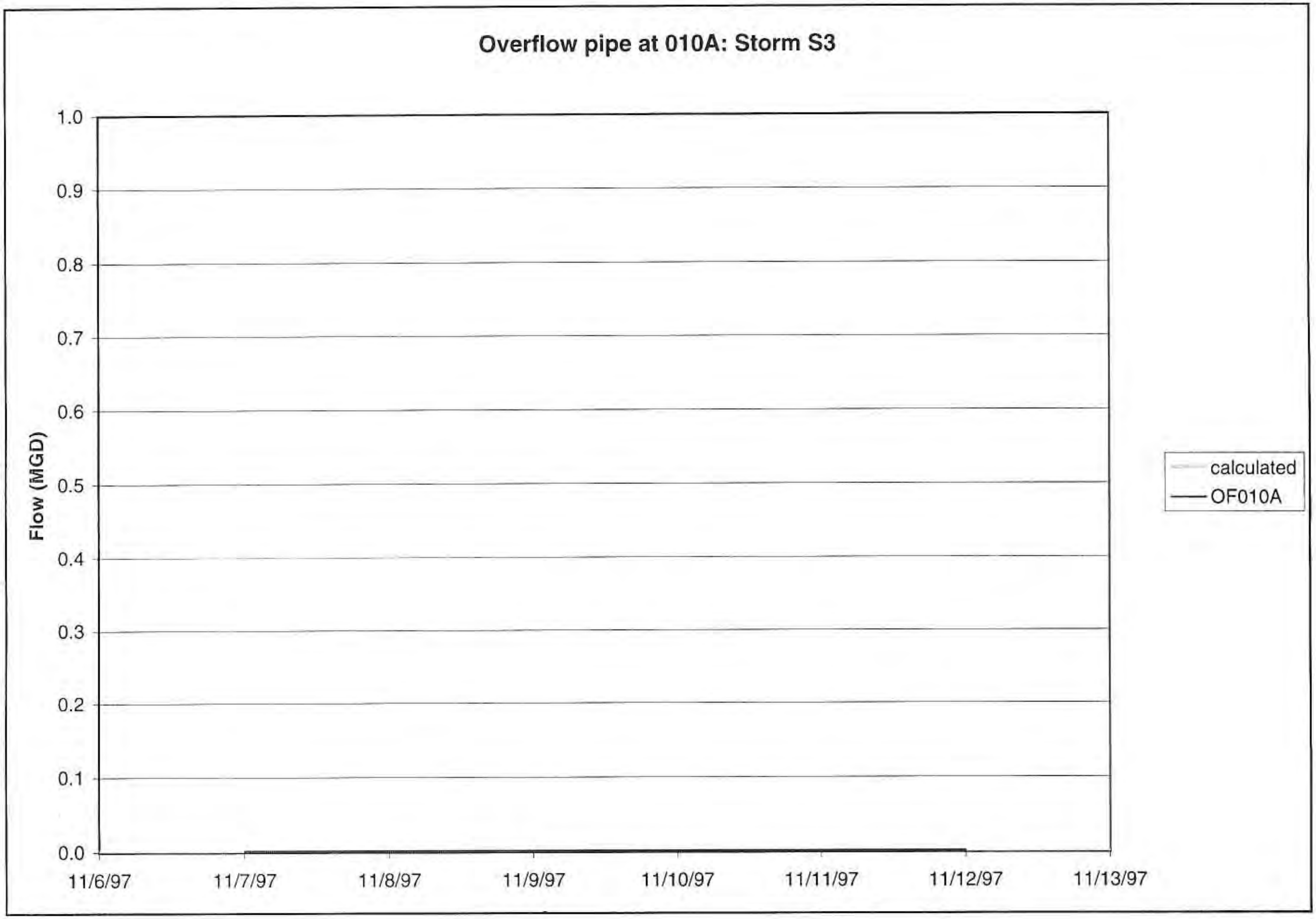


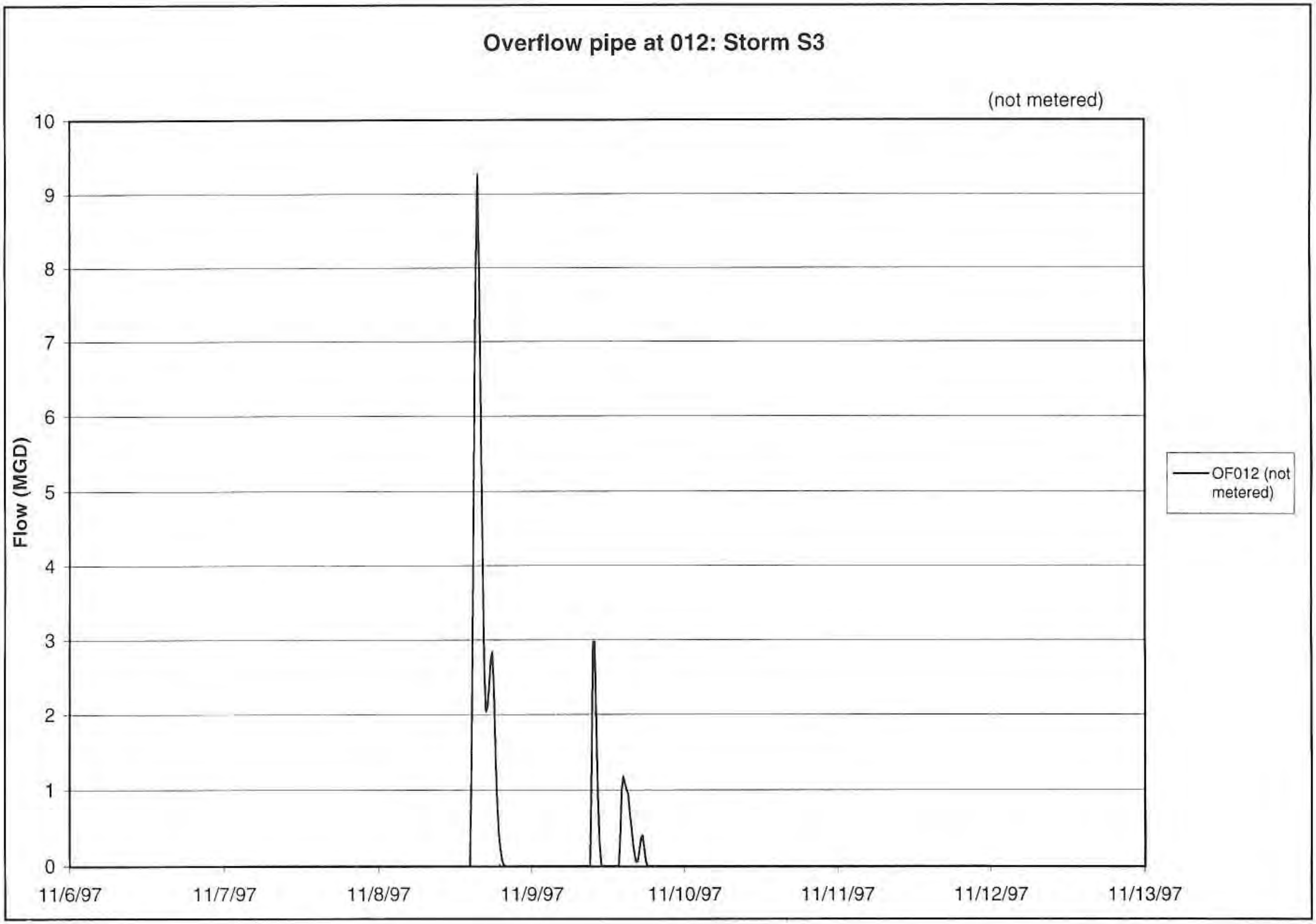
NH04 (External): Storm S3
Winchester Ave
Flow (MGD)
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
11/6/97
11/7/97
11/8/97
11/9/97
11/10/97
11/11/97
11/12/97
11/13/97
NH04meter
NH04

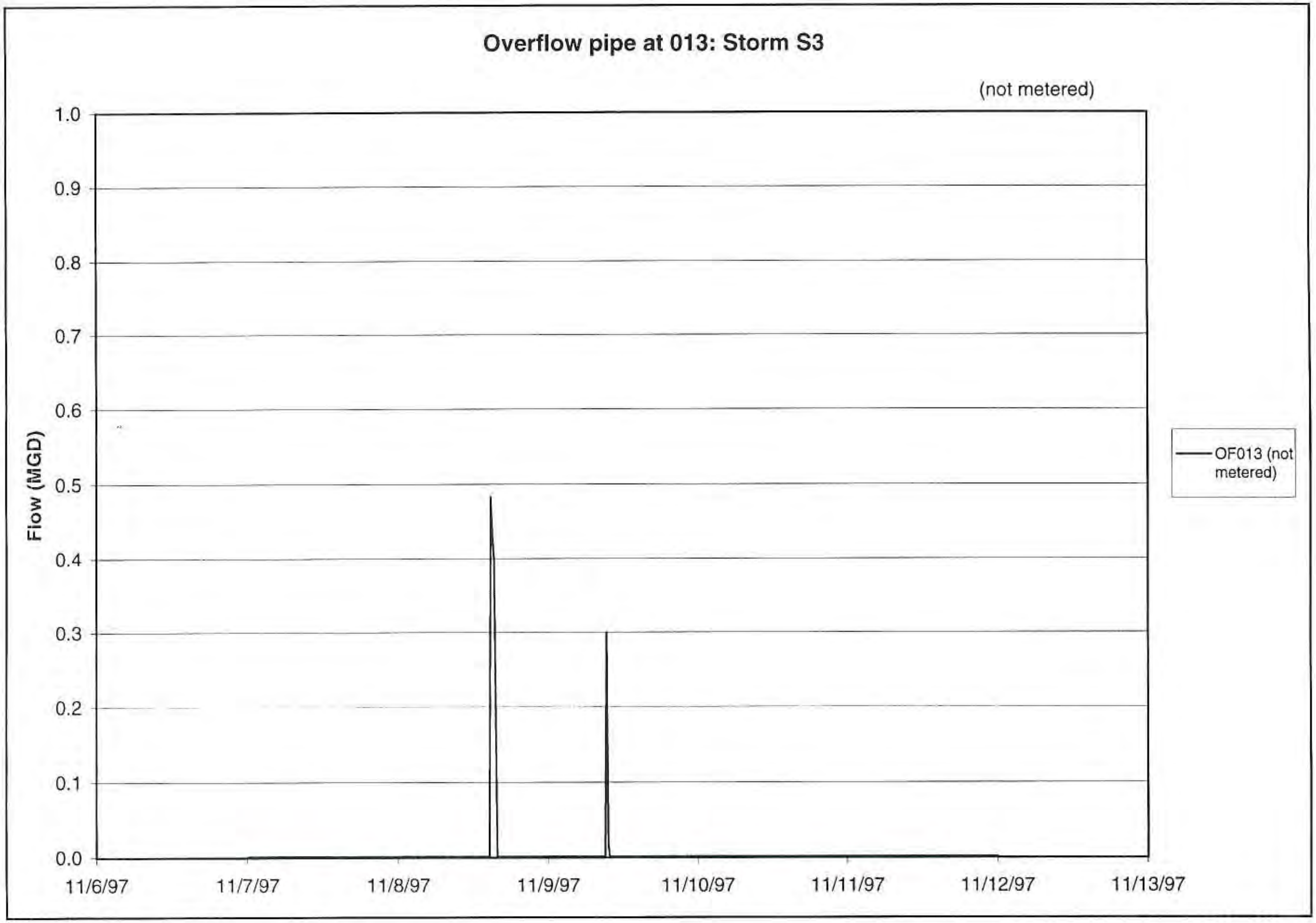


Interceptor at 010: Storm S3
Flow (MGD)
25
20
15
10
5
0
11/6/97
11/7/97
11/8/97
11/9/97
11/10/97
11/11/97
11/12/97
11/13/97
meter
REG010a u/s

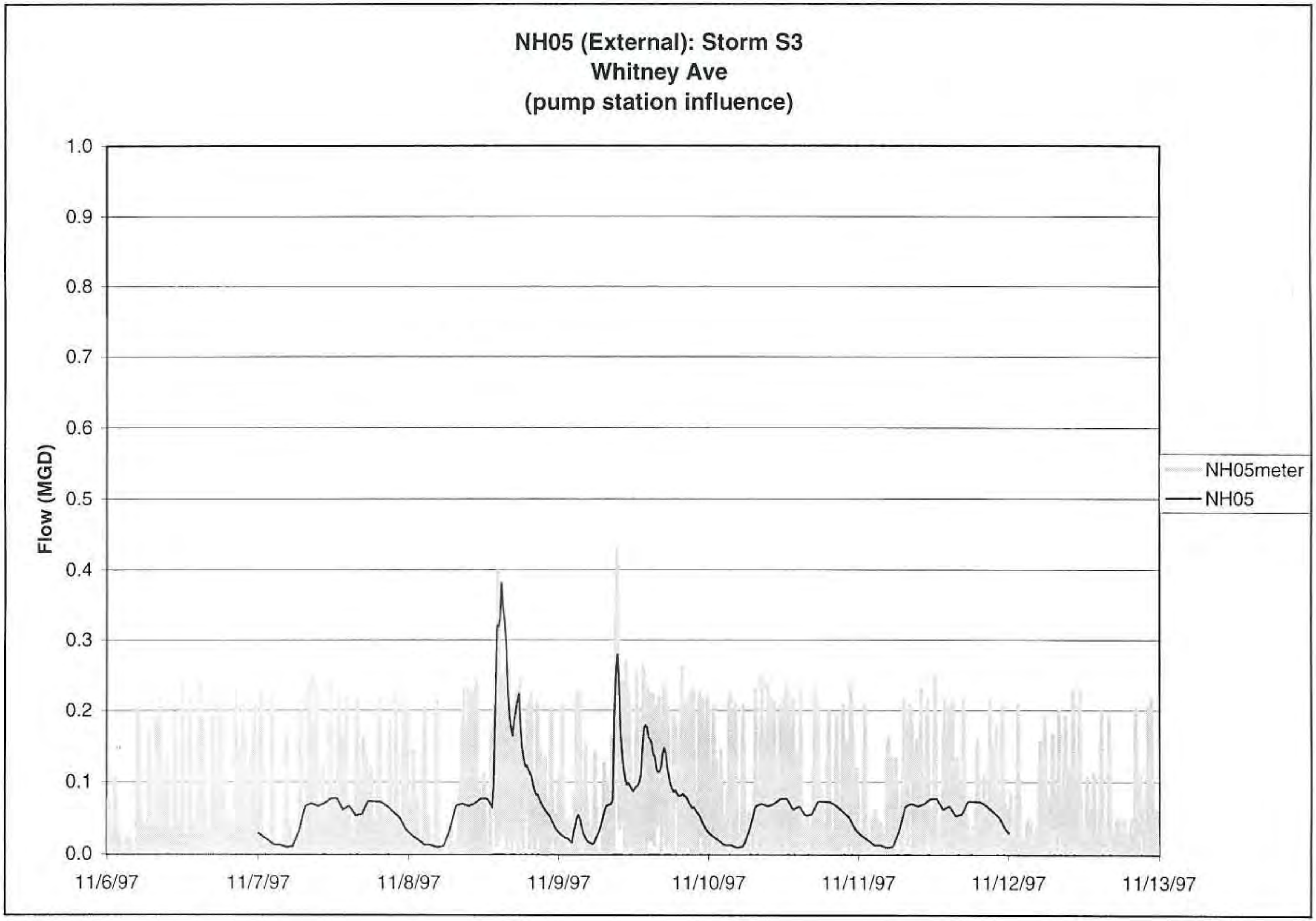

Overflow pipe at 010: Storm S3
Flow (MGD)
1.2
1.0
0.8
0.6
0.4
0.2
0.0
11/6/97
11/7/97
11/8/97
11/9/97
11/10/97
11/11/97
11/12/97
11/13/97
calculated
OF010

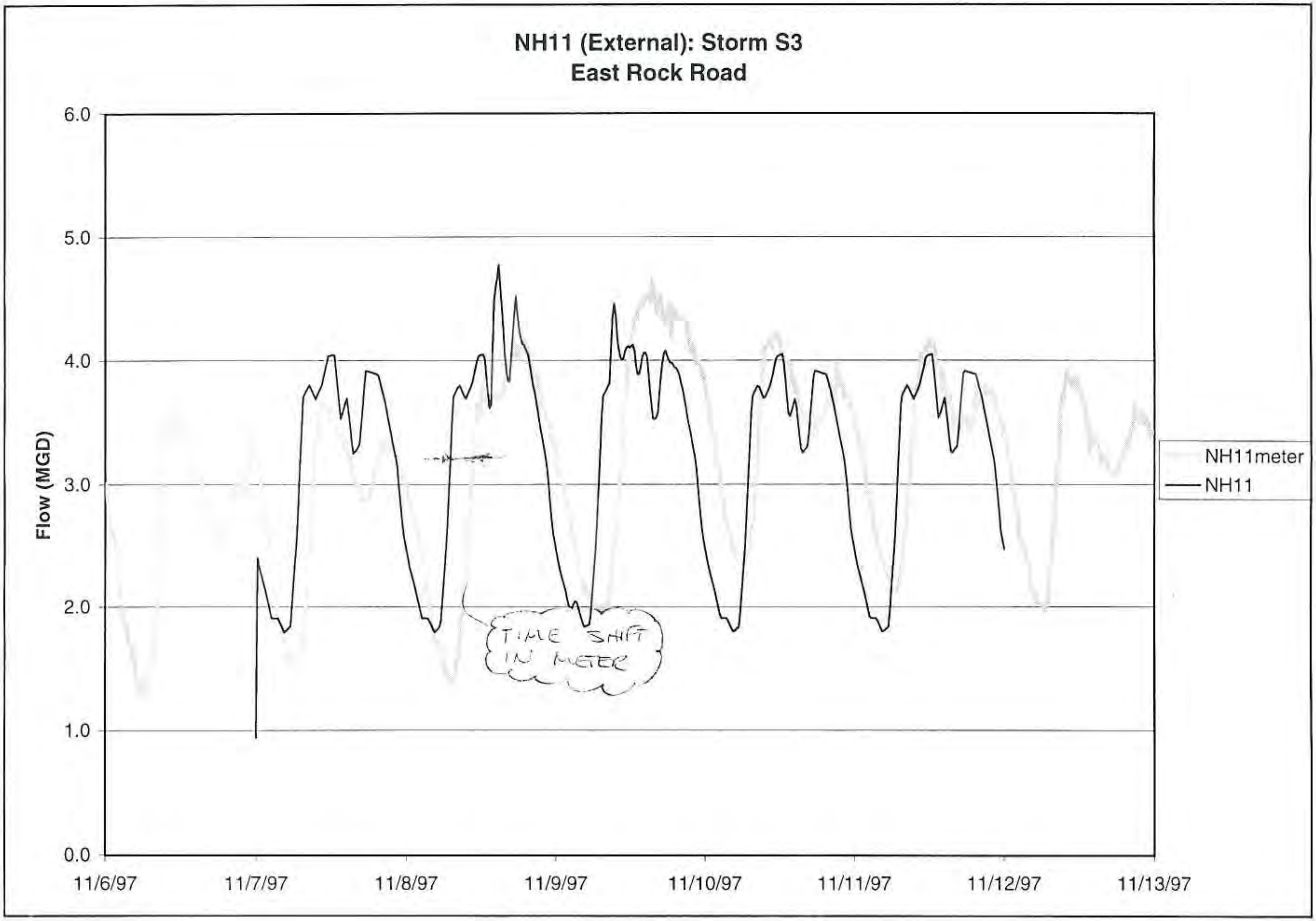

Overflow pipe at 010A: Storm S3
Flow (MGD)
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
11/6/97
11/7/97
11/8/97
11/9/97
11/10/97
11/11/97
11/12/97
11/13/97
calculated
OF010A


Overflow pipe at 012: Storm S3
(not metered)
Flow (MGD)
10
9
8
7
6
5
4
3
2
1
0
11/6/97
11/7/97
11/8/97
11/9/97
11/10/97
11/11/97
11/12/97
11/13/97
OF012 (not metered)

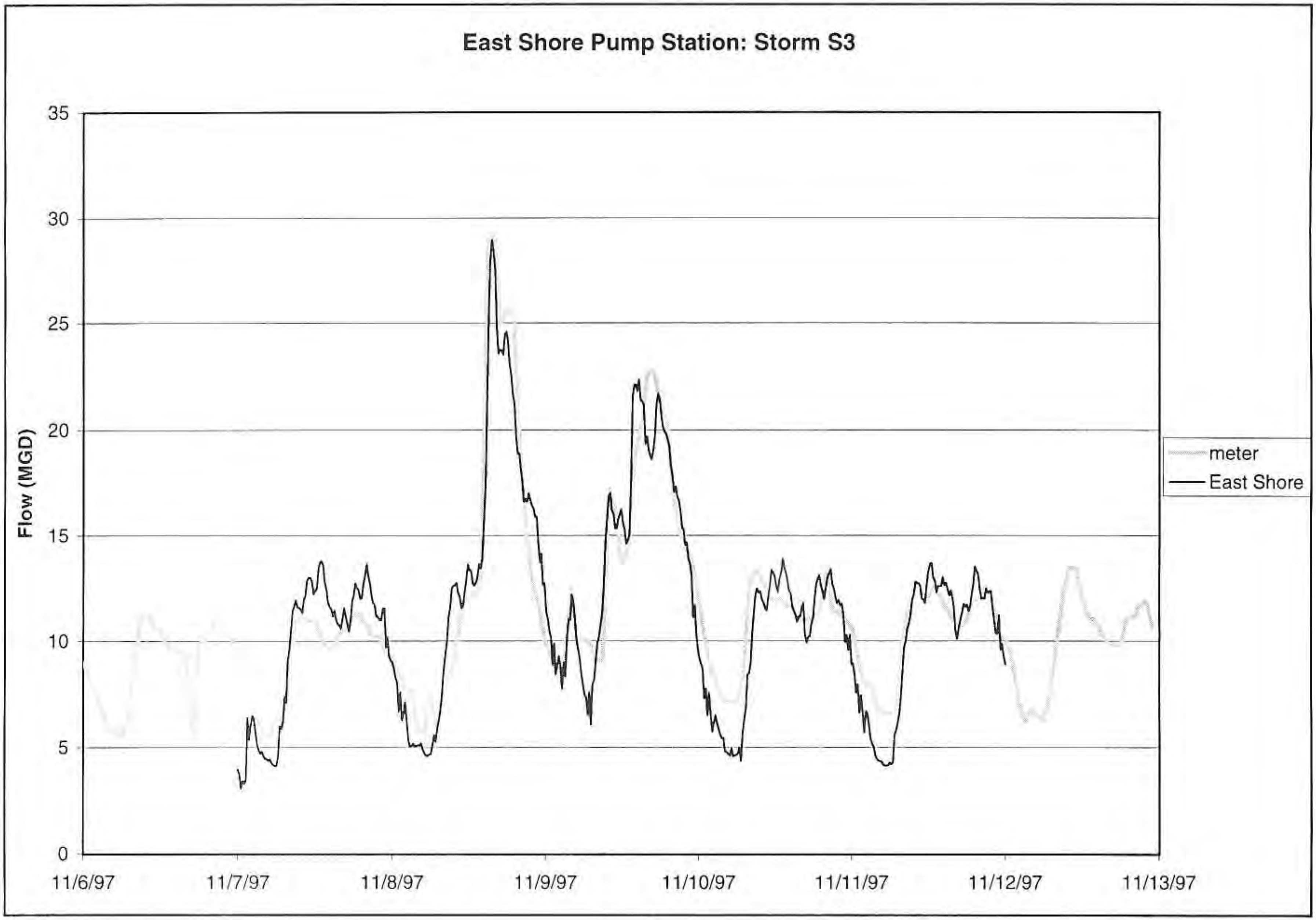


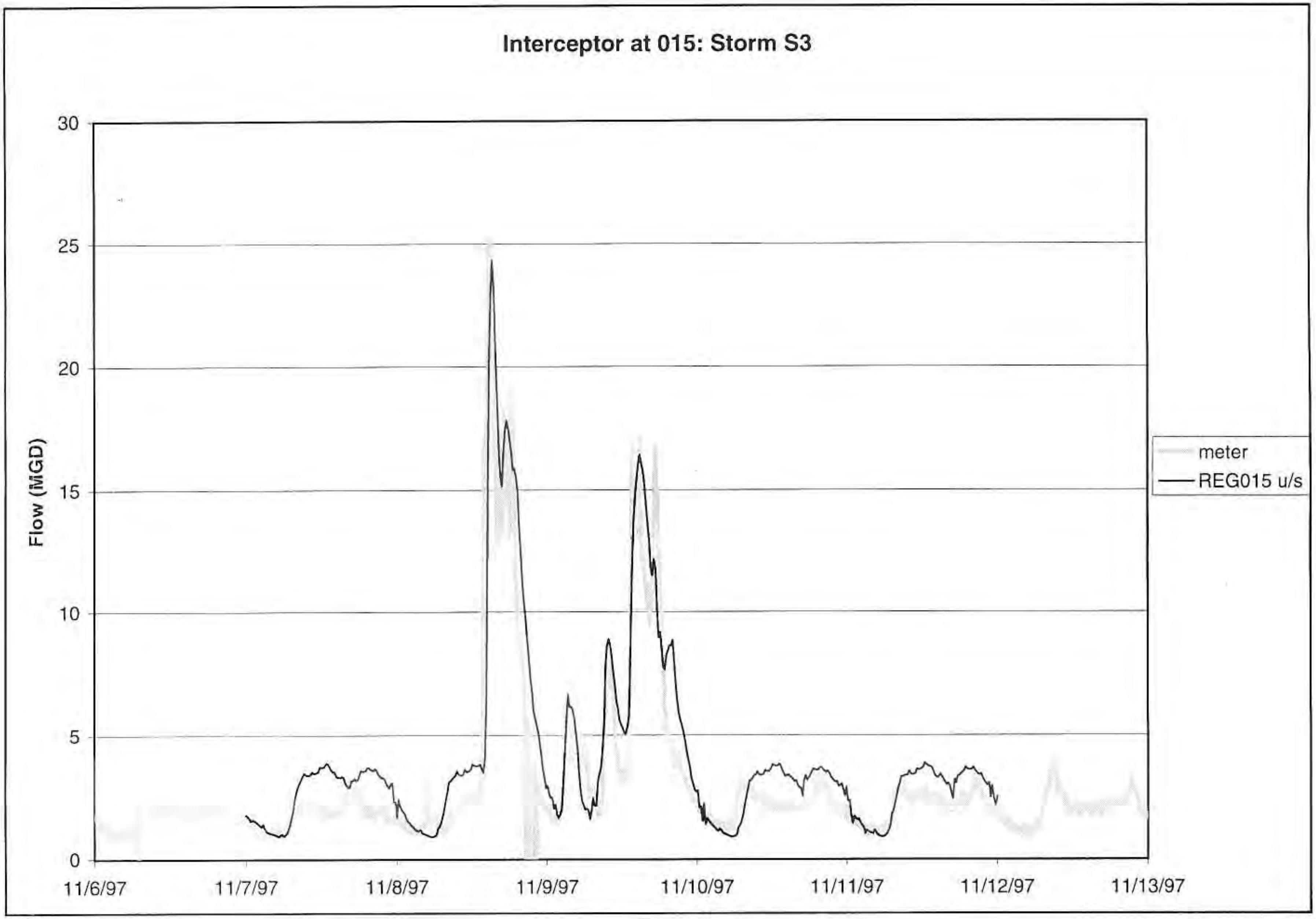
Overflow pipe at 013: Storm S3
(not metered)
Flow (MGD)
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
11/6/97
11/7/97
11/8/97
11/9/97
11/10/97
11/11/97
11/12/97
11/13/97
OF013 (not metered)


NH05 (External): Storm S3
Whitney Ave
(pump station influence)
Flow (MGD)
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
11/6/97
11/7/97
11/8/97
11/9/97
11/10/97
11/11/97
11/12/97
11/13/97
NH05meter
NH05

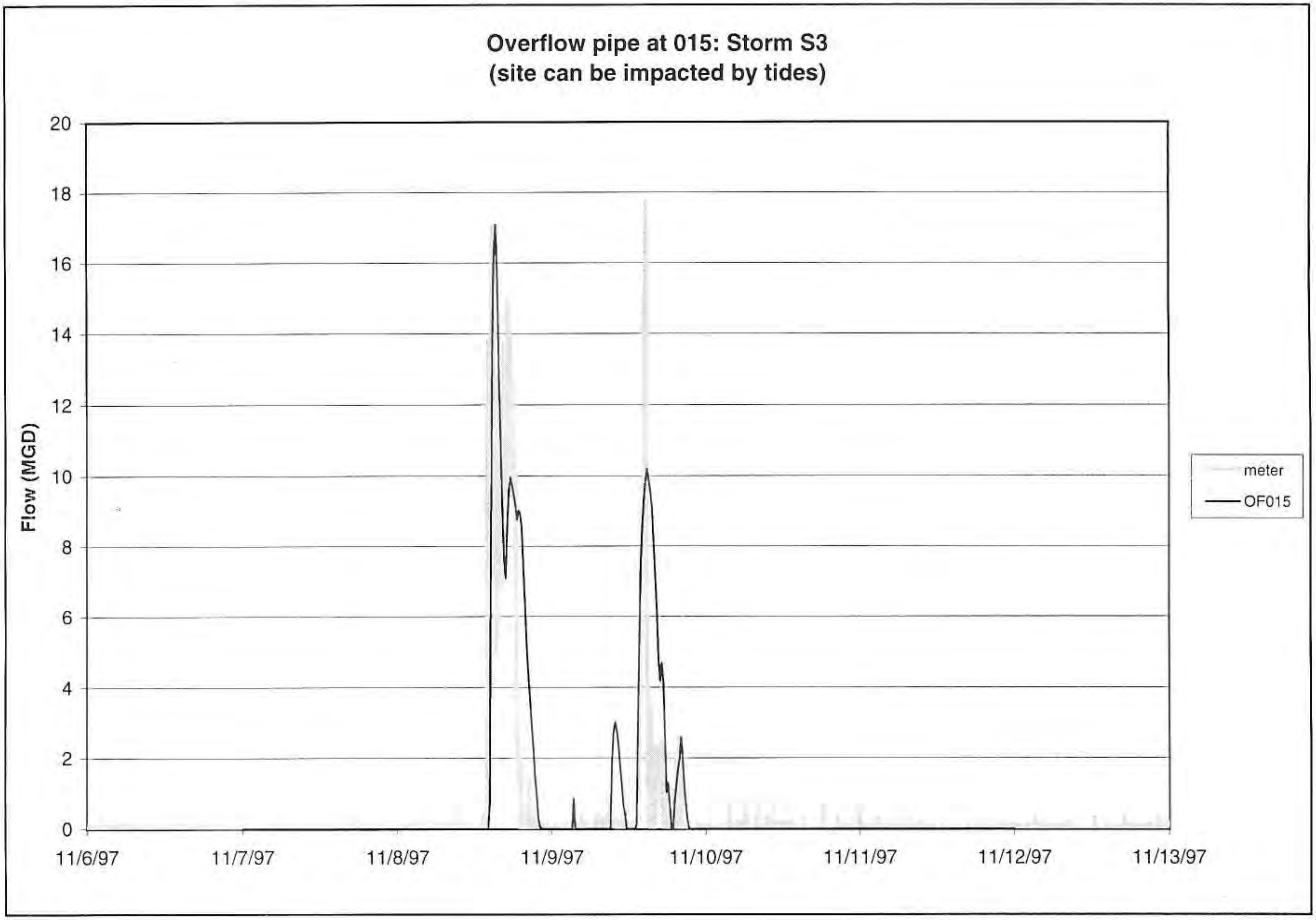


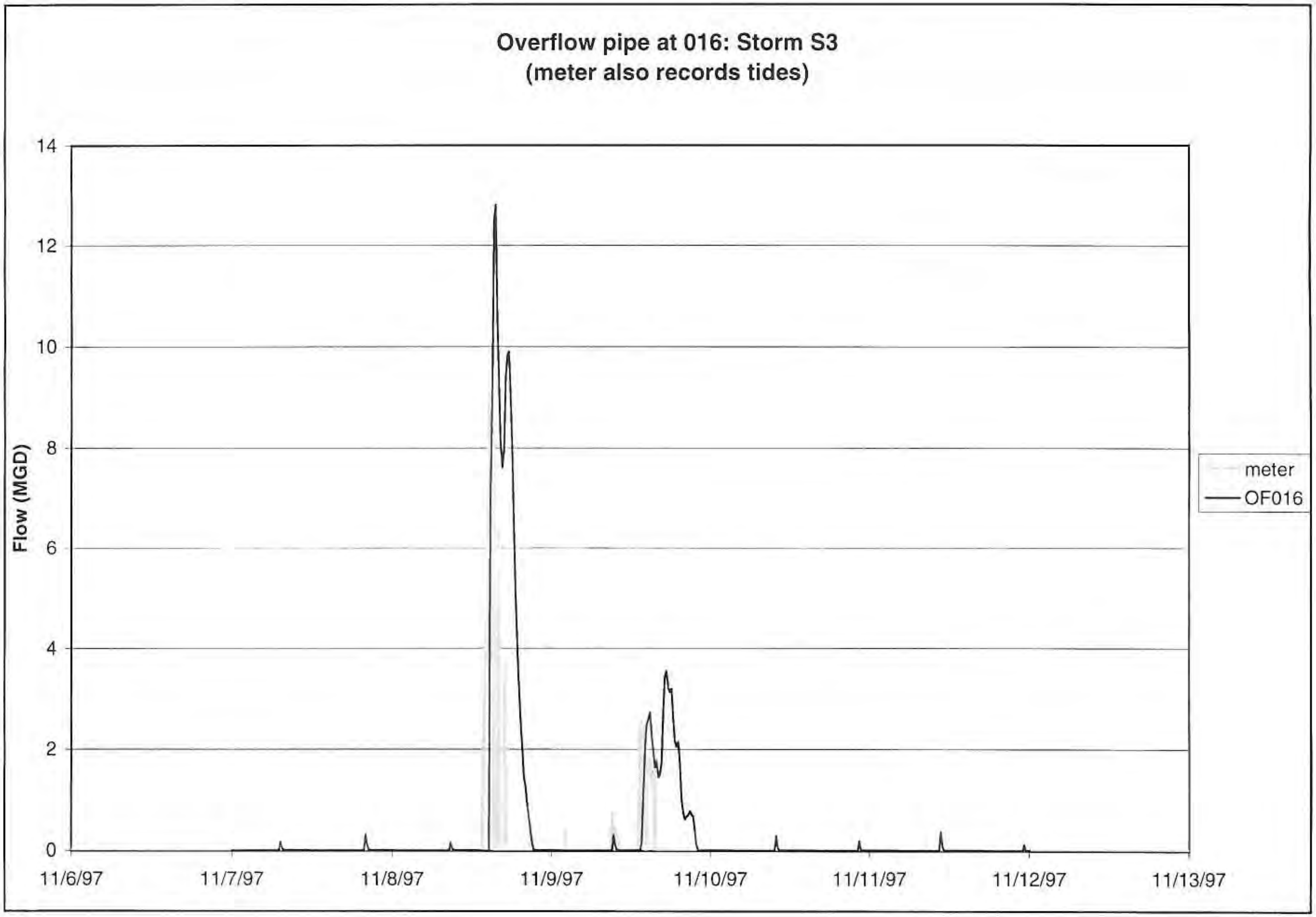
NH11 (External): Storm S3
East Rock Road
Flow (MGD)
6.0
5.0
4.0
3.0
2.0
1.0
0.0
11/6/97
11/7/97
11/8/97
11/9/97
11/10/97
11/11/97
11/12/97
11/13/97
NH11meter
NH11
TIME SHIFT
IN METER

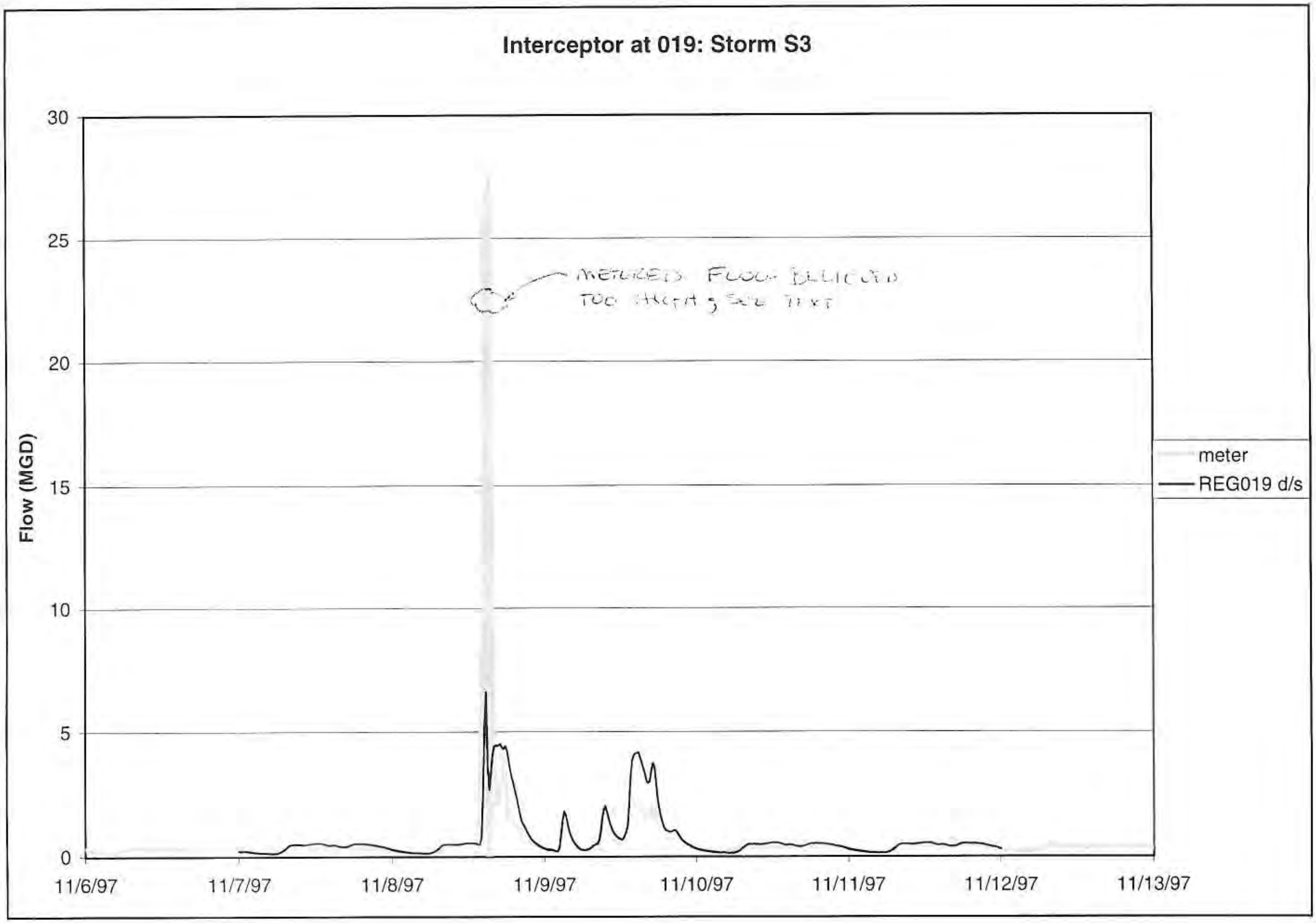

East Shore Pump Station: Storm S3
Flow (MGD)
35
30
25
20
15
10
5
0
11/6/97
11/7/97
11/8/97
11/9/97
11/10/97
11/11/97
11/12/97
11/13/97
meter
East Shore

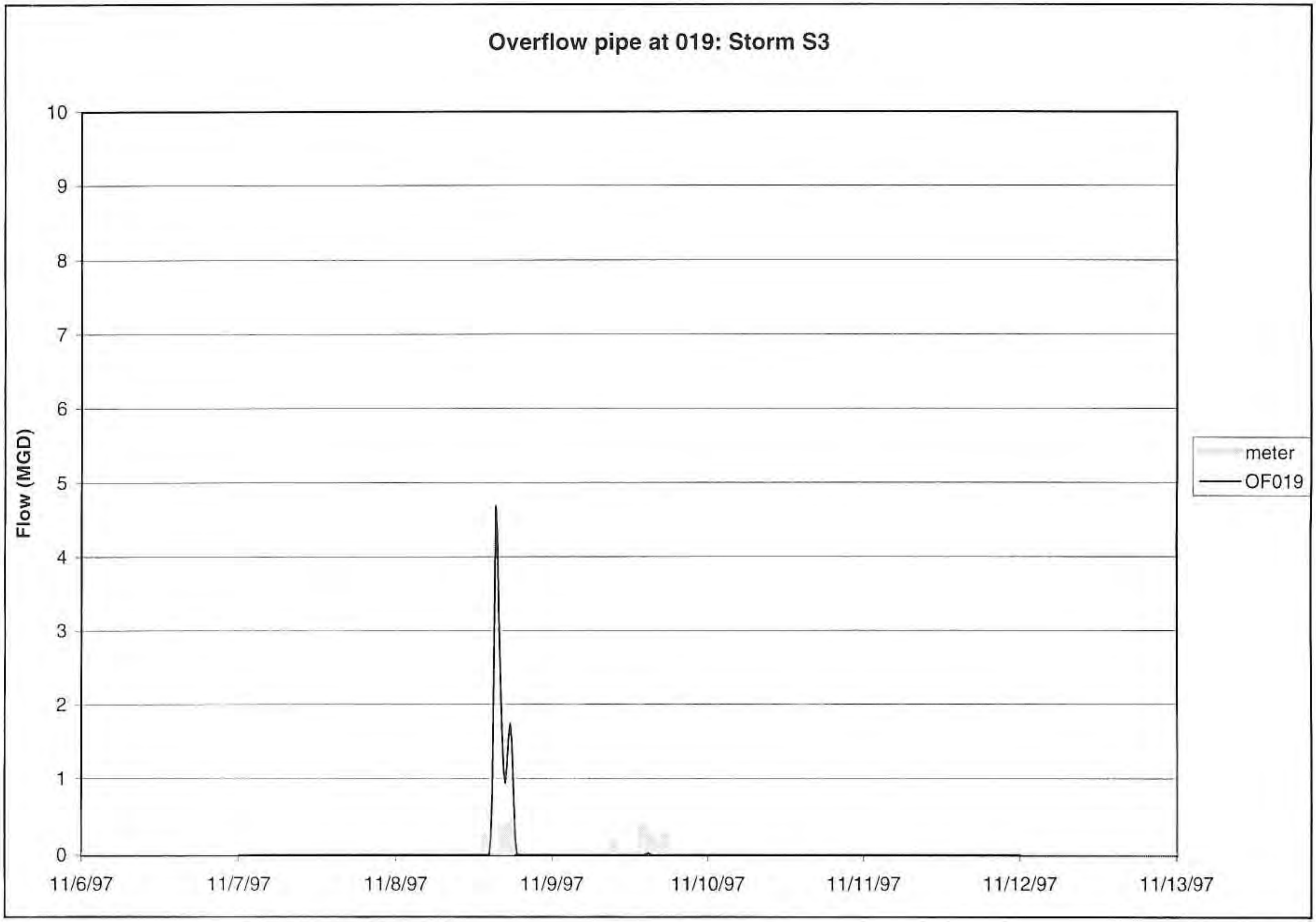


Interceptor at 015: Storm S3
Flow (MGD)
30
25
20
15
10
5
0
11/6/97
11/7/97
11/8/97
11/9/97
11/10/97
11/11/97
11/12/97
11/13/97
meter
REG015 u/s

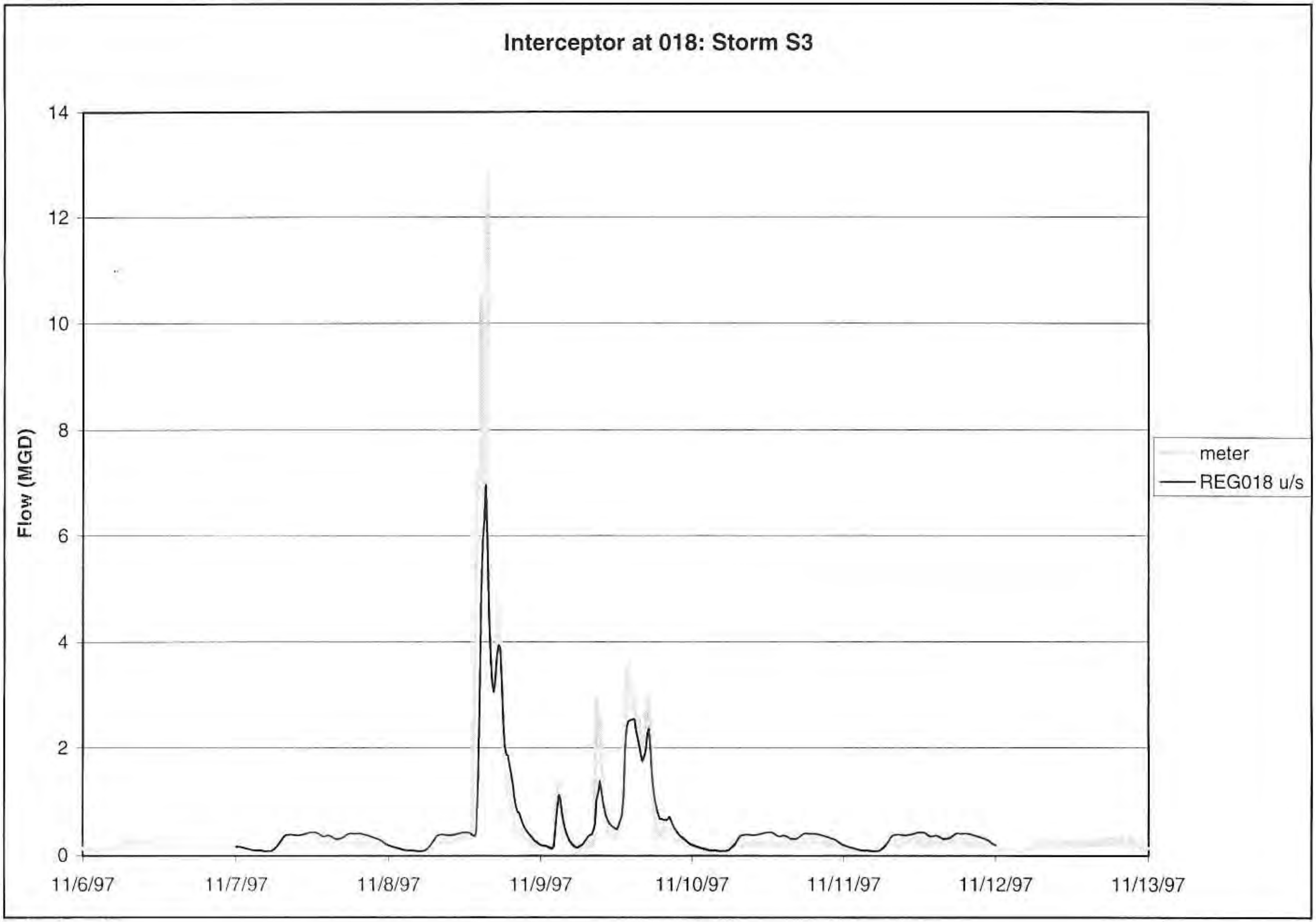

Overflow pipe at 015: Storm S3
(site can be impacted by tides)
Flow (MGD)
20
18
16
14
12
10
8
6
4
2
0
11/6/97
11/7/97
11/8/97
11/9/97
11/10/97
11/11/97
11/12/97
11/13/97
meter
OF015

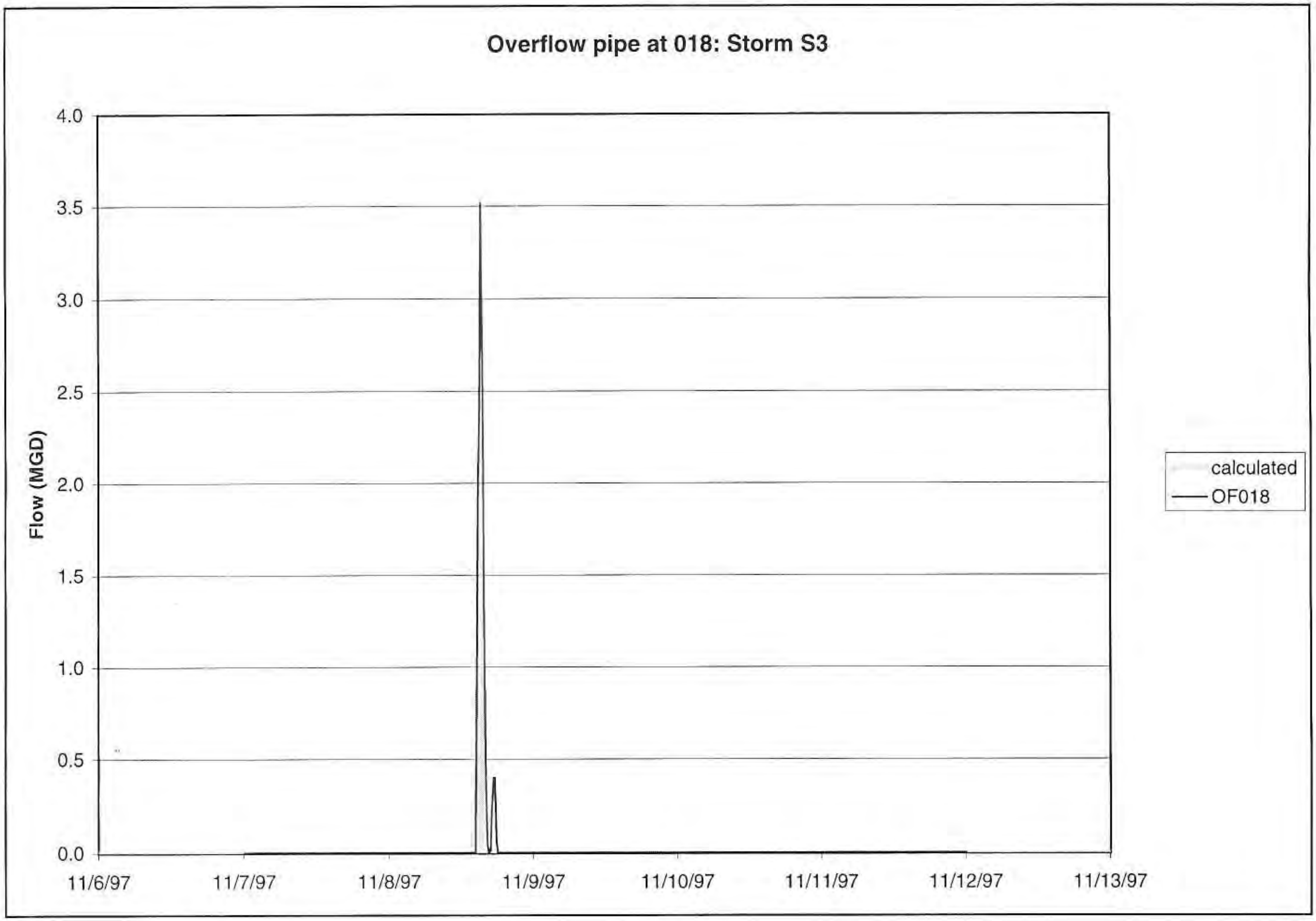

Overflow pipe at 016: Storm S3
(meter also records tides)
Flow (MGD)
14
12
10
8
6
4
2
0
11/6/97
11/7/97
11/8/97
11/9/97
11/10/97
11/11/97
11/12/97
11/13/97
meter
OF016

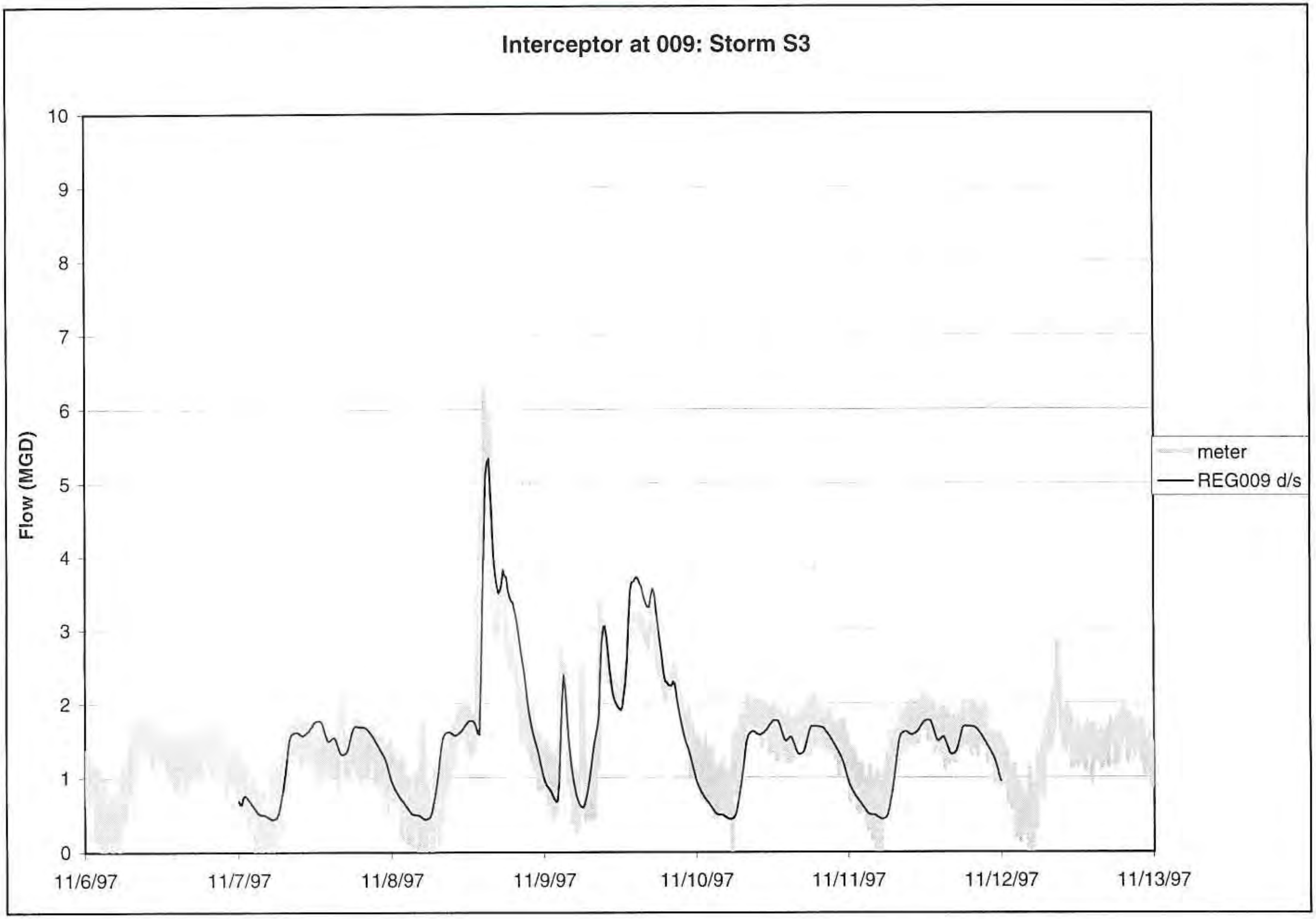

Interceptor at 019: Storm S3
Flow (MGD)
30
25
20
15
10
5
0
11/6/97
11/7/97
11/8/97
11/9/97
11/10/97
11/11/97
11/12/97
11/13/97
meter
REG019 d/s
METERED FLOW BELIEVED TOO HIGH; SEE TEXT



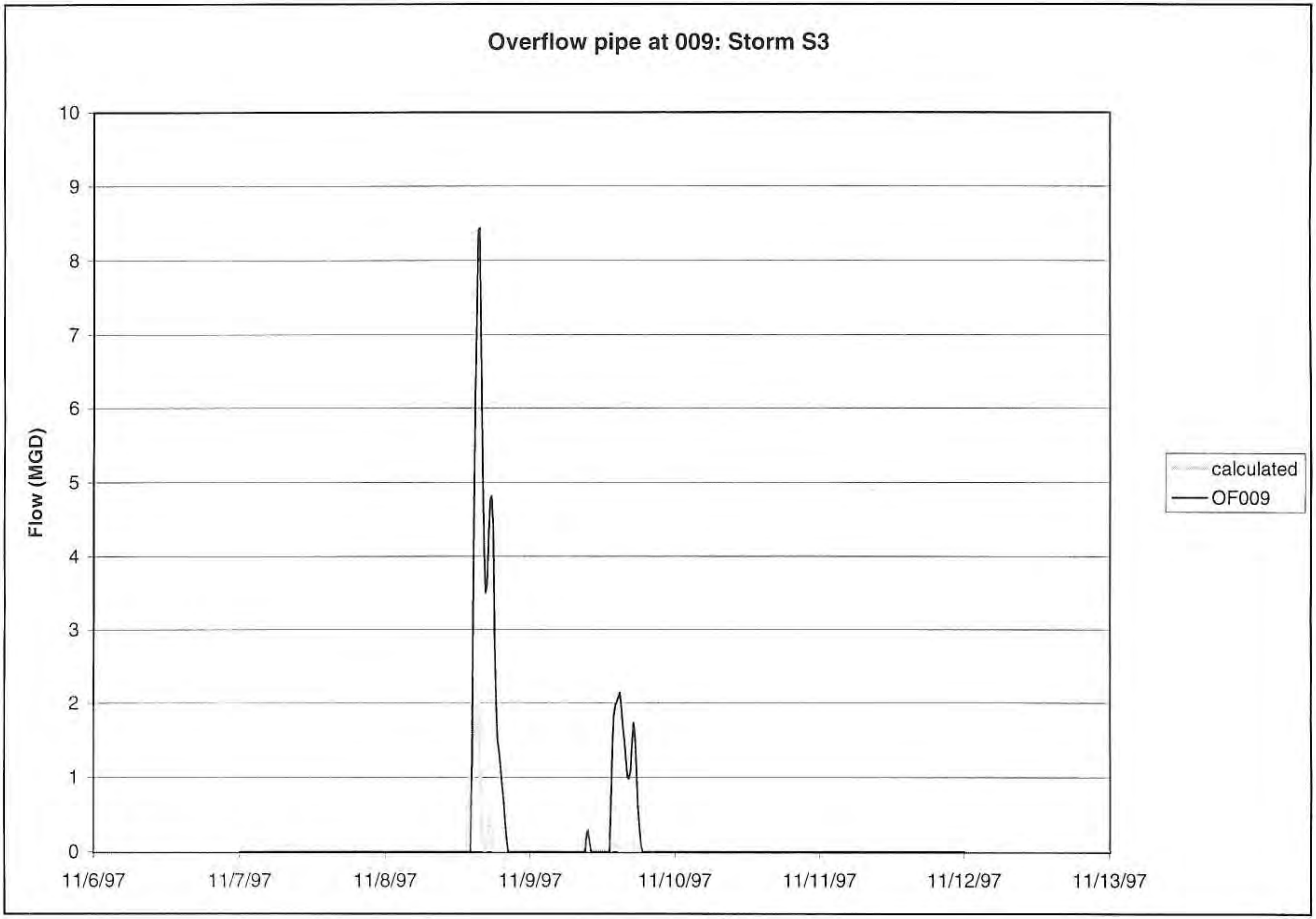
Overflow pipe at 019: Storm S3
Flow (MGD)
10
9
8
7
6
5
4
3
2
1
0
11/6/97
11/7/97
11/8/97
11/9/97
11/10/97
11/11/97
11/12/97
11/13/97
meter
OF019


Interceptor at 018: Storm S3
Flow (MGD)
14
12
10
8
6
4
2
0
11/6/97
11/7/97
11/8/97
11/9/97
11/10/97
11/11/97
11/12/97
11/13/97
meter
REG018 u/s

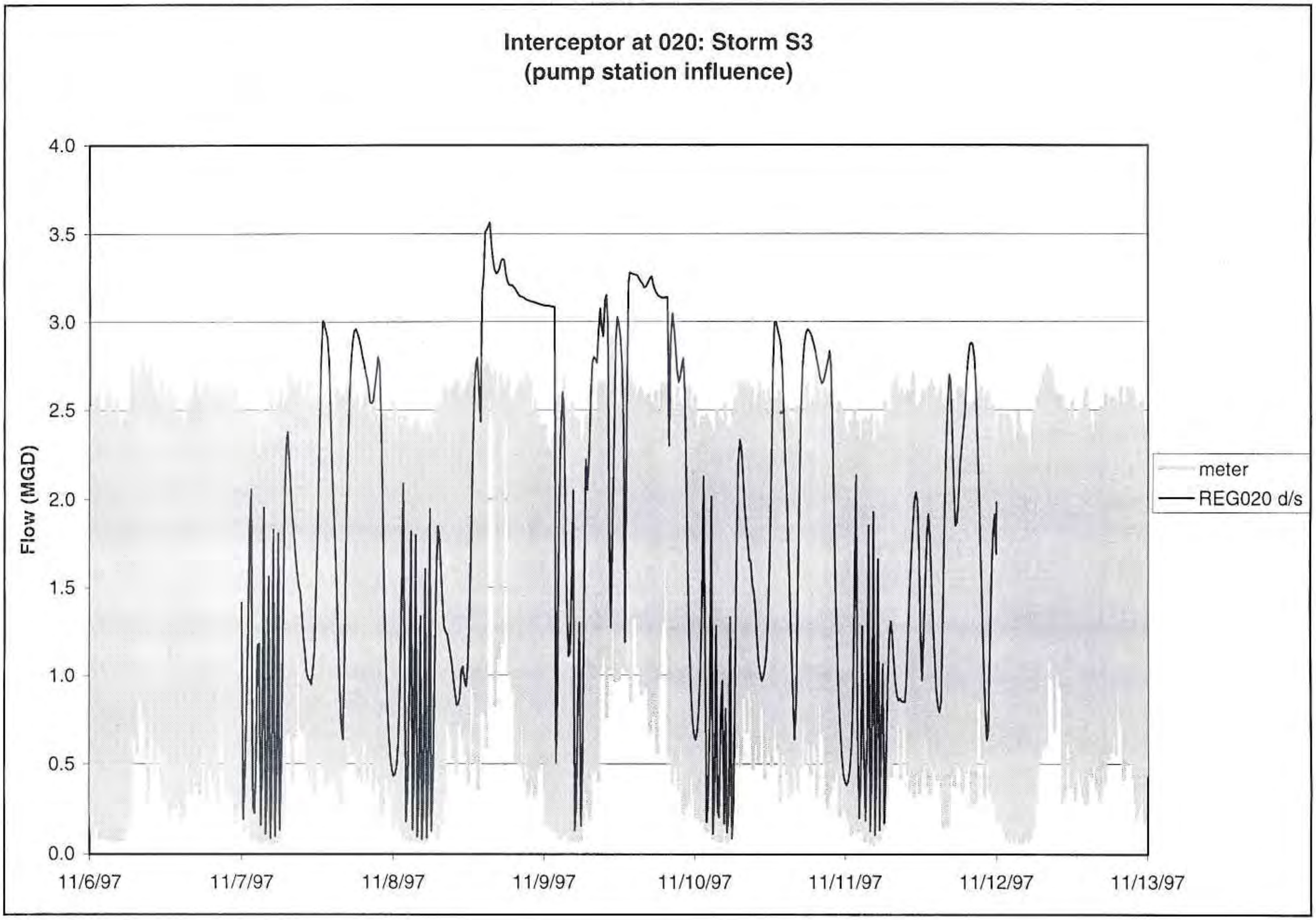

Overflow pipe at 018: Storm S3
Flow (MGD)
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
11/6/97
11/7/97
11/8/97
11/9/97
11/10/97
11/11/97
11/12/97
11/13/97
calculated
OF018



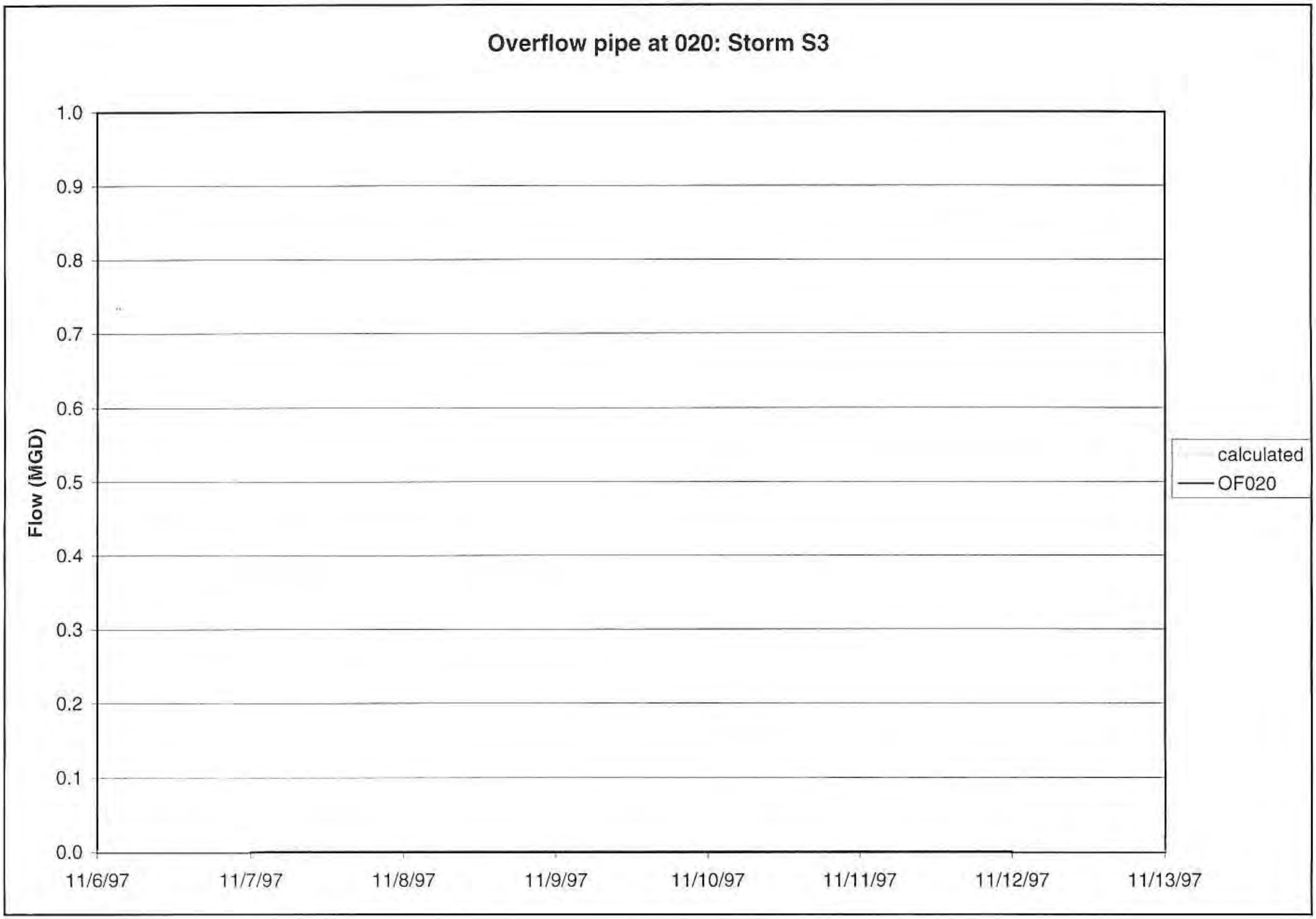
Interceptor at 009: Storm S3
Flow (MGD)
10
9
8
7
6
5
4
3
2
1
0
11/6/97
11/7/97
11/8/97
11/9/97
11/10/97
11/11/97
11/12/97
11/13/97
meter
REG009 d/s

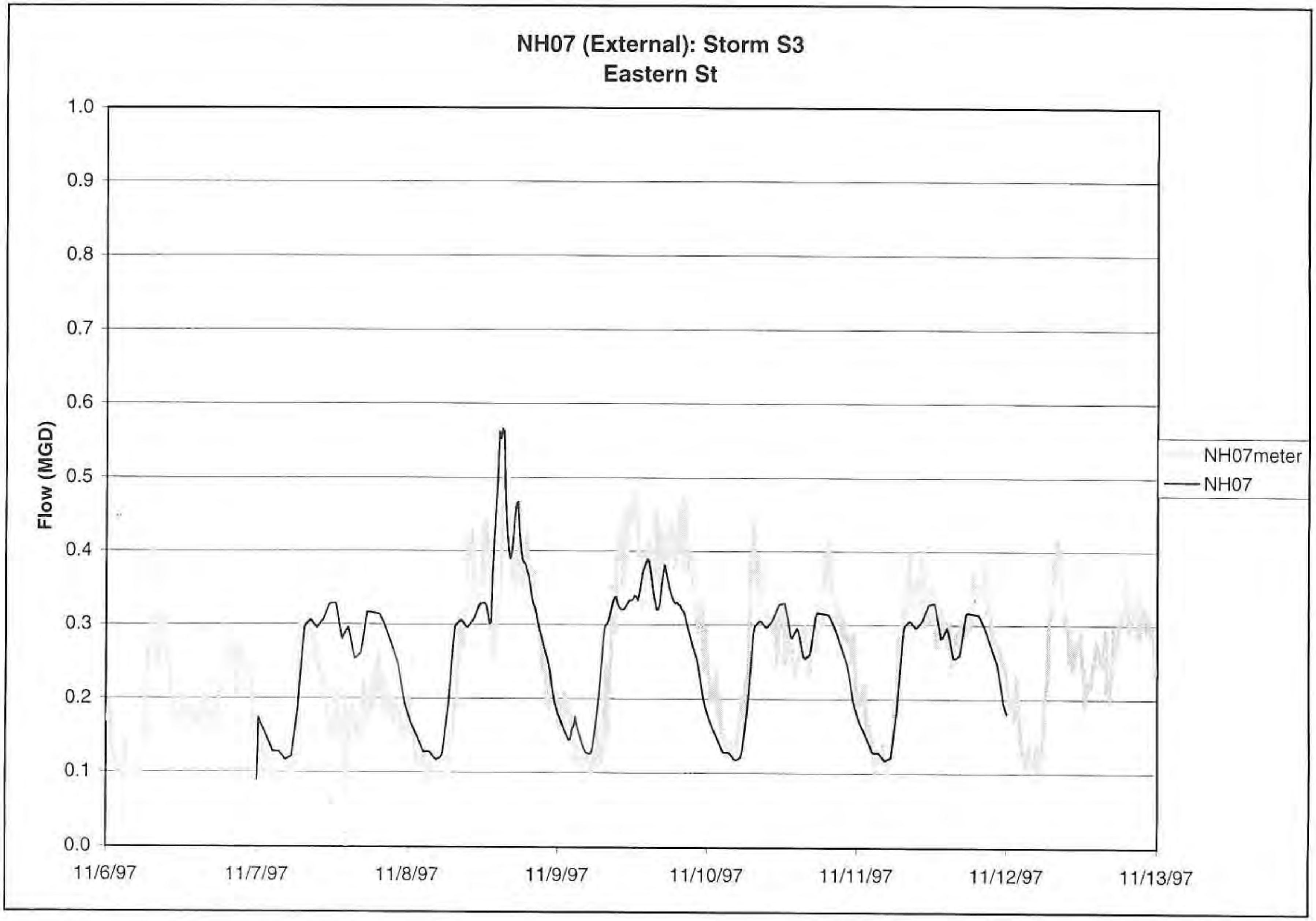


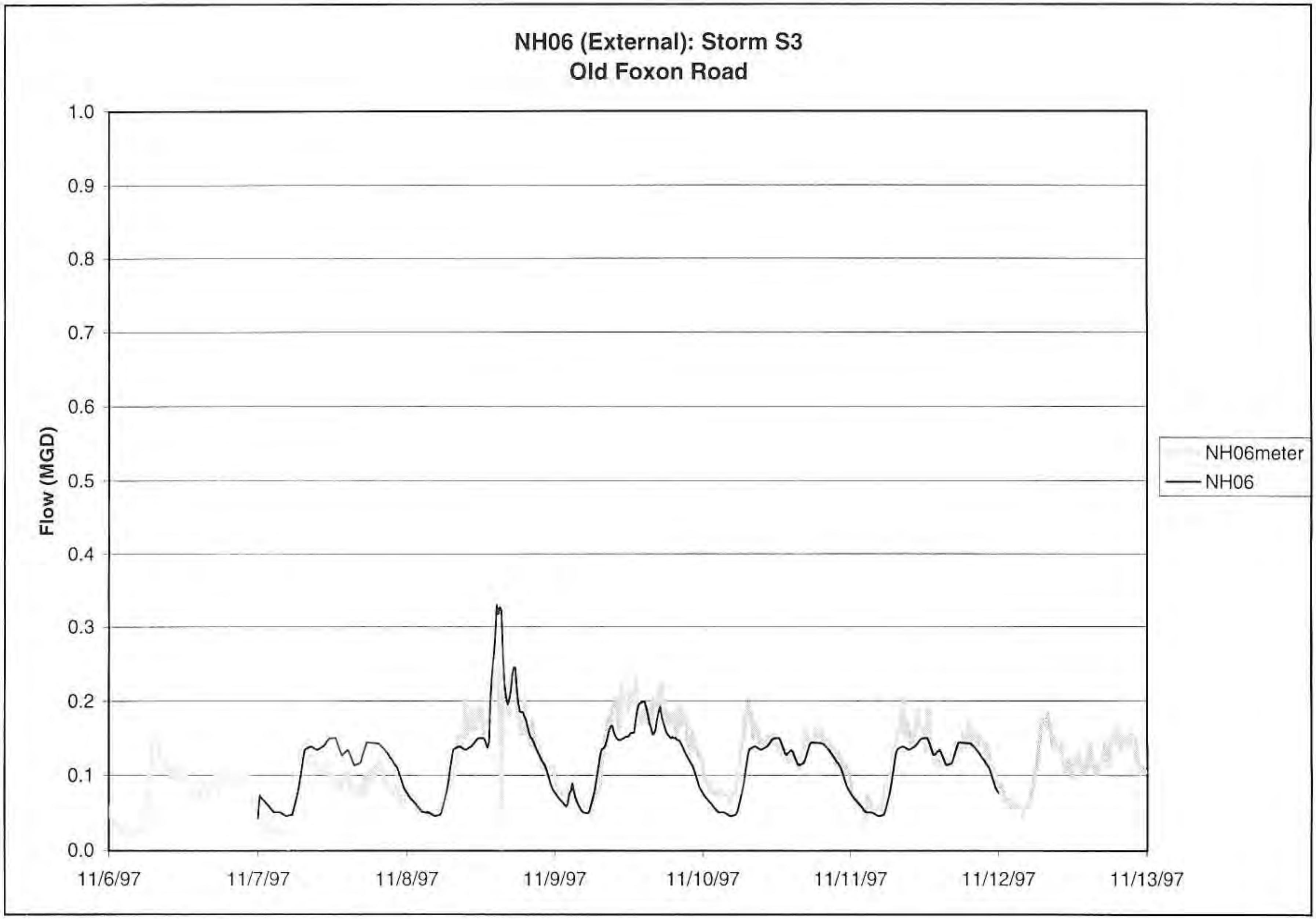
Overflow pipe at 009: Storm S3
Flow (MGD)
10
9
8
7
6
5
4
3
2
1
0
11/6/97
11/7/97
11/8/97
11/9/97
11/10/97
11/11/97
11/12/97
11/13/97
calculated
OF009



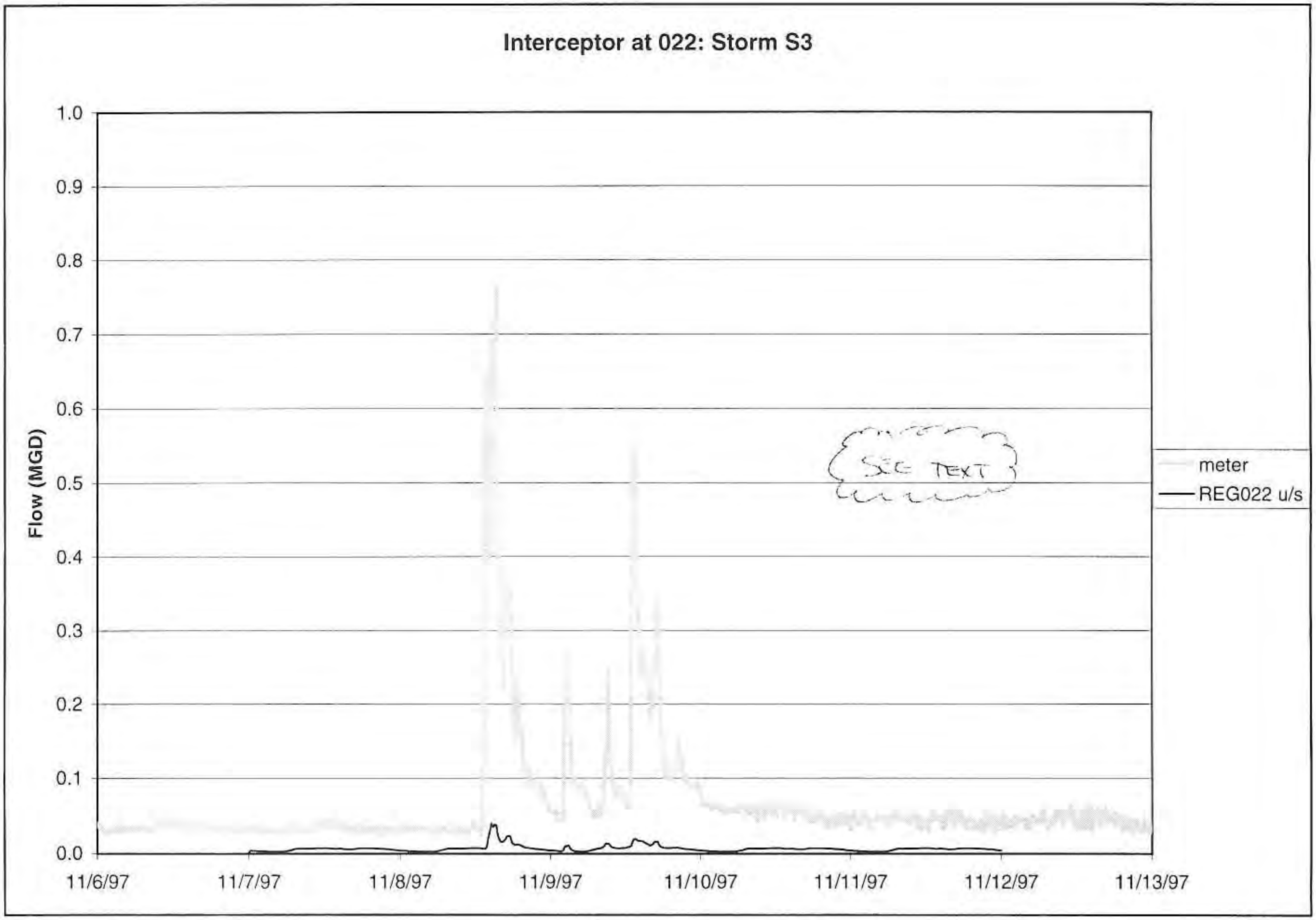
Interceptor at 020: Storm S3
(pump station influence)
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
Flow (MGD)
11/6/97
11/7/97
11/8/97
11/9/97
11/10/97
11/11/97
11/12/97
11/13/97
meter
REG020 d/s


Overflow pipe at 020: Storm S3
Flow (MGD)
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
11/6/97
11/7/97
11/8/97
11/9/97
11/10/97
11/11/97
11/12/97
11/13/97
calculated
OF020

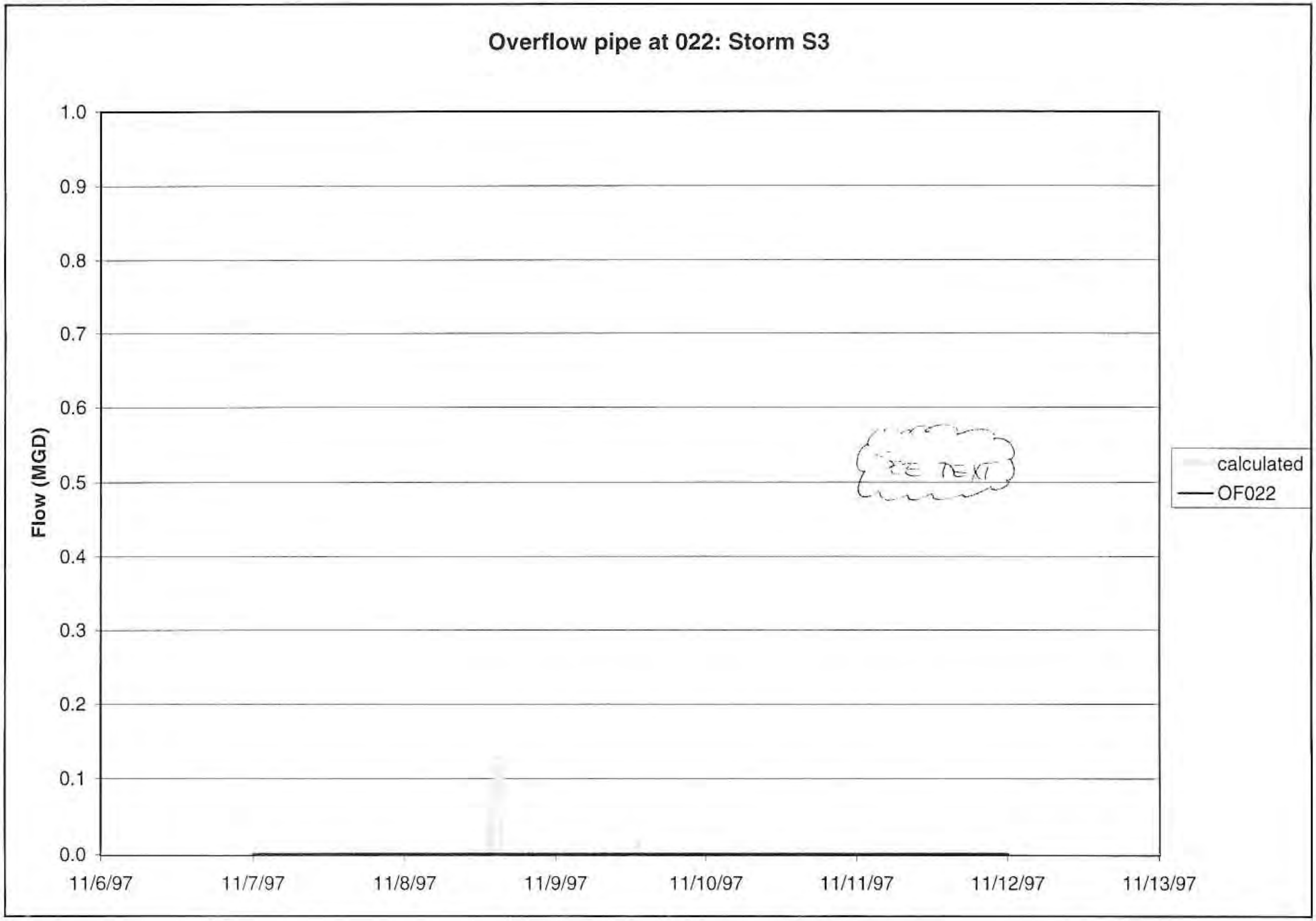

NH07 (External): Storm S3
Eastern St
Flow (MGD)
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
11/6/97
11/7/97
11/8/97
11/9/97
11/10/97
11/11/97
11/12/97
11/13/97
NH07meter
NH07

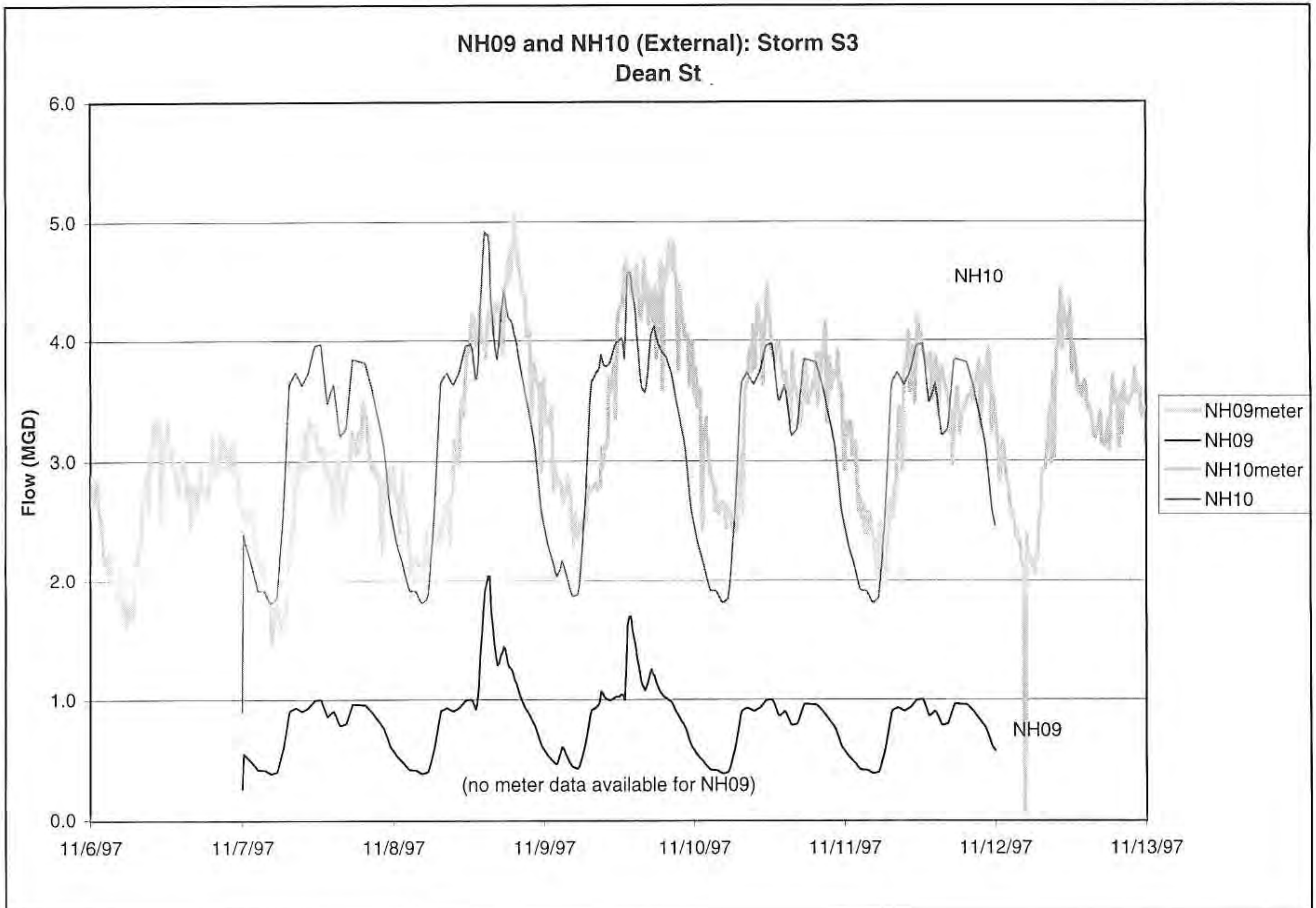


NH06 (External): Storm S3
Old Foxon Road
Flow (MGD)
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
11/6/97
11/7/97
11/8/97
11/9/97
11/10/97
11/11/97
11/12/97
11/13/97
NH06meter
NH06



Interceptor at 022: Storm S3
Flow (MGD)
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
11/6/97
11/7/97
11/8/97
11/9/97
11/10/97
11/11/97
11/12/97
11/13/97
meter
REG022 u/s
SEE TEXT

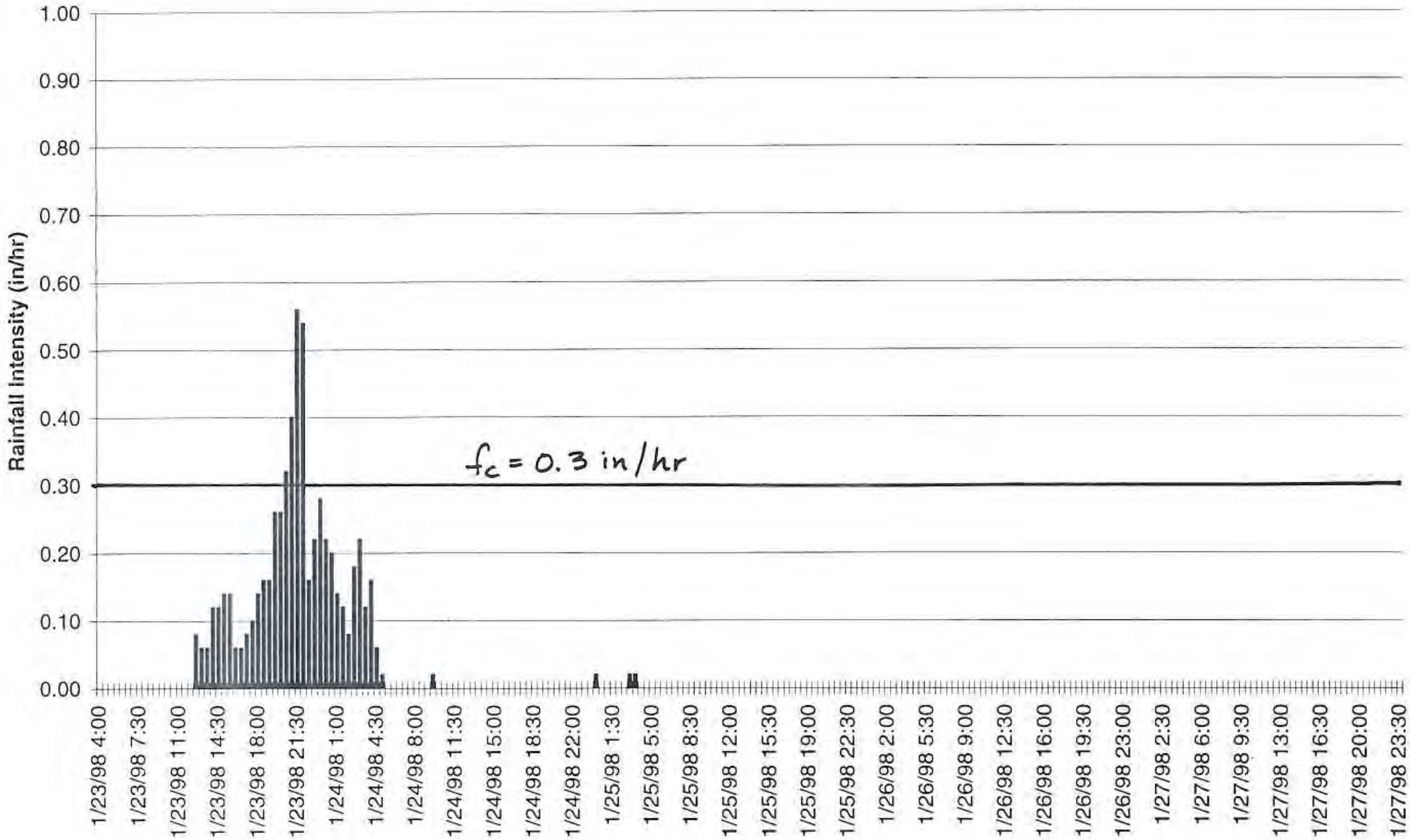

Overflow pipe at 022: Storm S3
Flow (MGD)
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
11/6/97
11/7/97
11/8/97
11/9/97
11/10/97
11/11/97
11/12/97
11/13/97
calculated
OF022

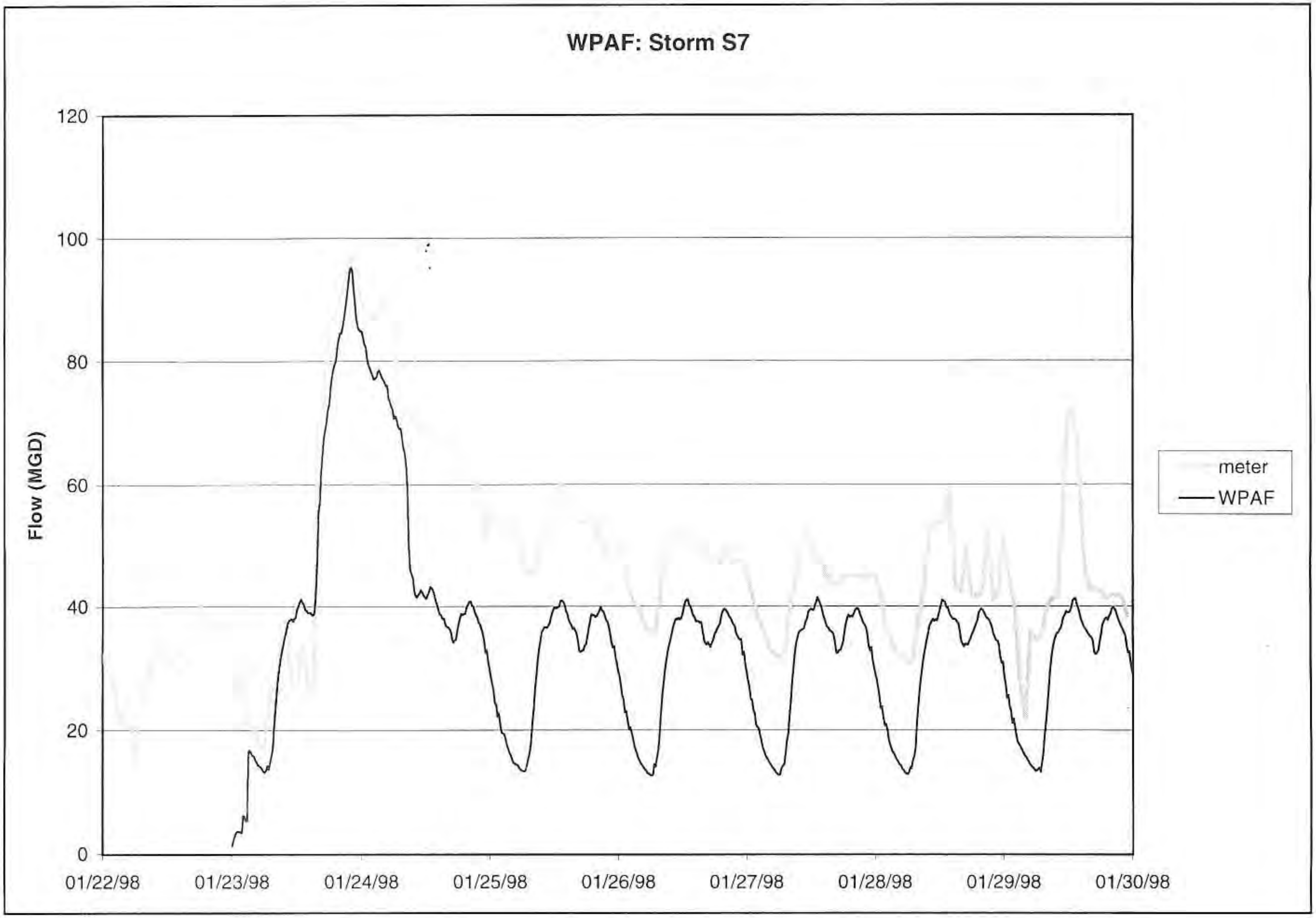


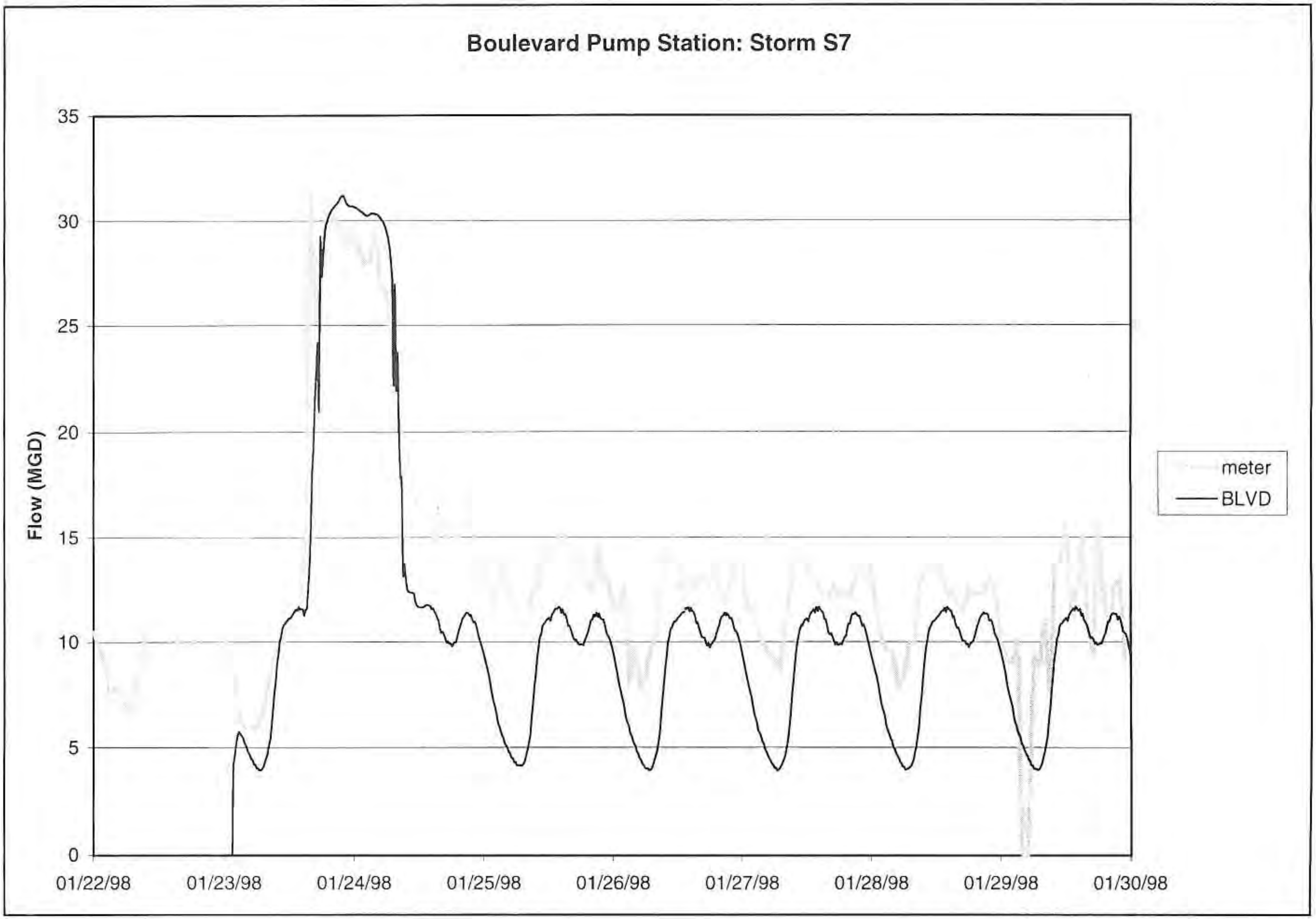
NH09 and NH10 (External): Storm S3
Dean St
Flow (MGD)
6.0
5.0
4.0
3.0
2.0
1.0
0.0
11/6/97
11/7/97
11/8/97
11/9/97
11/10/97
11/11/97
11/12/97
11/13/97
NH10
NH09
(no meter data available for NH09)
NH09meter
NH09
NH10meter
NH10

## Storm S7

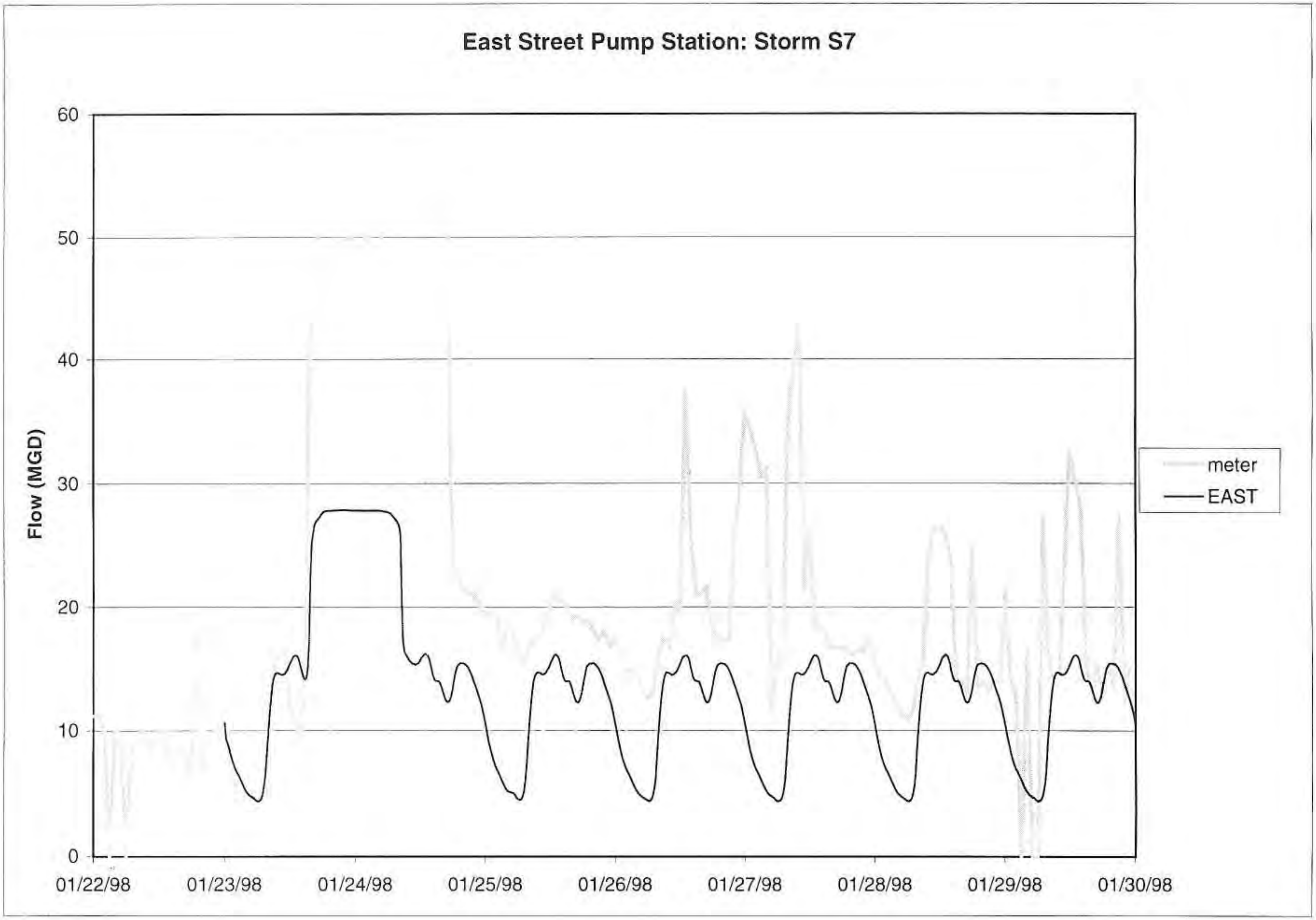
## S7 (WPAF)
30-minute intensity



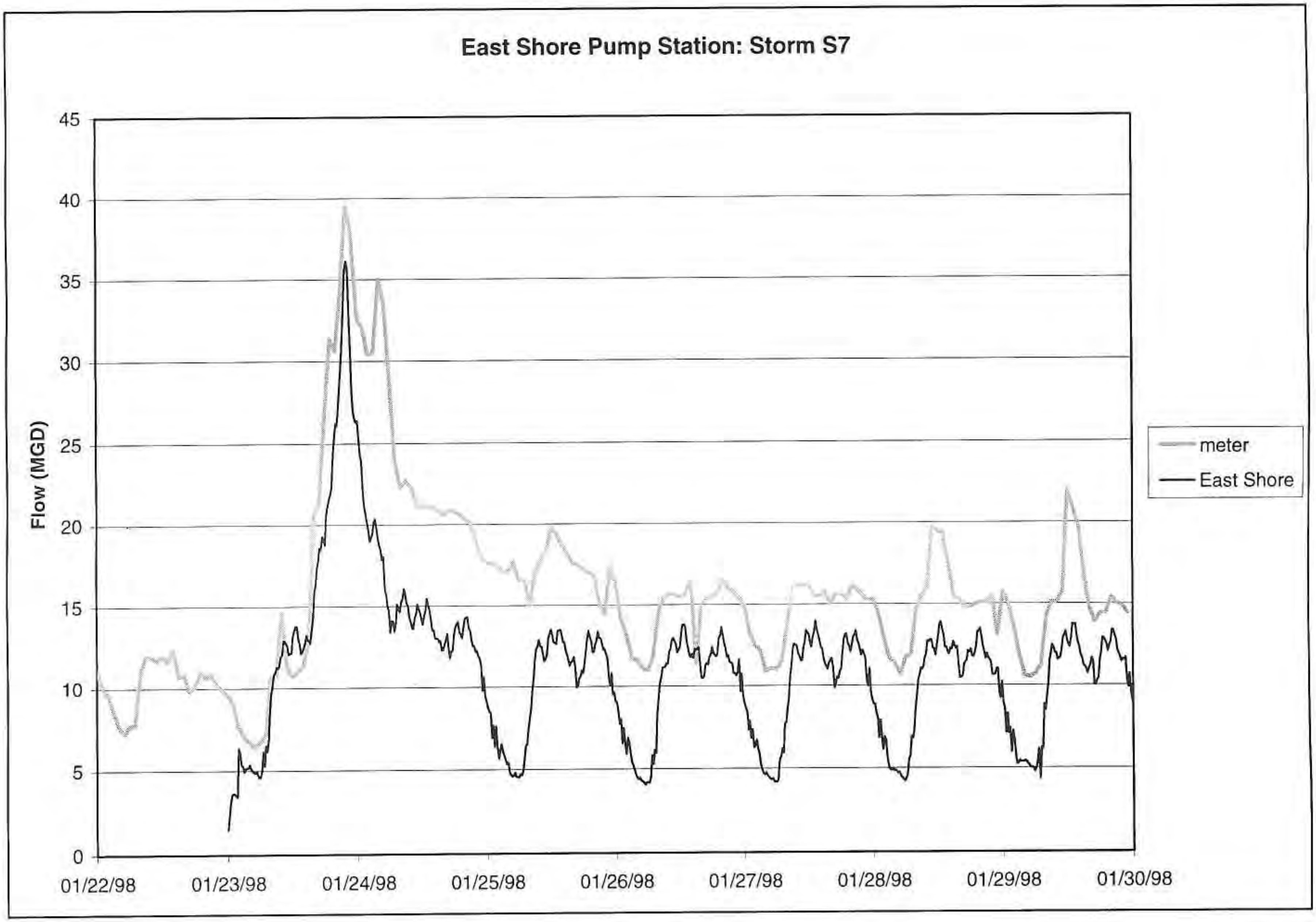

WPAF: Storm S7
Flow (MGD)
120
100
80
60
40
20
0
01/22/98
01/23/98
01/24/98
01/25/98
01/26/98
01/27/98
01/28/98
01/29/98
01/30/98
meter
WPAF



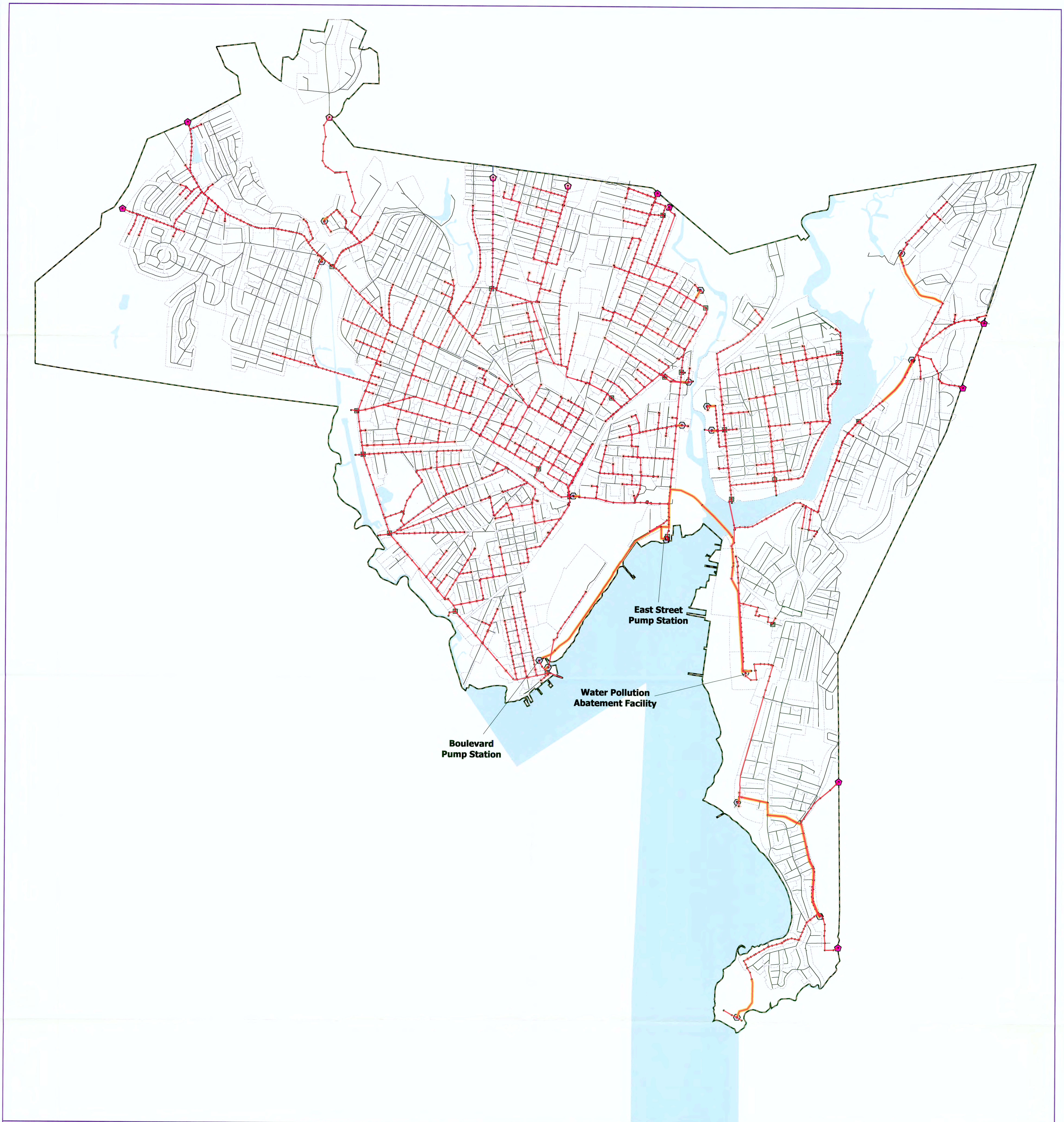
Boulevard Pump Station: Storm S7
Flow (MGD)
35
30
25
20
15
10
5
0
01/22/98
01/23/98
01/24/98
01/25/98
01/26/98
01/27/98
01/28/98
01/29/98
01/30/98
meter
BLVD



East Street Pump Station: Storm S7
Flow (MGD)
60
50
40
30
20
10
0
01/22/98
01/23/98
01/24/98
01/25/98
01/26/98
01/27/98
01/28/98
01/29/98
01/30/98
meter
EAST



East Shore Pump Station: Storm S7
Flow (MGD)
45
40
35
30
25
20
15
10
5
0
01/22/98
01/23/98
01/24/98
01/25/98
01/26/98
01/27/98
01/28/98
01/29/98
01/30/98
meter
East Shore




Sewers, Modeled

Sewers, not Modeled

Forcemain

Modeling Subcatchment

New Haven City Boundary

Water

Pump Station

Manhole, Modeled

Flow Regulator

Flow Inlet

External Flow Meter

N

2000 0 2000 4000 Feet

# Figure F-1

## Extent of Interceptor Model

New Haven Long Term CSO Control Plan

CH2MHILL