The City of New York
Department of Environmental Protection
Bureau of Wastewater Treatment

City-Wide Long Term CSO

Control Planning Project

Hutchinson River CSO

Waste Load Allocation

Water Quality and Sewer System Report

June 2013
Updated September 2014

Table of Contents

List of Appendices

List of Tables

List of Figures

Executive Summary

The Hutchinson River is listed as an impaired waterbody on the New York State 303(d) list for low dissolved oxygen levels, the presence of oil/grease, and pathogens attributed to CSOs and stormwater runoff. Previous planning efforts demonstrated that attainment of water quality standards in the portion of the river within New York City (NYC) could be affected by pollutant loads originating in the upstream portions of the river located in Westchester County. As required by the CWA, a total maximum daily load (TMDL) must be developed for waterways on the 303(d) list to establish the pollutant loadings from the various sources. As an interim step in the TMDL process, and as required by the New York State Department of Environmental Conservation (DEC) 2012 CSO Order on Consent (DEC Case No CO2-20110512-25), the New York City Department of Environmental Protection (DEP) has prepared this report which presents the baseline flow, volumes and pollutant loadings to the Hutchinson River, as well as the results of representative reductions in various loadings upon attainment of water quality criteria. The goal of this report is to characterize and quantify the CSO, stormwater, and other flows and pollutant loads into Hutchinson River, from both NYC and from sources upstream of the city, and to study how the river reacts to those inputs. This report includes a summary of the water quality sampling program implemented by DEP and the development of landside and receiving water models used to support the analysis.

Landside, water, and marsh area sampling were conducted to gather water quality data with the emphasis on collection of an extensive set of pathogen data in both New York City and Westchester County. Prior to commencement of the sampling program, DEP and DEC collaborated in the establishment of the sampling goals, locations, frequency, and laboratory analyses to be performed to obtain the information needed to develop the waste load allocation. The resulting sampling program consisted of four major elements: ambient water quality sampling during dry and wet weather, point of discharge sampling during wet weather at CSOs and stormwater outfalls, flow monitoring, and marshland characterization. Collected samples were analyzed for fecal coliform and *Enterococci* concentrations, dissolved oxygen, temperature, salinity, and turbidity in accordance with standard EPA methods.

Existing landside and water quality models developed under the waterbody/watershed facility plan program were updated with the sampling results and recalibrated. The models were then used to quantify specific pollutant sources in the Hutchinson River including Westchester County r illicit discharges (dry weather flows) and stormwater, and NYC stormwater and CSOs, and to assess the impacts of those loads on attainment of water quality standards.

Model results presented in this report (LTCP baseline conditions) show only sampling station HR01 would be in compliance with the fecal coliform criteria on an annual basis, while all stations from station HR02 through HR09 exceed the fecal coliform water quality criteria (see Section 3.3.1 Figure 3-1 for a map of all the stations). No locations have maximum enterococci 30-day geometric means less than 30 org/100mL during the recreational period. Concentrations continue to rise approaching the headwaters of the river with peak concentrations observed at sampling station HR08 located in Westchester County. While there is some variability to the primary source of *Enterococci* concentration loading, dry weather and stormwater discharges from Westchester County are typically the greatest contributors. At station HR08, dry weather sources from Westchester County become the dominant source and remain so as far downstream as station HR03.

Dry weather sources alone can account for nonattainment in the Hutchinson River from station HR08 to station HR05. During wet weather, Westchester stormwater discharges also account for a significant portion of the *Enterococci* concentrations in the river. NYC sources of *Enterococci* are present at locations HR01 through HR06. Based on the results of the 30-day maximum calculation, significant reductions in *Enterococci* concentrations from Westchester County dry and wet weather sources are required to achieve 100 percent attainment of the *Enterococci* standards.

This report presents the Water Quality Standards for the Hutchinson River (Section 2), the data collection program (Section 3), the modeling calibration analyses (Section 4) and a summary of future conditions analyzed using the model (Section 5).

1.0 Introduction

1.1 History of Hutchinson River LTCP Effort

The New York City Department of Environmental Protection (DEP) has a long history of environmental stewardship and abatement of combined sewer overflow (CSO). New York City first developed conceptual plans in the 1950s to minimize CSO. New York City's 1984 Citywide CSO abatement program successfully controlled dry weather discharges. In 1992, DEP entered into an Administrative Consent Order with the New York State Department of Environmental Conservation (DEC), the requirements of which were incorporated into the State Pollutant Discharge Elimination System (SPDES) permits. This 1992 Order was modified in 1996 to add a catch basin cleaning, construction, and repair program. A new Order on Consent became effective in 2005 and this Order on Consent was modified several times through 2012. On March 8, 2012, the most recent Order took effect; for purposes of this document, this most recent Order on Consent, as well as the provisions of the 2005 Order that remain in effect, are collectively referred to as the "Order."[1]

For the Hutchinson River, pre-2012 planning efforts demonstrated that attainment of water quality standards in the portion of the river within New York City (NYC) could be affected by pollutant loads originating in the upstream portions of the river located in Westchester County. In addition, the Hutchinson River was placed on the 2002 New York State 303(d) list of impaired waterbodies due to the presence of oil/grease, low dissolved oxygen (DO) levels, and pathogens attributed to CSOs and stormwater runoff. Inclusion on the 303(d) list indicates that the river does not meet water quality standards even after control measures have been implemented. As required by the CWA, a total maximum daily load (TMDL) must be developed for waterways on the 303(d) list. The TMDL would establish the pollutant loadings from the various sources that would allow attainment of the water quality standards. For these reasons, the Order includes a sampling program to support the setting of a waste load allocation (WLA) for the Hutchinson River and subsequent development of a TMDL. The approach and results of the sampling program were presented in the December 2012 *Field Sampling Data Report Long Term Control Project Water Quality Monitoring Program for Hutchinson River TMDL/WLA* (DEP 2012). This *Report on Water Quality and Sewer System* is specifically required by the Order, and is intended to present the baseline flow volumes and pollutant loadings to the Hutchinson River, as well as the results of representative reductions in various loadings on attainment of water quality criteria.

1.2 Goal of the Report

The goal of this report is to characterize and quantify the CSO, stormwater, and other flows and pollutant loads into Hutchinson River and to study how the river reacts to those inputs. By sampling from the land, water, and marsh area, a comprehensive program to gather water quality and pathogen data in both New York City and Westchester County was performed. These data, obtained as a result of the sampling program, were used to characterize the impact from CSOs as well as stormwater and other sources. The hydraulic/hydrologic model used during the waterbody/watershed program for landside flows (such as CSO and stormwater discharge) and the water quality model used to evaluate the impact of the pollutants on the water bodies during the waterbody/watershed program were recalibrated using the sampling data.

[1] The 2012 Order on Consent modifies certain provisions of the 2005 Order. Any provision of the 2005 Order that was not modified remains in effect.

These re-calibrated models were then used to define the relative loadings to the Hutchinson River from the various sources and to analyze impacts of the discharges on the river for baseline conditions.

2.0 Hutchinson River Water Body and Watershed

This section presents an overview of the water quality standards, 303(d) status, and CSO and stormwater outfalls associated with the Hutchinson River.

2.1 Applicable Water Quality Standards

In accordance with the provisions of the CWA, the DEC has promulgated water quality standards for all waters within its jurisdiction. DEC developed a system of waterbody classifications based on designated uses which include freshwater and marine classifications. The Hutchinson River is a Class SB (saline) waterbody from Eastchester Bay to E. Colonial Avenue and a Class B (freshwater) waterbody from E. Colonial Avenue to Pelham Lake. NYS water quality criteria for fecal coliform and future water quality criteria for *Enterococci* are listed in Table 2-1. It should be noted that the enterococci criterion currently does not apply to tributaries such as the Hutchinson River, however DEC intends to adopt this criteria in 2015.

A Class SB waterbody is defined as “suitable for fish, shellfish and wildlife propagation and survival” with the best usages “primary and secondary contact recreation and fishing.” (6 NYCRR 701.11).

Table 2-1. Hutchinson River Numerical Water Quality Standards

Class	Usage	DO (mg/l)	Total Coliform (#/100 mL)	Fecal Coliform (#/100 mL)	Enterococci (#/100 mL)
SB	Primary and secondary contact recreation, fishing. Suitable for fish propagation and survival.	>= 4.8 (1) >= 3.0 (2)	2,400 (3) 5,000 (4)	≤200 (5)	≤30 (6)
B	Primary and secondary contact recreation, fishing. Suitable for fish propagation and survival.	>= 5.0 (1) >= 4.0 (2)	2,400 (3) 5,000 (4)	≤200 (5)	≤30 (6)

Notes:
(1) Daily average
(2) Minimum
(3) Monthly median
(4) Maximum for 80% of samples
(5) Monthly GM
(6) Future Primary Contact WQ Criterion: 30-day Moving GM during recreational season (May 1st –October 31st)

2.2 303(d) Listed Segments

As noted above, the Hutchinson River was placed on the 2002 New York State 303(d) list of impaired waterbodies due to the presence of oil/grease, low dissolved oxygen (DO) levels, and pathogens attributed to CSOs and stormwater runoff. In the 2014 draft 303(d) list, the “Middle” reach of the river in

Westchester County remains listed as impaired and requiring a TMDL. The lower part of the river within NYC was moved to the Category 4b Waters list (TMDL not necessary because other required control measures are expected to result in restoration in a reasonable period of time). Inclusion on the 303(d) list denotes that the river does not meet water quality standards even after control measures have been implemented. As required by the CWA, DEC must establish a priority listing of impaired waterbodies, and a TMDL must be developed to establish and allocate the pollutant loadings that would allow for attainment of water quality standards for each impaired waterbody.

Development of a TMDL involves characterizing the impaired waterbody and its watershed, identifying sources of pollution, calculating the loading capacity based on water quality modeling, identifying source allocations, preparing TMDL reports and coordinating with stakeholders. TMDLs specify the maximum amount of a pollutant a waterbody can receive and still meet water quality standards while allocating pollutant loadings among point and nonpoint pollutant sources. TMDLs can be described as the summation of the WLA per point source(s) of pollution, load allocation from nonpoint sources, and a factor of safety. Due to the presence of point sources of pollution to the Hutchinson River in both NYC and Westchester County, it was determined that a WLA is necessary. As an interim step in the TMDL process, and as required by the Order, DEP conducted sampling and prepared a WLA as described in this report.

2.3 Permitted CSO and Stormwater Outfalls

The headwaters of the Hutchinson River are located outside NYC boundaries in Westchester County. From there the river flows through the Bronx and ultimately discharges into the upper East River. The watershed is serviced by the Hunts Point Wastewater Treatment Plant (WWTP). Five permitted CSO outfalls are located within the NYC boundary as listed in Table 2-2. Figure 2-1 shows the locations of the CSOs within the extent of the tributary watershed and the two stormwater sampling locations are shown in Figure 3-1.

Table 2-2. Hutchinson River CSO Locations, Size and Drainage Area from InfoWorks Model

SPDES Outfall No.	Location	Size (W x H)	Drainage Area (Acres)
HP-005	Hollers Ave (Hollers Ave Pump Station)	12’ diameter	Emergency Overflow
HP-006	Bartow Ave (Co-op City South Pump Station)	15’ x 8’-6”	Emergency Overflow + 288 (stormwater only)
HP-023	Conner St (Reg. #15)	12’ x 6’6”	169
HP-024	E233rd St (Reg. #15A)	12’-6” x 10’	408
HP-031	Bellamy Loop (CSO-32, Co-op city North PS)	6’ diameter	91

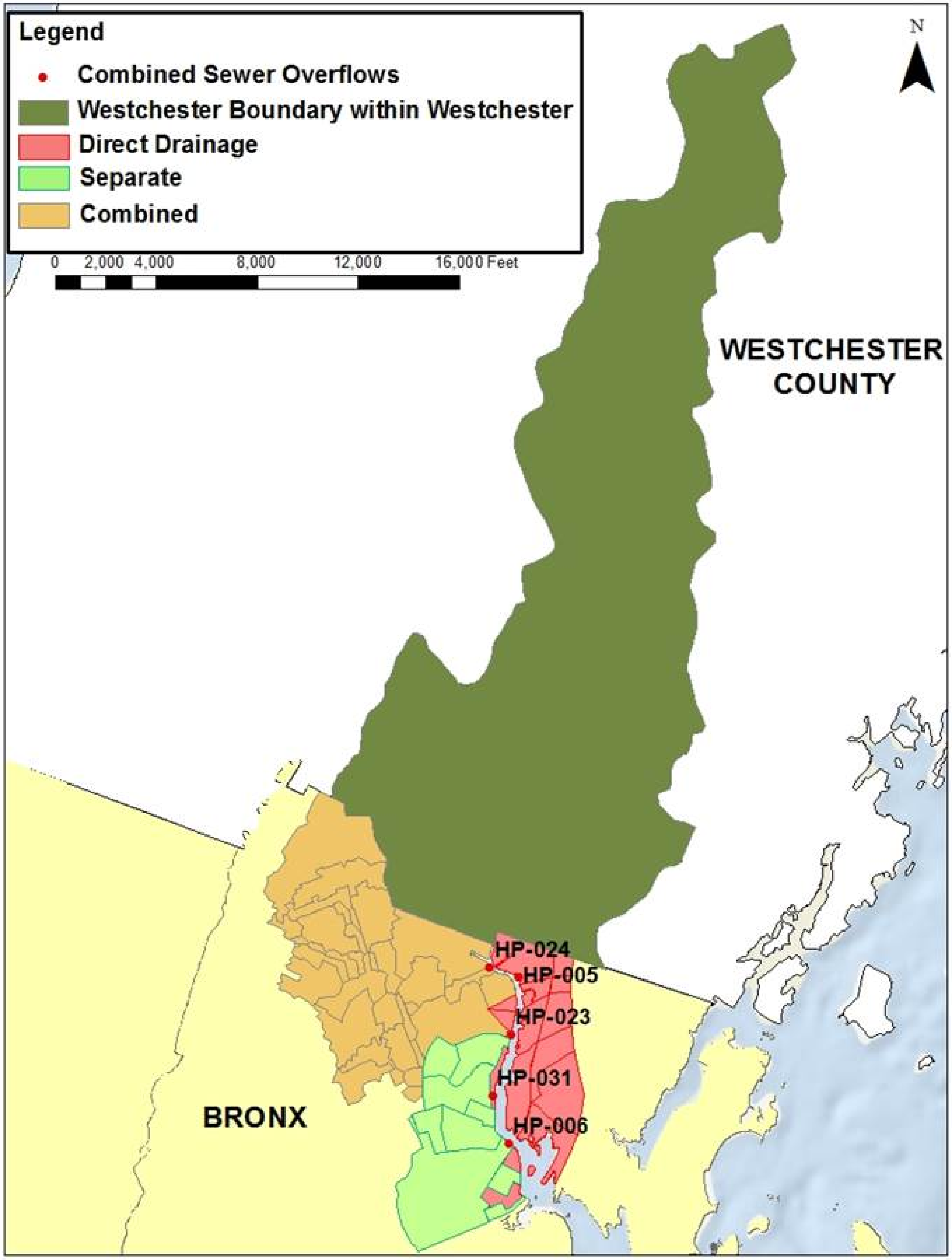


Figure 2-1. Hutchinson River Watershed Showing Runoff Area Delineations and CSO Locations from InfoWorks Model

3.0 Description of Sampling Program and Results

This section describes the sampling program executed to support the development of a waste load allocation for Hutchinson River. Data collected as part of this sampling program were used to calibrate the receiving water model that will ultimately be used to develop the pathogen TMDL. The following paragraphs provide a general description of the sampling program. Additional details can be found in the *Field Sampling and Analysis Plan Long Term Control Project Water Quality Monitoring Plan for Hutchinson River TMDL/WLA* (DEP 2012a) and the *Field Sampling Data Report Long Term Control Project Water Quality Monitoring Program for Hutchinson River TMDL/WLA* (DEP 2012b).

3.1 Sampling Requirements

Prior to commencement of the sampling program, DEP and DEC collaborated in the establishment of sampling goals, locations, frequency, and laboratory analyses to be performed to obtain the information required to develop the waste load allocation. The resulting sampling program consisted of four major elements:

- Ambient water quality sampling during dry and wet weather
- Point discharge sampling during wet weather at CSOs and stormwater outfalls
- Flow monitoring
- Marshland characterization

Sampling frequency by type is summarized in Table 3-1 below. The same set of testing procedures, standards, and methodology was used for all testing. A summary of the testing parameters and methods is provided in Table 3-2.

3.2 Landside Sampling

Two categories of point discharges were sampled: stormwater and CSO outfalls (See Figure 3-1). There are more than 20 storm outfalls to the Hutchinson River within the Borough of the Bronx. To identify waste load contributions from these point sources, samples considered representative of discharges from the stormwater outfalls were collected during wet weather.

Table 3-1. Sampling Type, Frequency, and Number of Events for 2012 Sampling Program (DEP 2012a)

Sampling Type	Frequency	Total Number of Events
Ambient Sampling	2x per day to capture tide; AM and PM sampling runs	7 Wet Weather 5 Dry Weather
Point of Discharge Sampling	Every ½ hour for 90 minutes; Total 4 samples to capture 'first flush'	4 Wet Weather
Marshland Sampling	Every hour at each location; 12 hour sampling period	2 Wet Weather 2 Dry Weather

Table 3-2. Sampling and Analysis Methods and Standards by Parameter for 2012 Sampling Program (DEP 2012a)

Parameter	Analysis Method	Field or Laboratory Test	Field Instrument Name/Type	Minimum Levels/ Instrument Range	Accuracy of Field Instruments	Precision
Fecal Coliform	Membrane filter (MF) 2, single step SM -9222D	Laboratory	NA	NA	NA	NA
Enterococci	EPA Method 1600 (or SM 9320C)	Laboratory	NA	NA	NA	NA
DO	Standard Methods 4500-O G	Field	YSI 6820 V2 Probe	0 to 50 mg/L	0 to 20 mg/L: ± 0.2 mg/L or 2% of reading, whichever is greater; 20 to 50 mg/L: ±6% of reading	0.01 mg/L
Temperature	Standard Methods 2550 B	Field	YSI 6820 V2 Probe	-5°C to +50°C	±0.15°C	0.01°C
Salinity	Standard Methods 2520B	Field	YSI 6820 V2 Probe	0 to 70 ppt	±1% of reading or 0.1 ppt, whichever is greater	0.01 ppt
Turbidity	EPA Method 180.1 or SM 2130B	Field	YSI 6820 V2 Probe	0 to 1,000 NTU	±2% of reading or 0.3 NTU, whichever is greater	0.1 NTU

Sampling events were conducted at manholes upstream from tidal influences in stormwater conduits flowing to outfalls HP-637 and HP-639. Discrete samples were collected every half hour for two consecutive hours. The water quality parameters sampled for and measured were the same as for the ambient water quality sampling. A total of four events were sampled. CSO sampling took place only within NYC limits, since there are no CSO outfalls in Westchester County. As noted previously, five CSO outfalls currently discharge to the Hutchinson River. To characterize the pollutant concentrations at these outfalls, samples were collected from the two largest CSOs (outfalls HP-023 and HP-024). The sampling frequency and parameters were the same as those for stormwater outfall discharge sampling. A total of four events were sampled.

Bacteriological samples were collected using an automatic ISCO sampler during wet weather and by direct grab during dry weather. Samples were placed into sterile sample containers provided by the testing laboratory. Samples were stored in a cooler with ice for transport to a DEC-approved testing laboratory within the required six-hour holding time. The measured parameters of dissolved oxygen, temperature, turbidity and salinity (conductivity) were performed in the field, using the YSI 6820 V2 Probe.

3.3 Water Sampling

Sampling of the receiving water included dry and wet weather grab samples. Hydrodynamic modeling was performed through continuous measurement of salinity and temperature at two depths at two locations for a two week period.

3.3.1 Ambient Water Quality Sampling

To establish ambient water quality characteristics in the Hutchinson River, samples were collected in both dry and wet weather conditions. Both dry and wet weather samples were tested for the parameters shown in Table 3-2. Seven wet weather events and five dry weather events were completed.

Ambient dry weather sampling consisted of collecting samples twice per day for a single day during which no rain was observed for 48 hours prior to the sampling event. Ambient wet weather samples were collected twice per day, within 24 hours of the first indication that all monitored CSO and stormwater outfalls had discharged into the Hutchinson River after a rainfall event. Sampling continued for three consecutive days over a 12-hour period per day, to account for tidal fluctuations. The purpose of this sampling was to define the attenuation of bacteria due to decay and dilution. Sampling locations for all categories are shown in Figure 3-1.

Bacteriological samples were collected using a Kemmerer sampler, and samples were placed directly into the laboratory-provided sterile sample containers. During wet weather events, samples were collected at two depths – two feet below the surface, and two feet above the bottom. The Kemmerer sampler was rinsed with site water prior to collection of each sample, to avoid cross-contamination. Samples were stored in a cooler with ice for transport to a DEC-approved testing laboratory within required the six-hour holding time. The measured parameters of dissolved oxygen, temperature, turbidity and salinity (conductivity) were performed in the field, using the YSI 6820 V2 Probe. The same methodology was used for dry weather and wet weather samples. All collected samples were prepared for delivery at the dock facility (located at Evers Marina, 1470 Outlook Ave., Bronx, NY), where the courier met the boat and land crews for transfer of coolers to the laboratory.

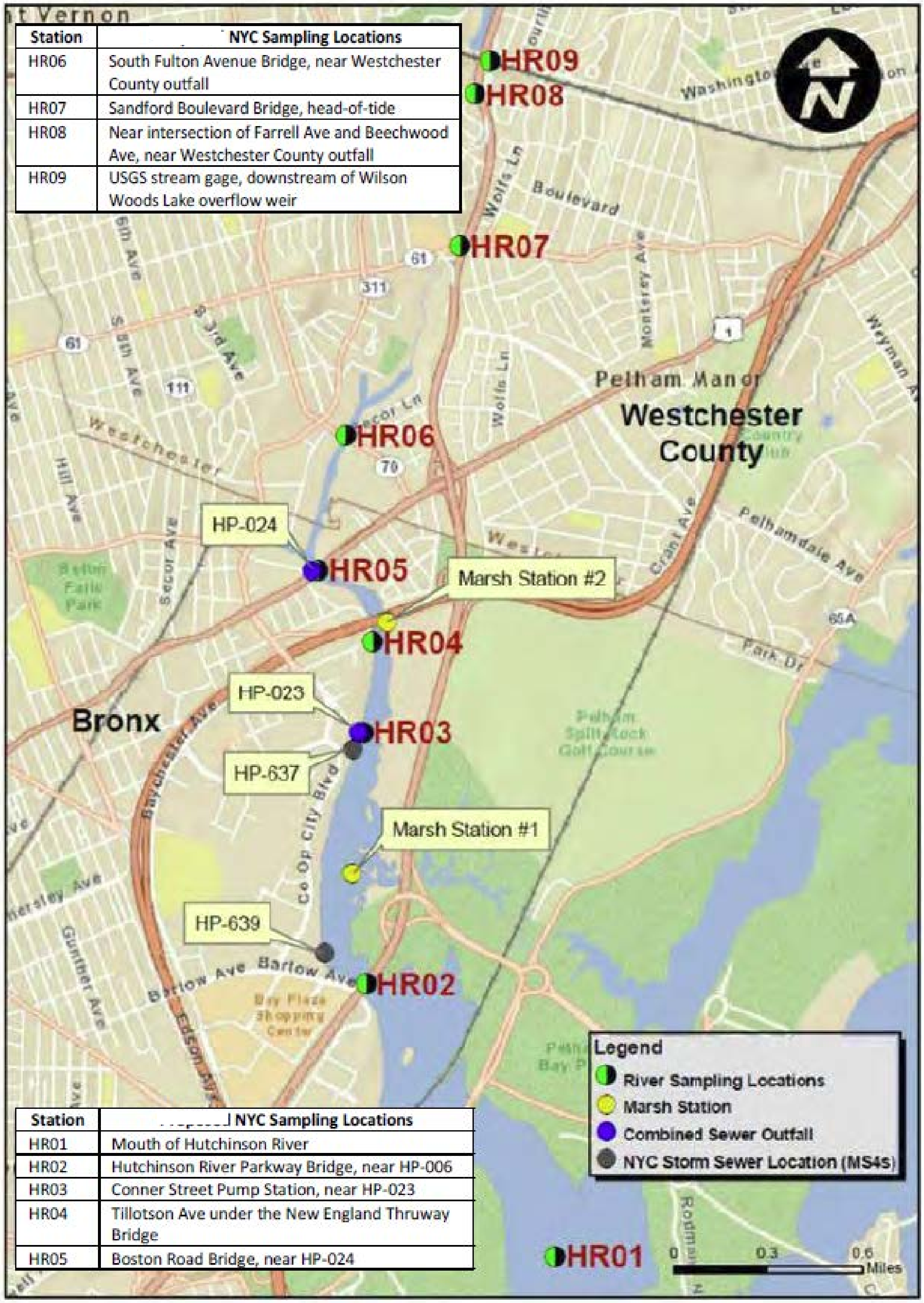


Figure 3-1. Hutchinson River Sampling Locations (DEP 2012a)

AECOM

3.3.2 Hydrodynamic Monitoring

Data sondes were installed at two locations and depths within the Hutchinson River, to continually measure temperature and salinity within the river. Continuous measurements were collected over a two-week period. The first meter was placed 30 feet downstream of CSO outfall HP-024, and the second was 5 feet downstream of CSO Outfall HP-023. These data were used to calibrate the hydrodynamic model. Water surface elevations through the tidal cycle were also monitored continuously throughout the two-week survey period.

3.4 Flow Monitoring

Both in-stream flow and flows in the CSO and stormwater outfall pipes were monitored to support the load quantification.

3.4.1 Upstream Flow Quantification

For development of a TMDL, the upstream loading must be defined for calibration, baseline and projected future conditions. To provide projected upstream loadings for baseline conditions (if different from calibration conditions) and future conditions, loadings are typically correlated to flow or rainfall. In either case, determination of the flow rate during sampling would be needed. A United States Geological Survey (USGS) flow gauge (USGS 01301500), is located on the Hutchinson River where it crosses under the Pelham Parkway (downstream of Pelham Lake). This flow gauge, which is managed and maintained by the New York Water Science Center for the USGS, continuously collects flow data that was obtained from the USGS website. An area velocity flow meter was also installed at this location to provide additional real-time data used for flow quantification. To obtain local rainfall data, a wireless rain gauge was installed at the Conner Street Pump Station.

3.4.2 Point Source Flow Monitoring

Flow meters were installed at the two stormwater monitoring locations (outfalls HP-637 and HP-639), as well as at the two CSO monitoring locations (HP-023 and HP-024). Discrete samples were collected every half hour for two consecutive hours for both stormwater and CSO monitoring locations. Flows at HP-023 were monitored at two locations: the influent to the regulator chamber and the branch connection (diverted flow). Flow was monitored at three locations for HP-024: the influent to the regulator chamber from both the Boston Road and East 233rd Street combined sewers, and the branch connection (diverted flow). These measurements were used for watershed InfoWorks model calibration. For the flow quantification, continuous wave area-velocity flow loggers were used. Teledyne ISCO Model 2150 flow meters were installed and maintained on a weekly basis by Flow Assessment, a sub-consultant to the LTCP team. Flow Assessment also retrieved the data and calculated the flows.

3.5 Marsh Sampling

The eastern side of the Hutchinson River is a relatively large wetland. It is possible that wildlife within this wetland could contribute to the bacteria loading, particularly during the summer months. Therefore, influent and effluent concentrations at two existing rivulets entering and exiting the wetland were monitored. The marsh sampling locations are shown in Figure 3-2. Samples were collected once per hour at each location over a tidal cycle of 12 hours

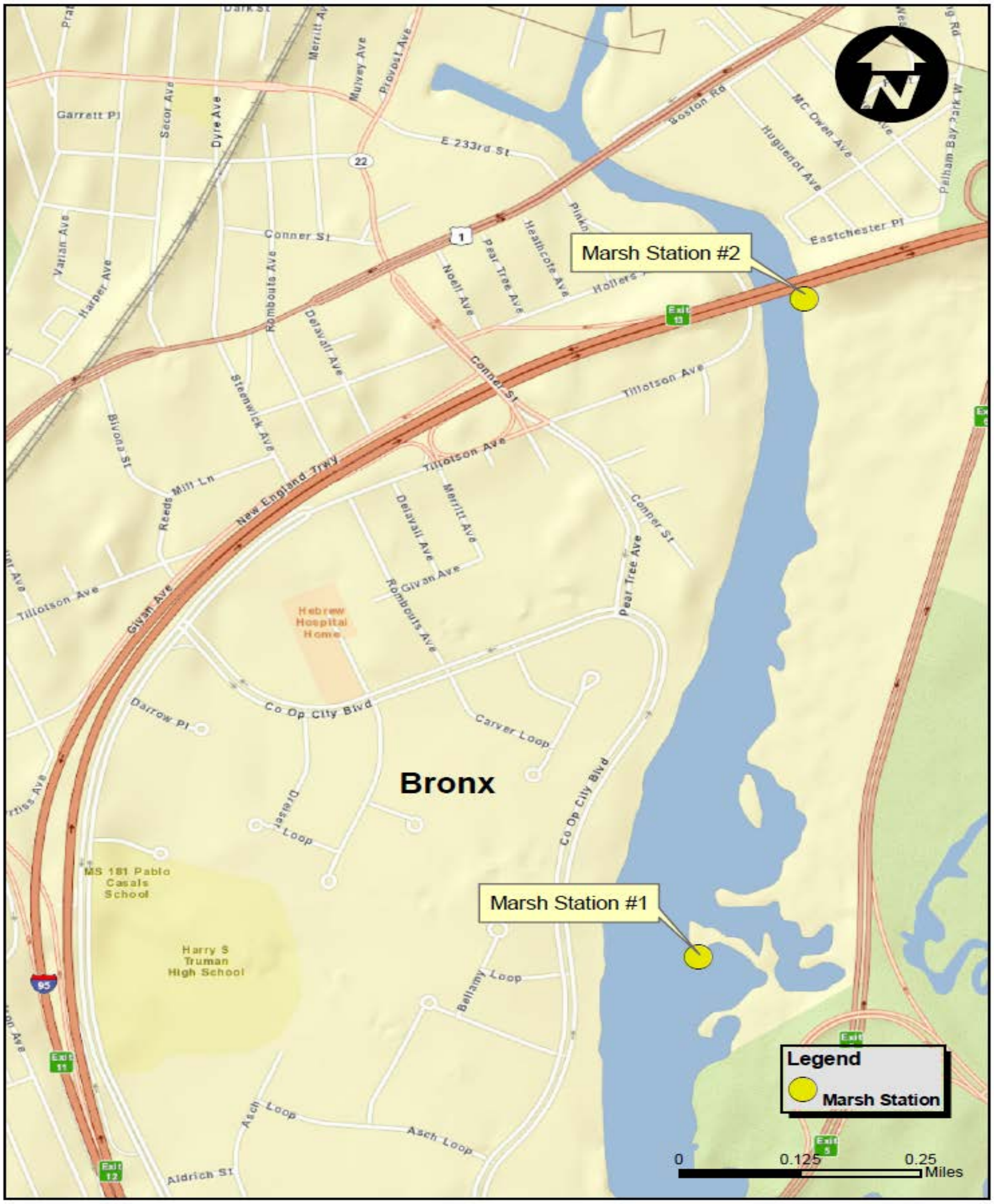


Figure 3-2. Marsh Sampling Locations (DEP 2012a)

Bacteriological samples were collected using a Kemmerer sampler, and samples were placed directly into the laboratory-provided sterile sample containers. Samples were stored in a cooler with ice for transport to a DEC-approved testing laboratory within the required six-hour holding time. The measured parameters of dissolved oxygen, temperature, turbidity and salinity (conductivity) were performed in the field, using the YSI 6820 V2 Probe.

4.0 Model Recalibration

This section presents a review of previous landside and receiving water modeling, and describes the update and recalibration of the land-side and receiving water models for use in assessing the impact of pollutant loads on water quality in the Hutchinson River.

4.1 Overview of Previous Landside Modeling Efforts

During development of the Waterbody/Watershed Facility Plan (WWFP) under the Long-Term CSO Control Plan Project, the commercially-available hydrologic/hydraulic model InfoWorks (IW) was used to model the Hunts Point WWTP service area (and associated conveyance system) as documented in the *City-Wide Long Term CSO Control Planning Project, Landside Modeling Report*, dated October 2007, Volume 4 (DEP 2007a). This report documented the development and the status of the collection/conveyance system model as of October 2007 and presented results showing the goodness of fit between calculated model flows and depths with those measured within the collection system at various times prior to 2007. The version of the model employed by the DEP as documented in this report was InfoWorks CS version 7.5.

The 2007 report contains an extensive amount of information relative to the collection system and the configuration and application of the model to it. The report should be considered a starting point for understanding the collection system modeling process being followed by DEP during the development of the LTCPs. Over time, the sewer system model has been modified and updated based on new information obtained during various facility planning and design projects. Since 2007, various activities related to inspection of the combined sewer system, flow monitoring, compilation of data to refine the understanding of system hydraulics, and hydraulic calculations have been conducted as part of on-going projects. All of these activities provide information which can and has been used over time to update and improve the IW model discussed herein.

4.1.1 Previous Model Hydrology

The InfoWorks model calculates runoff in a hydraulic module within the software that is based on hydrology originally contained within the United States Environmental Protection Agency (EPA) Stormwater Management Model (SWMM). The runoff module contains two surfaces: a pervious surface and an impervious surface. When rainfall is imposed on pervious surfaces, a fraction of it can infiltrate into the soil using different modeling approaches while the remaining fraction will form overland surface flow (i.e., runoff) that is then routed to the entry point to a storm or combined sewer. Rainfall flowing on an impervious surface would have a small fraction that could pond on the surface with by far the largest portion of the rainfall flowing directly into the sewer system. The approach followed during the IW modeling documented in the October 2007 reports was to use the Horton equation to calculate the amount of rainfall that infiltrates into the ground from pervious surfaces. For impervious surfaces all rainfall, except a very small initial amount that ponds, was assumed to flow directly into the sewer system. For any given area, the portion that was defined as impervious was estimated using available data from the NYCMap GIS street and building footprint layers, with an additional 10% to account for sidewalks and additional impervious surfaces not in the street right of way.

4.2 Description of Current Landside Model

The current landside model was updated from its previous version through a global recalibration effort for the entire Hunts Point WWTP sewer system. As DEP started to focus attention on the use of green infrastructure to manage street runoff by either slowing it down as it enters the combined sewer network or preventing it from entering the network entirely, it became clear that a more detailed evaluation of impervious cover would be important. In addition, DEP realized that it would be important to distinguish, during this evaluation, between impervious surfaces that directly introduce runoff into the sewer system from impervious surfaces that may not contribute runoff to the system. For example, a rooftop with roof drains directly connected to the combined sewers, as required by the NYC Plumbing Code, would be an impervious surface that is directly contributing runoff to the combined sewer system. A road or right-of-way sidewalk would also be directly contributing runoff. However, a sidewalk in a park or cemetery may not contribute runoff to the combined sewer system. A portion of a sloped roof draining onto a lawn would be another type of impervious surface that may not be directly connected to a combined sewer system.

In 2009 and 2010, DEP invested in the development of high quality satellite measurements of impervious surfaces at a 7.9 ft by 7.9 ft (2.4 meter) pixel level to provide such planning level impervious data. These data were provided by the Columbia University Lamont Earth Observatory. The main focus of the model recalibration was to refine the IW model with these new impervious cover data.

The general approach was to recalibrate the model in a stepwise fashion with the main emphasis of the calibration being to focus on the hydrology module (runoff). The following steps summarize the approach to model recalibration.

- Site Scale Calibration (Hydrology): The first step in the recalibration process was to focus on the hydrologic component of the model, which was the portion of the model most affected by the changes made since October 2007. The runoff module is where the impervious areas were modified. Flow monitoring data were collected in upland areas of the collection system, remote from (and hence largely unaffected by) tidal influences and in-system flow regulation for use in understanding the runoff characteristics of the impervious surfaces. These areas were on the order of 15 to 400 acres in spatial extent. The main focus of this element of the recalibration was to adjust pervious and impervious area runoff coefficients to provide the best fit of the runoff observed at the upland flow monitors.

- Areawide Recalibration (Hydrology): The next step in the process was to focus on larger areas of the modeled system where historical flow metering data were available and which were still unaffected by tidal backwater conditions and not subjected to flow regulation. Where necessary, runoff coefficients were further adjusted to provide reasonable matches to flow measurements made at the downstream end of these larger areas.

- Areawide Recalibration (Hydraulics): The calibration process then moved downstream further into the collection system where flow data were available, in portions of the conveyance system where tidal backwater conditions could exist as well as potential backwater conditions from throttling at the Hunts Point WWTP. The flow measured in these downstream locations would further be impacted by regulation at in-system control points (regulators, internal reliefs, etc.). During this step in the recalibration, little if any changes were made to runoff coefficients as other elements such as sediment levels in interceptors had more of an impact on calculated system flows.

- Hunts Point WWTP Calibration: The final step in the recalibration process was to examine the calculated flows reaching the Hunts Point WWTP, the most downstream portion of the conveyance system. At this step in the recalibration process, the focus of the recalibration was on both the impervious cover runoff coefficients as well as operational actions taken at the Hunts Point WWTP to control inflows to the facilities.

4.2.1 Updated Model Hydrology

A major change made to the IW model was the way in which the subcatchments were set up. Each subcatchment was represented by two different surfaces that had unique characteristics.

4.2.1.1 Pervious Surfaces

Previously, pervious surfaces were considered to infiltrate rainfall into soils based on the Horton equation. The basic premise of the Horton equation is that the amount of infiltration within the soils is based on the soil properties and that rainfall would continue to infiltrate as long as the intensity was less than the soil absorption capacity. More intense rainfall would produce runoff which would enter the collection system.

In the updated setup, the runoff coefficient approach was adopted for the model after researching the types of soil and infiltration data available from the NYC Water and Soil Conservation Service. In short, the available data would not provide additional insight on surface infiltration characteristics to allow refinement or continued use of the Horton equation approach to characterizing runoff behavior from pervious surfaces. As such, two types of pervious surfaces were developed for each subcatchment and appropriate land areas developed from GIS analyses; open space pervious surfaces and non-open space pervious surfaces. Open space pervious surfaces included parks, cemeteries, highway medians and similar surfaces where surface soils were not subjected to consolidation by constant use. Non-open space pervious surfaces were defined as front and backyards in developed areas where soils would likely be consolidated through use. Open space pervious surfaces were assigned a runoff coefficient of 0.2 while non-open pervious surfaces were assigned a runoff coefficient of 0.4. These coefficients were consistent with DEP drainage planning design values as well as common usage in other similar modeling assessments.

4.2.1.2 Impervious Surfaces

Previously, the runoff coefficient for impervious surfaces was assigned an initial value of 1.0, and then the GIS-based imperviousness values were adjusted during calibration.

However, as it was recognized that the directly-connected impervious areas (DCIA) were the areas of interest since they produce the runoff that would reach the collection system. The greatest impervious area runoff coefficient was treated as the primary calibration parameter during the recalibration analyses. As a result, the starting value for the impervious surfaces was the area provided by the Columbia University analysis. The final value for the DCIA in acres would then be the area provided by the Columbia University analysis multiplied by the final runoff coefficient for the impervious area developed during the recalibration process. This resulted in an approach that utilized the detailed imperviousness data, while controlling the runoff predicted from those surfaces through a coefficient, such that modeled output matched observed data.

In addition, to simulate runoff from impervious areas that have little or no initial rainfall losses (depression storage), one fourth of the impervious areas was assumed to have no initial losses. This assumption was made based on site-scale data analyses. Thus, the total drainage area in a subcatchment was subdivided into four types of surfaces: impervious surface without depression storage, impervious surface with depression storage, pervious non-open surface and pervious open surface.

4.2.2 Other Updates

InfoWorks software version 10.5, being a more up-to-date version of the model, was employed in all analyses described herein for this recalibration effort. This allowed all of the sewer system models to be applied in the most updated and advanced software framework available at the time.

In the 2007 LTCP model, an average of 0.1 in/hr evaporation rate was used for model calibration, while no evaporation rate was used in the future condition simulations, as a conservative measure. The Northeast Regional Climate Center (NRCC) affiliated with Cornell University has developed a semi-physical model which estimates hourly evapotranspiration (ET). Continuous hourly ET estimates were obtained from Cornell for the New York City NOAA climate stations (JFK, EWR, CPK and LGA) for an 11-year period from 2000 to 2011. The data were then used to calculate monthly average ET. The monthly average ET rates developed from these long-term data were then used in the models. The June 2012 *InfoWorks Citywide Recalibration Report* provides additional information on the revised evaporation rates used in the model.

Finally, detailed pipe sediment data were incorporated into the modeled interceptors to represent a more realistic representation of the pipe conditions after DEP completed a citywide inspection and cleaning program.

4.3 Recalibration of Landside Model

This section summarizes the efforts undertaken to recalibrate and/or validate the landside model specifically in the Hutchinson River tributary area.

4.3.1 Hutchinson River Tributary Area

After the overall model recalibration was completed, the specific tributary area of the Hutchinson River was calibrated.

The updated landside model in the vicinity of the Hutchinson River tributary area (shown in Figure 4-1) contains two CSO outfalls (HP-023 and HP-024) that were validated using flow monitoring data collected and described in Section 3.4. In addition, monitoring data for stormwater outfalls HP-637 and HP-639 were also used to validate the model’s predictions of flows in these two conduits, tributary to the Hutchinson River. Figure 4-2 illustrates the combined sewer meter locations. Table 4-1 summarizes the rain events observed during the monitoring period that were used to validate the model. The monitoring period data set spanned 5/1/2012 through 10/1/2012, and the six events chosen for use in the model captured a variety of storm depths and intensities, including a large event, medium-sized event, and smaller ones.

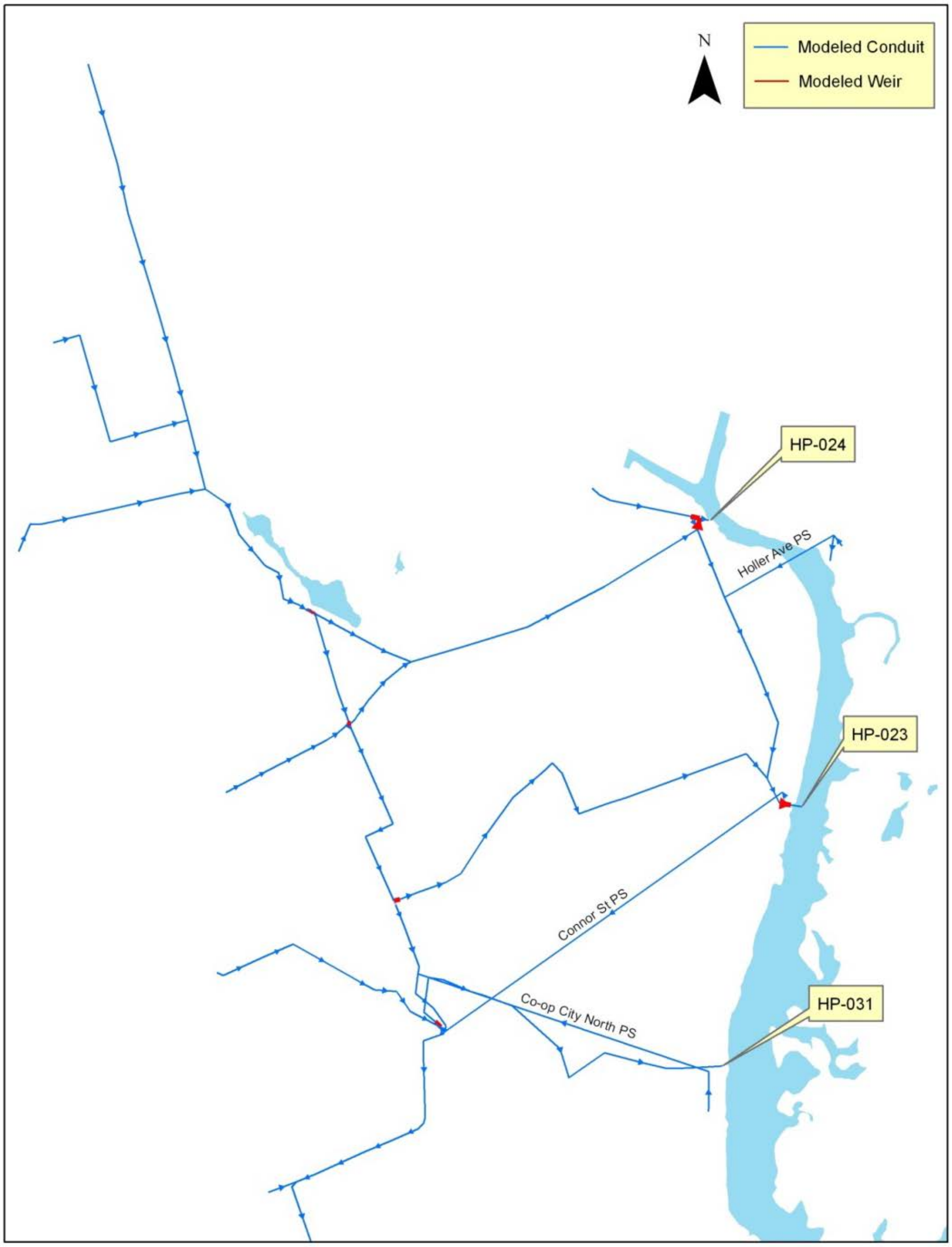


Figure 4-1. InfoWorks Collection System Model Schematic Adjacent to the Hutchinson River

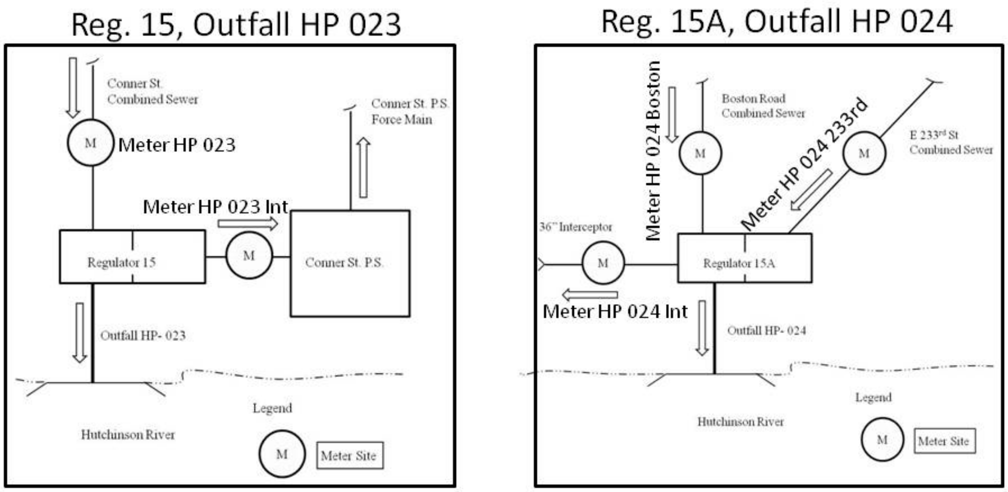


Figure 4-2. Combined Sewer Meter Locations at Outfalls HP023 and HP024 (DEP 2012b)

Table 4-1. Summary of Rain Events in Monitoring Period used to Validate InfoWorks Model Calibration (DEP 2012b)

Event	Rain Duration (minutes)	Peak Intensity (in/5 min)	Time of Peak	Total depth (in)
9/29 Event	590	0.41	9/28/2012 9:35	3.08
5/22 Event	1515	0.08	5/21/2012 8:30	1.28
9/18 Event 1	325	0.16	9/18/2012 4:55	0.59
9/18 Event 2	150	0.28	9/18/2012 19:00	1.12
9/8 Event	100	0.11	9/8/2012 9:25	0.59
5/30 Event	320	0.13	5/29/2012 20:35	0.32

Criteria suggested in the Wastewater Planning Users Group (WaPUG, 2002) guidance document were used to evaluate the adequacy of the model calibration. The criteria were:

The timing of the peaks and troughs should be similar, having regard to the duration of the event.

- The difference between observed and modeled peak flow rates at each significant peak should be in the range +25% to -15% and should be generally similar throughout the complete simulation of each event.

- The differences between observed and modeled volume of flow should be in the range +20% to -10%.

- The differences between observed and modeled depth of surcharge should be in the range +16 inches to –4 inches

- The differences between observed and modeled un-surcharged depth at any key points, where this is important having regard to the objectives of the model (e.g., at combined sewer overflows), should be within the range ±4 inches.

For each validation event, modeled versus observed hydrographs were generated to evaluate the model's performance. In addition, the goodness-of-fit was also examined by comparing the modeled event volume, peak flow and maximum water depth of the events to the observed data in goodness-of-fit scatter plots. The upper and lower WaPUG calibration criteria bounds were marked for comparison in goodness-of-fit plots. Hydrographs and goodness-of-fit plots comparing model and data at HP-024, HP-024, 637 and 639 are included in Appendix A. A brief discussion of the model calibration follows.

The model predictions at Regulator 15 (HP-023 influent, Figure 4-3) for the monitoring period storms demonstrate that the model is reasonably calibrated, with most data points within or near the WaPUG guidance ranges. Depth was slightly under-predicted, but this could be due to local sediment or issues with the upstream piping vertical alignment. Flows to the interceptor (branch connection) are also well calibrated as shown in Figure 4-4, with most data points falling within or near the guideline ranges. Depths at this location, which are indicative of overflow potential (relative to the diversion weir), were well calibrated.

Model predictions at Regulator 15A (HP-024 influent, from 233rd St) were slightly over-predicted for volume and peak flow, but the drainage area is very small and the magnitudes of flows are small also. An edit was made to this subcatchment in the model to reduce its contributing area (to reflect current mapping) and it still over-predicted the measured flows. The majority of the influent to Regulator 15A (HP-024) comes from Boston Street, and is well calibrated. Flows to the interceptor (branch connection) are also well calibrated, with most data points falling near the guideline ranges. Volumes and peak flows were slightly over-predicted, but this is due to local variations in dry weather flow during this monitoring period. This was confirmed with sensitivity analyses of local base flow variations. Depths at this location, which are indicative of overflow potential (relative to the diversion weir), were well calibrated.

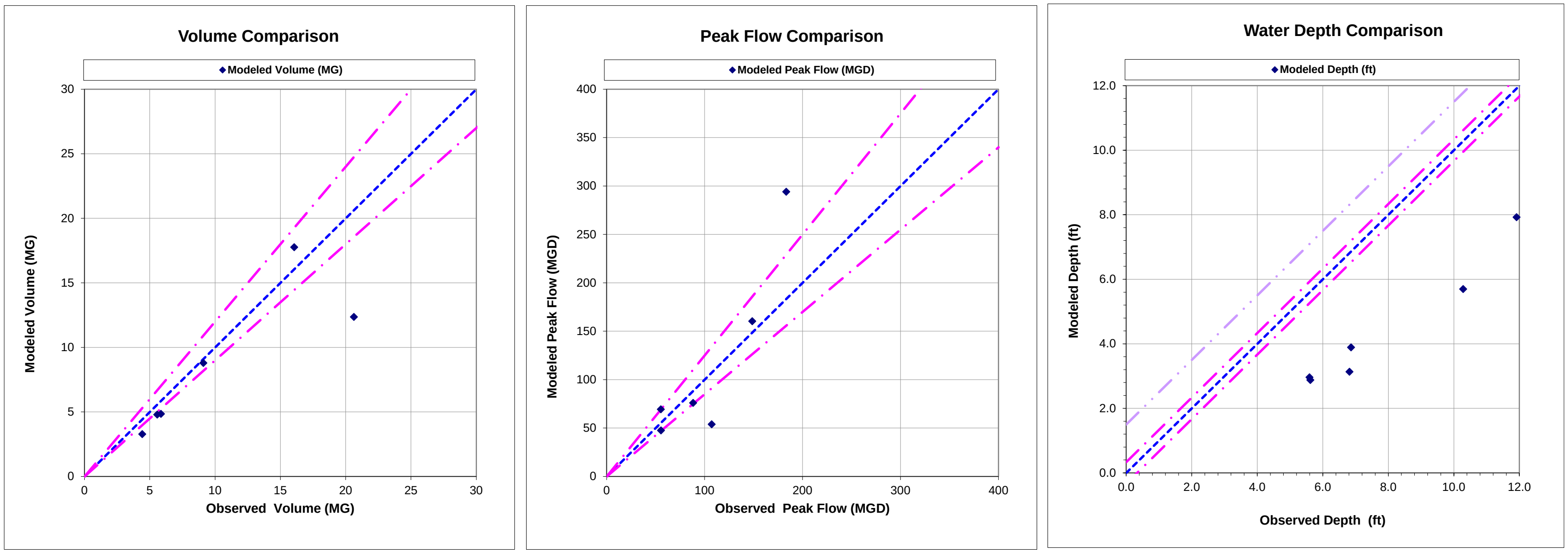


Figure 4-3. Goodness of Fit Plots (Modeled vs. Measured) for Volume, Peak Flow and Peak Depth for Regulator 15 Influent Flow (HP 023)

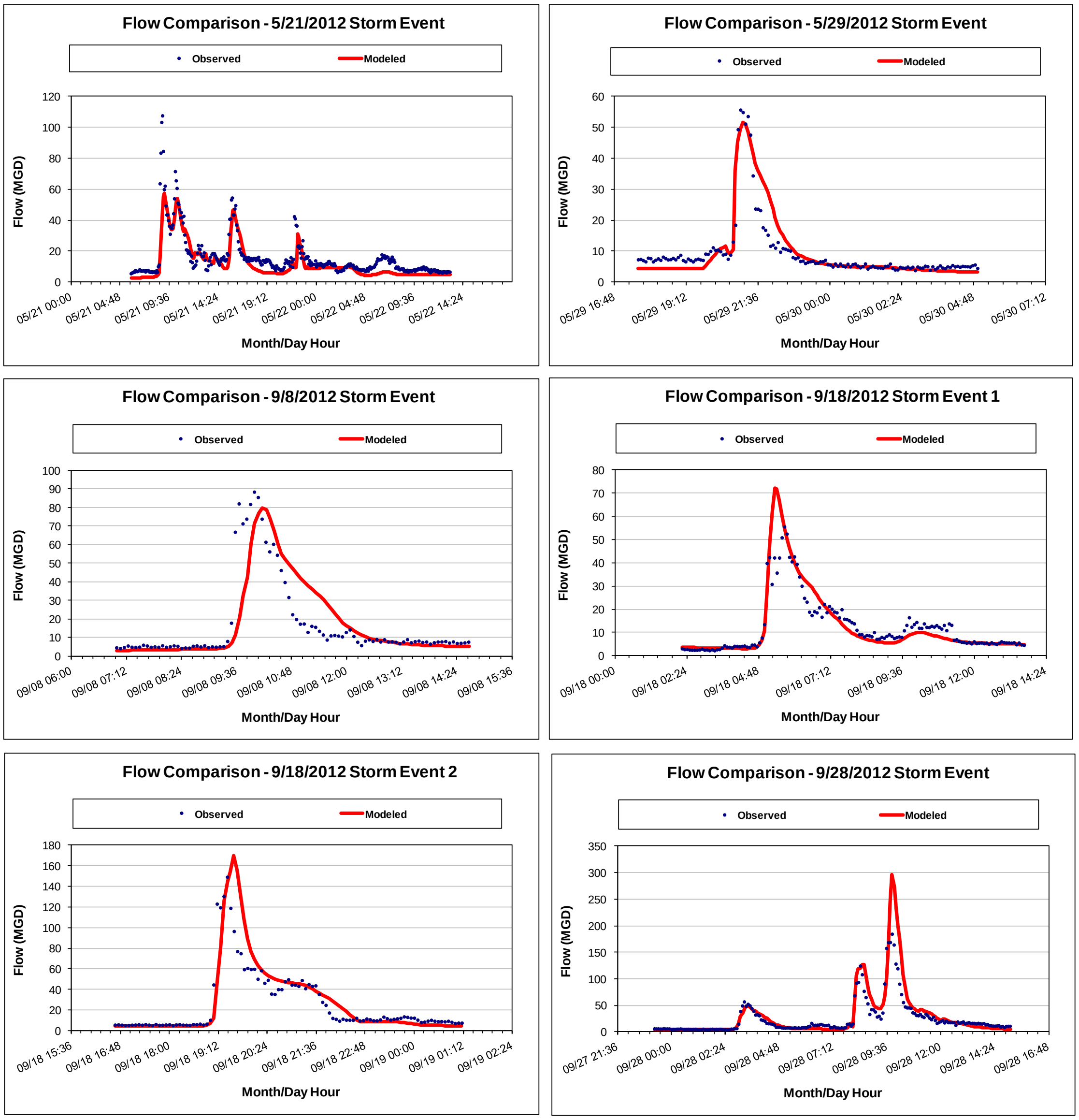


Figure 4-4. Comparison of Observed and Modeled Flow in Interceptor Connection at Regulator 15 (HP 023) for Six Storm Events in Monitoring Period

Modeled volume was slightly over-predicted for both separate stormwater measurement locations (637 and 639), but peak flow was well calibrated. Both areas had very small tributary drainage areas (30 acres +/-) and the magnitudes of flows and volumes measured reflect this fact. The runoff coefficients are already relatively low (0.5) and thus engineering judgment dictated that these values not be reduced any further based on knowledge of the land area and runoff potential. A detailed evaluation of the time series hydrographs was also performed and it was found that the model performed reasonably well from this perspective.

Overall the model performs well in capturing the response of each of the observed events, matching total storm volume, peak flow and depth within a reasonable confidence range. Only a minor adjustment was required to the existing model in order to match the meter data at the CSO locations. Specifically, the contributing (tributary) area upstream of the 233rd St meter (HP-024) was reduced from 155.1 to 137.5 acres, based on available mapping and review of the system. This review indicated that a portion of the originally modeled sewershed area was actually not contributing to the meter and directly runs off into the water body, so the area value was modified accordingly.

4.3.2 Overview of Previous Water Quality Modeling Efforts

Hutchinson River water quality improvements were assessed using a mathematical water quality model as part of the June 2007 Waterbody Watershed Facility Plan development. During this assessment, the Hutchinson River was included as a portion of the larger area-wide East River Tributaries water quality model (DEP, 2007b). The East River Tributaries Model (ERTM) is a spatially continuous, three-dimensional, time-dependent, receiving-water model of the East River and western Long Island Sound and is comprised of a hydrodynamic model (ECOM) coupled to a eutrophication and pathogens (i.e., water-quality) model (RCA). The ECOM hydrodynamic modeling program was specifically developed for estuarine systems. The driving forces for the ECOM model include tidal elevations, freshwater flows, density (temperature and salinity), and wind. The model calculates water velocities and mixing characteristics. The results of the hydrodynamic model then serves as input to the water quality model. The hydrodynamic model was calibrated to observed salinity and temperature data. Additional details of the ERTM are summarized in the *City-Wide Long Term CSO Control Planning Project: Receiving Water Quality Modeling Report Volume 3 East River Tributaries Model (ERTM), Draft* (DEP, 2007b).

4.3.3 Description of Current Water Quality Model

Previously, the model for the Hutchinson River and Eastchester Bay began at the head of the channelized river used by barge traffic in Westchester County. NYC waters commenced approximately 3,075 feet downstream of the transect origin. For the current water quality model, the model grid was extended further upstream into the non-tidal portion of the river, terminating at Pelham Lake. The computational grid employs an orthogonal-curvilinear coordinate or boundary-fitted system that represents the complex and irregular shorelines. The model uses a vertical sigma-coordinate system that is scaled to the local water column depth and segments the water column into 10 vertical layers. The model grid cells have resolutions from 300 meters in the mouth of the river to about 20 meters near the head of the river reflecting the natural narrowing of the river upstream. The non-tidal portion of the model begins approximately one mile upstream of the Westchester County line. Figure 4-5 presents the updated model grid.

In addition, the model was segregated into non-tidal and tidal sections. The non-tidal portion of the model begins approximately one mile upstream of the Westchester County line. The model was segregated into two sections in order to allow simulation of the non-tidal portion of the river upstream of the Westchester/New York City border and simulation of the tidal portion of the river. By segregating the model into non-tidal and tidal parts, saltwater cannot propagate into the freshwater portion of the river. The upstream sections of the reconfigured grid with demarcation of the older ERTM model upstream boundary are shown in Figure 4-6.

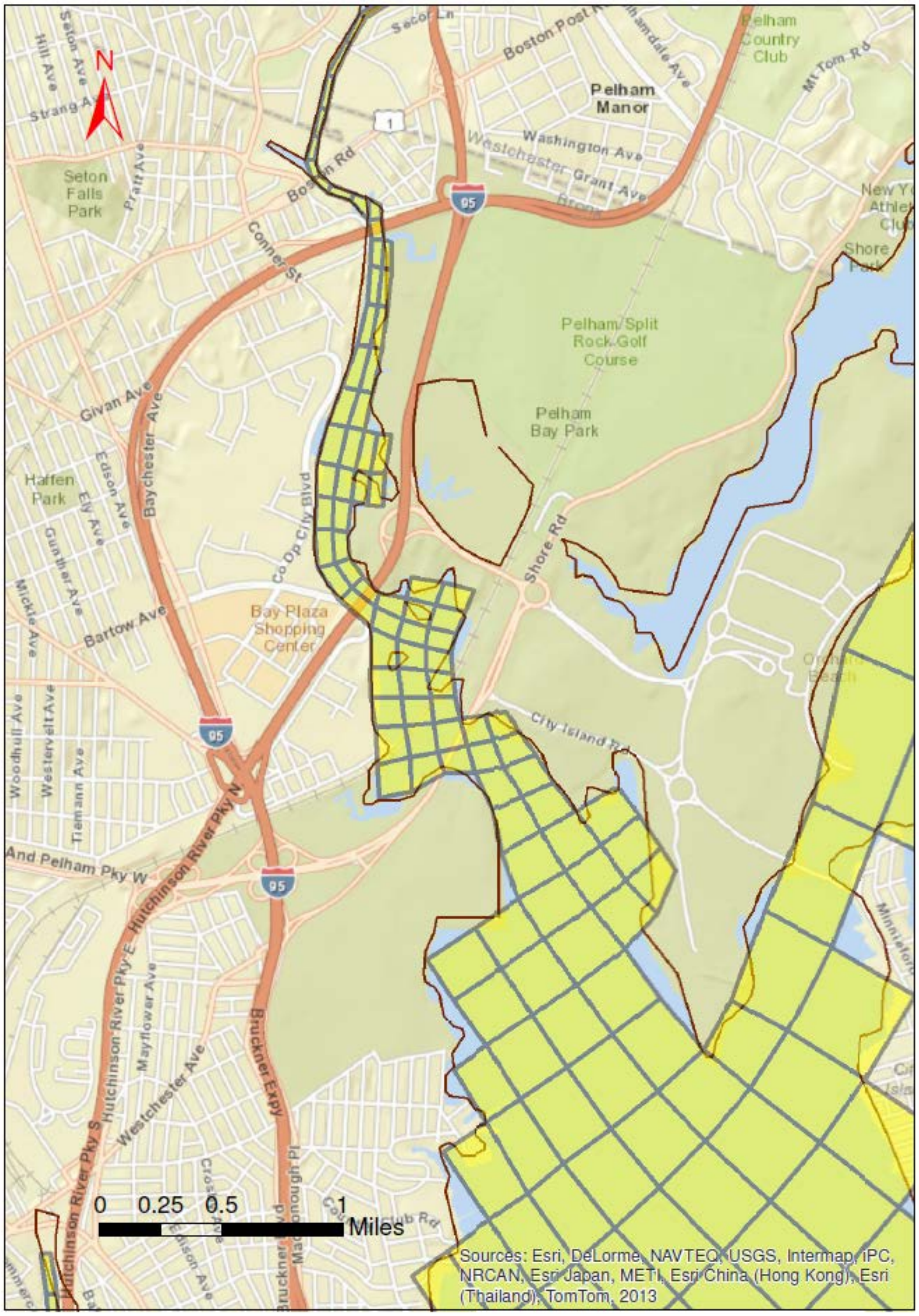


Figure 4-5. Updated ERTM Model Grid for the Hutchinson River

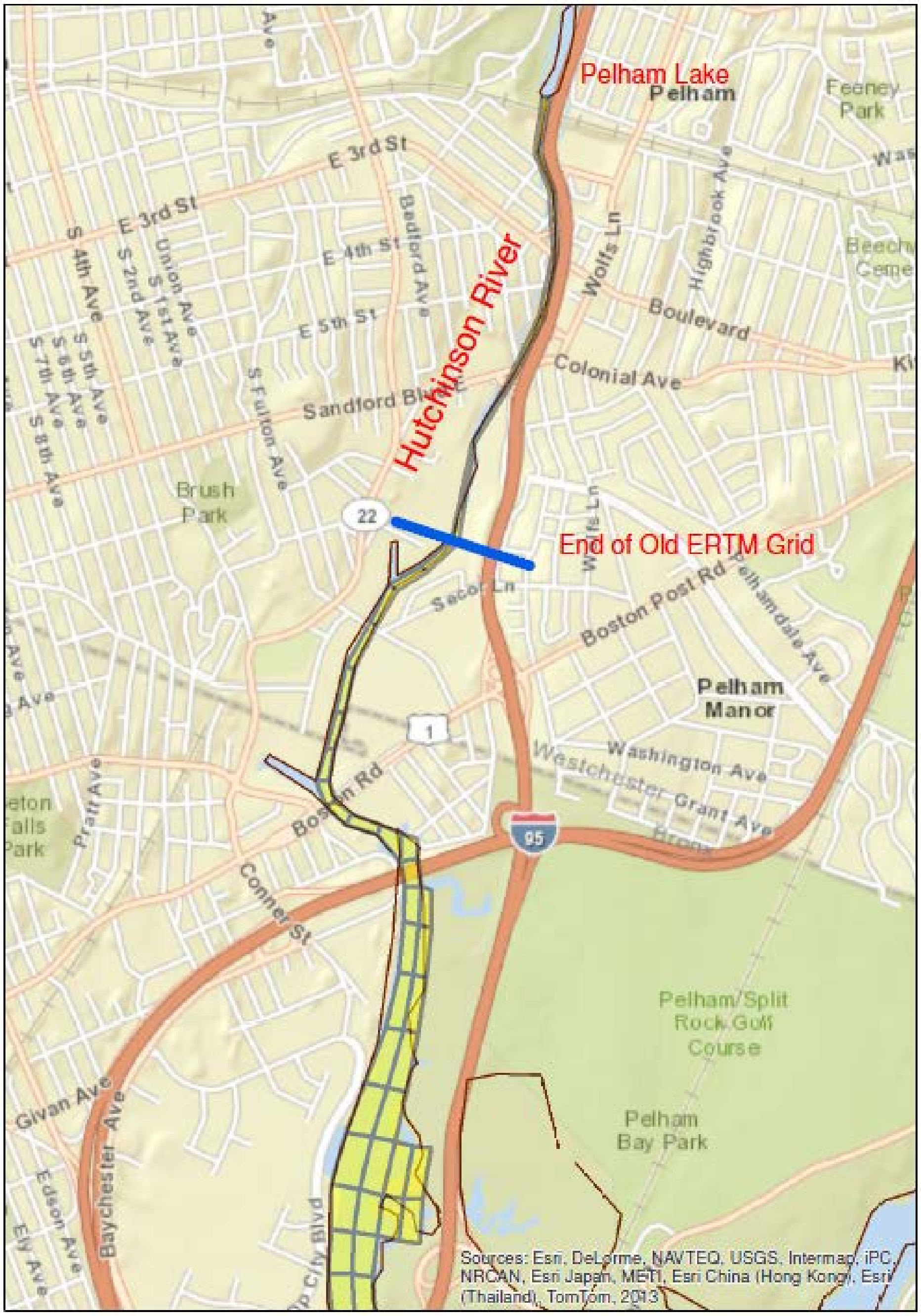


Figure 4-6. Model Grid In Upstream Area of the Hutchinson River, Showing Upstream Limit of Previous ERTM Model

4.4 Recalibration of Water Quality Model

The updated Hutchinson River portion of the ERTM water quality model was recalibrated to temperature, salinity, fecal coliform and *Enterococci* data collected during mid-2012 (see Section 3). The calibration consisted of updating river, CSO, stormwater from separate drainage systems, overland stormwater runoff and dry weather flows and loads for 2012 conditions. The flows and loads were developed using a combination of InfoWorks output, USGS gauge flow data, and pathogen concentrations based on monitoring data and previous modeling efforts. This section describes the development of the model inputs and the resulting model calibration.

4.4.1 Westchester County Flows

As discussed in Section 4.3, the InfoWorks model was calibrated to provide inflows from CSOs and storm sewers to the NYC portion of the river. Since the model was extended upstream into Westchester County, inflows to the river in Westchester County were needed as additional model input. These inflows include upstream boundary flow, stormwater discharge and dry weather flows. No CSOs are located in the Westchester County section of the Hutchinson River.

4.4.1.1 Upstream Boundary Flow

The upstream model boundary is located just downstream of the Pelham Lake overflow weir. During the 2012 monitoring, a flow meter and rain gauge were placed at the upstream boundary sample location (HR-09). In addition, a USGS stream gauge (01301500) has been operational at this location since June 2009. Comparisons between the USGS flow and the project flow meter showed that the flow measurements were consistent. The USGS gauge flow was used as input for the 2012 full year model run.

4.4.1.2 Westchester County Inflows

Stormwater

Westchester County stormwater flows are included in the recalibrated model input. The NYC InfoWorks model for the Hunts Point WWTP was modified to include a portion of Westchester County. This new portion of the model is a 2,295 acre area representative of the Hutchinson River drainage area from the USGS gauge to the Westchester County/NYC border. The 2,295 acre area was modeled by converting a SWMM model developed by Westchester County (Westchester County, 2012) with detailed subcatchment areas into the NYC InfoWorks model. Figure 4-7 shows the Westchester County subcatchments. All of these Westchester County subcatchments drain areas of Mount Vernon downstream from Pelham Lake.

The Westchester County SWMM model also included subcatchments and land areas north of Pelham Lake that were not directly included in the InfoWorks model. However, since the downstream portion of that part of the model produced flows at the USGS gauge (downstream end of Pelham Lake), it was used in this analysis to estimate typical model parameters, such as impervious cover. This portion of the watershed model was calibrated to 18 storm events that occurred between October 2009 and May 2011 and included storms ranging between 0.49 inches to 5.54 inches. Figures 4-8(a) and 4-8(b) show the

SWMM model goodness-of-fit between monitored and modeled peak flow rates and volumes for summer storms (blue diamonds) and winter storms (green triangles) at the USGS gauge. As shown, the model reproduced peak flows and runoff volumes that are consistent with the monitored data, especially for peak flows corresponding to large storms (upper end of the flow duration curve). This calibration of the model parameters for the areas of the Westchester County SWMM model was then used as a basis for adjusting model parameters for the Westchester County portion of the SWMM model for the area between Pelham Lake and New York City.

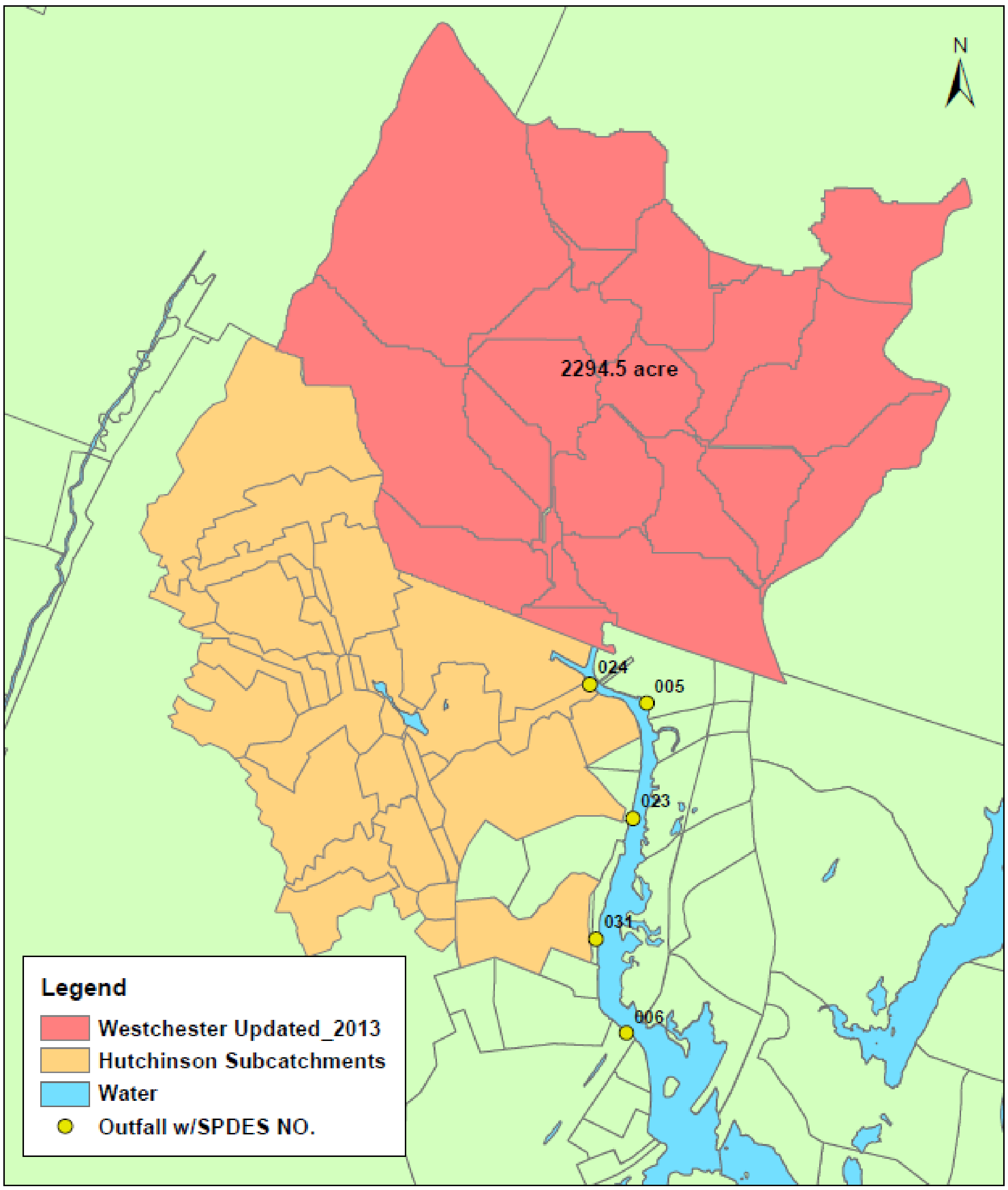


Figure 4-7. Subcatchment Delineation of Westchester County Drainage Area Below Pelham Lake, from Westchester County SWMM Model

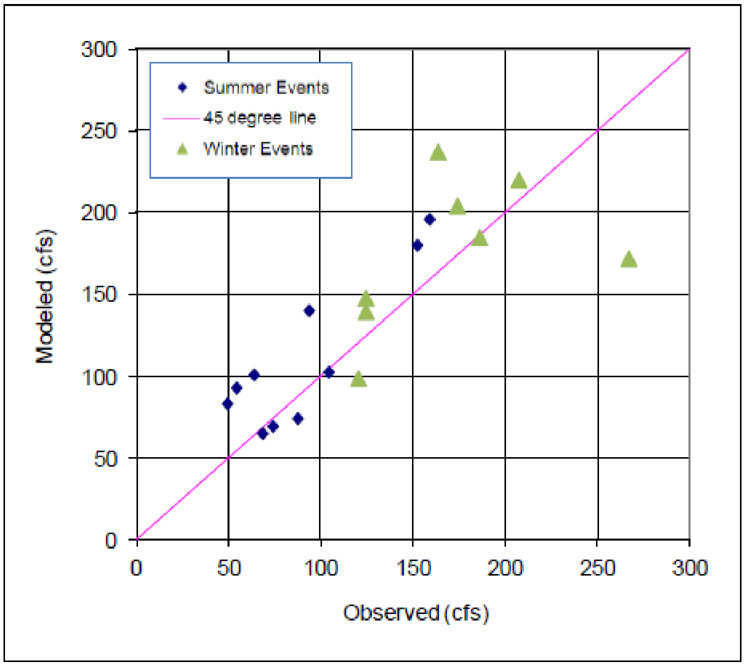


Figure 4-8(a). Goodness-of-Fit (Measured vs. Modeled) Plot of Storm Peak Flow at USGS Gauge below Pelham Lake (Source: Westchester County, 2012)

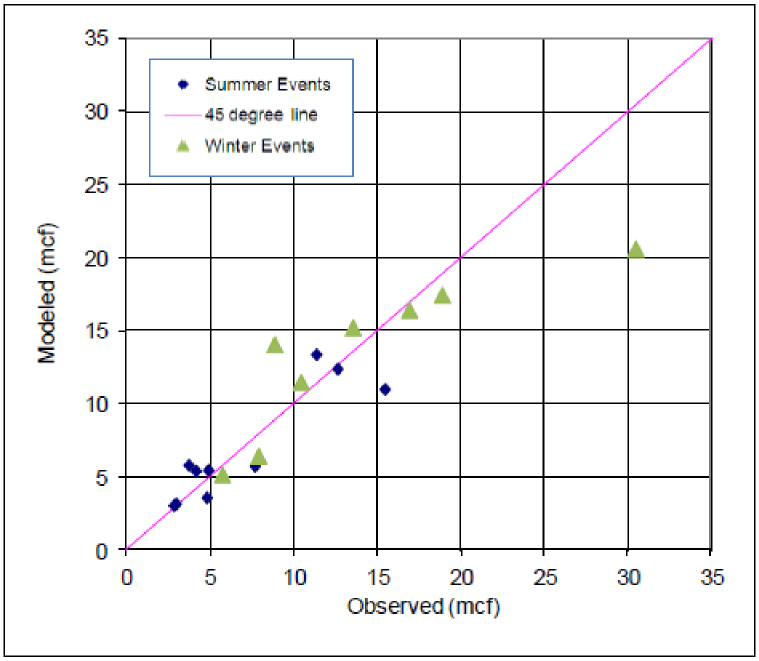


Figure 4-8(b). Goodness-of-Fit (Measured vs. Modeled) Plot of Storm Volume at USGS Gauge below Pelham Lake (Source: Westchester County, 2012)

Dry Weather

In addition to stormwater, Westchester County dry weather flows are included in the recalibrated model. Dry weather inflows at HR-08 and HR-06 were calculated as 1.44 MGD and 0.2 MGD respectively, using the 2012 sample period storm sewer flow data. During the calibration process, dry weather inflow at HR-08 was reduced to 0.72 MGD in the model to reduce the pathogens load in order to reproduce pathogen concentration in the freshwater section of the river.

4.4.2 *Enterococci* and Fecal Coliform Loading

Time variable bacteria loads were developed using source concentrations measured during the 2012 sampling program and flow from the USGS gauge and InfoWorks output. As noted in Section 2, wet weather bacteria concentrations were measured in four stormwater pipes and two CSO pipes. Two of the stormwater pipe locations (HR-08, HR-06) were in Westchester County and two stormwater pipe locations (HP-637, HP-639) were in NYC. Of the three CSOs within NYC that discharge to the river, two of these were sampled during 2012 (HP-023, HP-024). Dry weather sampling was also completed in 2012 at HP-06 and HP-08. These sampling data were used to develop concentrations that were utilized to develop loads to the model as described below. There are no WWTP discharges to the Hutchinson River. Since this model is run as part of the larger ERTM, effects of WWTPs outside of the Hutchinson River are appropriately accounted for.

4.4.2.1 CSO, Storm, Dry Weather and Upstream Boundary Concentrations

Maximum likelihood estimates (MLE) of discharge concentrations for each of the wet weather stormwater and CSO discharges and for the dry weather stormwater sewer discharges were calculated. The process is presented in Appendix B. Since the direct drainage runoff (flow that reaches the river via overland flow) could not be sampled directly, the bacteria concentrations in the direct drainage were assumed to be equal to the 15^{th} percentile values of the stormwater samples collected for fecal coliform and *Enterococcus* from the 2005 city-wide stormwater monitoring database (Villari, 2005). Those values were judged to be reasonable, and were generally consistent with data from other municipalities for direct runoff from primarily undeveloped areas. Table 4-2 presents the wet and dry weather storm water concentrations applied in the model based on MLE calculations. For CSO discharges, InfoWorks model calculated sanitary and stormwater flows were used with Table 4-2 concentrations to calculate loads. Sanitary bacteria concentrations are those that have been derived for the Hunts Point WWTP influent measurements.

The upstream model boundary is located downstream of the Pelham Lake overflow weir. In-stream measurements at location HR-09 represent bacteria concentrations at the upstream boundary. Statistical analyses were completed in order to relate upstream bacteria concentrations to wet and dry weather flow conditions. Hourly bacteria boundary concentrations for the 2012 calibration were then calculated using statistical relationships between rainfall, and upstream flows. The development of these relationships is presented in Appendix B.

Table 4-2. Bacteria Concentrations Applied to Stormwater and Sanitary Discharges for Input into ERTM Water Quality Model

	***Enterococci* (MPN/100mL)**	**Fecal Coliform (MPN/100mL)**
Stormwater		
Westchester County(1)	50,000	100,000
NYC(1)	50,000	35,000
Direct Drainage(2)	6,000	4,000
Dry Weather		
Westchester County		
HR-06(1)	10,000	12,700
HR-08a (South) (1)	16,700	82,600
HR-08b (North) (1)	6,800	28,600
Sanitary		
NYC(3)	1,000,000	4,000,000

Notes:
(1) Concentrations based on MLE of 2012 samples.
(2) Concentrations based on 15th percentile value from 2005 NYC city-wide stormwater quality database.
(3) Sanitary concentrations based on Hunts Point WWTP values.

4.4.2.2 CSO, Stormwater, Dry Weather and Upstream Boundary Loads

Table 4-3 presents the annual CSO, stormwater, dry weather and upstream loads from the NYC and Westchester County sources calculated for 2012. Figure 4-9 presents the percent contribution of each river inflow and bacteria source.

Table 4-3. Hutchinson River Annual Inflow and *Enterococci* and Fecal Coliform Loading, Based on Volumes from InfoWorks and Concentrations from Table 4-2

Location	Outfall Type	Inflow (MG)	*Enterococci* (Organisms) x 10^13	Fecal Coliform (Organisms) x 10^13
NYC	**CSO**	276	167	506
	Storm Sewers	133	25	18
	Direct Drainage	150	3.4	2.3
Westchester County	**Storm Sewers**	692	131	262
	Dry Weather Flow	337	10	37
	Hutchinson River[1]	1816	13	31

Notes: (1) At the outlet of Pelham Lake

4.4.3 Water Quality Model Calibration

Enterococci calibration results at HR06 and HR05 for the June and July period are presented in Figure 4-10 and Figure 4-11 for descriptive purposes. All dry event samples for HR-01 to HR-06 were taken at mid depth at the time of sample. All wet event samples for HR01 to HR06 were taken at both two feet from the surface and two feet from the bottom. All samples (dry or wet event) for HR-07, HR-08 and HR-09 were taken at mid depth. The data points are the solid symbols and the model calculations are the solid lines. Average concentrations over the ten layer model segmentation are presented. HR06 is the southernmost station in Westchester County. In Figure 4-10, the model peak concentrations compare favorably with the data, suggesting the Westchester County loads are being accurately calculated. HR05 is nearest the largest CSO (HP-024) in the river. In Figure 4-11, the model peak concentrations compare favorably with the data suggesting the CSO loads are being accurately estimated. Comparison of data and model indicate that the model is also reproducing the combination of die-off and dilution to match the measured decrease in *Enterococci* concentration over time. The model is able to capture peak concentrations that occur during rain events as well as an approximately two day decline to dry weather levels.

Figure 4-12 presents *Enterococci* data and model frequency distributions further demonstrating that the model appropriately represents bacteria conditions in the river. In order to use the same y-axis scale on all of the figures, the model calculated *Enterococci* concentrations less than 1 MPN/100mL were set equal to 1 MPN/100mL for plotting purposes. Model calibration results for *Enterococci* and fecal coliform for the full five month calibration period at all nine sample locations are presented in Appendix B. Figures in Appendix B present model calibration at sample locations within Westchester County (HR-09 to HR-06) on one page and for the sample locations within NYC (HR-05 to HR-01) on one page.

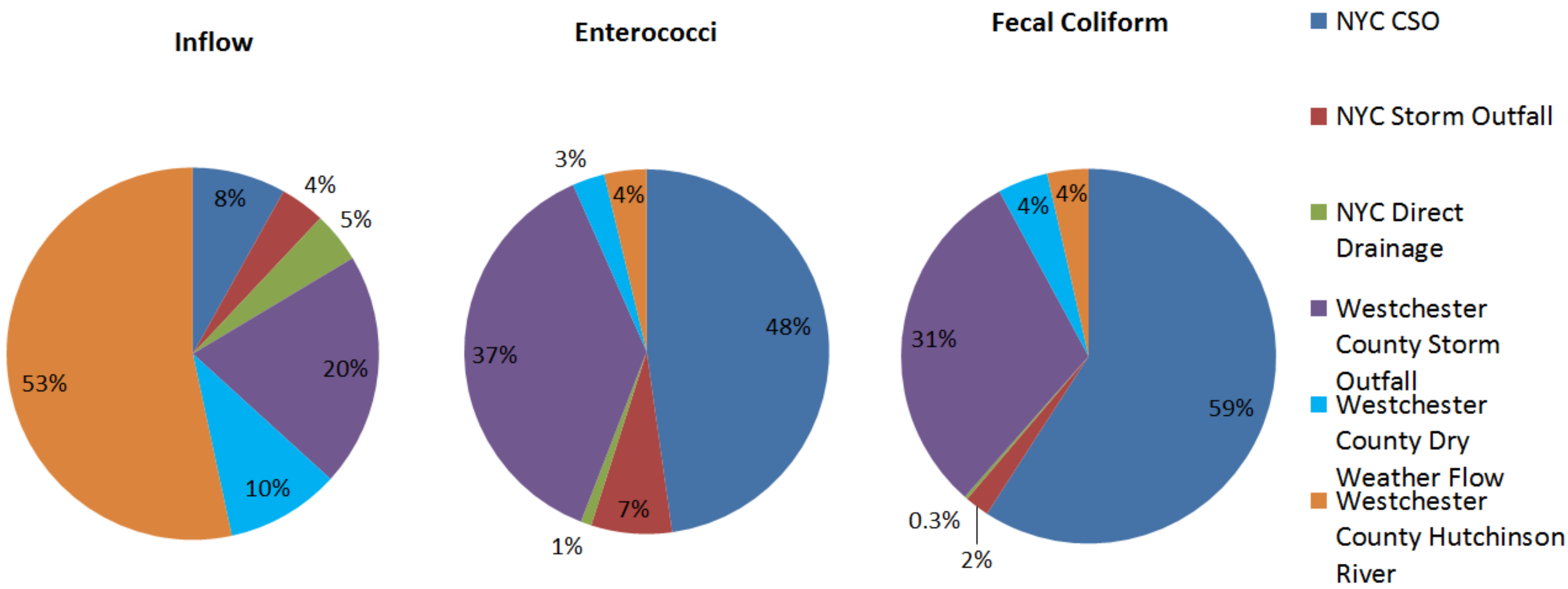


Figure 4-9. Percentage Distributions of Hutchinson River Annual Inflow and *Enterococci* and Fecal Coliform Loading Based on Numerical Data in Table 4-3

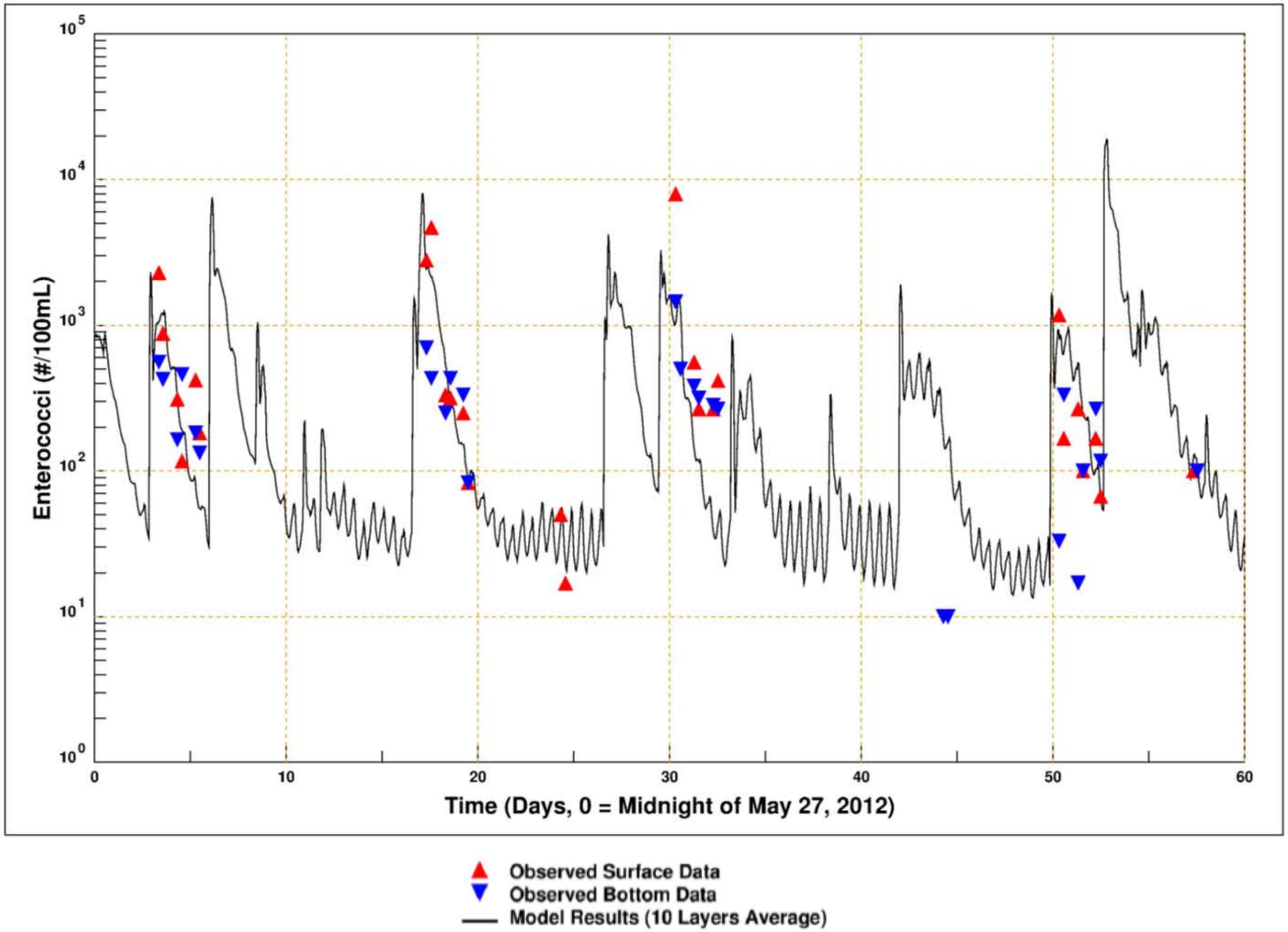


Figure 4-10. Hutchinson River Measured vs. Modeled Values for 2012 *Enterococci Calibration* – Westchester County Sample Location HR06

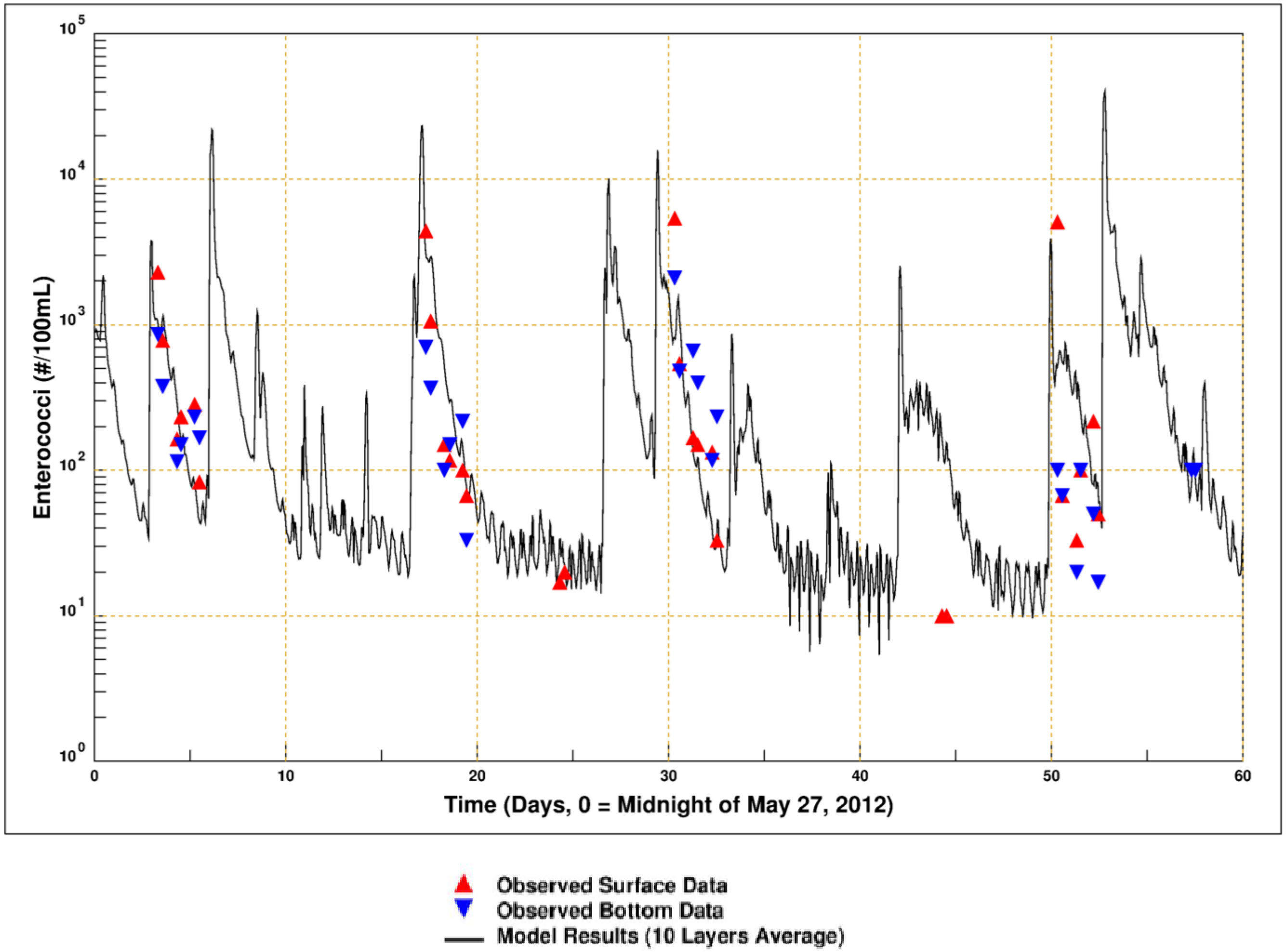


Figure 4-11. Hutchinson River Measured vs. Modeled Values for 2012 *Enterococci* Calibration – NYC Sample Location HR05

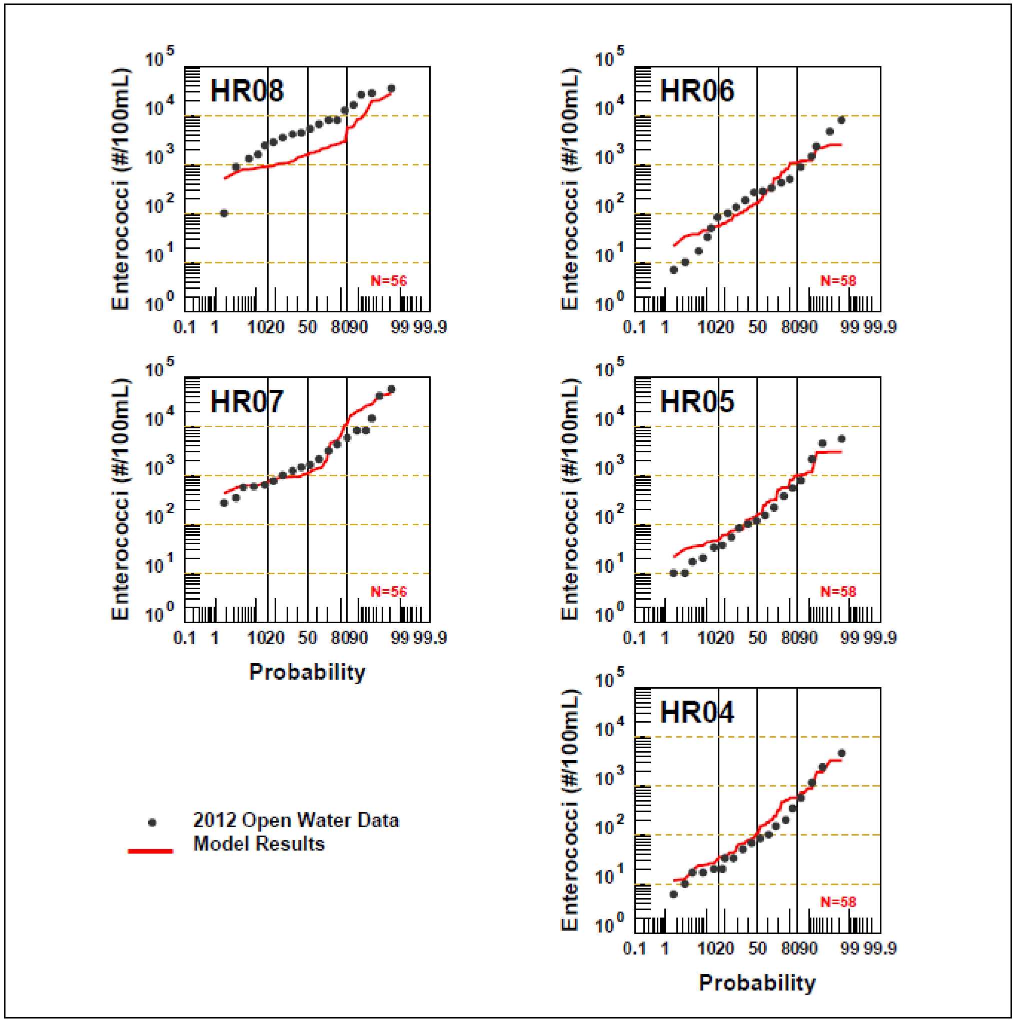


Figure 4-12. Probability Distribution Comparisons of Hutchinson River Measured and Modeled Values for 2012 *Enterococci* Comparison

5.0 Future Conditions Analysis

5.1 Model Parameters for Future Conditions Analysis

The Baseline conditions used in this Hutchinson River analysis were developed in a manner similar to that described in the Long Term Control Plan reports. The specific model input values that were applied in this report reflect recent meteorological conditions, current operating characteristics of various collection and conveyance system components, model configuration changes that reflect a better understanding of dry and wet weather sources, specifically catchment runoff contributions, and new or upgraded physical components of the system. InfoWorks Model input changes that have resulted from physical changes in the system were described in Section 4.2 of this report. Such changes, once incorporated into the model, form the baseline conditions with which other alternative operating strategies and physical changes to the system can be compared and evaluated.

The specific conditions described in this section primarily relate to Dry Weather Flow (DWF) rates, wet weather capacity rates assigned for the Hunts Point WWTP, sewer sediment conditions, precipitation conditions, and tidal boundary conditions. Each of these is briefly discussed below.

5.1.1 Rainfall

To date, the annual rainfall from 1988 has been considered to be representative of long-term average rainfall conditions in NYC, and therefore had been used for analyzing facilities where “typical” conditions, rather than extreme conditions, serve as the basis of design in accordance with the federal CSO policy of using an “average annual basis” for analyses (59 Fed. Reg. Section II.C.4). Previous WWFP evaluations for various New York City watersheds used 1988 as the typical rainfall year, and DEP has consistently used the 1988 annual precipitation with the landside models. The selection of 1988 as the average condition was, however, re-considered in light of the increasing concerns over climate change, and the potential for more extreme and more frequent storm events. Recent landside modeling analyses in the City have used the 2008 precipitation pattern to drive the runoff-conveyance processes, along with the 2008 tide observations, which have been judged to be more representative than 1988 conditions as a typical year. Hutchinson River future baseline/alternative runs will be conducted using 2008 as the “typical” precipitation year. A comparison of these rainfall years that led to the 2008 selection is shown in Table 5-1. As indicated in Table 5-1, for three of the parameters considered, the 2008 rainfall data were much closer to the averages from the 1969 to 2010 data than the 1988 rainfall data, while for two of the parameters, the two rainfall data sets were equal.

Table 5-1.Comparison of 1988 and 2008 Rainfall from JFK Gage to 40-Year Average JFK Data

	WWFP JFK 1988	40-Year Average JFK 1969-2010	Present Best Fit JFK 2008
Annual Rainfall (in)	40.7	45.5	46.3
July Rainfall (in)	6.7	4.3	3.3
November Rainfall (in)	6.3	3.7	3.3
Number of Very Wet Days (>2.0 in)	3	2.4	3
Average Peak Storm Intensity (in/hr)	0.15	0.15	0.15

5.1.2 Tides

In association with the 2008 precipitation pattern, the observed tide conditions that existed in 2008 were also applied in the IW models as the tidal boundary conditions at the CSO Outfalls to properly reflect the Average Annual Overflow Volumes (AAOVs) projection analyses.

5.1.3 Sewer System Sediments

Previous evaluations included the presence of sediment in portions of the interceptor system, some of which led to the reduced peak flow rates reaching the Hunts Point WWTP during wet weather periods. With the interceptor cleaning undertaken during 2010-2011, most of the sediment has now been removed from the interceptors. For the current evaluations, only sediment depths as reported by DEP subsequent to its cleaning operations are included in the interceptor portions of the IW model.

5.1.4 Sanitary Flow

As described in the previous reports, dry weather sanitary sewage flows used in the baseline modeling were escalated to reflect anticipated growth in the City. In the past, flow estimates were based on the 2000 census, and growth rates were estimated by the Mayor's Office and City Planning to arrive at projected 2045 sanitary flow rates that were then applied to the model. For the current analyses, the 2010 census was used to reassign population values to the watersheds in the model. Projected flow rates to the year 2040 by the City were then used to define the per capita wastewater generation rates applied in the models. The methodology used by the City in establishing the 2040 flow rates was based on averaging the annual average daily flow rates to the WWTP for the five-year period from 2007-2011 to arrive at a 2012 base flow number. This inherently included the water conservation efforts that have been undertaken by the City over the past decade. The 2012 rate was then escalated to the 2040 rate in 5-year increments. For the Hunts Point WWTP drainage area, this resulted in using a dry weather sanitary flow of 122 MGD for the Baseline condition.

5.1.5 WWTP Maximum Flow

Previous evaluations had established the Baseline condition for the Hunts Point WWTP system with a wet weather treatment capacity of 260 MGD. Since then, significant improvements at the plant have been completed that have restored the ability of the WWTP to accept and treat two times Design Dry Wastewater Flow (2xDDWF). Since the DDWF is 200 MGD this results in a 400 MGD 2xDDWF capacity during wet weather. This flow rate is now used as the baseline plant capacity for this report.

5.1.6 Non-CSO Discharges

For several sections of the Hunts Point WWTP drainage area within the Hutchinson River watershed, some storm water drains directly to receiving waters without entering the combined system. These areas were depicted as “stormwater drainage” if they drain through the City’s storm sewers or “direct drainage” if the storm water occurs as sheet flow or piped flow through non-NYC Municipal Separate Storm Sewer System (MS4) storm sewers. In general, shoreline areas adjacent to waterbodies comprise the overland stormwater runoff category. Significant overland stormwater runoff areas include a large marsh on the eastern shoreline of the Hutchinson River and some smaller industrial areas along the western shoreline.

Overall the stormwater, overland stormwater runoff and “other” areas cover roughly 10,660 acres of the total 22,927 acres of the Hunts Point WWTP drainage area, with stormwater comprising 2,378 acres and overland stormwater runoff and “other” comprising 8,308 acres, respectively. In the Hutchinson River watershed, the stormwater, overland stormwater runoff plus “other” areas are 610 acres and 606 acres, respectively, totaling 1,216 acres within NYC and an additional 1,066 acres in Westchester County.

The drainage area in Westchester County between the head of the river and the Westchester County/NYC border is 2,295 acres. Upstream of that, the drainage area of the freshwater inflow at the head of the Hutchinson River at the location of the USGS gauge is 3,866 acres.

5.1.7 Grey and Green Infrastructure

The InfoWorks modeling analyses for the Baseline conditions included grey and green infrastructure in accordance with the Order. No grey infrastructure is currently planned for implementation within the Hutchinson River watershed. Grey infrastructure within the Hunts Point WWTP sewershed included the following:

- Pumping and headworks improvements at the Hunts Point WWTP
- Weir improvements at CSO-014 at the head end of Westchester Creek
- Pugsley Creek parallel sewer
- Floatables controls at outfalls on the Bronx River

In accordance with the *NYC Green Infrastructure Plan* (DEP 2010), green infrastructure was included in the Hunts Point WWTP sewershed and more specifically within the Hutchinson River watershed as part of the Baseline conditions. Green infrastructure included bioswales to manage right-of-way impervious areas to the first one inch of rainfall, other controls on public properties and onsite controls on private lots in accordance with the newly issued sewer connection rules.

The characterization of the Hutchinson River watershed, based on the designated criteria, ultimately determined the watershed's individual green infrastructure application rate. This particular watershed has a combined sewer impervious area totaling 1,128 acres, which is without any grey infrastructure specifically constructed to control CSOs. Therefore, DEP assumed that they will be making a significant investment in green infrastructure implementation in the right-of-way, on public properties and on onsite private properties. DEP expects to manage 126 acres of impervious right-of way areas with bioswales and other public onsite technologies. DEP also expects to manage 32 acres of impervious areas using green infrastructure on private properties by 2030. This acreage would represent 14% of the total combined sewer impervious area in the watershed, and assumes new development based on Department of Building (DOB) building permit data from 2000 to 2011. The data has been projected for the 2012-2030 period to account for compliance with the stormwater performance standard.

In summary, DEP expects stormwater to be managed through right-of-way and onsite private green infrastructure implementation in 14% of the total combined sewer impervious areas in the Hutchinson River watershed within the NYC boundary by 2030. This green infrastructure implementation rate is included in the IW model as part of the Baseline condition and was allocated proportionally to each subcatchment in the overall tributary area.

5.2 LTCP Baseline Water Quality Projections

The model configuration and parameters for the future conditions baseline for the Hutchinson River are summarized below.

- 2008 JFK Airport rainfall,
- No Westchester County illicit connection dry weather inflows and loads,
- Westchester County upstream model boundary concentrations calculated using wet and dry weather relationships developed for the 2012 calibration,
- IW recalibrated model configuration with no sewer sediment and 2040 sanitary flow,
- Hunts Point WWTP @ 400 MGD capacity,
- Cost effective grey projects in place including Westchester Creek weir changes and Pugsley Creek sewer extension, and Hunts Point 400 mgd 2XDDWF capacity, and
- Green Infrastructure managing 14% of CSO impervious area (158 acres of which 126 acres are right-of-way bioswales)

In addition, since the USGS gauge at the head of the Hutchinson River was not operational in 2008, Westchester County upstream flows at Pelham Lake for 2008 were developed using the Westchester County SWMM model. The 2008 Westchester County SWMM model was run using JFK Airport rainfall. Inflows below Pelham Lake to the NYC border were based on the 2,295 acre portion of the IW model upstream of NYC. Annual CSO, stormwater and upstream flows and loads from NYC and Westchester County sources calculated for the 2008 baseline water quality projection are presented in Table 5-2. Figure 5-1 presents percent contribution of each river inflow and bacteria source.

Table 5-2. Hutchinson River Baseline Annual Inflow and *Enterococci* and Fecal Coliform Loading – Future Baseline (2008 Rainfall); Based on Volumes from InfoWorks and Concentrations from Table 4-2

Location	Outfall Type	Inflow (MG)	Enterococci (Organisms) x 10^13	Fecal Coliform (Organisms) x 10^13
NYC	CSO	322	173	512
	Storm Outfall	176	33	23
	Direct Drainage	198	37	26
Westchester County	Storm Outfall	923	175	350
	Hutchinson River	2018	19.6	47

The Hutchinson River is a Class SB waterbody from Eastchester Bay to E. Colonial Avenue and a Class B waterbody from E. Colonial Avenue to Pelham Lake. Class SB and Class B NYS water quality standards for fecal coliform and future water quality criteria for *Enterococci* were listed in Table 2-1. Fecal coliform and *Enterococci* concentrations were calculated using the calibrated ERTM model of the Hutchinson River and the source concentrations discussed previously. The water quality model calculated concentrations were then compared to the existing fecal coliform criterion (monthly GM <200) on an annual basis and future *Enterococci* criterion (rolling 30-day GM <30) for the recreation period (May 1st to October 31st). Resulting compliance with the existing fecal coliform and future *Enterococci* Class SB or Class B standards for the baseline condition at each of the sample locations is presented in Table 5-3. The fecal coliform criterion is met 100% of the time at HR01, 10 of 12 months (83%) at locations HR02, HR03, and HR04, and 8 of 12 months (67%) at HR05 and HR06 on an annual basis. The recreation period fecal coliform criterion is exceeded at all locations upstream of HR06 on an annual basis.

Thirty-day moving geometric means, during the recreation period, are in attainment of the future *Enterococci* criterion 100% of the time at HR01, 83% of the time at HR02, 69% of the time at HR03, 60% of the time at HR04, 49% of the time at HR05, 42% of the time at HR06 and 0% of the time upstream of HR06. Upstream from HR06 the calculations show the river to be in non-compliance 100% of the time.

These results indicate that source loadings are significant contributors to bacteria exceedances within the river, while levels at the downstream locations reflect boundary influences. Annually there is 0% attainment of the fecal coliform criterion from the head of the river to sample location HR07. There is 0% attainment of the future *Enterococci* criteria from the head of the river to sample location HR07. Conversely, criteria at the downstream boundary are being met for fecal coliform and *Enterococci* 100% of the time for the respective periods.

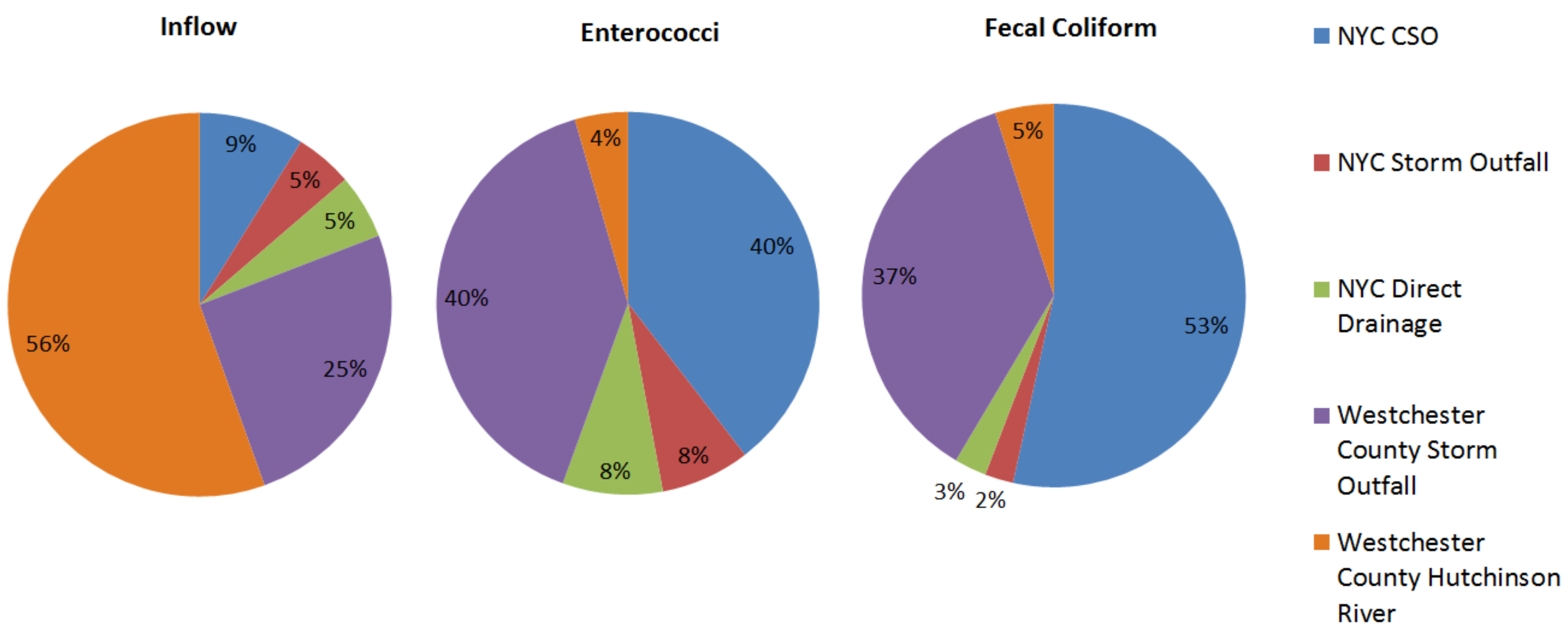


Figure 5-1. Percent Contribution of Annual Baseline Hutchinson River Inflow, and *Enterococci* and Fecal Coliform Loading – Future Baseline (2008 Rainfall), Based on Numerical Data in Table 5-2

Table 5-3. *Enterococci* and Fecal Coliform Percent Annual Compliance with Bacteria Standards for Future Baseline Conditions (2008 Rainfall), from ERTM Model

Station	Class	Fecal Coliform Percent Attainment, <200 #/100mL	Enterococci, Percent Attainment, 30 #/100mL
		Annual	Recreation Period* 30-Day Rolling GM
HR01	**SB**	100	100
HR02	**SB**	83	83
HR03	**SB**	83	69
HR04	**SB**	83	60
HR05	**SB**	67	49
HR06	**SB**	67	42
HR07	**B**	0	0
HR08	**B**	0	0
HR09	**B**	0	0

* Recreation Period is May 1st to October 31st

5.3 Model Forecast Analysis

Hutchinson River bacteria levels are a result of numerous sources including CSO, stormwater, dry weather loads, and upstream inputs as well as East River boundary influences. The water quality model was used to assess the contribution of each of these sources to bacteria levels in the river. Specific pollutant sources that contribute to bacteria levels in the river include:

- Pelham Lake,
- Westchester County Stormwater,
- NYC Stormwater including overland flow,
- NYC CSOs and
- East River

Model runs were completed that yielded water column concentrations attributable to each of the above sources. However, it should be noted that the Westchester County dry weather illicit discharges were removed from the model for this analysis. Maximum 30-day geometric means (GM), during the recreation period were then computed at each of the nine Hutchinson River locations for each of the contributing sources or components for *Enterococci* bacteria. The annual worst month GM for fecal coliform was also computed. These statistics for *Enterococci* and fecal coliform are presented in Table 5-4. Some conclusions regarding the loading sources that contribute to nonattainment of the future *Enterococci* criterion of a 30-day GM of less than 30 org/100mL during the recreation period and the fecal coliform criterion of less than 200 org/100mL annually, can be made from the statistics in Table 5-4. Yellow highlighted areas indicate nonattainment due to individual components. The green highlighted areas call out the overall Baseline GMs. Results are provided from the mouth of the river (HR01) north into Westchester County (HR06 through HR09). The dominant sources of *Enterococci* and fecal coliform are from the upstream Hutchinson River at Pelham Lake and Westchester County stormwater components. However all components contribute to the overall calculated exceedences from HR02 to HR09 for both *Enterococci* and fecal coliform. At all stations, Westchester County stormwater contributes more to the recreation period GM concentrations for *Enterococci* and the annual worst month for fecal coliform than NYC CSOs.

Table 5-4. Source Contributions of *Enterococci* Concentration in the Hutchinson River, Future Baseline Conditions (2008 Rainfall), from ERTM Model

Source	Station	Enterococcus Contribution, #/100mL	Fecal Coliform Contribution, #/100mL
		Geomean, #/100mL	Geomean, #/100mL
		Recreational Season Max 30-Day Rolling GM	Annual Worst Month February Monthly GM
Hutchinson River	HR01	1	4
Westchester Stormwater	HR01	3	26
NYC Stormwater	HR01	3	27
NYC Direct Runoff	HR01	0	2
NYC CSO	HR01	2	23
East River	HR01	2	14
Total	HR01	11	96
Hutchinson River	HR02	1	14
Westchester Stormwater	HR02	16	122
NYC Stormwater	HR02	18	135
NYC Direct Runoff	HR02	3	6
NYC CSO	HR02	5	96
East River	HR02	1	6
Total	HR02	44	379
Hutchinson River	HR03	3	28
Westchester Stormwater	HR03	35	254
NYC Stormwater	HR03	18	109
NYC Direct Runoff	HR03	5	11
NYC CSO	HR03	11	153
East River	HR03	1	3
Total	HR03	73	559
Hutchinson River	HR04	4	39
Westchester Stormwater	HR04	52	351

Table 5-4. Source Contributions of *Enterococci* Concentration in the Hutchinson River, Future Baseline Conditions (2008 Rainfall), from ERTM Model

Source	Station	Enterococcus Contribution, #/100mL	Fecal Coliform Contribution, #/100mL
		Geomean, #/100mL	Geomean, #/100mL
		Recreational Season Max 30-Day Rolling GM	Annual Worst Month February Monthly GM
NYC Stormwater	HR04	11	78
NYC Direct Runoff	HR04	9	17
NYC CSO	HR04	10	156
East River	HR04	1	3
Total	HR04	87	643
Hutchinson River	HR05	6	61
Westchester Stormwater	HR05	79	523
NYC Stormwater	HR05	13	78
NYC Direct Runoff	HR05	16	28
NYC CSO	HR05	13	179
East River	HR05	1	2
Total	HR05	128	872
Hutchinson River	HR06	9	87
Westchester Stormwater	HR06	113	713
NYC Stormwater	HR06	9	82
NYC Direct Runoff	HR06	11	20
NYC CSO	HR06	13	192
East River	HR06	1	2
Total	HR06	156	1096
Hutchinson River	HR07	218	830
Westchester Stormwater	HR07	309	1207
NYC Stormwater	HR07	0	0
NYC Direct Runoff	HR07	0	0
NYC CSO	HR07	0	0
East River	HR07	0	0
Total	HR07	527	2037
Hutchinson River	HR08	251	865
Westchester Stormwater	HR08	185	773
NYC Stormwater	HR08	0	0
NYC Direct Runoff	HR08	0	0
NYC CSO	HR08	0	0
East River	HR08	0	0
Total	HR08	436	1638

Table 5-4. Source Contributions of *Enterococci* Concentration in the Hutchinson River, Future Baseline Conditions (2008 Rainfall), from ERTM Model

Source	Station	Enterococcus Contribution, #/100mL	Fecal Coliform Contribution, #/100mL
		Geomean, #/100mL	Geomean, #/100mL
		Recreational Season Max 30-Day Rolling GM	Annual Worst Month February Monthly GM
Hutchinson River	HR09	322	1096
Westchester Stormwater	HR09	50	150
NYC Stormwater	HR09	0	0
NYC Direct Runoff	HR09	0	0
NYC CSO	HR09	0	0
East River	HR09	0	0
Total	HR09	372	1246

Yellow Shading - Component Geometric Mean, ENTERO >30/100 mL, FECAL > 200/100mL
Green Shading - Total (Baseline) Geometric Mean

6.0 Observations and Conclusions

NYC sources contribute to in-stream *Enterococci* and fecal coliform concentrations at locations HR01 through HR06. Based on extensive component analyses performed using the comprehensive water quality model of Hutchinson River, no single individual NYC source category (CSO, stormwater, direct drainage) results in the calculated *Enterococci* maximum 30-day rolling GM from that source to be higher than the future 30 org/100mL criterion during the recreation period. This is also the case for individual NYC source impacts on the fecal coliform GMs being higher than 200 org/100mL. Based on the results presented in Table 5-4, reductions in both *Enterococci* and fecal coliform concentrations are required to achieve 100 percent attainment of the criteria. Considering all sources, stations HR02 to HR09 have concentrations higher than the potential future *Enterococci* criterion of less than 30 org/100mL during the recreation period. Considering all sources, on an annual basis, stations HR02 to HR09 have concentrations higher than the fecal coliform criterion of less than 200 org/100mL.

Station HR01 shows that the Hutchinson River is in compliance with the recreation period maximum 30-day rolling GM criterion for *Enterococci* and the monthly fecal coliform GM on an annual basis. Results for the remainder of the stations (station HR02 through HR09) indicate that the criteria are exceeded in the Hutchinson River. Bacteria concentrations continue to rise approaching the headwaters of the river with peak concentrations observed at sampling station HR08 located in Westchester County. Once in the upper reaches of the river in Westchester County (sampling station HR09), the sources that would contribute to the bacteria loading of Hutchinson River come from areas upstream of Pelham Lake, which were not assessed in this study.

The data set forth in Section 5.3 indicate that while there is some variability to the primary source of *Enterococci* and fecal coliform concentration loading, generally the primary source of these bacteria concentrations are Pelham Lake flow and Westchester County stormwater flow. Upstream of HR06, Hutchinson River at the Pelham Lake outflow and stormwater sources from Westchester County become the dominant sources and these remain significant contributors until station HR03. NYC sources from stormwater, direct runoff, and CSOs contribute to nonattainment in the Hutchinson River from station HR06 to station HR02. Complete removal of Pelham Lake loads plus a large reduction of Westchester County wet weather loads would be required to reduce the recreation period GM *Enterococci* concentrations to below 35 org/100mL and GM fecal coliform concentrations to below 200 org/100mL at between stations HR07 and HR09. In addition to reductions in Pelham Lake and Westchester County wet weather loads, reductions in NYC sources for both *Enterococci* and fecal coliform would be needed to meet respective criteria at HR02 to HR06.

In anticipation of developing and finalizing the Hutchinson River LTCP by the consent order date of September 2014, DEP will continue to study and evaluate load reduction alternatives in the Hutchinson River as they are impacted by combined sewer overflows.

7.0 References

DEP 2007a. City-Wide Long Term CSO Control Planning Project, Landside Modeling Report, Volume 4. New York City Department of Environmental Protection. October 2007.

DEP. 2007b. *City-Wide Long Term CSO Control Planning Project: Receiving Water Quality Modeling Report Volume 3 East River Tributaries Model (ERTM), DRAFT*. The City of New York Department of Environmental Protection Bureau of Engineering Design & Construction. Sept 2007.

DEP. 2010. *NYC Green Infrastructure Plan: A Sustainable Strategy for Clean Waterways.* New York City Department of Environmental Protection.

DEP 2012a. *Field Sampling and Analysis Plan Long Term Control Project Water Quality Monitoring Plan for Hutchinson River TMDL/WLA.* New York City Department of Environmental Protection.

DEP. 2012b. *Field Sampling Data Report Long Term Control Project Water Quality Monitoring Program for Hutchinson River TMDL/WLA*. New York City Department of Environmental Protection.

DEP, 2012. *InfoWorks Citywide Recalibration Report*. New York City Department of Environmental Protection.

Villari 2005, Memo from Dujardin and Leo to Chris Villari, May 4, 2005, NY/NJ Harbor Estuary Program, Model Application of Stormwater Sampling Results

WaPUG. 2002 *Code of Practice for the Hydraulic Modeling of Sewers 3rd Edition.* Wastewater Planning Users Group. December 2002.

Westchester County. 2012. Lower Long Island Sound Watershed Flood Mitigation and Water Quality Improvement Planning Report, May 2012.

APPENDIX A

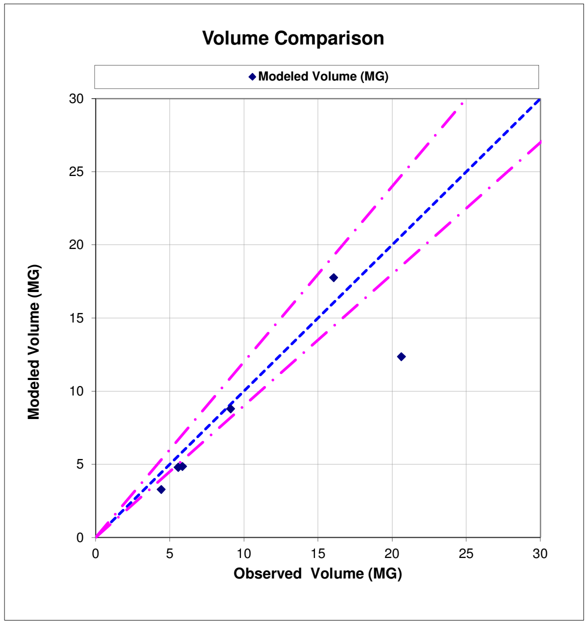
HUNT'S POINT INFOWORKS CALIBRATION GOODNESS-OF-FIT PLOTS

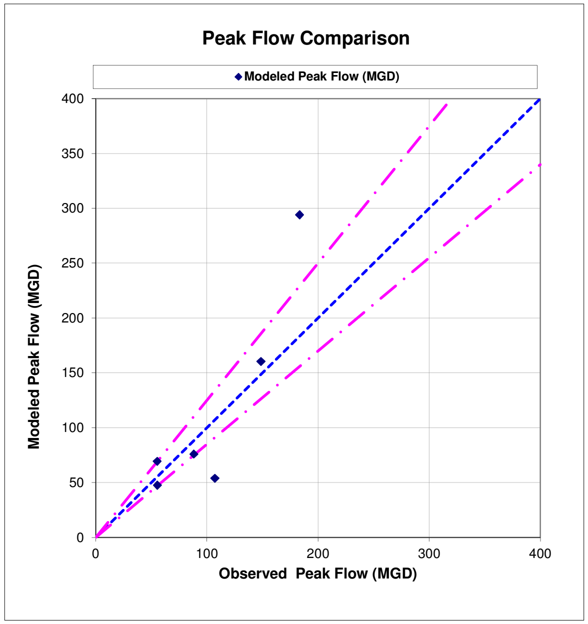
Appendix A

Hunt's Point InfoWorks Calibration Goodness-of-Fit Plots

List of Figures

Figure A-1
HP 023 Goodness of Fit Plots for Volume, Peak Flow and Peak Depth





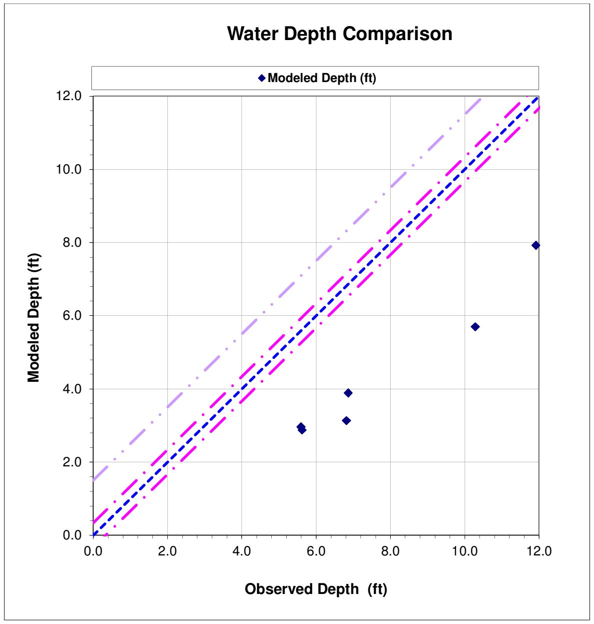
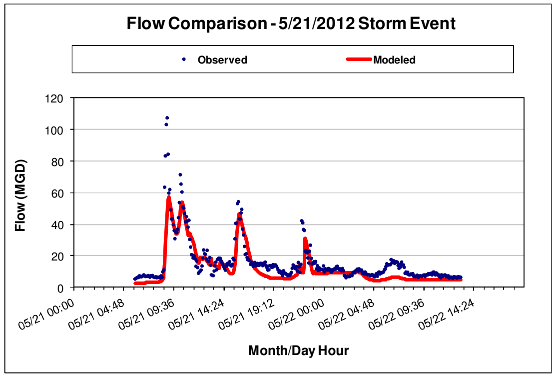
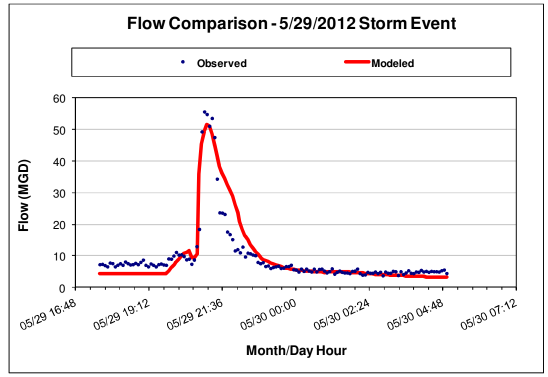
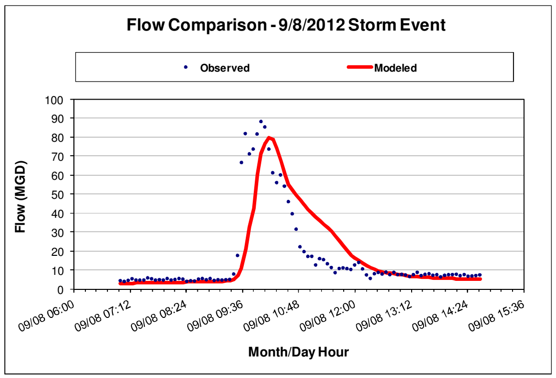
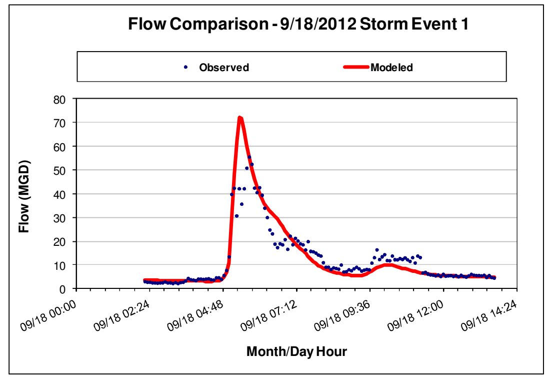


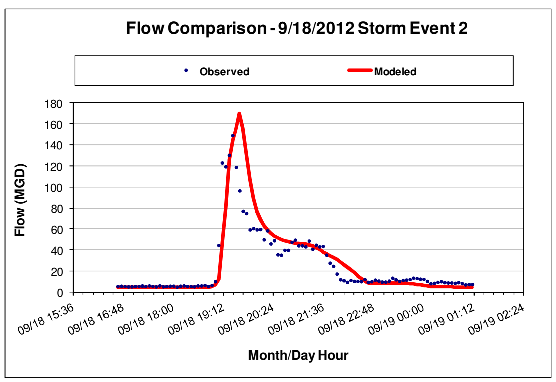
Figure A-2
HP 023 Flow Comparison











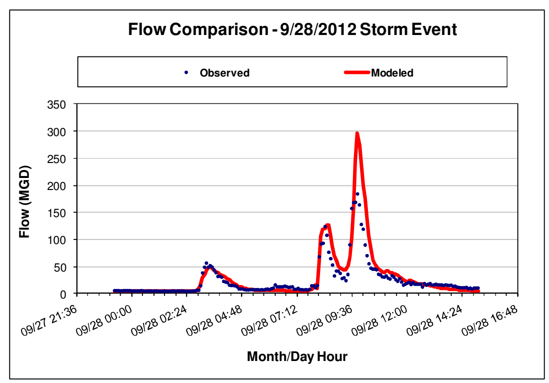


Figure A-3
HP 023 Interceptor Goodness of Fit Plots for Volume, Peak Flow and Peak Depth

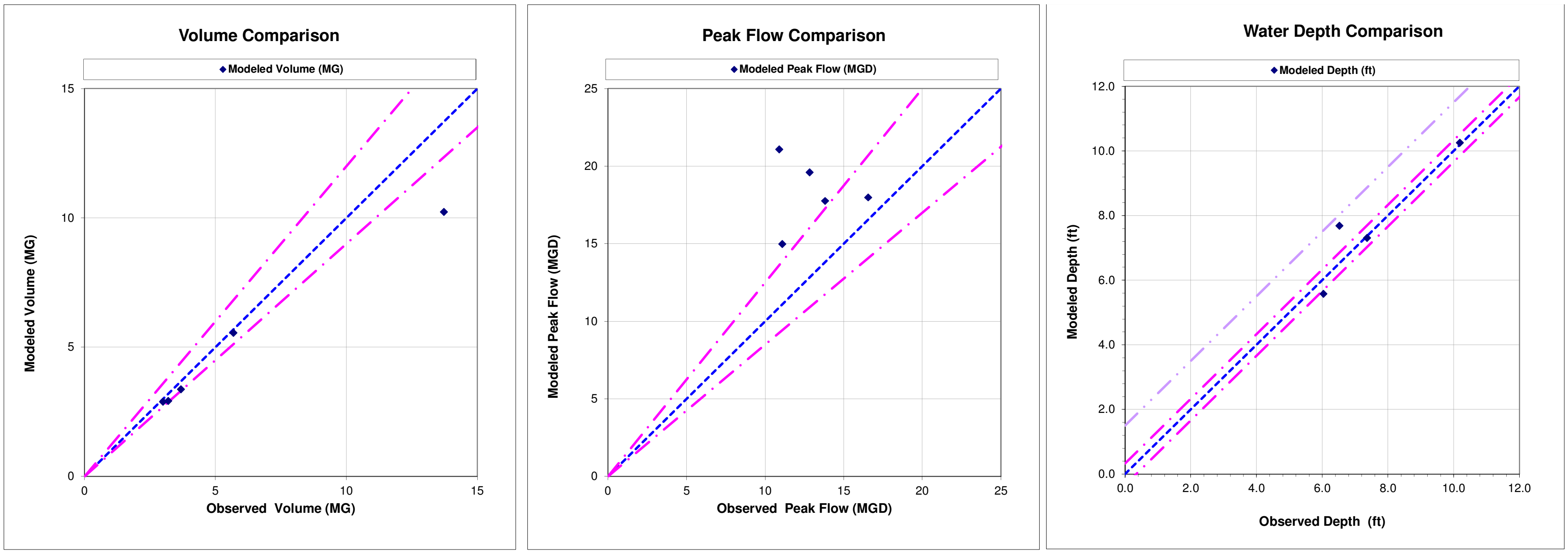


Figure A4
HP 023 Interceptor Flow Comparison

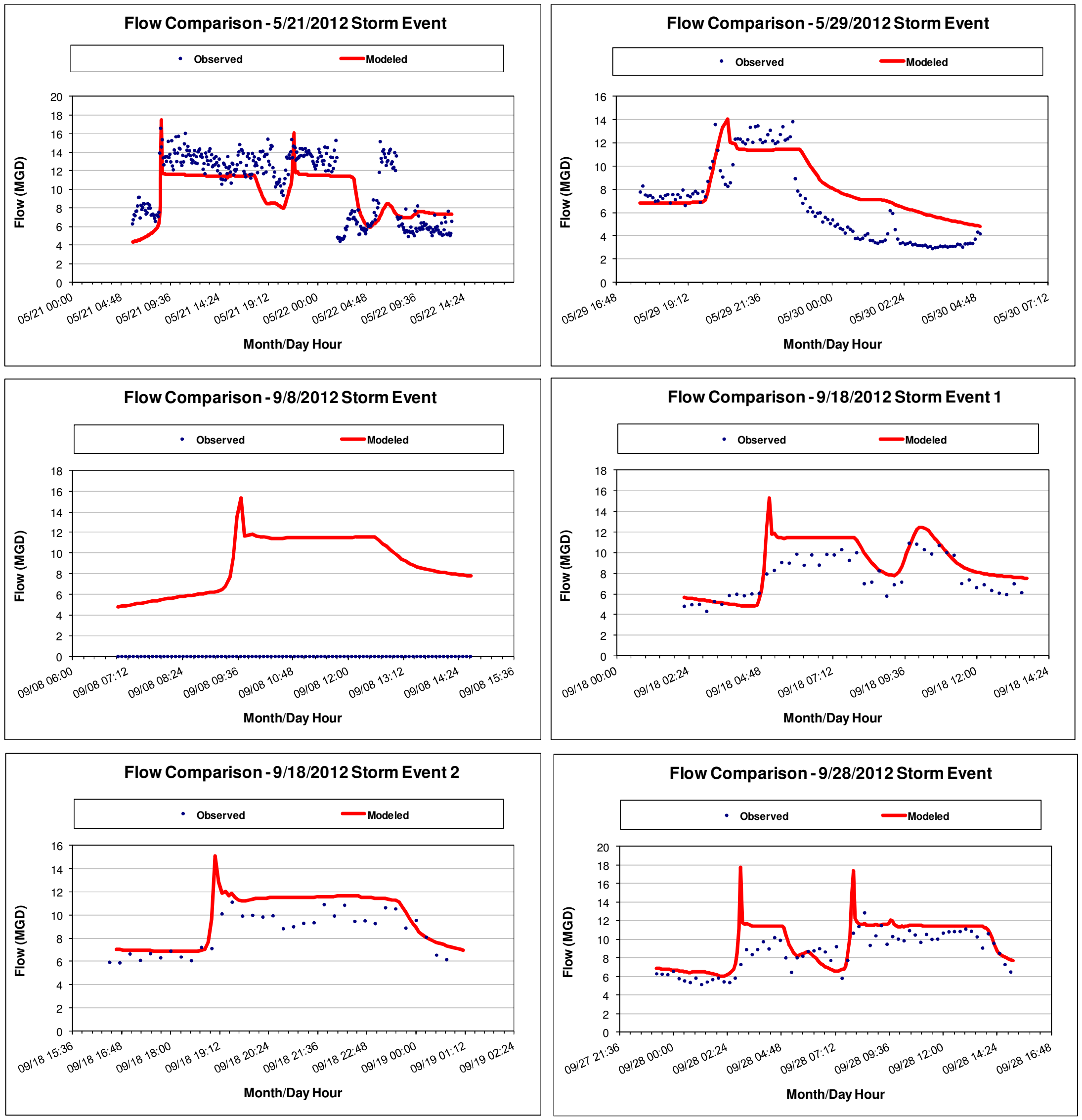


Figure A-5
HP 024 233rd Street Goodness of Fit Plots for Volume, Peak Flow and Peak Depth

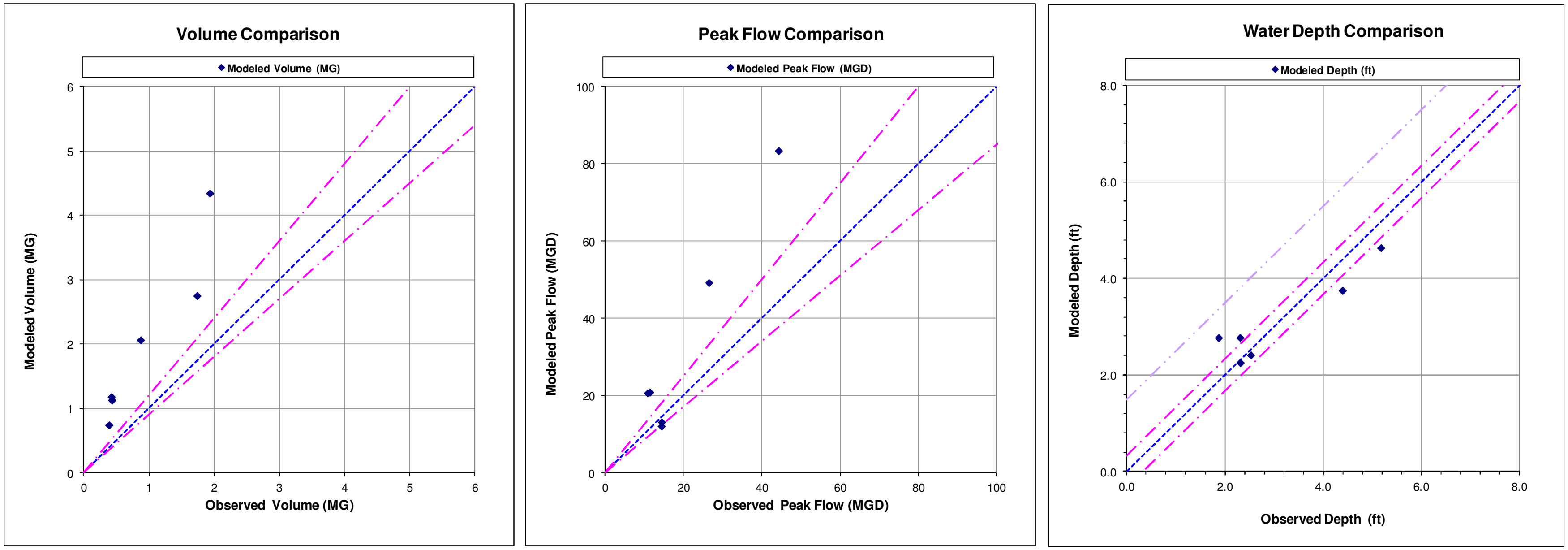


Figure A-6
HP 024 233rd Street Flow Comparison

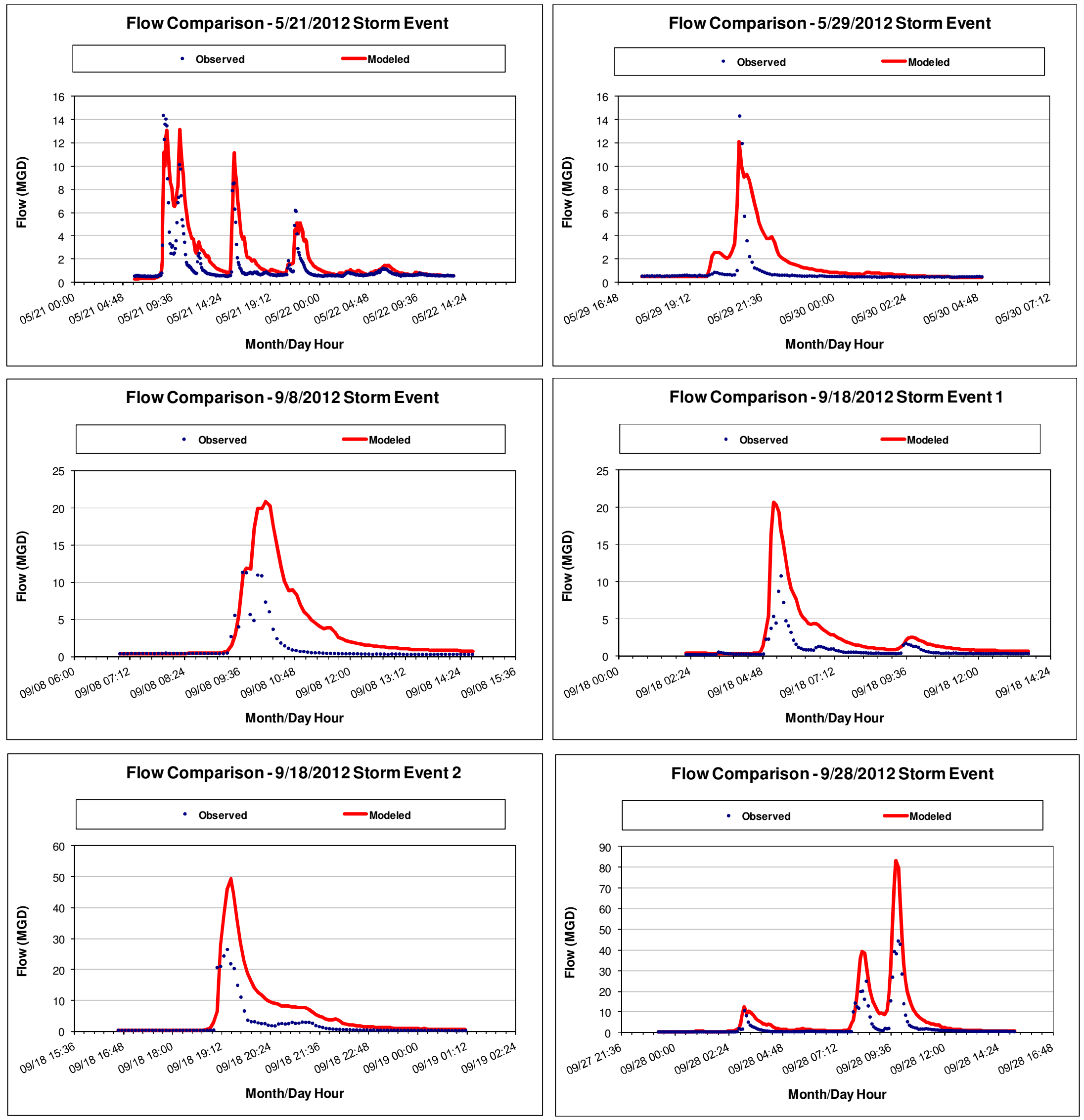
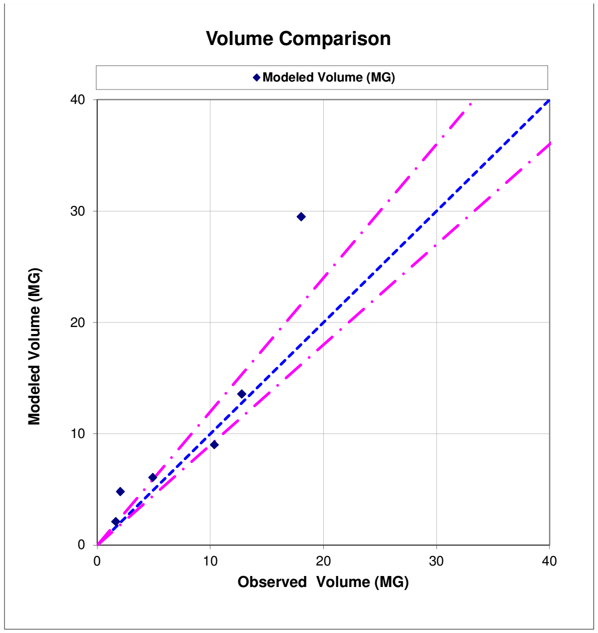
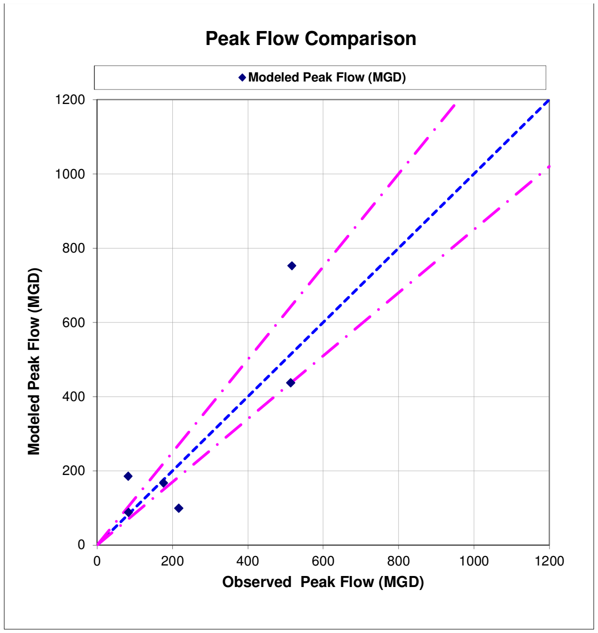


Figure A-7
HP 024 Boston Road Goodness of Fit Plots for Volume, Peak Flow and Peak Depth





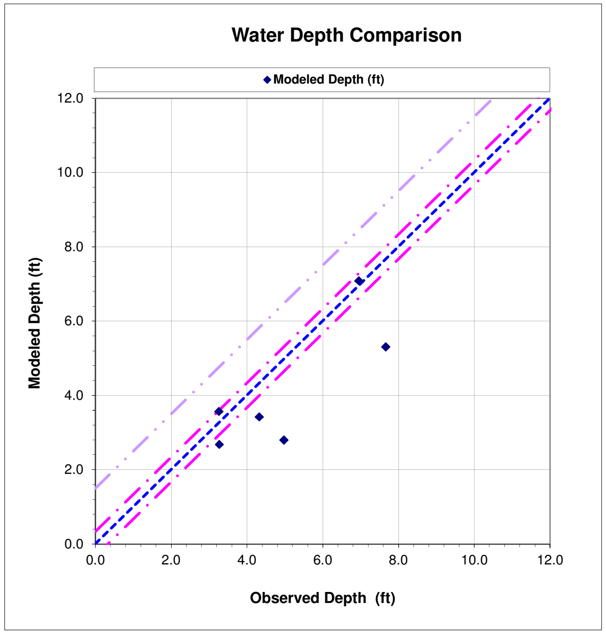


Figure A-8
HP 024 Boston Road Flow Comparison

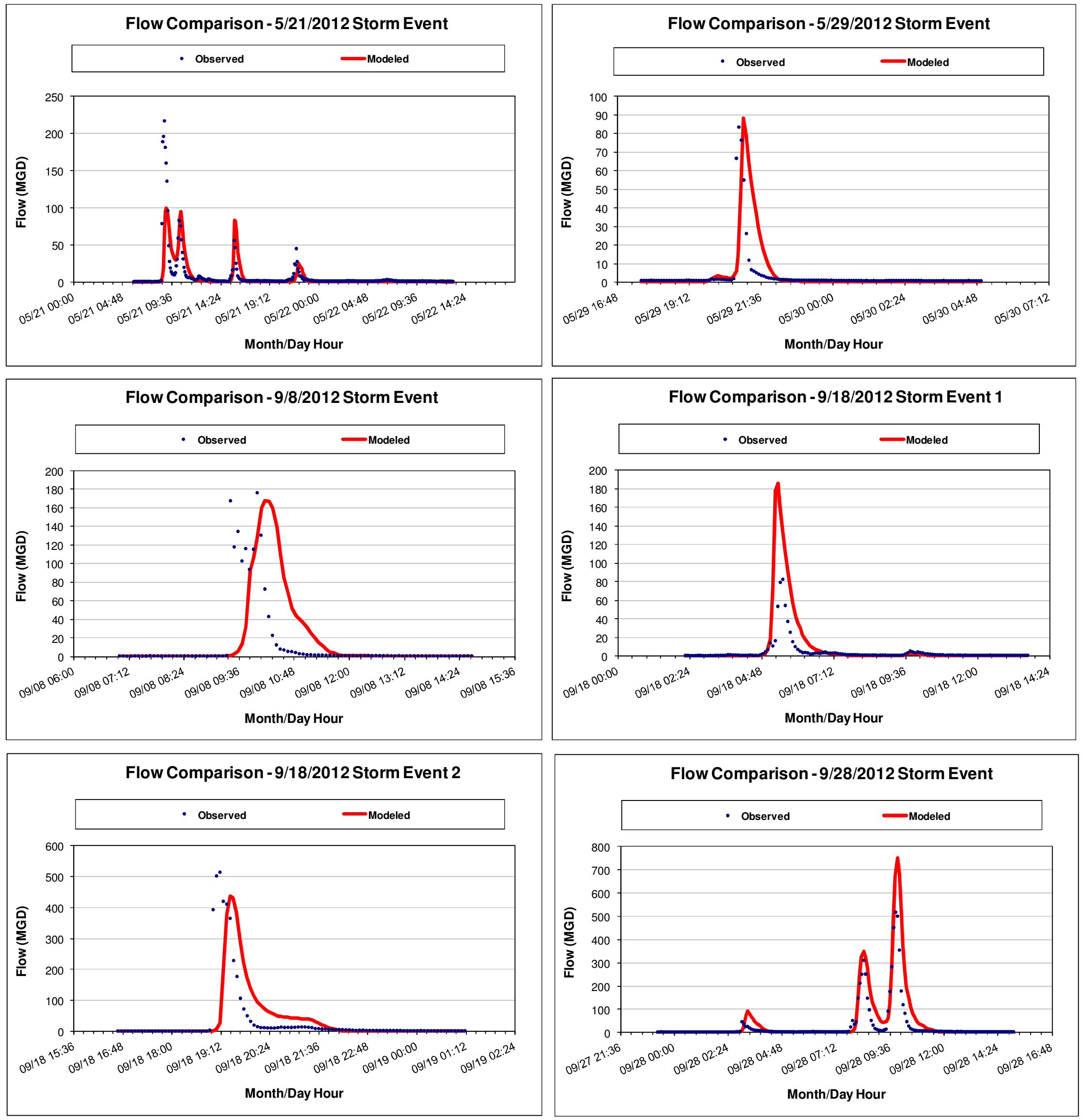


Figure A-9
HP 024 Interceptor Goodness of Fit Plots for Volume, Peak Flow and Peak Depth

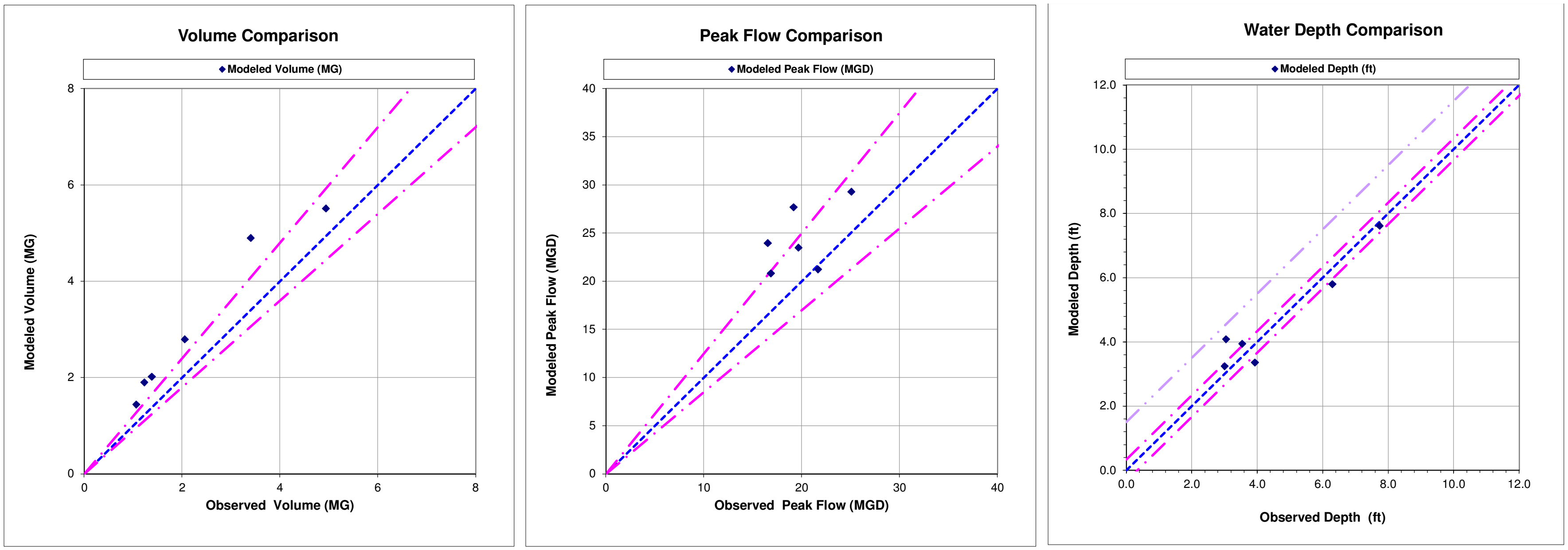


Figure A-10
HP 024 Interceptor Flow Comparison

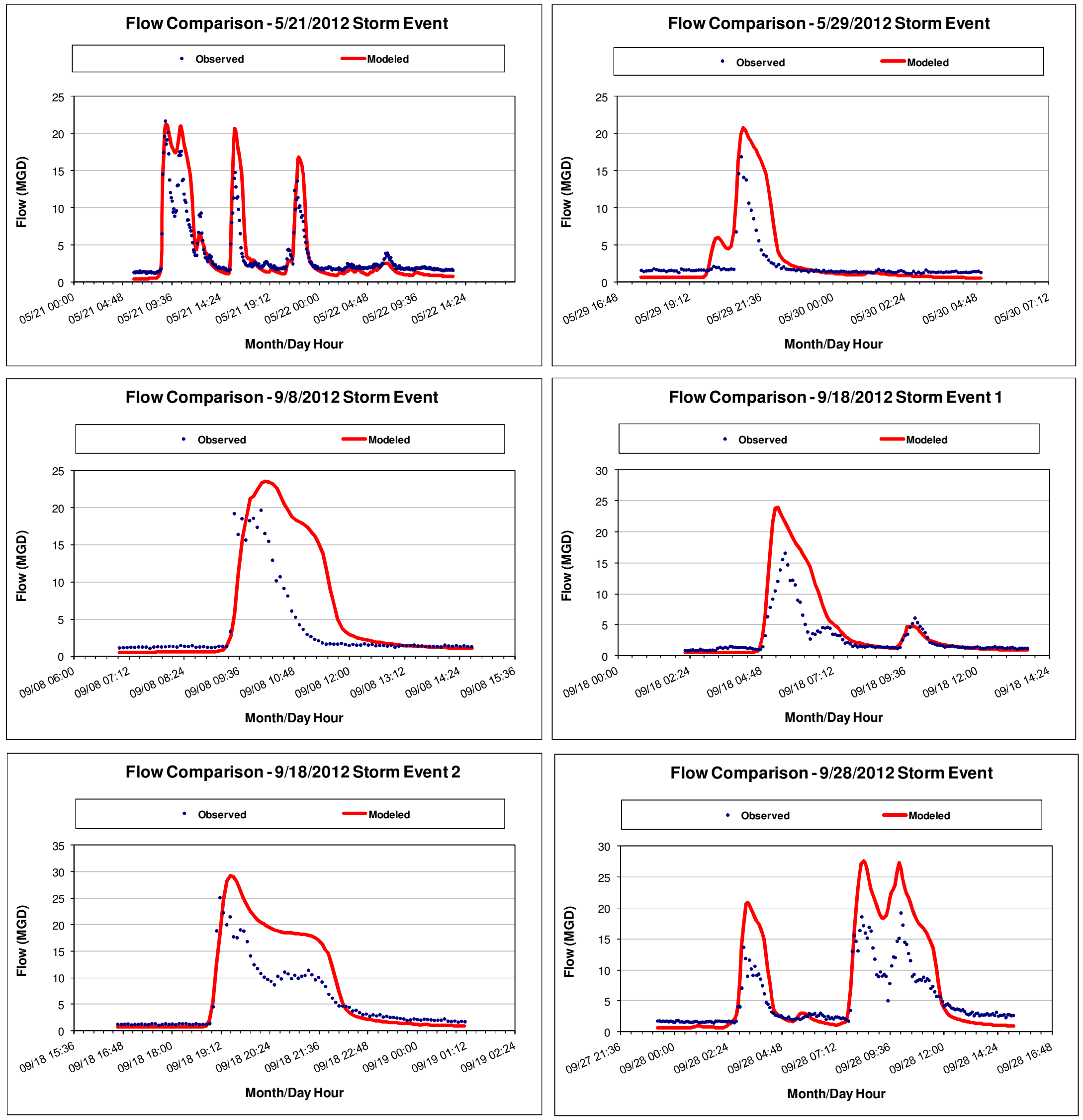


Figure A-11
HP 637 Goodness of Fit Plots for Volume, Peak Flow and Peak Depth

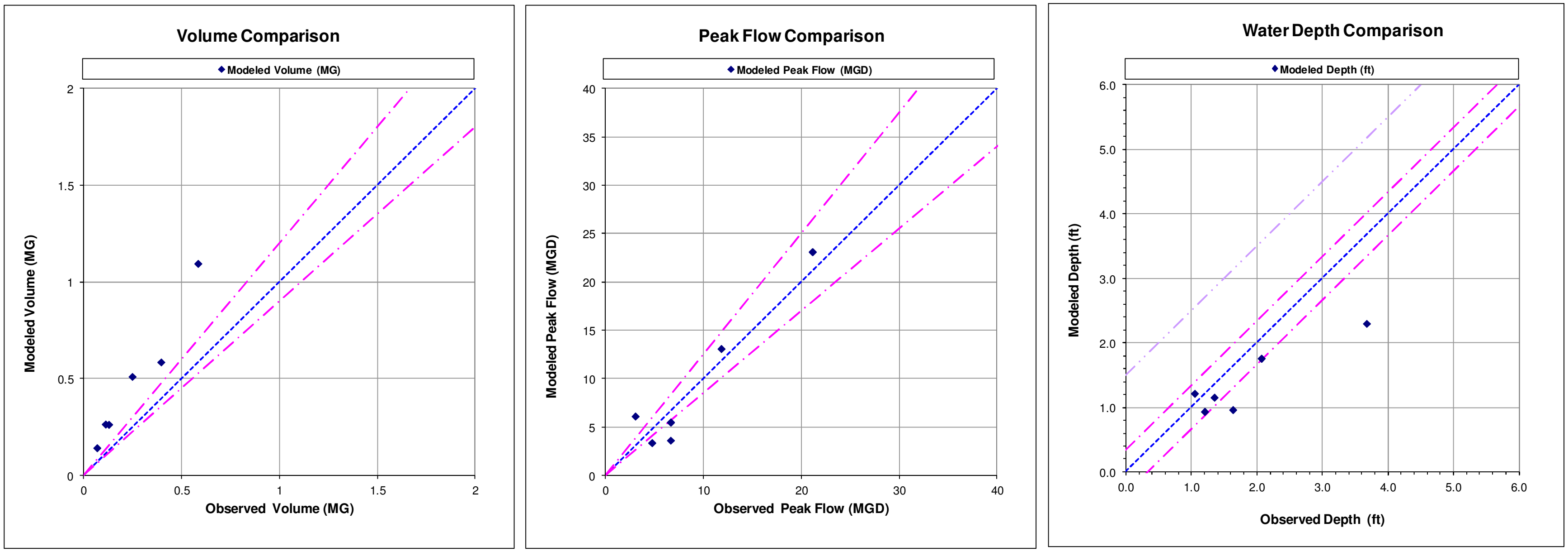


Figure A-12
HP 637 Flow Comparison

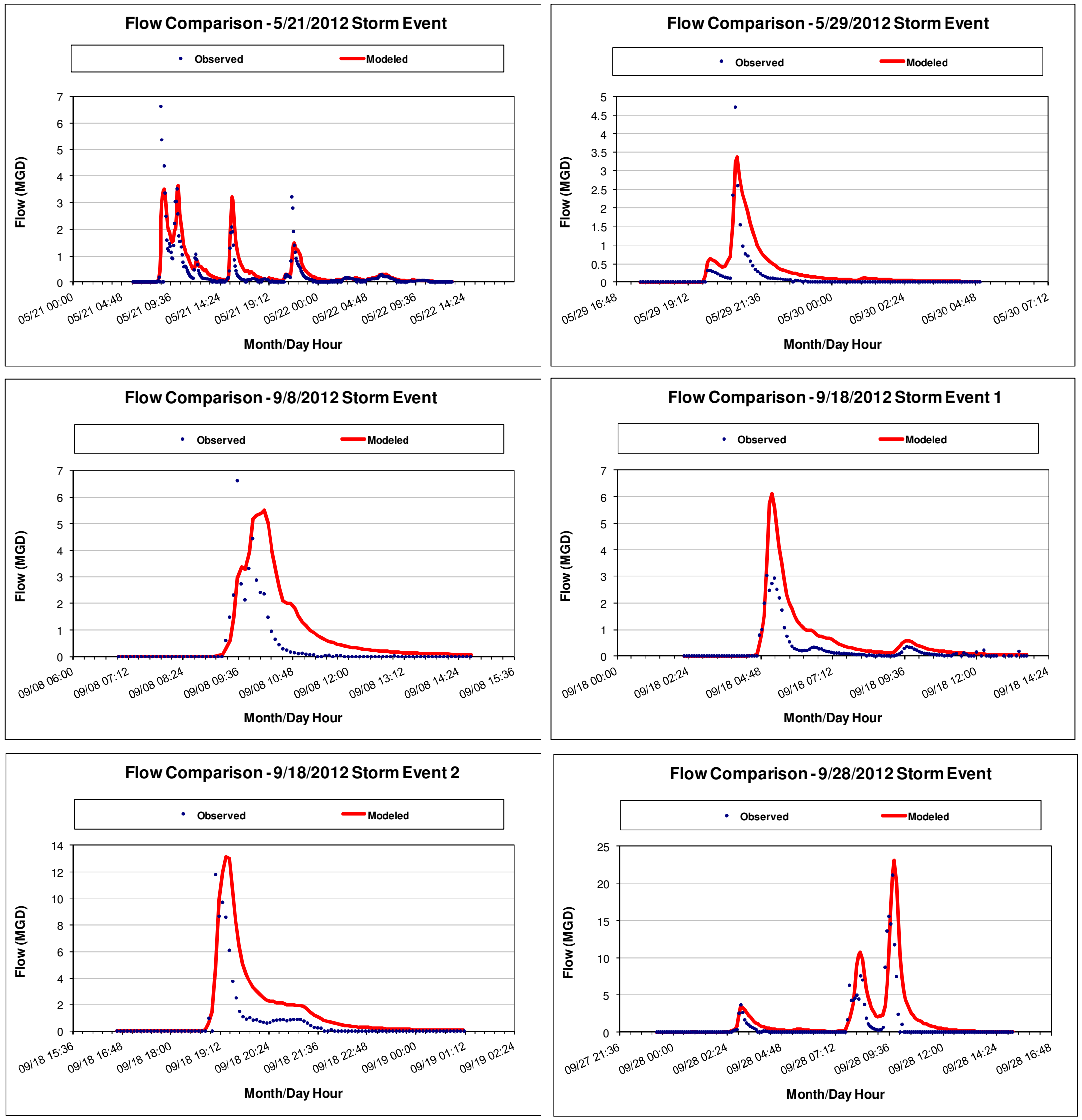
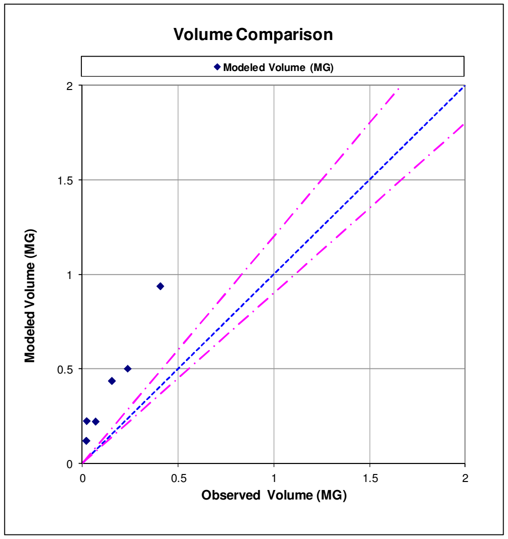
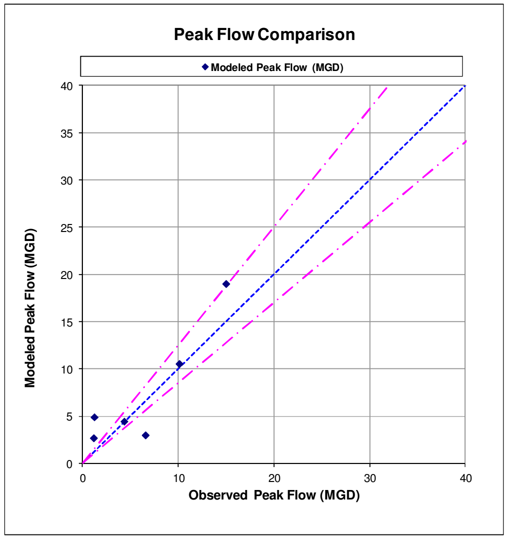


Figure A-13
HP 639 Goodness of Fit Plots for Volume, Peak Flow and Peak Depth





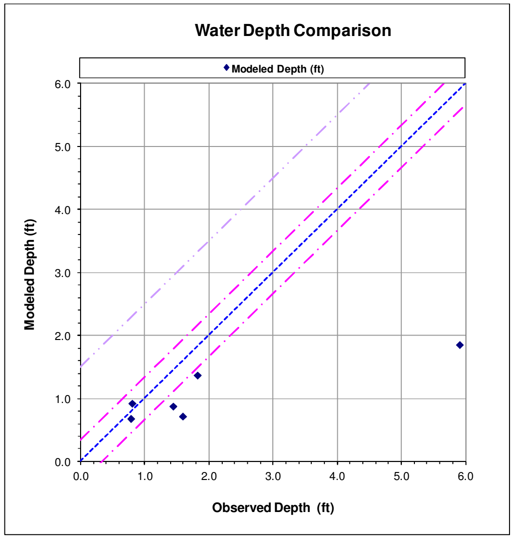
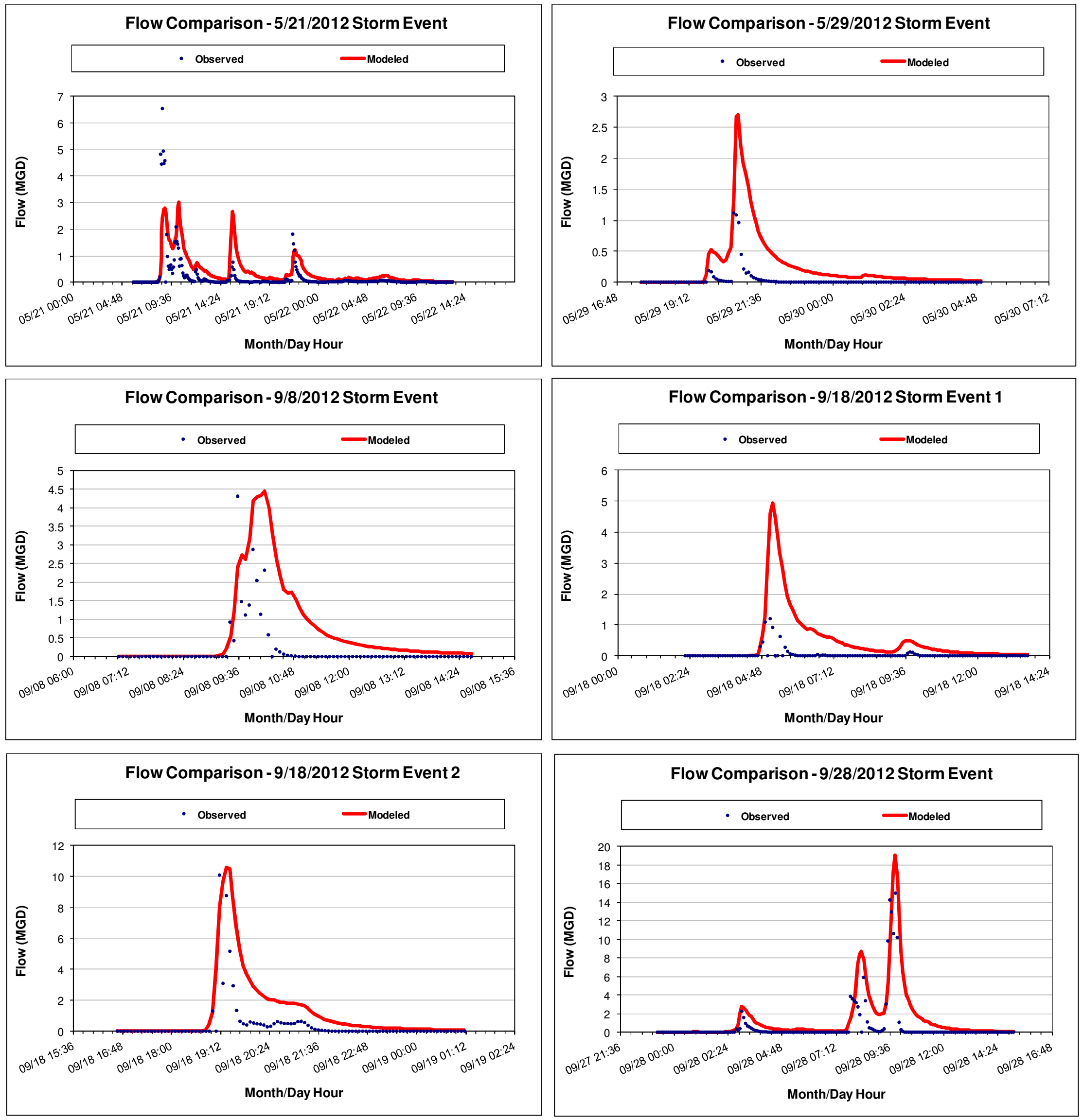


Figure A-14
HP 639 Flow Comparison



APPENDIX B

RECALIBRATION OF THE HUTCHINSON RIVER MODEL

Appendix B

Re-Calibration of the Hutchinson River Model

Table of Contents

List of Figures

List of Tables

Appendix B

Re-Calibration of the Hutchinson River Model

As stated in Section 4.1, the Hutchinson River is included as part of the larger area wide ERTM water quality model of the East River and western Long Island Sound. ERTM is a nested model of the regional System Wide Eutrophication Model SWEM model. The three-dimensional ERTM model framework is comprised of a hydrodynamic model Estuarine, Coastal, and Ocean Model (ECOM) coupled to a eutrophication and pathogens (i.e., water-quality) model Row-Column Aesop (RCA). The SWEM model also uses the ECOM and RCA model framework. This appendix is intended to describe the ERTM recalibration effort for the Hutchinson River.

Hydrodynamic Model

The ECOM hydrodynamic modeling program is a state-of-the-art, time-dependent, three-dimensional hydrodynamic model derived from the Princeton Ocean Model, which was developed by Alan F. Blumberg and George L. Mellor (1987). The model code is well known and respected within the international hydrodynamic modeling community. The code has been refined and upgraded constantly to include both more realistic physics and more robust numerical-solution techniques. The model incorporates the Mellor-Yamada (1982) Level-2.5 turbulent-closure scheme to provide a realistic parameterization of vertical mixing. Water surface elevation, water velocity in three dimensions, temperature and salinity, and eddy turbulence are predicted in response to time-variable meteorology (wind, rain, and incident solar radiation), tributary inflows, point-source and non-point-source inflows, changing bathymetry, tides, temperature, and salinity.

ERTM employs a version of ECOM called ECOMsi, which includes a semi-implicit time stepping algorithm developed by Vincenzo Casulli (1992) that allows ECOMsi to simulate wetting and drying of intertidal mudflats and marshland. Many of the East River tributaries of interest include large intertidal areas, so wetting and drying is important to simulating tidal hydrodynamics correctly in these waterbodies.

The hydrodynamic model solves a coupled system of differential prognostic equations describing the conservation of mass, momentum, temperature, salinity, turbulent kinetic energy, and a turbulence macroscale. The ECOM model governing equations have been fully defined in the ERTM Receiving Water Quality Modeling Report (NYCDEP 2007).

Hydrodynamic Model Recalibration

A 2012 regional SWEM simulation was completed to provide the 2012 ERTM boundary for model calibration. ERTM 2012 forcing includes meteorological data; elevations, salinity and temperature from the regional SWEM model near Kings Point in Western Long Island and near The Battery; and freshwater input from watershed model RAINMAN and USGS gages. Profiles of meteorological forcings are included in Attachment 1. The 2012 SWEM elevation, salinity and temperature model was then used for ERTM boundary conditions. ERTM was calibrated for 2012 by comparing model elevation to NOAA's elevation at Kings Point and also by comparing salinity and temperature data at Harbor Survey stations within the ERTM domain to the model results. These calibration figures are included in Attachment 2.

The hydrodynamic and water quality models utilize the same model segmentation to realistically represent the physical features of the Hutchinson River. Previously, the model for the Hutchinson River and Eastchester Bay began at the head of the channelized river used by barge traffic in Westchester County, NY. New York City waters commence approximately 3,075 ft. downstream of the transect origin. For this recalibration the model grid has been extended further upstream into the non-tidal portion of the river to Pelham Lake. The model domain extends throughout the Hutchinson River study area. The computational grid employs an orthogonal-curvilinear coordinate or boundary-fitted system that represents the complex and irregular shorelines. The model uses a vertical sigma-coordinate system that is scaled to the local water column depth and segments the water column into 10 vertical layers. The current model grid has a 90 column by 57 row configuration with 5,130 segments. The model grid cells have resolutions from 300 meters in the mouth of the river to about 20 meters near the head of the river, reflecting natural narrowing of the river upstream. The reconfigured segmentation has been shown in Figure 4-5, Section 4.3.3.

The non-tidal portion of the model begins approximately one mile upstream of the Westchester County line. The model was segregated into two sections in order to allow simulation of the non-tidal portion of the river upstream of the Westchester/New York City border and simulation of the tidal portion of the river. By segregating the model into non-tidal and tidal parts, saltwater cannot propagate into the freshwater portion of the river. The upstream portion of the reconfigured grid with demarcation of the older ERTM model upstream boundary has been shown in Figure 4-6, Section 4.3.3.

Calibration Source Flows

Recalibration runs include river, CSO, stormwater, overland runoff and dry-weather flows for 2012 conditions. Model input flows are provided from InfoWorks output, USGS gage flow data, and monitoring. This section describes the development of model input flows.

As discussed in Section 4.3, the InfoWorks model was calibrated to provide inflows from CSOs and storm sewers to the NYC portion of the river. Since the model was extended upstream into Westchester County, inflows to the river in Westchester County were needed as additional model input. These inflows include upstream boundary flow, stormwater discharge and dry-weather flows. There are no CSOs in the Westchester County section of the Hutchinson River included in the model.

Pelham Lake Upstream Boundary Flow

The upstream model boundary is located just downstream of the Pelham Lake overflow weir. During the 2012 monitoring, a flow meter and rain gage were placed at the upstream boundary sample location (HR-09). In addition, a USGS stream gage (01301500) has been operational at this location since June 2000. Comparisons between the USGS flow and the project flow meter indicated that the flow measurements were consistent. The USGS gage flow was used as input for the 2012 full year model run.

Westchester County Inflows

Stormwater

Westchester County stormwater flows are included in the recalibrated model input. The NYC InfoWorks model for the Hunts Point WWTP was modified to include a portion of Westchester

County. This new portion of the model is a 2,295 acre area representative of the Hutchinson River drainage area from the USGS gauge to the Westchester County/NYC border. The 2,295 acre area was modeled by converting a SWMM model developed by Westchester County (Westchester County, 2012) with detailed subcatchment areas into the NYC InfoWorks model. Figure 4-7, Section 4.4.1.2 shows the Westchester County subcatchments. All of these Westchester County subcatchments drain areas of Mount Vernon downstream from Pelham Lake.

The Westchester County SWMM model also included subcatchments and land areas north of Pelham Lake that were not directly included in the InfoWorks model. However, since the downstream portion of that part of the model produced flows at the USGS gauge (downstream end of Pelham Lake), it was used in this analysis to get a handle on typical model parameters, such as impervious cover. This portion of the water watershed model was calibrated to 18 storm events that occurred between October 2009 and May 2011 and included storms ranging between 0.49 inches to 5.54 inches. Figure 4-8, Section 4.4.1.2 shows goodness-of-fit plots of the SWMM calibration at the USGS gage. As shown, the model reproduced peak flows and runoff volumes that are consistent with the monitored data, especially for peak flows corresponding to large storms (upper end of the flow duration curve). This calibration of the model parameters for the areas of the Westchester County SWMM model was then used as a basis for adjusting model parameters for the Westchester County portion of the SWMM model for the area between Pelham Lake and New York City. InfoWorks runs for Hunts Point used rainfall from the La Guardia International Airport (LGA) rain gage for the 2012 calibration. The LGA rainfall record was adjusted for two rain events where Hutchinson River rain gage values were used as part of the calibration process

Dry Weather

Westchester County dry weather flows are included in the recalibrated model input. Dry weather inflows at HR-08 and HR-06 were calculated as 1.44 MGD and 0.2 MGD respectively, using the 2012 sample period storm sewer flow data. In order to reproduce pathogen concentrations in the freshwater section of the river during the calibration process, dry weather bacteria loading at HR-08 was reduced by reducing the flow to 0.72 MGD in the model. This adjustment reflects a loading adjustment that could be due to concentration, flow or a combination of concentration and flow.

Salinity and Temperature Calibration

Model calibration of salinity is presented in Figures B-1 and B-2 for the five month sampling period (May through September 2012). Figure B-1 presents model calibration at sample locations within Westchester County (HR09 to HR06) and Figure B-2 presents data and model comparisons for the sample locations within NYC (HR05 to HR01). All dry event samples for HR01 to HR06 were taken at mid depth at the time of sample. All wet event samples for HR01 to HR06 were taken at both two feet from the surface and two feet from the bottom. All samples (dry or wet event) for HR07, HR08 and HR09 were taken at mid depth. Model results in these and the following calibration figures are depth averaged concentrations. The model is in good agreement with the data.

Figures B-3 and B-4 present comparisons of temperature data and model for the five month calibration period. Water column seasonal and diurnal temperature patterns are captured by the model. Diurnal effects are more pronounced in the Westchester County (HR09 to HR06, Figure B-3) than in the NYC (HR05 to HR01, Figure B-4). This can be expected since the Westchester County locations are shallower and do not experience tidal and boundary influences.

Continuous surface and bottom salinity and temperature data was also monitored at two locations in the river from July 10 to July 26, 2013. Figure B-5 shows salinity and temperature data and model results at sample locations HR05 and HR03, respectively.

Water Quality Model

The water quality model of the Hutchinson River uses the RCA model framework that was developed for the East River Planning Project. This framework is capable of calculating eutrophication parameters (DO, nutrients, algae) and bacteria. However, the intent of this modeling analysis is to investigate point and non-point source origin and fate of pathogens within the Hutchinson River. Therefore, for the purposes of this analysis, only calculations of bacteria levels are being performed. The water quality model uses the circulation patterns from ECOM and the pollutant loadings from the landside model as inputs to calculate enterococci and fecal coliform concentrations, and to track the fate of bacteria in the water column. The kinetic portion of the model computes the loss of bacteria due to a first order die-off rate. This die-off rate is comprised of three mechanisms: a base mortality rate, death due to salinity, and death due to solar radiation. The effect of solar radiation on the total death rate is generally small during and following wet weather events and is not included in the model. The overall death rate varies with water temperature, and is greater at higher ambient water temperatures. Indicator bacteria are intestinal microbes, so the model does not include bacterial growth within the receiving water. Bacteria kinetic equations are defined in the ERTM Receiving Water Quality Modeling Report (NYCDEP 2007).

Time-variable bacteria loads were developed using source concentrations measured during the 2012 sampling program and flow from the USGS gage and InfoWorks output. Wet weather bacteria concentrations were measured in four stormwater pipes and two CSO pipes. Two of the stormwater pipe locations (HR-08, HR-06) were in Westchester County, and two stormwater pipe locations (HP-637, HP-639) were in NYC. There are no CSOs within Westchester that discharge to the Hutchinson River. Of the three CSOs within NYC that discharge to the river, two of these were sampled during 2012 (HP-023, HP-024). Dry weather sampling was also completed in 2012 at stormwater pipes HP-06 and HP-08. These sampling data were used to derive concentrations needed to develop loads to the model as described below. There are no WWTP discharges to the Hutchinson River. Since this model is run as part of the larger ERTM model, effects of WWTPs outside of the Hutchinson River are appropriately accounted for.

CSO, Storm and Dry Weather Concentrations

Maximum likelihood estimates (MLE) of discharge concentrations for each of the wet weather stormwater and CSO discharges and for the dry weather stormwater sewer discharges were calculated. MLE estimates were derived by calculating the mean and standard deviation of the natural log transformed data. The MLE of the data is then estimated as a function of the natural log mean and standard deviation by the following equation:

$$MLE = e^{(\mu_{ln\,x} + 0.5\sigma_{ln\,x}^2)}$$

Table 4.2, Section 4.4.2.1 presents the wet and dry weather storm water concentrations applied in the model based on MLE calculations. Note that dry weather samples at HR06 and HR08 are based on a three sample events in September 2012. Of these dry weather samples, those collected on September 21, 2012 were not used to calculate the dry weather MLE as high values indicate that a 1.71 inch rain event that ended on September 18 at 9:00 pm may have affected bacteria levels. Also, high dry weather bacteria values at HR06 on September 12 were considered outliers and were not used.

Upstream Boundary Concentrations

The upstream model boundary is located just downstream of the Pelham Lake overflow weir. In-stream measurements at location HR09 represent bacteria concentrations at the upstream boundary. Statistical analyses were completed in order to relate upstream bacteria concentrations to wet and dry weather flow conditions. Hourly bacteria boundary concentrations for the 2012 calibration were then calculated using statistical relationships and the rainfall data. A more detailed development of these relationships and the development of the upstream boundary concentrations for the 2012 calibration is presented.

The distinction between dry weather and wet weather sample results are demonstrated through probability distributions of these data in shown in Figure B-6. Samples were collected during either dry periods when samples were collected twice per day for one day, or for wet periods when samples were collected twice per day for three days after a rain event as described in Section 3.2 of this report. A sample is considered “wet” if it rained within 48 hours of the sample collection time; likewise, a sample is considered “dry” if there was no rainfall for at least 48 hours prior to the collection time. The results are shown for collected fecal coliform, and enterococci bacteria. Data in Figure B-7 indicate that there is a clear distinction between dry and wet weather samples; the “wet” are generally higher than the “dry” samples.

The next step in the boundary concentration analysis is to develop the relationship between bacteria concentrations and rainfall. Figure B-7 shows wet weather bacteria concentrations at the HR09 sampling location as a function of 24 and 48 hour rainfall recorded at the same location (Hutchinson River rain gage). These results indicate a relationship with rainfall; the highest observed bacteria concentrations occur during rainfall events that occur within 24 or 48 hours prior to sampling. It should be noted that samples were collected for three days during wet weather events and bacteria concentrations at observed zero rainfall generally reflect samples collected on day three when rain effects have diminished. As a result, the regression analysis of rainfall to bacteria concentrations was done using the first two days of wet weather sampling. The regression analysis indicated that use of variables of 0-24 hour and 25-48 hour rainfall prior to sampling for rain events greater than 0.05 inches, resulted in the best correlation of rainfall to measured concentration with correlation coefficients of 0.792 for enterococcus and 0.652 for fecal coliform.

Figure B-7 shows that there is considerable variability in the observed data at "zero" rainfall, indicating there is variability in bacteria levels during dry periods. The cause of the dry weather variability is not fully understood. The variability in the data may reflect affects from Pelham Lake which could be causing a dampening or lag of the wet weather concentrations. The variability could also be the result of intermittent illicit connections to storm sewers or the result of bird and animal waste that could build up and unload. Since it is not fully understood, however, the observed dry weather variability in this analysis is considered to be random.

Wet Weather Analysis

In order to correlate bacteria concentrations to rainfall, a multiple-linear regression analysis was performed. In this analysis, the dependent variable is the log of the bacteria concentration on the sample date. There are two independent variables in the analysis; these are, R1, the total rainfall in the 24 hours prior to sampling, and R2, the total rainfall 24 to 48 hours prior to sampling. The form of the equation is as follows:

$$\text{Log}(C) = a + bR1 + cR2$$

Where: a, b, c are coefficients resulting from the regression analysis
The resulting coefficients with the correlation coefficient, R2, are summarized on Table B-1.

Table B-1.
Results of Multiple-Linear Regression Analysis

Location	Parameter	Coefficents			Correlation
		a	b	c	
HR09	**Entero**	2.31	0.827	0.237	0.792
	F. Coli	3.04	0.657	0.019	0.652

Probability distributions were developed for the bacteria parameter at the HR09 location by applying the above equations to the wet days of sampling. These calculated concentration distributions are compared the actual wet day sample results. These results are shown on Figure B-8. As shown on the figure, the calculated probability distribution agrees well with the measured distribution.

Dry Weather Analysis

As discussed previously, the observed variability with the dry weather data is not fully understood; therefore, in this analysis, the dry weather concentrations are assumed to be random in accordance with the observed distribution. Assigning a concentration during dry weather was accomplished through a Monte-Carlo approach whereby the concentrations are randomly assigned using the statistical properties of the observed distribution. The key statistics required for the analysis include the mean and standard deviation of the observed distribution and the number of values to be assigned. Therefore, if for example 100 values are to be assigned, the Monte-Carlo analysis will randomly choose 100 values which will have an underlying distribution with the mean and standard deviation that were assigned from the observed data.

Daily Predictions

Combining the wet weather regression analysis and the Monte-Carlo approach for the dry weather days, the bacteria concentrations for each day of the sampling period can be calculated. Probability distributions of the calculated and observed data are developed for comparison purposes. Figure B-9 shows the calculated and observed distributions considering only those days when samples are collected. The figure shows the results for fecal coliform and enterococci bacteria at sample location HR09. As shown, the methodology outlined above does a very good job of reproducing the observed data and its characteristics.

This predictive methodology is applicable to any given rainfall pattern under current conditions that produced the wet and dry weather measured bacteria concentrations. This is particularly useful for evaluating conditions other than those of the sample collection period. Therefore, the predictive tool has been used to calculate the upstream boundary condition of the Hutchinson River for the 2012 calibration period as well as for projection conditions. Should conditions upstream of HR09 change, such as the elimination of dry weather sources, then this prediction methodology would need to be revisited.

In addition, the methodology can also be used to adjust the geometric mean concentration to meet water quality standards. For example, if a concentration profile is required for projection purposes that will meet an enterococci geometric mean concentration of 35 #/100 mL, the geometric mean of the distribution can be adjusted downward to meet this criterion while maintaining the same variability (coefficient of variation) that was observed in the data. This methodology has been used to meet bacteria standards at Pelham Lake for projection analyses discussed in Section 5.3.

Figure B-10 demonstrates how this methodology can be applied to a continuous rainfall record. These figures show the probability distribution for the 2012 sampling period. In these figures, the calculated concentrations use the daily rainfall records – not just the days of sampling. As shown on the figures, the calculated distributions agree well with the observed distribution even though the calculated distribution uses the continuous rainfall record.

CSO, Stormwater, Dry Weather and Upstream Boundary Loads

The concentrations and flows discussed above are applied in the model on an hourly basis to develop loads for the 2012 calibration. Hourly NYC CSO and NYC stormwater loads were calculated using InfoWorks model sanitary and stormwater flows along with concentrations presented in Table 4.2, Section 4.4.2.1. Hourly Westchester County stormwater loads were calculated using Infoworks flows for the Westchester County discharges HR06 and HR08 as described above and concentrations in Table 4.2, Section 4.4.2.1. Westchester County dry weather loads were calculated at HR08 and HR06 using calibrated flows of 0.72 MGD and 0.2 MGD, respectively and concentrations in Table 4.2, Section 4.4.2.1. Upstream boundary concentrations were calculated using statistical methods described based on the 2012 LGA rainfall record. Annual flow and loads and percent contribution for CSO, stormwater, dry weather and upstream contributions from the NYC and Westchester County sources calculated for the 2012 model calibration is given in Table 4.3, Section 4.4.2.2 and Figure 4-9, Section 4.4.2.2.

Model calibration figures for enterococcus and fecal coliform are presented in Figures B-11 to B-14. All dry event samples for HR-01 to HR-06 were taken at mid depth at the time of sample. All wet event samples for HR01 to HR06 were taken at both two feet from the surface and two feet from the bottom. All samples (dry or wet event) for HR-07, HR-08 and HR-09 were taken at mid depth. The data points are the solid symbols and the model calculations are the solid lines. Average concentrations over the ten layer model segmentation are presented. The enterococci and fecal coliform model peak concentrations at Westchester locations in Figure B-11 and Figure B-13, respectively, compare favorably with the data suggesting the Westchester County bacteria loads are not being overestimated. The enterococci and fecal coliform model peak concentrations at NYC locations in Figure B-12 and Figure B-14 respectively, compare favorably with the data suggesting the CSO loads are not being underestimated. Comparison of data and model indicate that the model is also reproducing the combination of die-off and dilution to match the decrease in bacteria concentration over time. The model is able to capture peak concentrations that occur during rain events as well as an approximately two day decline to dry weather levels. An increase in dry weather enterococci concentrations downstream of HR-09, at sample location HR-08, demonstrates effects of dry weather inflow (Figure B-11). In order to use the same y-axis scale on all of the figures, the model calculated enterococci concentrations less than 1 MPN/100mL were set equal to 1 MPN/100mL for plotting purposes. The enterococci concentrations at HR01 reflect Eastchester Bay and East River influences.

Figure B-1
Hutchinson River 2012 Salinity Calibration – Westchester County Sample Locations

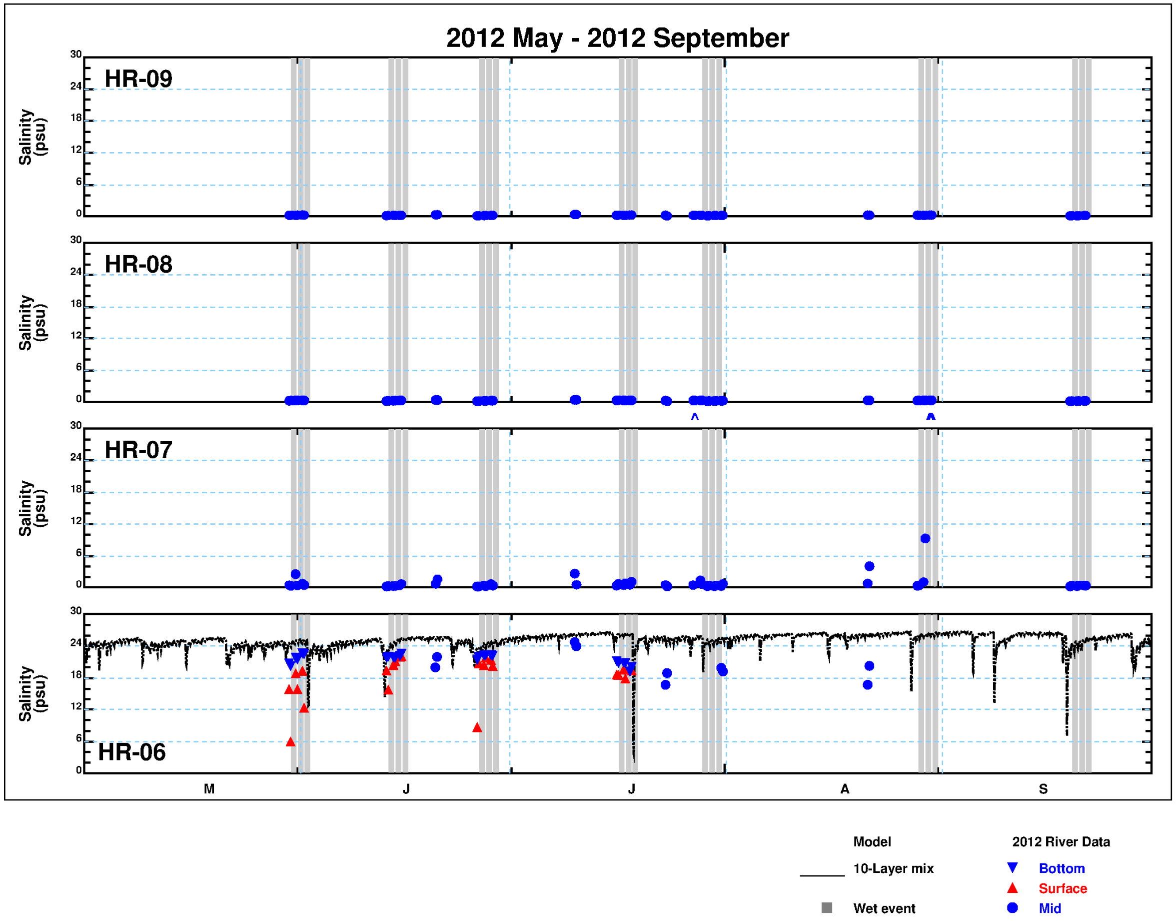


Figure B-2
Hutchinson River 2012 Salinity Calibration – NYC Sample Locations

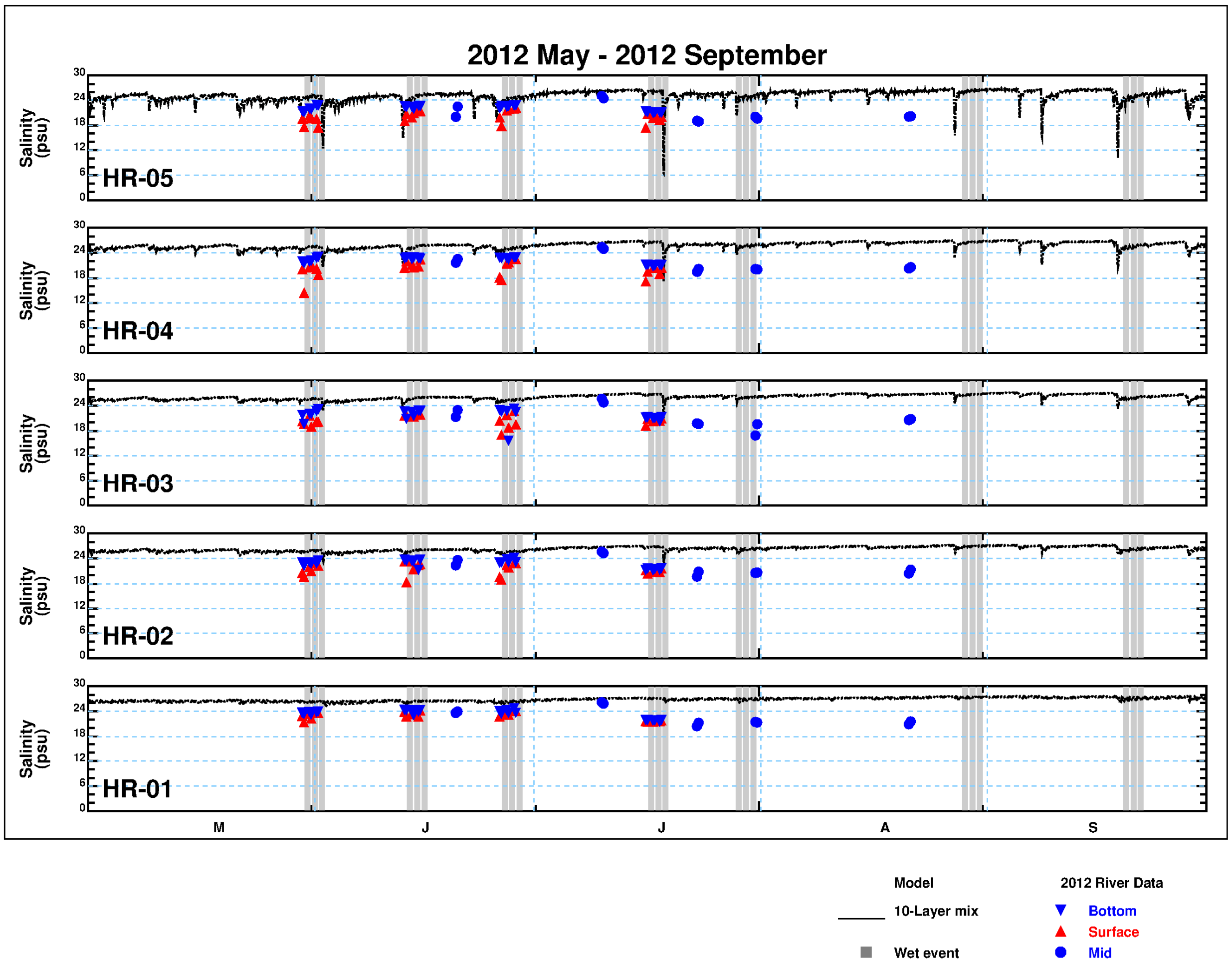


Figure B3
Hutchinson River 2012 Temperature Calibration – Westchester County Sample Locations

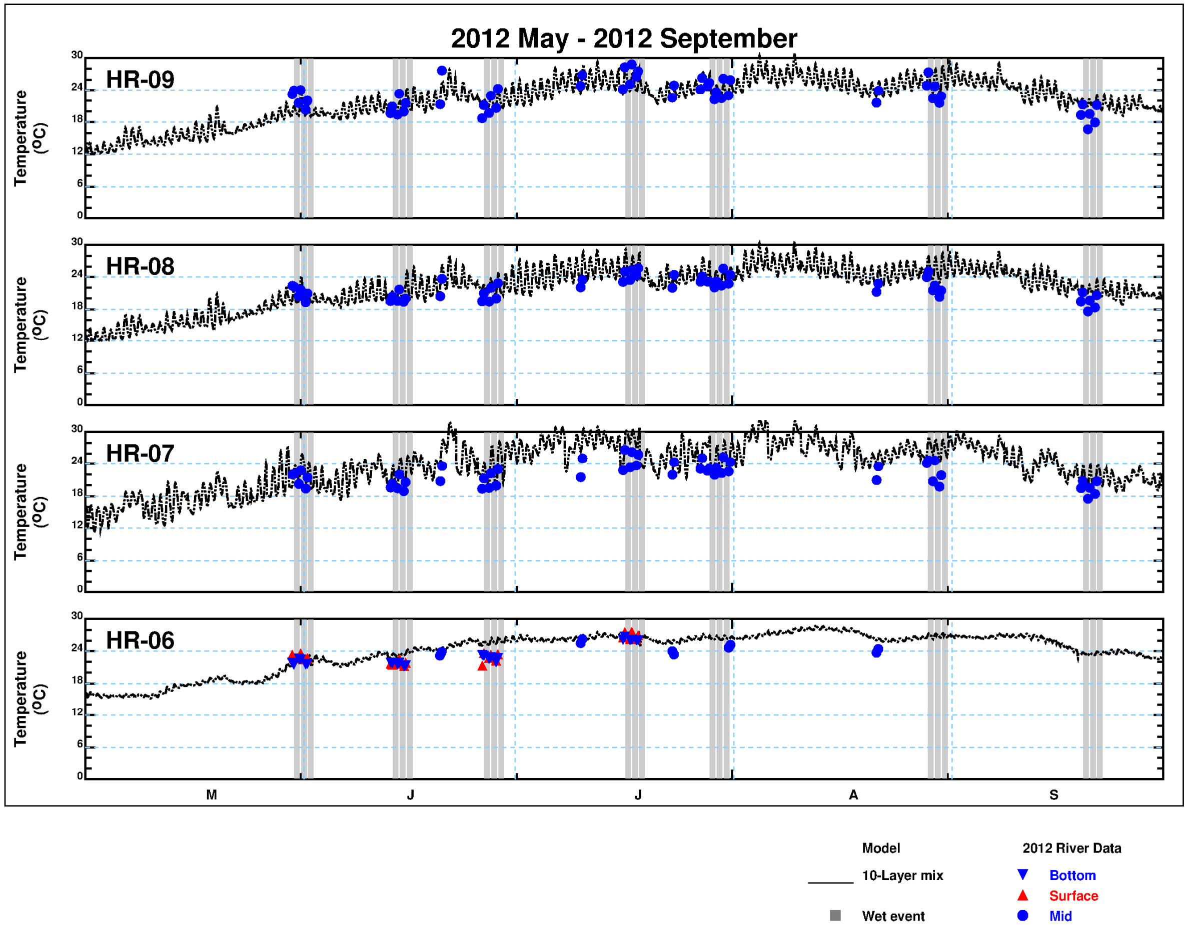


Figure B-4
Hutchinson River 2012 Temperature Calibration – NYC Sample Locations

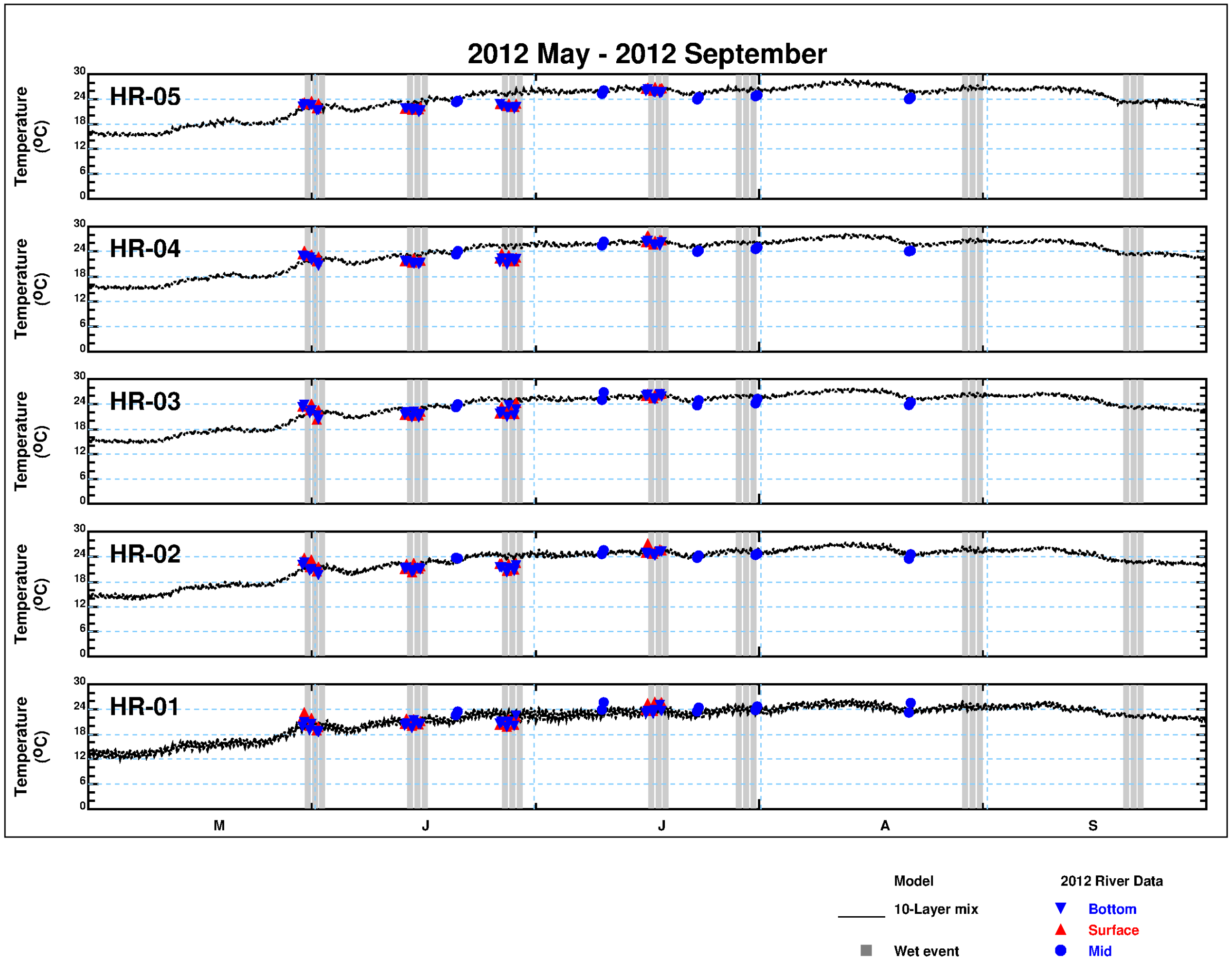


Figure B-5
Salinity and Temperature Continuous and Grab Data Compared to Model Results: July 10 -26, 2012

Figure B-6
Hutchinson River Observed Wet & Dry Weather Bacteria Data Sample Location HR09, May 30, 2012 to September 21, 2012

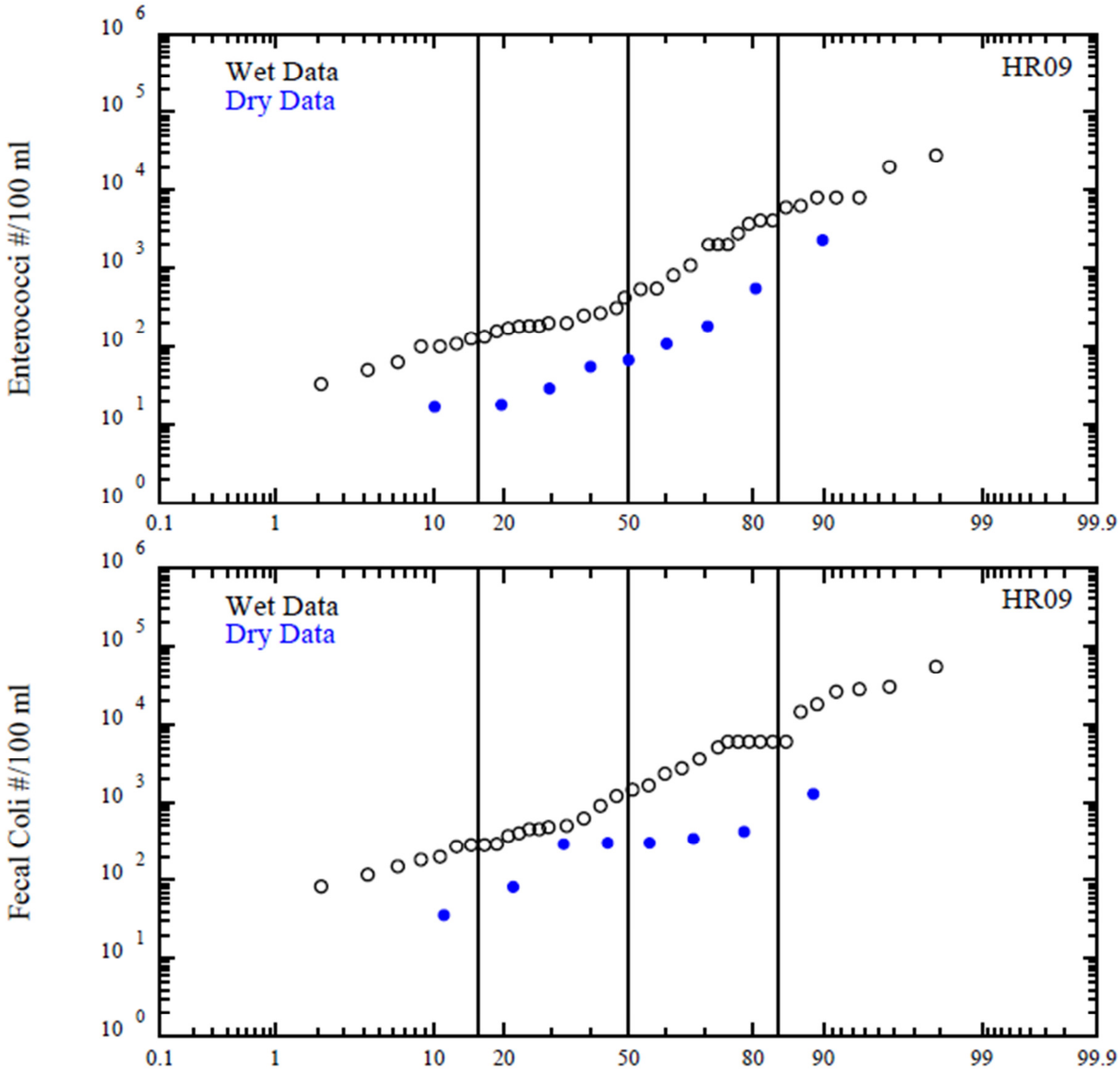


Figure B-7
Hutchinson River Wet Weather Data versus Rain at Sample Location HR09, May 30, 2012 to September 21, 2012

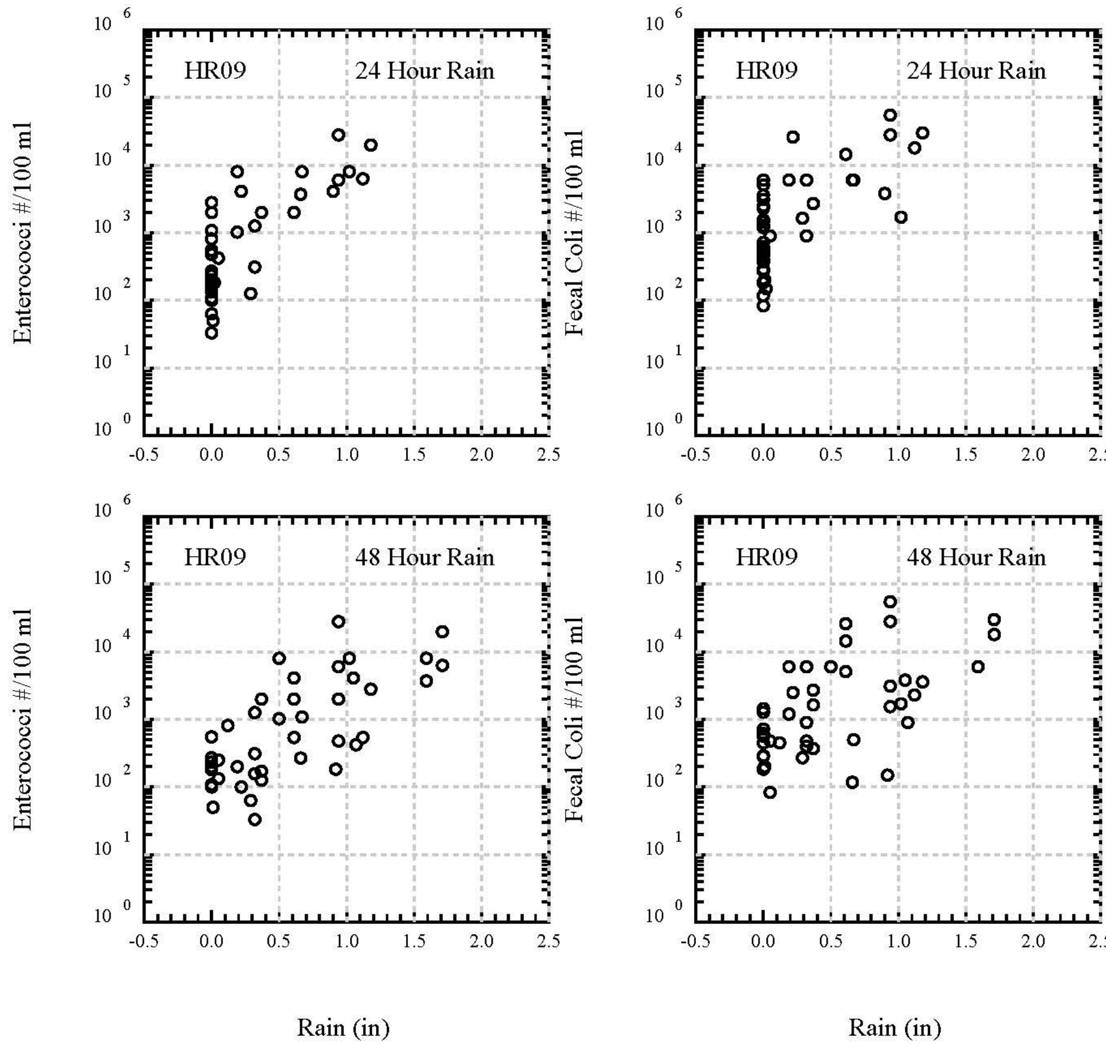


Figure B-8
Observed and Calculated Wet Weather Bacteria Concentrations

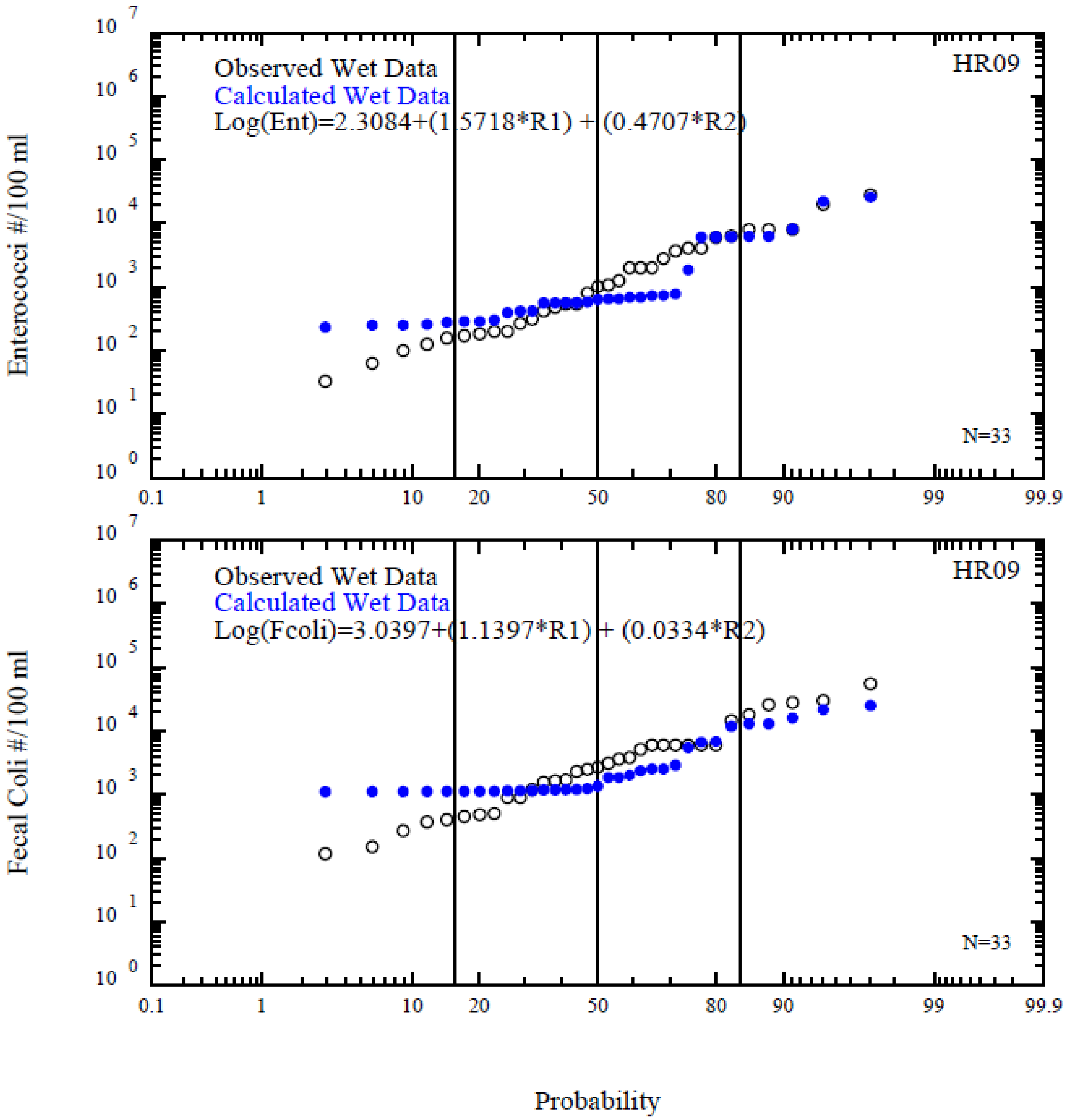


Figure B-9
Observed and Calculated Wet and Dry Weather Bacteria Concentrations

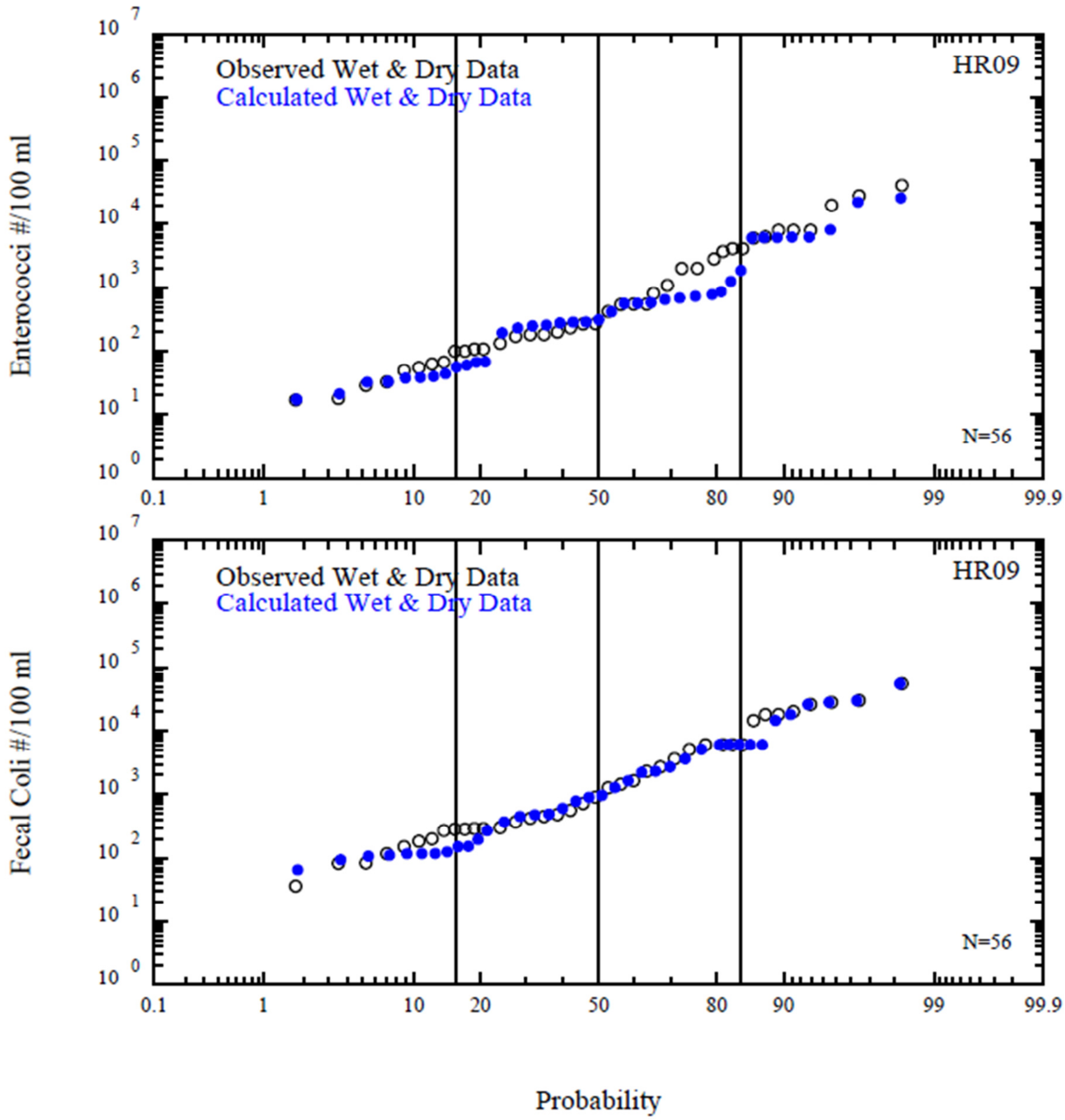


Figure B-10
Observed and Annual Calculated Wet and Dry Weather Bacteria Concentrations

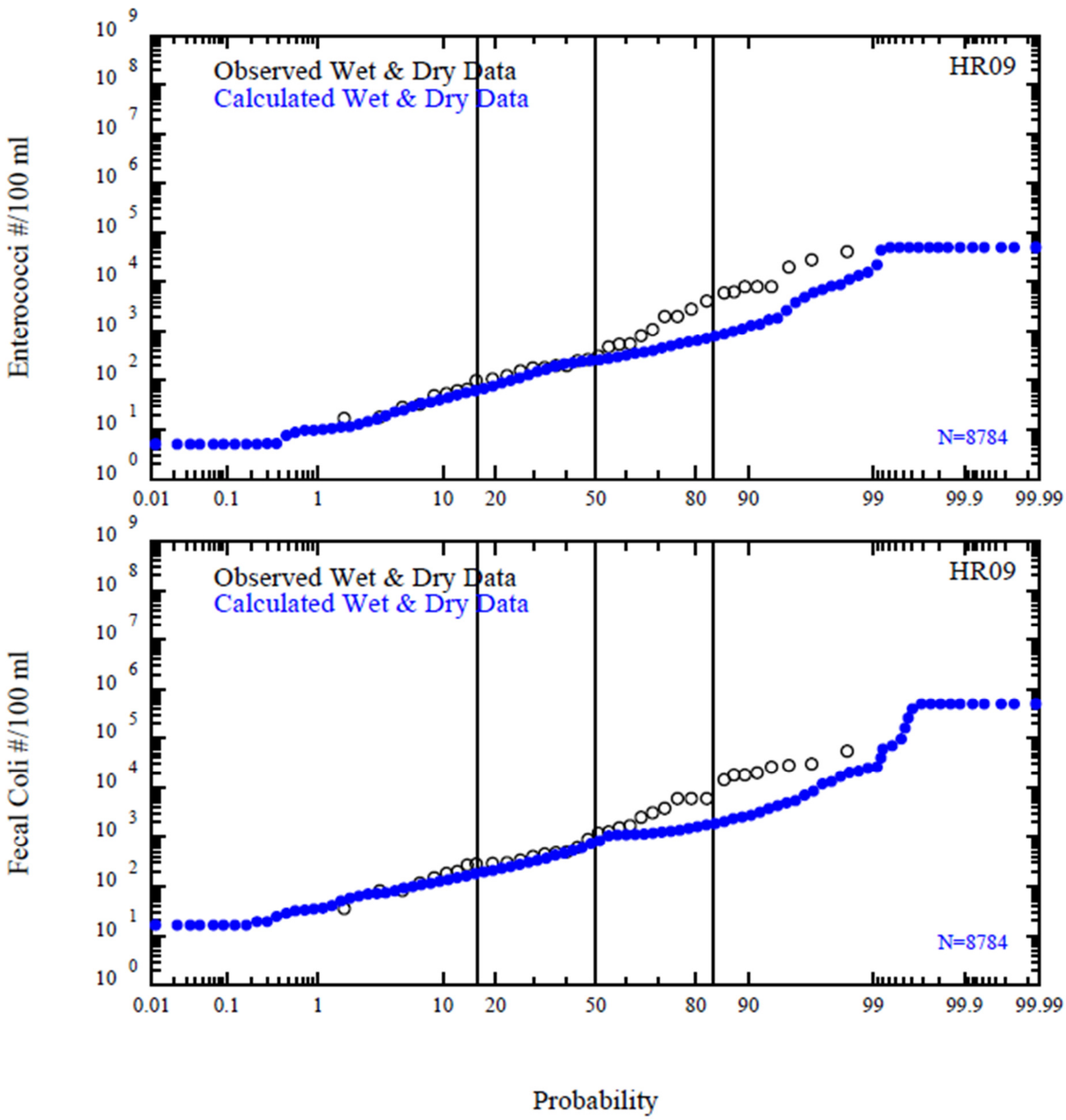


Figure B-11
Hutchinson River 2012 Enterococci Calibration – Westchester County Locations

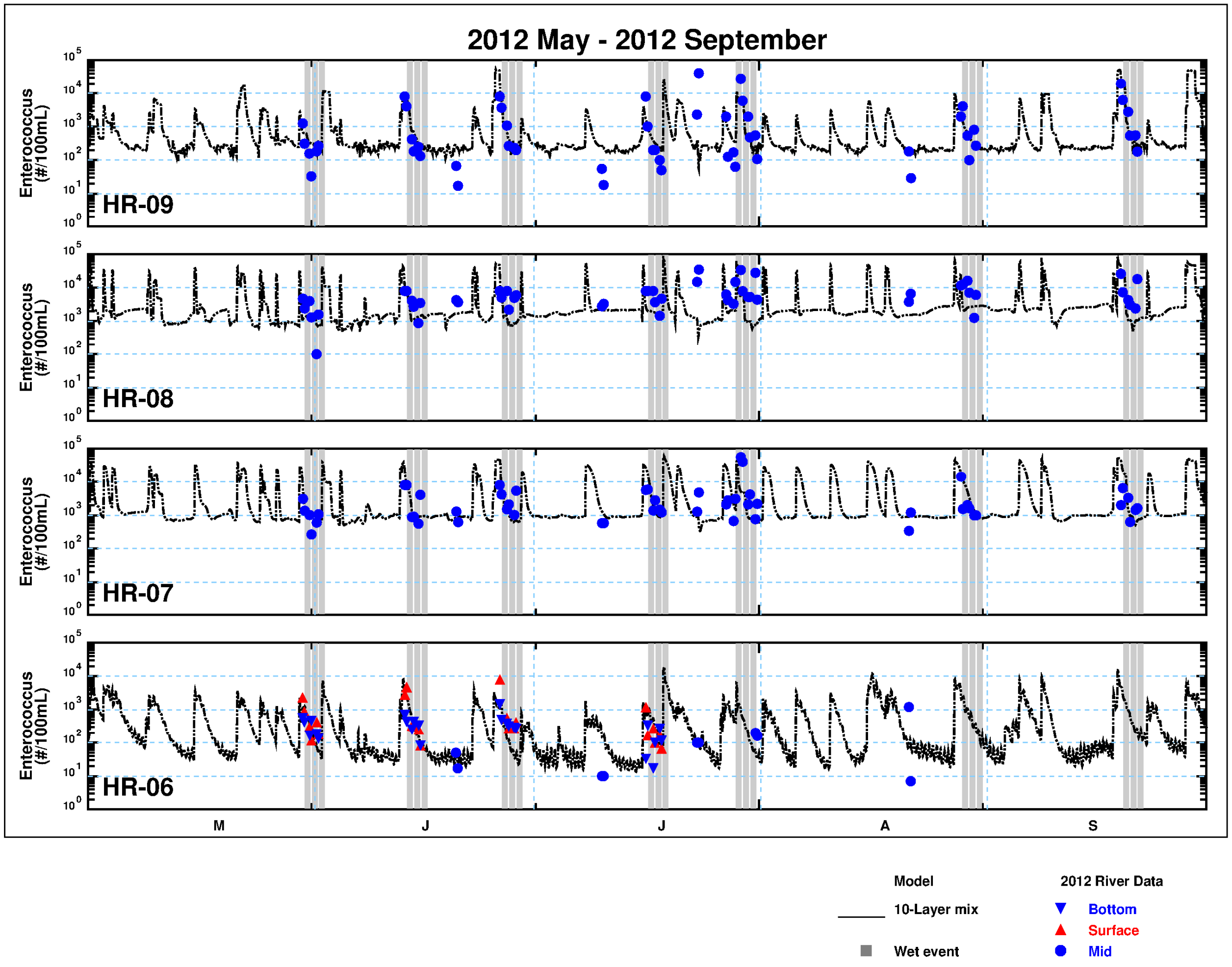


Figure B-12
Hutchinson River 2012 Enterococci Calibration – NYC Sample Locations

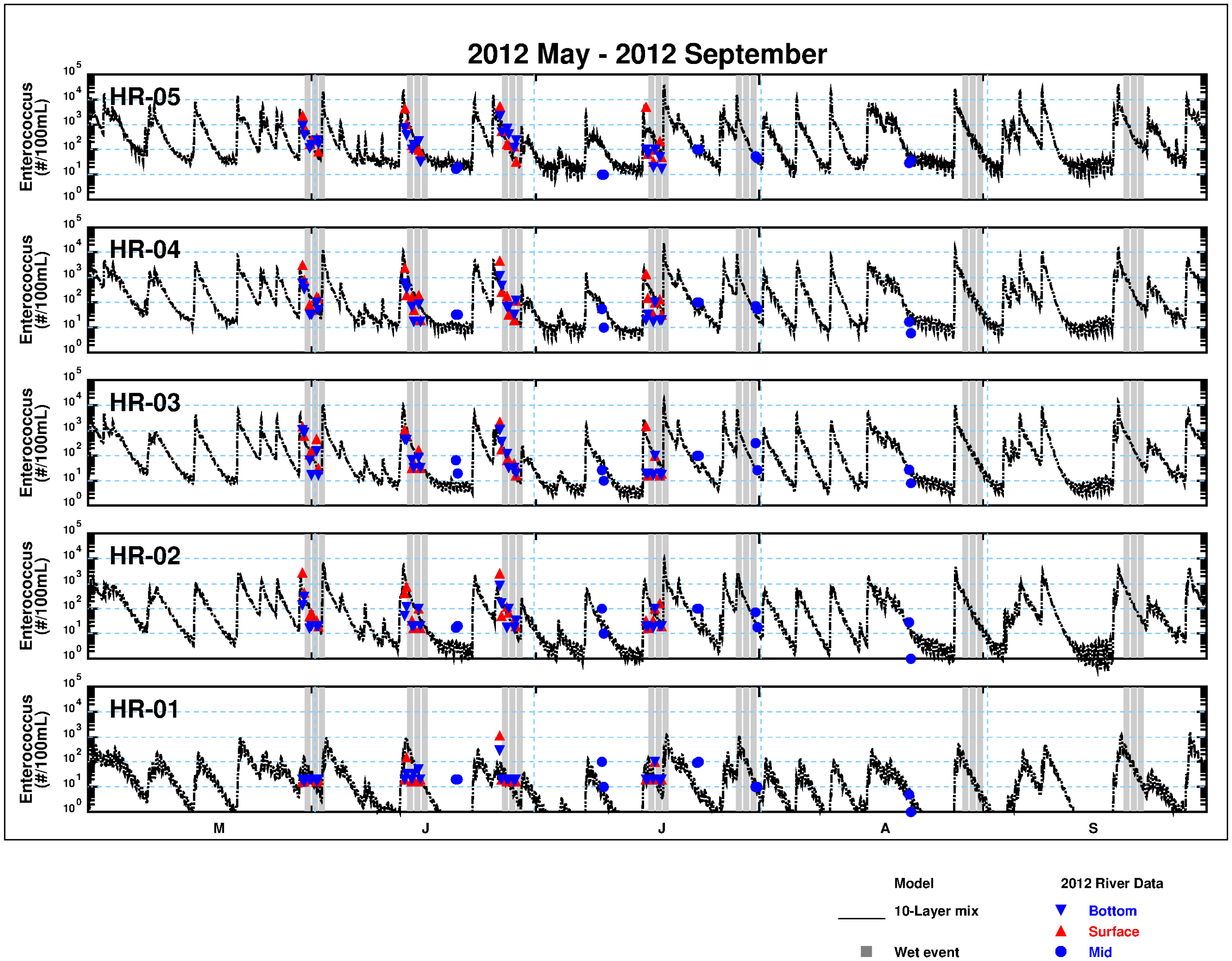


Figure B-13
Hutchinson River 2012 Fecal Coliform Calibration – Westchester County Locations

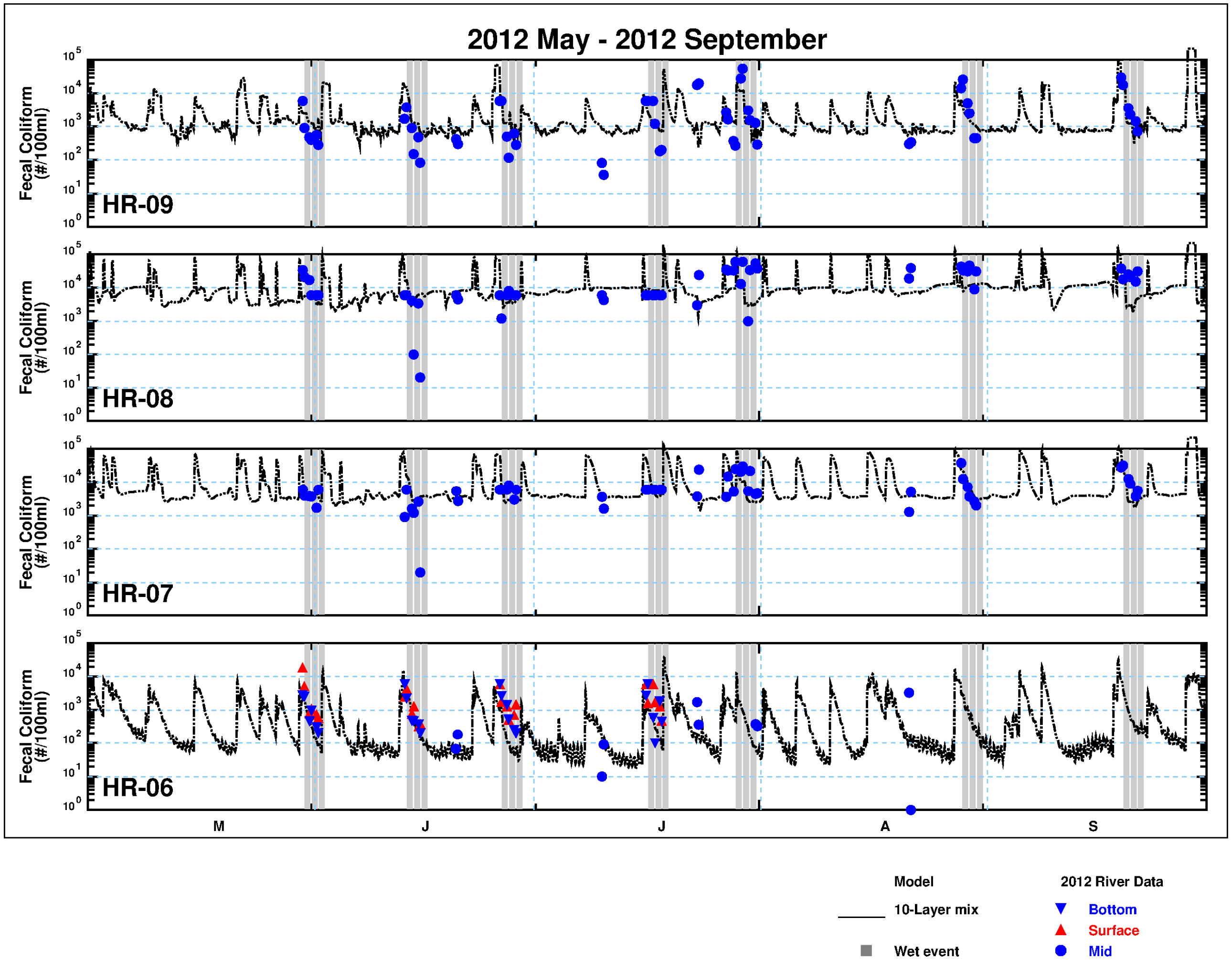
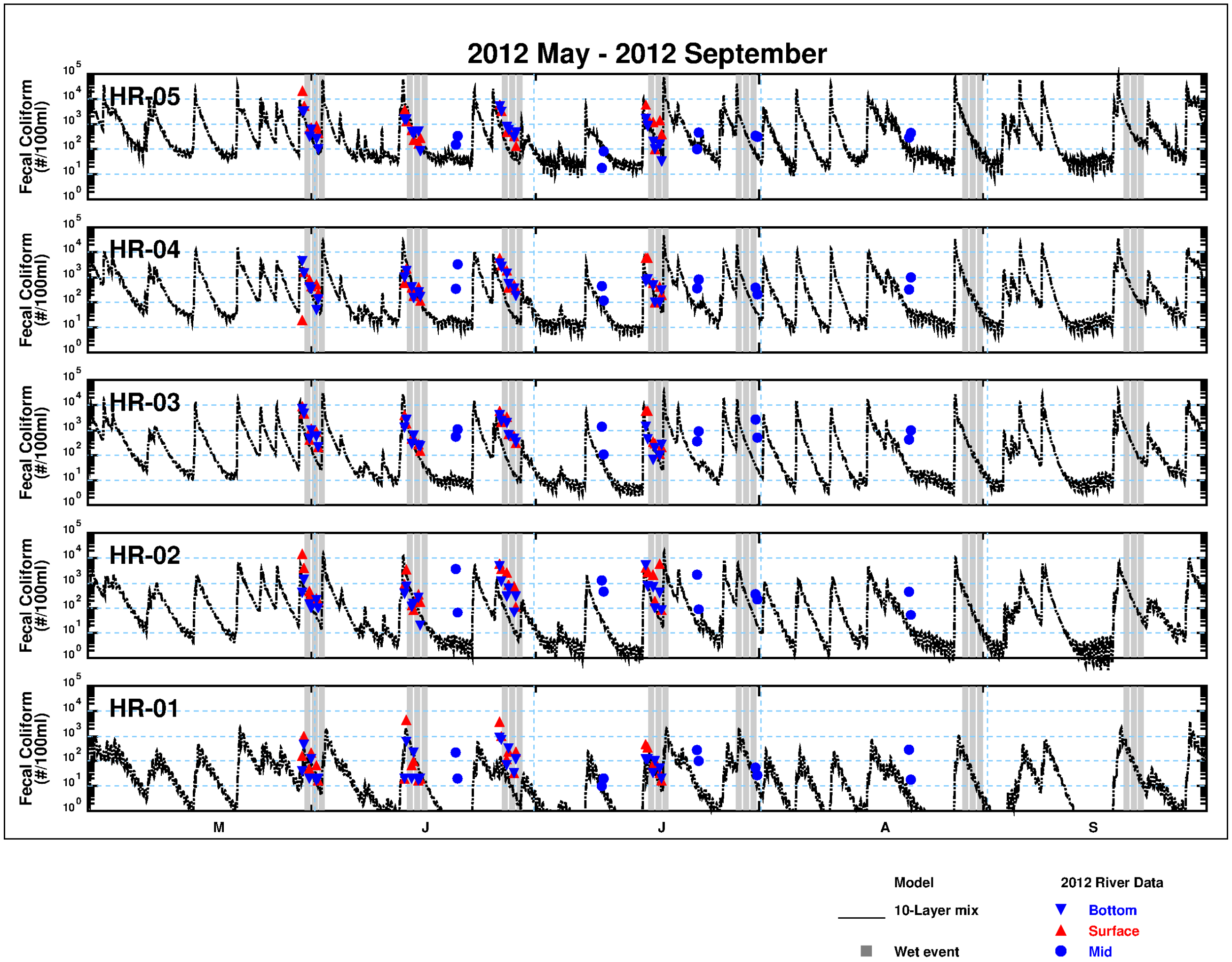


Figure B- 14
Hutchinson River 2012 Fecal Coliform Calibration – NYC Locations



References

Blumberg, A. F., and G. L. Mellor. 1987. A description of a three-dimensional coastal ocean circulation model, p. 1-16. *In* N. S. Heaps [ed.], Three-Dimensional Coastal Ocean Models. Coastal and Estuarine Sciences, Vol. 4. American Geophysical Union, Washington, D.C.

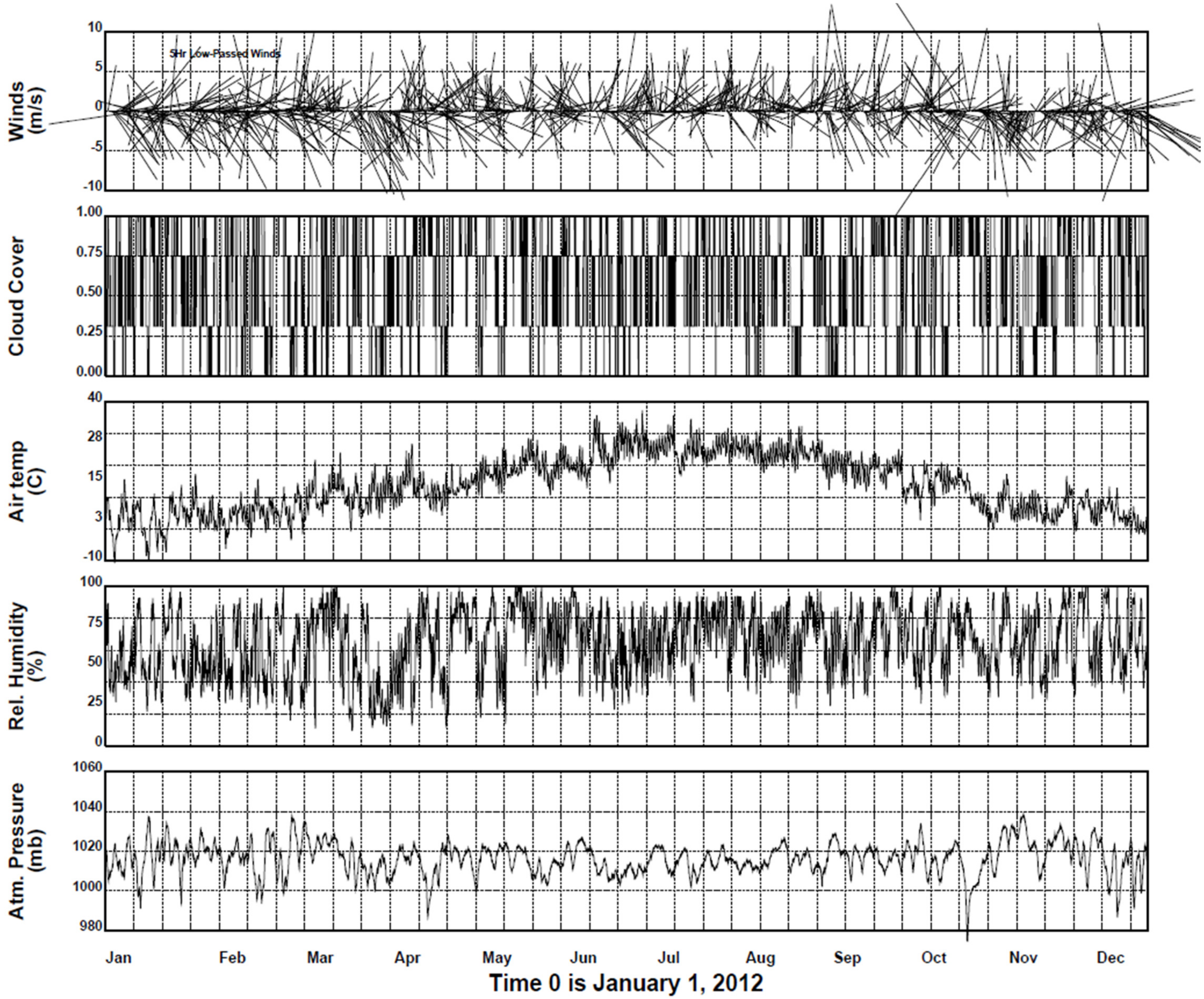
Casulli, V., and R. T. Cheng. 1992. Semi-implicit finite difference methods for three-dimensional shallow water flow. International Journal for Numerical Methods in Fluids, 15: 629–648.

Mellor, G. L. and T. Yamada. 1982. Development of a turbulence closure model for geophysical fluid problems. Reviews of Geophysics and Space Physics, 20: 851-875.

New York City Department of Environmental Protection (NYCDEP), Sept 2007. City-Wide Long Term CSO Control Planning Project: Receiving Water Quality Modeling Report Volume 3 East River Tributaries Model (ERTM), DRAFT. The City of New York Department of Environmental Protection Bureau of Engineering Design & Construction.

Attachment 1

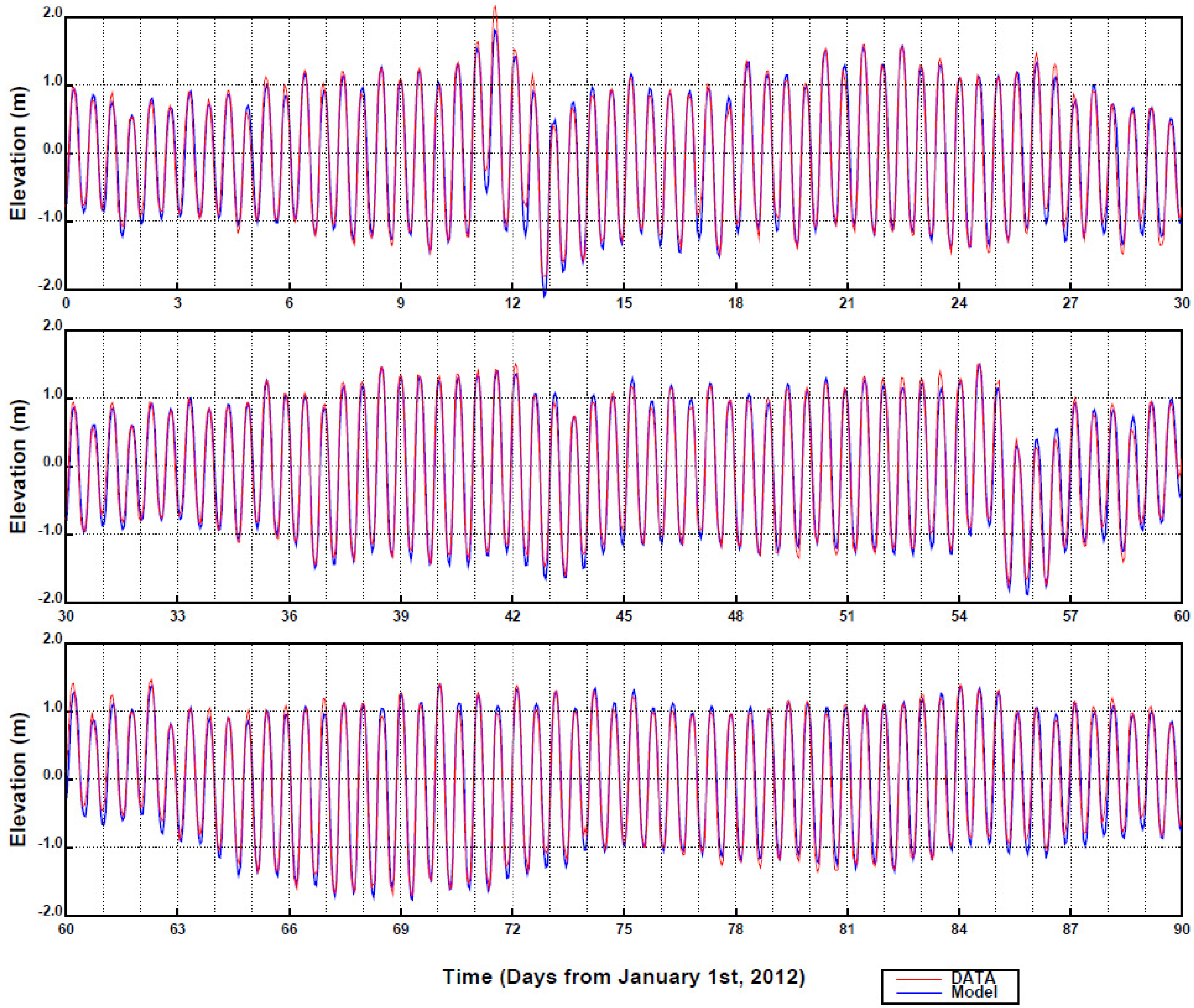
Meteorological Forcings for 2012 SWEM and ERTM Calibration



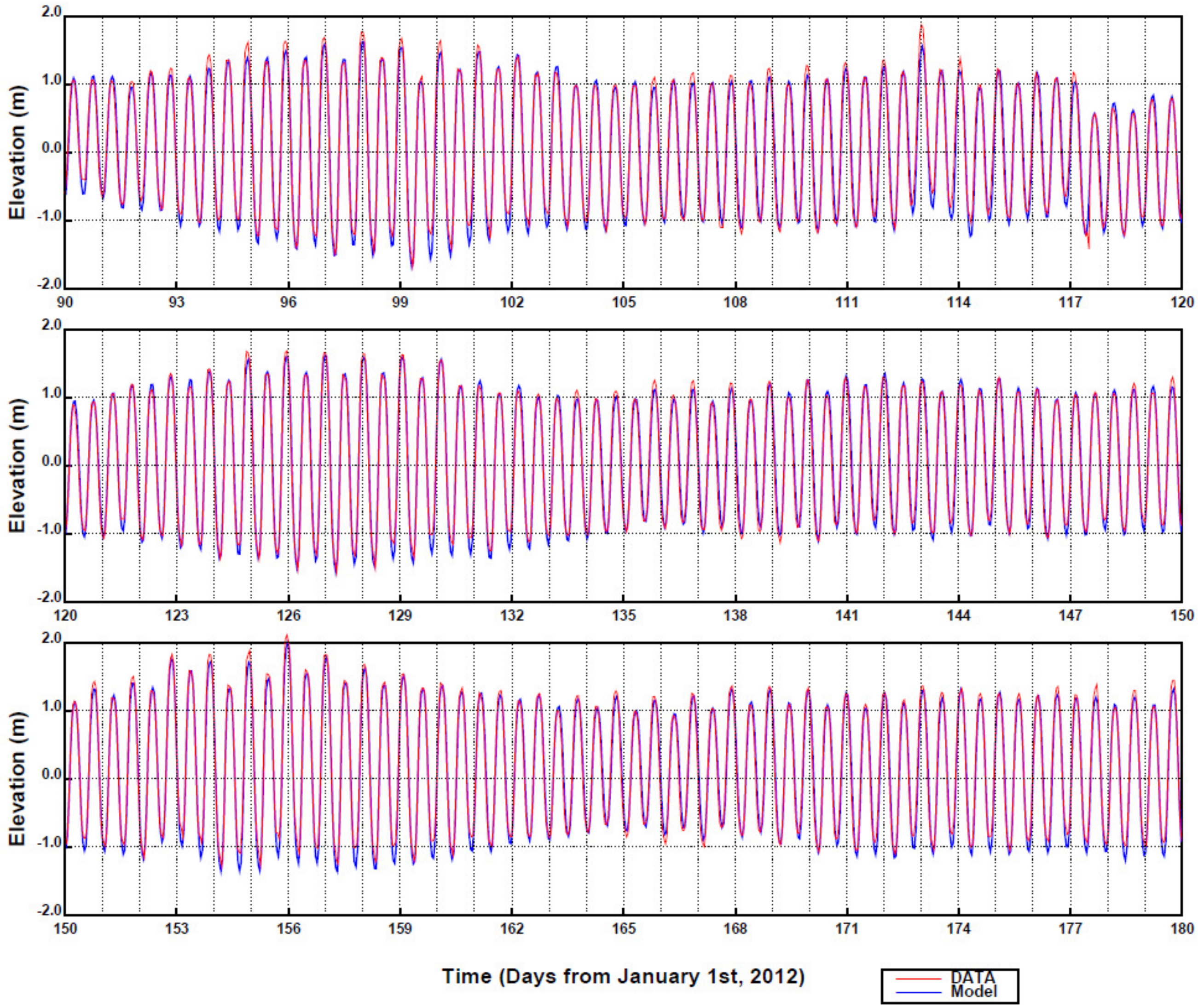
2012 Meteorological Conditions

Attachment 2

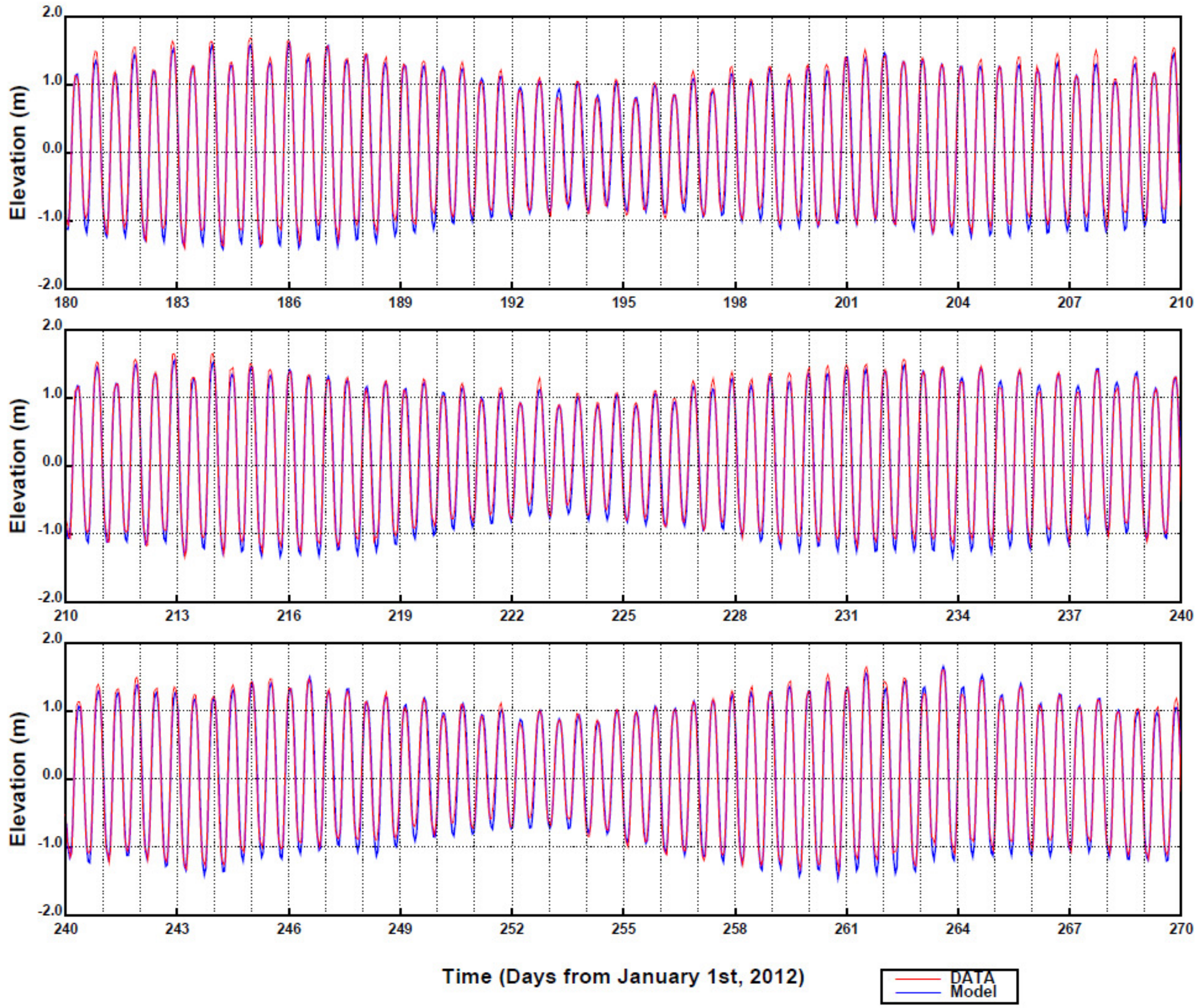
2012 ERTM Salinity and Temperature Calibration



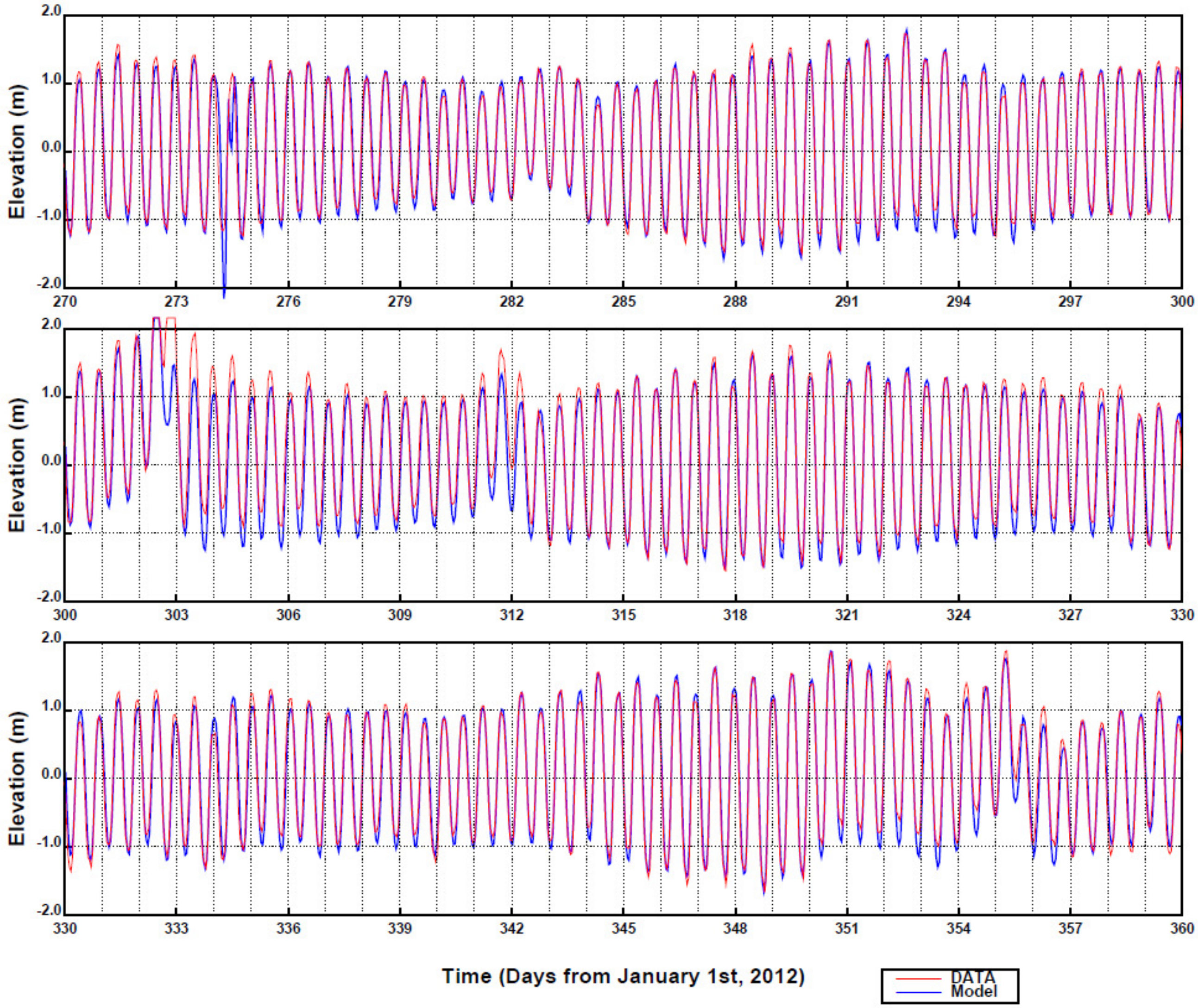
ERTM Elevation Calibration at King's Point – Days 0 – 90



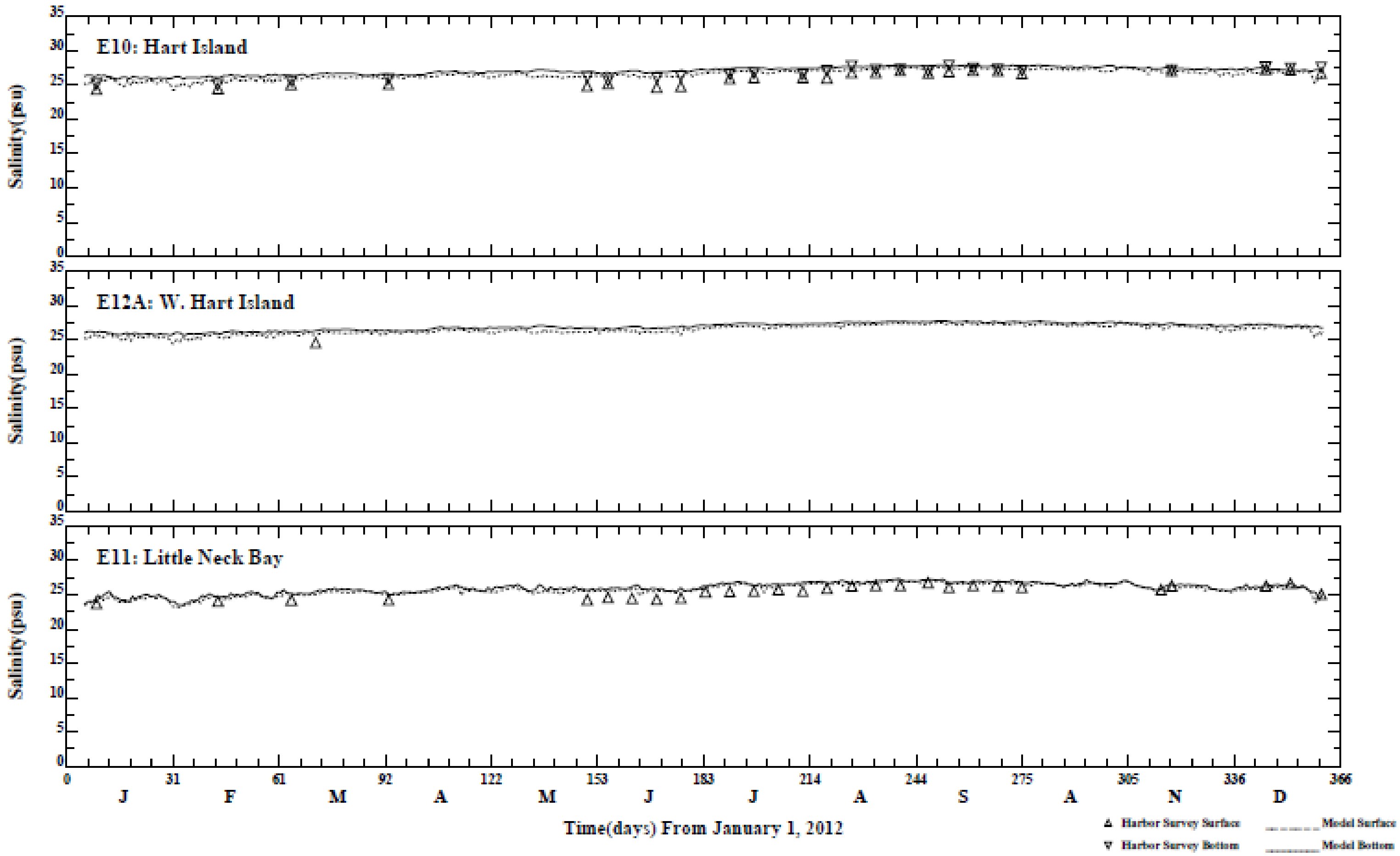
ERTM Elevation Calibration at King's Point – Days 90 – 180



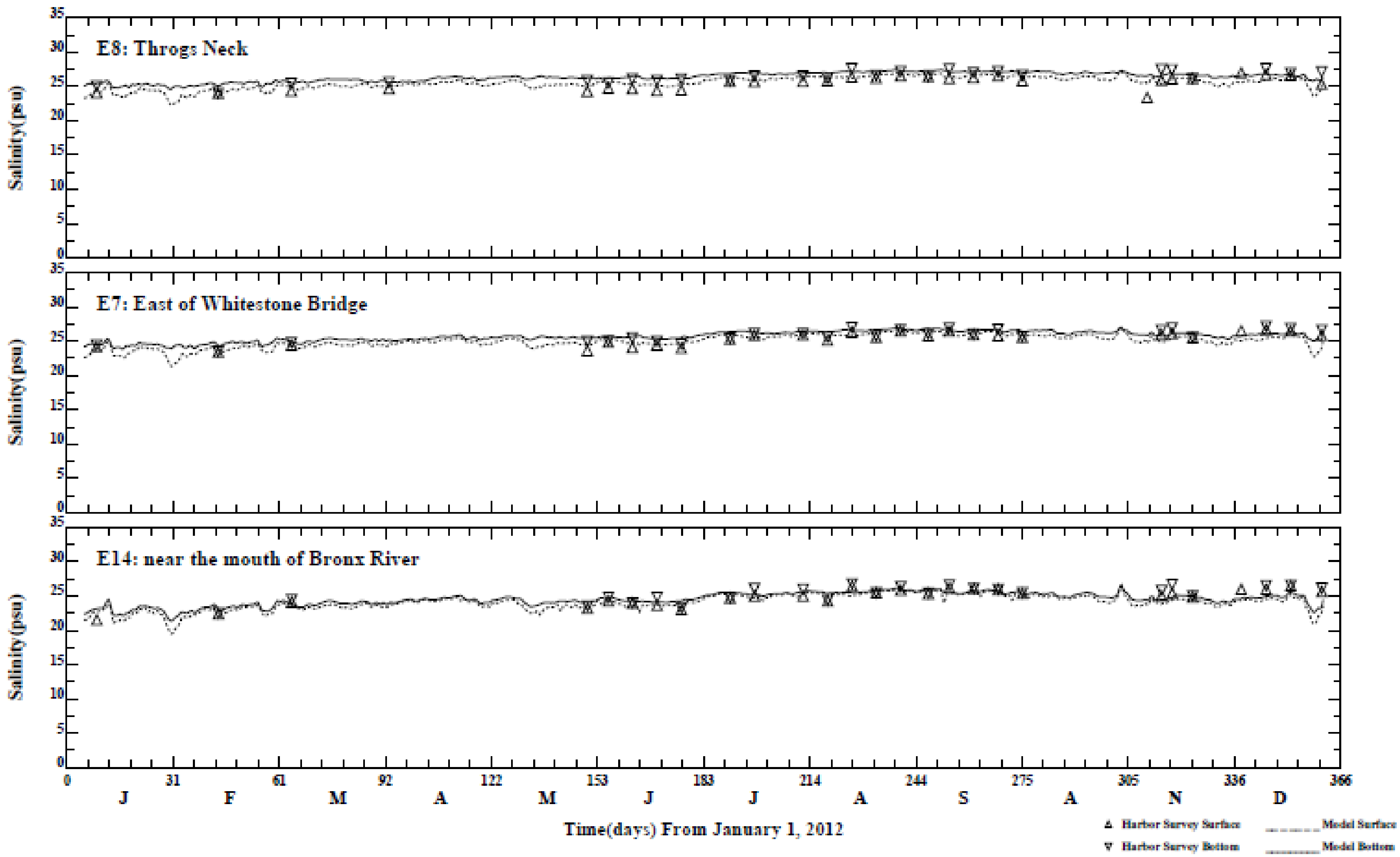
ERTM Elevation Calibration at King's Point – Days 180 – 270



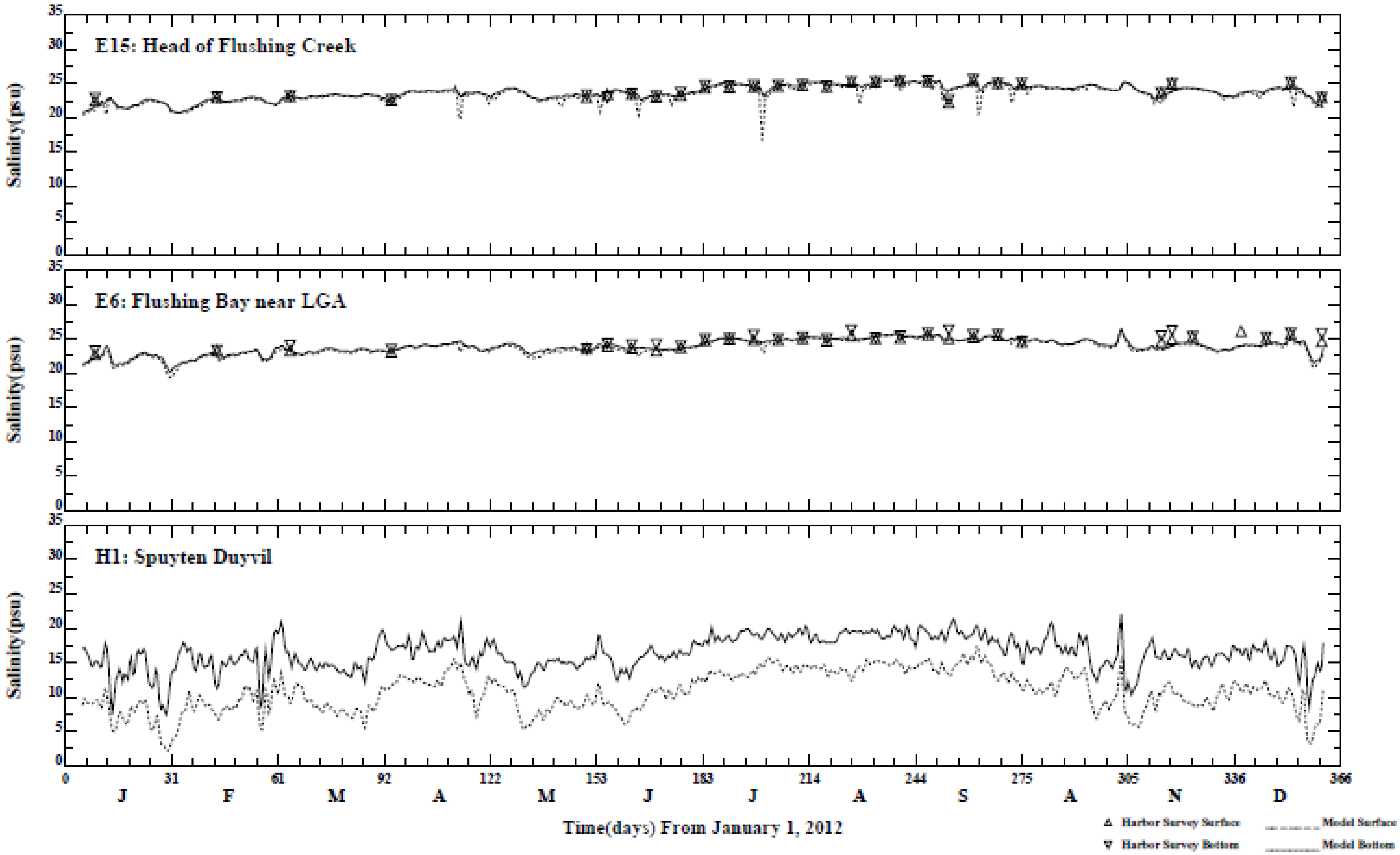
ERTM I Elevation Calibration at King's Point – Days 270 – 360



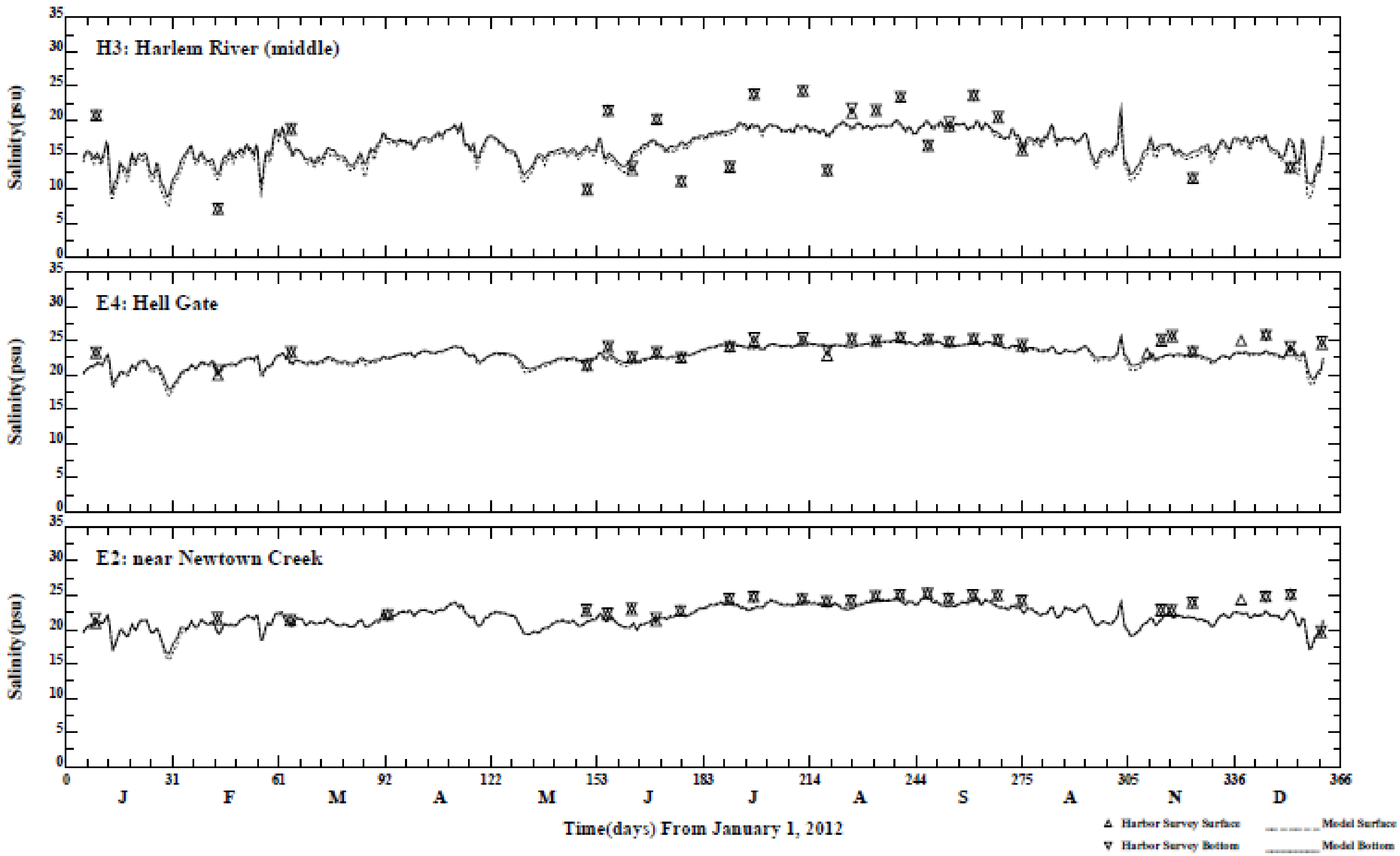
ERTM Salinity Calibration at Harbor Survey Stations E10, E12A, E11.



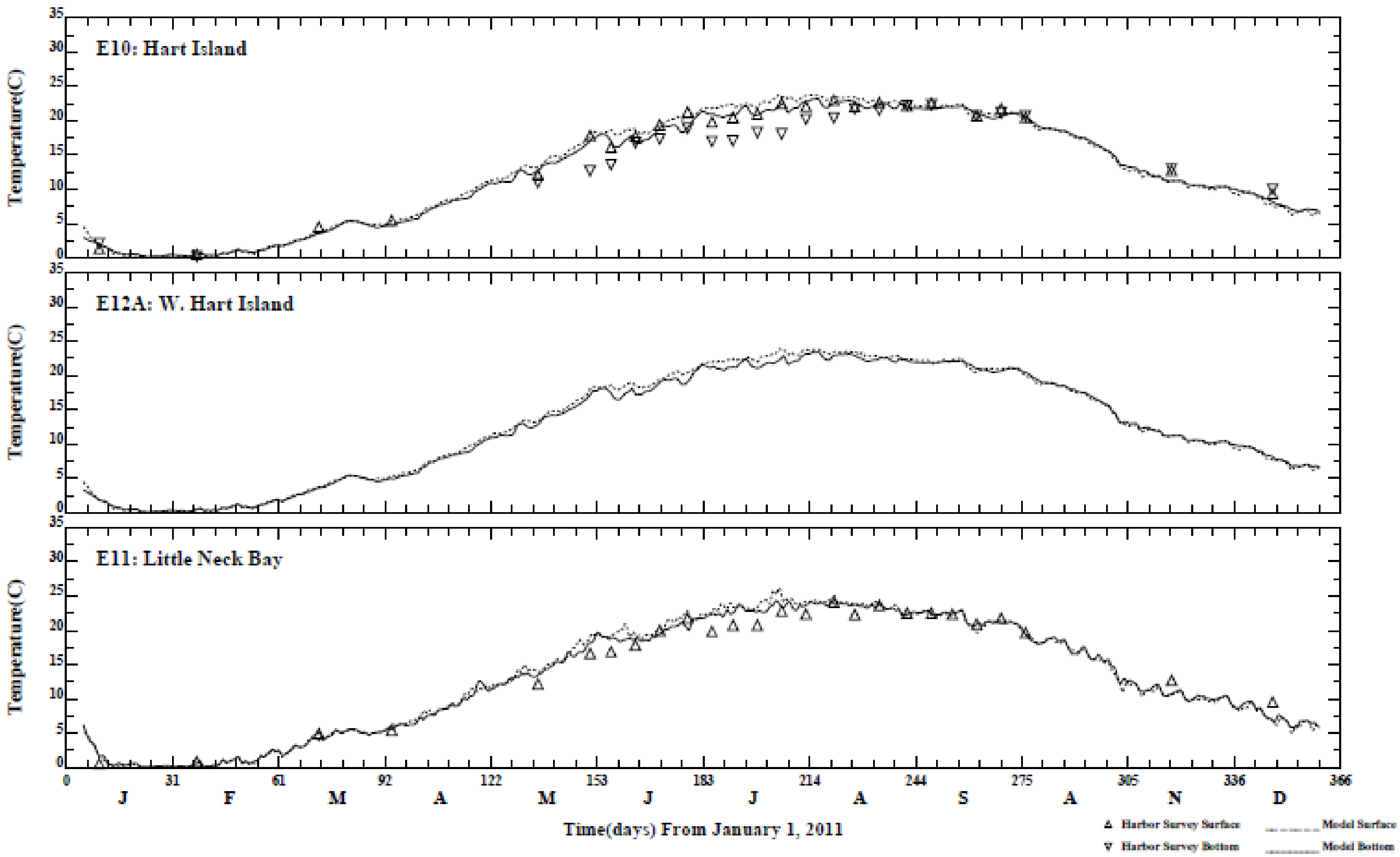
ERTM Salinity Calibration at Harbor Survey Stations E8, E7, E14.



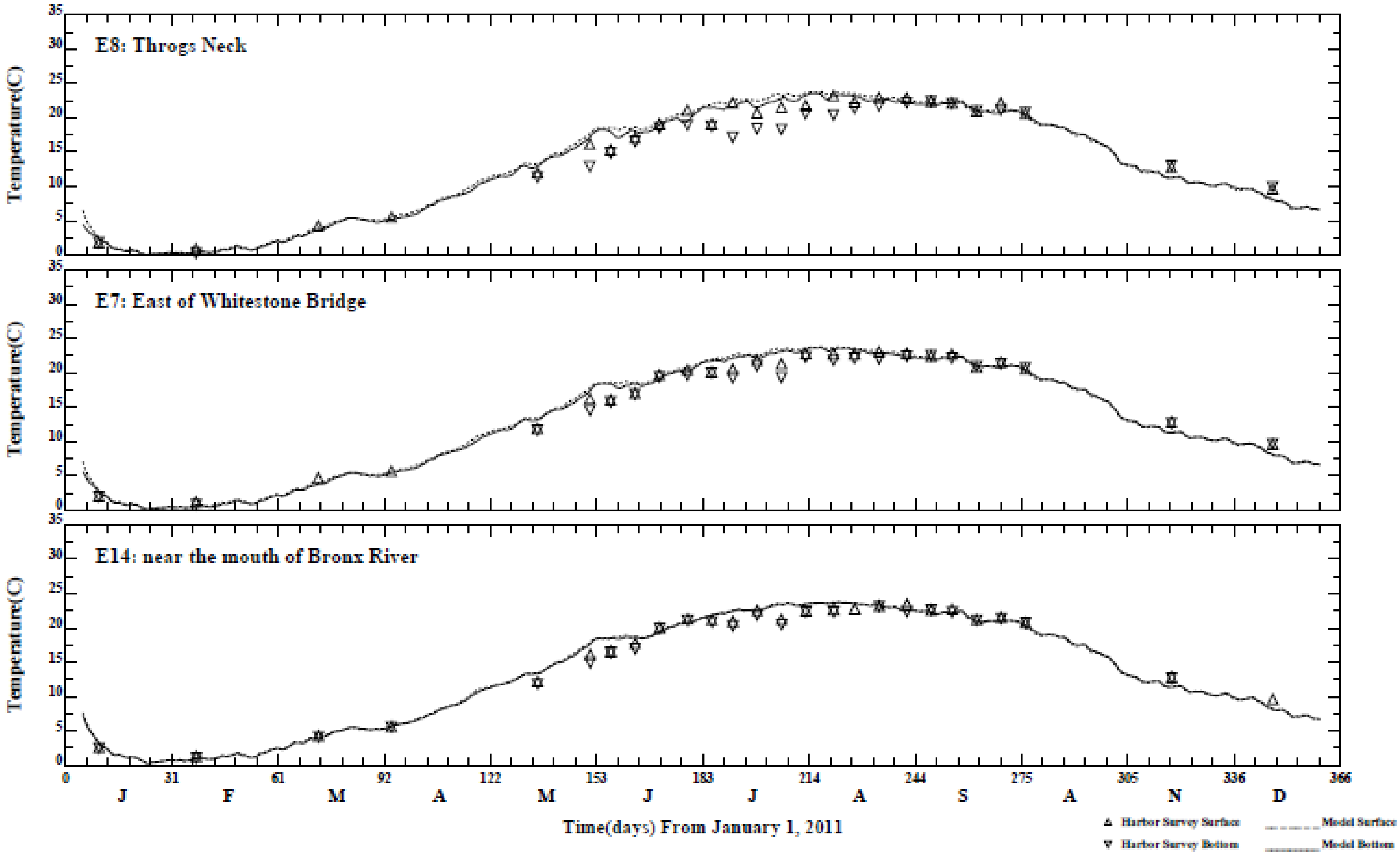
ERTM Salinity Calibration at Harbor Survey Stations E15, E6, H1



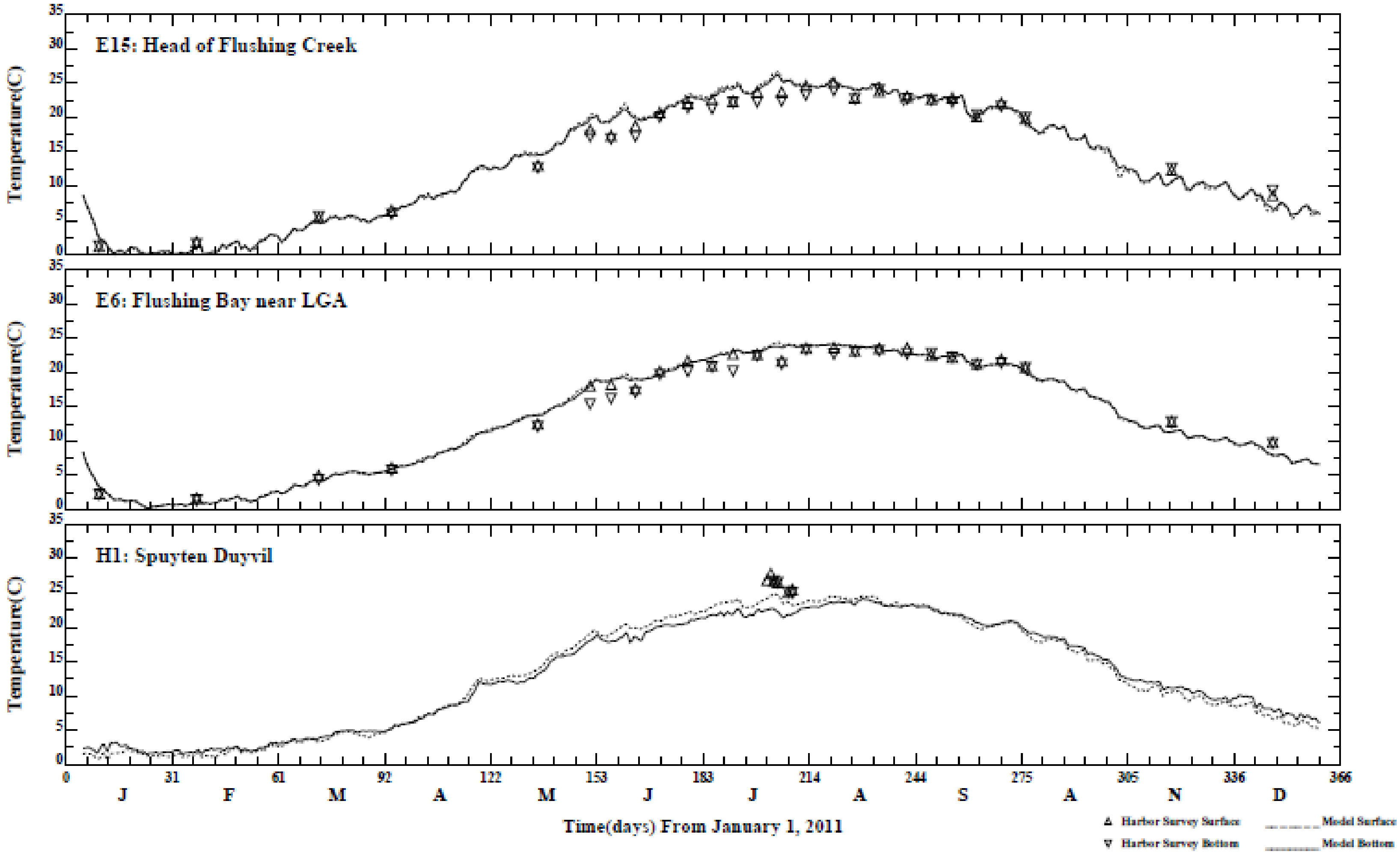
ERTM Salinity Calibration at Harbor Survey Stations H3, E4, E2



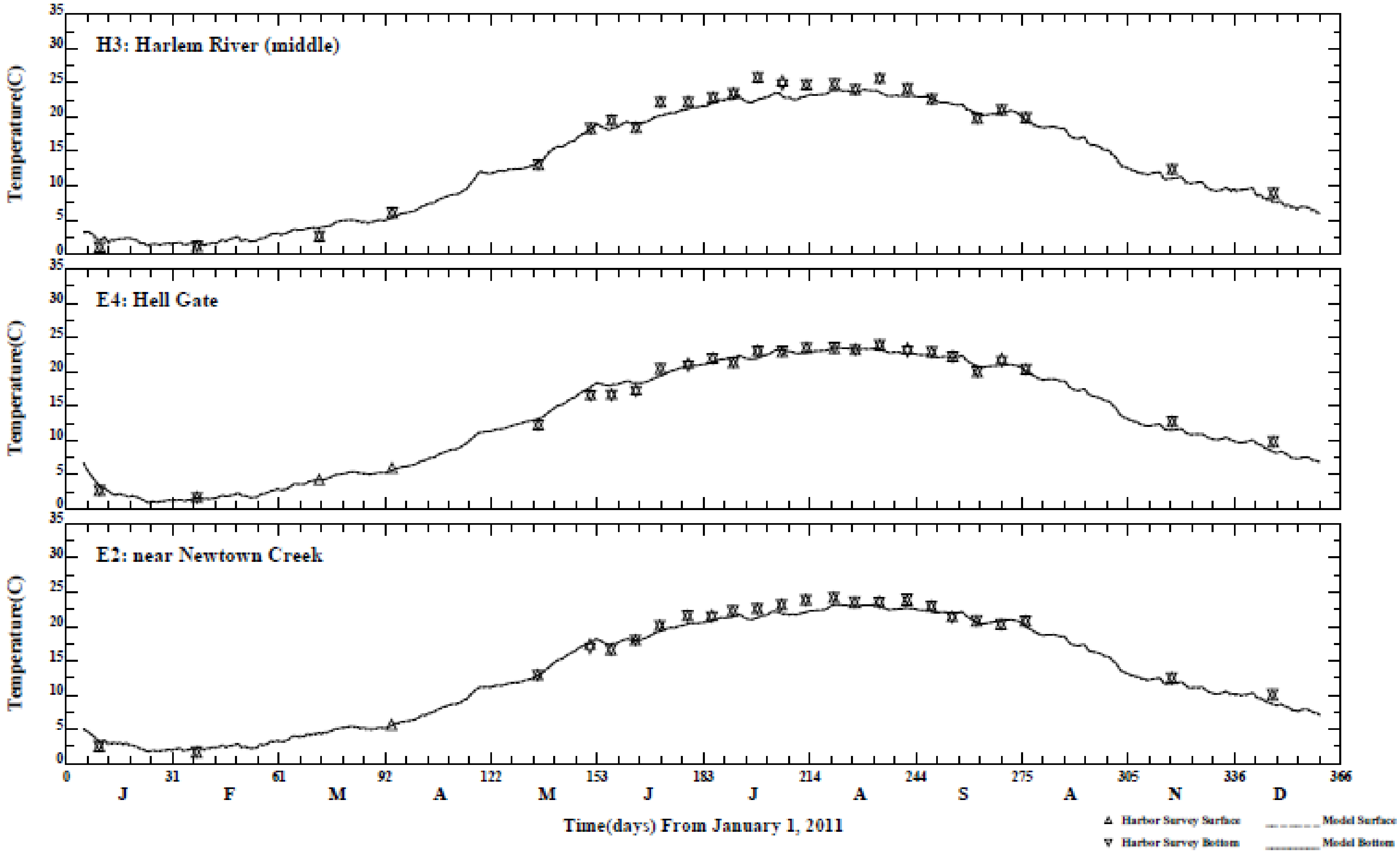
ERTM Temperature Calibration at Harbor Survey Stations E10, E12A, E11



ERTM Temperature Calibration at Harbor Survey Stations E8, E7, E14.



ERTM Temperature Calibration at Harbor Survey Stations E15, E6, H1



ERTM Temperature Calibration at Harbor Survey Stations H3, E4, E2