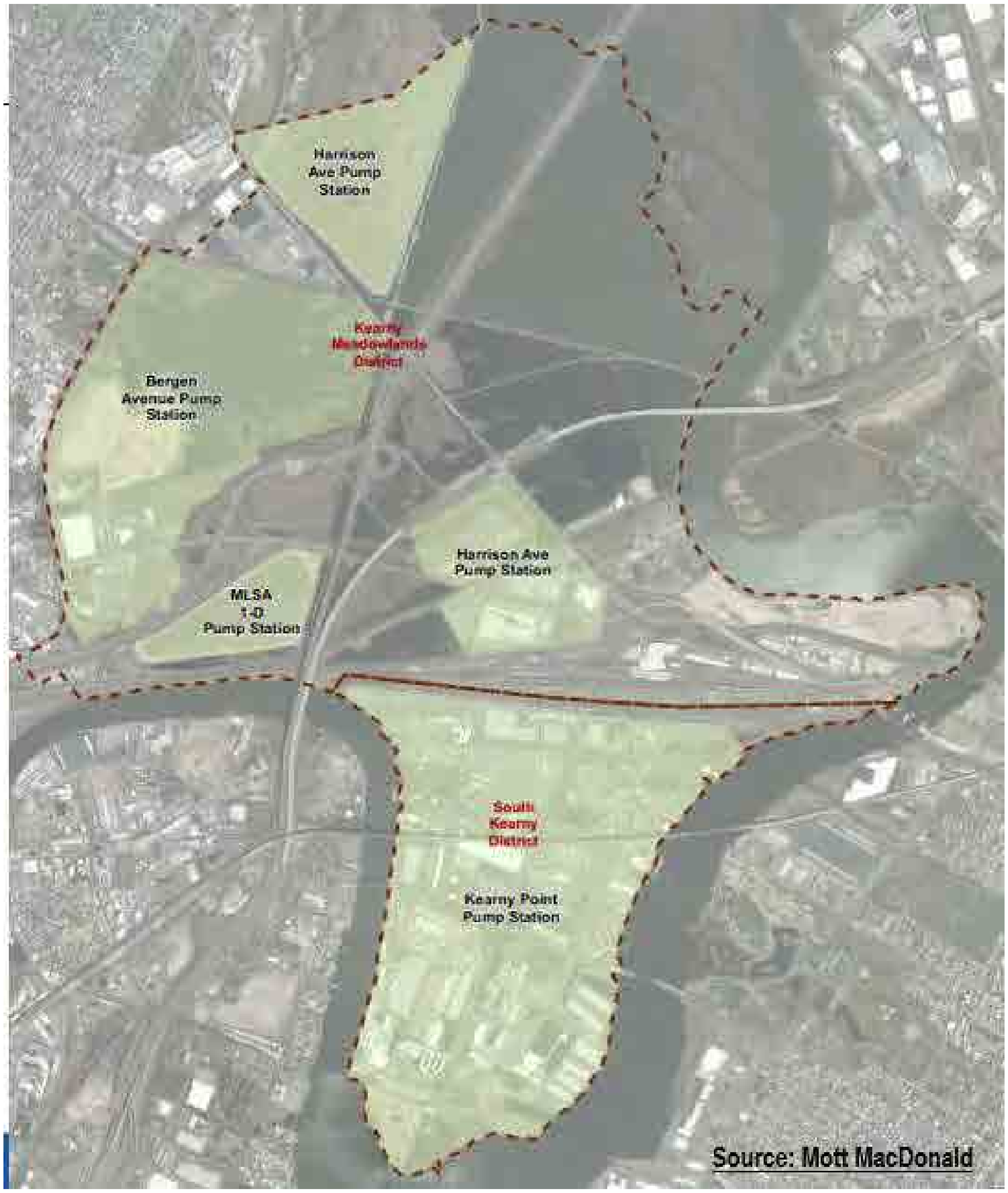


Figure I-23: South Kearny Pump Station Service Area

I.3.8 Rainfall Derived Infiltration and Inflow (RDII)

The model uses the RTK unit hydrograph (UH) to estimate RDII into the separate area sewer systems. As shown in **Figure I-24**, a RTK UH set contains up to three hydrographs (Muleta & Boulos, 2008): one for a short-term response (UH1), one for an intermediate-term response (UH2), and one for a long-term response (UH3). UH1 represents the most rapidly responding inflow component and has a short T value, UH2 includes both inflow and infiltration and has a longer T value, and UH3 includes infiltration that may continue long after the storm event has ended and has the longest T value. The unit hydrograph is defined by the following three parameters:

- R: the fraction of rainfall volume that enters the sewer system and equals to the volume under the hydrograph,
- T: the time from the onset of rainfall event to the peak of the unit hydrograph in hours, and
- K: the ratio of time to recession of the unit hydrograph to the time to peak.

The same set of RDII parameters were applied in the same metershed because of the availability of the flow hydrograph for model calibration. The initial values of RTK were estimated based on previous modeling document. The RTK values are calibration parameters to be refined during model calibration.

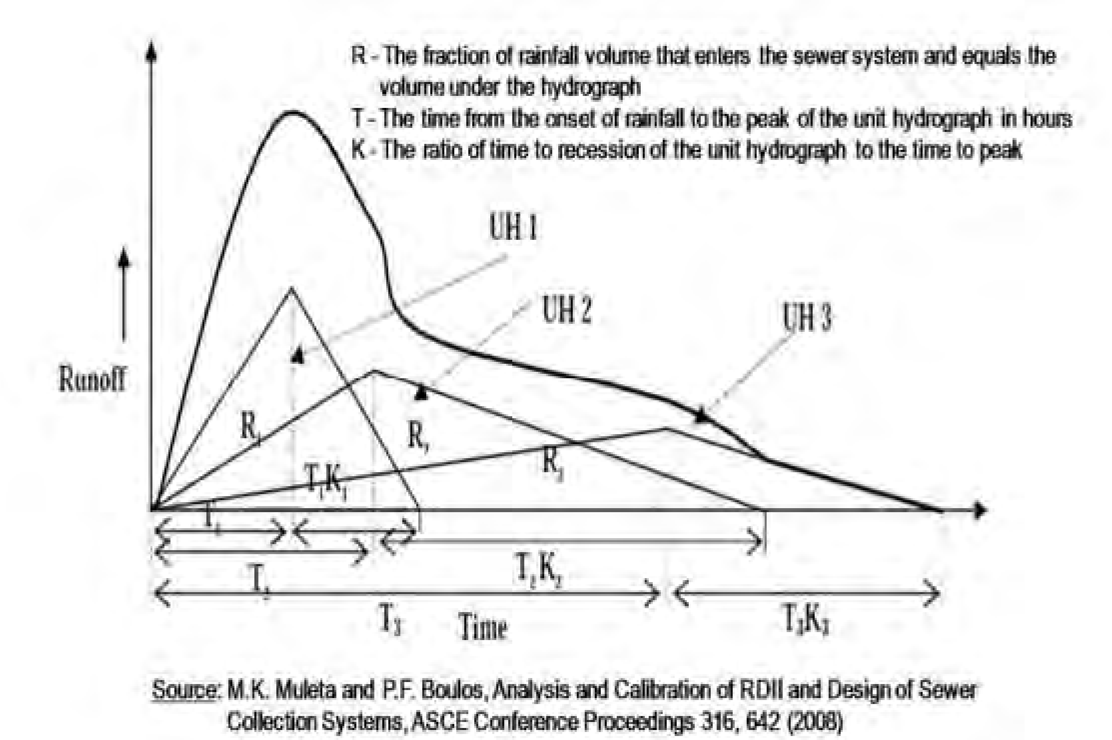


Figure I-24: RTK Unit Hydrograph

I.3.9 Dry Weather Flow

Dry Weather flow shown in **Figure E-4** was assigned to subcatchments in proportion to the service area in the same metershed. Same weekday and weekend dry weather flow diurnal patterns (example **Figure E-5**) developed from flow metering data were assigned to the subcatchments in the same metershed. Concentration of Pollutant PL1 was assumed to be 100 for all dry weather input, this allows users to differentiate wet weather flow quantity from the dry weather flow quantity.

I.3.10 Real Time Control (RTC)

RTC for Gate Operation of Regulators along PVSC Interceptor

Real time controls for gate operation of regulators along PVSC interceptor were developed based on the PVSC Primary Clarifier Auto Fill System Operating Procedure (SOP, October 27, 2016). The SOP includes sequenced procedures to be performed during wet weather conditions. These procedures were incorporated into the PVSC model through real time controls. Schematics in **Figure I-25** illustrate the following wet weather operating procedures in the model:

(a) When the WRRF flow (including flows from the Hudson County Force Main) is less than 350 MGD, all regulator gates are kept open

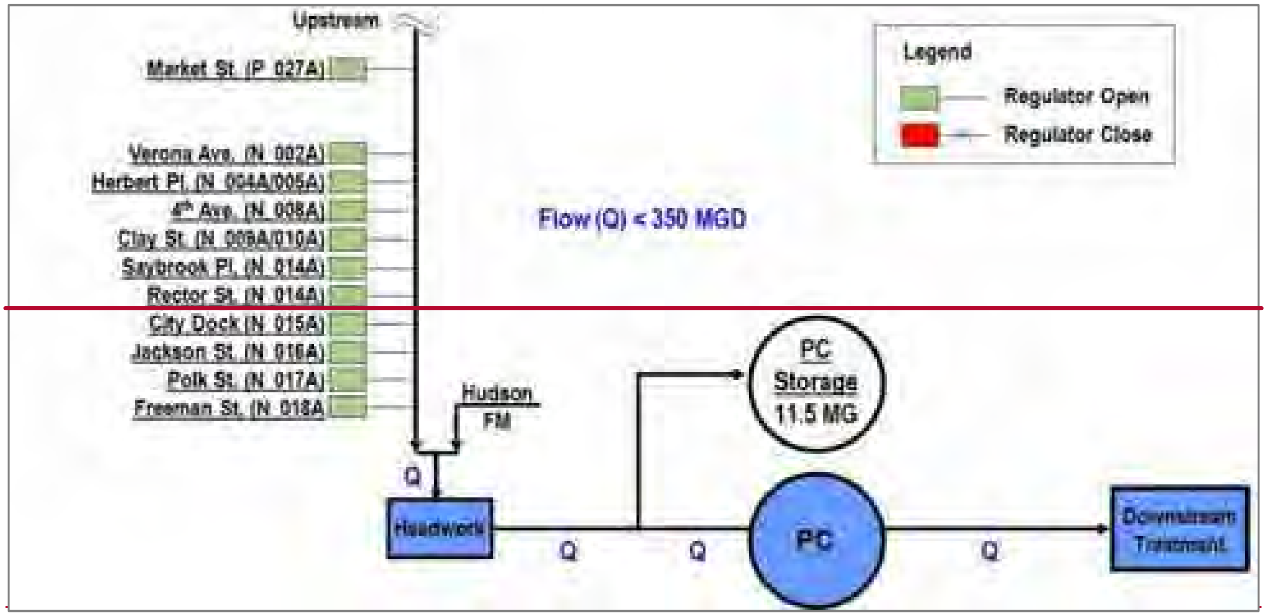
(b) When the WRRF flow increases above 350 MGD, close regulator gates on Verona Ave. (N_002A), Herbert Pl. (N_004A/005A), 4th Ave. (N_008A), Saybrook Pl. (N_014A), City Dock (N_015A), Jackson St. (N_016A), Polk St. (N_017A), and Freeman St. (N_018A).

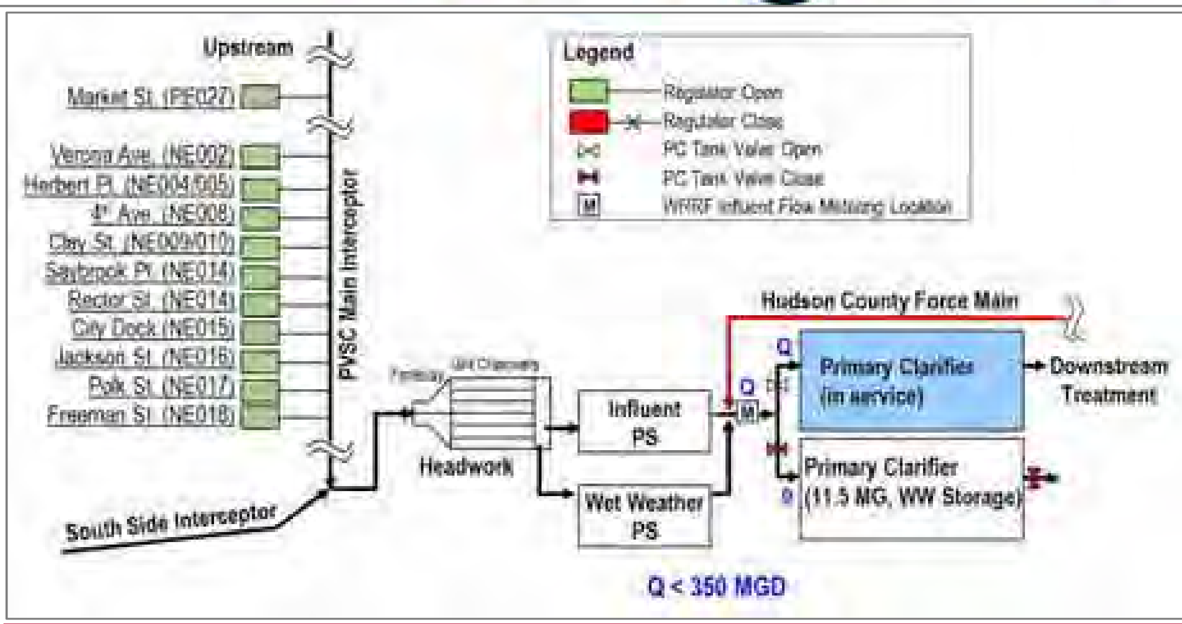
During 10/7/2015 to 7/7/2016 (model calibration events were in this period), these regulator gate were put in use at plant flow 400 MGD.

(c) When the WRRF flow further increases to above 400 MGD, start primary clarifier (PC) filling at flow rate 50 MGD

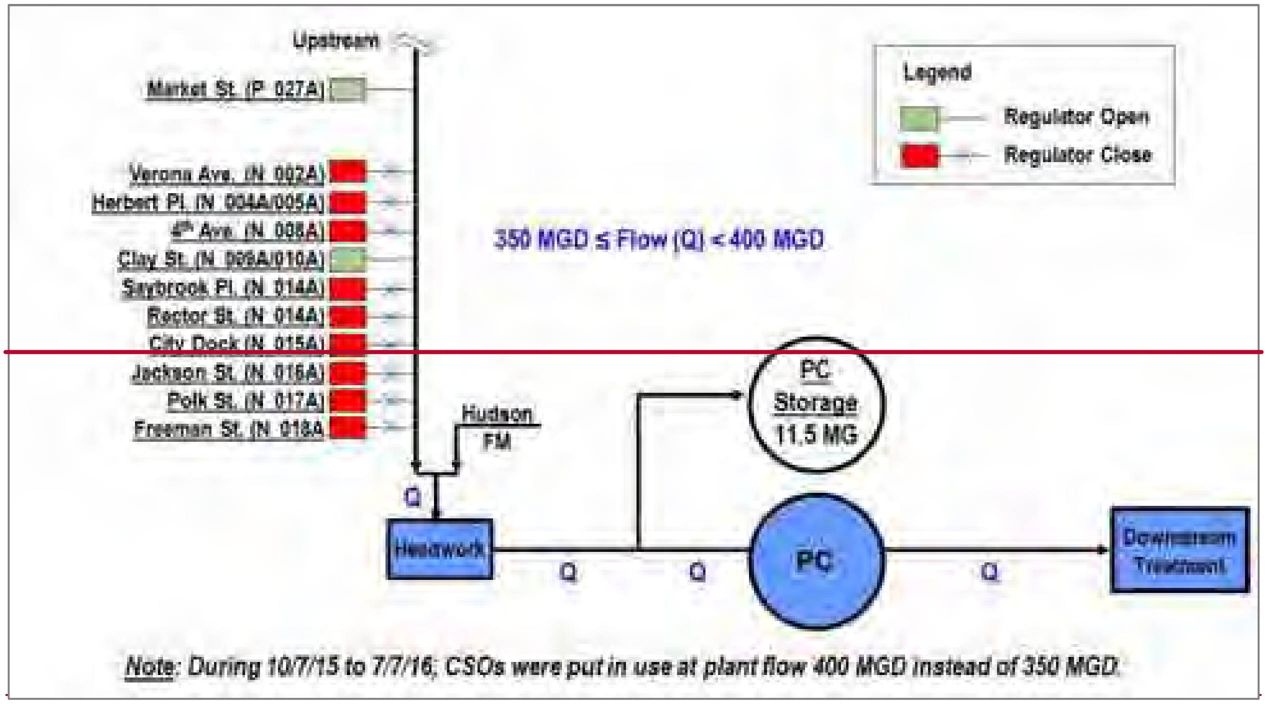
(d) When the PC storage is full, stop PC filling and close regulator gate at Clay St.

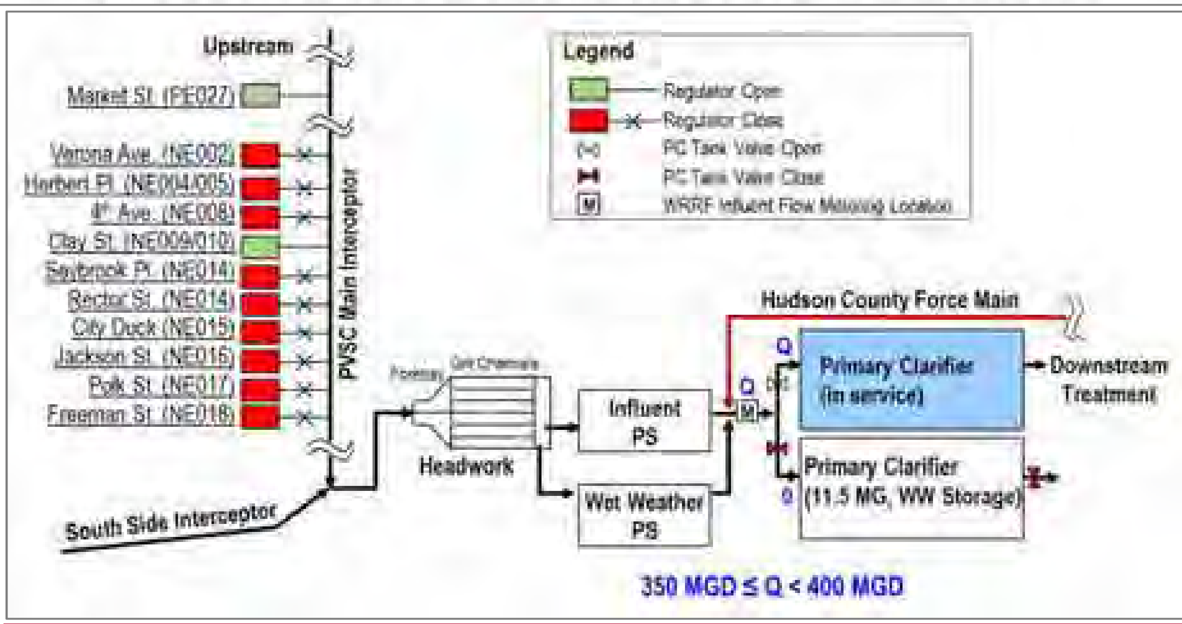
(e) When the WRRF flow recede to 350 MGD post storm event, open all regulator gates and start dewatering PC storage



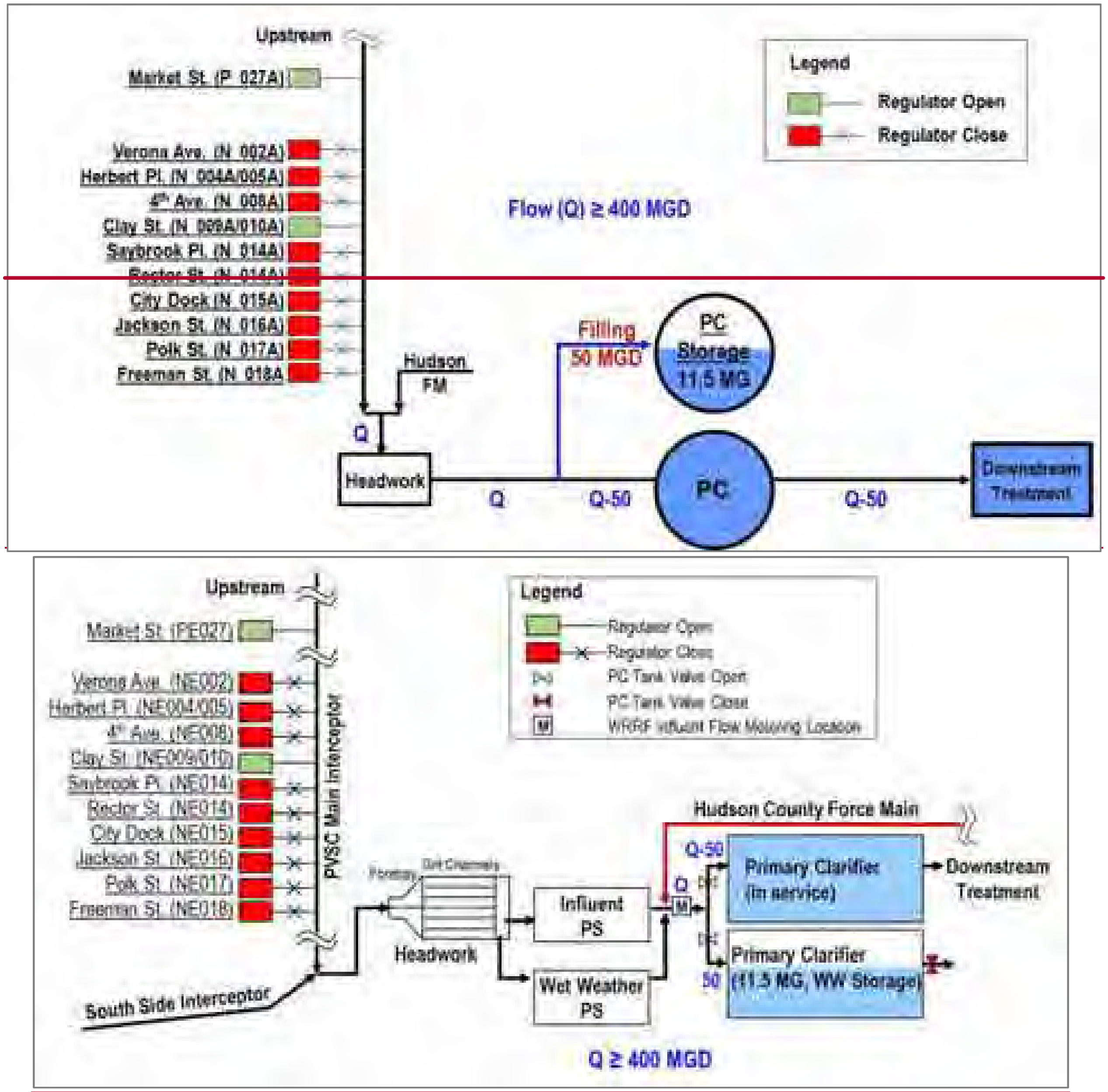


(a) Keep regulator gate open when WRRF flow is less than ~~400~~ 350 MGD

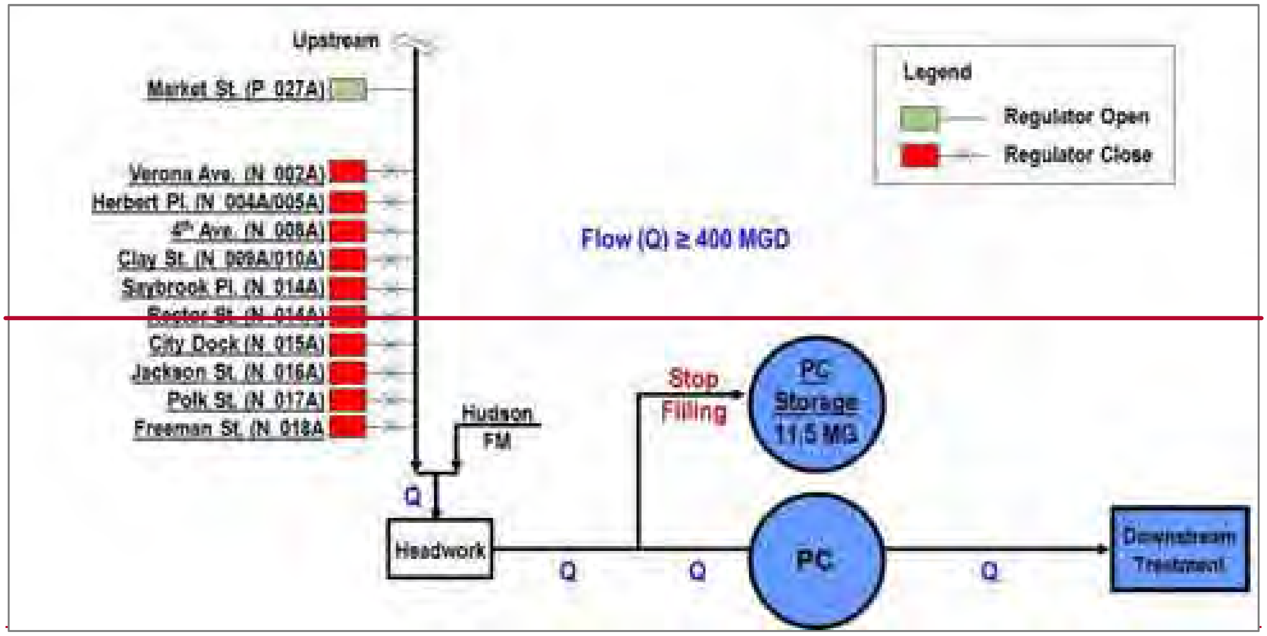


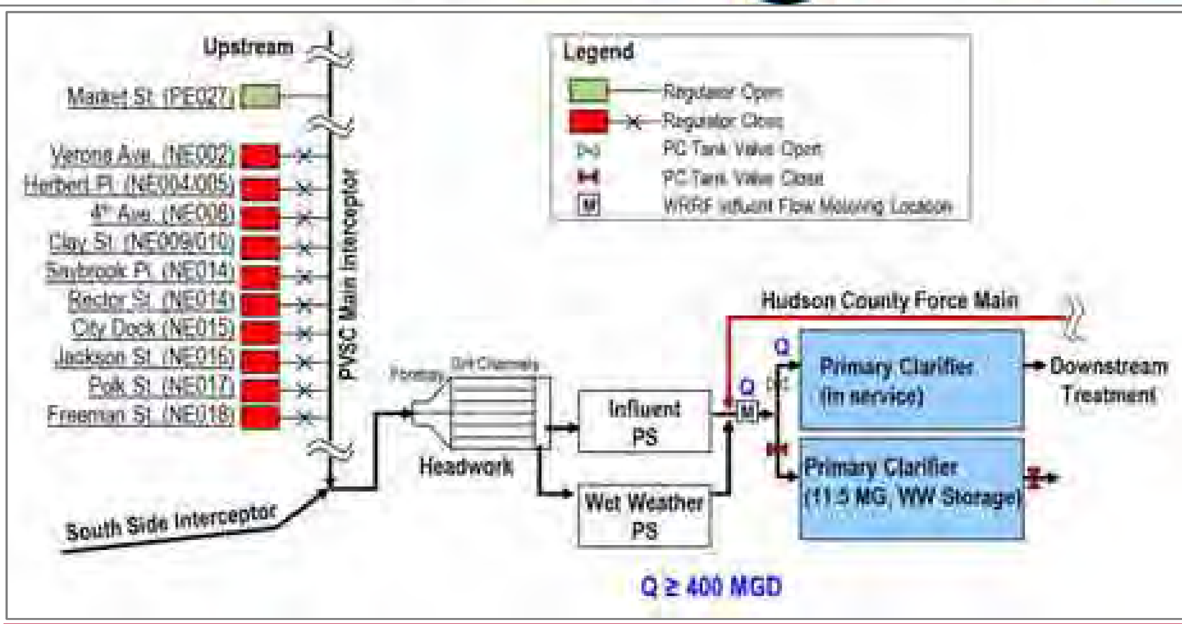


(b) Close regulator gates (except Clay Street) when WRRF flow is greater than 350 MGD

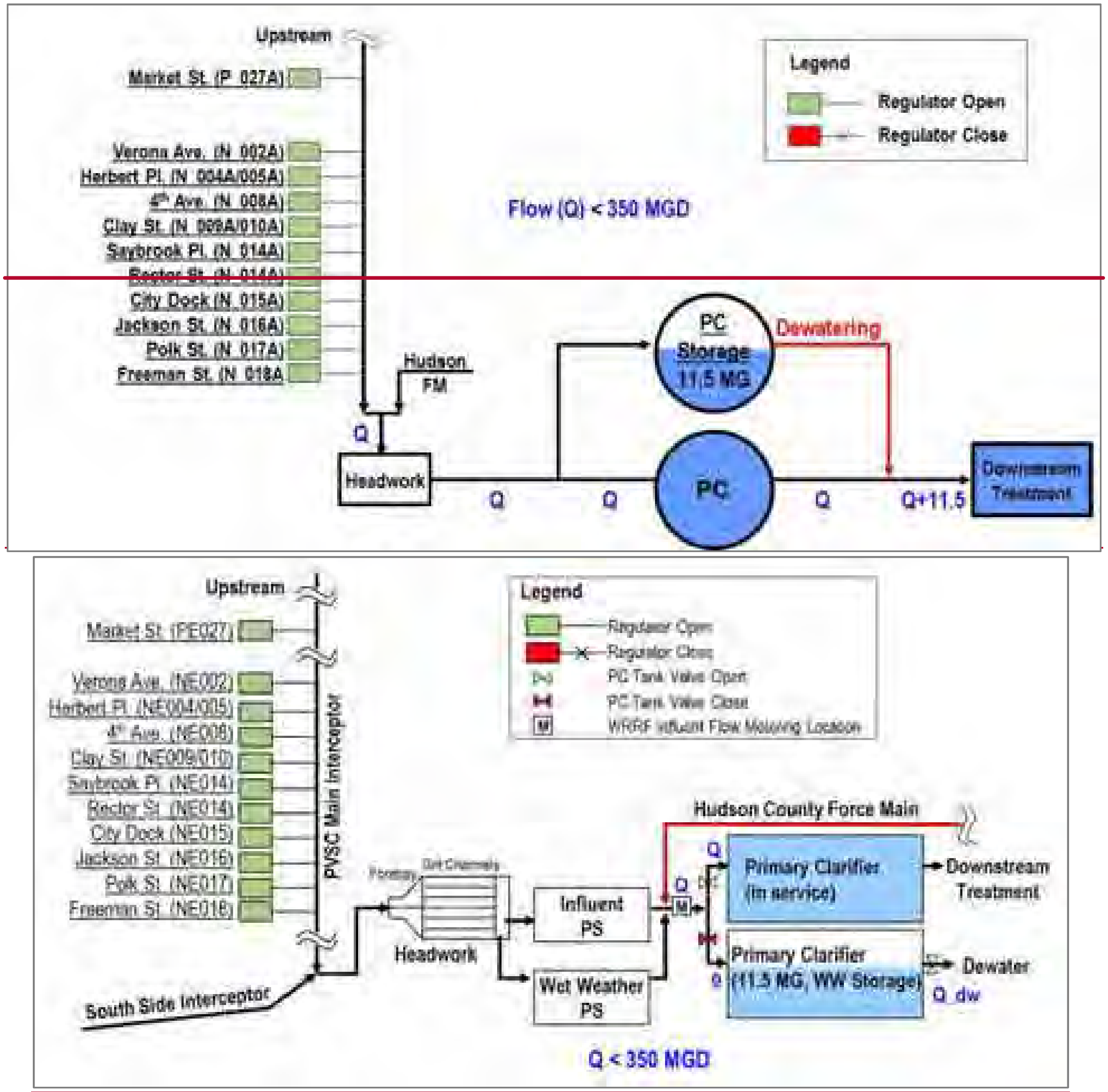


(c) Start filling PC Storage when flow is greater than 400 MGD





(d) Close Clay Street regulator gate when the PC Storage is full



(e) Open regulator gate and dewater PS Storage when WRRF flow recedes to 350 MGD

Figure I-25: PVSC Wet Weather Operating Procedure

RTC for Gate Operation of Regulators in City of Bayonne

All real time controls for City Bayonne regulators are inherited from its original model, with update of unit conversion detailed in **Table I-4.**

I.4 MODEL CONSTRUCTION SUMMARY

The PVSC CSO LTCP model was developed from the integration of four existing CSO community models in InfoWorks ICM 9.0 based on PVSC datum. The model was then further expanded to include all separate sewer service areas. The model has the following features:

- 1121 subcatchments, including all 48 served communities (both combined and separate)
- 4216 nodes, including 4081 manholes, 123 CSO outfalls, and 12 storage for pump station wet well and primary clarifier serving as a storage facility. Real time control rules were set up for filling the primary clarifiers served as storage facility based on the wet weather Standard Operating Procedure (SOP) of PVSC WRRF.
- 4413 links, including 4039 conduits, 42 orifice, 120 weirs, 101 flap valves, 95 sluice gates, and 16 pumps. 34 of the 95 gates are with variable gate openings to be regulated during wet weather conditions. Real time control rules were set up for the variable gate based on wet weather SOP.
- Hudson County Force Main was extended to the PVSC WRRF based on drawings to convey flows from the Hudson County to the WRRF. Force main from Bayonne was extended to the tie-in point to the Hudson County Force Main. Force Main from North Bergen was extended to the Jersey City sewer system.
- South Kearny pump station and force main are also added and tied into the Hudson County Force Main. The force main receive flows from Kearny Meadowlands District and South Kearny District, both areas are with separate sewer.
- Dry weather flow based on 2016 flow monitoring data.
- Wet weather flow simulated as runoff from the combined areas and RDII from the separate areas.
- Real time control based on the current PVSC WRRF wet weather SOP.

Model network of the integrated PVSC model is shown in **Figure I-26**. Quantities of subcatchments, nodes and links are also shown on the map. Two permanent meters (Jersey City West Pump Station and Jersey City East Pump Station) shown on the map are the meters used for flow verification. Calibration/validation of Jersey City model is not part of the efforts of this study because Jersey City is in charge of its model and the received model has been calibrated. Therefore the characteristics of Jersey City model remains unchanged in the integrated PVSC model.

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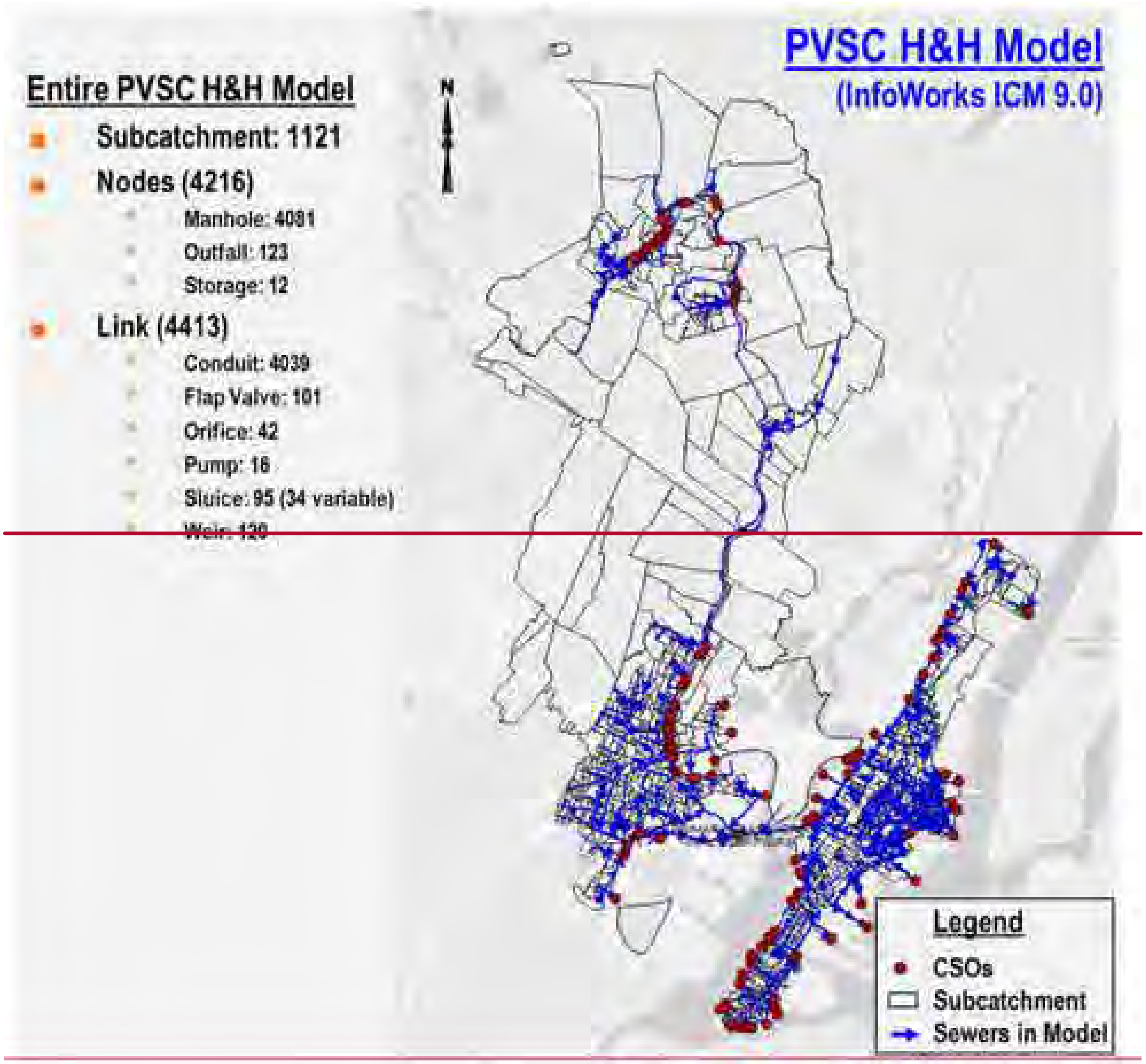

PVSC H&H Model
(InfoWorks ICM 9.0)
Entire PVSC H&H Model
Subcatchment: 1121
Nodes (4216)
Manhole: 4081
Outfall: 123
Storage: 12
Link (4413)
Conduit: 4039
Flap Valve: 101
Orifice: 42
Pump: 16
Sluice: 95 (34 variable)
N
Legend
CSOs
Subcatchment
Sewers in Model

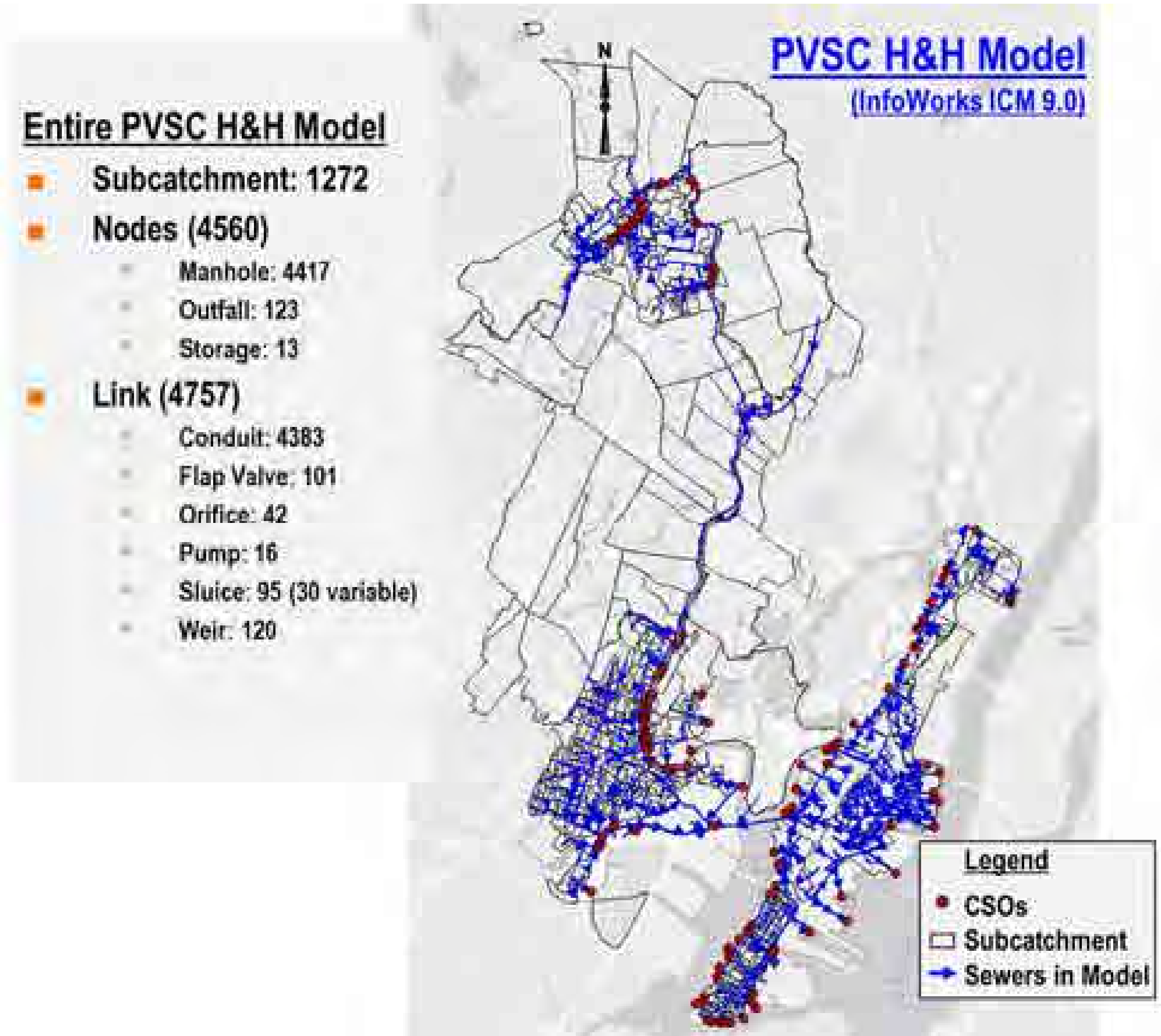


Figure I-26: Snapshot of Entire PVSC H&H Model Network

I.5 H&H MODEL CALIBRATION/VALIDATION

Model credibility is developed through model calibration and validation. Model calibration involves application of the model to known external inputs (e.g., rainfall), evaluation of the model's ability to replicate monitored conditions (e.g., flow and volume), and adjustment of key model parameters as needed until an acceptable level of agreement is reached between simulated and monitored conditions. Model validation generally involves verifying model performance with additional independent storm events. Further model adjustments are often made during model validation process to improve model accuracy. Due to the limited availability of monitoring data, it is common practice for H&H models to undergo and single calibration/validation process. In this approach, model parameters are adjusted to improve model accuracy across all of the events, and then each event is evaluated independently to verify model performance cross a range of conditions. The four storm events identified in Section E.9 were used for the PVSC model calibration/validation.

The collection system H&H Model was calibrated in conjunction with the flow monitoring. The H & H Model was calibrated by running the model with rainfall data collected from selected storms and then comparing the calculated results to the actual flow monitoring data collected. The model parameters were adjusted and the process repeated until the calculated results approximated the actual flow monitor measurements. Goals for the model calibration included:

- To match visually the shape of the curve between model and flow monitor.
- To match model runoff volumes (volume under curve) to actual runoff volumes.
- To match model runoff peak flow rates to actual runoff peak flow rates.

I.5.1 Dry Weather Flow Calibration/Validation

Dry weather flow (DWF) analysis was based on the rainfall and flow monitoring results. DWF distribution in the collection system was based on land use data. Weekday, weekend and monthly diurnal factors from the DWF analysis were applied for each flow meter service area. Upstream meters in the system were calibrated first, then flows through the system to the pumps stations and to the WRRF were balanced. **Figure E-4** shows the arrangement of the meters in the system and meter identification.

The DWF calibration goals are included below based on the "Code of Practice for the Hydraulic Modeling of Sewer Systems" by the Wastewater Planning Users Group (WPUG):

- The simulated hydrograph should match the general observed hydrograph shape,
- The simulated time of peaks and troughs will be within 1 hour of the observed,
- The simulated peak flow will be within 10% of the observed flow, and
- The simulated flow volume over 24 hours will be within 10% of observed flow.

After the dry weather calibration was considered to be satisfactory, the model was calibrated for wet weather periods as described below.

I.5.2 Wet Weather Calibration/Validation

Wet weather flow (WWF) includes surface runoff from the combined area and RDII from the combined and separate sewered areas. Surface runoff parameters for the combined area and RDII parameters for the separate area were adjusted to calibrate the system response to the wet weather conditions.

The WWF calibration goals are also based on the "Code of Practice for the Hydraulic Modeling of Sewer Systems" by WPUG:
:

- The simulated hydrograph should match the general observed hydrograph shape,
- The simulated time of peaks and troughs will be similar,

- The simulated peak flow for significant peaks will be within the range of -15% to +25%,
- The simulated flow volume will be within the range of -10% to +20%,

Storm events were analyzed based on precipitation data from the Newark Liberty International Airport. Four storm events selected for calibration/validation of the collection system model met all the desired storm characteristics as describe in **Section E** of this Report. The July 25, 2016 storm was a 1.81-inch storm with a duration of approximately 3 hours and a maximum intensity of 1.68 in/hr. The May 29, 2016 storm was a 1.60-inch storm with a duration of 5.75 hours and a maximum intensity of 1.09 inches/hour. The July 25, 2016 storm was a 1.84 inch storm with a duration of 3 hours and a maximum intensity of 1.68 in/hr. The July 29, 2016 storm was a 0.87 inch storm with a duration of 8.5 hours and a maximum intensity of 0.43 in/hr. The July 30, 2016 rain event was a 1.07-inch storm with a duration of 32.75 hours and a maximum intensity of 0.49 in/hr. Detailed storm characterizations can be found in **Table E-5** for all eight rain gauges. Precipitation data collected by the eight rain gauges throughout the PVSC service area were applied to modeling subcatchments based on Thiessen Polygons for model calibration. Examples of model calibration/validation results are shown in the following figures for the observed and simulated flow, the one-to-one plots for modeled versus observed volumes, and the one-to-one plots for modeled versus observed peak flows. A well calibrated model will result in plotted values that are close to a one-to-one relationship. Deviations from this one-to-one relationship can be result from a variety of factors including error inherent with monitoring data, special variations in rainfall, and model limitations. When a modeled versus observed point is well outside of the calibration goal range, a note is provided to explain the likely cause of the discrepancy. Examples of model calibration results are shown in **Figure I-27** to **Figure I-52** for flow meters in different locations of the collection systems. **Appendix D** shows calibration plots for all meters.

- **Figure I-27** to **Figure I-34** for flow meters in along the PVSC Interceptor;
- **Figure I-35** to **Figure I-42** for flow meters in the separate sewer area,
- **Figure I-43** to **Figure I-50** for flow meters in the combined sewer area, and
- **Figure I-51** to **Figure I-54** for flow meters in the CSO overflow lines.

Obtaining accurate flow monitoring in an outfall pipe is often challenging. Most of the time the meter is recording no flow but when the overflow begins the flow rate can increase rapidly. This can result in instabilities in the recorded flows and difficulties in matching modeled and monitored timing for individual overflow meters. Another way to consider how the outfall meters are performing overall is to consider the total predicted vs. monitored overflow volumes for each event across all of the overflow meter locations. **Figure I-55** shows that the model underpredicts the total overflow volume for Event 4, but shows a very good fit for the remaining 3 events. Overall the predicted overflow volume at these metered locations is consistent with the monitored data.

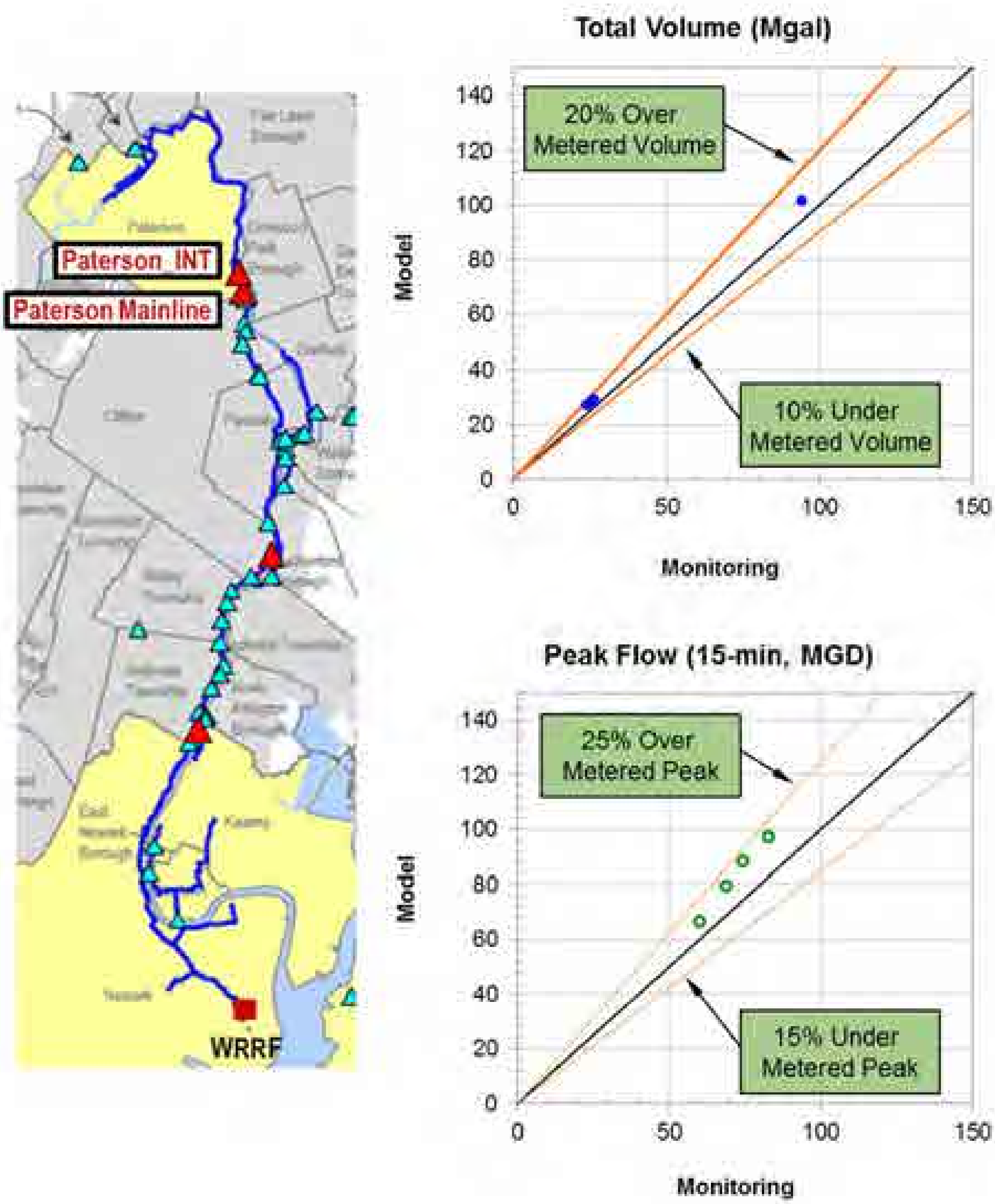


Figure I-27: Calibration Plot for Interceptor_Paterson Main Line_I

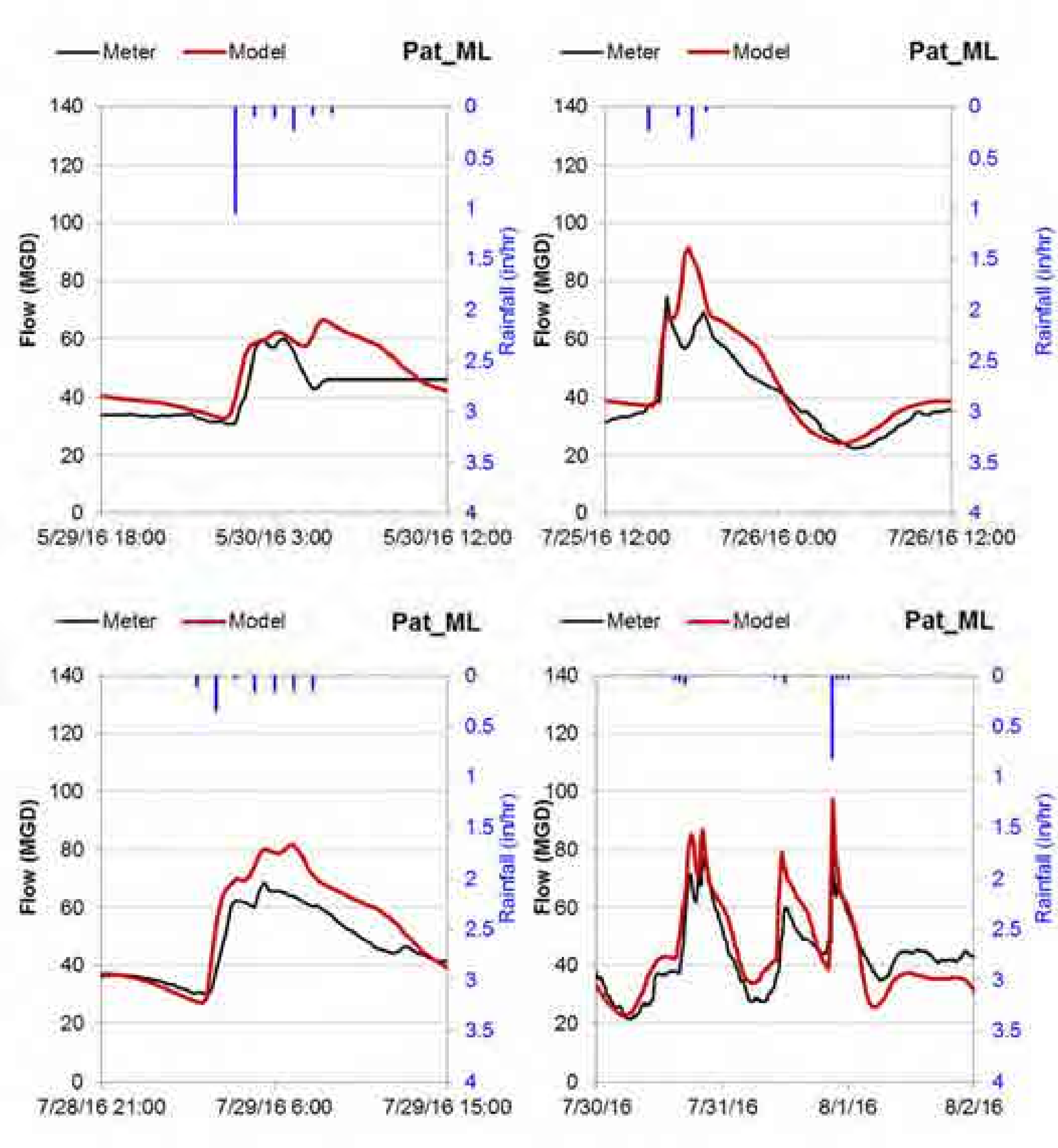


Figure I-28: Calibration Plot for Interceptor_Paterson Main Line_II

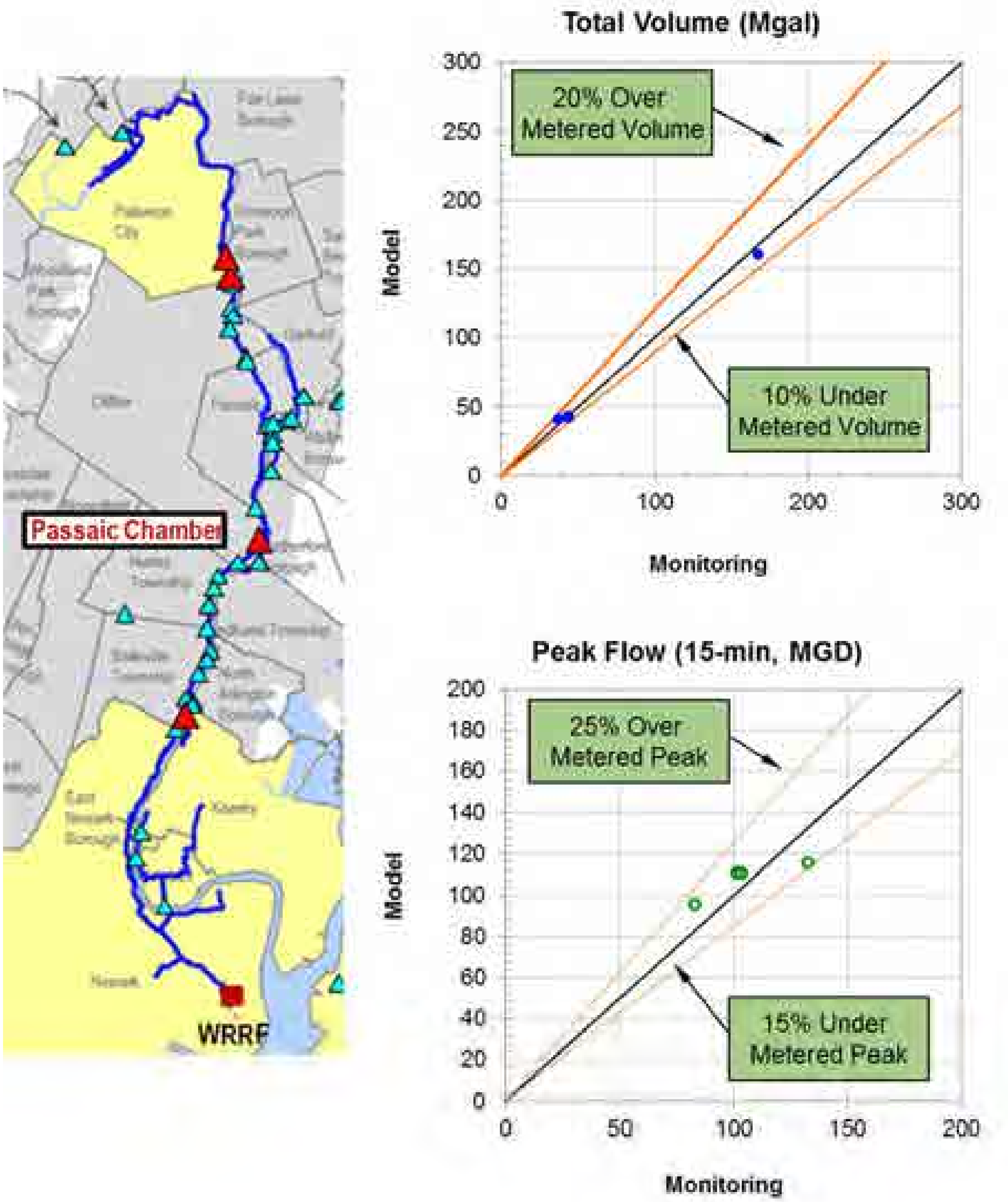


Figure I-29: Calibration Plot for Interceptor_Passaic Chamber_I

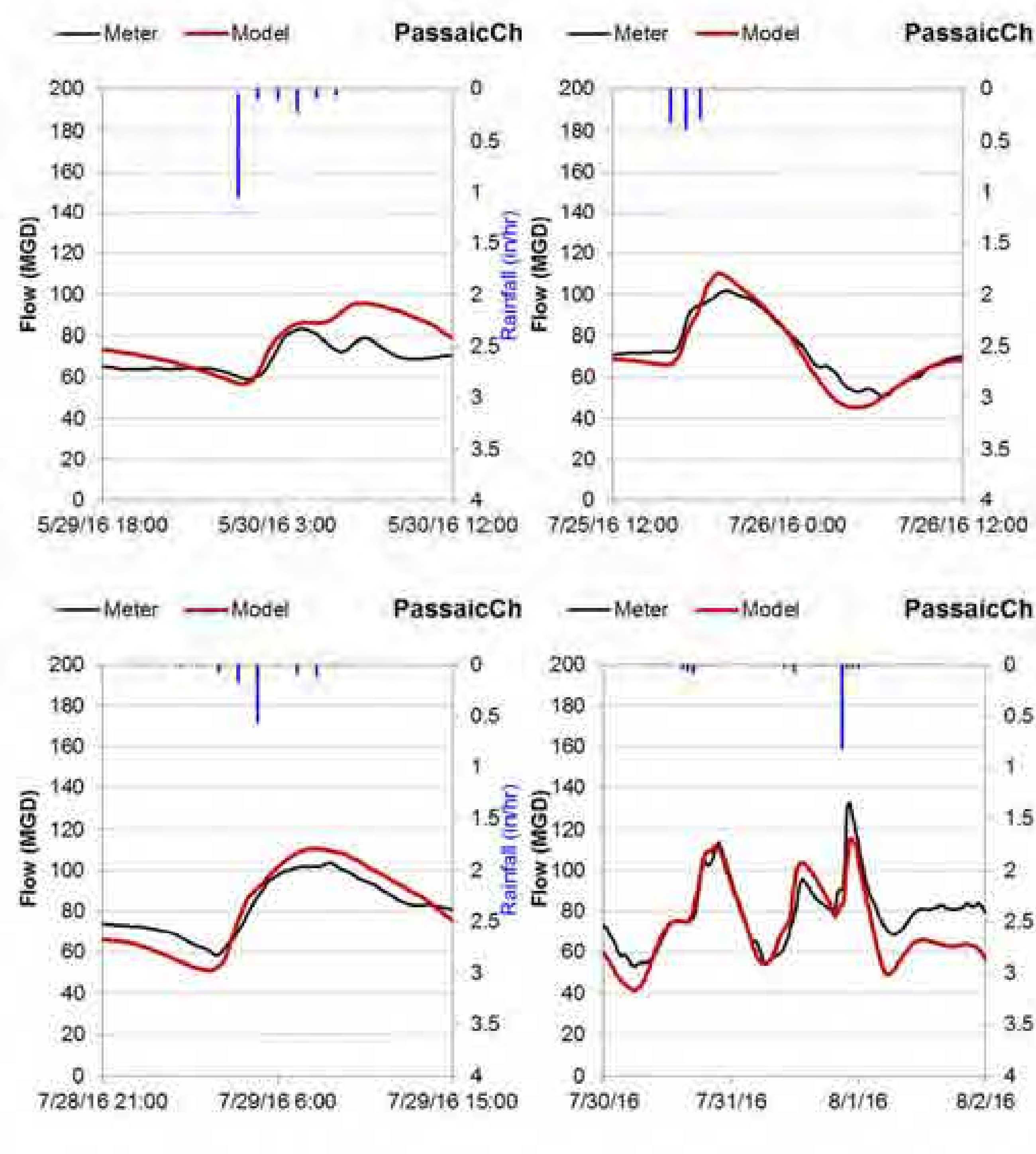


Figure I-30: Calibration Plot for Interceptor_Passaic Chamber_II

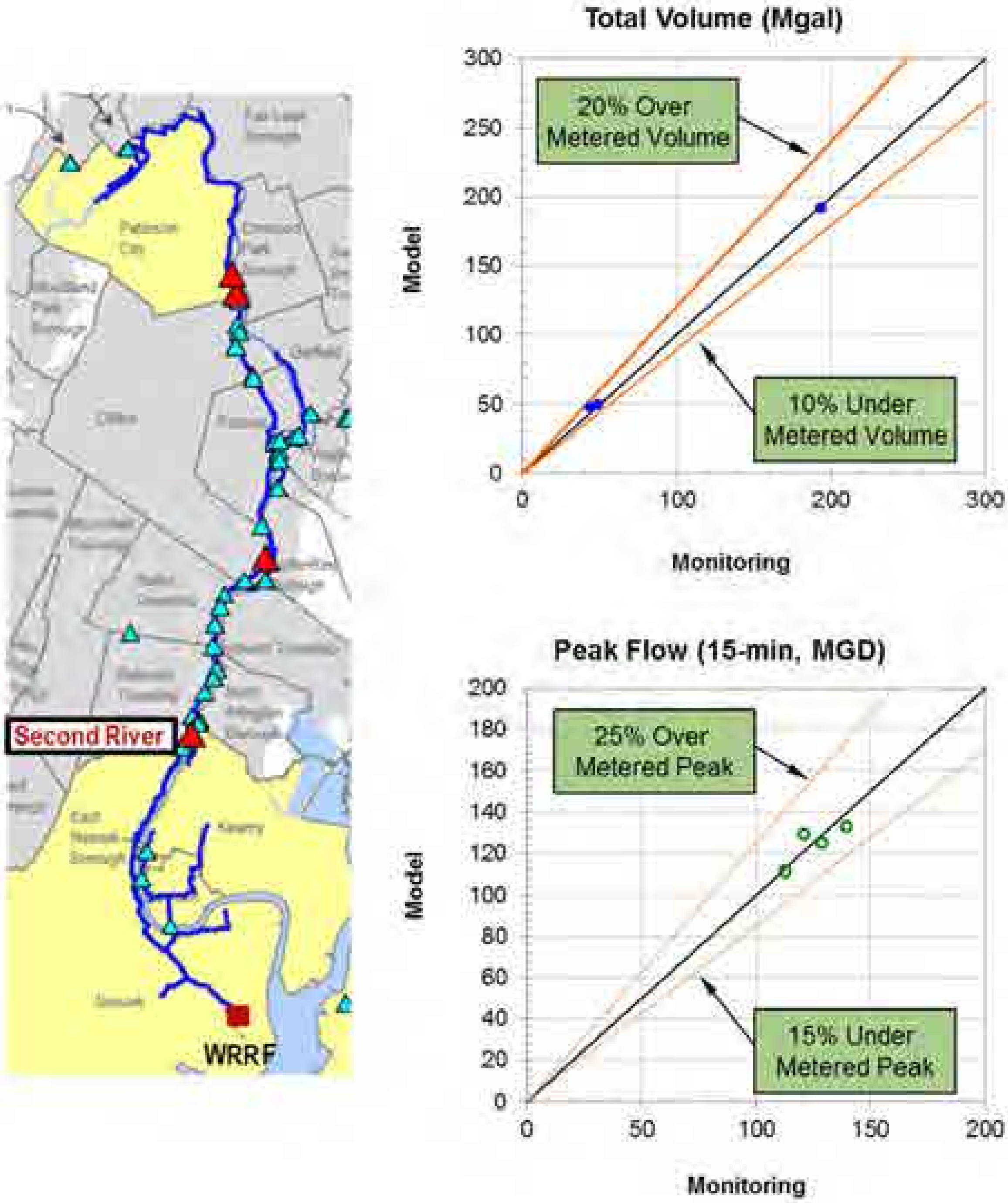


Figure I-31: Calibration Plot for Interceptor_Second River Crossing_I

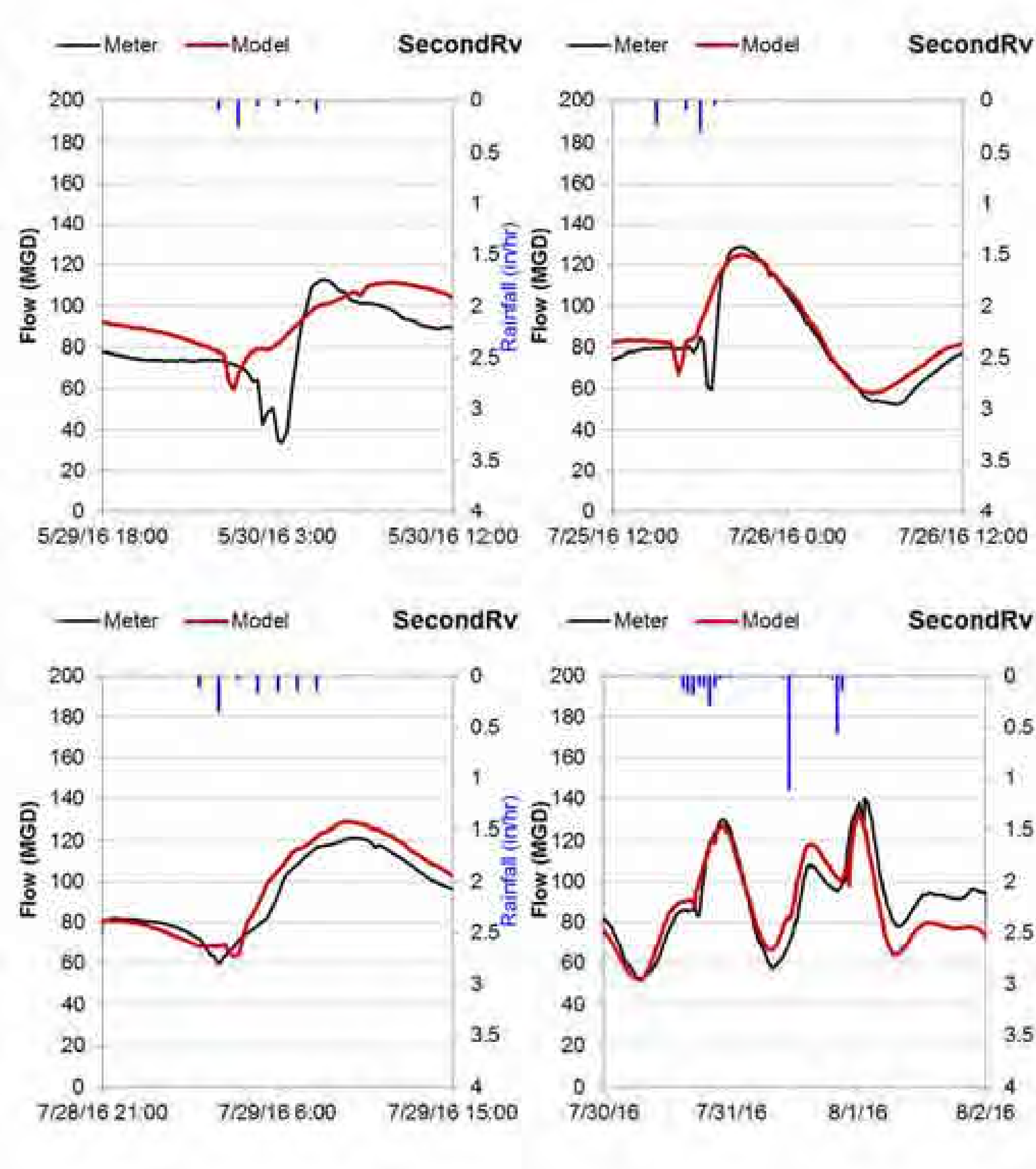


Figure I-32: Calibration Plot for Interceptor_Second River Crossing_II

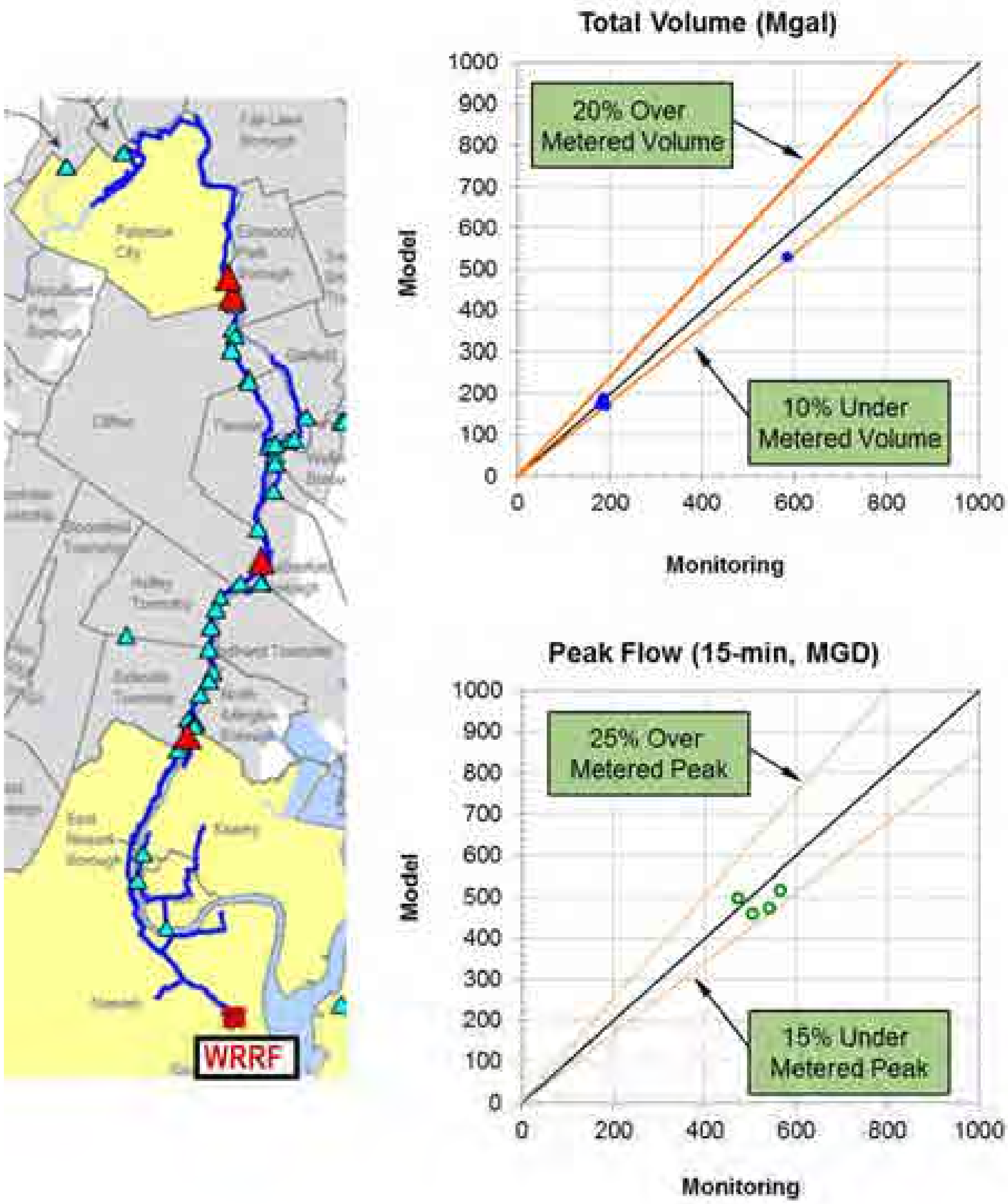


Figure I-33: Calibration Plot for PVSC WRRF_I

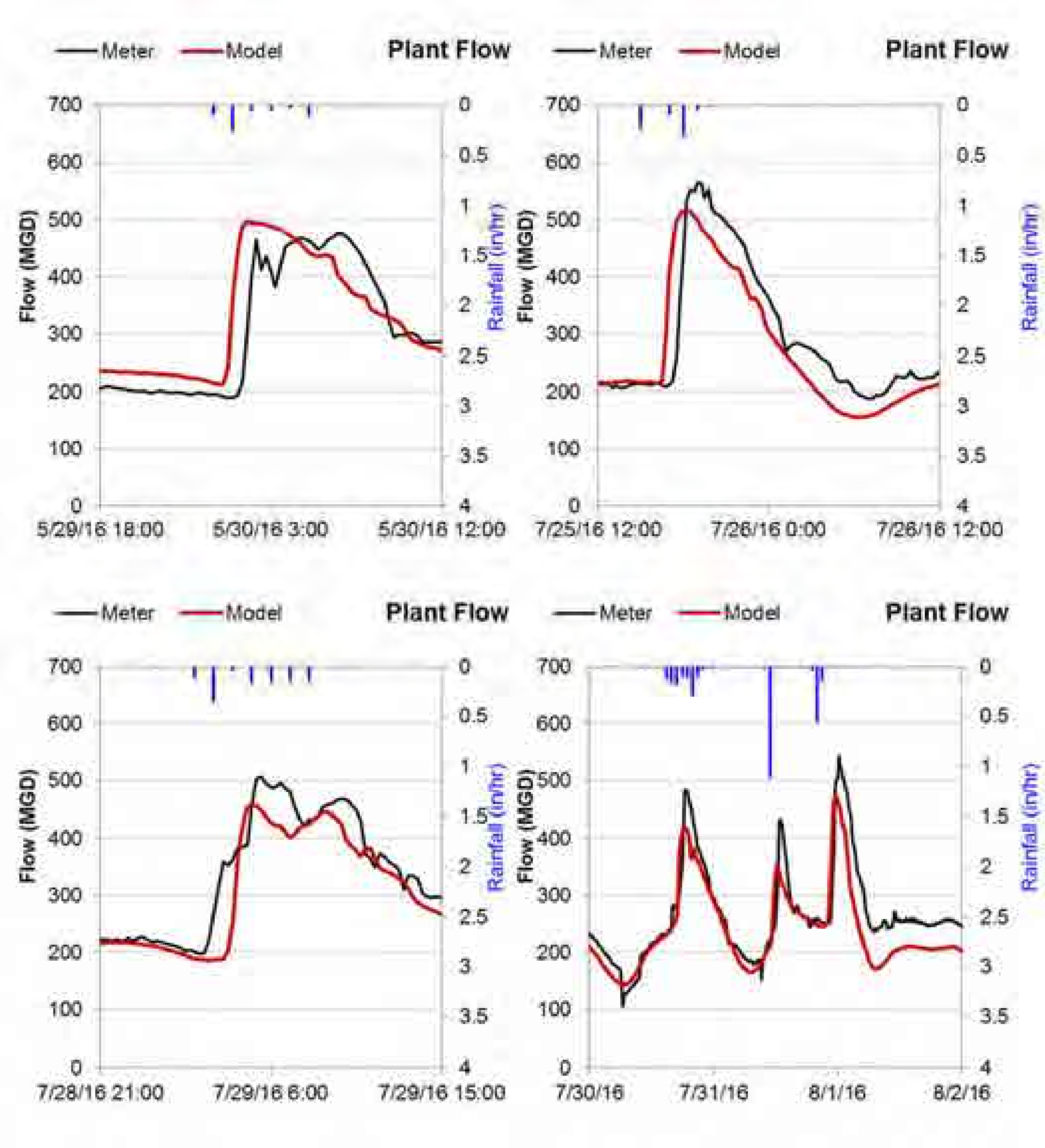


Figure I-34: Calibration Plot for PVSC WRRF_II

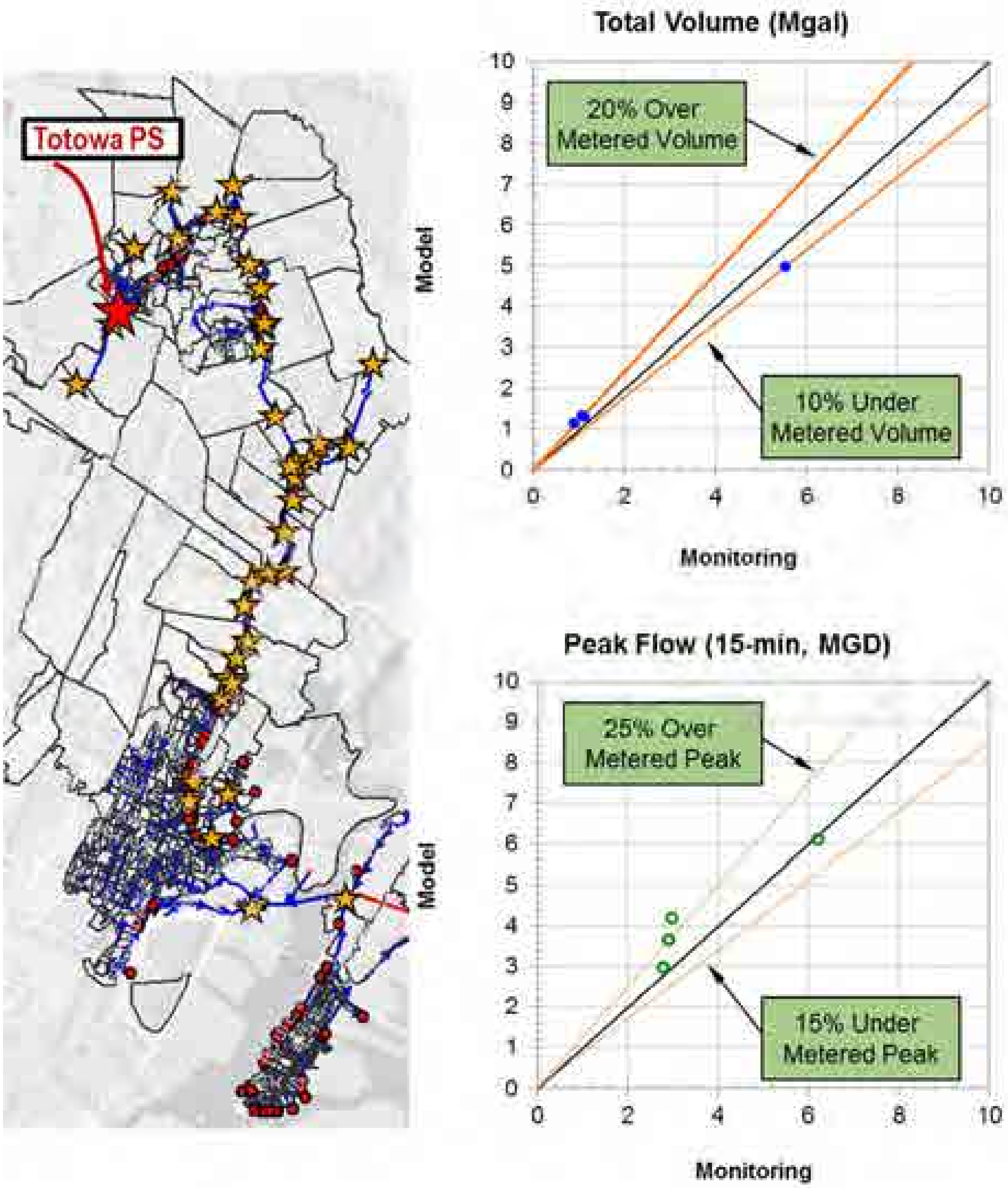


Figure I-35: Calibration Plot for Separate Area_Totowa PS_I

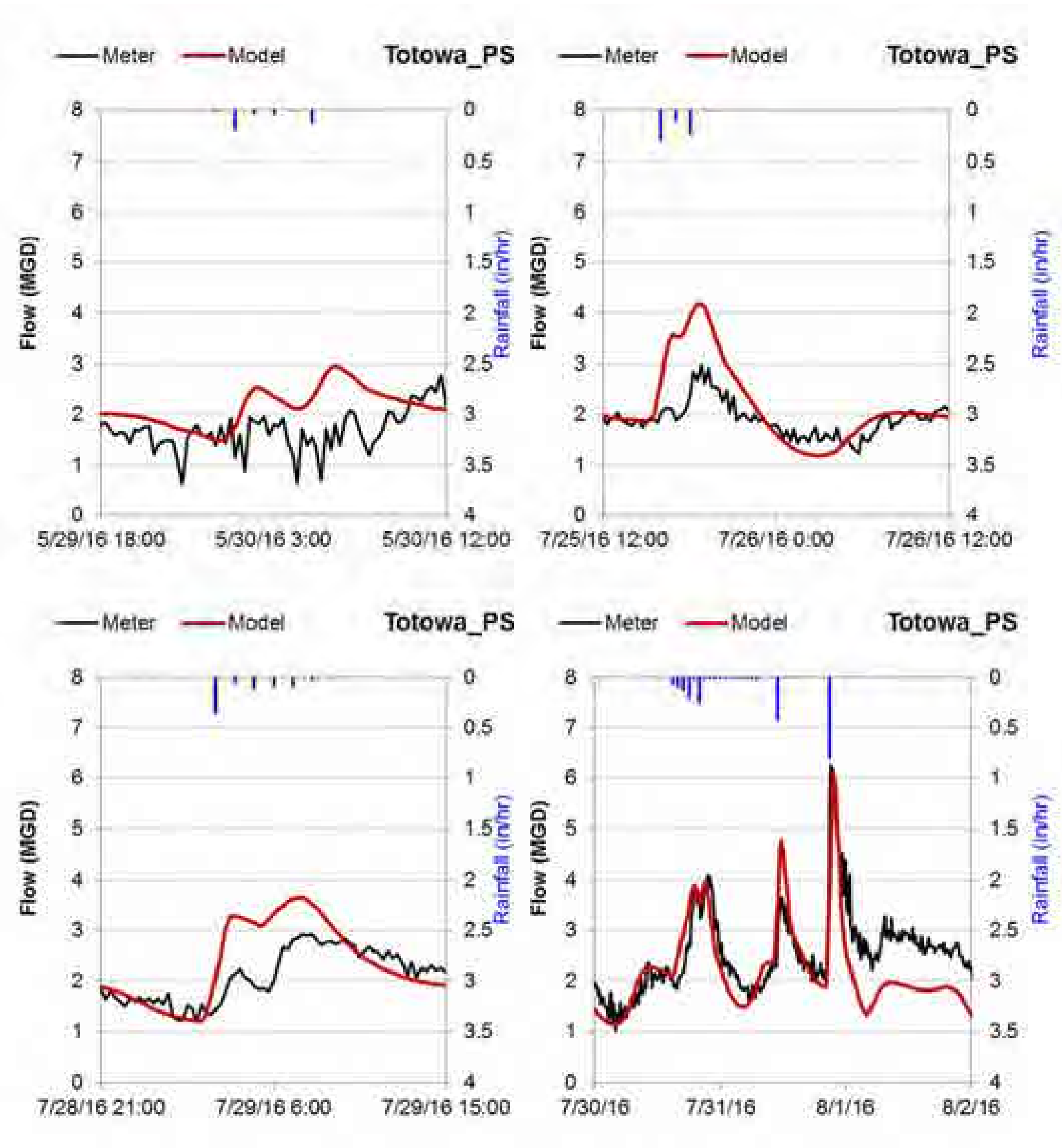


Figure I-36: Calibration Plot for Separate Area_Totowa PS_II

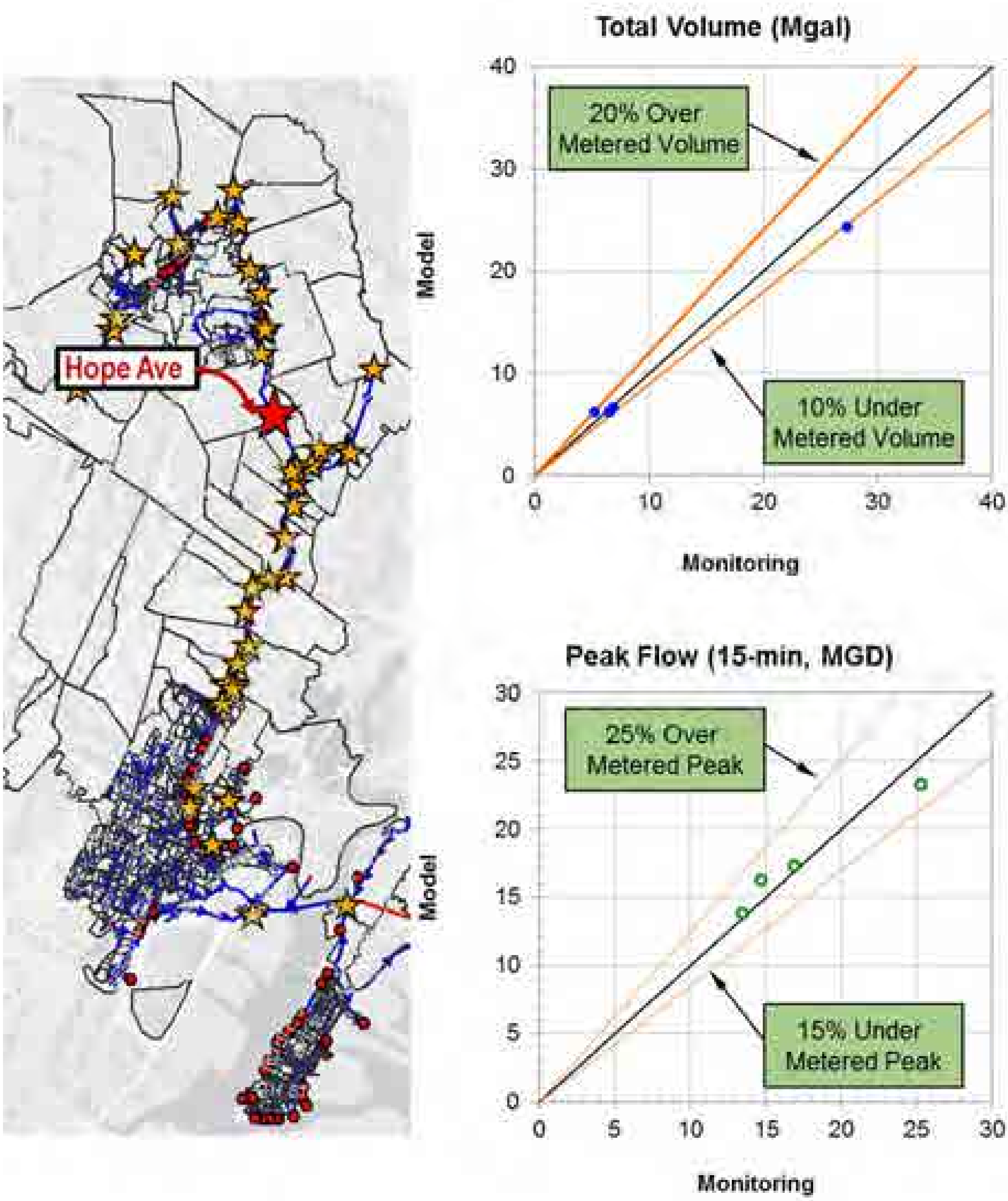


Figure I-37: Calibration Plot for Separate Area_Hope Ave_I

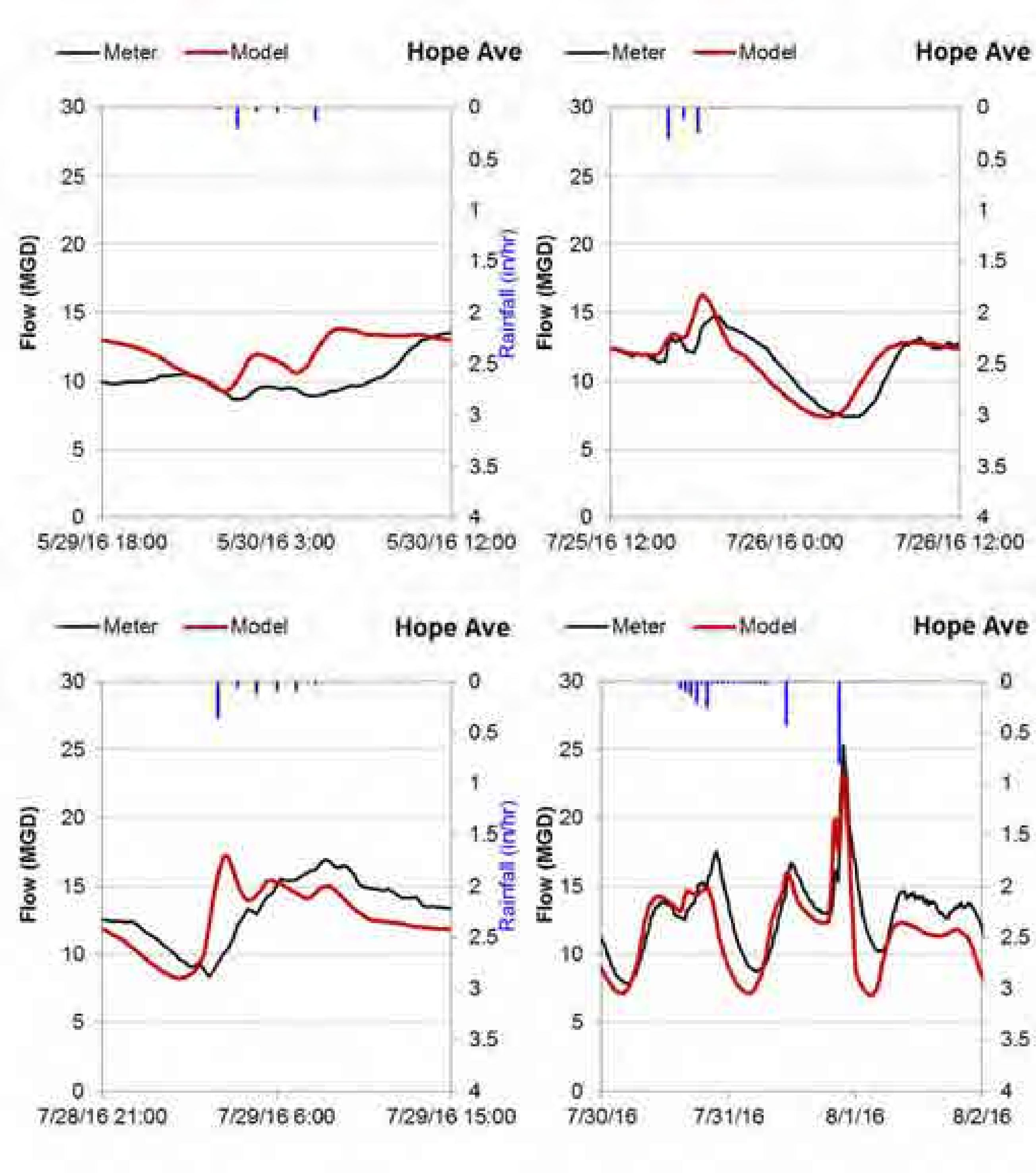


Figure I-38: Calibration Plot for Separate Area_Hope Ave_II

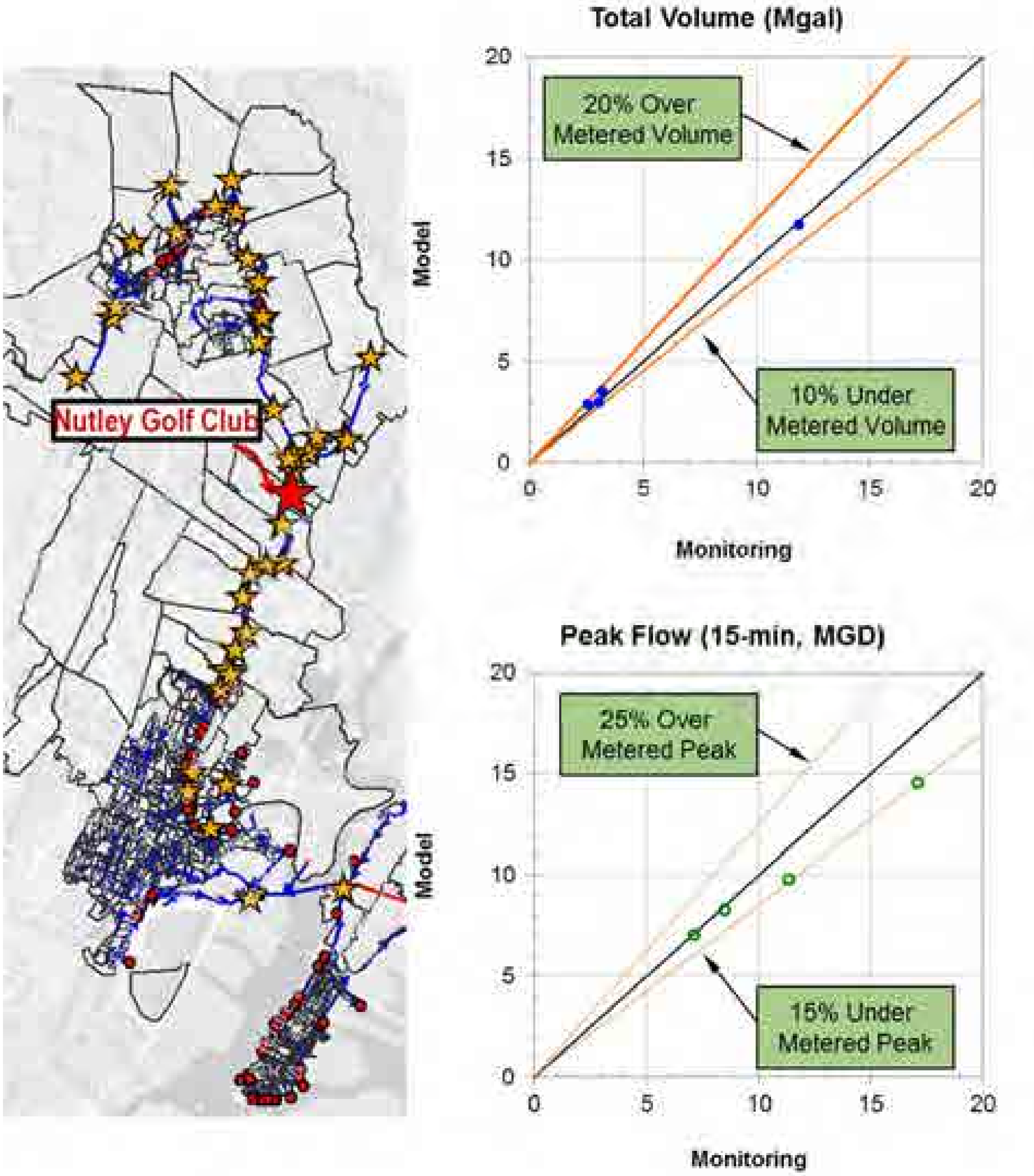


Figure I-39: Calibration Plot for Separate Area_Nutley Golf Club_I

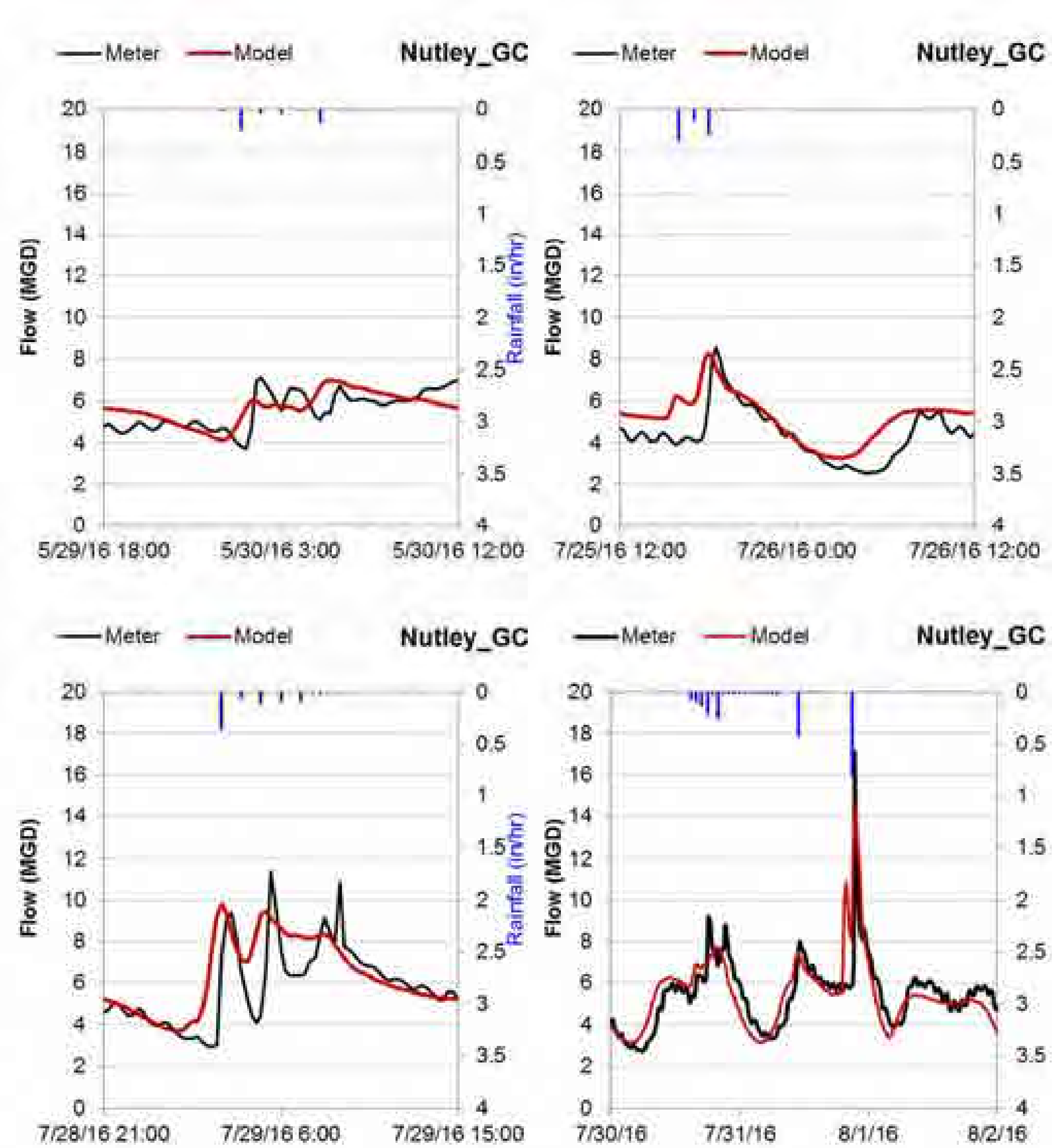


Figure I-40: Calibration Plot for Separate Area_Nutley Golf Club_II

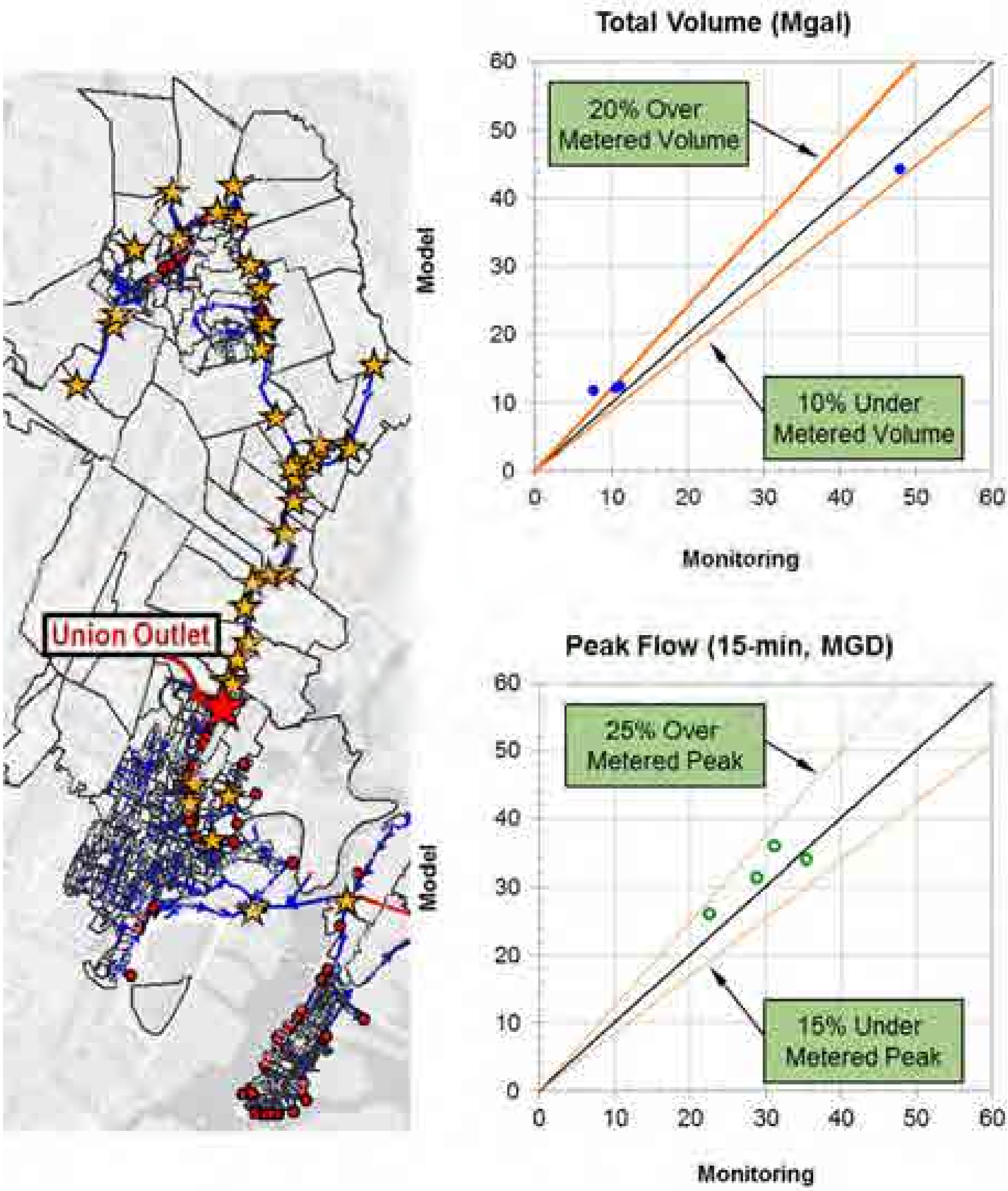


Figure I-41: Calibration Plot for Separate Area_Union Outlet_I

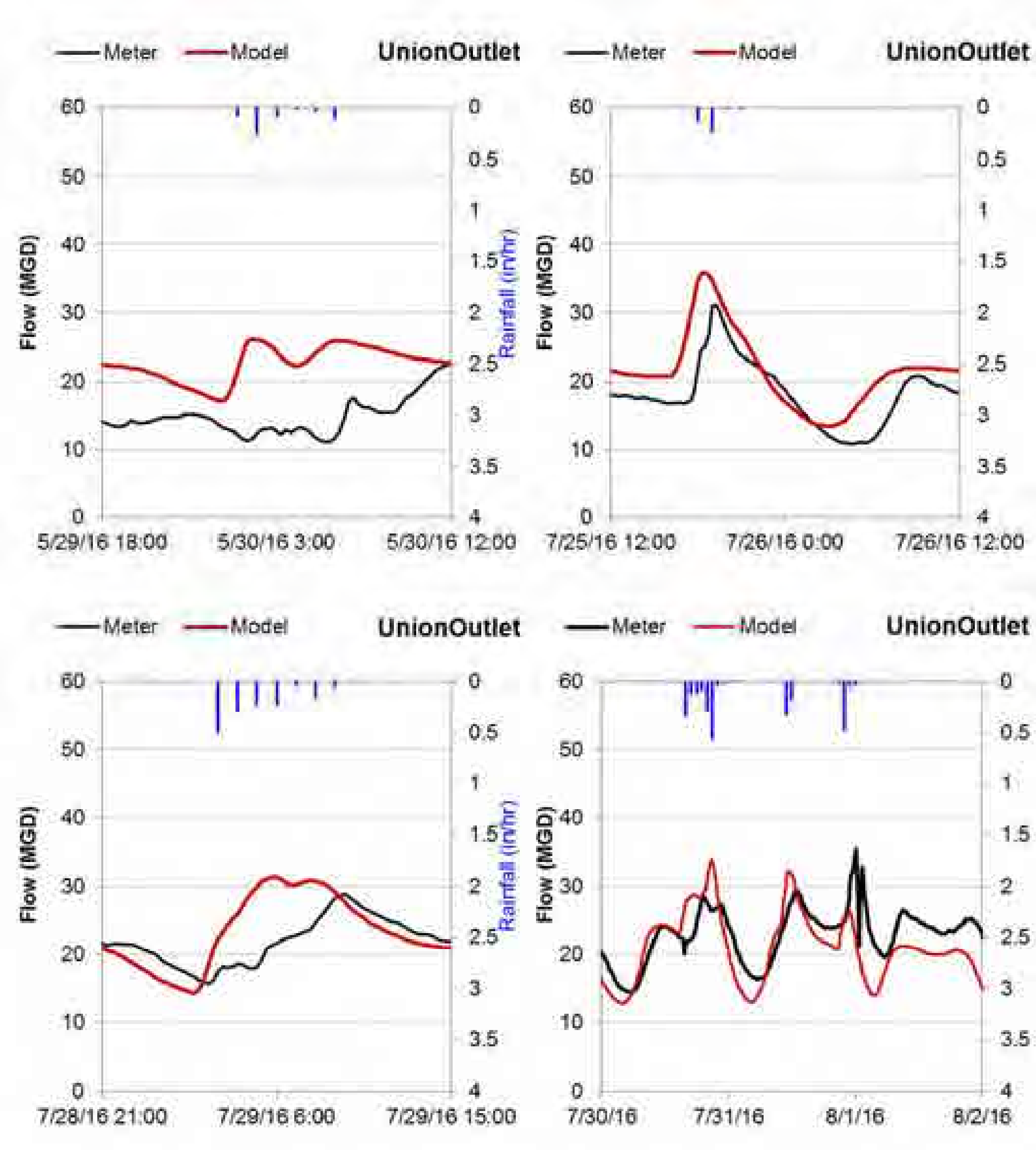


Figure I-42: Calibration Plot for Separate Area_Union Outlet_II

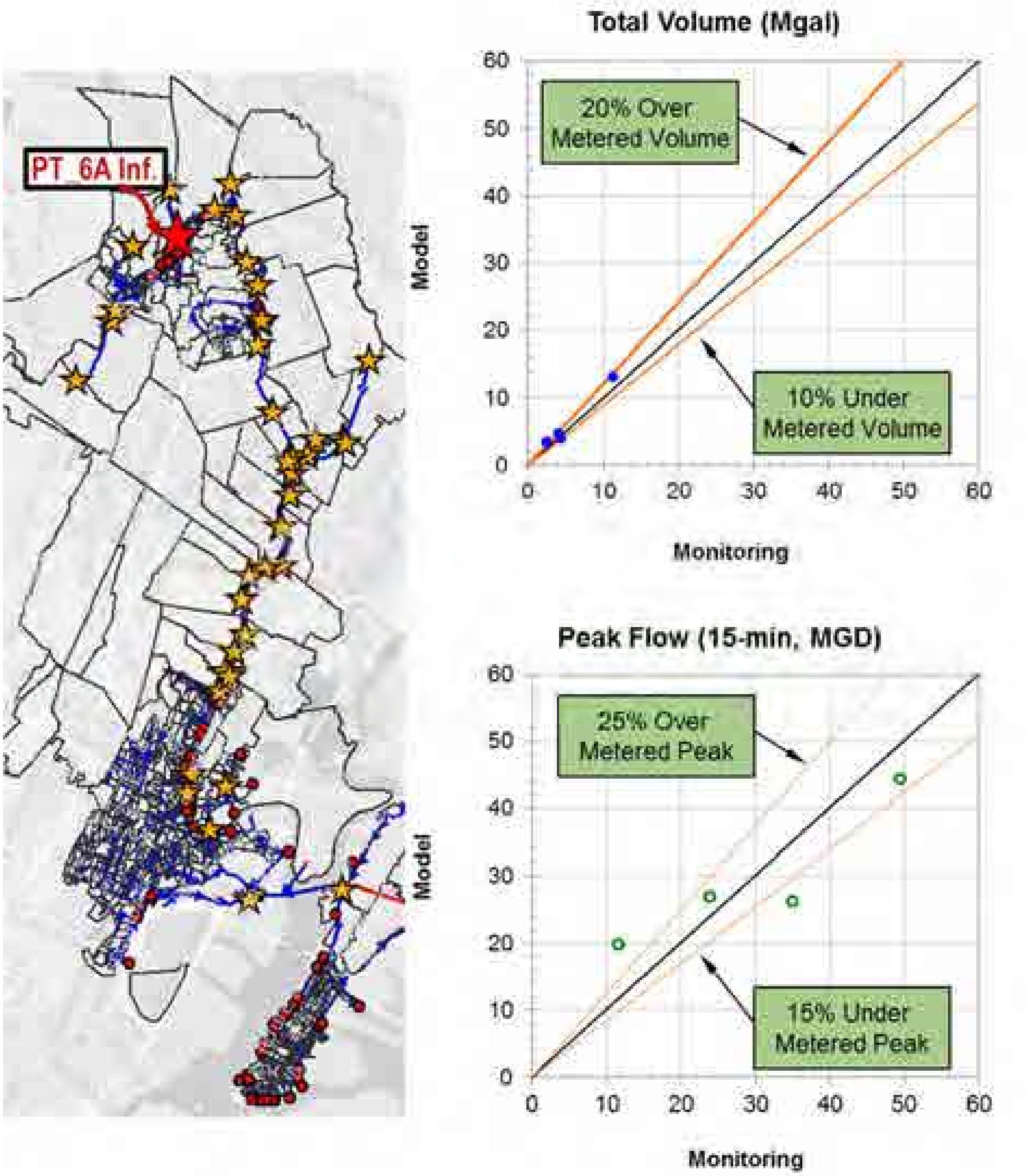


Figure I-43: Calibration Plot for Combined Area_Paterson 6A Influent_I

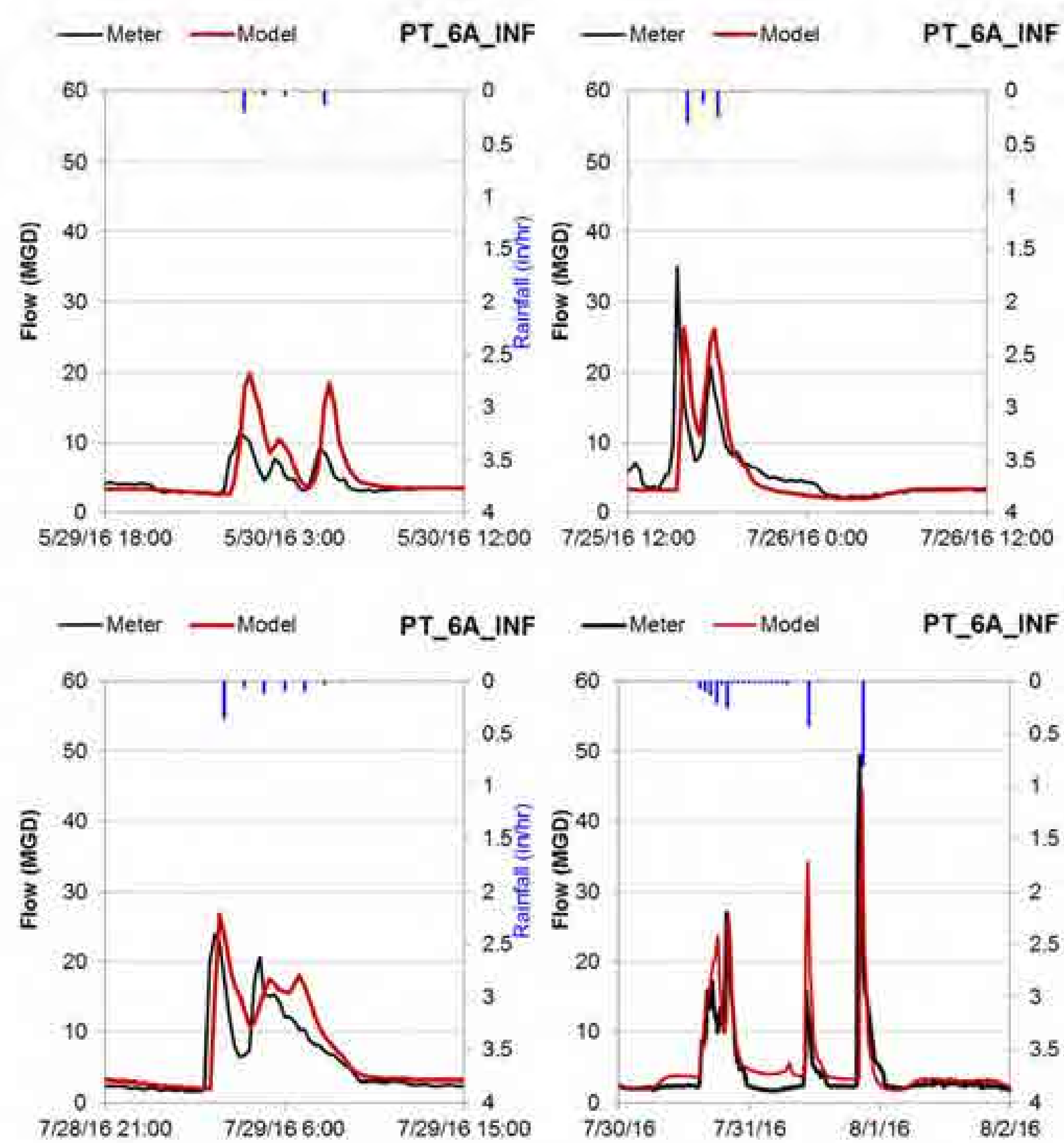


Figure I-44: Calibration Plot for Combined Area_Paterson 6A Influent_II

Note: The simulated volume and peak flow for the May 29, 2016 event exceeded the monitored values beyond the targeted calibration ranges. Adjusting the model parameters to provide a better fit for this event would have resulted in under simulation of the larger events.

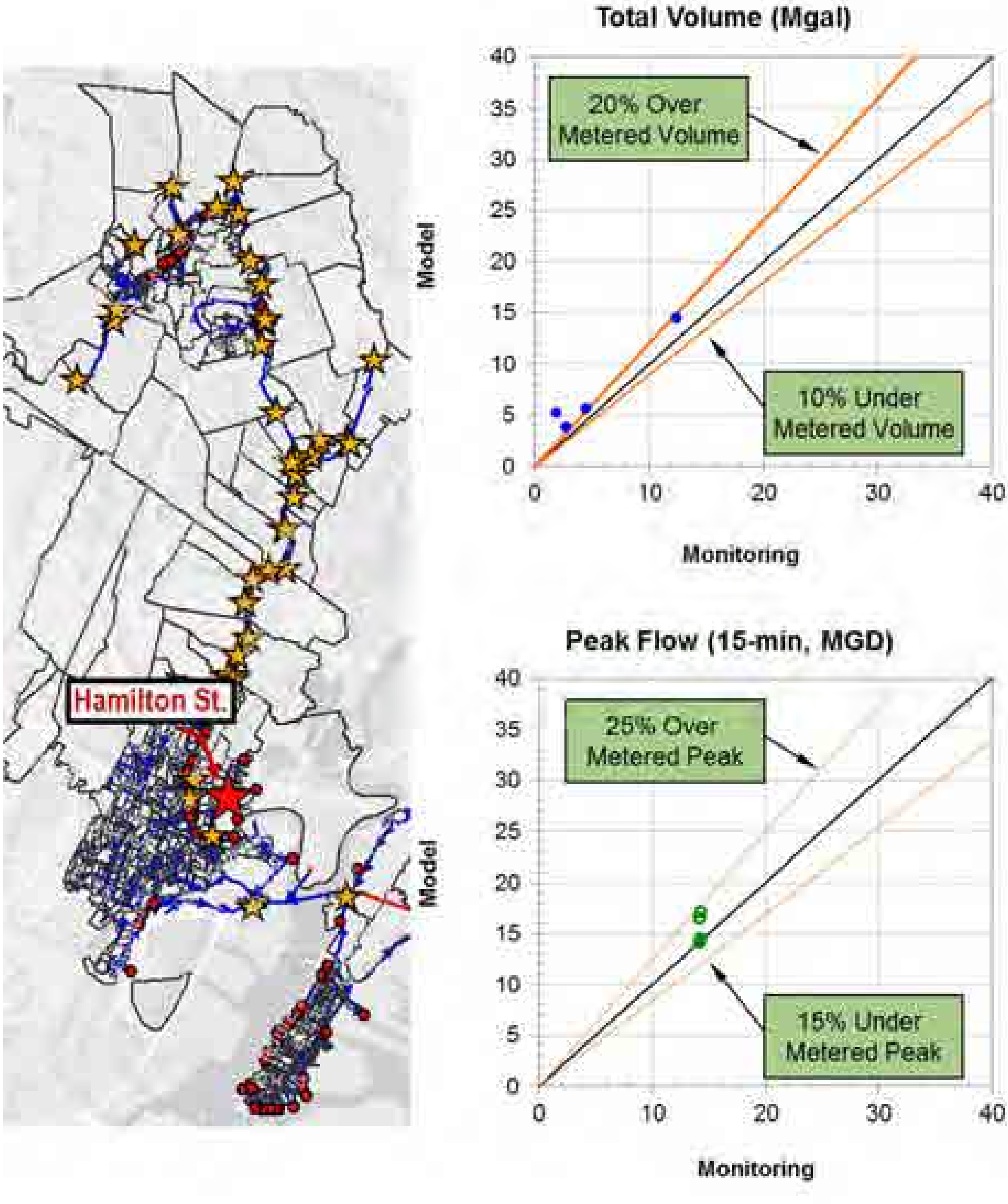


Figure I-45: Calibration Plot for Combined Area_ Hamilton St._I

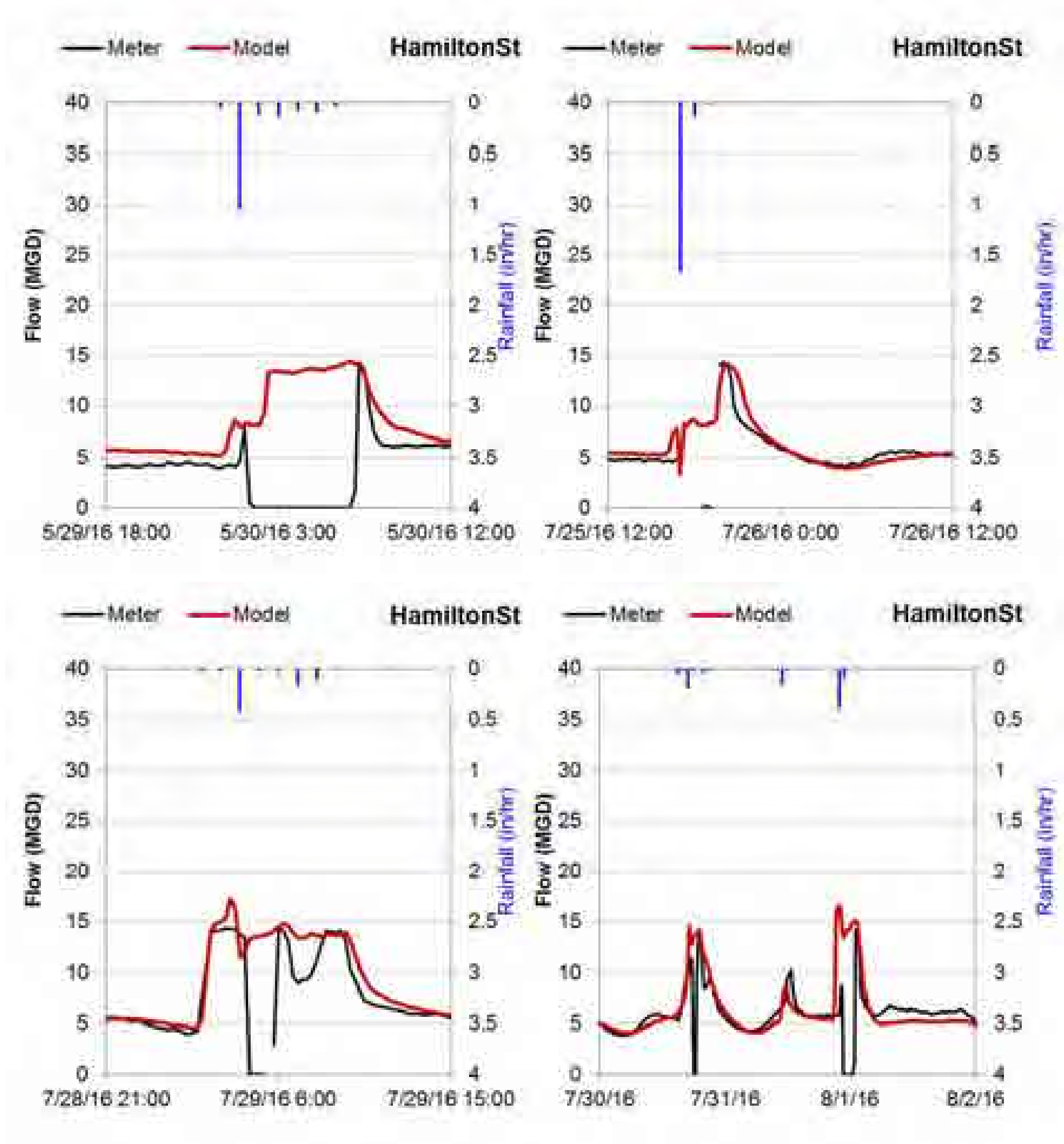


Figure I-46: Calibration Plot for Combined Area_ Hamilton St._II

Note:

1. Monitored data was not available for an extended portion of the May 29th, 2016 event. Therefore, this event was not considered during model calibration.
2. The monitored data for the July 29th, 2016 and July 30th, 2016 events also has some missing or periods of zero flow. The calibration effort for this site focused on matching peak flows and the hydrograph pattern.

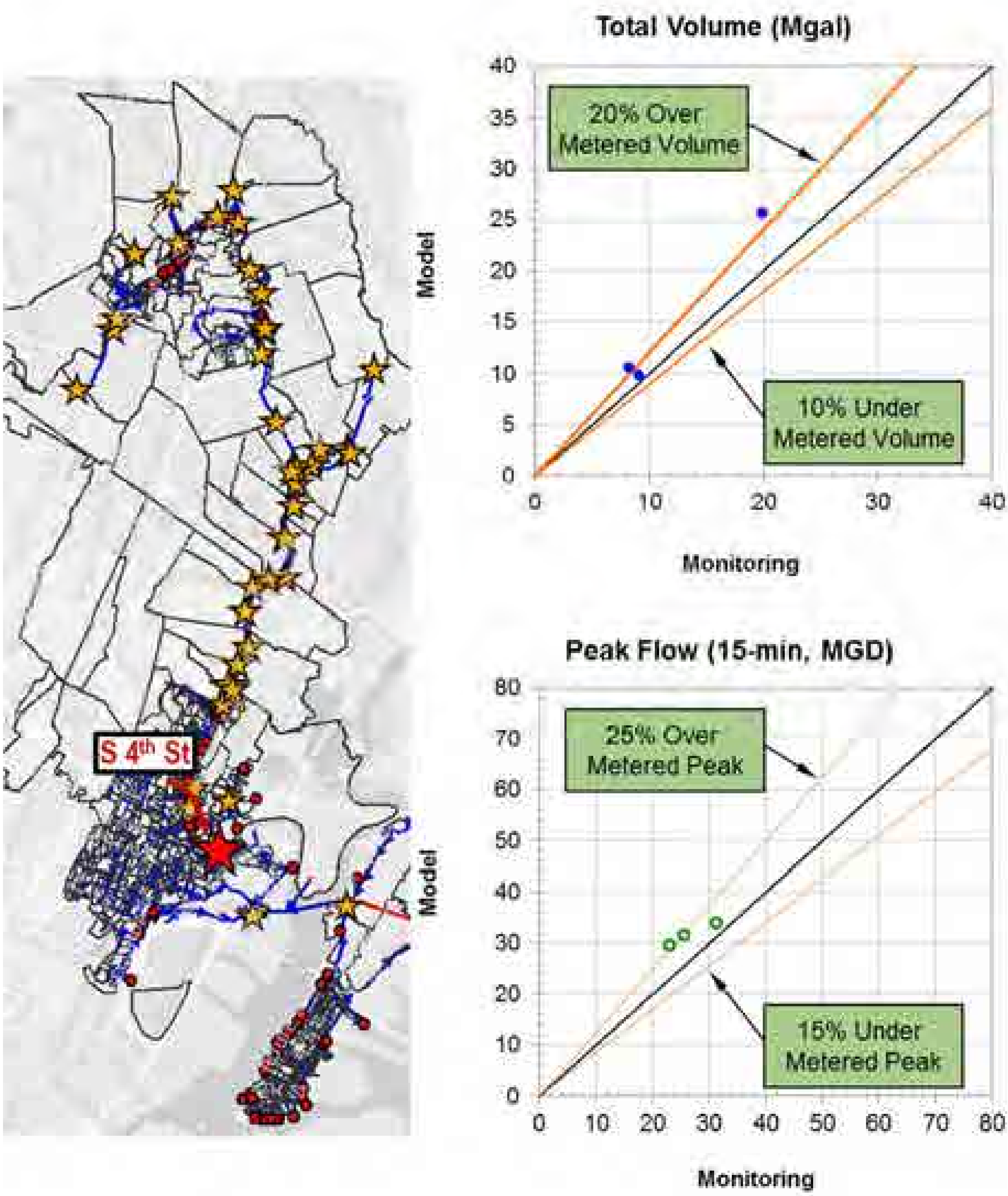


Figure I-47: Calibration Plot for Combined Area_ South 4th St._I

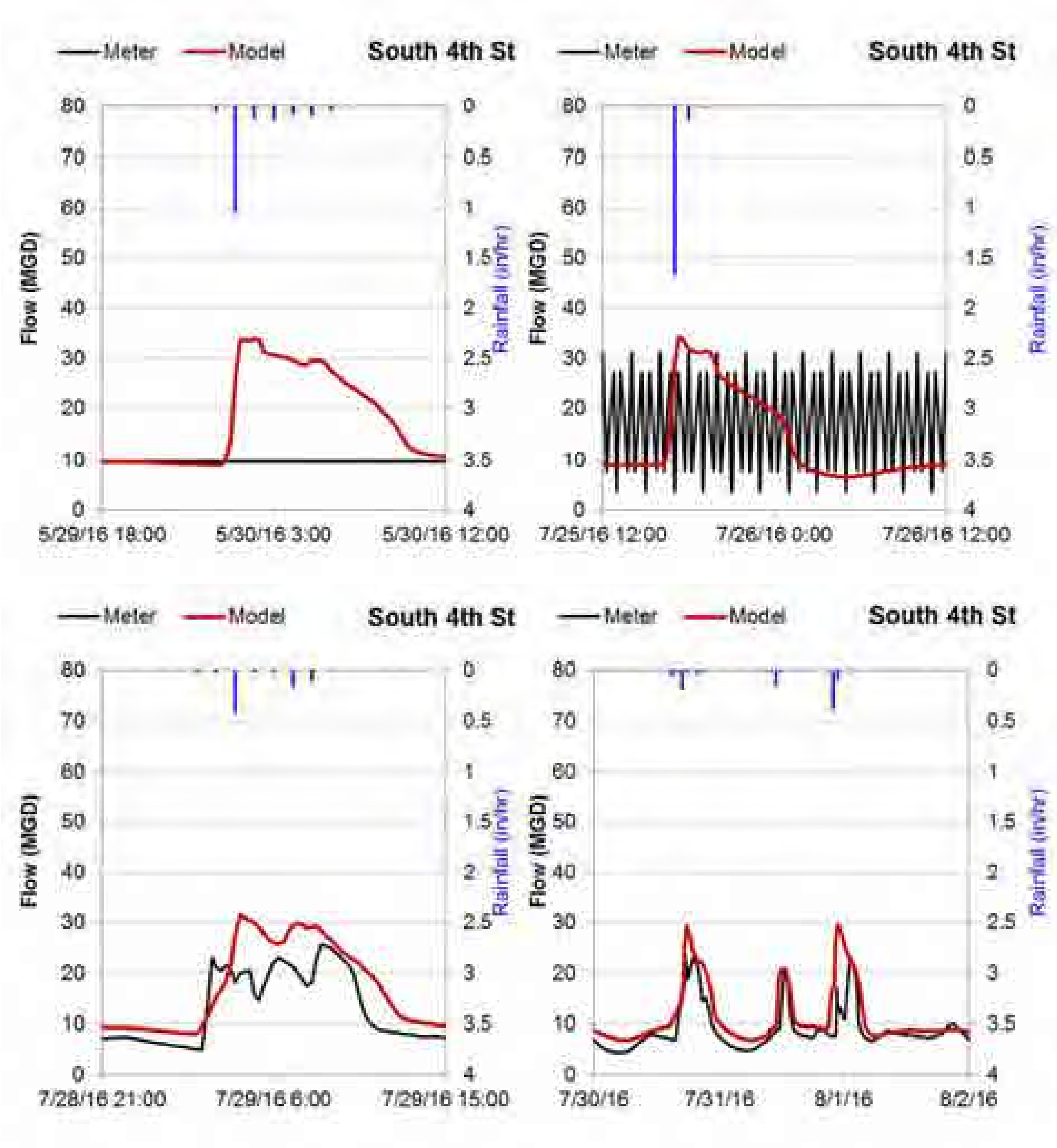


Figure I-48: Calibration Plot for Combined Area_ South 4th St._II

Note:

1. Accurate monitoring data was not available for the May 29th, 2016 event. Therefore, this event was not considered during model calibration and is not shown on the one-to-one plots.
2. Monitored data for Event July 25, 2016 has significant fluctuations and was therefore not considered during model calibration.

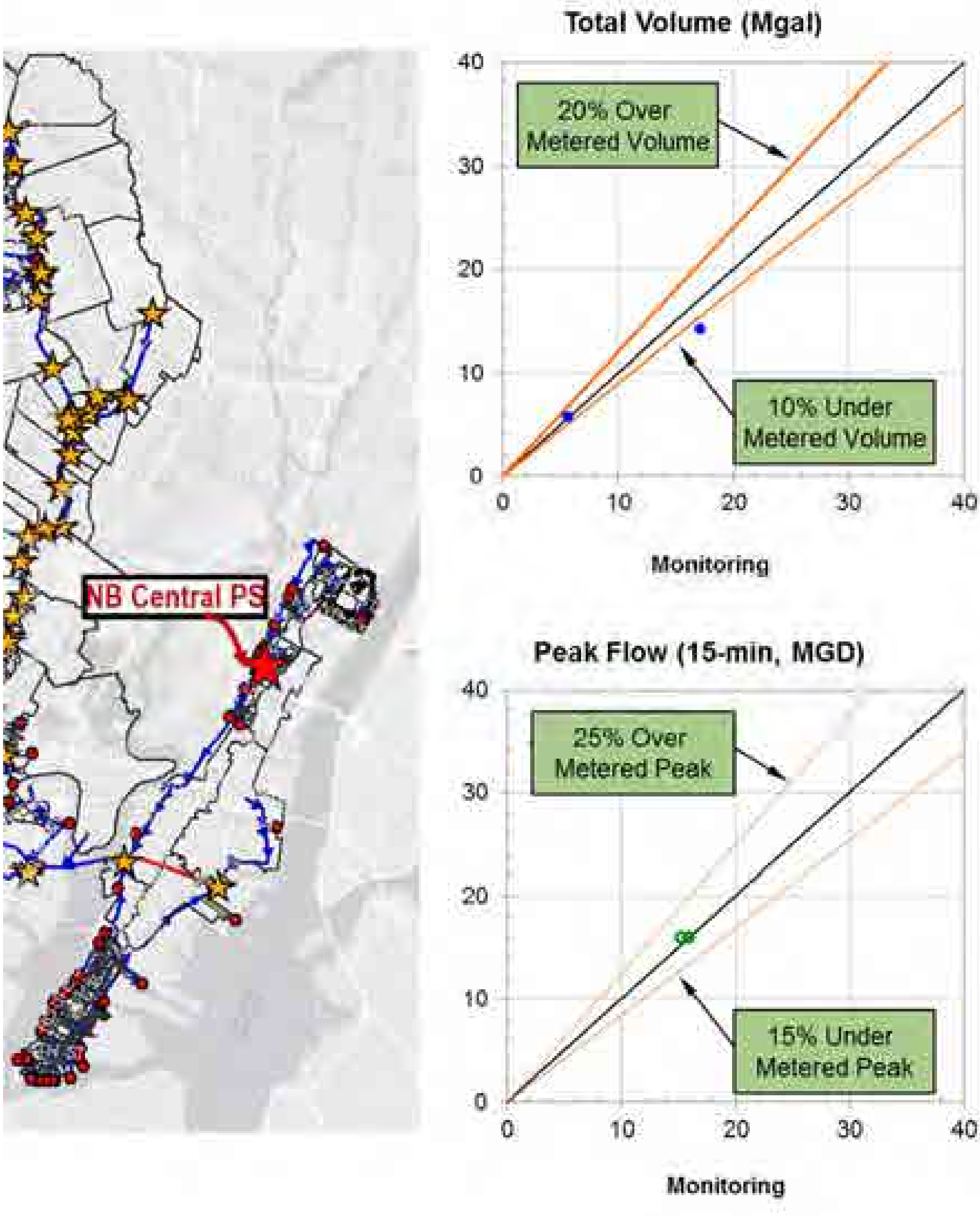


Figure I-49: Calibration Plot for Combined Area_ NB Central Pump Station I

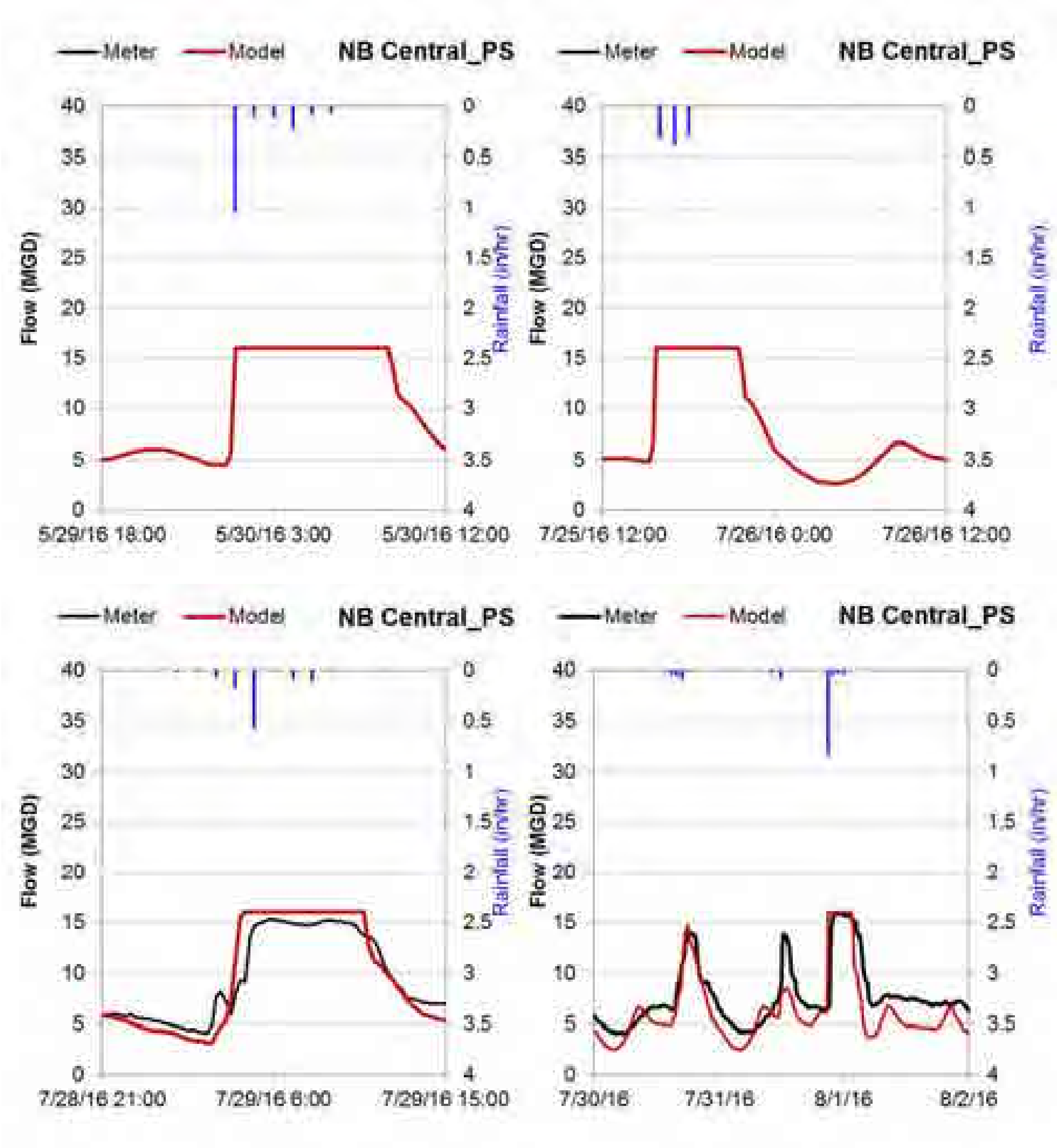
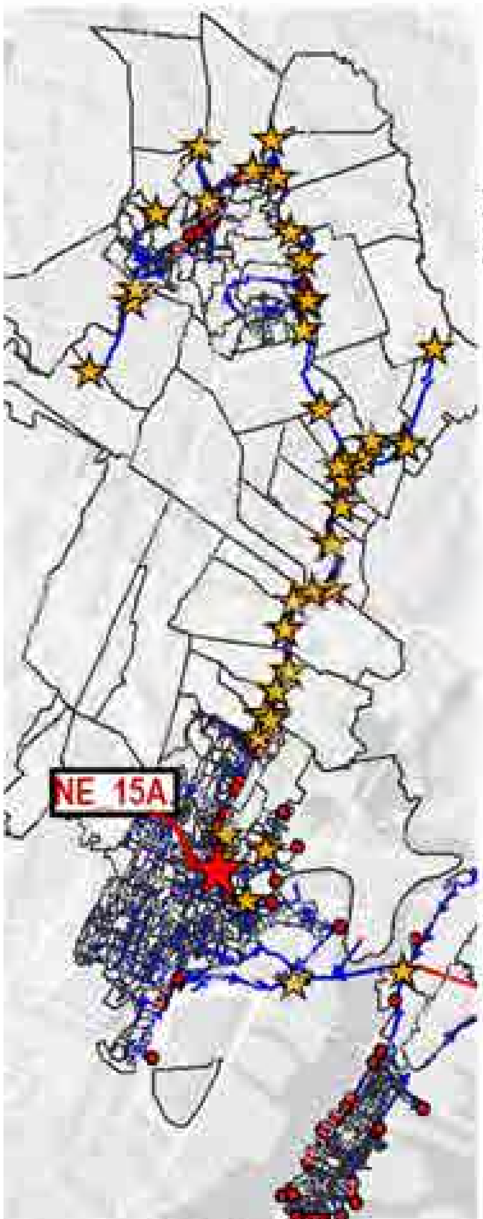


Figure I-50: Calibration Plot for Combined Area_ NB Central Pump Station_II

Note:

1. Monitored data was not available for the May 29th, 2016 and July 25, 2016 events. Therefore, these events were not considered during model calibration and are not shown on the one-to-one plots.



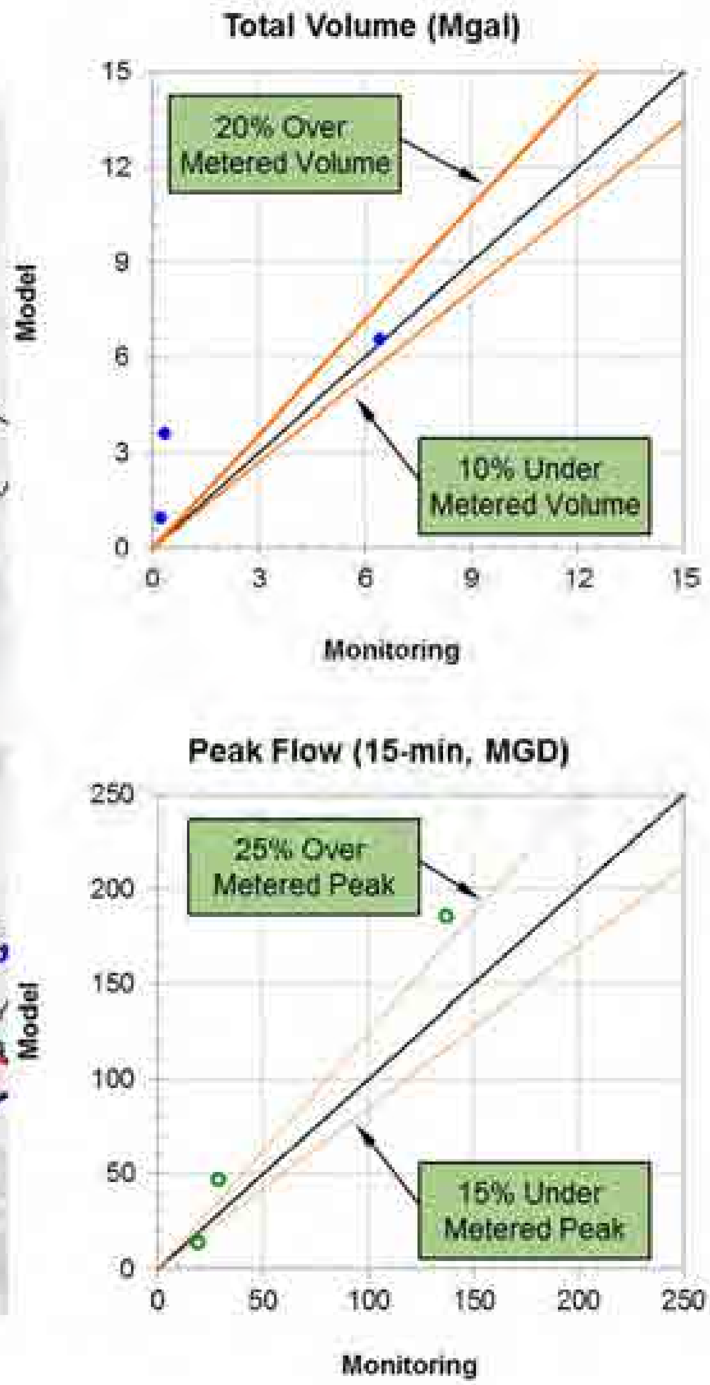


Figure I-51: Calibration Plot for CSO Overflow_ NE_15A_I

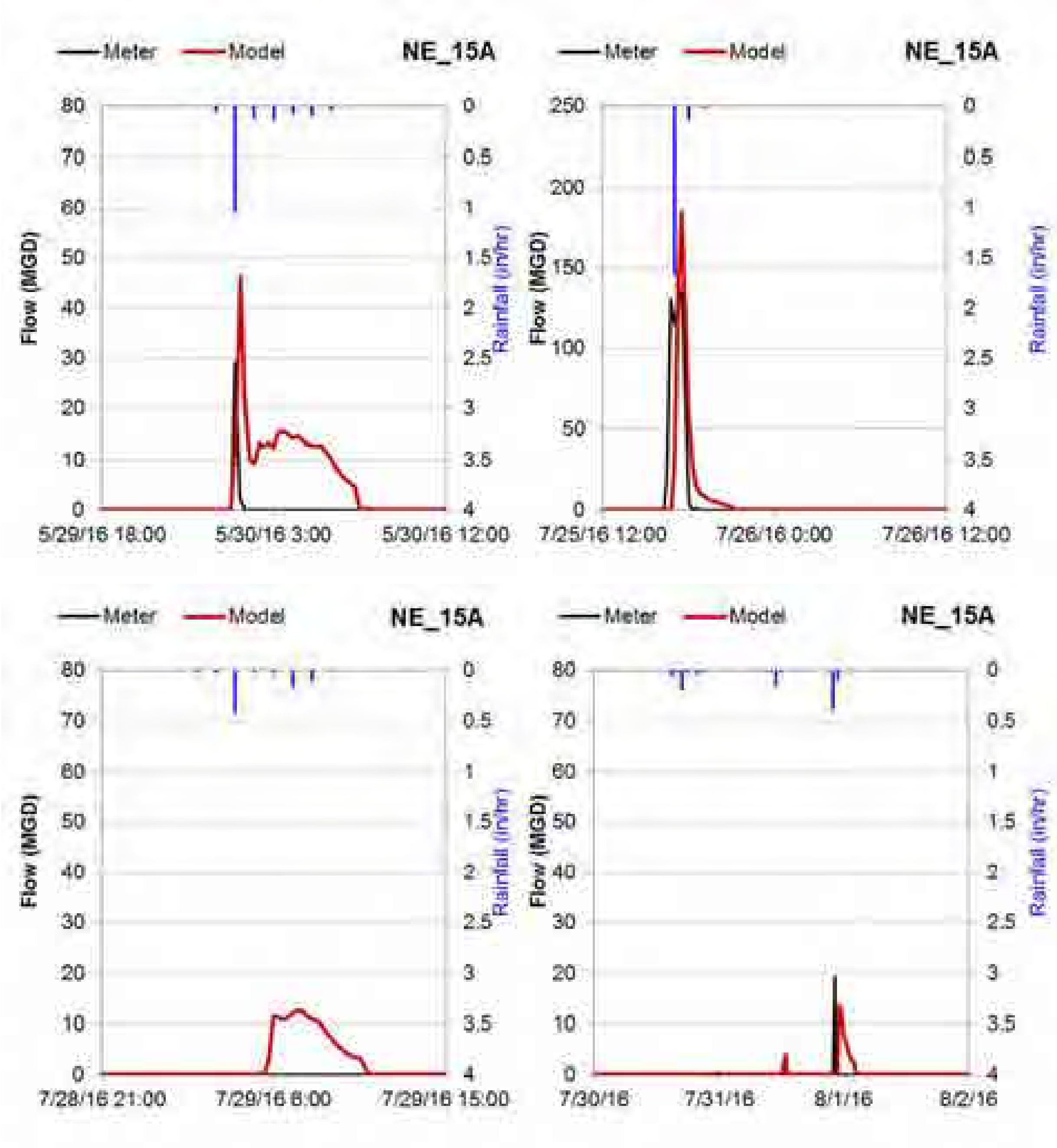


Figure I-52: Calibration Plot for CSO Overflow_ NE_15A_II

Note:

1. Calibration efforts were focused on the July 25, 2016 event because it had the most reasonable wet weather response to rainfall pattern and as the largest event has the most significant impact on overflows. The model is producing overflows during smaller precipitation increments which are not reflected in the monitoring data.

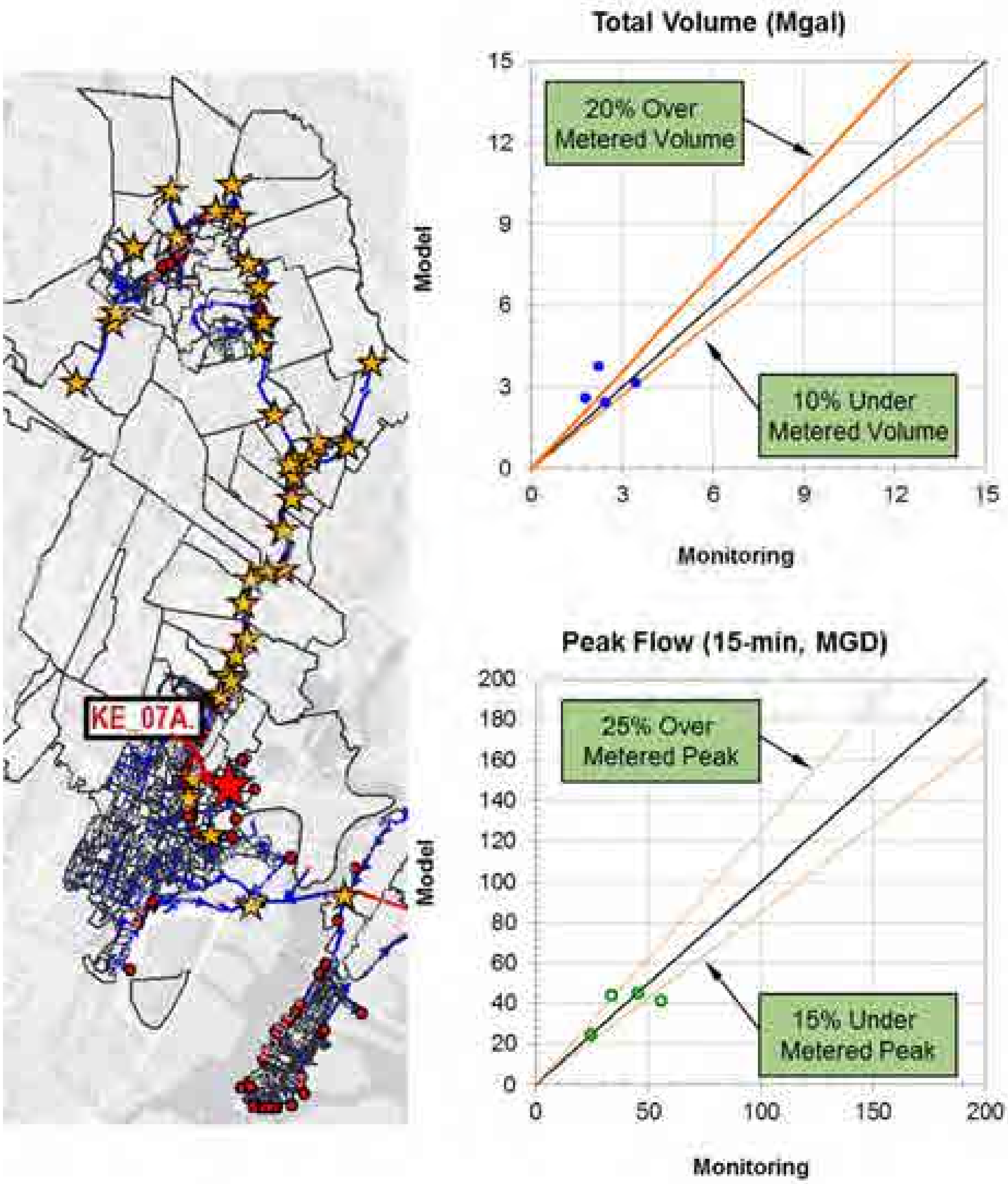


Figure I-53: Calibration Plot for CSO Overflow_ KE_07A_I

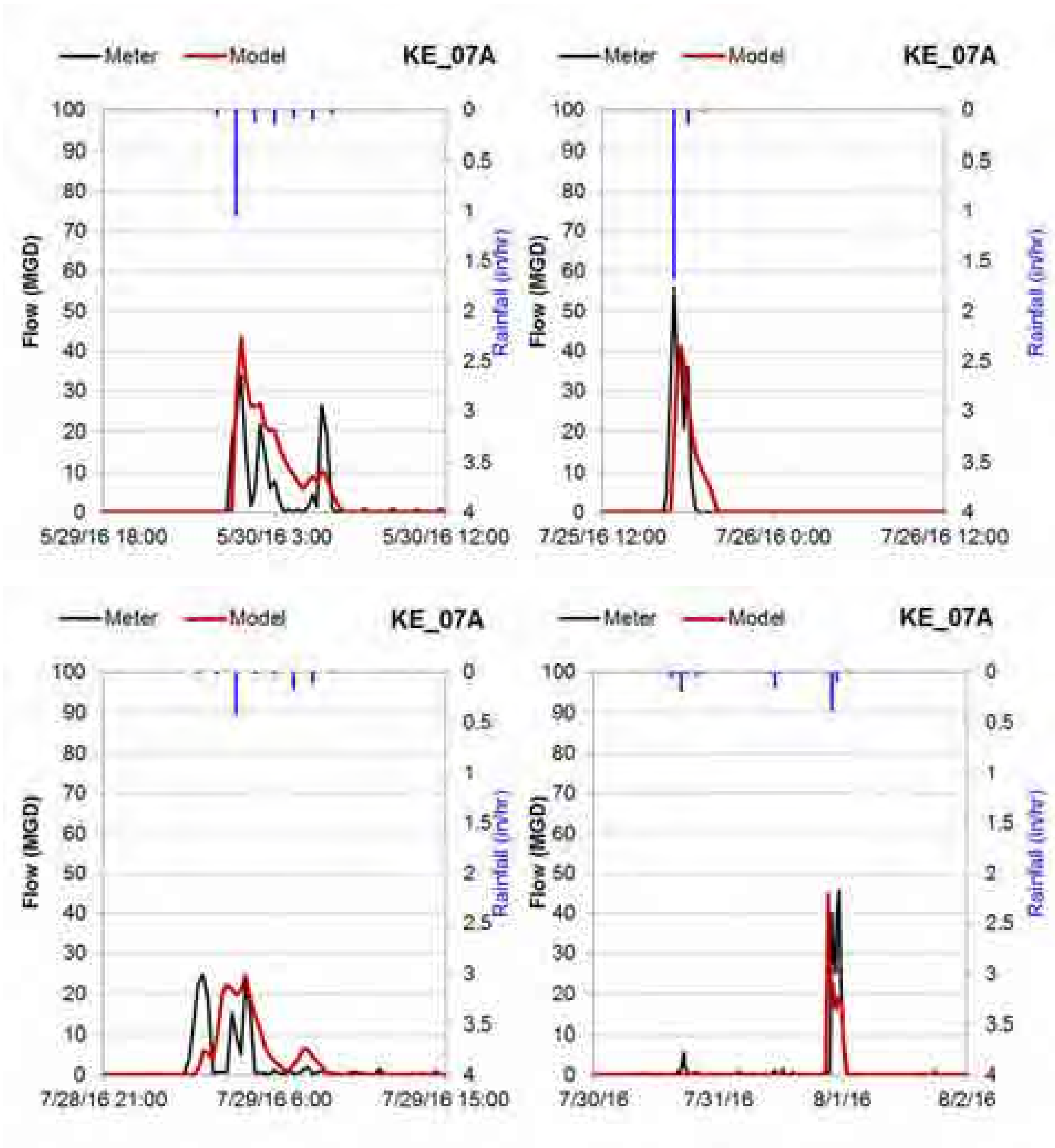


Figure I-54: Calibration Plot for CSO Overflow_ KE_07A_II

Note:

1. The calibration was performed to have a balanced calibration on both overflow volume and peak (both on conservative side).

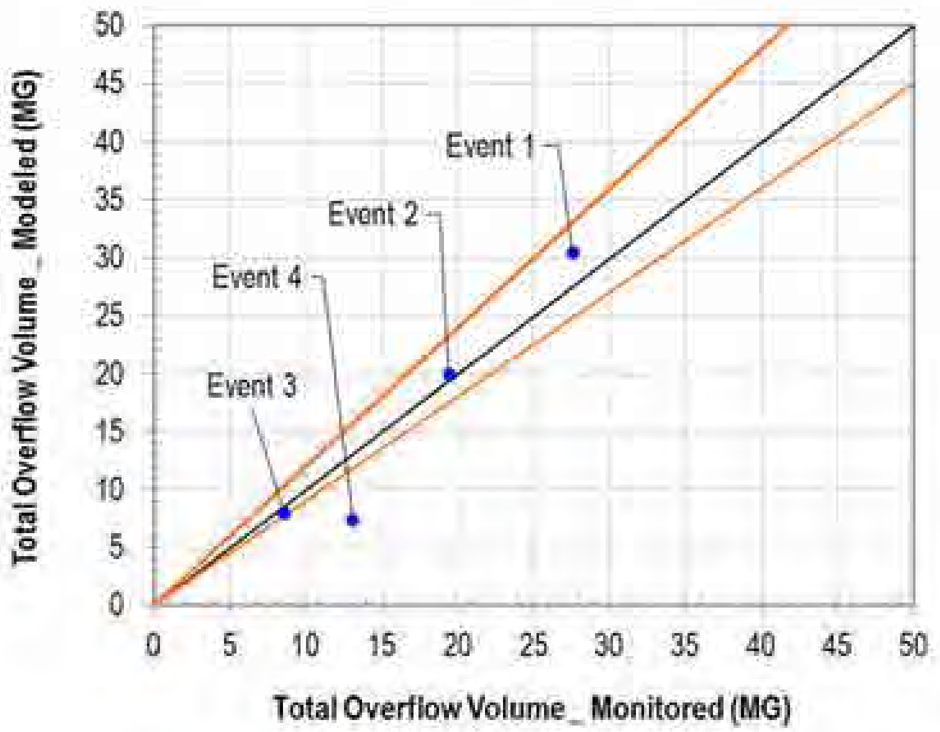


Figure I-55: System-Wide Overflow Volume Calibration

I.5.3 Model Calibration/Validation Result Statistics

The coefficient of determination, R^2, is used to evaluate the goodness-of-fit of modeled peak flow and event volume vs. the observed values. The calculation of R^2 is based on the most general definition detailed below.

- Assuming the observed data (event peak or event volume) is represented by a data set with n values marked $x_1, \ldots, x_n$, each associated with a modeled value $y_1, \ldots, y_n$.
- Define the *residuals* as $e_i = x_i - y_i$
- Define the mean of the observed data

$$x_0 = \frac{1}{n}\sum_{i=1}^{n} x_i$$

- The total sum of squares (proportional to the variance of the data) is:

$$SS_{tot} = \sum_{i=1}^{n} (x_i \quad x_0)^2$$

- The sum of squares of residuals (i.e. residual sum of squares) is

$$SS_{res} = \sum_{i=1}^{n} (x_i \quad y_i)^2 = \sum_{i=1}^{n} {e_i}^2$$

- The definition of R^2 is

$$R^2 = 1 \quad \frac{SS_{res}}{SS_{tot}}$$

The R^2 defined above is also known as the Nash-Sutcliffe Efficiency (NSE). It is an appropriate statistical measure of the goodness-of-fit for model calibration/validation. It has been widely applied in hydrologic models (Moriasi et al., 2007) and thus can be used to assess the event predictions of the hydrologic component of the model. Although interpretation of NSE values may be subjective, model calibration is generally considered satisfactory for values greater than 0.5, with values greater than 0.75 being considered very good (Moriasi et al., 2007).

Figure I-56 shows modeled vs. observed event peak of all calibrated flow meters for individual events. The R^2 values was calculated for individual event and shown on the figure, they are 0.945, 0.885, 0.947, and 0.879 for Event 1, Event 2, Event 3, and Event 4 respectively.

Figure I-57 shows modeled vs. observed event volume of all calibrated flow meters for individual events. The R^2 values are 0.996, 0.994, 0.992, and 0.995 for Event 1, Event 2, Event 3, and Event 4 respectively.

Figure I-58 shows modeled vs. observed event volume (and peak) of all calibrated flow meters for all four events. The overall R^2 values are 0.909 for event peak and 0.994 for event volume. This is consistent with individual event R^2.

The R^2 of the event volume is closer to 1 than the R^2 of the event peak for both individual event statistics and entire event statistics, indicating that the model has a more satisfied prediction of the wet weather event volume than the event peak flow. All the R^2 values are greater than 0.85, which means the calibrated model can predict wet weather flows in a great agreement with the metered data for the PVSC sewer collection system.

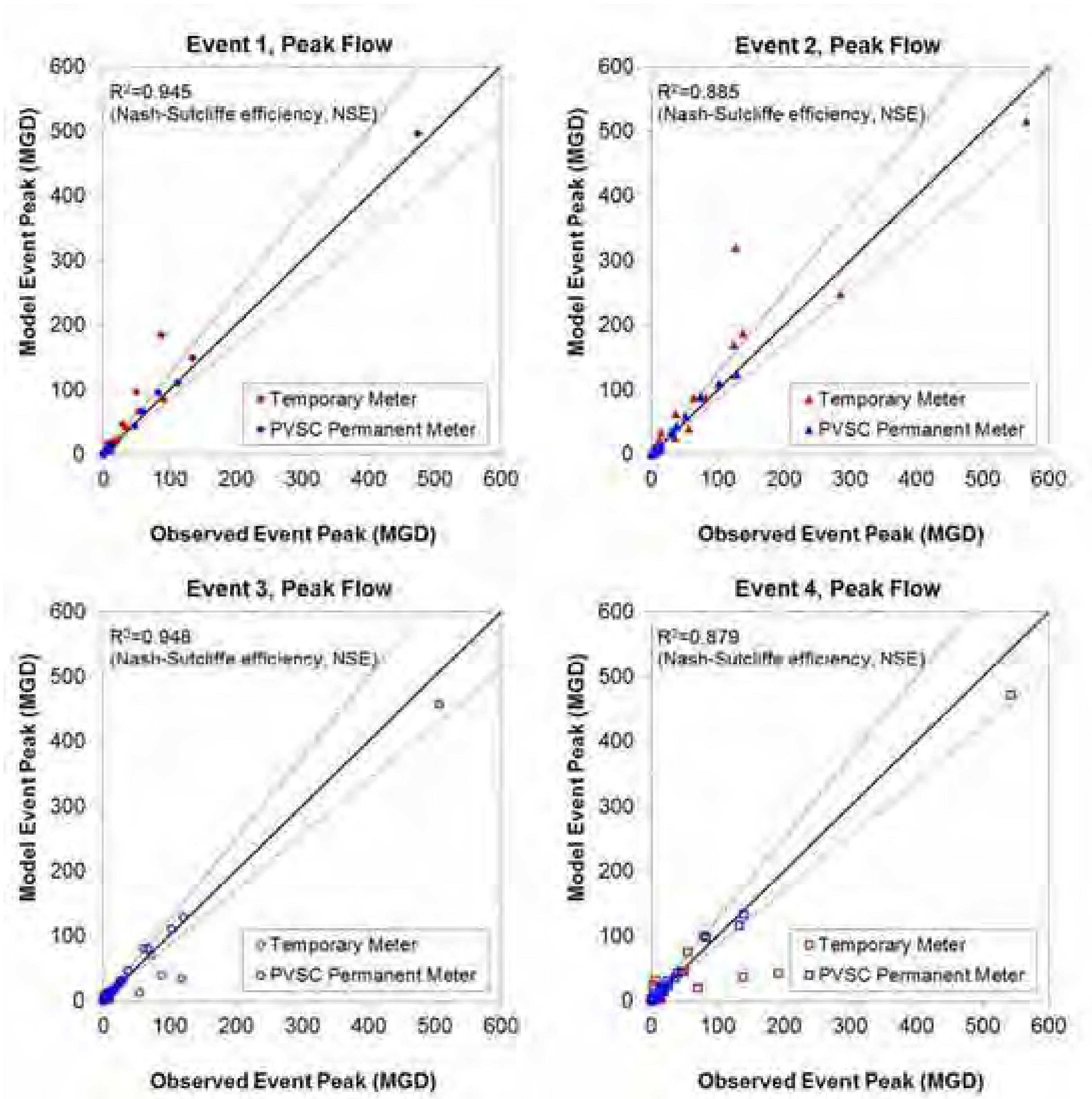


Figure I-56: Modeled vs. Observed Flow Peak for Individual Events

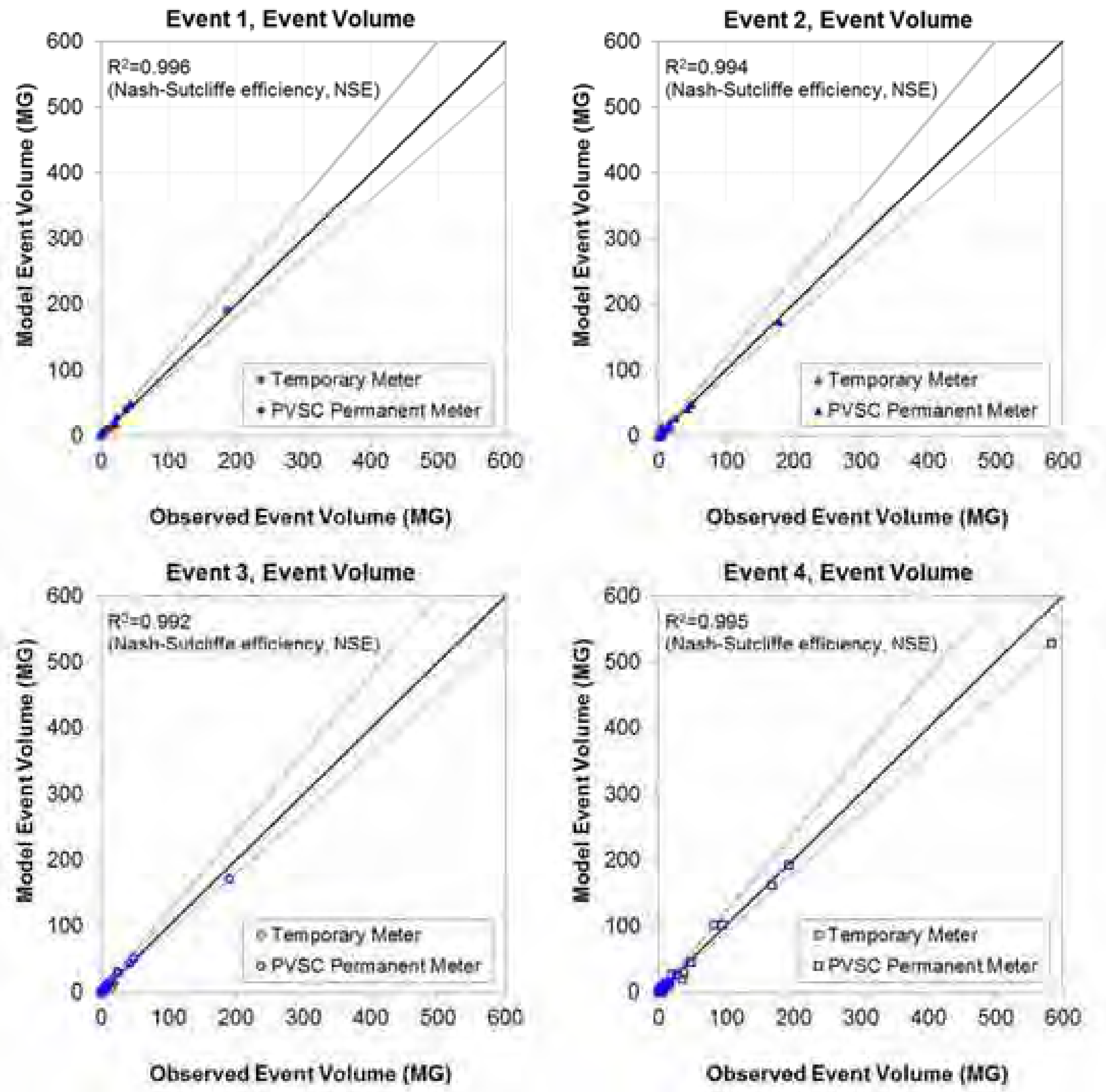


Figure I-57: Modeled vs. Observed Flow Volume for Individual Events

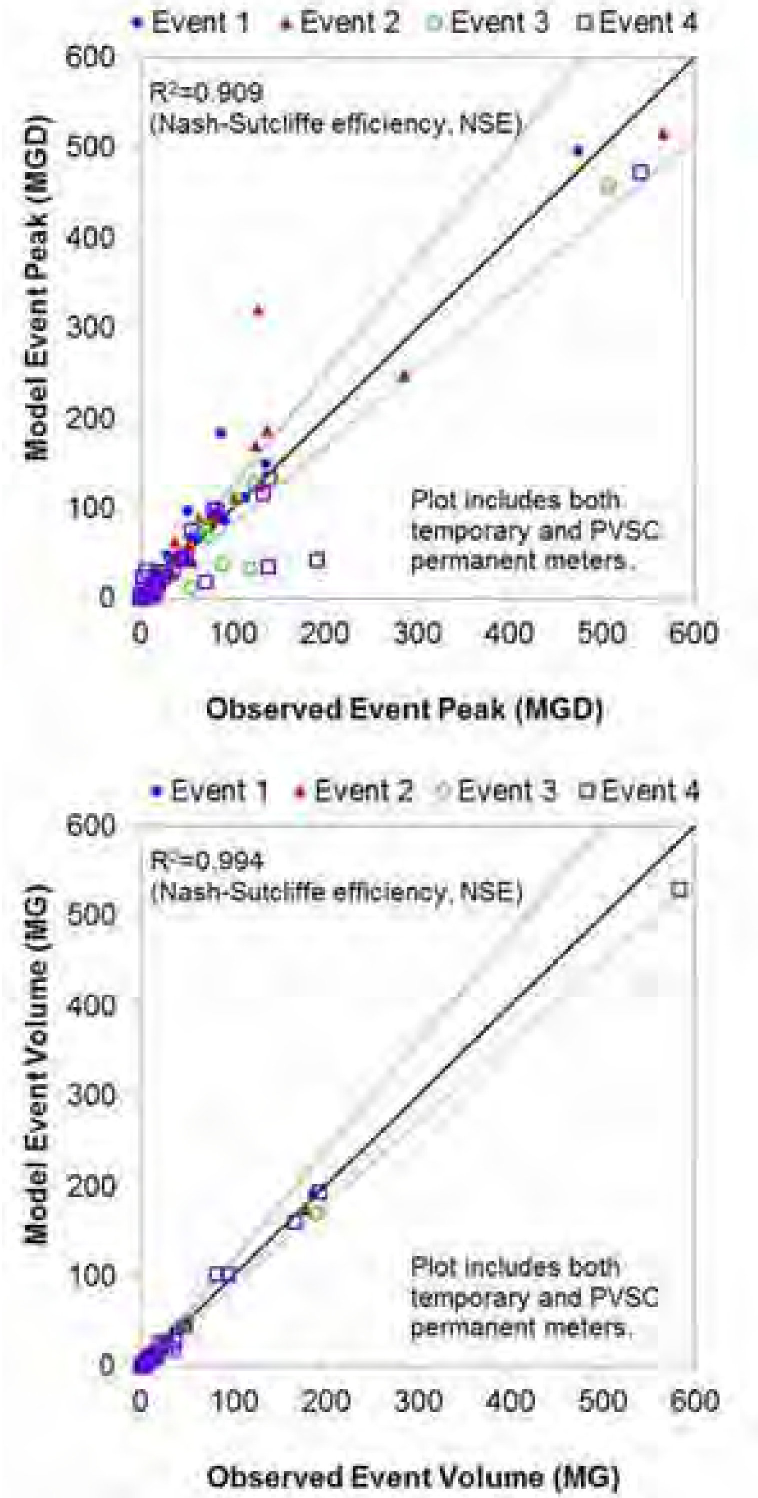


Figure I-58: Modeled vs. Observed Flow Peak and Volume for All Four Events

I.6 H&H MODEL RESULTS

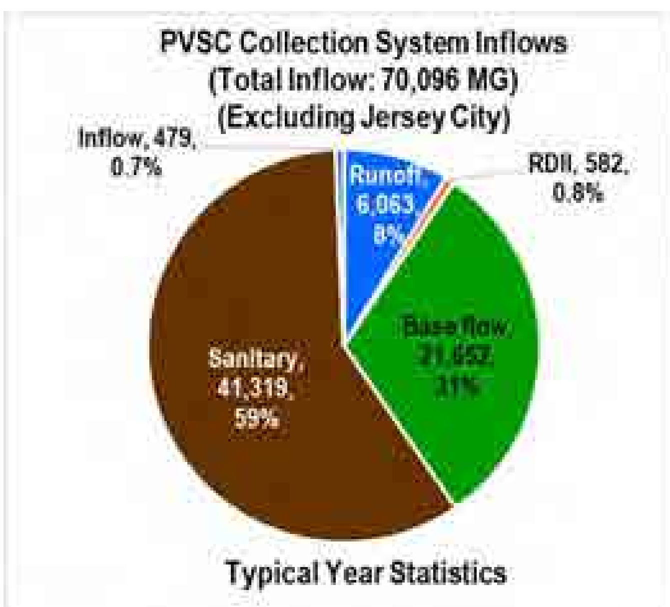
The calibrated model was run using 2004 rainfall and tides to evaluate collection system performance under existing conditions.

Five-minute precipitation data was developed from 1-minute NOAA ASOS (Automated Surface Observing System, National Centers for Environmental Information) for Newark. Minor gaps in the 5-minute data were filled using corresponding hourly and daily data for the airport. The same precipitation data was applied uniformly system wide.

Model results were extracted for all CSO overflow points and for WRRF and other community effluent flows at 5-minute intervals. The data were converted to 15-minute intervals for overflow event statistics analysis. A 24-hour inter-event-time was used for overflow event definition.

The following figures present a partitioning of the simulated volumes in the typical year. ~~Jersey City flows and runoff have been included in the typical year statics.~~

- **Figure I-59** ~~**Figure I-62**~~ presents the total collection system inflows. Approximately ~~1~~29% of the total influent volume is attributed to rainfall runoff and RDII, with the remainder coming from sanitary and baseflow.
- **Figure I-60** ~~**Figure I-63**~~ presents the runoff and losses in the combined sewer areas. Approximately ~~32~~27% of the precipitation volume over the combined sewered portions of the model reaches the collection system as runoff. The remainder is lost to hydrologic process such as evaporation and infiltration.~~,~~
- **Figure I-61** ~~**Figure I-64**~~ presents the total outflow from the model. Approximately 9~~5~~6% of the flow reaches the plant, with ~~5~~4% discharging through CSOs.
-



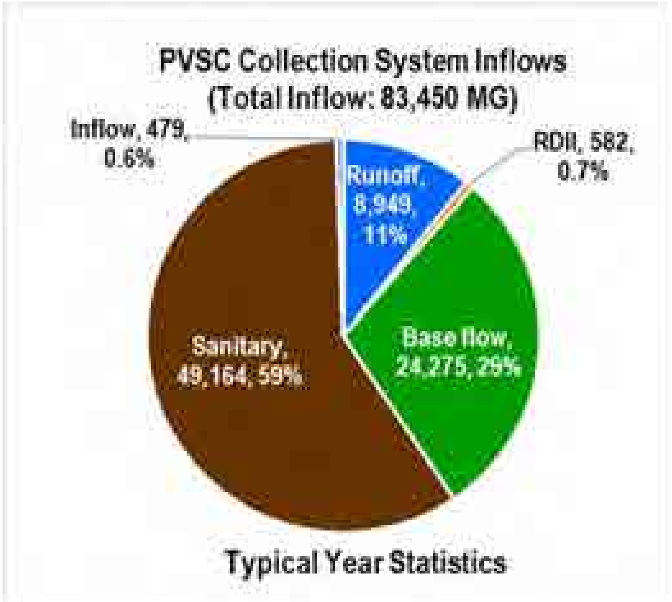
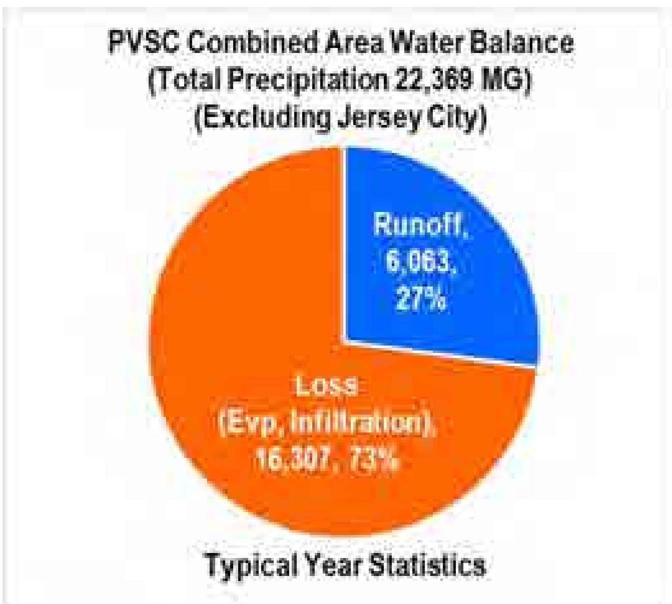


Figure I-59: Typical Year Collection System Inflows



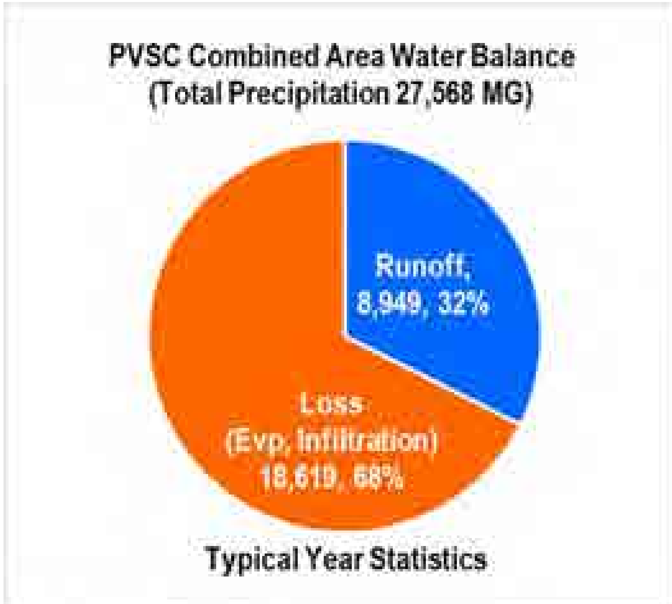
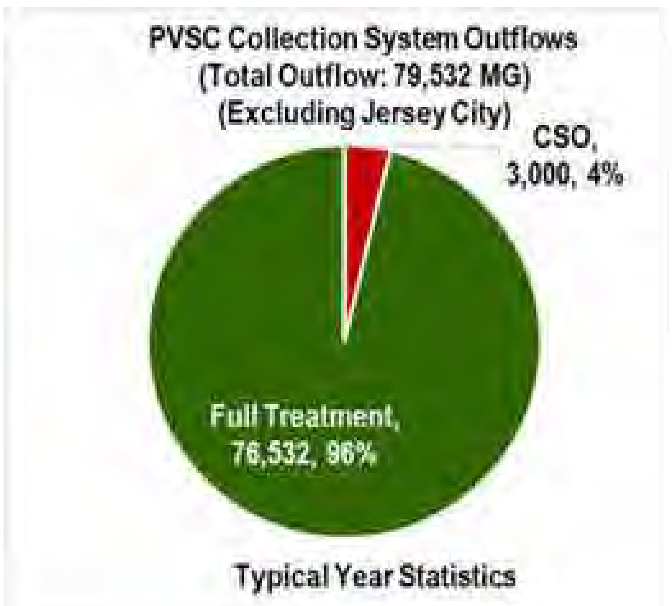


Figure I-60: Typical Year Runoff and Losses



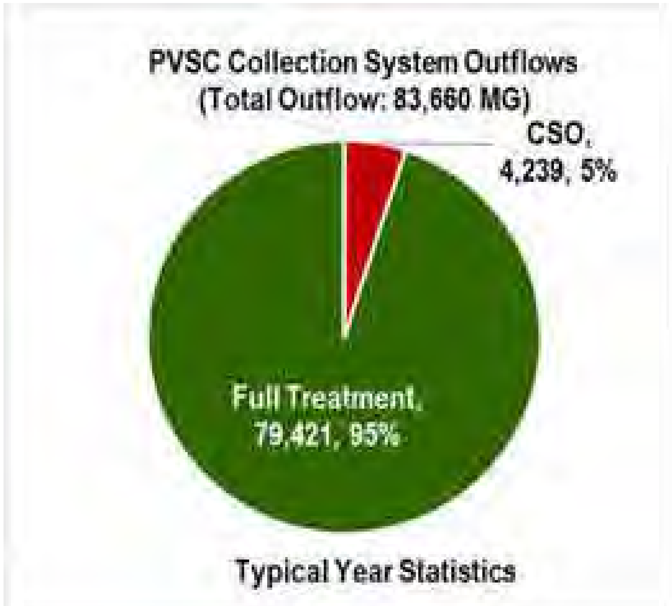


Figure I-61: Typical Year Total Outflows

I.6.1 Characterization of System Performance

There are 97 rainfall events in the typical year (IET 12 hours), including events with a total rainfall depth less than 0.1 inch. Overflows at each CSO outfall were analyzed for event overflow volume for each rainfall event. Community overflow volume was then estimated by summing CSO event volumes from all CSOs located within the same community. For example, Paterson's total overflow volume is 63 million gallons (from all 23 CSO outfalls in Paterson) for the 3.68-in storm event on Sep 28, 2004. The effects of the same size storm event on different communities are different, this is reasonable because each community has different regulator configurations, system storage capacities, and wet weather operation rules. However, most of the PVSC combined communities start to experience CSO overflow occurrences in a rainfall depth range of 0.2 to 0.3 inches.

- Correlations between community CSO volume and rainfall depth are shown in **Figure I-62** for Paterson and Newark. A rainfall depth of 0.2 inch will trigger overflows in Paterson and Newark.
- Correlations between community CSO volume and rainfall depth are shown in **Figure I-63** for Kearny and Harrison. A rainfall depth of 0.15 inch will trigger overflows in Kearny and a rainfall depth of 0.2 inch will trigger overflows in Harrison.
- Correlations between community CSO volume and rainfall depth are shown in **Figure I-64** for East Newark. A rainfall depth of 0.3 inch will trigger overflows in East Newark.
- Correlations between community CSO volume and rainfall depth are shown in **Figure I-65** for Bayonne and North Bergen. A rainfall depth of 0.15 inch will trigger overflows in Bayonne and a rainfall depth of 0.2 inch will trigger overflows in North Bergen.

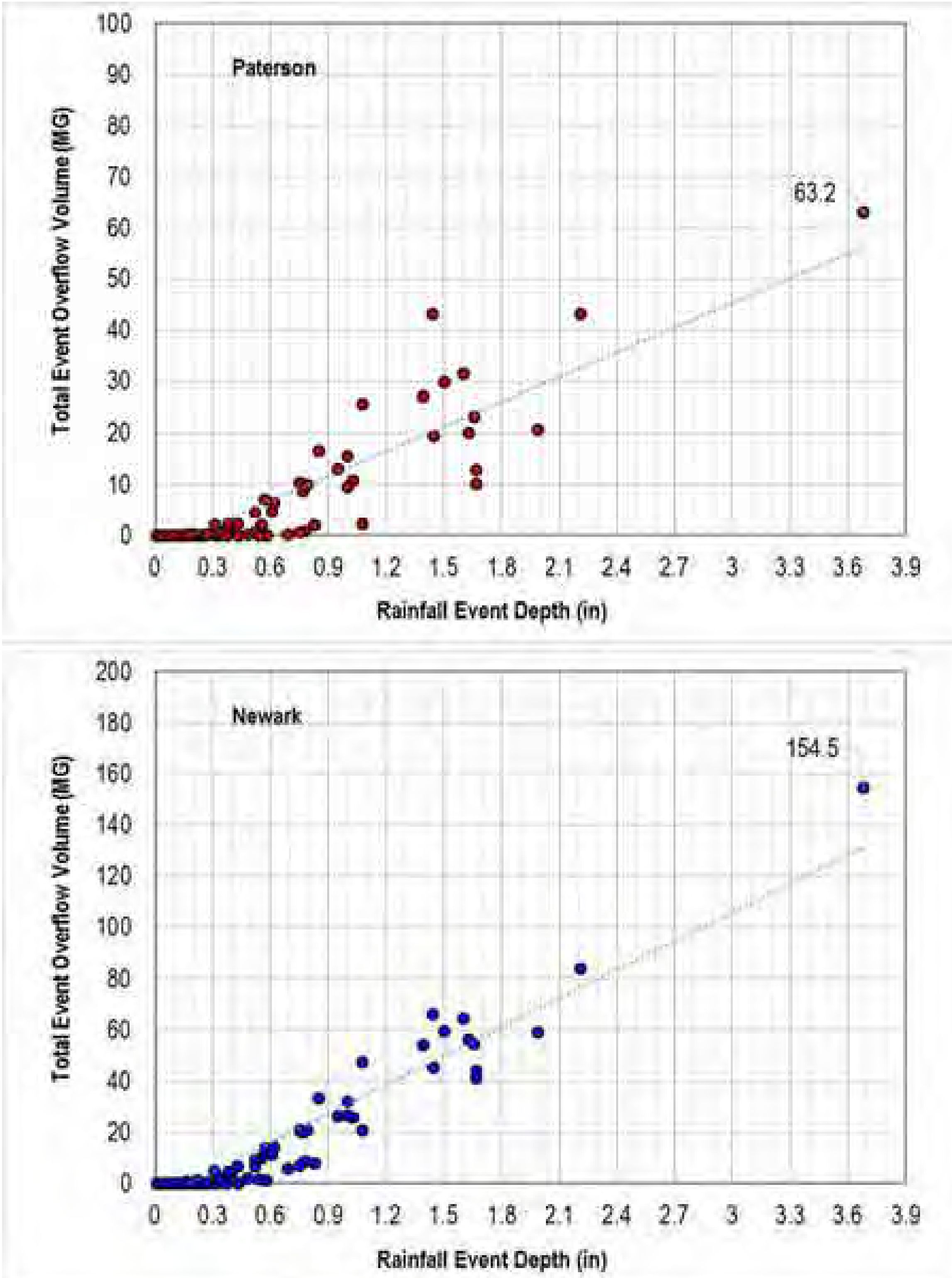


Figure I-62: Correlation between Rainfall Depth and CSO Volume (Patterson, Newark)

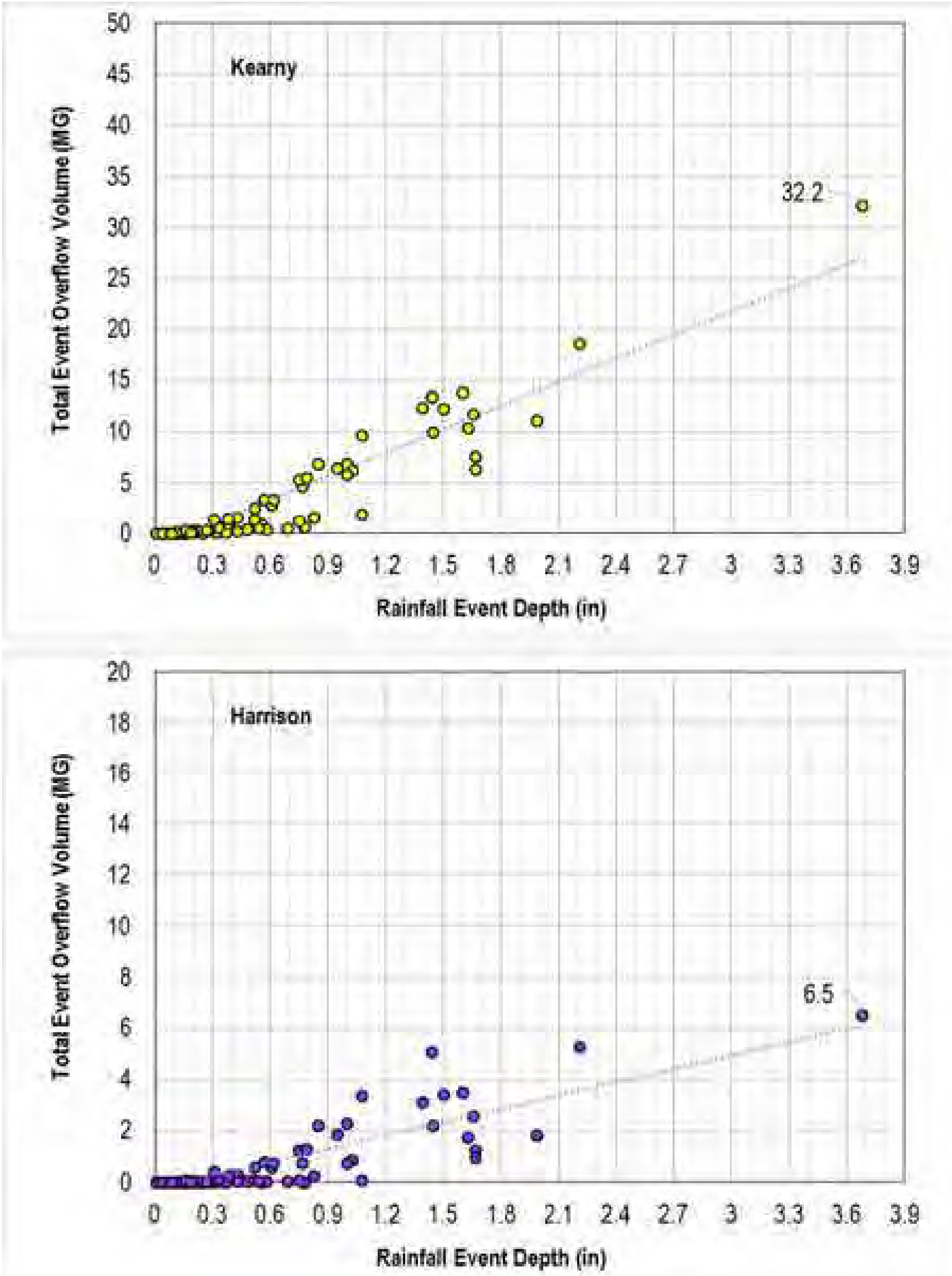


Figure I-63: Correlation between Rainfall Depth and CSO Volume (Kearny, Harrison)

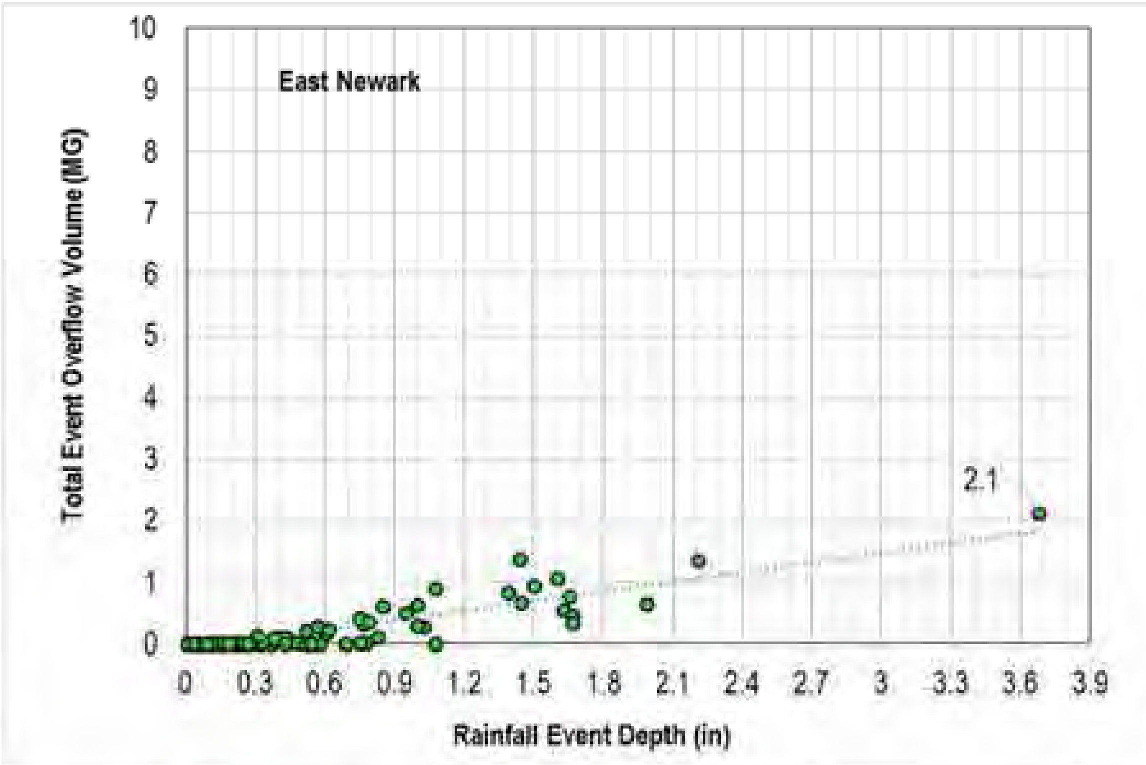


Figure I-64: Correlation between Rainfall Depth and CSO Volume (East Newark)

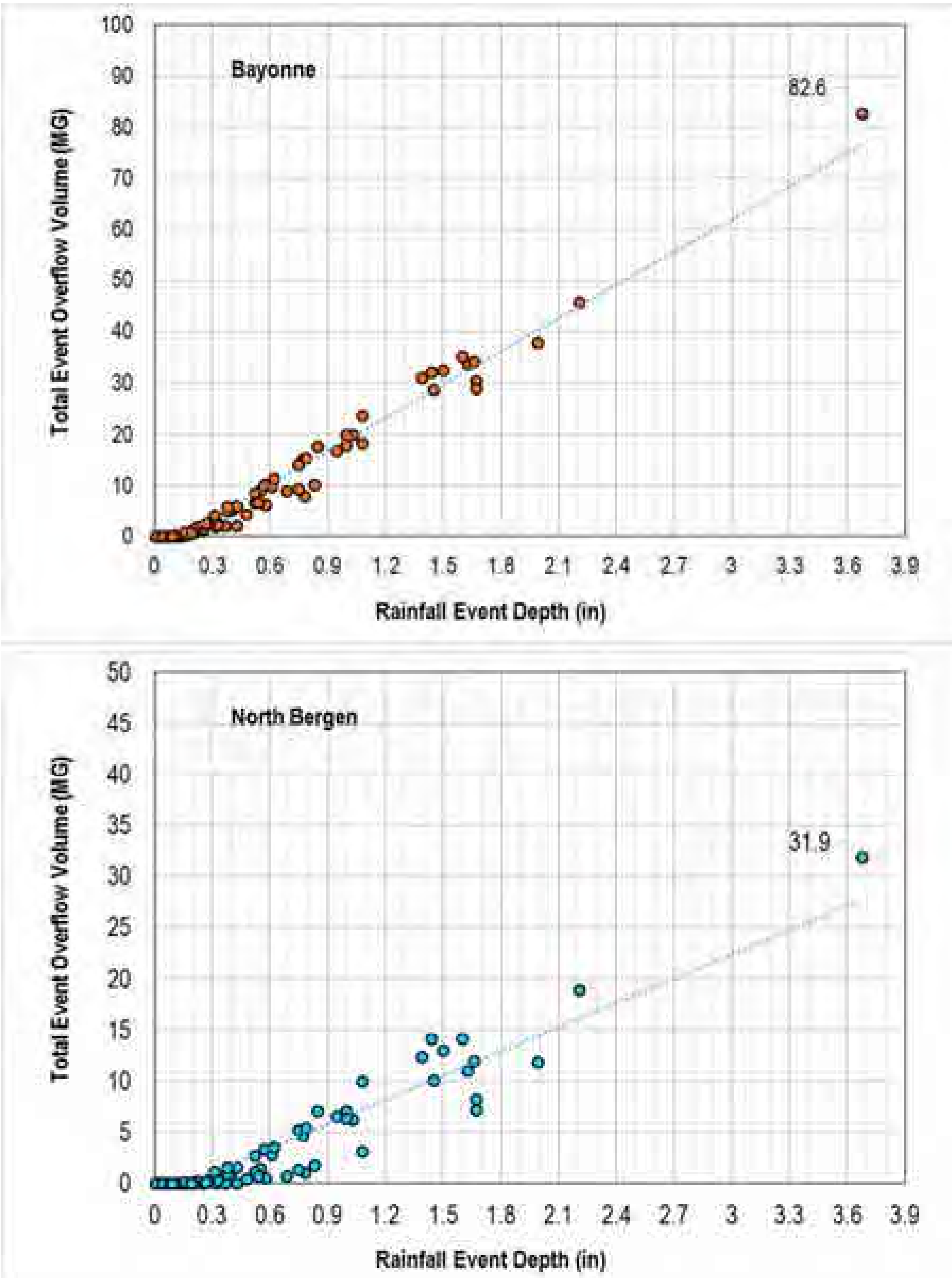


Figure I-65: Correlation between Rainfall Depth and CSO Volume (North Bergen, Bayonne)

I.6.2 Overflow Statistics

Typical year CSO volume, frequency and duration is summarized in **Table I-11** for CSO outfalls in Paterson, East Newark, Harrison, Kearny, Newark, North Bergen, and Bayonne. Jersey City was not included in the table. Inter-event time of 24 hours was used to identify overflow events, i.e., multiple periods of overflow from one or more outfalls are considered one overflow event if the time between periods of overflow is no more than 24 hours without a discharge from any outfall. Overflow duration in the table is the total overflow hours at the corresponding CSO outfall in the typical year.

The PVSC system (excluding Jersey City) overflows ~~59~~ 60 times in the typical year of 2004, with a total overflow volume of ~~3078~~ 3000 MG and overflow duration of ~~532~~ 414 hours. Newark has the highest annual overflow volume (1,288~~181~~ MG), followed by Bayonne (~~791~~ 712 MG), Paterson (~~5~~418~~34~~ MG), North Bergen (~~251~~ 255 MG), Kearny (~~247~~ 251 MG), Harrison (~~57~~ 59 MG), and East Newark (17 MG).

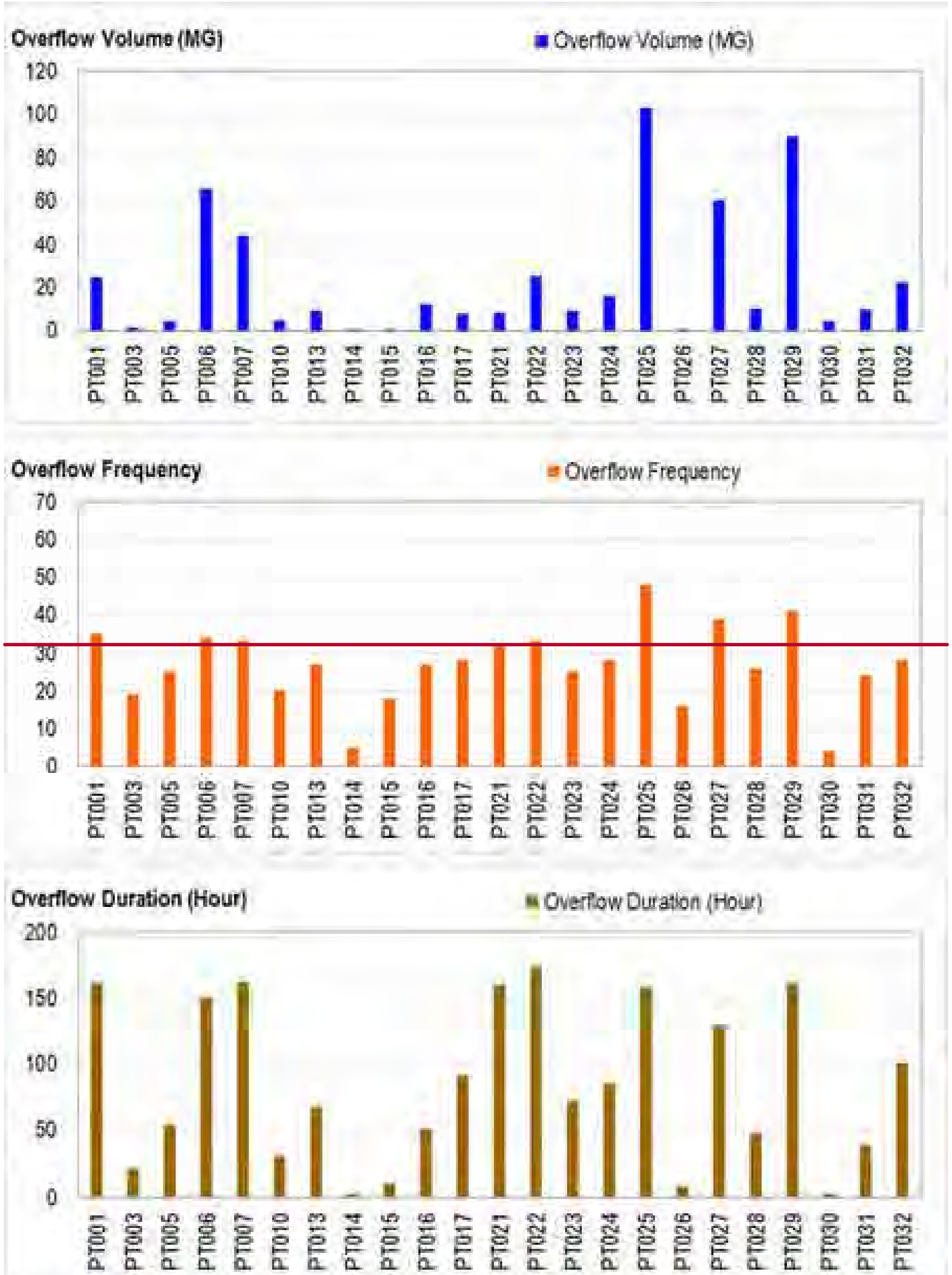
The following figures are provided for visual comparisons of CSO outfalls.

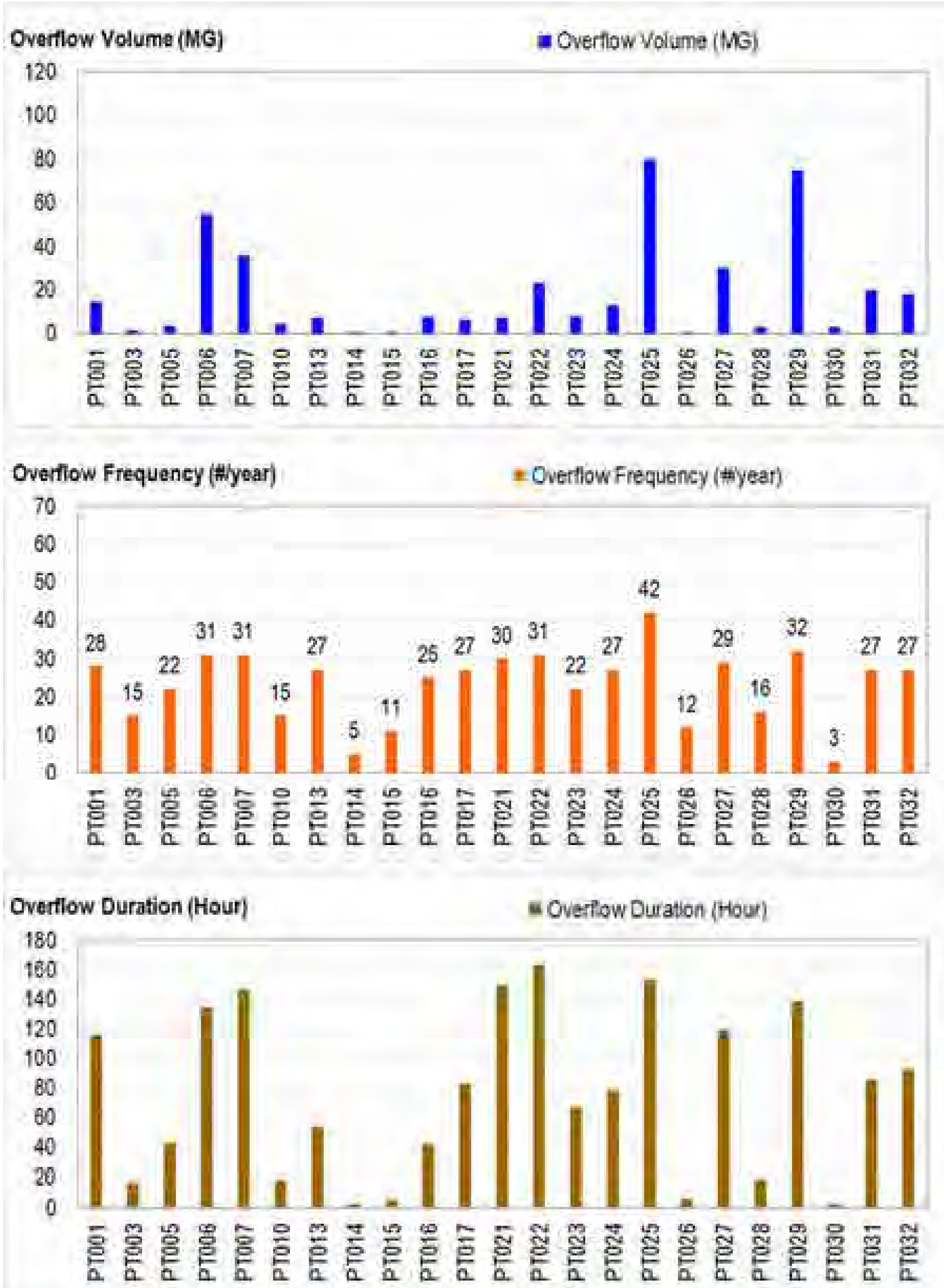
- **Figure I-66** shows overflow volume, frequency and duration for CSOs in Paterson.
- **Figure I-67** shows overflow volume, frequency and duration for CSOs in East Newark, Harrison, Kearny, and Newark. And
- **Figure I-68** shows overflow volume, frequency and duration for CSOs in North Bergen and Bayonne.

Table I-11: Typical Year CSO Overflow Volume, Frequency, and Duration

CSO ID	Overflow			CSO ID	Overflow			CSO ID	Overflow		
	Volume (MG)	# per Year	Duration (Hour)		Volume (MG)	# per Year	Duration (Hour)		Volume (MG)	# per Year	Duration (Hour)
PT001	14.5	28 ~~35~~	116 ~~162~~	EN001	17.0 ~~16.8~~	34 ~~34~~	101 ~~99~~	NB003	143.4 ~~141.4~~	43 ~~42~~	260 ~~254~~
PT003	1.4 ~~1.5~~	15 ~~19~~	17 ~~21~~					NB005	24.4 ~~24.1~~	47 ~~47~~	230 ~~227~~
PT005	3.4 ~~4.2~~	22 ~~25~~	43 ~~54~~	HR001	1.6 ~~1.4~~	27 ~~27~~	44 ~~39~~	NB006	0.02 ~~0.02~~	1 ~~1~~	1 ~~1~~
PT006	54.8 ~~66.0~~	31 ~~34~~	135 ~~151~~	HR002	3.0 ~~2.9~~	29 ~~29~~	53 ~~50~~	NB007	13.2 ~~12.9~~	30 ~~30~~	140 ~~137~~
PT007	35.7 ~~44.1~~	31 ~~33~~	147 ~~162~~	HR003	13.8 ~~13.7~~	29 ~~29~~	62 ~~61~~	NB008	20.9 ~~20.5~~	30 ~~29~~	116 ~~113~~
PT010	4.2 ~~4.9~~	15 ~~20~~	18 ~~30~~	HR004	0.4 ~~0.4~~	14 ~~13~~	10 ~~8~~	NB009	25.4 ~~25.0~~	35 ~~35~~	163 ~~159~~
PT013	7.1 ~~9.3~~	27 ~~27~~	54 ~~68~~	HR005	19.5 ~~18.9~~	32 ~~32~~	136 ~~133~~	NB010	1.2 ~~1.0~~	23 ~~23~~	37 ~~37~~
PT014	0.2 ~~0.1~~	5 ~~5~~	2 ~~3~~	HR006	7.4 ~~6.8~~	28 ~~28~~	55 ~~49~~	NB011	19.4 ~~19.2~~	34 ~~34~~	132 ~~132~~
PT015	0.3 ~~0.5~~	11 ~~18~~	5 ~~11~~	HR007	13.5 ~~13.3~~	42 ~~42~~	133 ~~133~~	NB014	6.4 ~~6.3~~	27 ~~27~~	94 ~~92~~
PT016	7.8 ~~12.0~~	25 ~~27~~	42 ~~51~~								
PT017	6.1 ~~7.6~~	27 ~~28~~	83 ~~92~~	KE001	3.9 ~~3.9~~	29 ~~29~~	54 ~~54~~	BA001	362.2 ~~373.9~~	56 ~~59~~	388 ~~532~~
PT021	7.3 ~~8.1~~	30 ~~32~~	150 ~~160~~	KE004	12.3 ~~12.3~~	49 ~~49~~	177 ~~177~~	BA002	8.0 ~~8.7~~	9 ~~9~~	13 ~~14~~
PT022	23.4 ~~25.2~~	31 ~~33~~	164 ~~174~~	KE006	120.6 ~~119.3~~	54 ~~53~~	251 ~~247~~	BA003	6.0 ~~10.9~~	27 ~~31~~	71 ~~108~~
PT023	7.8 ~~9.3~~	22 ~~25~~	67 ~~73~~	KE007	88.1 ~~86.0~~	32 ~~32~~	170 ~~165~~	BA004	0.0 ~~0.0~~	2 ~~3~~	1 ~~1~~
PT024	13.1 ~~15.9~~	27 ~~28~~	78 ~~85~~	KE010	26.3 ~~26.0~~	47 ~~47~~	146 ~~144~~	BA006	11.7 ~~16.0~~	28 ~~33~~	94 ~~138~~
PT025	79.7 ~~103.2~~	42 ~~48~~	153 ~~159~~					BA007	53.4 ~~72.1~~	29 ~~32~~	97 ~~125~~
PT026	0.4 ~~0.7~~	12 ~~16~~	6 ~~9~~	NE002	95.5 ~~91.4~~	42 ~~42~~	299 ~~266~~	BA008	2.5 ~~10.1~~	16 ~~30~~	13 ~~88~~
PT027	30.2 ~~60.2~~	29 ~~39~~	119 ~~130~~	NE003	0 ~~0~~	0 ~~0~~	0 ~~0~~	BA009	2.7 ~~4.2~~	26 ~~29~~	36 ~~58~~
PT028	2.9 ~~10.0~~	16 ~~26~~	19 ~~48~~	NE004	1.5 ~~1.4~~	23 ~~22~~	32 ~~29~~	BA010	10.1 ~~17.4~~	37 ~~49~~	107 ~~179~~
PT029	75.1 ~~89.9~~	32 ~~41~~	139 ~~161~~	NE005	23.7 ~~21.1~~	39 ~~39~~	281 ~~246~~	BA011	5.0 ~~5.9~~	29 ~~30~~	57 ~~71~~
PT030	3.0 ~~4.5~~	3 ~~4~~	2 ~~3~~	NE008	97.6 ~~93.1~~	46 ~~45~~	356 ~~323~~	BA012	11.5 ~~14.0~~	41 ~~49~~	108 ~~142~~
PT031	19.6 ~~9.5~~	27 ~~24~~	85 ~~39~~	NE009	187.2 ~~162.4~~	36 ~~36~~	234 ~~207~~	BA013	0.6 ~~0.8~~	24 ~~29~~	27 ~~35~~
PT032	18.0 ~~22.3~~	27 ~~28~~	93 ~~101~~	NE010	187.2 ~~162.4~~	36 ~~36~~	234 ~~207~~	BA014	13.3 ~~12.7~~	37 ~~37~~	129 ~~127~~
	~~0.4~~	~~10~~	~~8.5~~	NE014	191.0 ~~179.7~~	46 ~~45~~	414 ~~384~~	BA015	45.4 ~~46.6~~	44 ~~47~~	212 ~~231~~
	~~0.4~~	~~12~~	~~13.3~~	NE015	81.5 ~~74.3~~	40 ~~39~~	278 ~~244~~	BA016	5.8 ~~6.5~~	43 ~~43~~	119 ~~130~~
	~~1.8~~	~~11~~	~~11.0~~	NE016	56.8 ~~54.2~~	44 ~~44~~	272 ~~248~~	BA017	52.0 ~~54.2~~	52 ~~54~~	330 ~~350~~
				NE017	112.4 ~~107.1~~	45 ~~44~~	304 ~~277~~	BA018	13.7 ~~14.6~~	46 ~~50~~	200 ~~232~~
				NE018	79.1 ~~75.4~~	47 ~~46~~	357 ~~320~~	BA019	35.6 ~~38.8~~	30 ~~31~~	103 ~~112~~
				NE022	46.2 ~~45.7~~	60 ~~59~~	262 ~~262~~	BA020	9.7 ~~10.1~~	29 ~~29~~	60 ~~65~~
				NE023	18.3 ~~16.8~~	30 ~~30~~	111 ~~108~~	BA021	52.4 ~~62.9~~	44 ~~47~~	170 ~~212~~
				NE025	63.8 ~~58.2~~	17 ~~16~~	37 ~~30~~	BA022	0 ~~0~~	0 ~~0~~	0 ~~0~~
				NE026	21.5 ~~16.6~~	19 ~~17~~	35 ~~25~~	BA024	0.1 ~~0.1~~	3 ~~3~~	2 ~~2~~
				NE027	13.6 ~~11.3~~	17 ~~17~~	45 ~~38~~	BA026	1.3 ~~1.3~~	9 ~~9~~	4 ~~4~~
				NE030	10.8 ~~10.3~~	19 ~~19~~	22 ~~21~~	BA028	0 ~~0~~	0 ~~0~~	0 ~~0~~
								BA029	6.8 ~~6.8~~	23 ~~23~~	41 ~~41~~
								BA030	1.5 ~~1.5~~	16 ~~16~~	10 ~~10~~
								BA034	0.2 ~~0.1~~	7 ~~7~~	6 ~~4~~
								BA037	1.1 ~~1.0~~	9 ~~8~~	9 ~~8~~

Note: Overflow statistics were not included in the table for Jersey City.


Overflow Volume (MG)
Overflow Volume (MG)
120
100
80
60
40
20
0
PT001
PT003
PT005
PT006
PT007
PT010
PT013
PT014
PT015
PT016
PT017
PT021
PT022
PT023
PT024
PT025
PT026
PT027
PT028
PT029
PT030
PT031
PT032
Overflow Frequency
Overflow Frequency
70
60
50
40
30
20
10
0
PT001
PT003
PT005
PT006
PT007
PT010
PT013
PT014
PT015
PT016
PT017
PT021
PT022
PT023
PT024
PT025
PT026
PT027
PT028
PT029
PT030
PT031
PT032
Overflow Duration (Hour)
Overflow Duration (Hour)
200
150
100
50
0
PT001
PT003
PT005
PT006
PT007
PT010
PT013
PT014
PT015
PT016
PT017
PT021
PT022
PT023
PT024
PT025
PT026
PT027
PT028
PT029
PT030
PT031
PT032


Overflow Volume (MG)
Overflow Volume (MG)
120
100
80
60
40
20
0
PT001 PT003 PT005 PT006 PT007 PT010 PT013 PT014 PT015 PT016 PT017 PT021 PT022 PT023 PT024 PT025 PT026 PT027 PT028 PT029 PT030 PT031 PT032
Overflow Frequency (#/year)
Overflow Frequency (#/year)
70
60
50
40
30
20
10
0
28 15 22 31 31 15 27 5 11 25 27 30 31 22 27 42 12 29 16 32 3 27 27
PT001 PT003 PT005 PT006 PT007 PT010 PT013 PT014 PT015 PT016 PT017 PT021 PT022 PT023 PT024 PT025 PT026 PT027 PT028 PT029 PT030 PT031 PT032
Overflow Duration (Hour)
Overflow Duration (Hour)
180
160
140
120
100
80
60
40
20
0
PT001 PT003 PT005 PT006 PT007 PT010 PT013 PT014 PT015 PT016 PT017 PT021 PT022 PT023 PT024 PT025 PT026 PT027 PT028 PT029 PT030 PT031 PT032

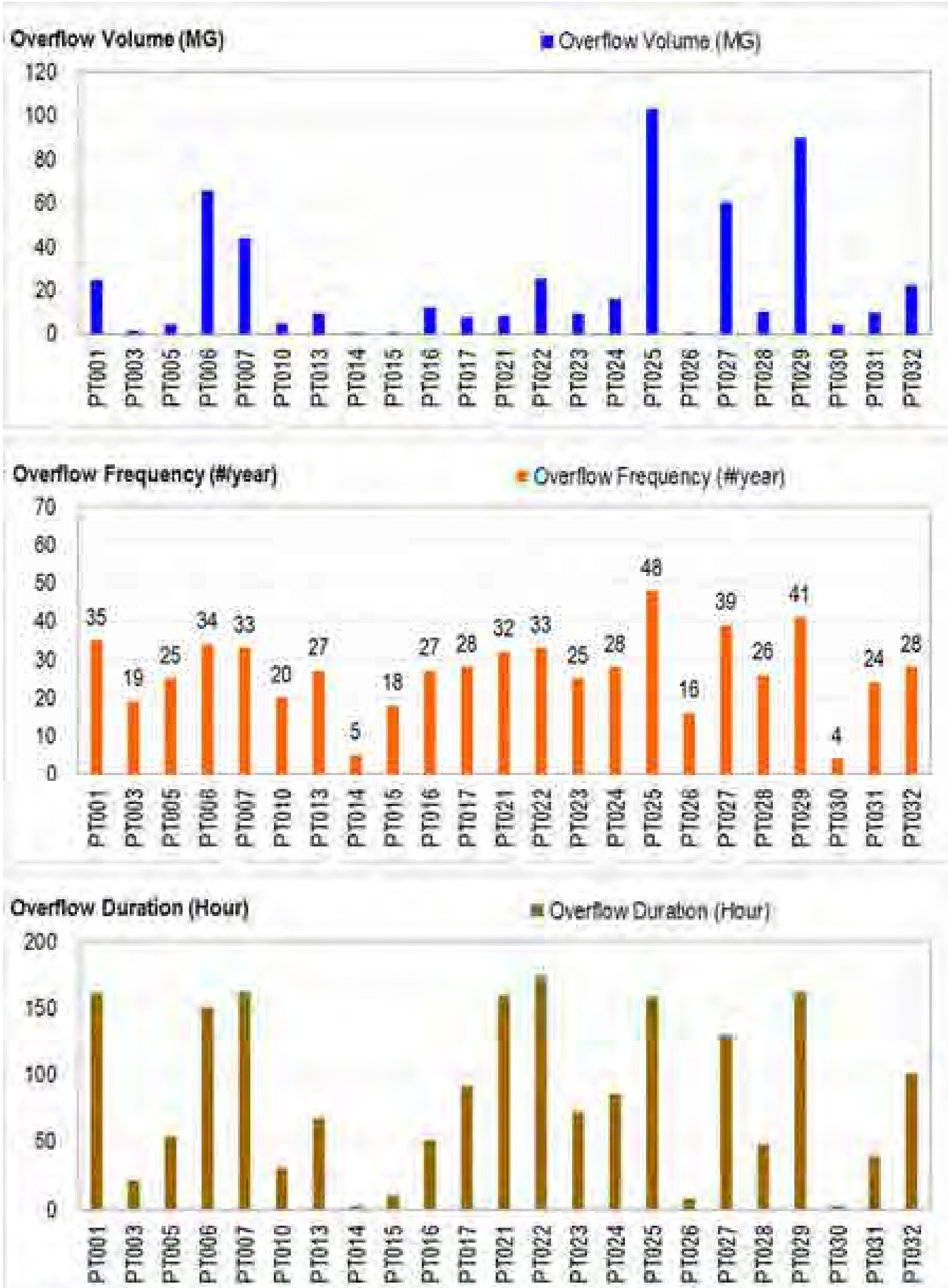
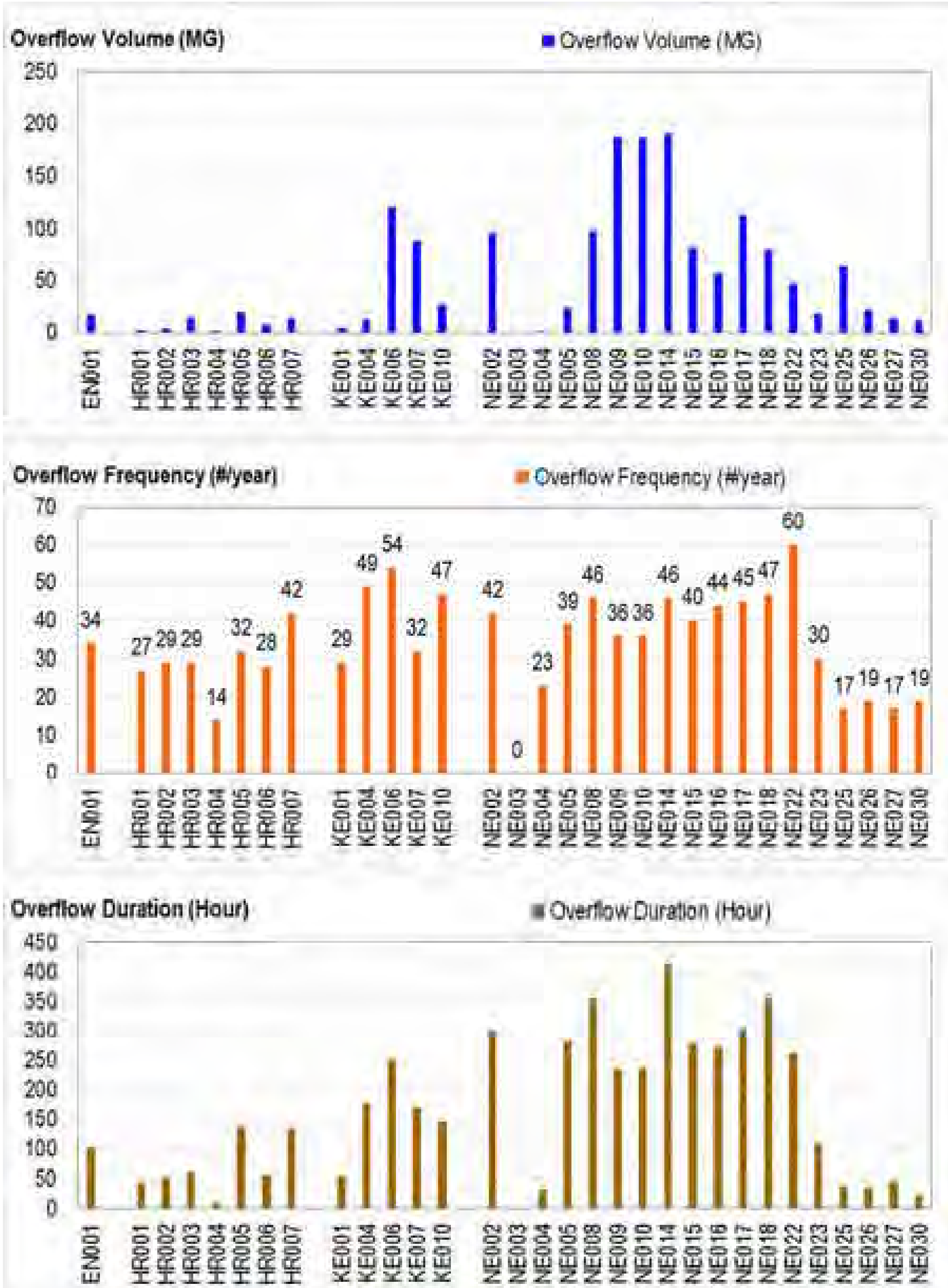
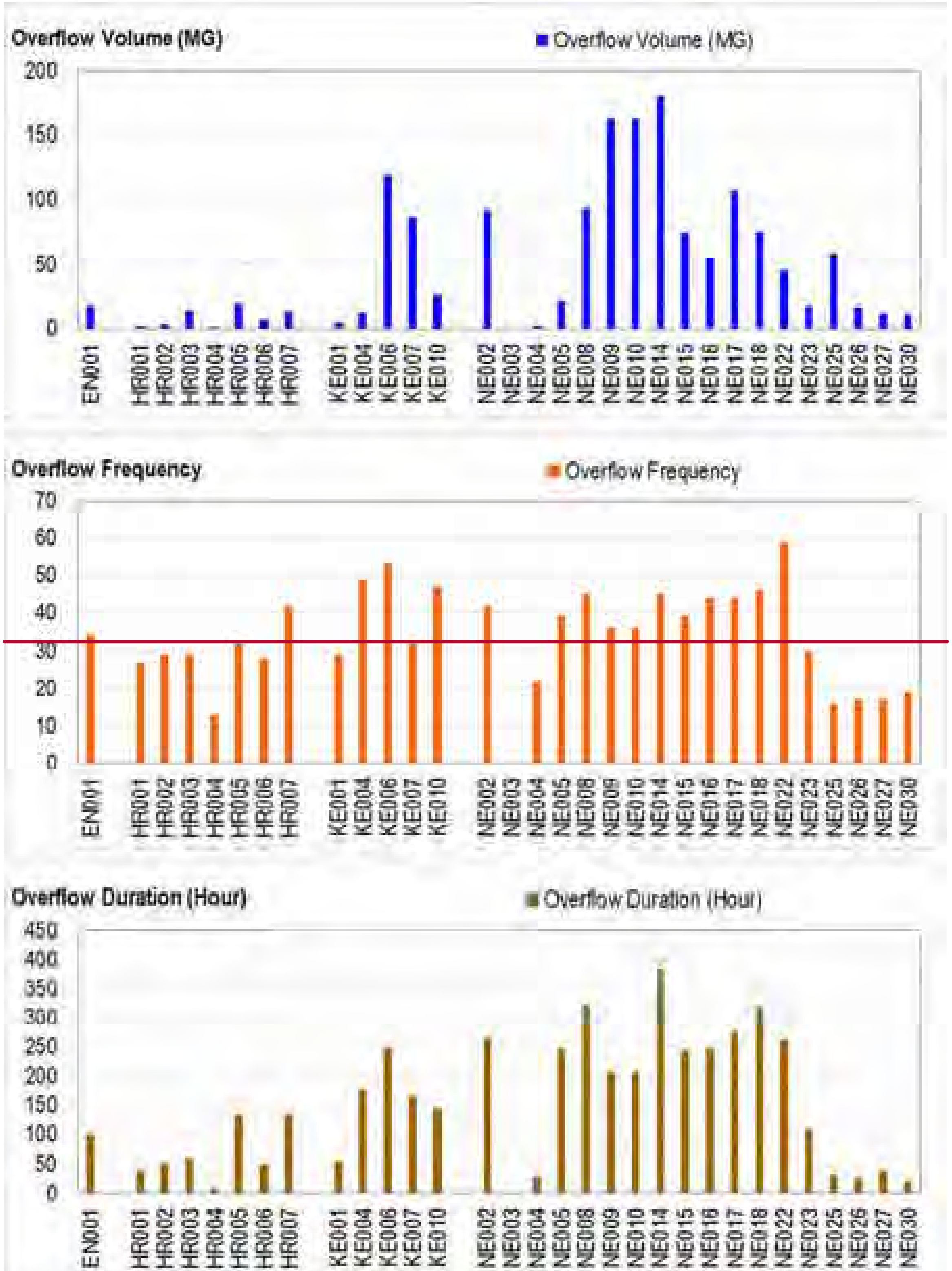


Figure I-66: Typical Year CSO Overflow Volume and Frequency Paterson


Overflow Volume (MG)
Overflow Volume (MG)
250
200
150
100
50
0
EN001
HR001 HR002 HR003 HR004 HR005 HR006 HR007
KE001 KE004 KE006 KE007 KE010
NE002 NE003 NE004 NE005 NE008 NE009 NE010 NE014 NE015 NE016 NE017 NE018 NE022 NE023 NE025 NE026 NE027 NE030
Overflow Frequency (#/year)
Overflow Frequency (#/year)
70
60
50
40
30
20
10
0
34
27 29 29 14 32 28 42
29 49 54 32 47
42 0 23 39 46 36 36 46 40 44 45 47 60 30 17 19 17 19
EN001
HR001 HR002 HR003 HR004 HR005 HR006 HR007
KE001 KE004 KE006 KE007 KE010
NE002 NE003 NE004 NE005 NE008 NE009 NE010 NE014 NE015 NE016 NE017 NE018 NE022 NE023 NE025 NE026 NE027 NE030
Overflow Duration (Hour)
Overflow Duration (Hour)
450
400
350
300
250
200
150
100
50
0
EN001
HR001 HR002 HR003 HR004 HR005 HR006 HR007
KE001 KE004 KE006 KE007 KE010
NE002 NE003 NE004 NE005 NE008 NE009 NE010 NE014 NE015 NE016 NE017 NE018 NE022 NE023 NE025 NE026 NE027 NE030


Overflow Volume (MG)
Overflow Volume (MG)
200
150
100
50
0
EN001
HR001
HR002
HR003
HR004
HR005
HR006
HR007
KE001
KE004
KE006
KE007
KE010
NE002
NE003
NE004
NE005
NE008
NE009
NE010
NE014
NE015
NE016
NE017
NE018
NE022
NE023
NE025
NE026
NE027
NE030
Overflow Frequency
Overflow Frequency
70
60
50
40
30
20
10
0
Overflow Duration (Hour)
Overflow Duration (Hour)
450
400
350
300
250
200
150
100
50
0

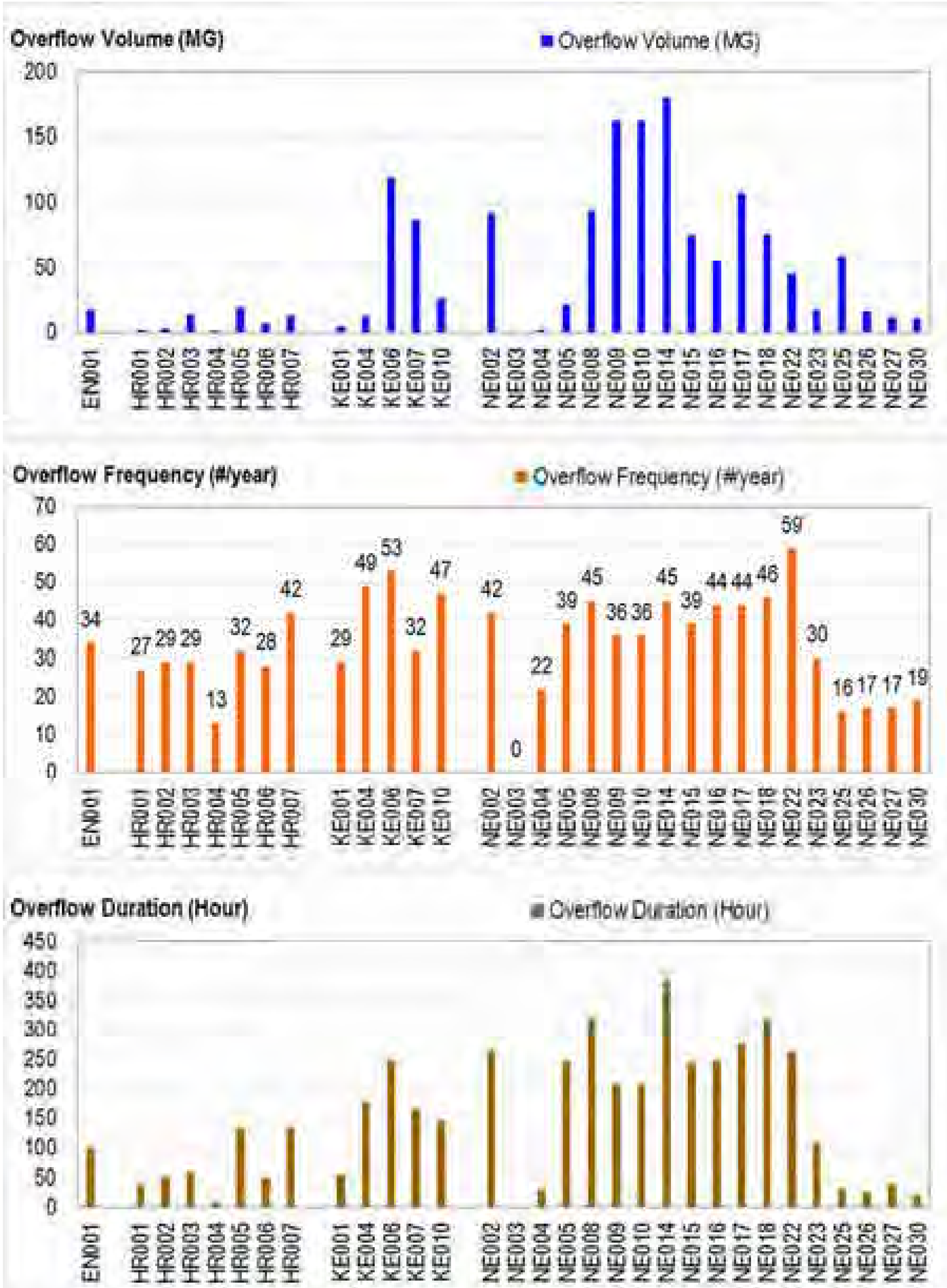
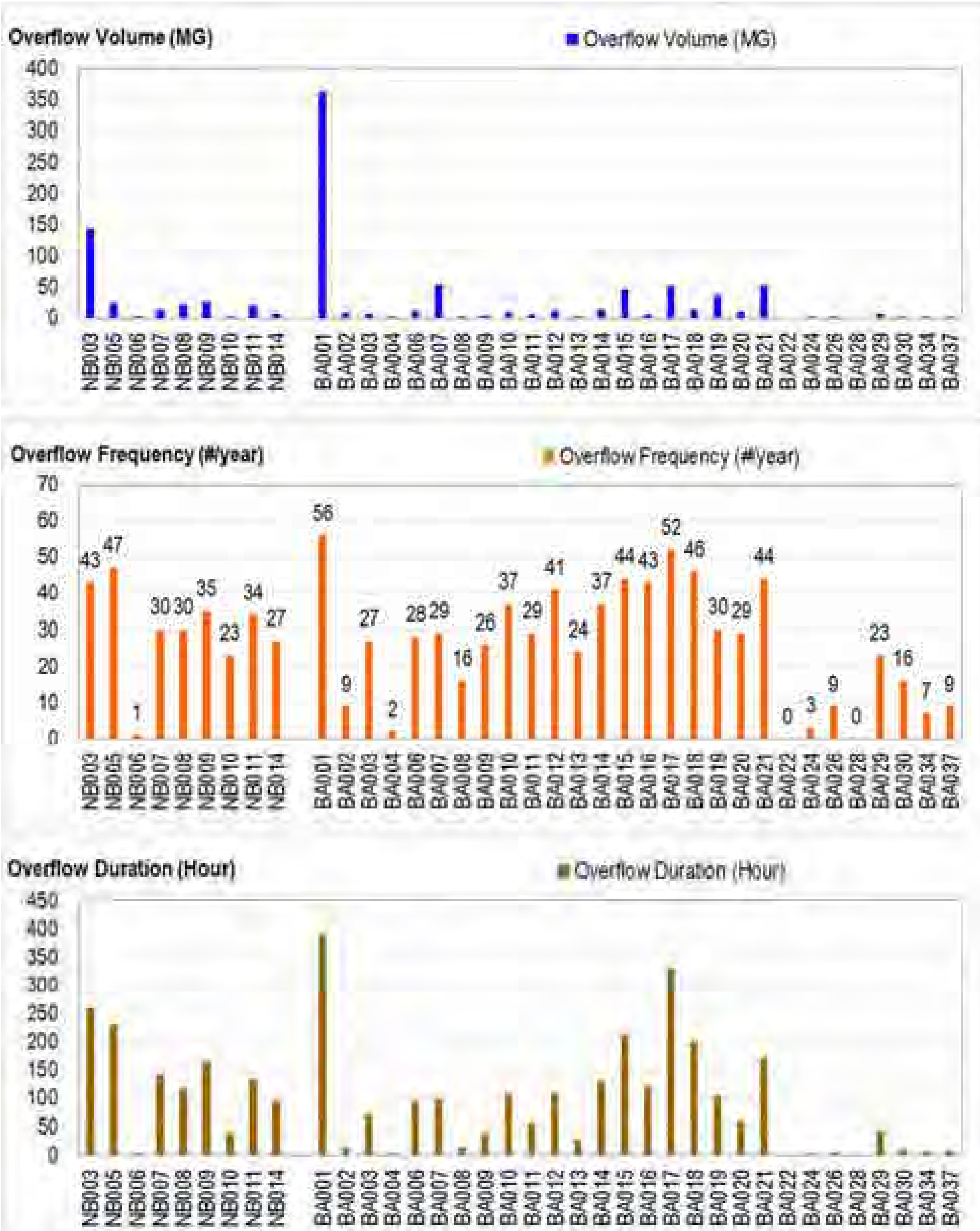


Figure I-67: Typical Year CSO Overflow Volume and Frequency East Newark, Harrison, Kearny and Newark


Overflow Volume (MG)
Overflow Volume (MG)
0
50
100
150
200
250
300
350
400
Overflow Frequency (#/year)
Overflow Frequency (#/year)
0
10
20
30
40
50
60
70
43 47 1 30 30 35 23 34 27 56 9 27 2 28 29 16 26 37 29 41 24 37 44 43 52 46 30 29 44 0 3 9 0 23 16 7 9
Overflow Duration (Hour)
Overflow Duration (Hour)
0
50
100
150
200
250
300
350
400
450
NB003
NB005
NB006
NB007
NB008
NB009
NB010
NB011
NB014
BA001
BA002
BA003
BA004
BA006
BA007
BA008
BA009
BA010
BA011
BA012
BA013
BA014
BA015
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BA020
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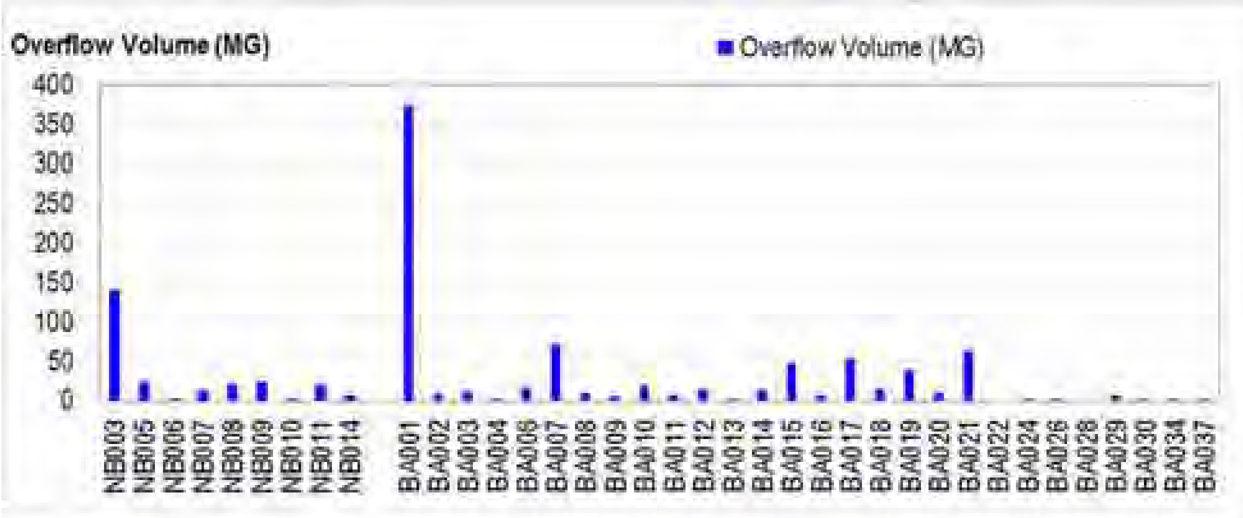
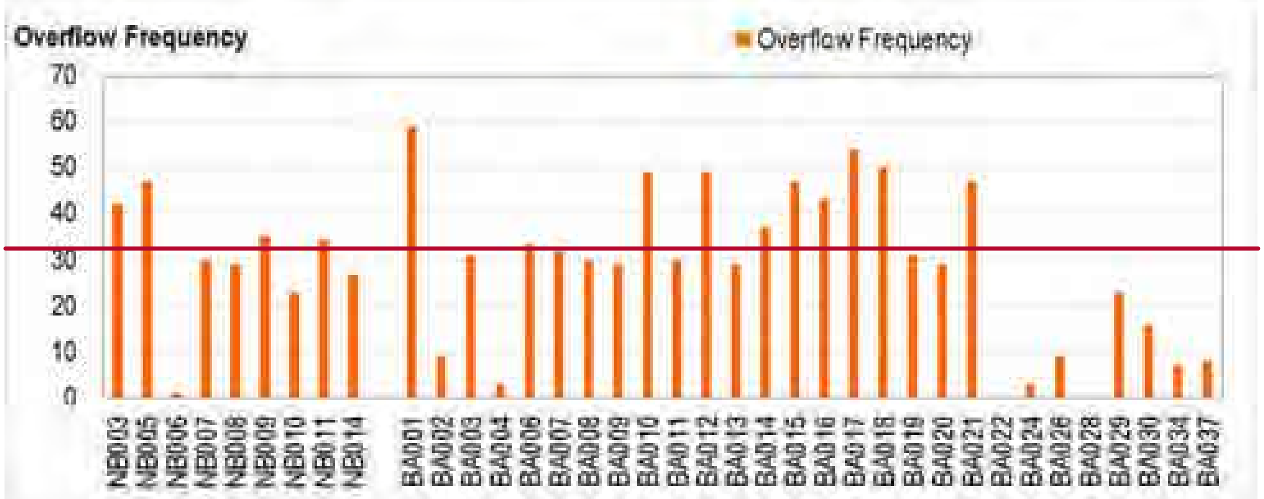
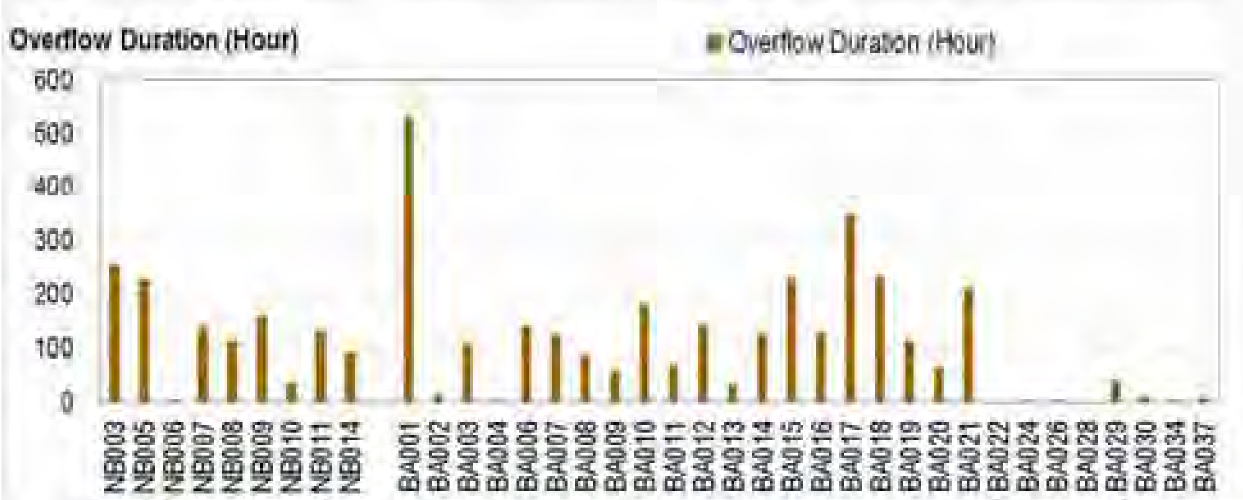
BA022
BA024
BA026
BA028
BA029
BA030
BA034
BA037


Overflow Volume (MG)
Overflow Volume (MG)
400
350
300
250
200
150
100
50
0
NB003 NB005 NB006 NB007 NB008 NB009 NB010 NB011 NB014 BA001 BA002 BA003 BA004 BA006 BA007 BA008 BA009 BA010 BA011 BA012 BA013 BA014 BA015 BA016 BA017 BA018 BA019 BA020 BA021 BA022 BA024 BA026 BA028 BA029 BA030 BA034 BA037


Overflow Frequency
Overflow Frequency
70
60
50
40
30
20
10
0
NB003 NB005 NB006 NB007 NB008 NB009 NB010 NB011 NB014 BA001 BA002 BA003 BA004 BA006 BA007 BA008 BA009 BA010 BA011 BA012 BA013 BA014 BA015 BA016 BA017 BA018 BA019 BA020 BA021 BA022 BA024 BA026 BA028 BA029 BA030 BA034 BA037


Overflow Duration (Hour)
Overflow Duration (Hour)
600
500
400
300
200
100
0
NB003 NB005 NB006 NB007 NB008 NB009 NB010 NB011 NB014 BA001 BA002 BA003 BA004 BA006 BA007 BA008 BA009 BA010 BA011 BA012 BA013 BA014 BA015 BA016 BA017 BA018 BA019 BA020 BA021 BA022 BA024 BA026 BA028 BA029 BA030 BA034 BA037

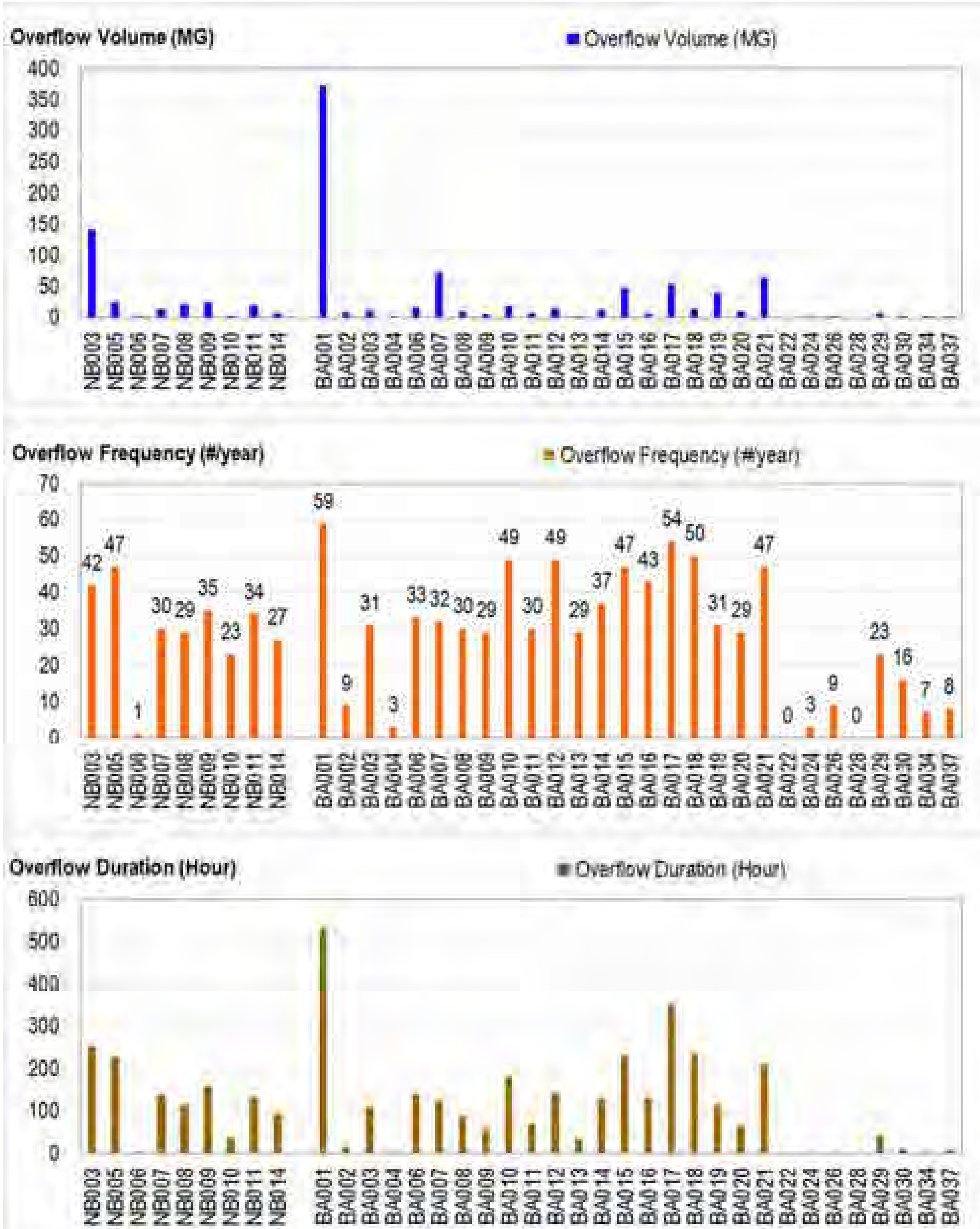


Figure I-68: Typical Year CSO Overflow Volume and Frequency North Bergen and Bayonne

I.6.3 Percent Capture

Wet weather percent capture was calculated for the PVSC Interceptor communities, North Bergen, and Bayonne. The wet weather volume was estimated based on durations from the time when the accumulated precipitation depth is over 0.1 inch to 12 hours after the storm event.

Table I-12: Typical Year % Capture

	PVSC Interceptor Communities	North Bergen	Bayonne
Total WWF Volume (MG)	12,529~~68~~	780~~64~~	1,4860~~01~~
Total CSO Volume (MG)	2,033~~7~~	254~~1~~	773~~91~~
% Capture	83.8%	67.4~~2~~%	52.1~~43.6~~%
Additional Capture Volume (MG) for 85% Capture	154~~2~~	137~~6~~	490~~581~~

SECTION J - REFERENCES

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SECTION K - ABBREVIATIONS

CSO: Combined Sewer Overflow
CSS: Combined Sewer System
CWA: Clean Water Act
DWF: Dry Weather Flow
EPA: United States Environmental Protection Agency
ESI: Environmental Sensitivity Index
GIS: Geographic Information System
H&H: Hydrologic and Hydraulic
LTCP: Long Term Control Plan
MGD: million gallons per day
NJPDES New Jersey Pollutant Discharge Elimination System
PCBs: polychlorinated biphenyls
QAPP: Quality Assurance Project Plan
SSS: Separate Sewer System
USEPA: United States Environmental Protection Agency
WRRF: Water Resources Recovery Facility

APPENDIX A

Combined Sewer Overflow and Stormwater Sampling Results

APPENDIX A

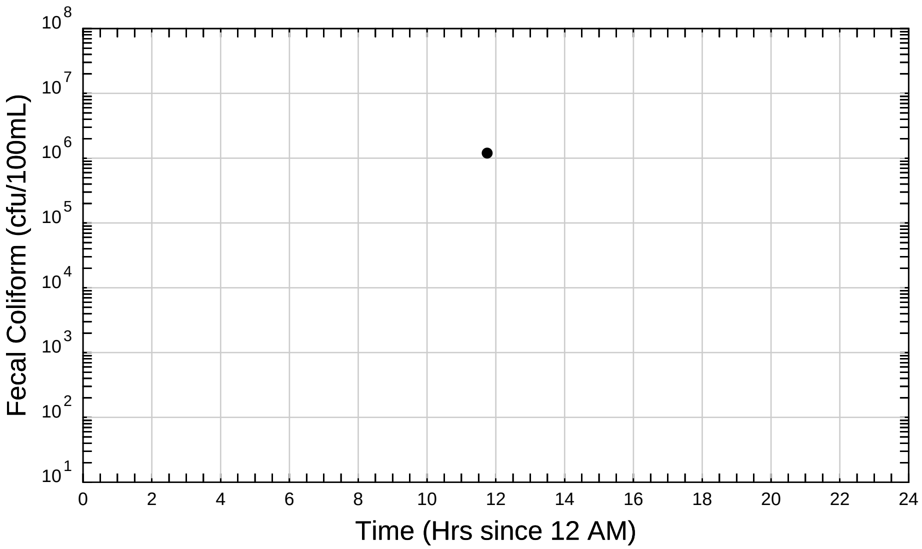
Sampling Schedule and Dates

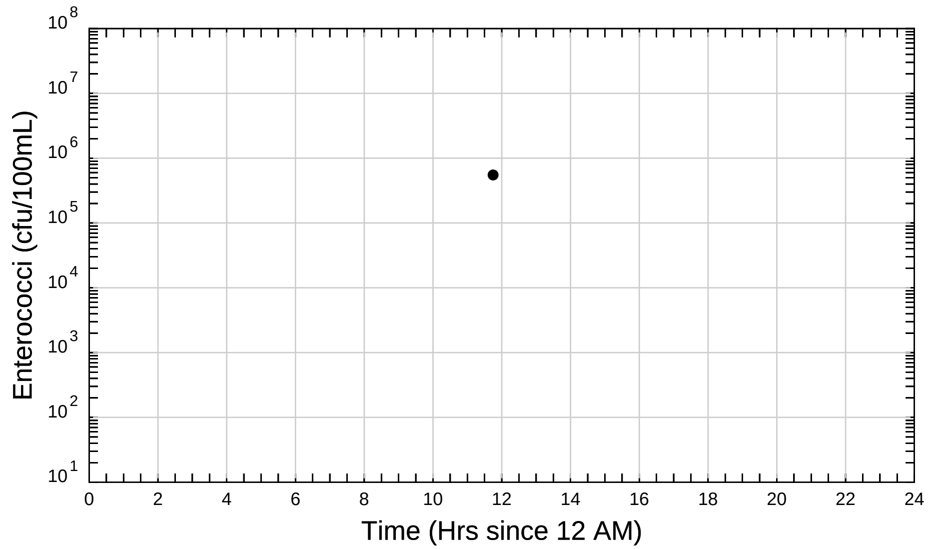
A summary of the sampling dates with corresponding locations and sample station identification numbers are shown in the table below. The Sampling Identification is noted at the top of each page in Appendix A.

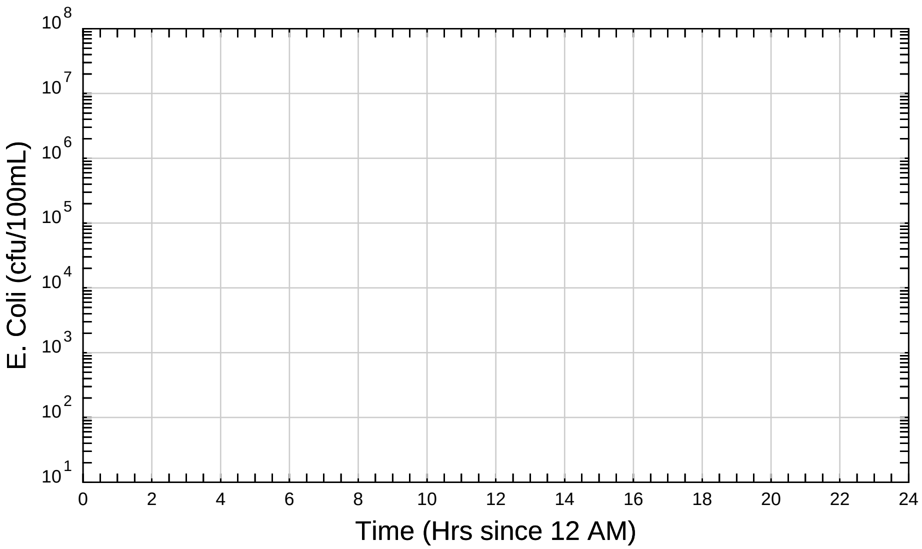
CSO Sampling		
Date	**Locations**	**CSO Sample Identification**
8/21/2016	1	PAT-06A
11/29/2016	5	HAR-06A, HAR-07A, KEA-07A, NWK-25A, NWK-45A
4/4/2017	4	HAR-06A, HAR-07A, KEA-07A, NWK-91A
4/6/2017	4	NWK-14A, NWK-45A, PAT-06A, PAT-27A
6/19/2017	4	BAY-08A, BAY-10A, PAT-25A, PAT-27A
7/23/2017	2	BAY-08A, BAY-10A
10/24/2017	4	NWK-14A, NWK-25A, NWK-45A, NWK-91A
Total	**13**	**Unique CSO Locations**
Total	**27**	**CSO Location-Events**

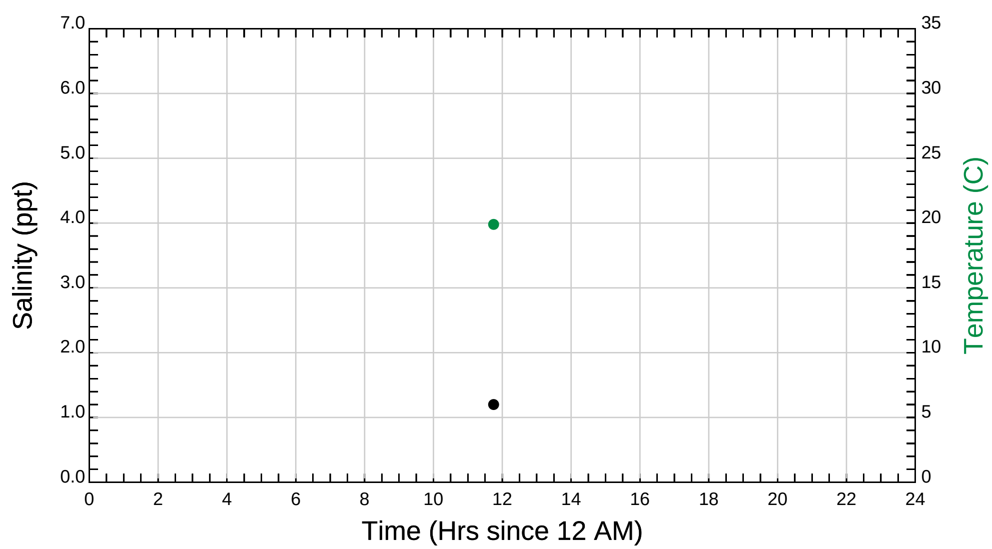
Stormwater Sampling		
Date	**Locations**	**Stormwater Sample Identification**
7/29/2016	2	OAK-LR4, PAT-LR1
9/19/2016	2	NWK-CI2, PAT-LR1
9/30/2016	2	NWK-CI2, OAK-LR4
10/21/2016	1	NWK-HR1
11/15/2016	4	NWK-CI2, NWK-HR1, OAK-LR4, PAT-LR1
12/6/2016	1	NWK-HR1
1/17/2017	2	NWK-HR2, NWK-LR2
5/5/2017	4	HAW-LR3, NWK-HR2, NWK-LR2, PAT-CI1
5/22/2017	2	NWK-HR2, NWK-LR2
5/25/2017	2	HAW-LR3, PAT-CI1
7/7/2017	2	HAW-LR3, PAT-CI1
Total	**8**	**Unique Stormwater Locations**
Total	**24**	**Stormwater Location-Events**

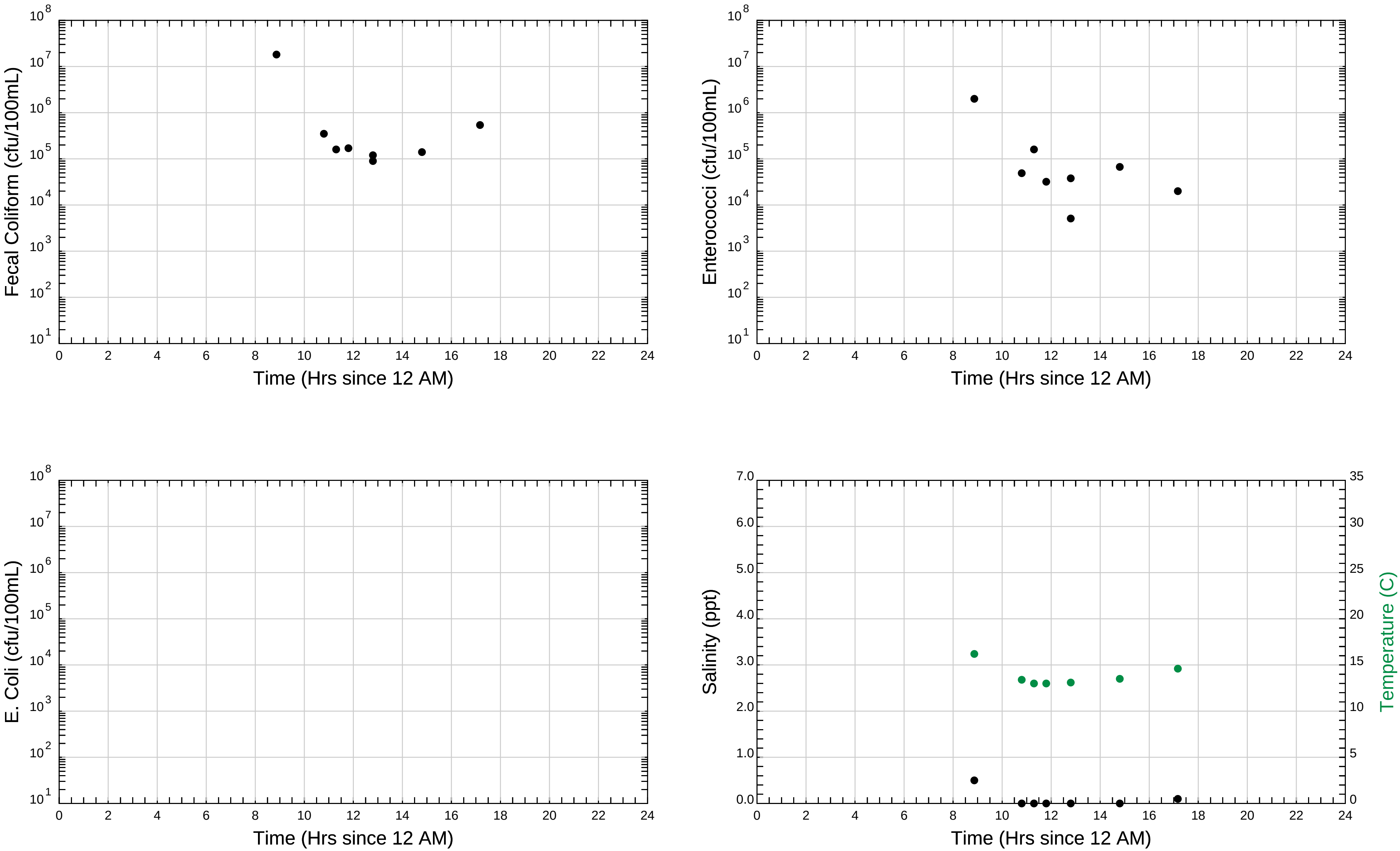
Station: C1-HAR-06A

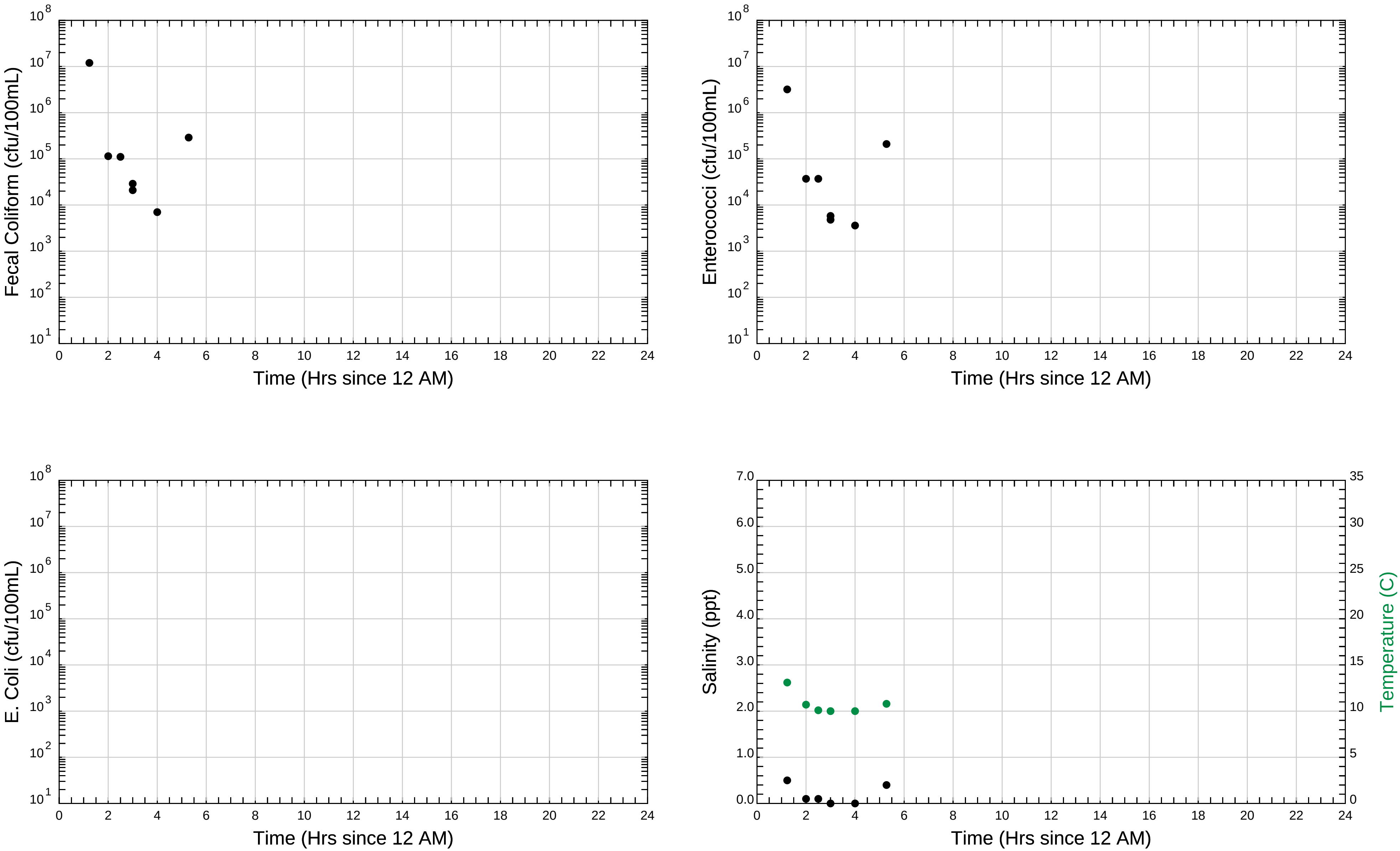






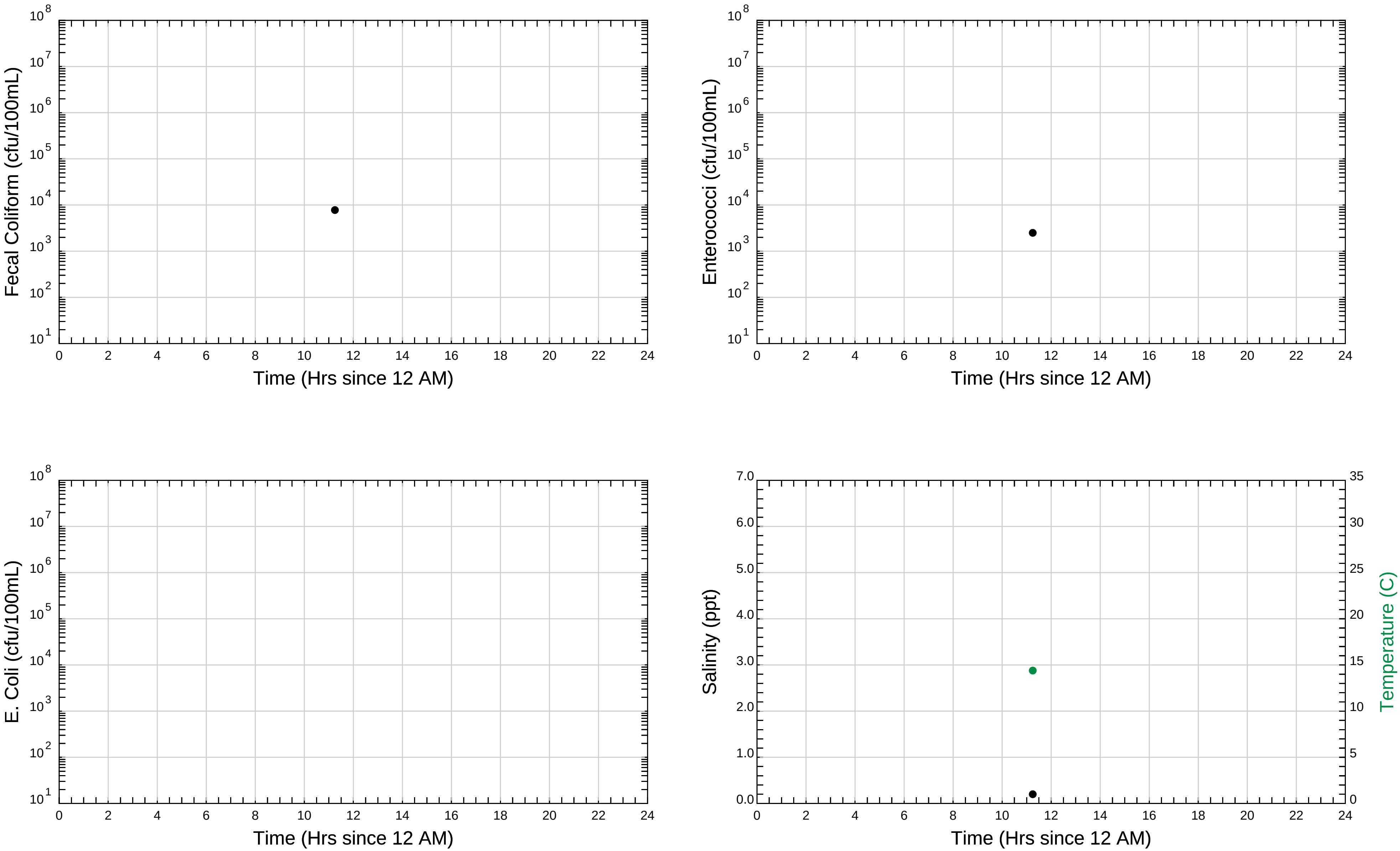


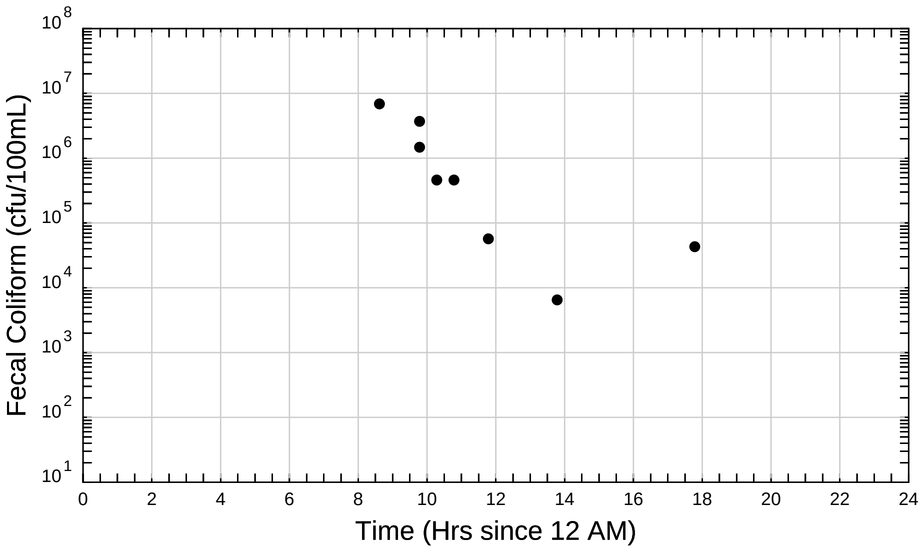

Fecal Coliform (cfu/100mL)
Time (Hrs since 12 AM)
Enterococci (cfu/100mL)
Time (Hrs since 12 AM)
E. Coli (cfu/100mL)
Time (Hrs since 12 AM)
Salinity (ppt)
Temperature (C)
Time (Hrs since 12 AM)


Fecal Coliform (cfu/100mL)
Time (Hrs since 12 AM)
Enterococci (cfu/100mL)
Time (Hrs since 12 AM)
E. Coli (cfu/100mL)
Time (Hrs since 12 AM)
Salinity (ppt)
Temperature (C)
Time (Hrs since 12 AM)

Wet-Weather Event 10. 27.2016.

Station: C1-HAR-07A

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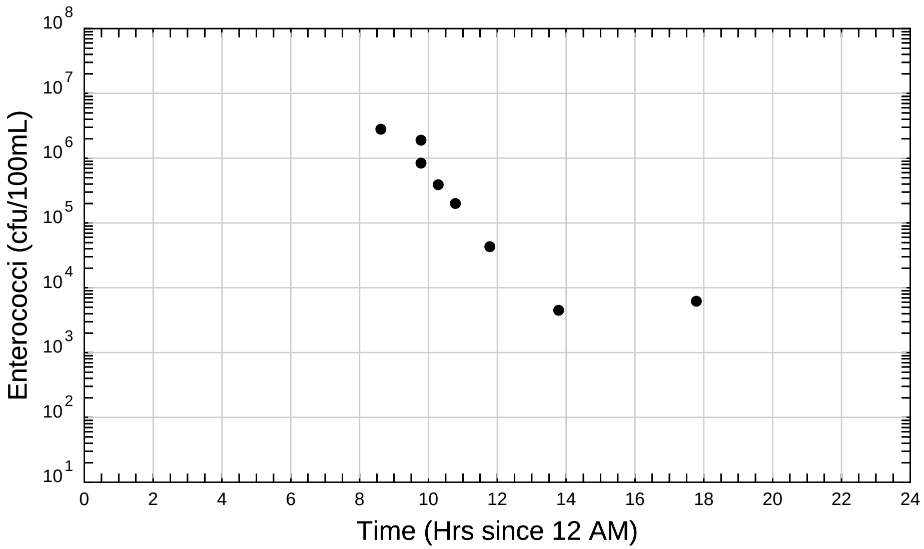
Time (Hrs since 12 AM)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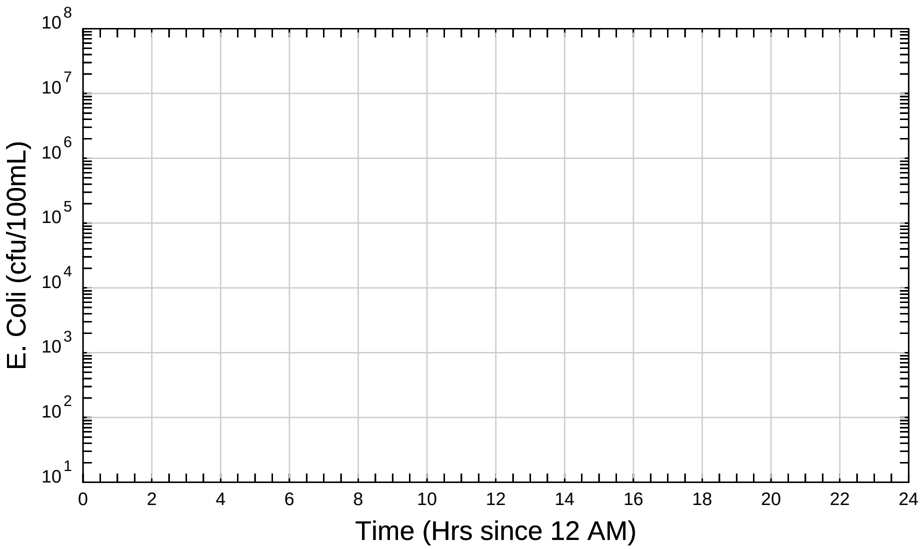
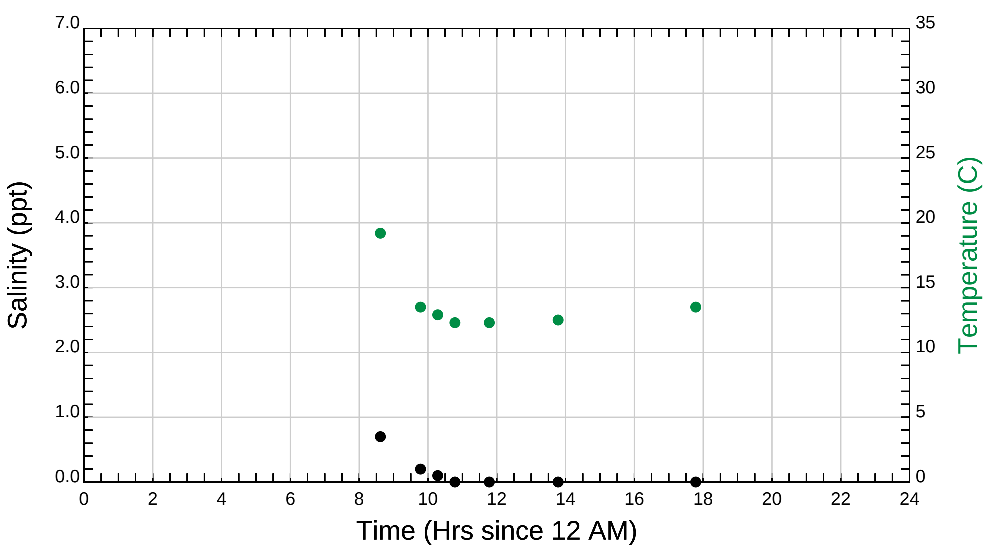
Time (Hrs since 12 AM)


E. Coli (cfu/100mL)
Time (Hrs since 12 AM)


Salinity (ppt)
Temperature (C)
Time (Hrs since 12 AM)

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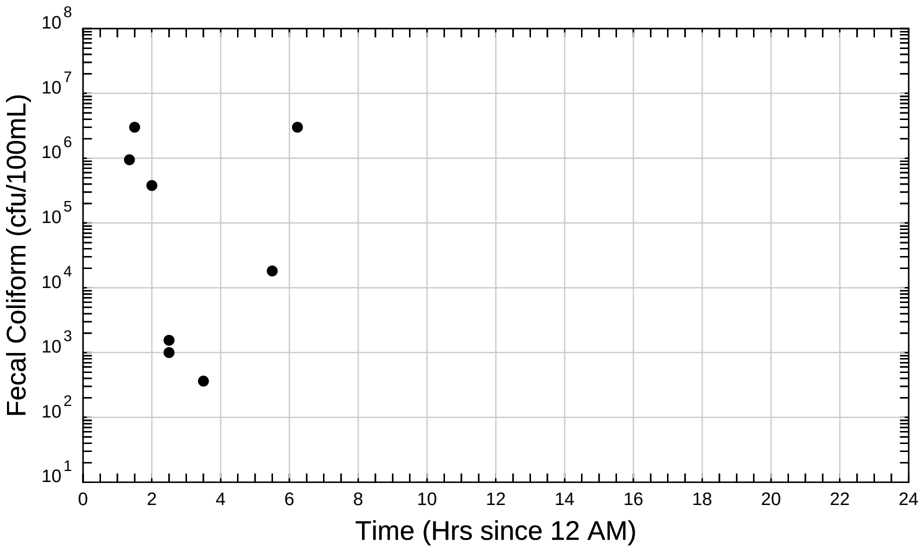

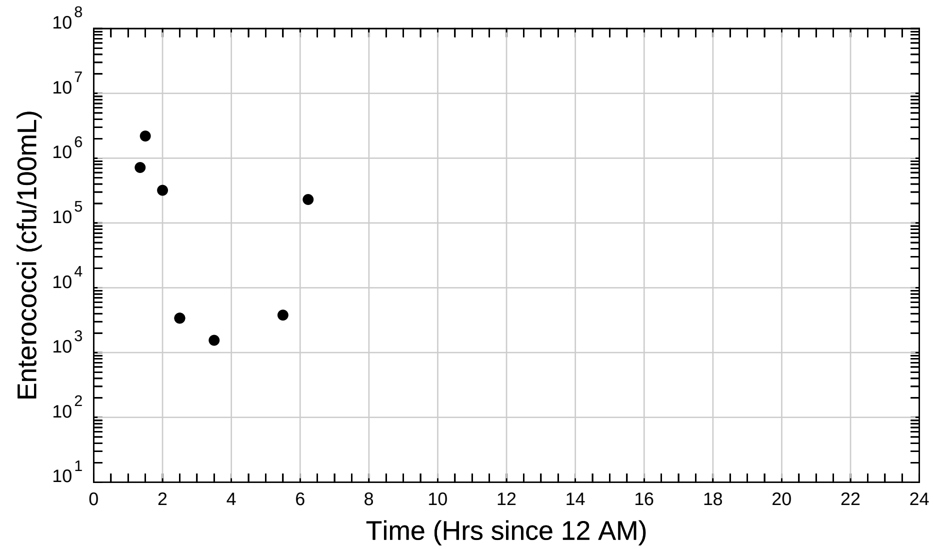

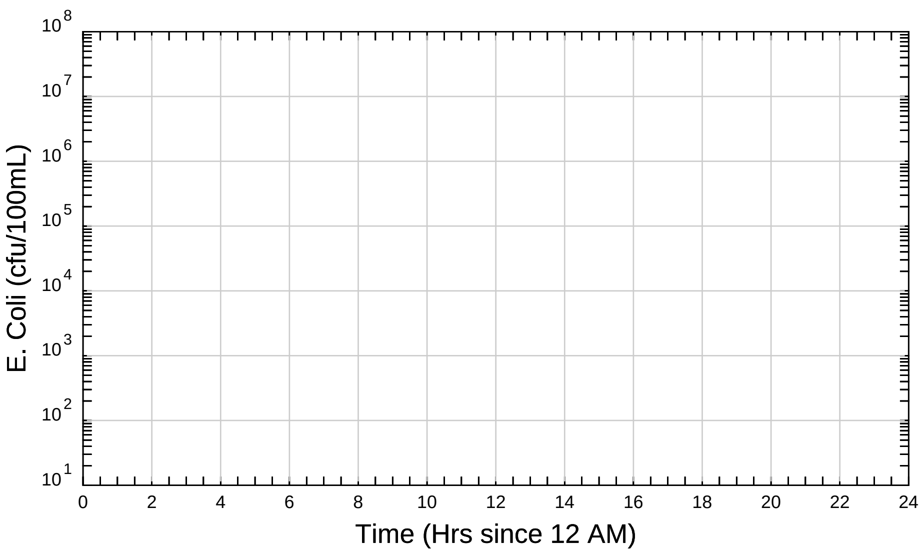

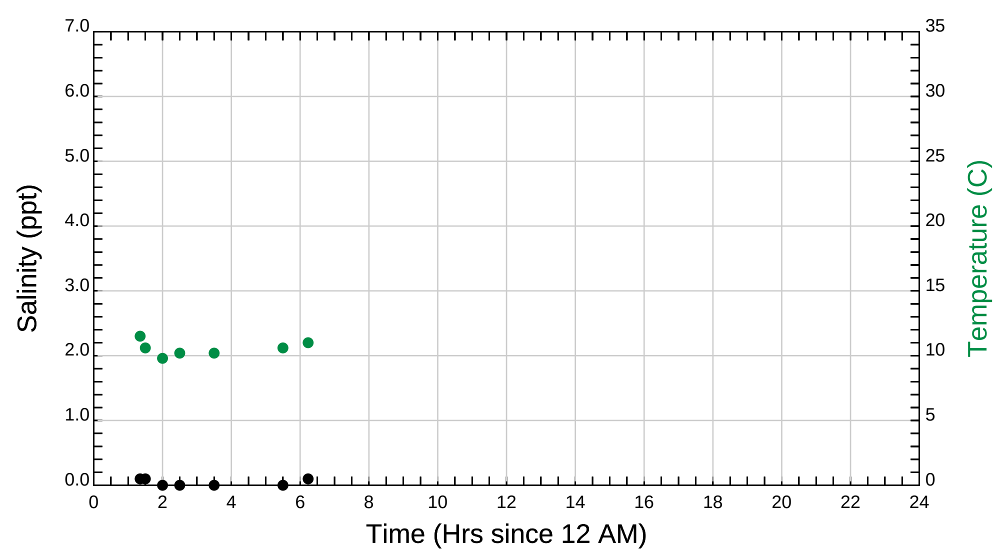

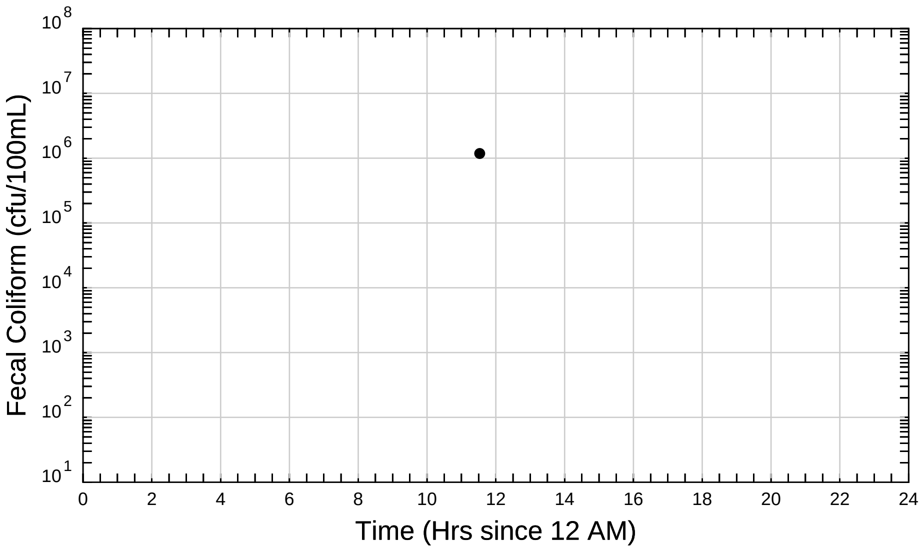
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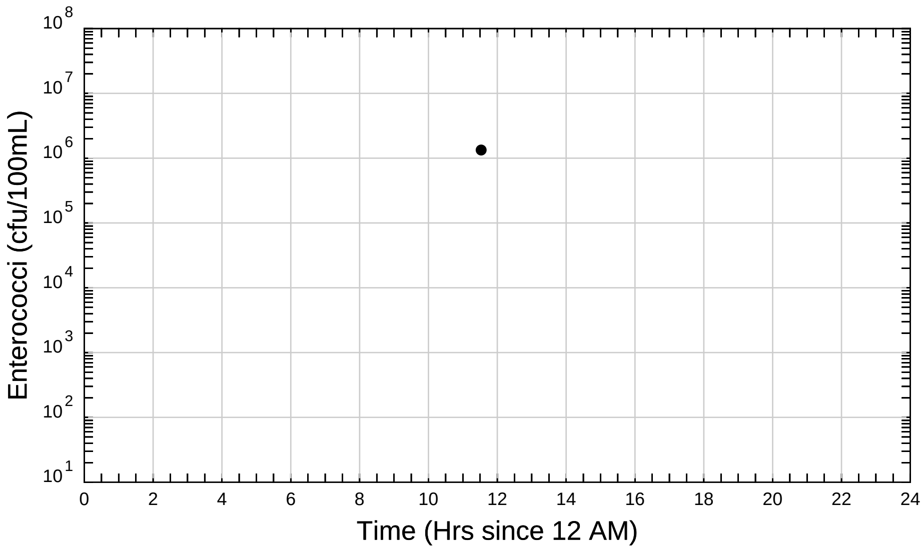
Time (Hrs since 12 AM)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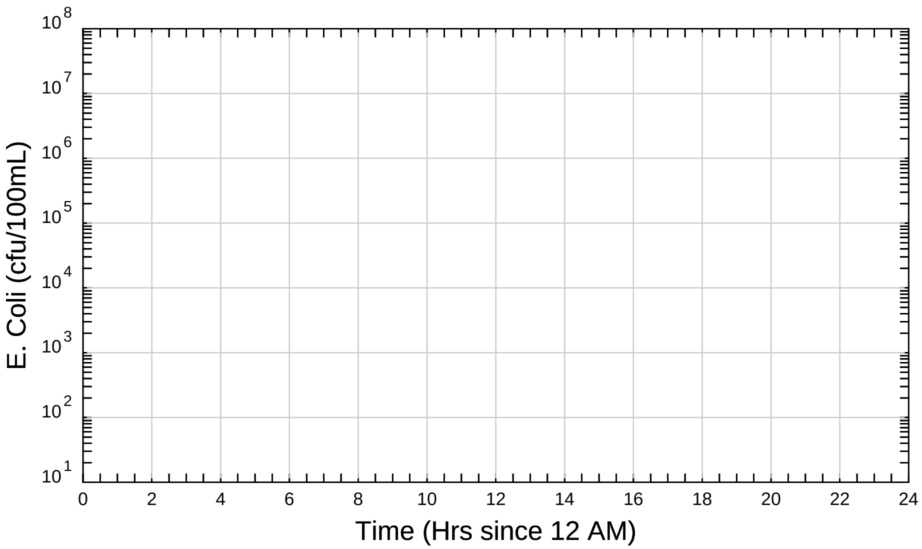
Time (Hrs since 12 AM)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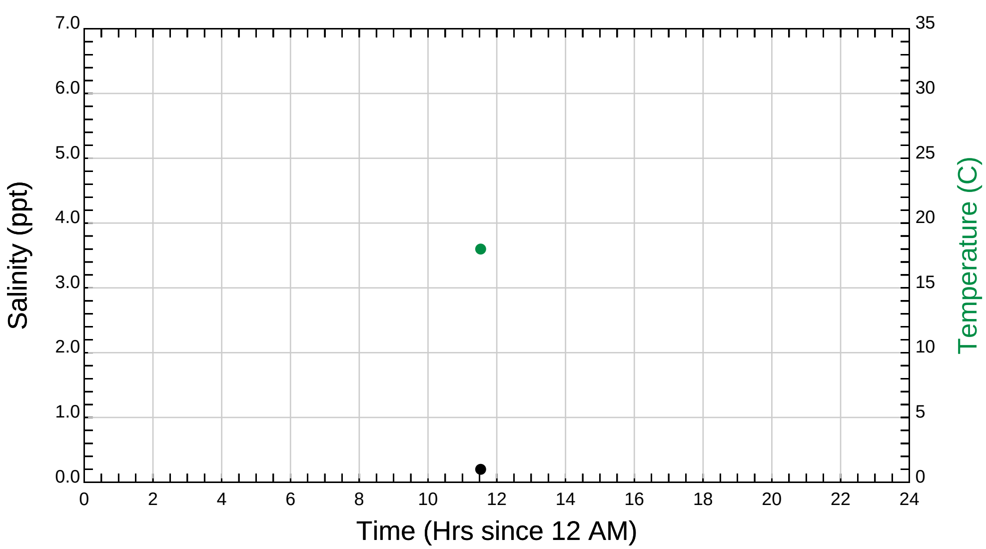
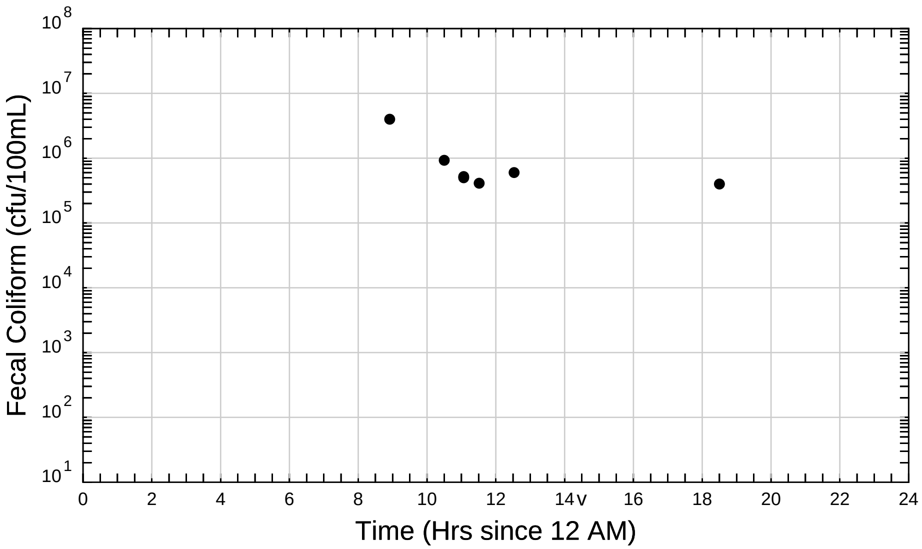
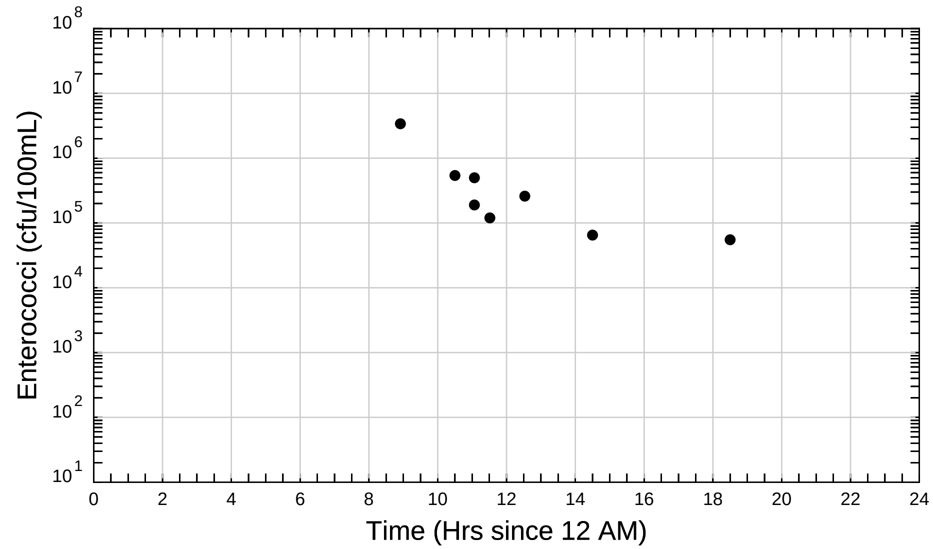
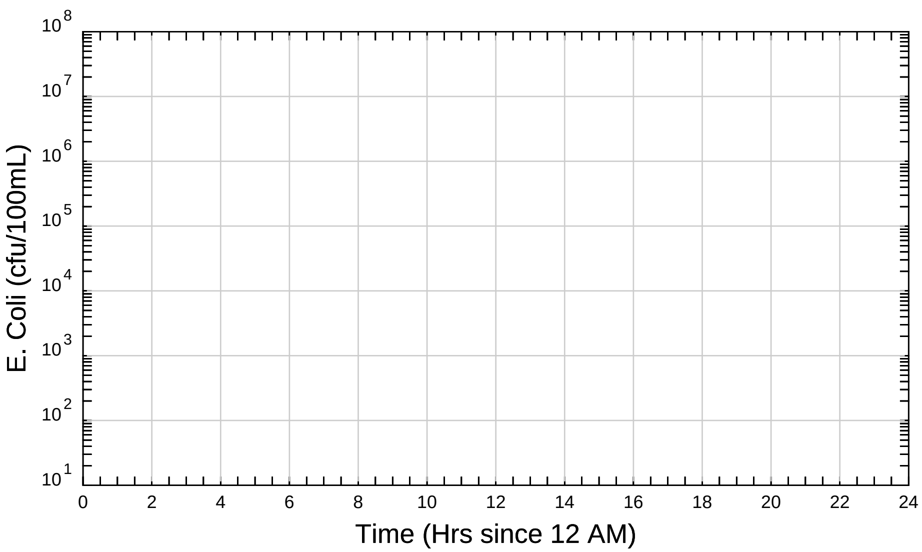
Time (Hrs since 12 AM)


Salinity (ppt)
Temperature (C)
Time (Hrs since 12 AM)


Fecal Coliform (cfu/100mL)
Time (Hrs since 12 AM)


Enterococci (cfu/100mL)
Time (Hrs since 12 AM)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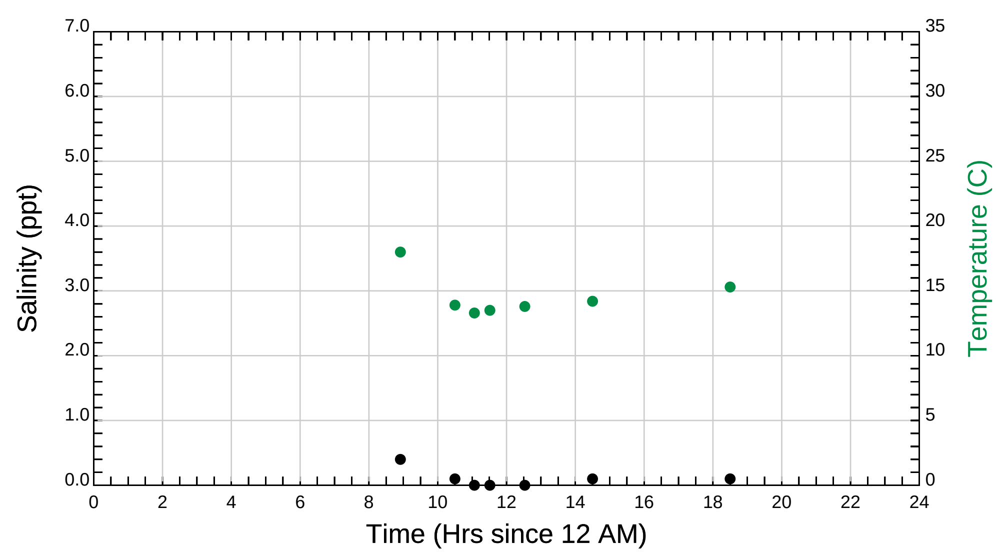
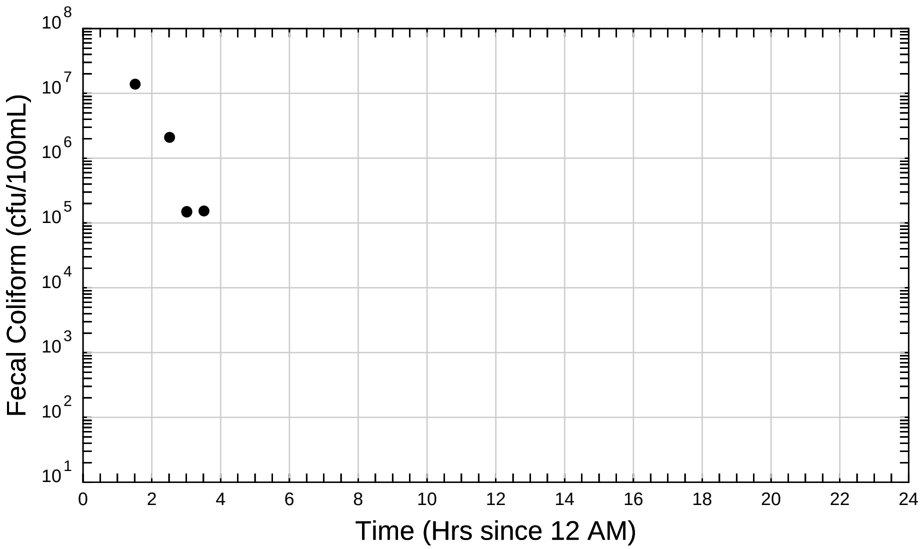
Time (Hrs since 12 AM)


Salinity (ppt)
Temperature (C)
Time (Hrs since 12 AM)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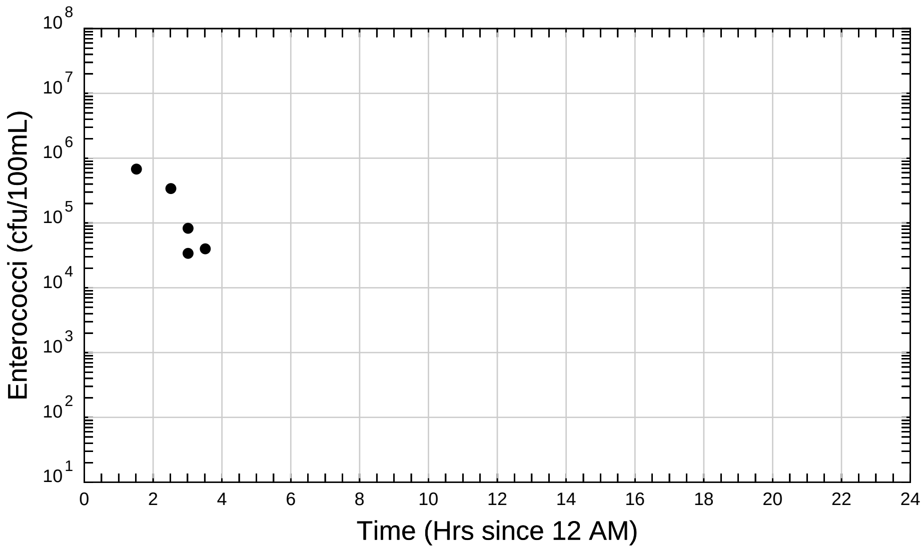
Time (Hrs since 12 AM)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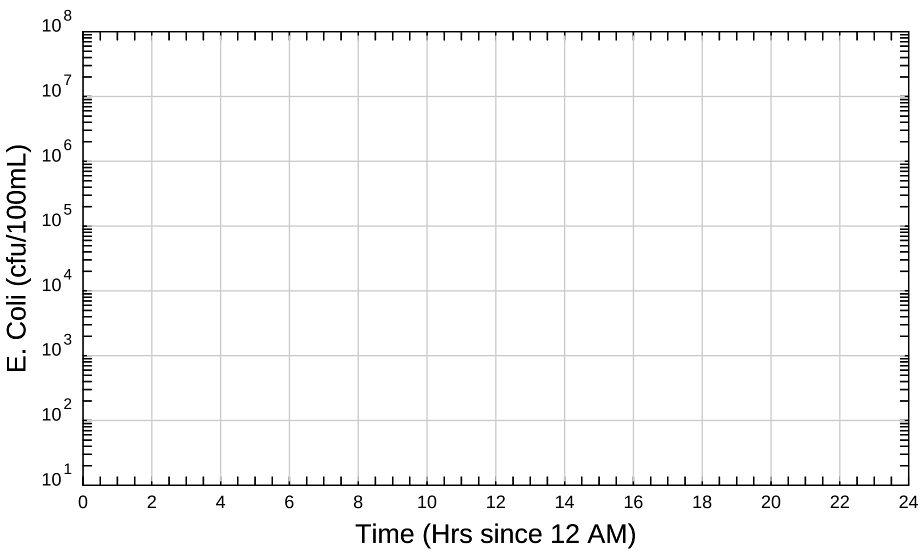
Time (Hrs since 12 AM)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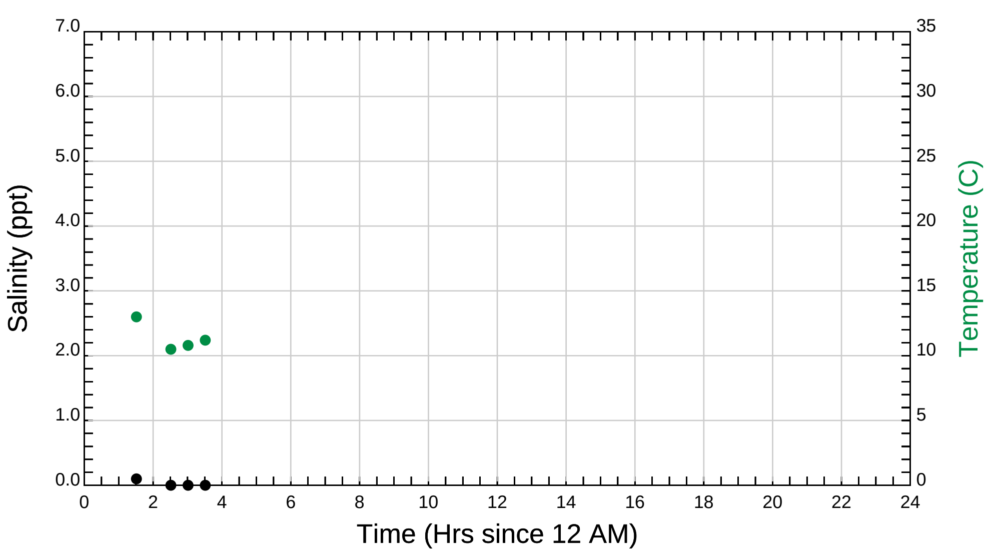
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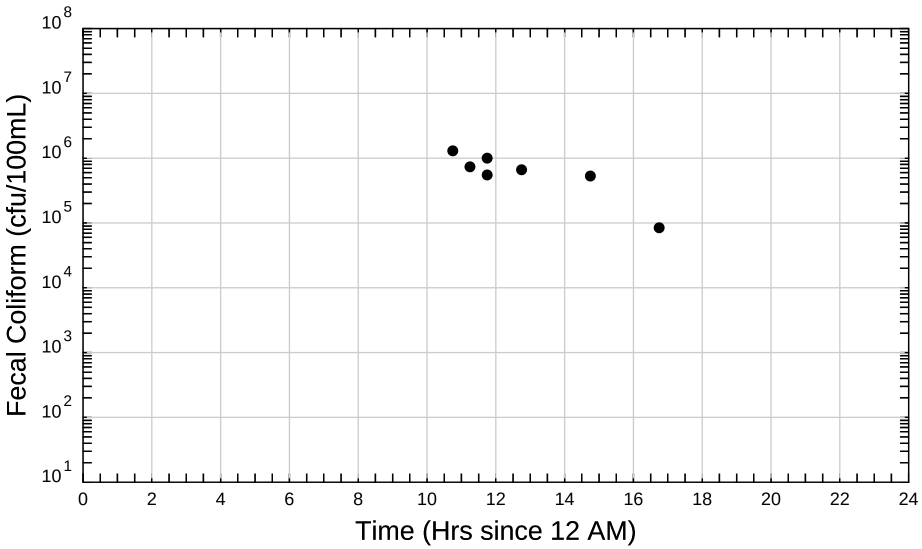
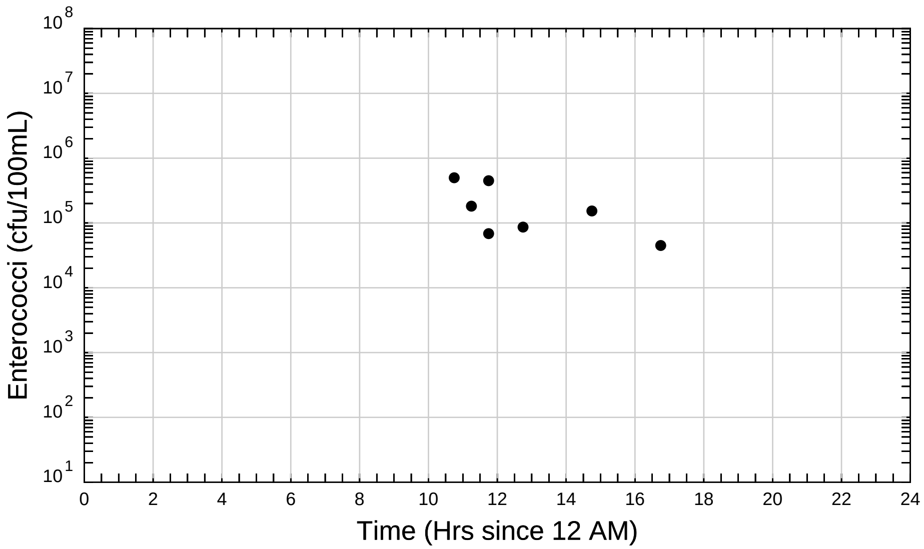
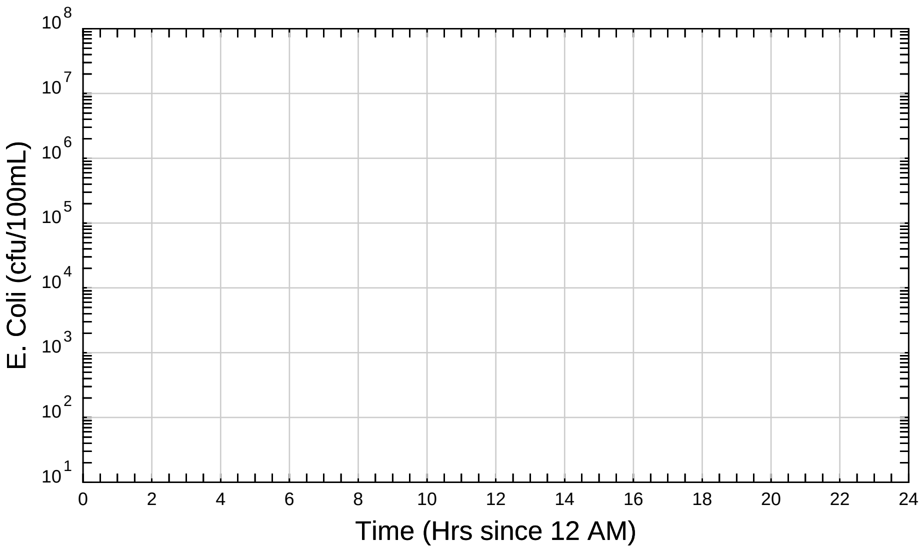
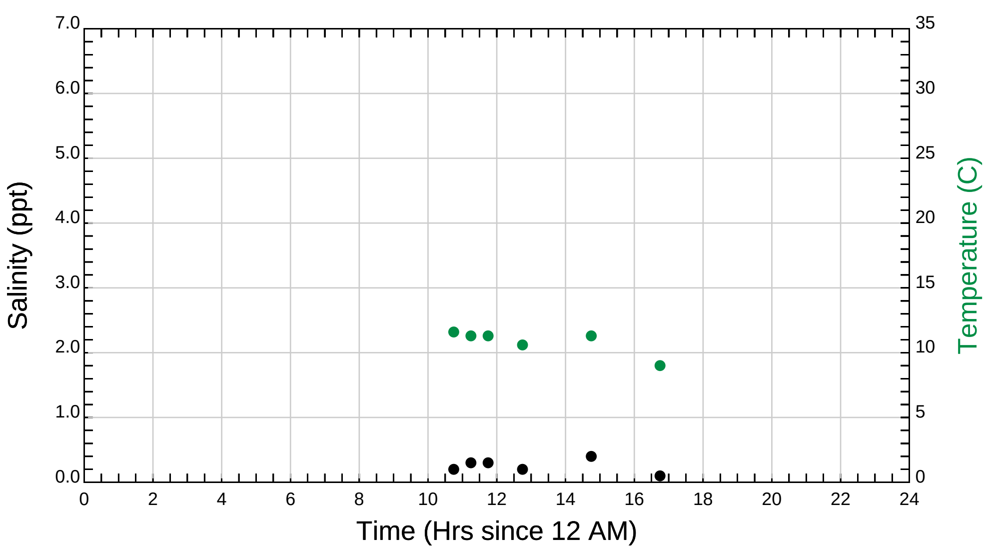


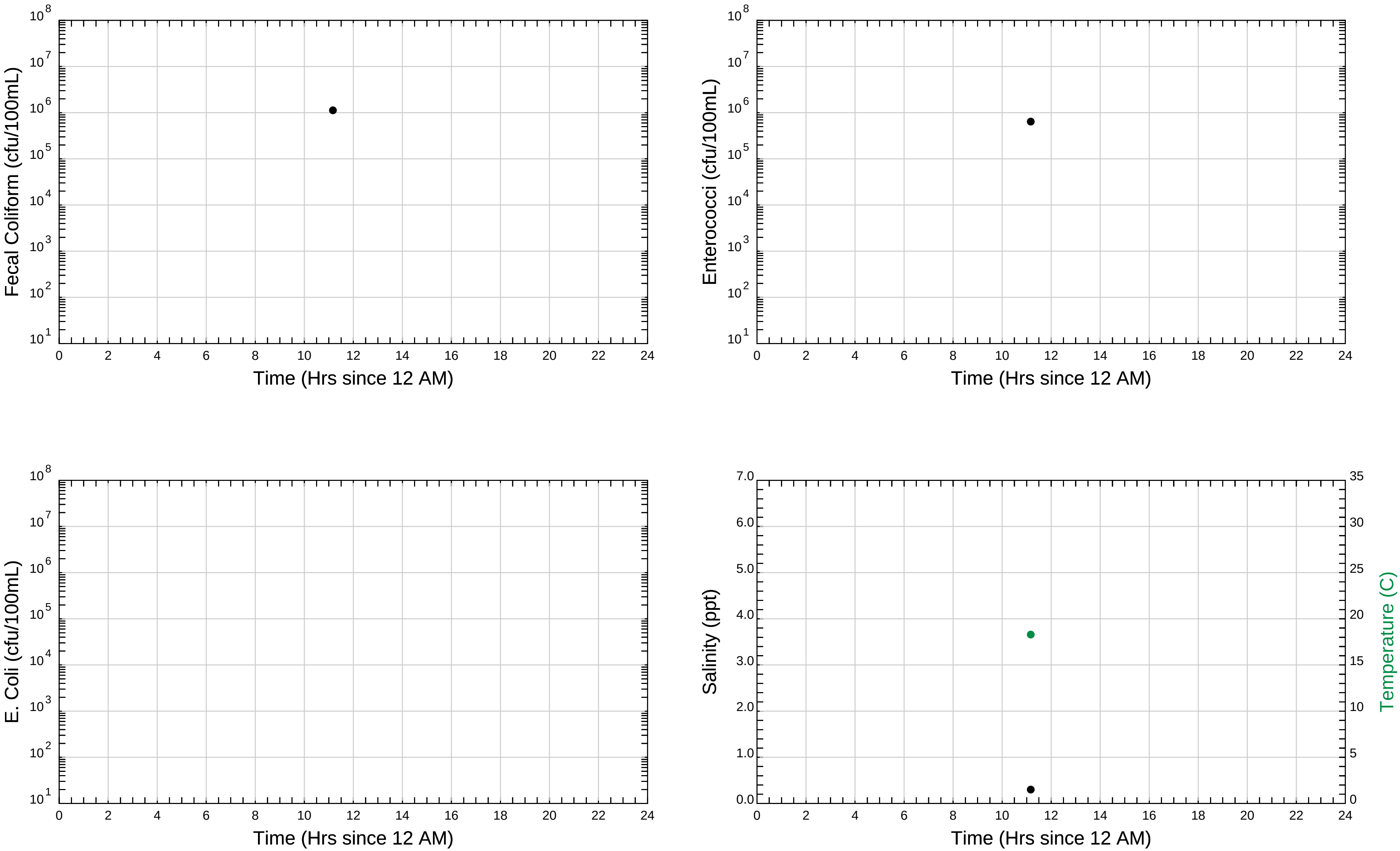


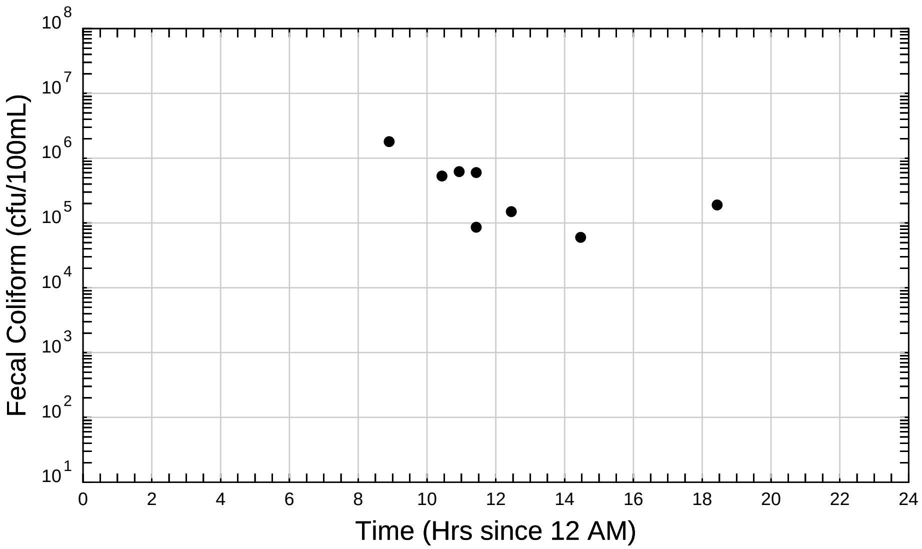


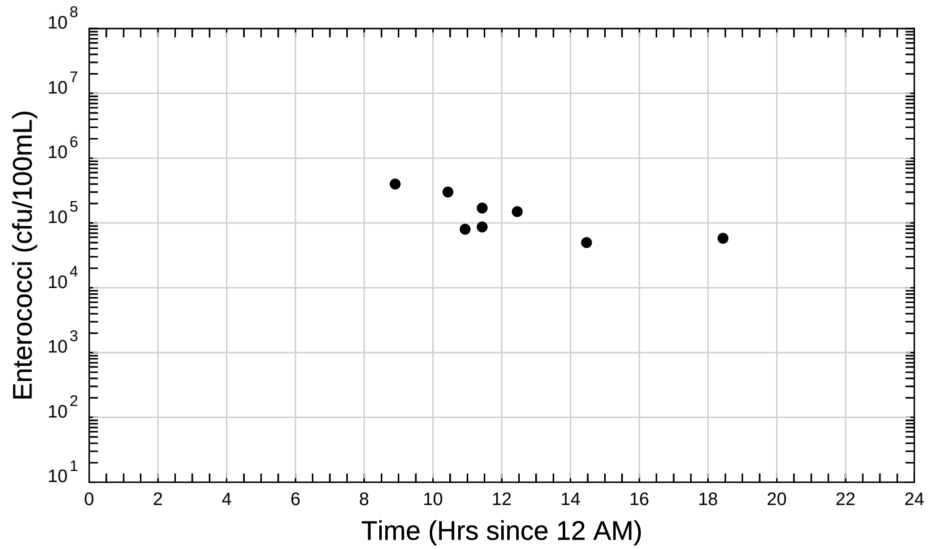


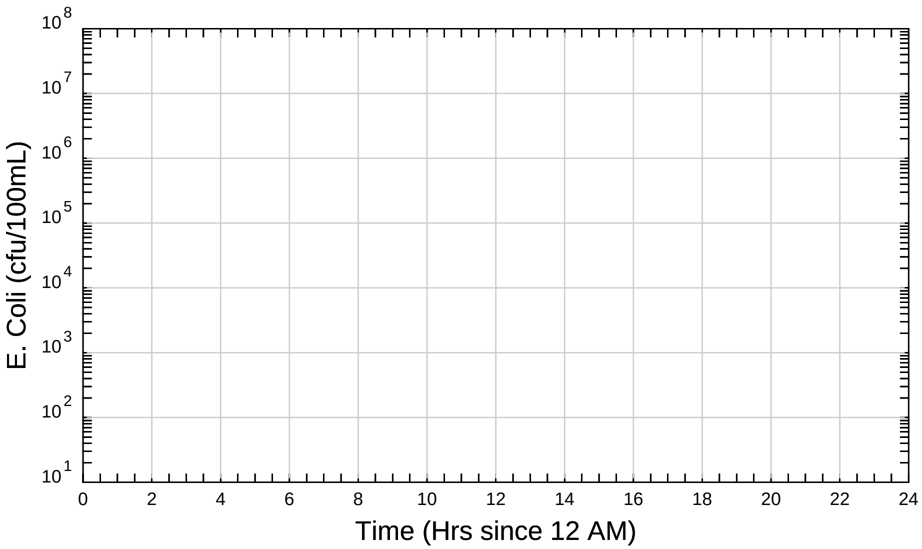
Wet-Weather Event 10. 27. 2016.

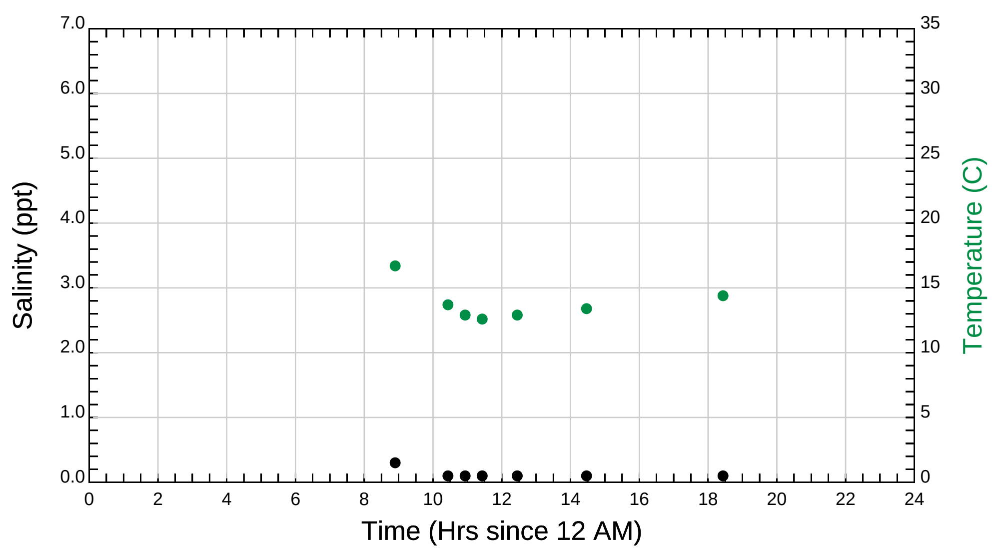
Station: C1-NWK-25A




Fecal Coliform (cfu/100mL)
Time (Hrs since 12 AM)


Enterococci (cfu/100mL)
Time (Hrs since 12 AM)


E. Coli (cfu/100mL)
Time (Hrs since 12 AM)


Salinity (ppt)
Temperature (C)
Time (Hrs since 12 AM)

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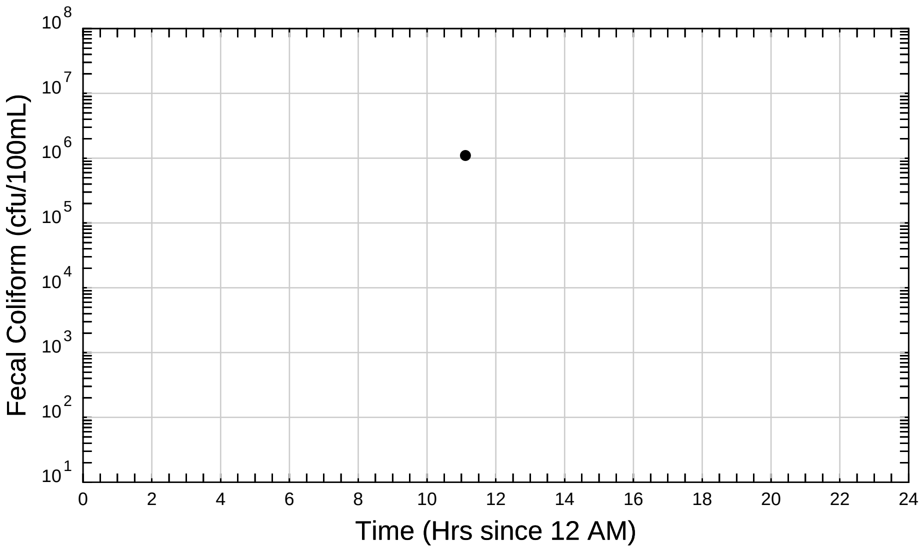
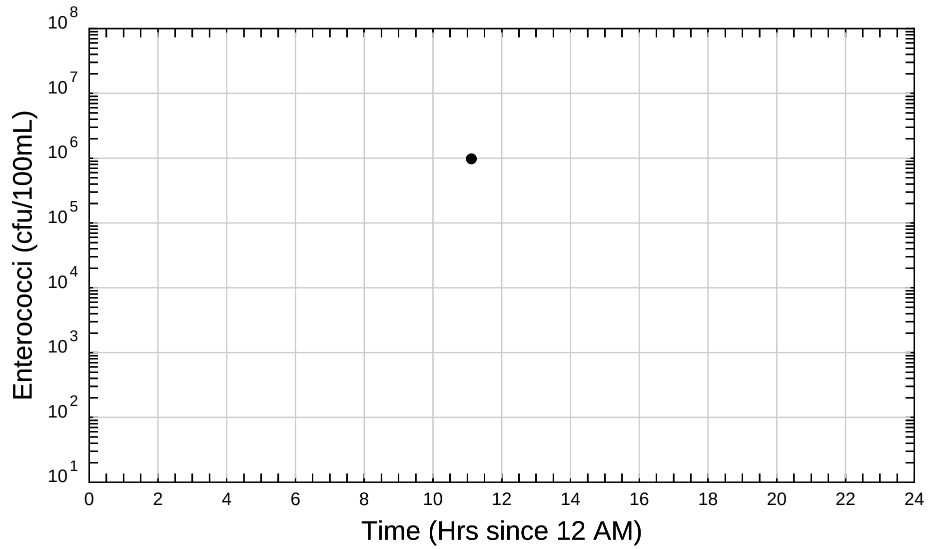
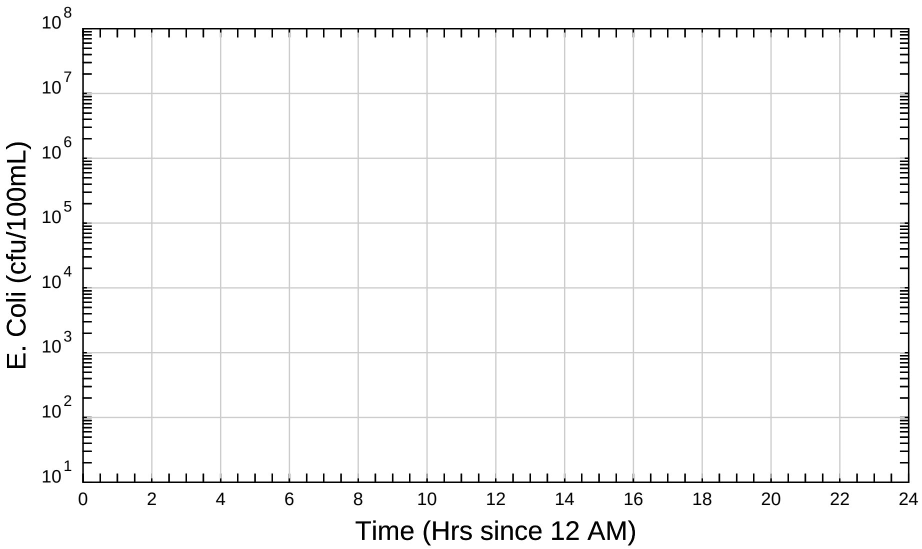
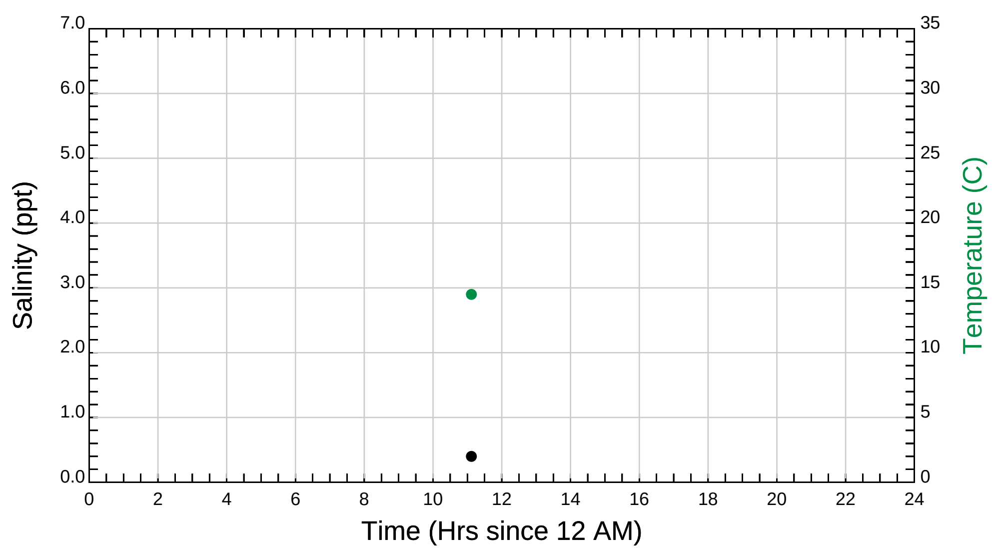
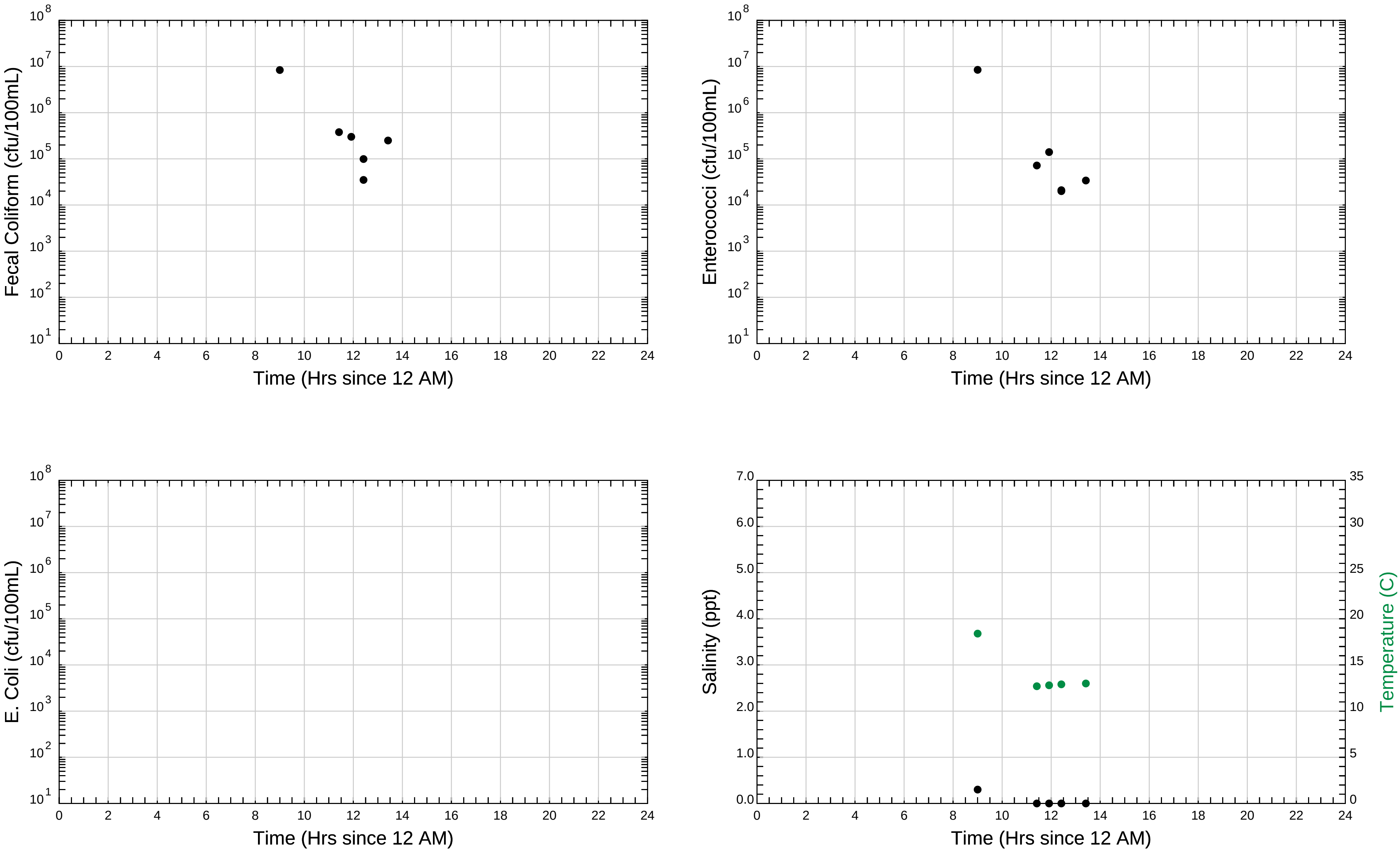


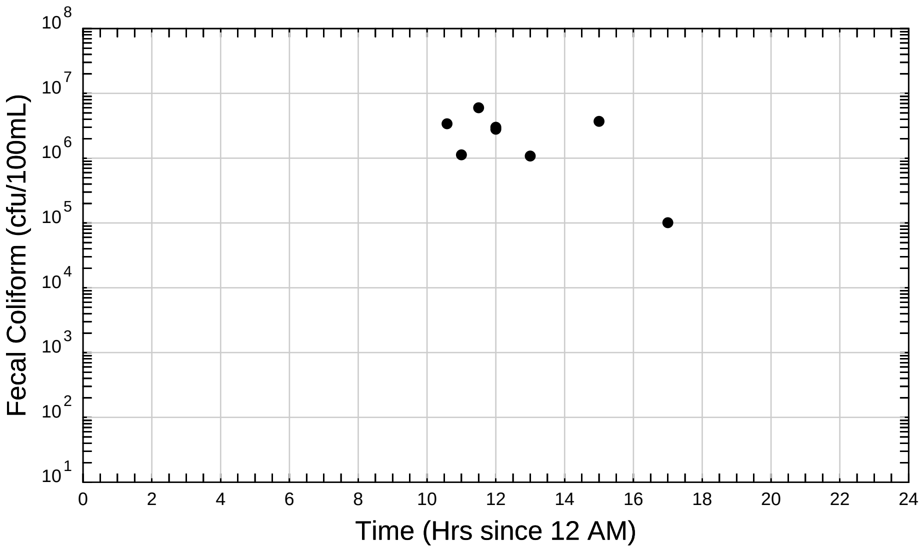


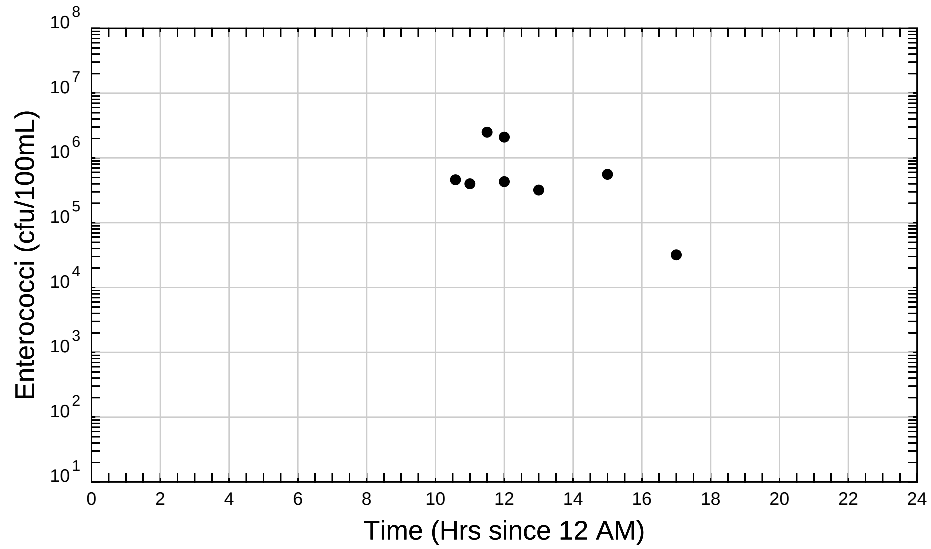


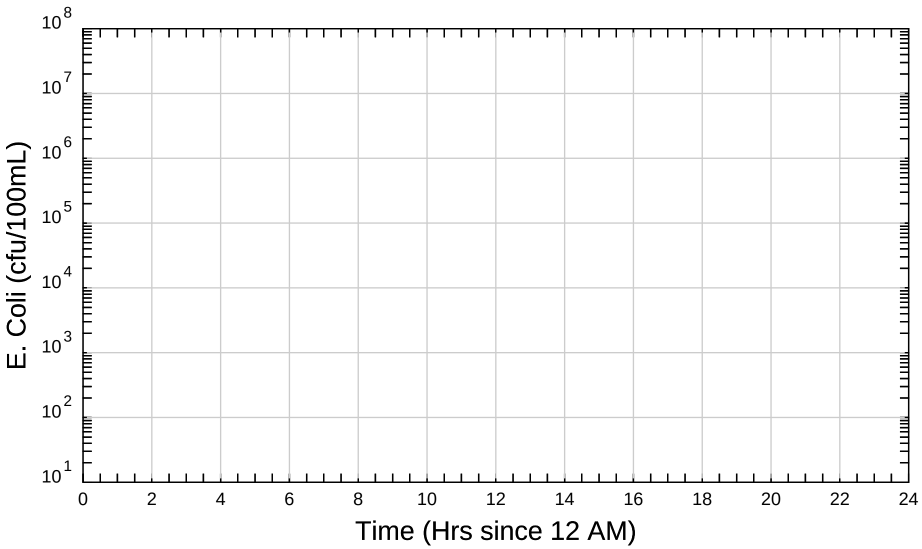


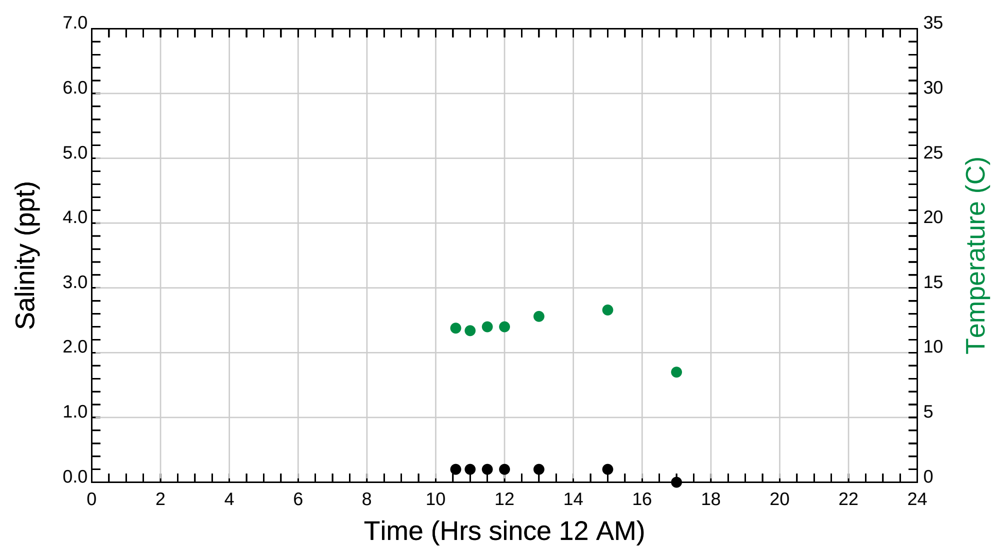
Station: C1-NWK-45A

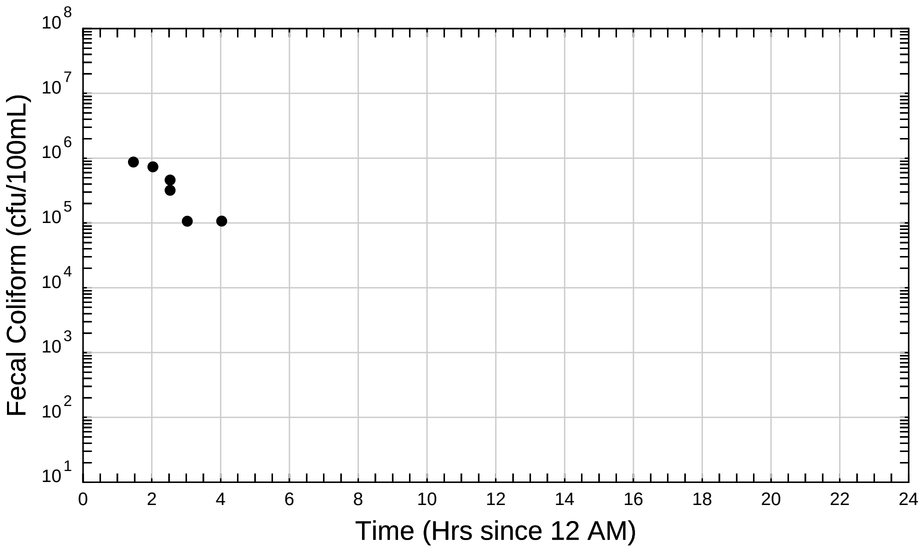


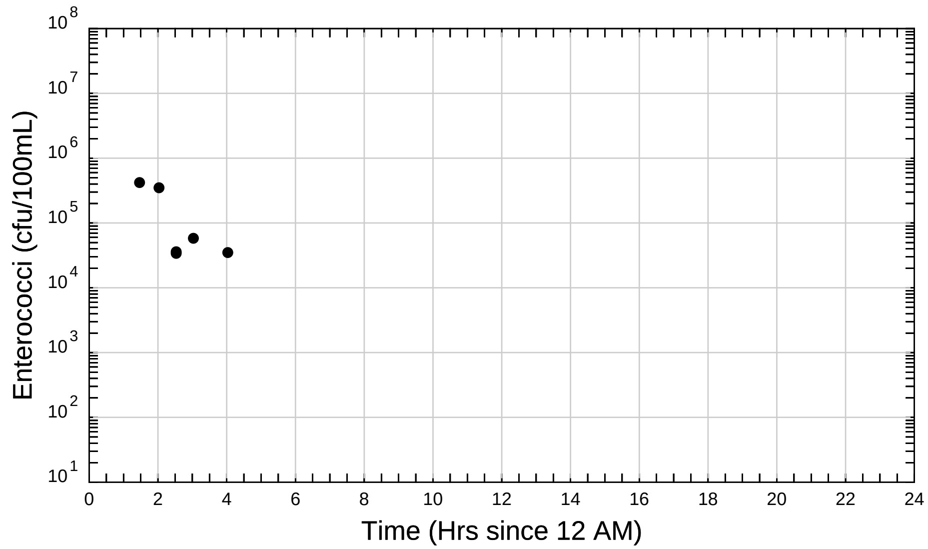

Fecal Coliform (cfu/100mL)
Time (Hrs since 12 AM)

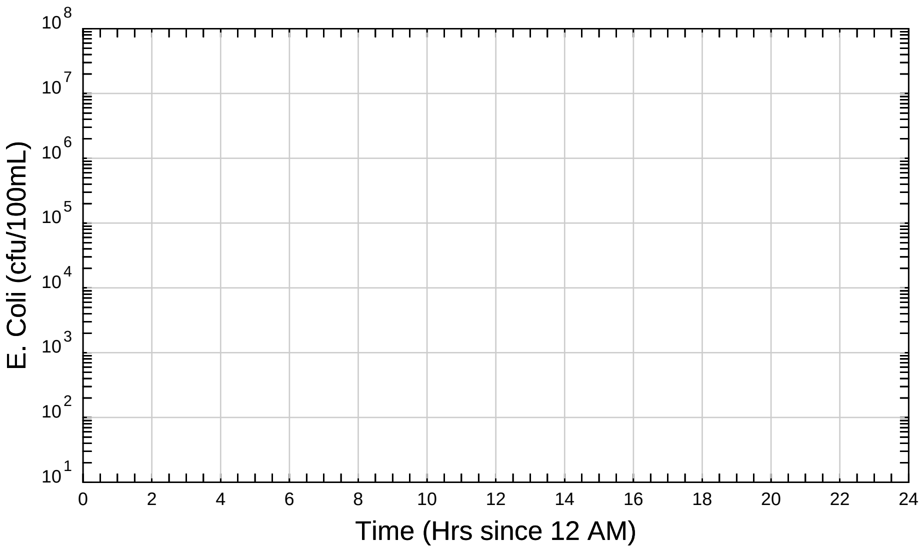

Enterococci (cfu/100mL)
Time (Hrs since 12 AM)

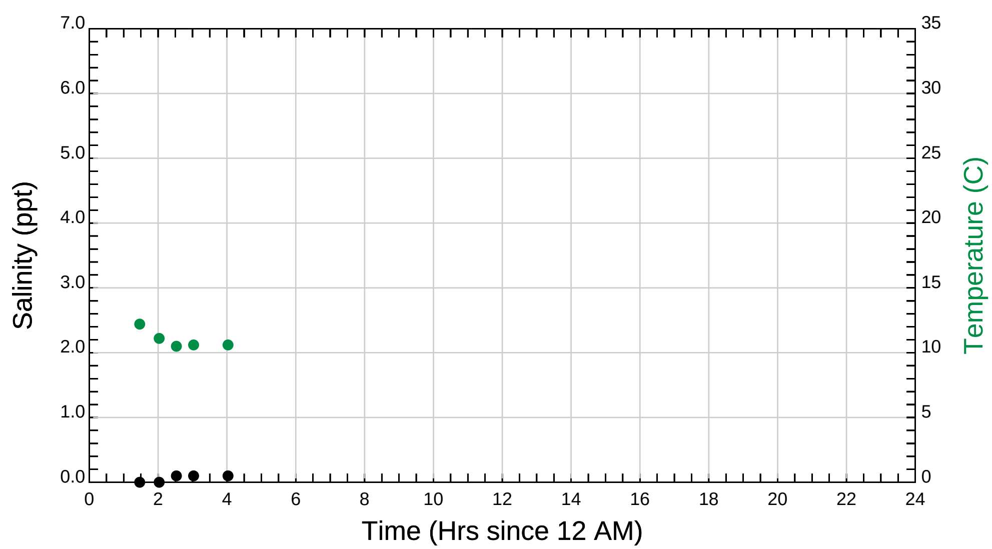

E. Coli (cfu/100mL)
Time (Hrs since 12 AM)

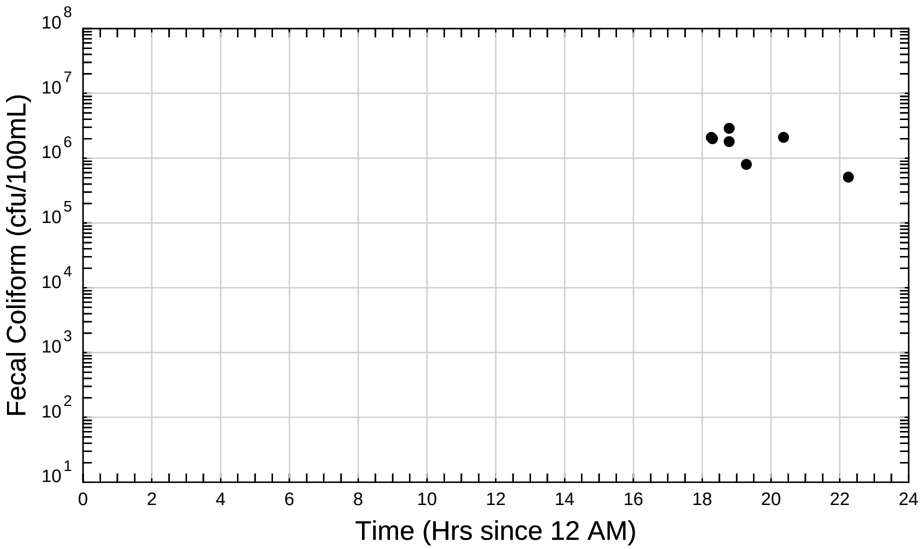

Salinity (ppt)
Temperature (C)
Time (Hrs since 12 AM)

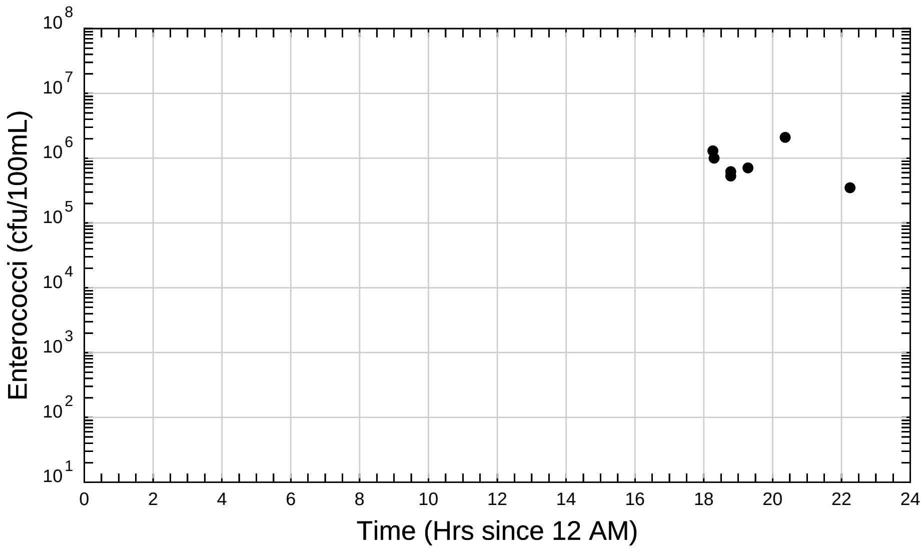

Fecal Coliform (cfu/100mL)
Time (Hrs since 12 AM)

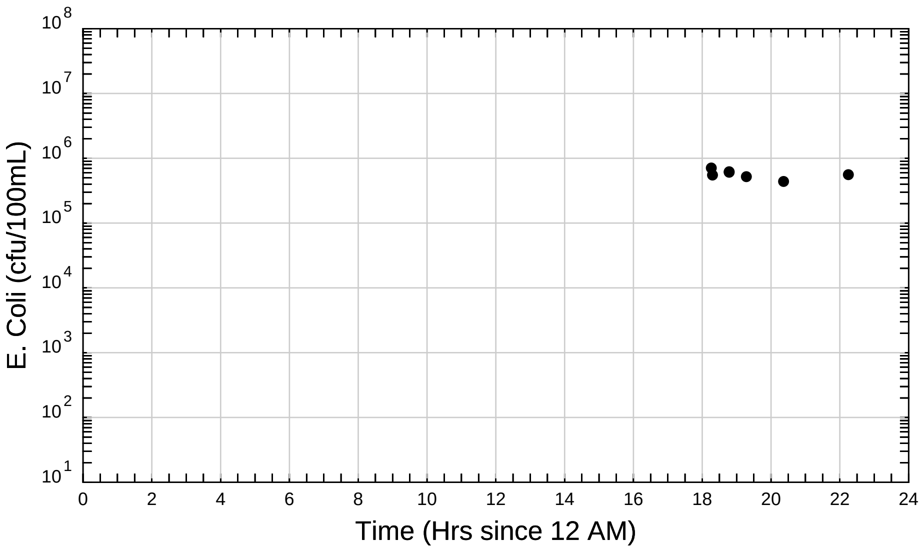

Enterococci (cfu/100mL)
Time (Hrs since 12 AM)

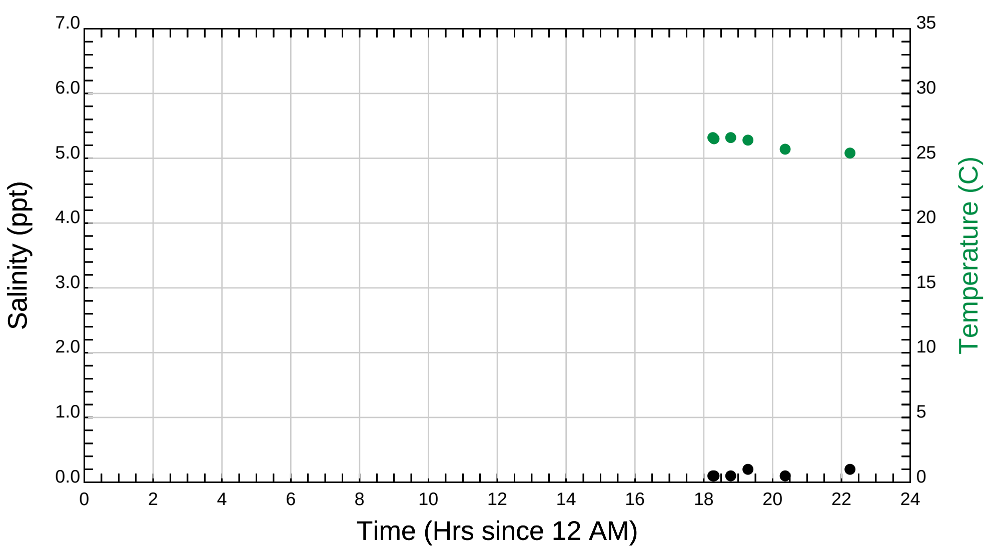

E. Coli (cfu/100mL)
Time (Hrs since 12 AM)

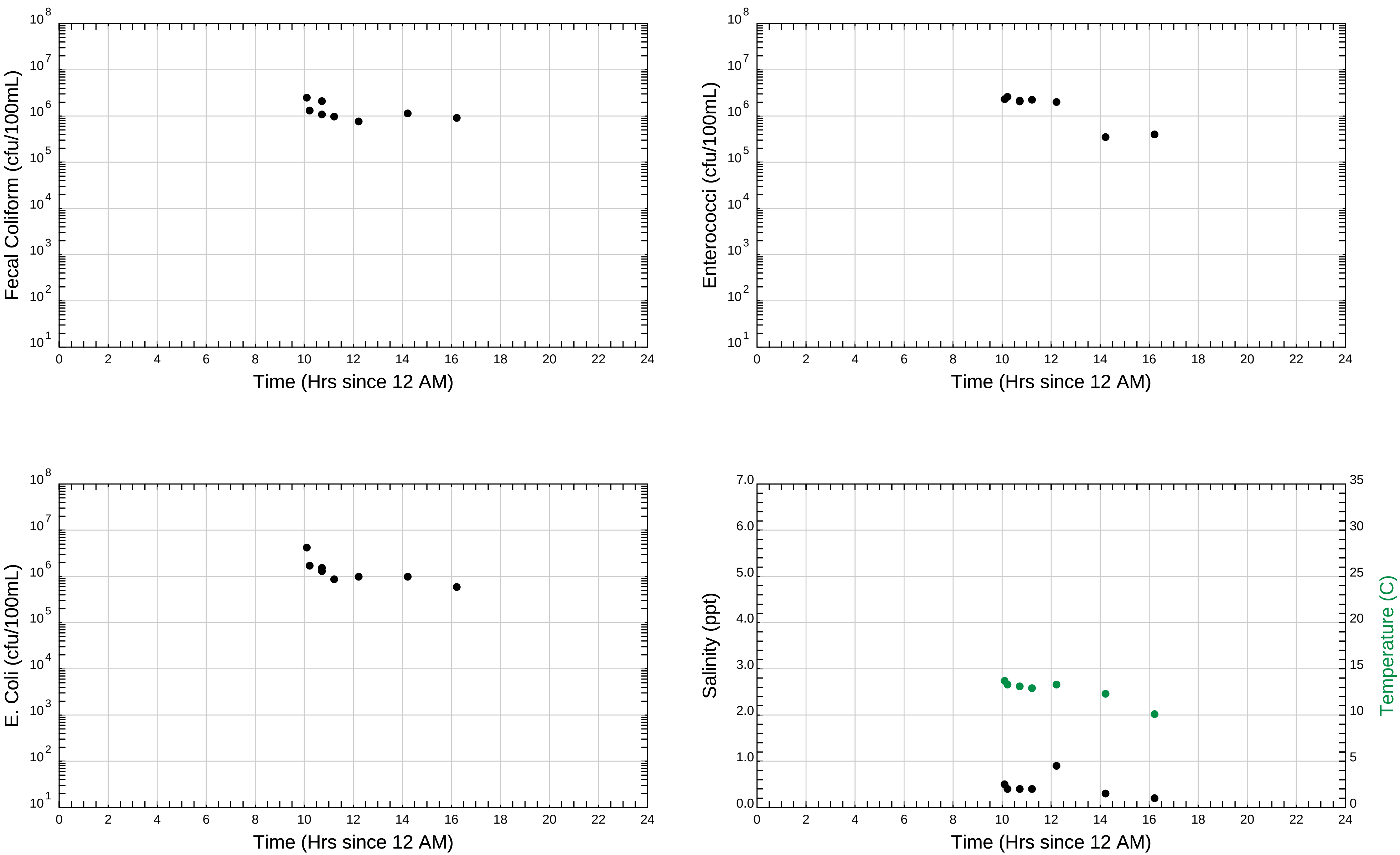

Salinity (ppt)
Temperature (C)
Time (Hrs since 12 AM)


Fecal Coliform (cfu/100mL)
Time (Hrs since 12 AM)

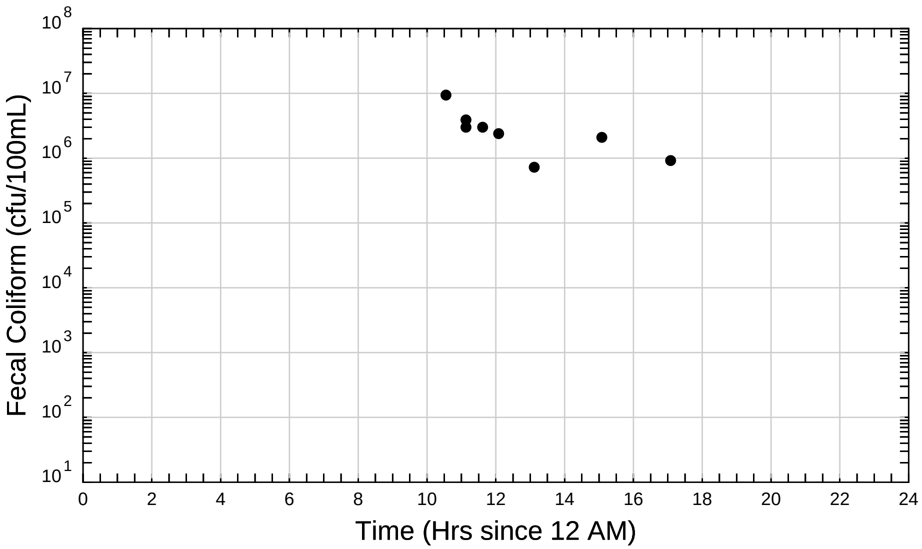

Enterococci (cfu/100mL)
Time (Hrs since 12 AM)

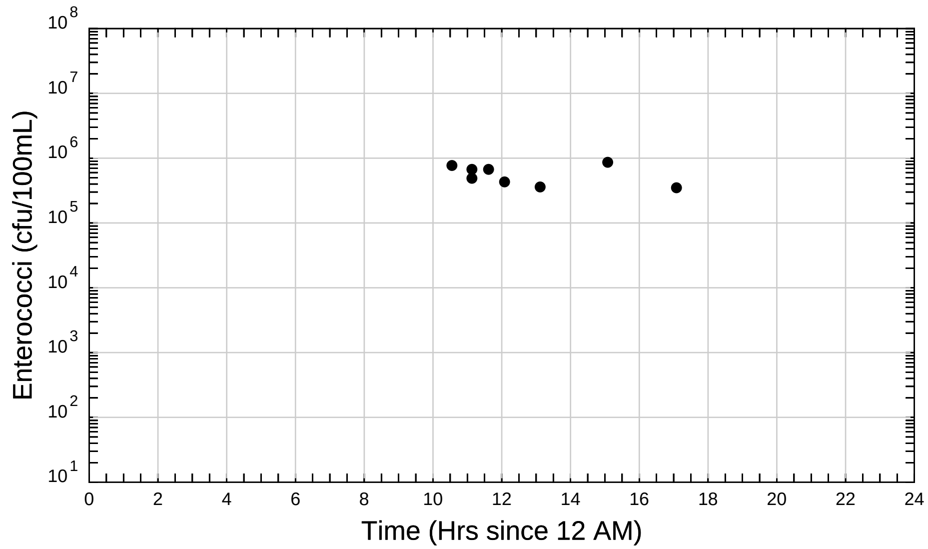

E. Coli (cfu/100mL)
Time (Hrs since 12 AM)

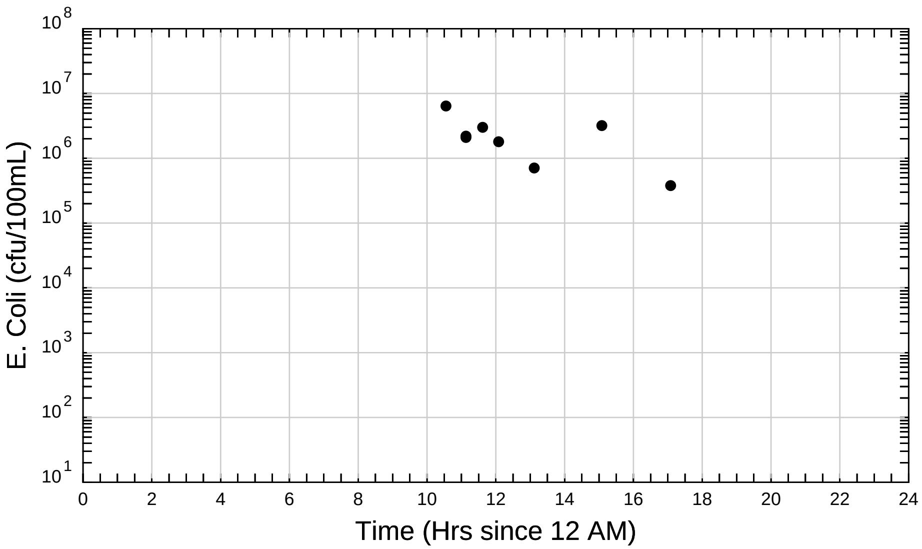

Salinity (ppt)
Temperature (C)
Time (Hrs since 12 AM)

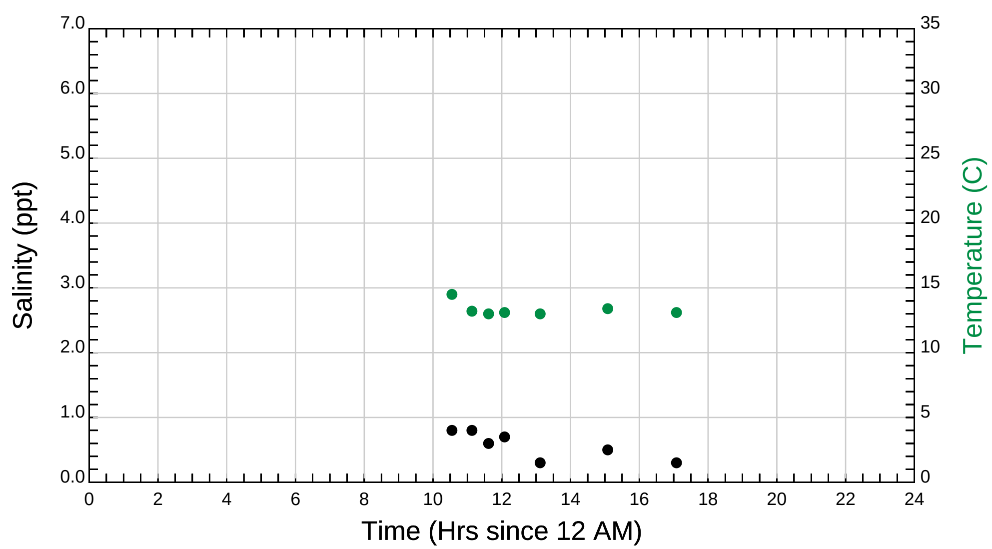

Fecal Coliform (cfu/100mL)
Time (Hrs since 12 AM)
Enterococci (cfu/100mL)
Time (Hrs since 12 AM)
E. Coli (cfu/100mL)
Time (Hrs since 12 AM)
Salinity (ppt)
Temperature (C)
Time (Hrs since 12 AM)

Station: C1-PAT-27A

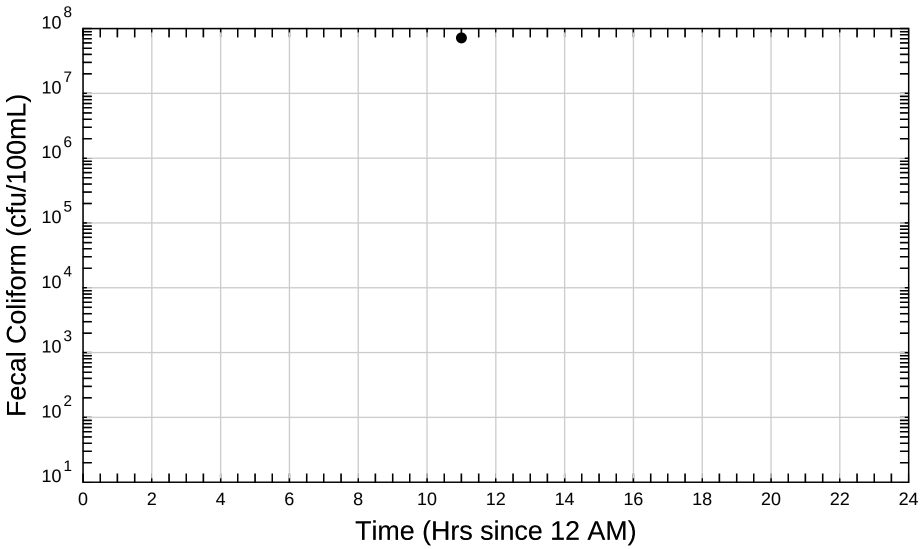


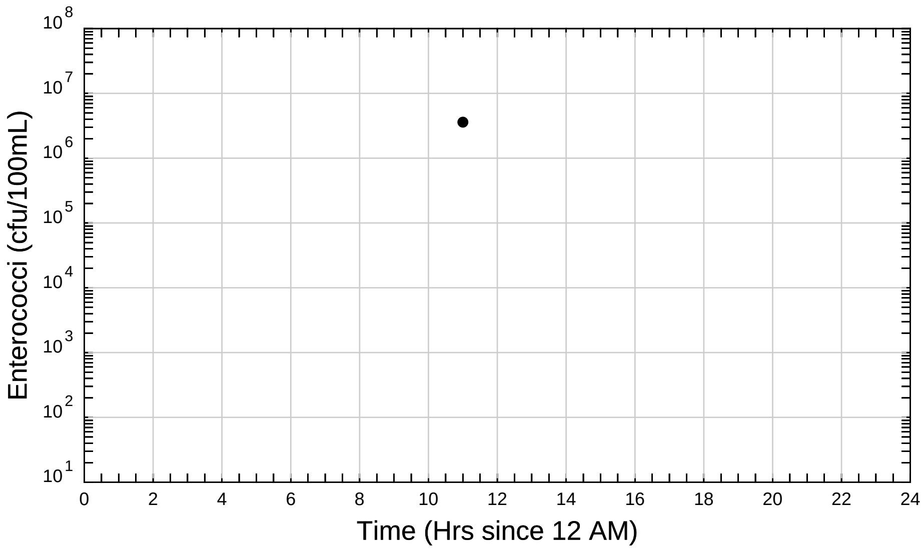


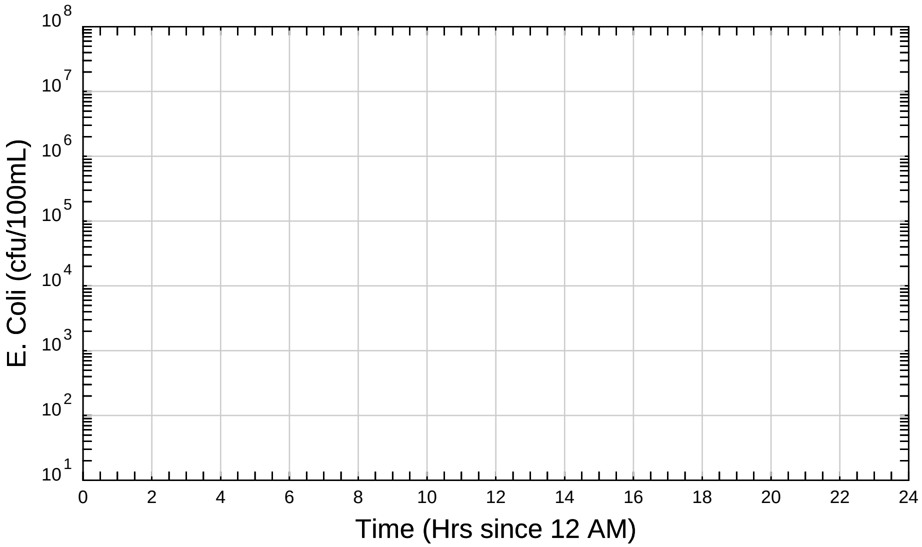


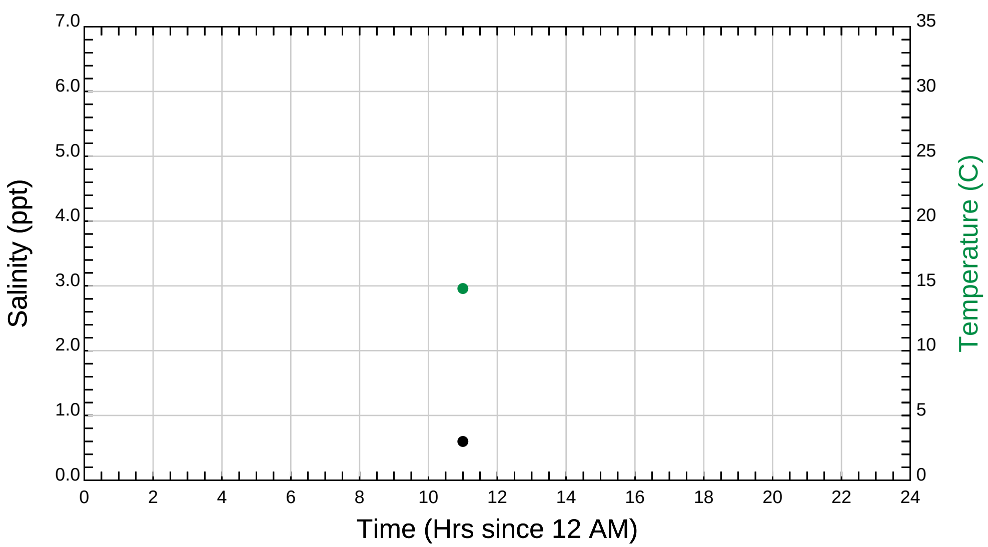


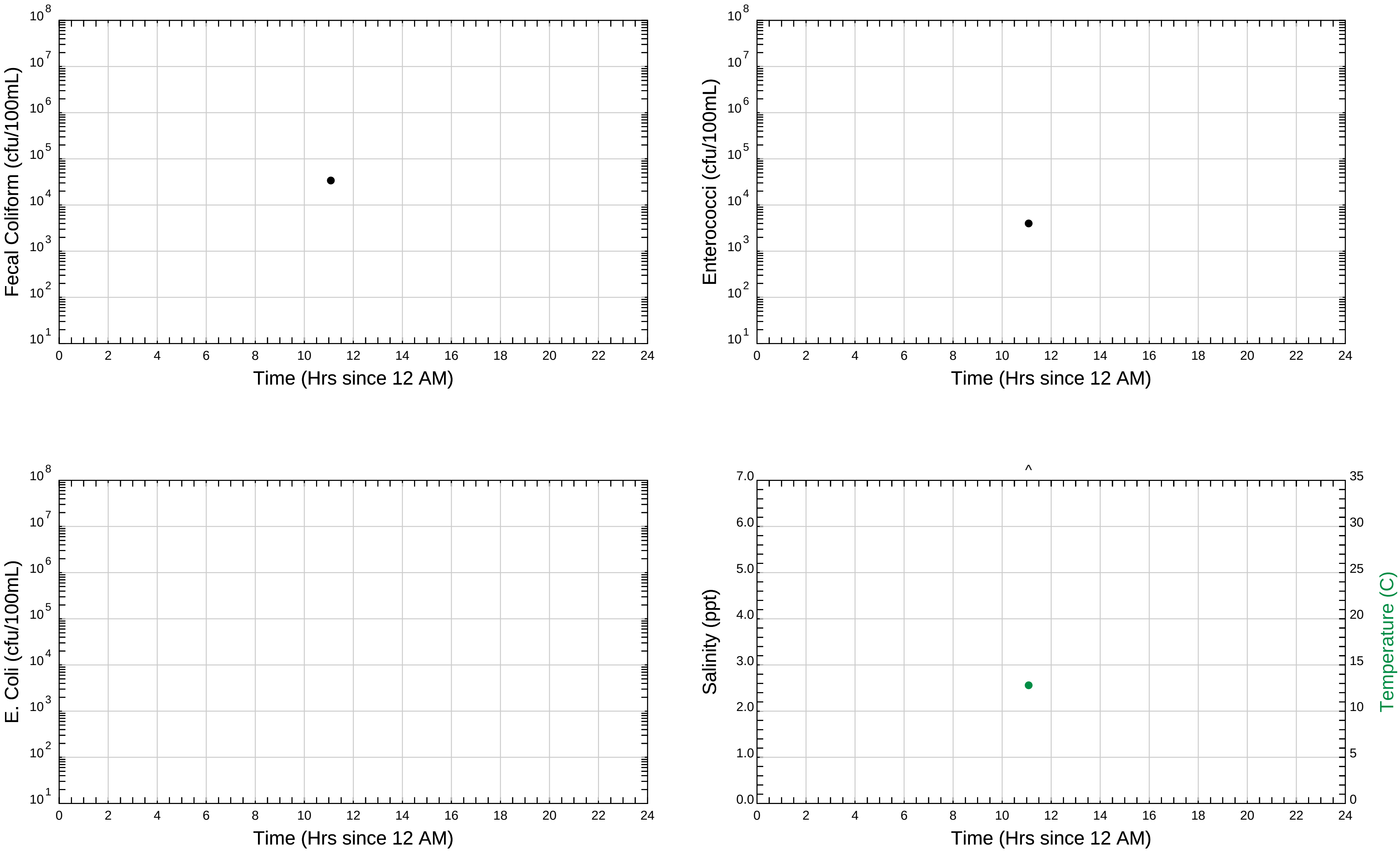
Station: C2-BAY-08A

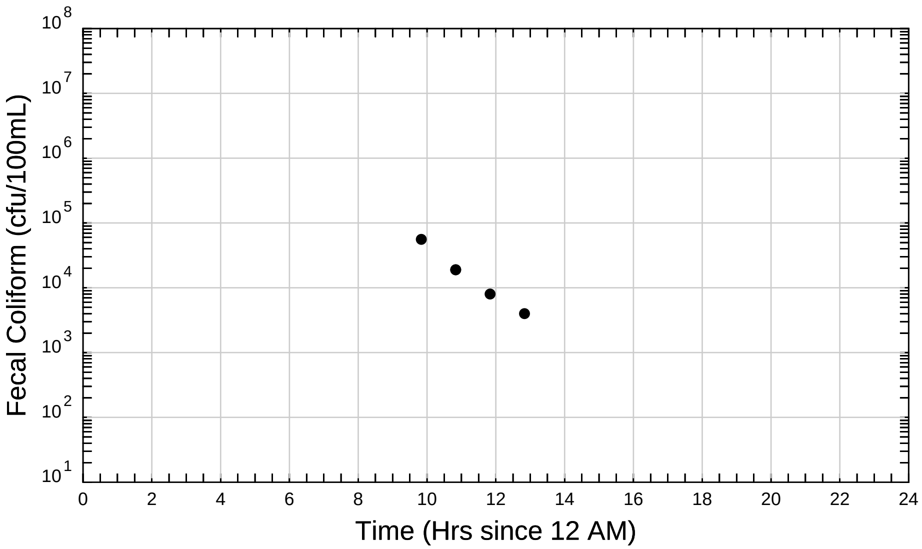


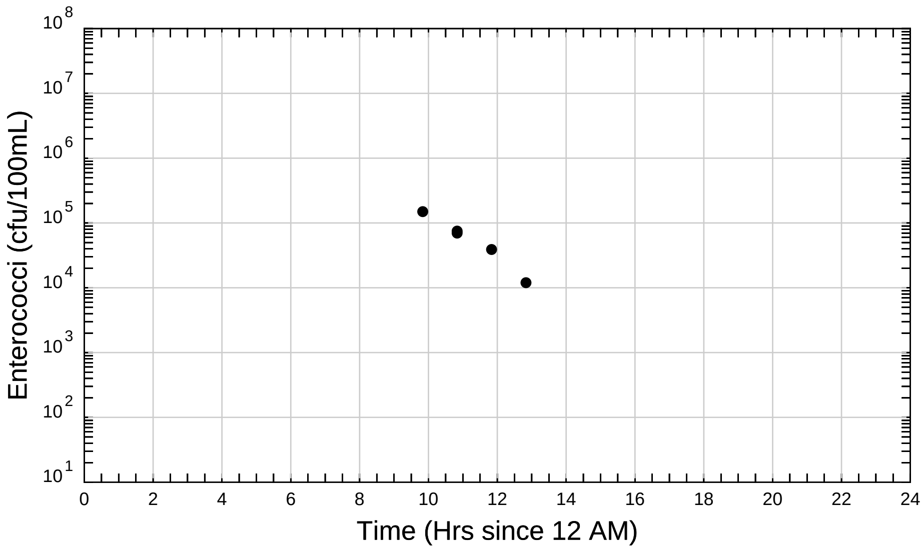


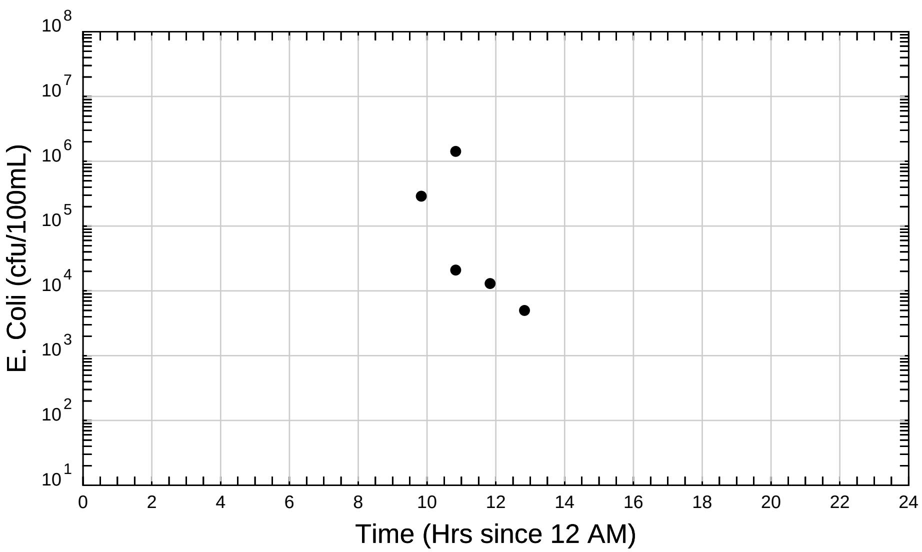


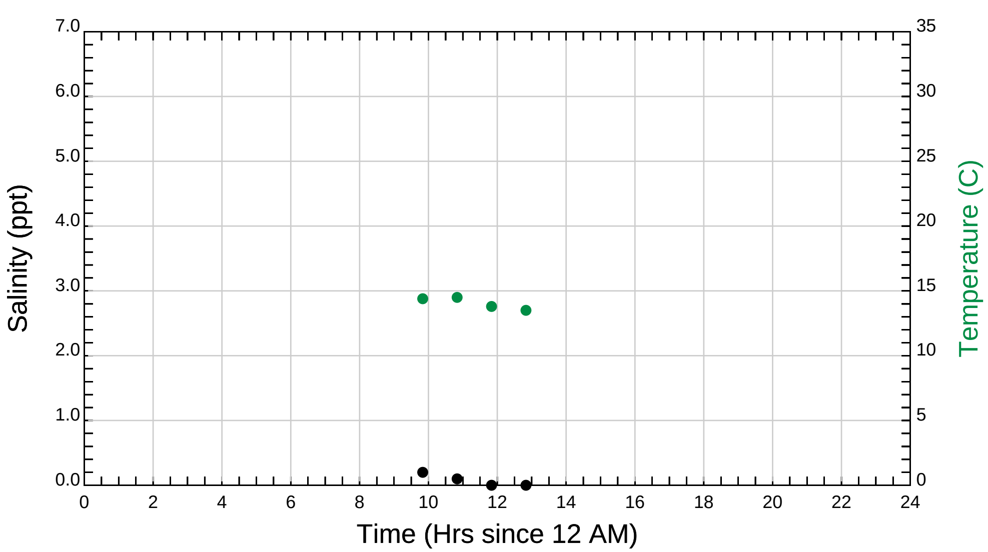


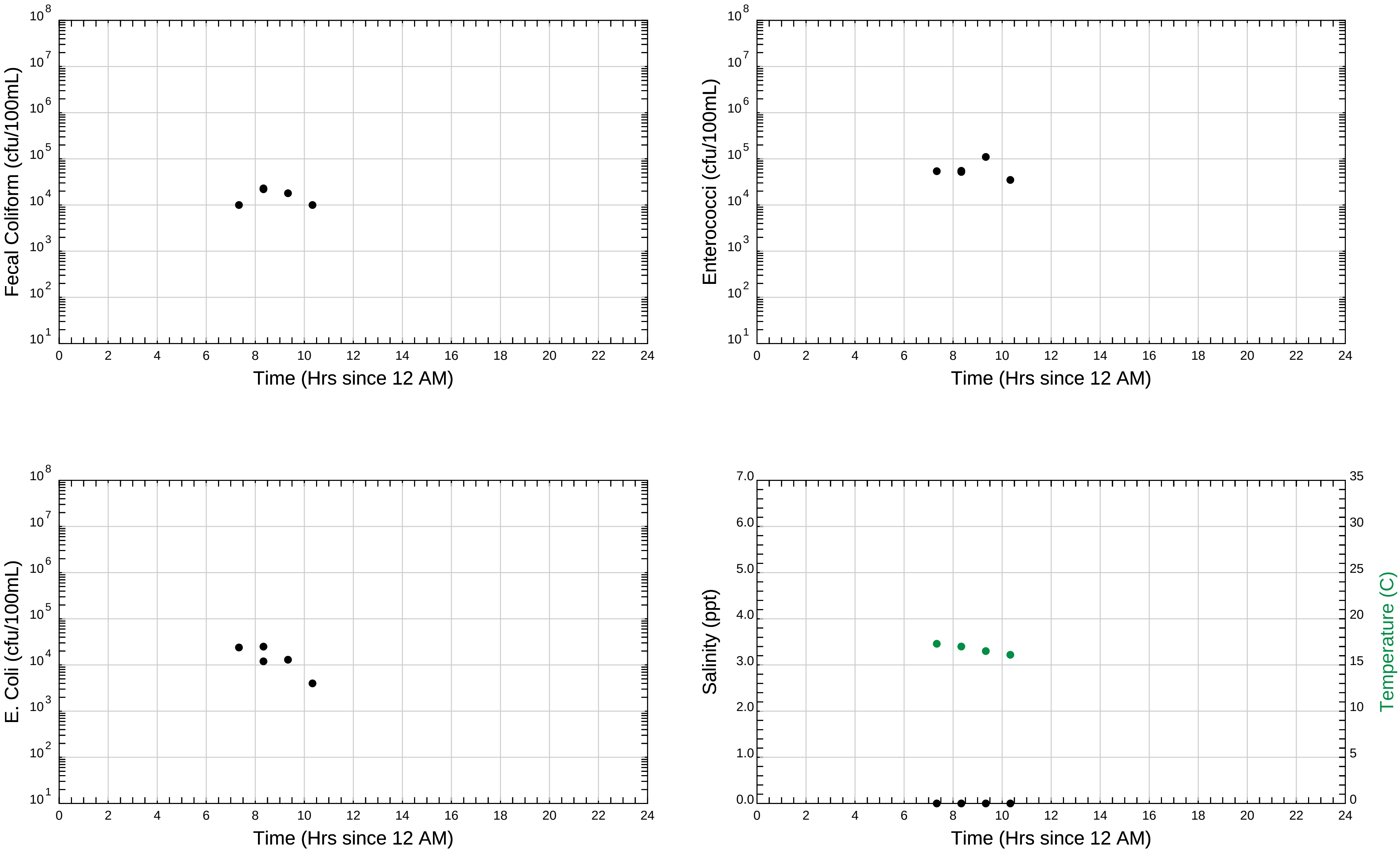

Fecal Coliform (cfu/100mL)
Time (Hrs since 12 AM)
Enterococci (cfu/100mL)
Time (Hrs since 12 AM)
E. Coli (cfu/100mL)
Time (Hrs since 12 AM)
Salinity (ppt)
Temperature (C)
^
Time (Hrs since 12 AM)

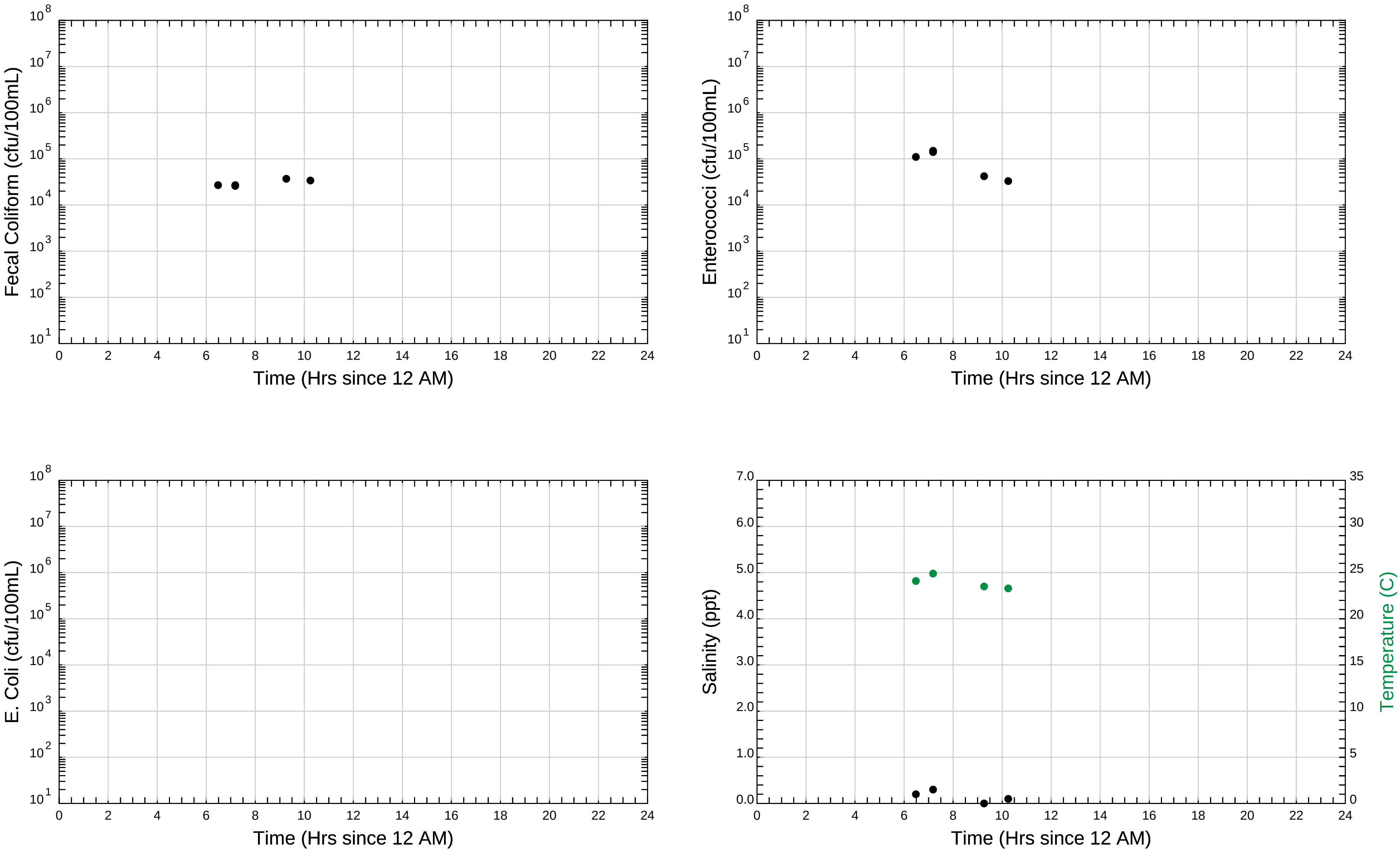

Fecal Coliform (cfu/100mL)
Time (Hrs since 12 AM)

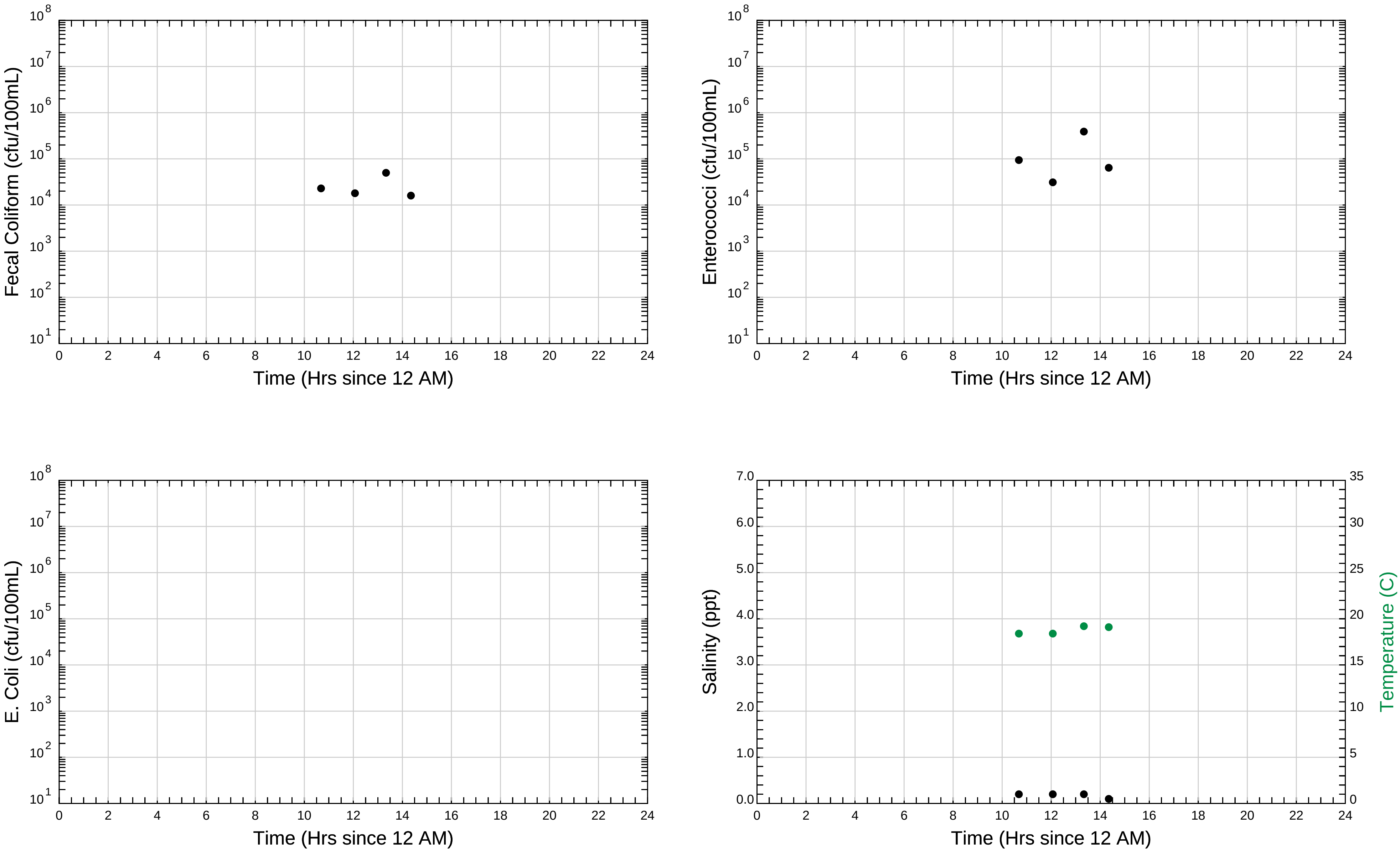

Enterococci (cfu/100mL)
Time (Hrs since 12 AM)

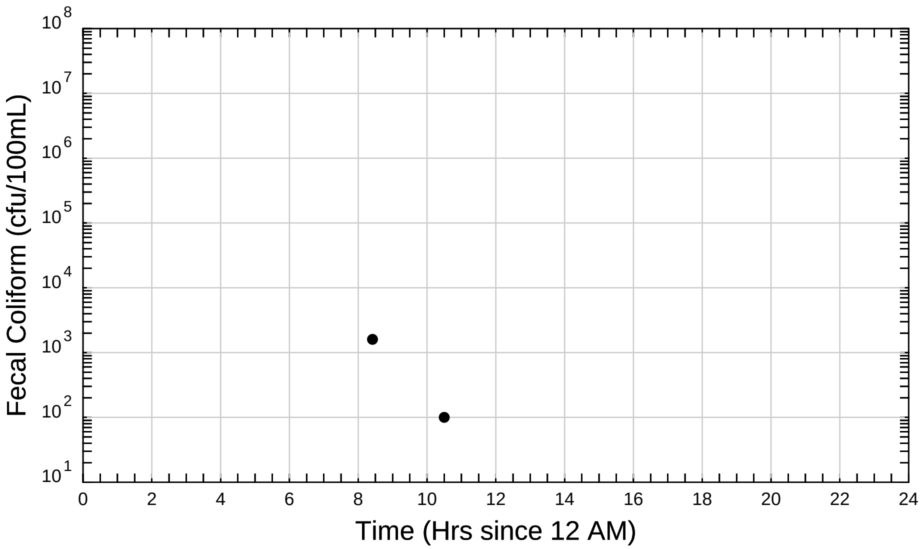

E. Coli (cfu/100mL)
Time (Hrs since 12 AM)

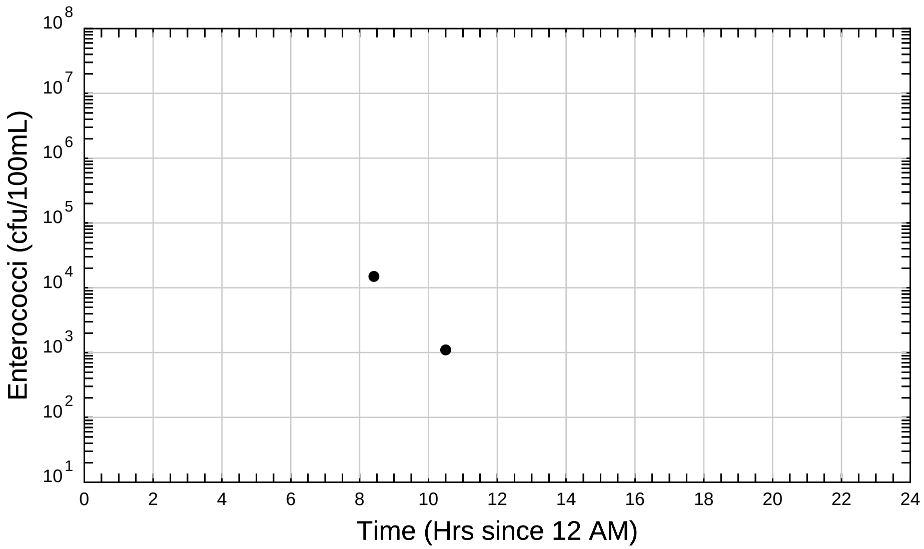

Salinity (ppt)
Temperature (C)
Time (Hrs since 12 AM)

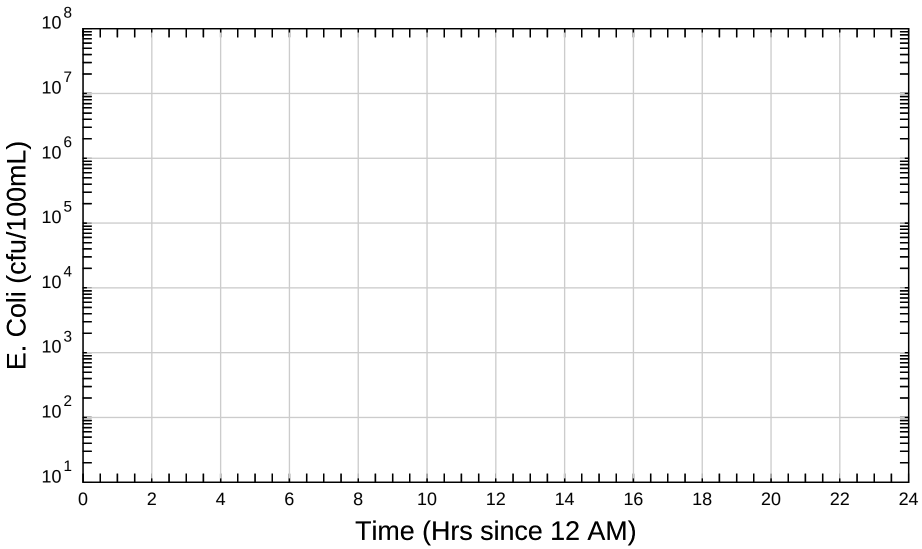

Fecal Coliform (cfu/100mL)
Enterococci (cfu/100mL)
E. Coli (cfu/100mL)
Salinity (ppt)
Temperature (C)
Time (Hrs since 12 AM)

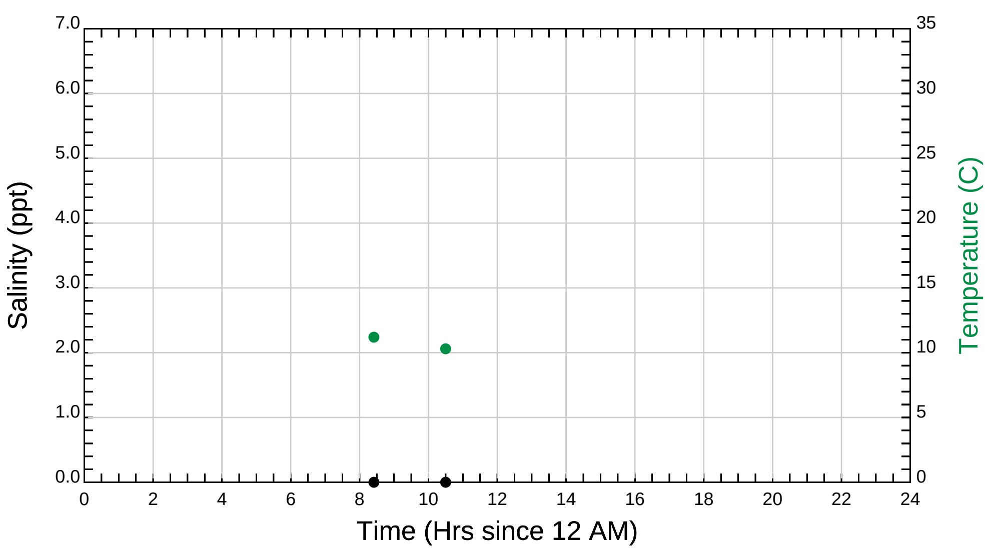

Fecal Coliform (cfu/100mL)
Time (Hrs since 12 AM)
Enterococci (cfu/100mL)
Time (Hrs since 12 AM)
E. Coli (cfu/100mL)
Time (Hrs since 12 AM)
Salinity (ppt)
Temperature (C)
Time (Hrs since 12 AM)

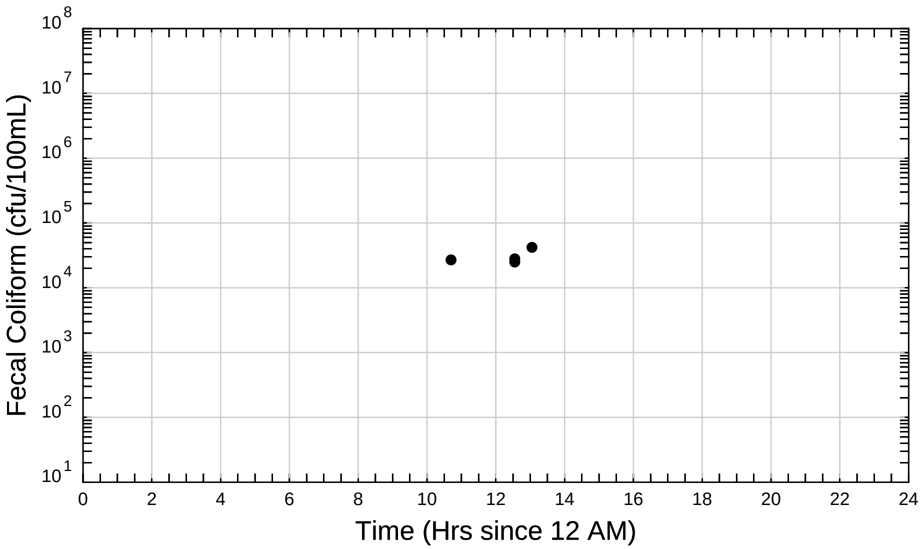

Fecal Coliform (cfu/100mL)
Time (Hrs since 12 AM)
Enterococci (cfu/100mL)
Time (Hrs since 12 AM)
E. Coli (cfu/100mL)
Time (Hrs since 12 AM)
Salinity (ppt)
Temperature (C)
Time (Hrs since 12 AM)

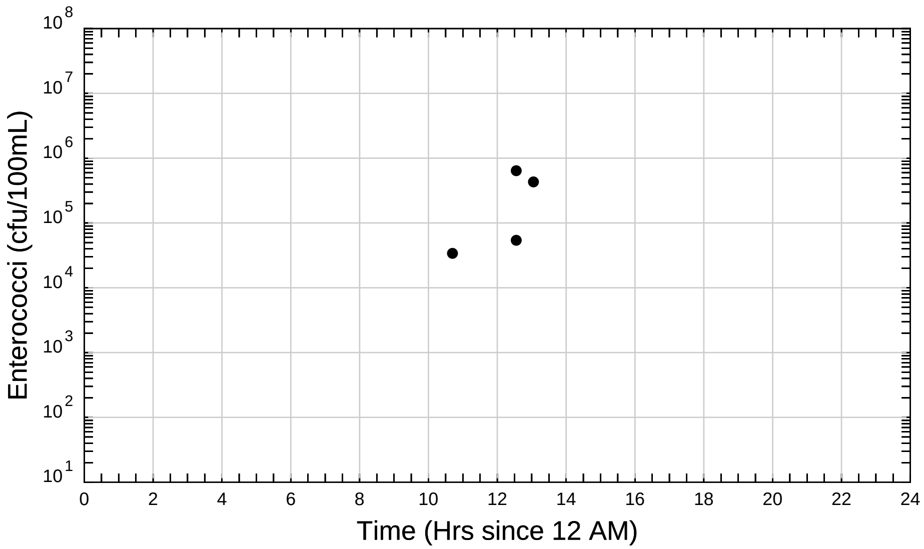

Fecal Coliform (cfu/100mL)
Time (Hrs since 12 AM)

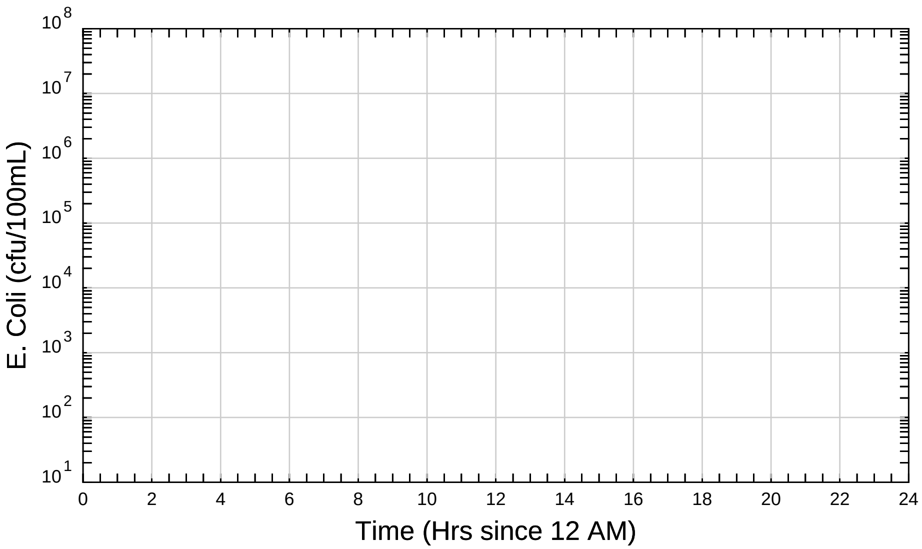

Enterococci (cfu/100mL)
Time (Hrs since 12 AM)

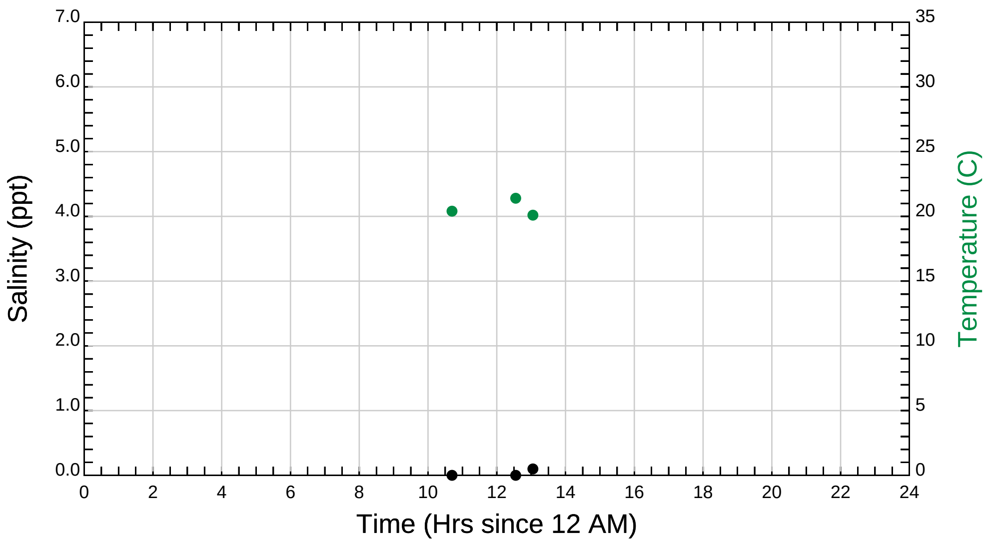

E. Coli (cfu/100mL)
Time (Hrs since 12 AM)


Salinity (ppt)
Temperature (C)
Time (Hrs since 12 AM)


Fecal Coliform (cfu/100mL)
Time (Hrs since 12 AM)

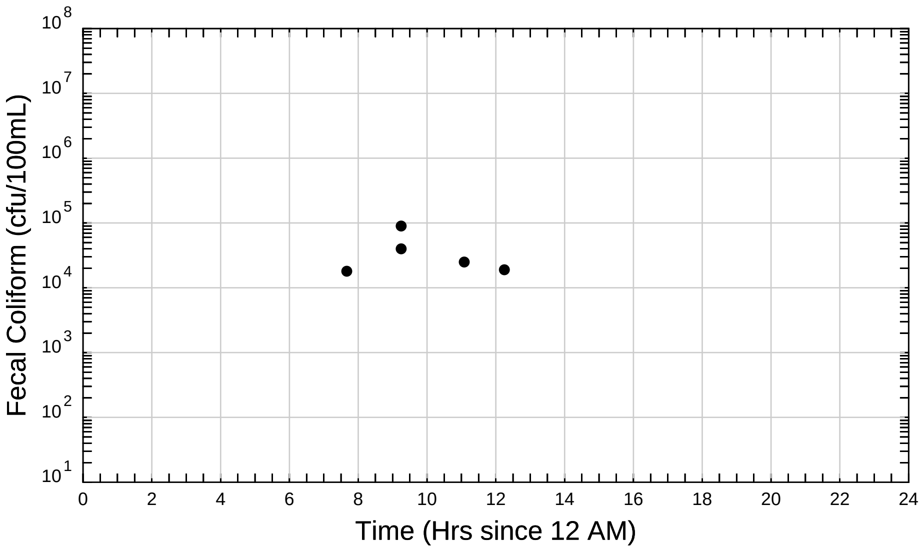

Enterococci (cfu/100mL)
Time (Hrs since 12 AM)

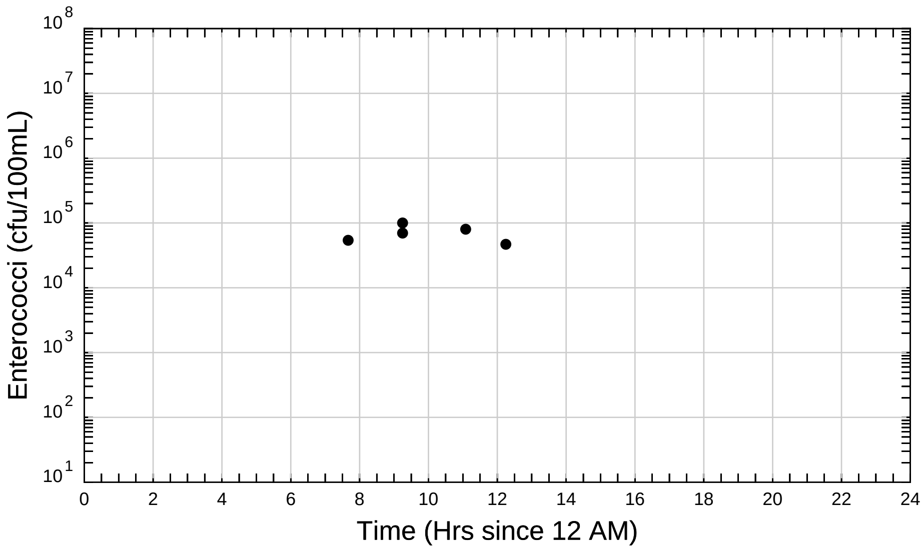

E. Coli (cfu/100mL)
Time (Hrs since 12 AM)

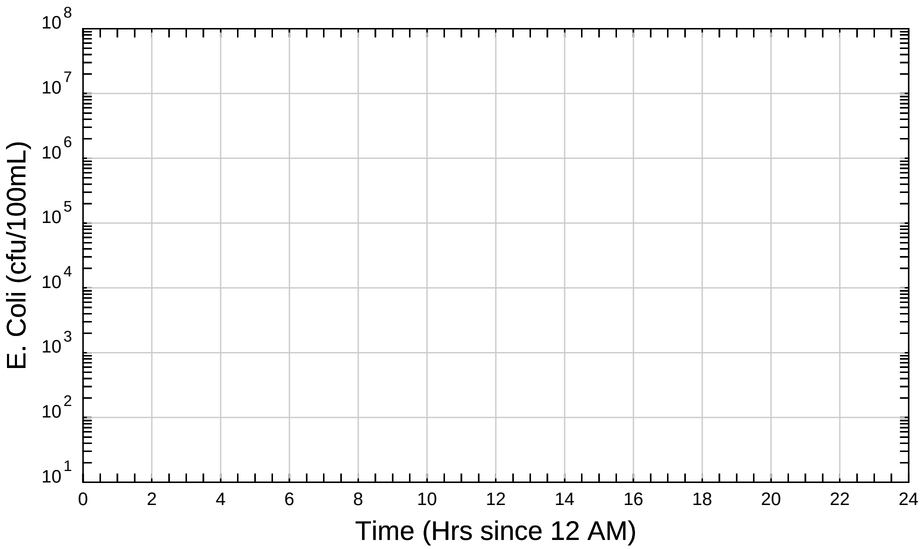

Salinity (ppt)
Temperature (C)
Time (Hrs since 12 AM)

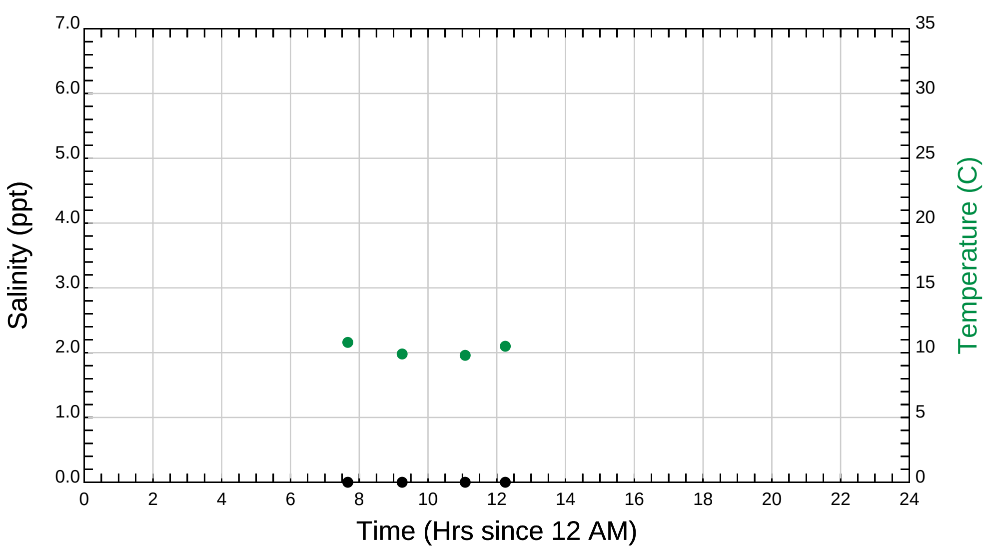
Wet-Weather Event 11. 15. 2016.

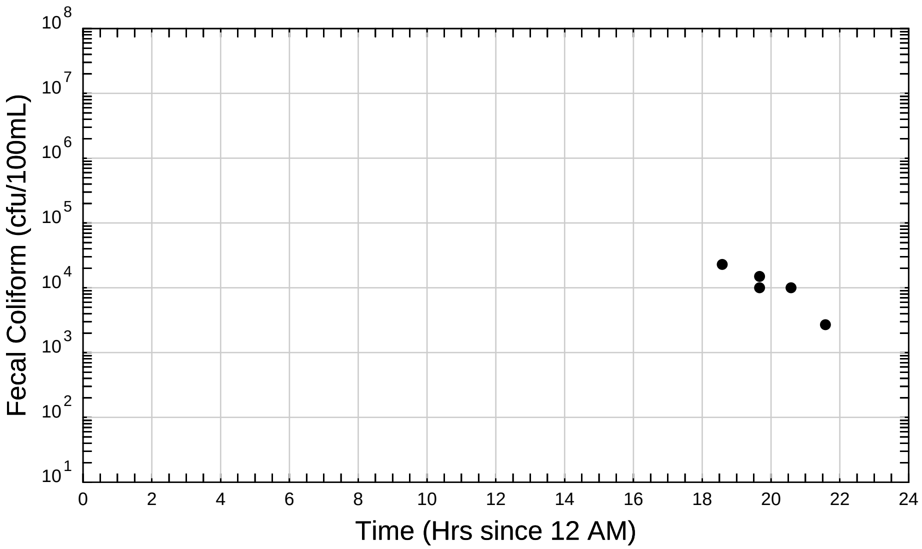
Station: S1-NWK-HR1

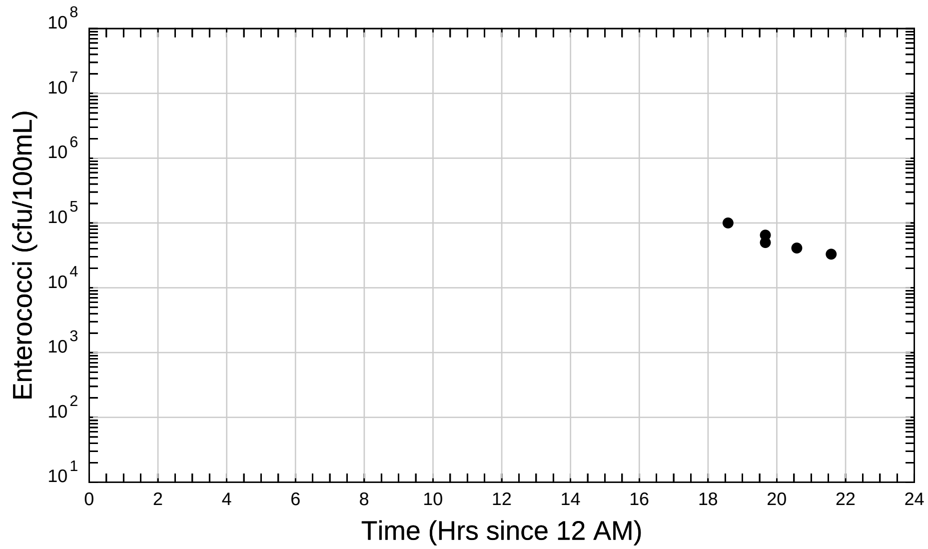


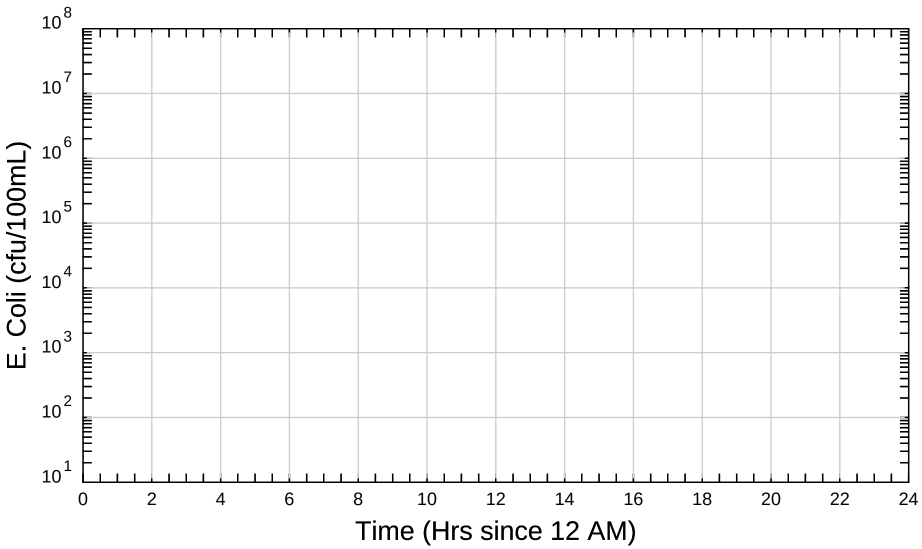


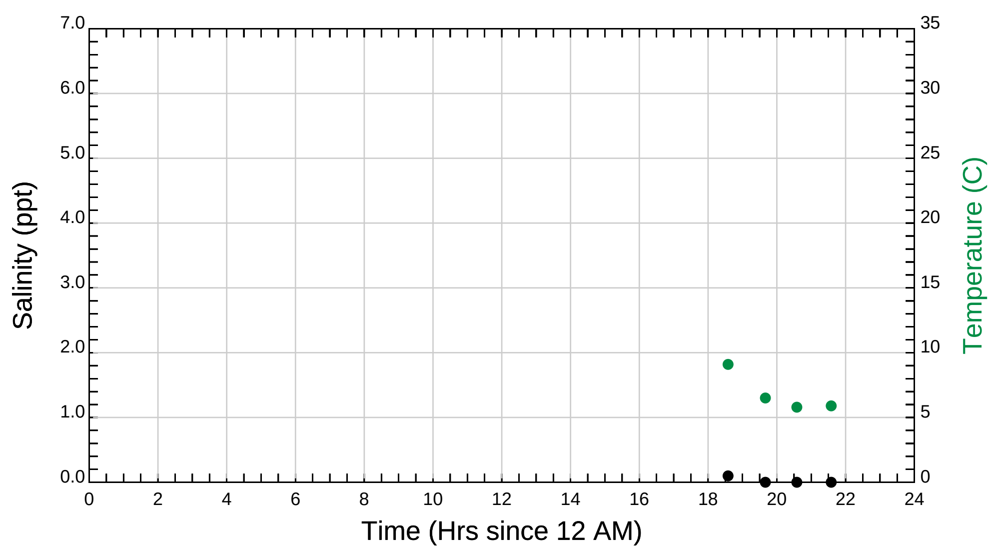


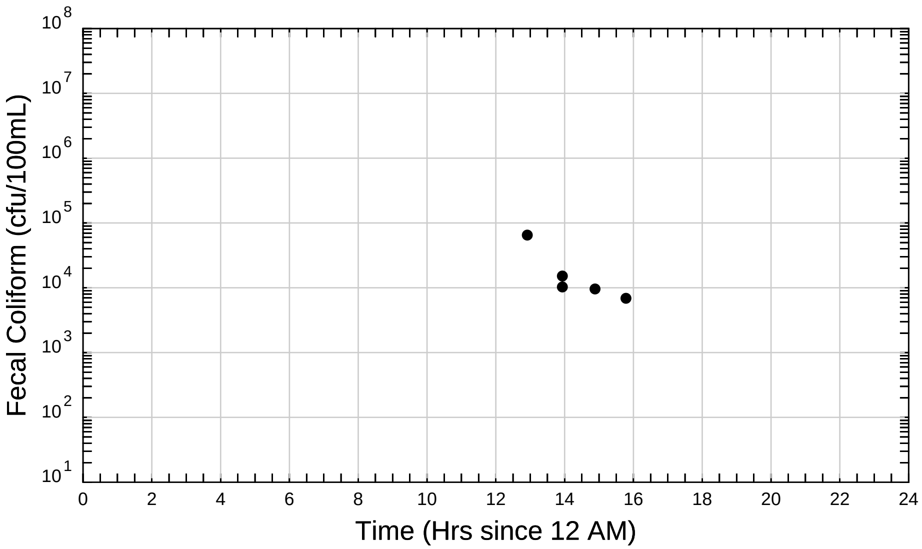


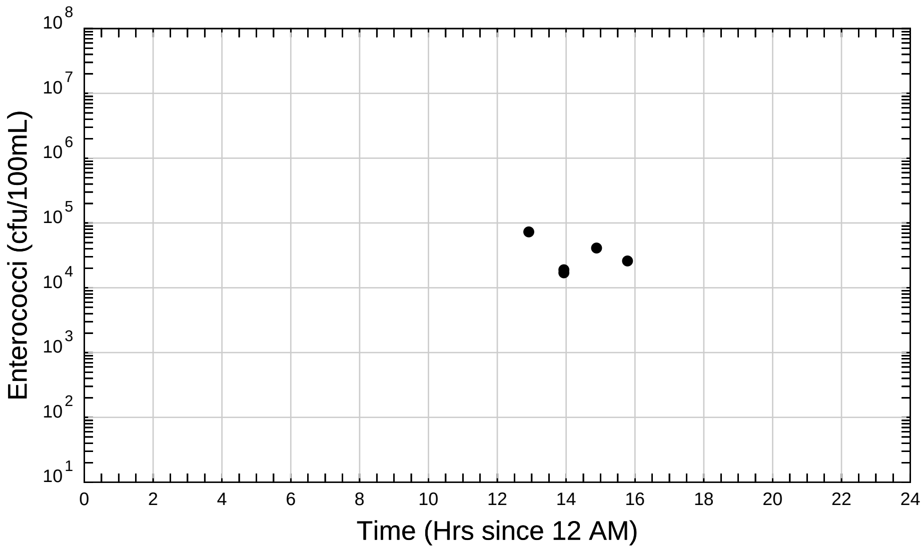

Fecal Coliform (cfu/100mL)
Time (Hrs since 12 AM)

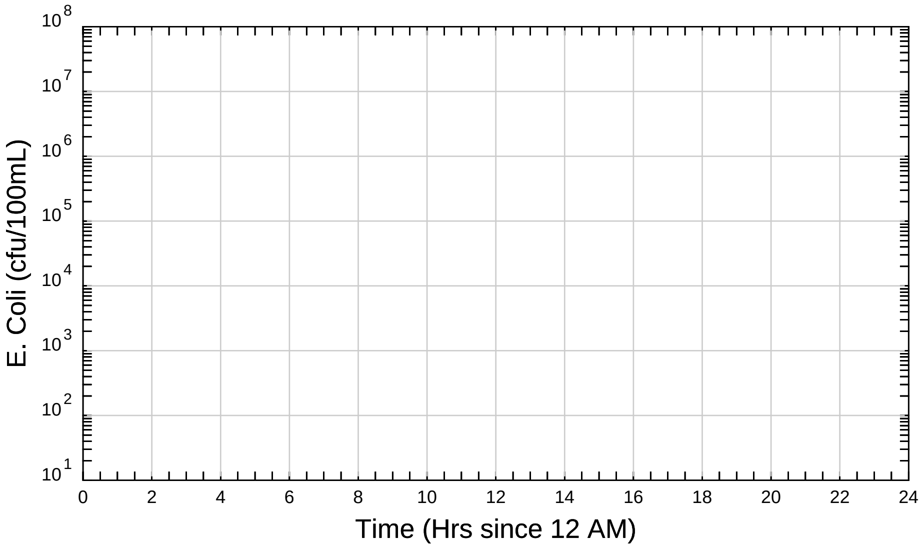

Enterococci (cfu/100mL)
Time (Hrs since 12 AM)

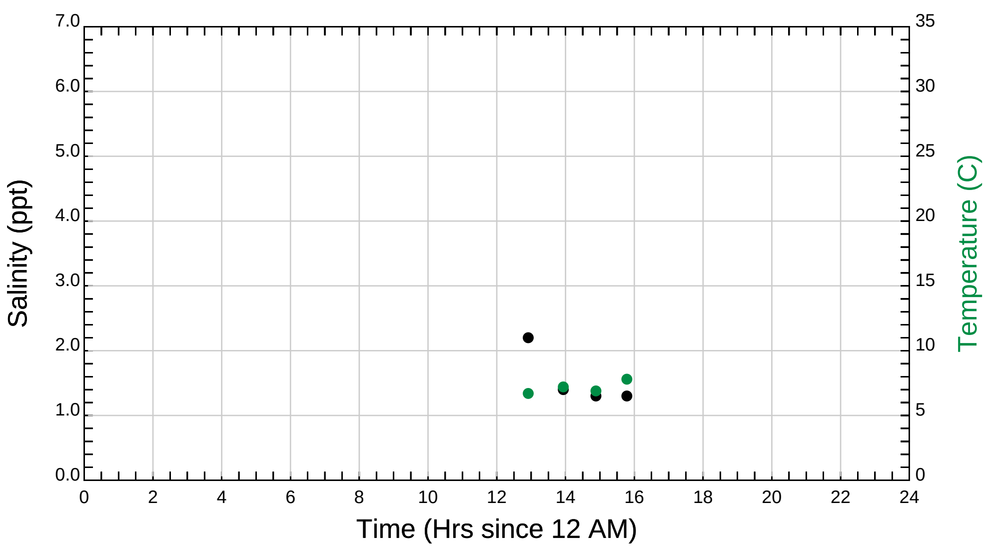

E. Coli (cfu/100mL)
Time (Hrs since 12 AM)

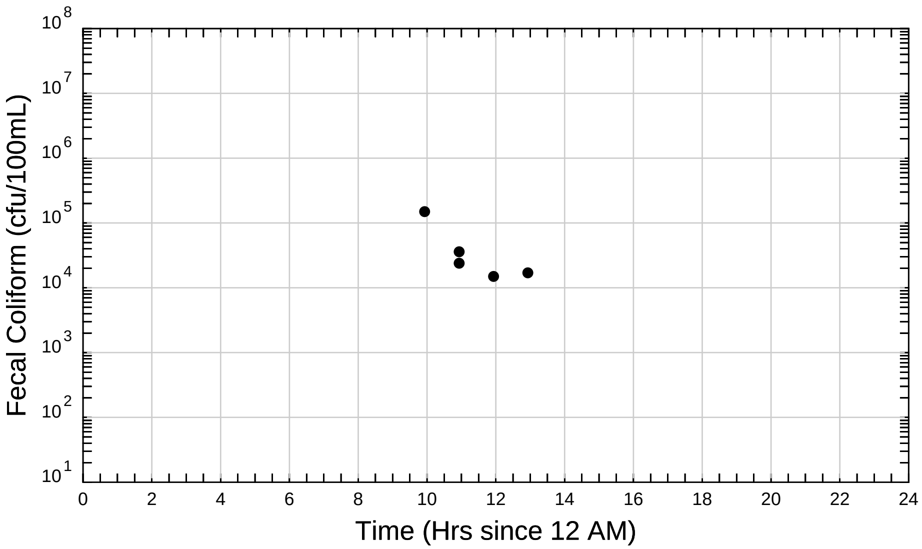

Salinity (ppt)
Temperature (C)
Time (Hrs since 12 AM)

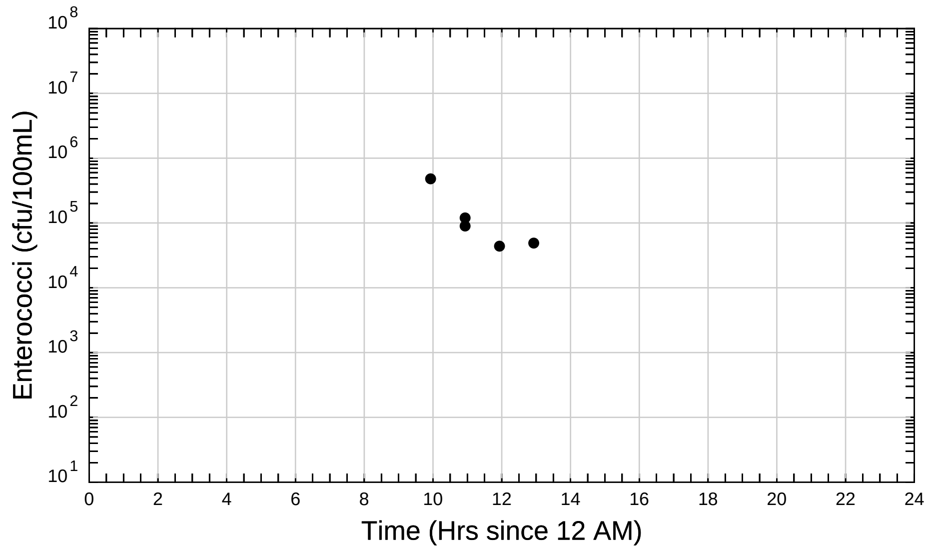

Fecal Coliform (cfu/100mL)
Time (Hrs since 12 AM)

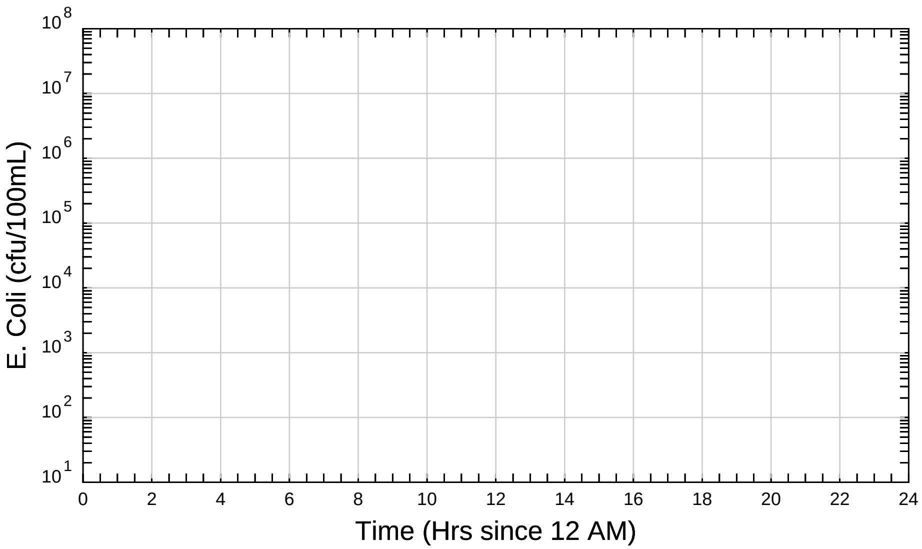

Enterococci (cfu/100mL)
Time (Hrs since 12 AM)

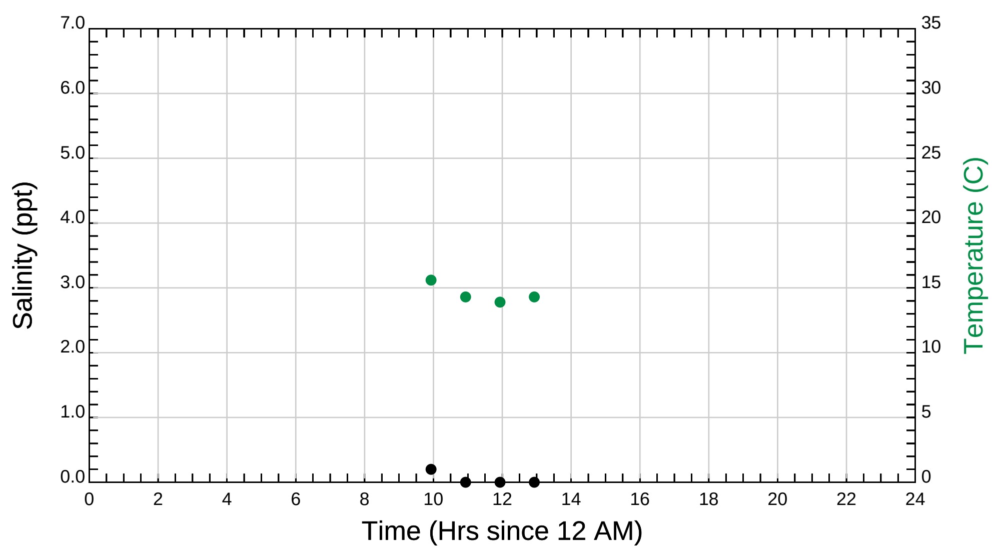

E. Coli (cfu/100mL)
Time (Hrs since 12 AM)

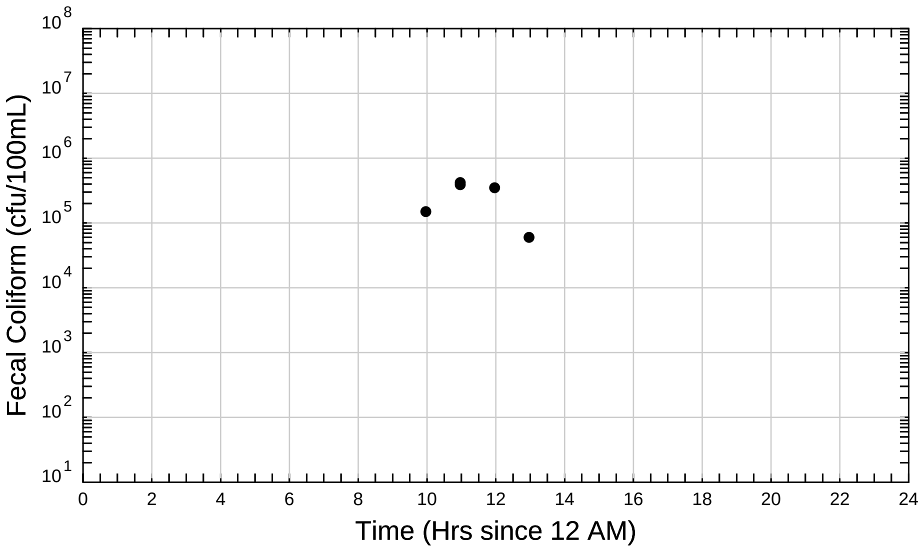

Salinity (ppt)
Temperature (C)
Time (Hrs since 12 AM)

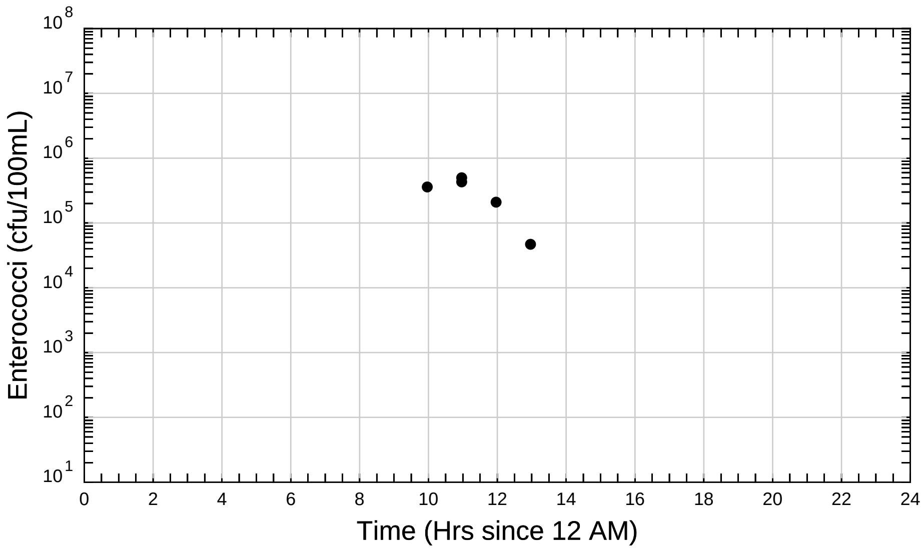

Fecal Coliform (cfu/100mL)
Time (Hrs since 12 AM)

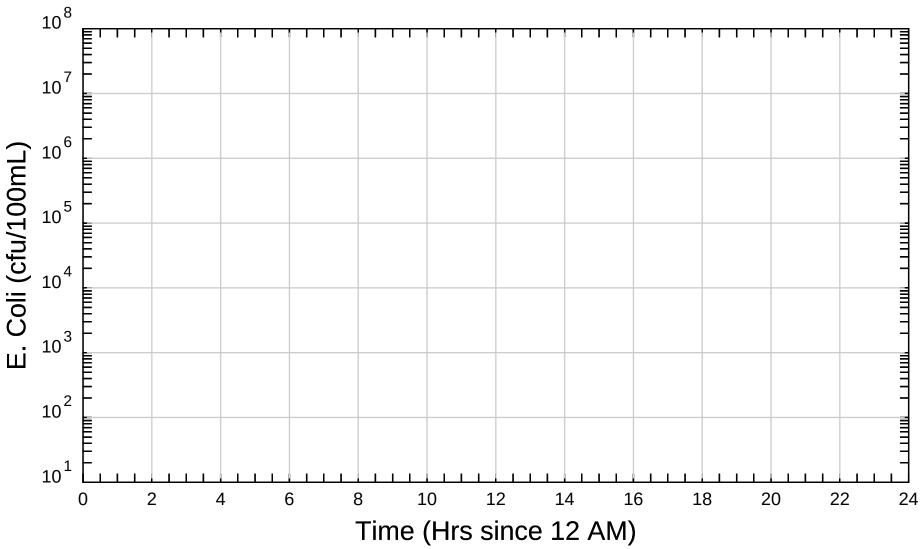

Enterococci (cfu/100mL)
Time (Hrs since 12 AM)

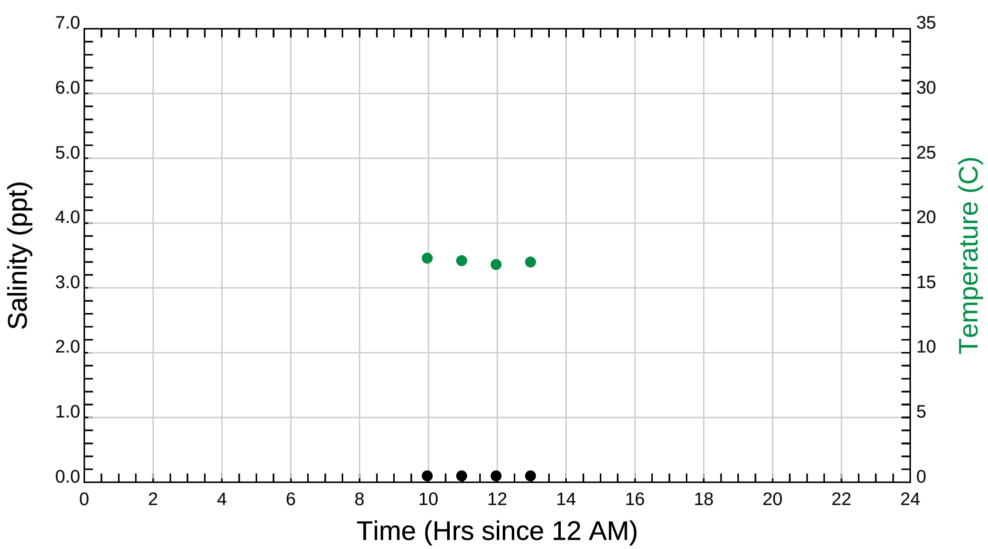

E. Coli (cfu/100mL)
Time (Hrs since 12 AM)

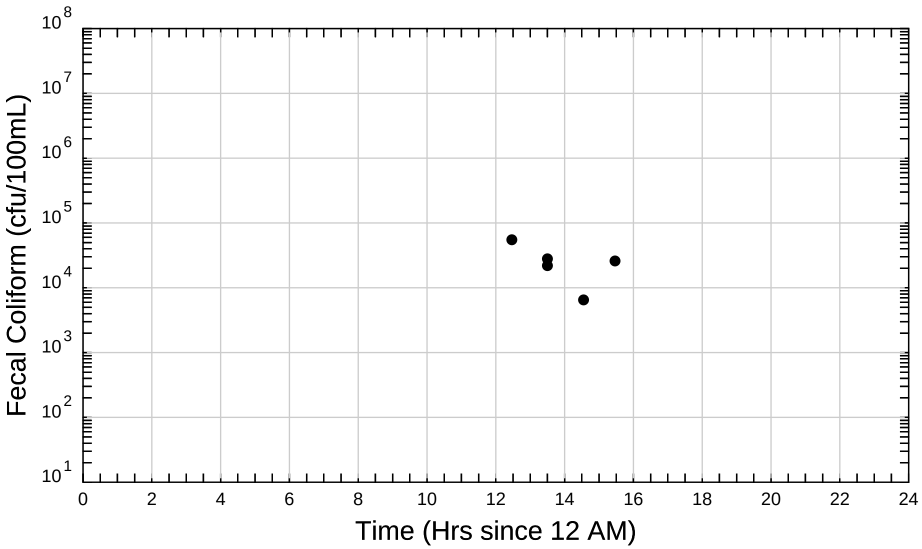

Salinity (ppt)
Temperature (C)
Time (Hrs since 12 AM)

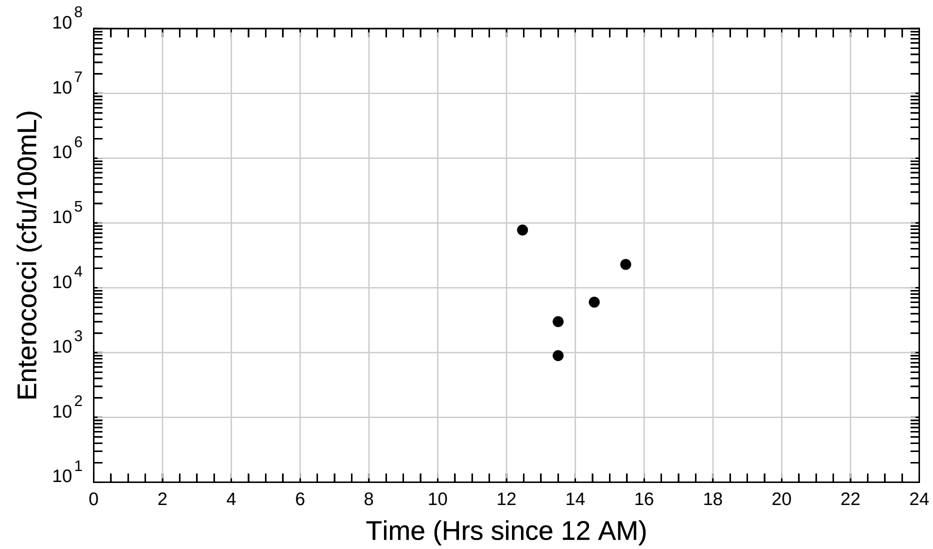

Fecal Coliform (cfu/100mL)
Time (Hrs since 12 AM)

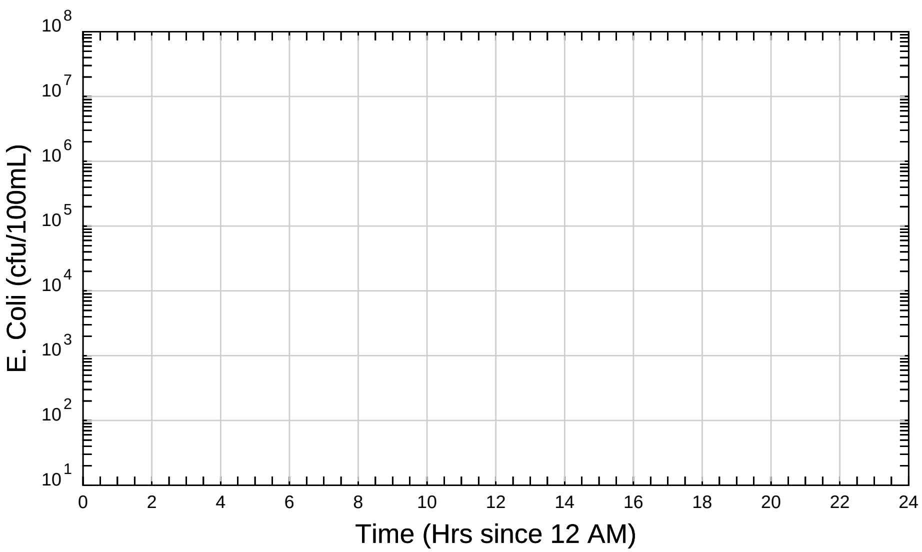

Enterococci (cfu/100mL)
Time (Hrs since 12 AM)

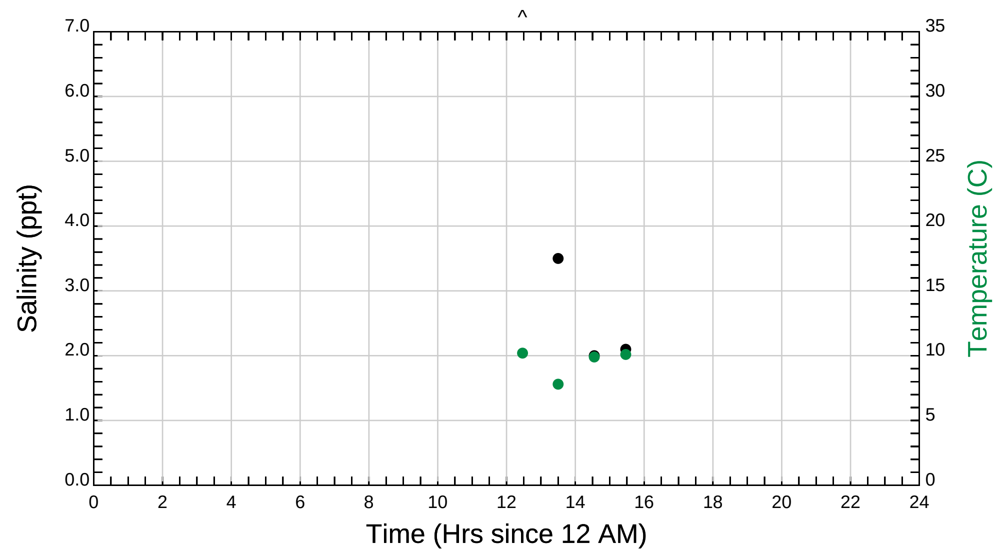

E. Coli (cfu/100mL)
Time (Hrs since 12 AM)


Salinity (ppt)
Temperature (C)
Time (Hrs since 12 AM)


Fecal Coliform (cfu/100mL)
Time (Hrs since 12 AM)


Enterococci (cfu/100mL)
Time (Hrs since 12 AM)


E. Coli (cfu/100mL)
Time (Hrs since 12 AM)


Salinity (ppt)
Temperature (C)
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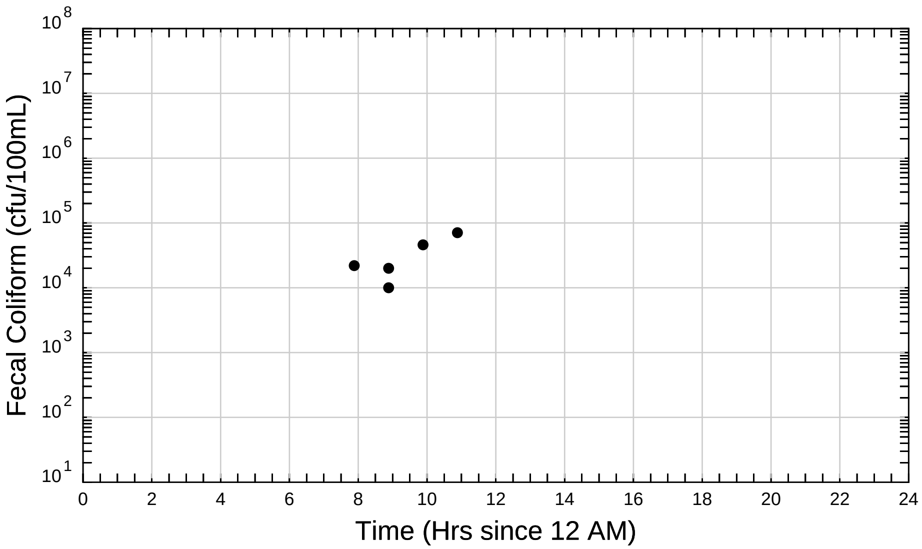
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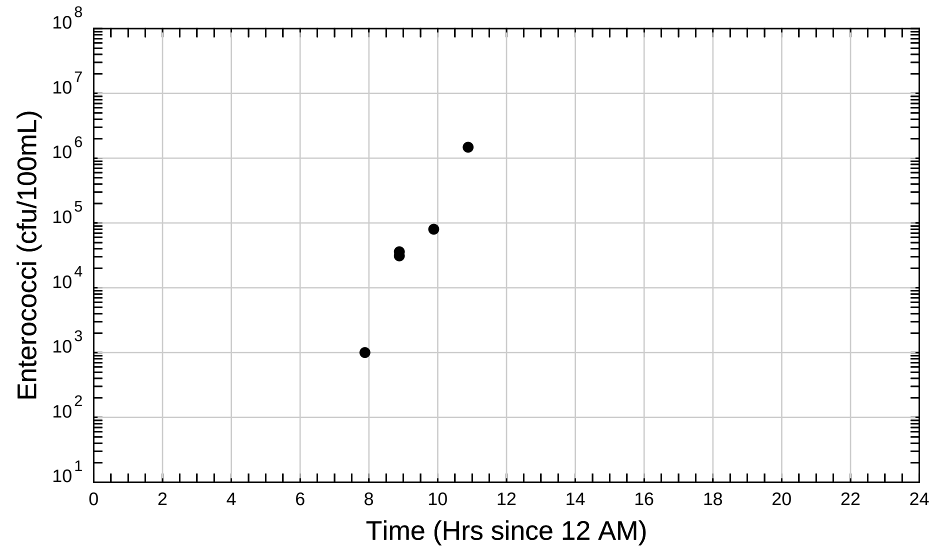
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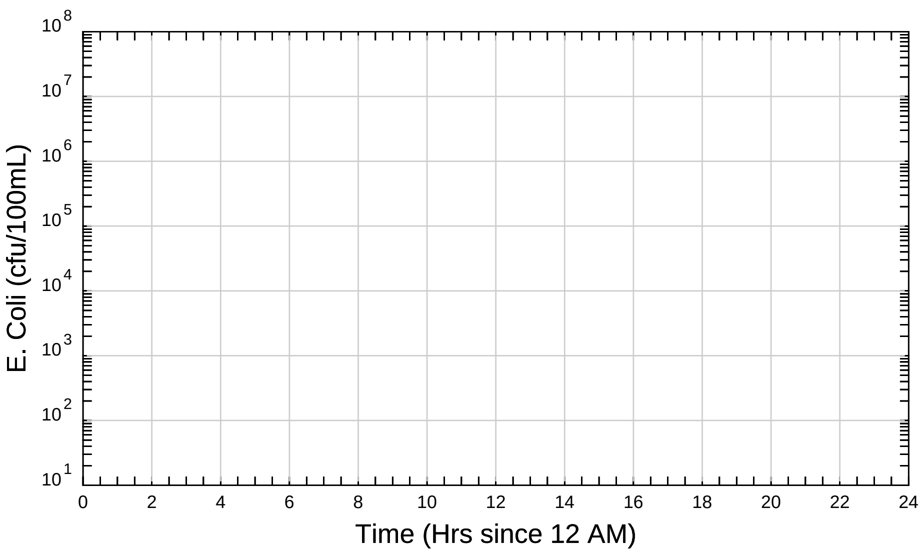
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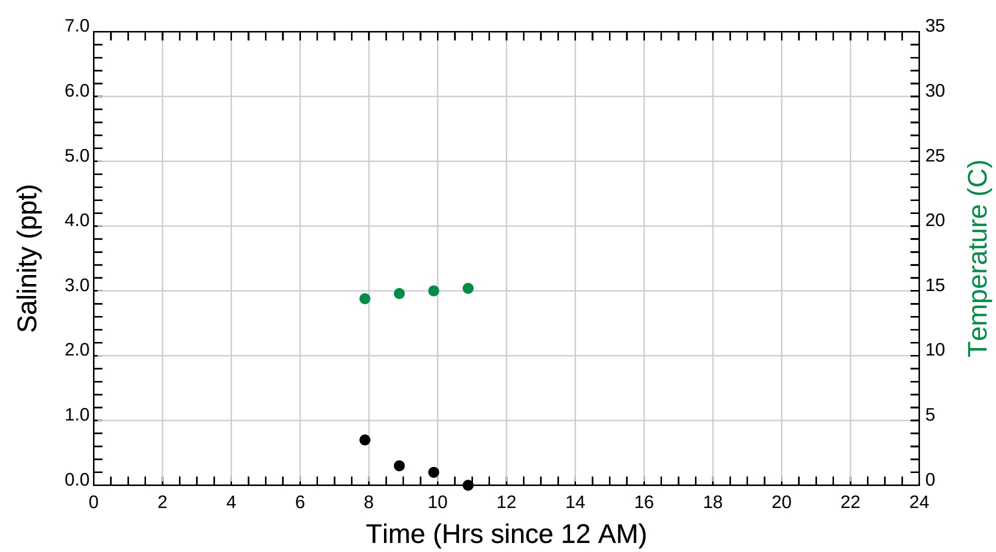
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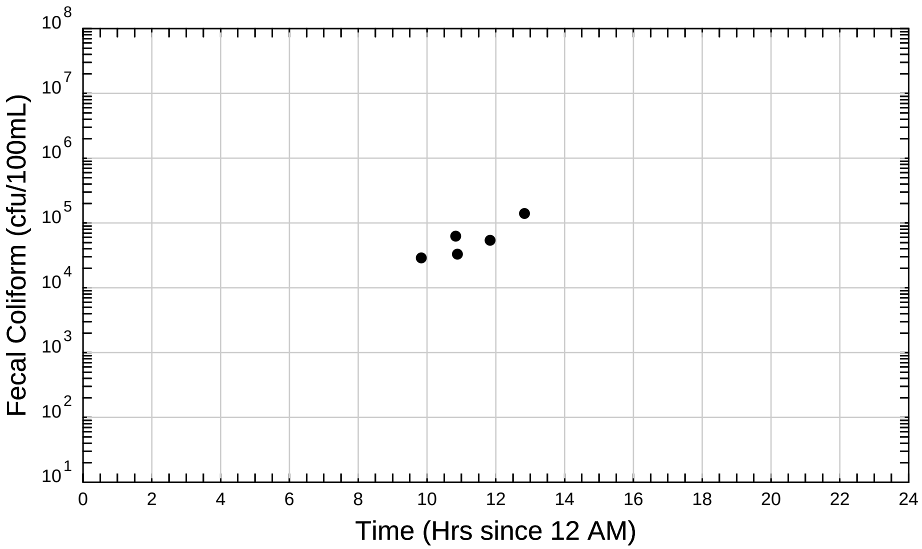
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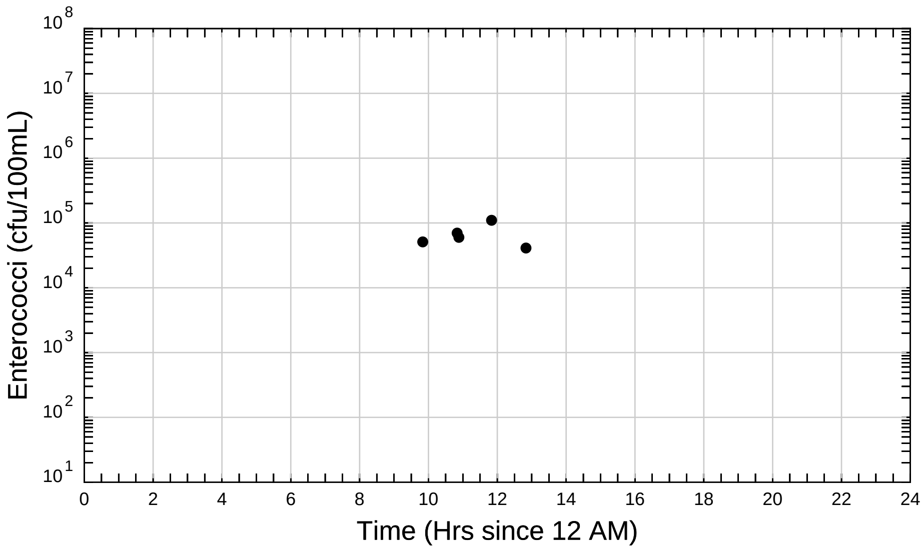
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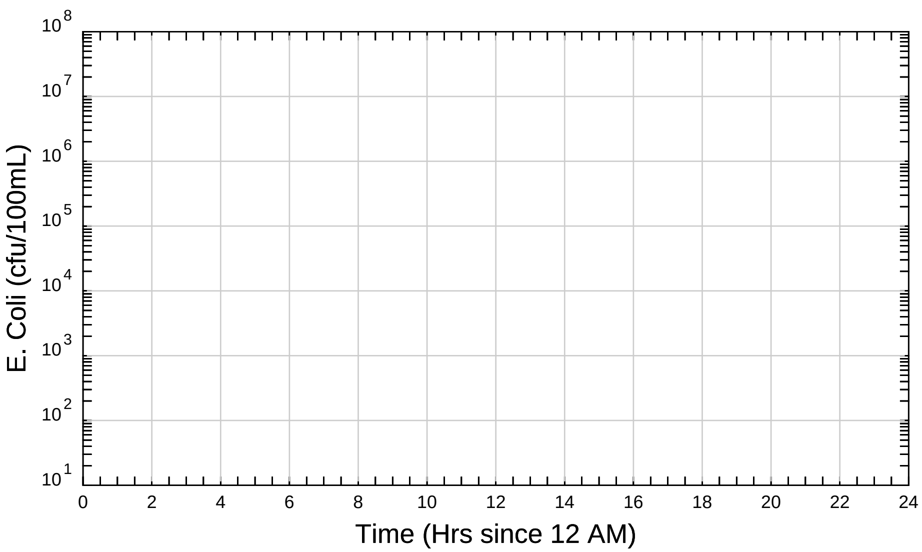
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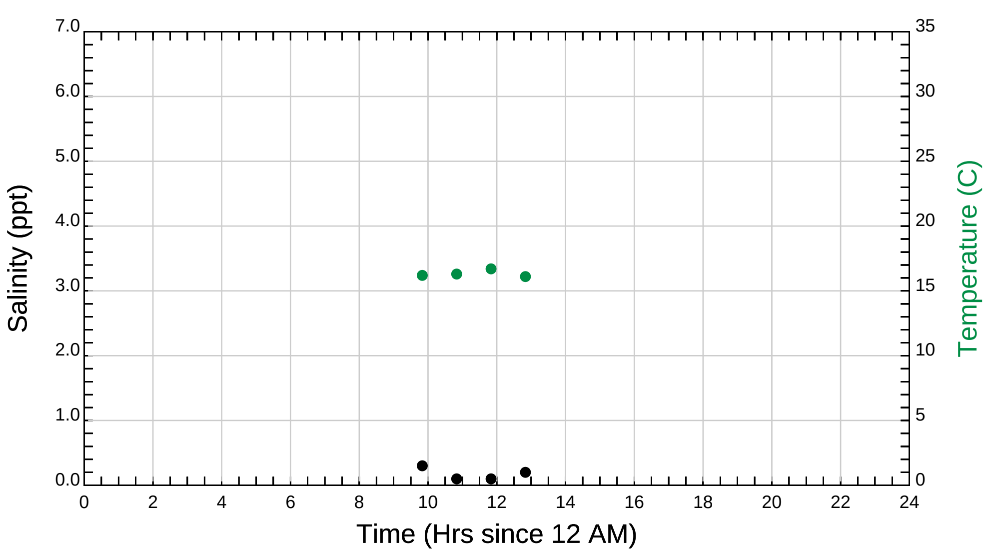
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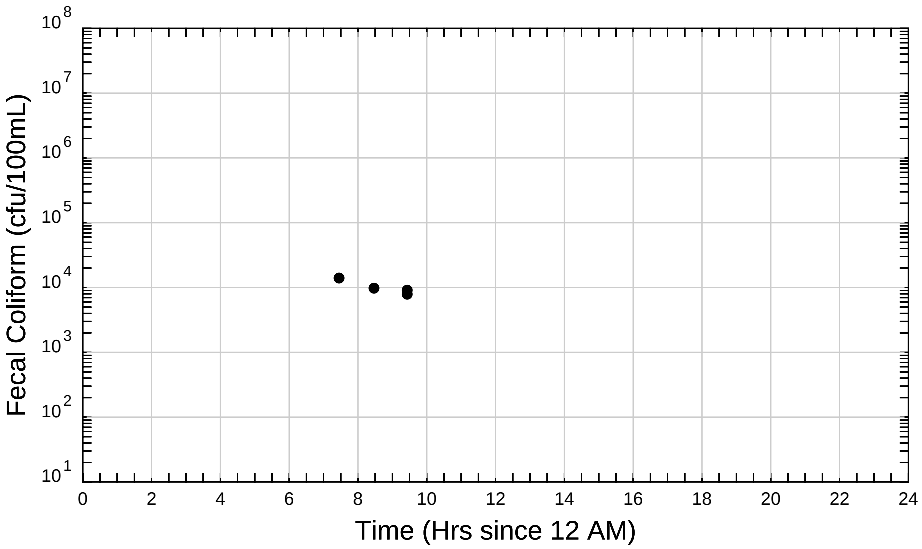
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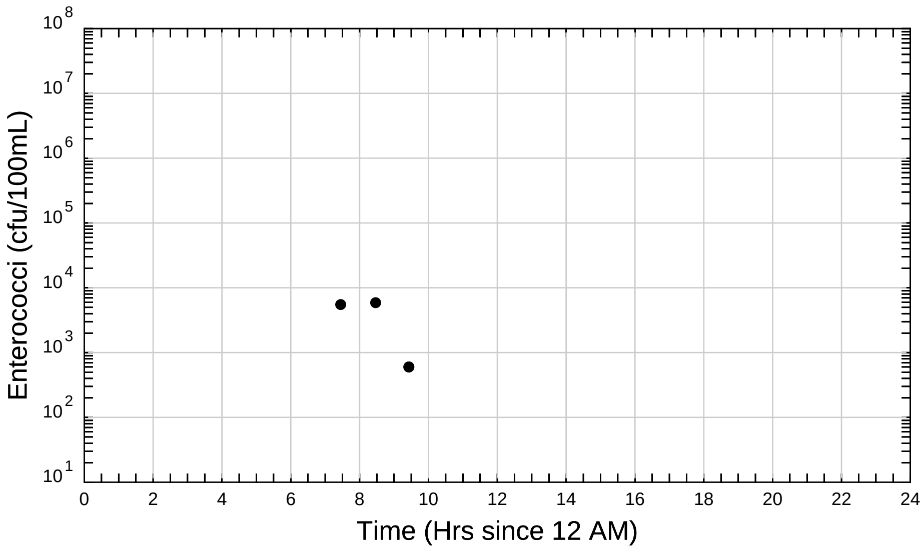
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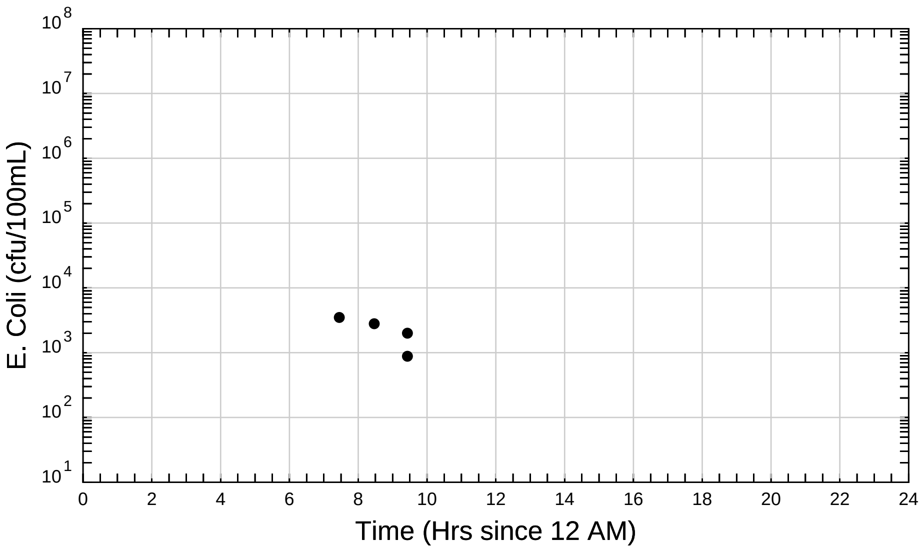
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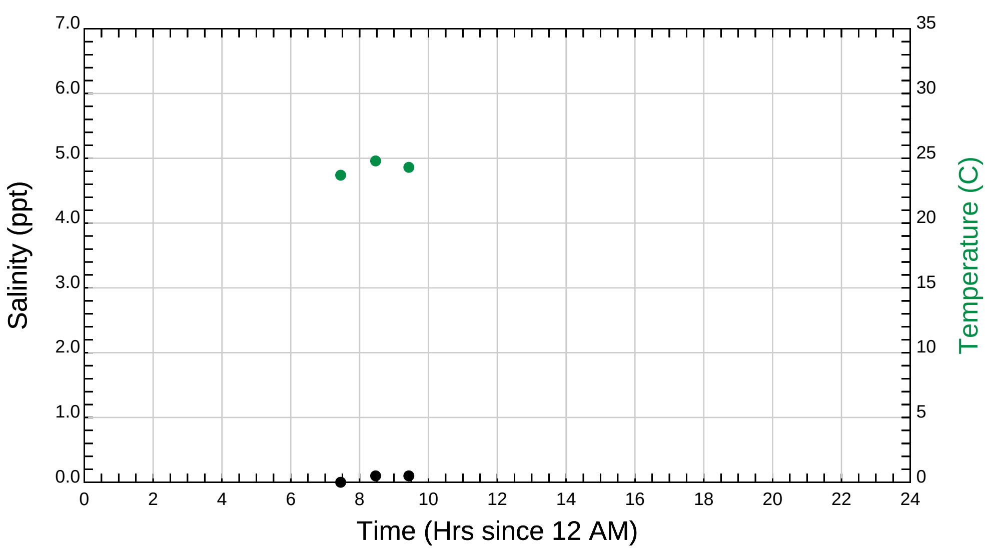
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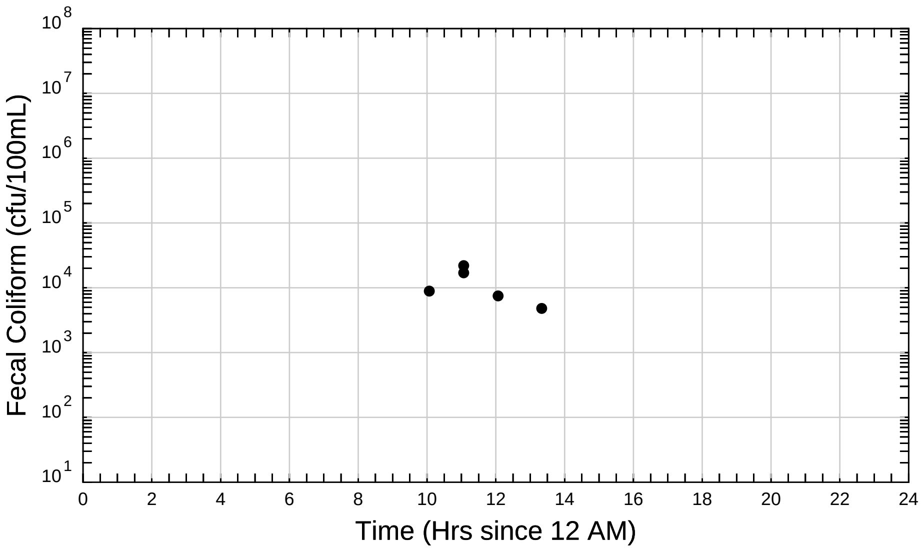
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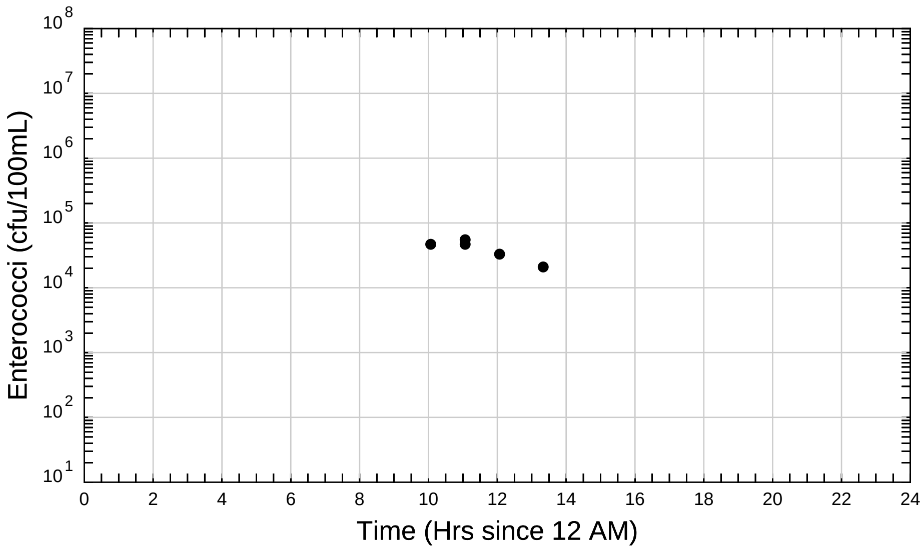
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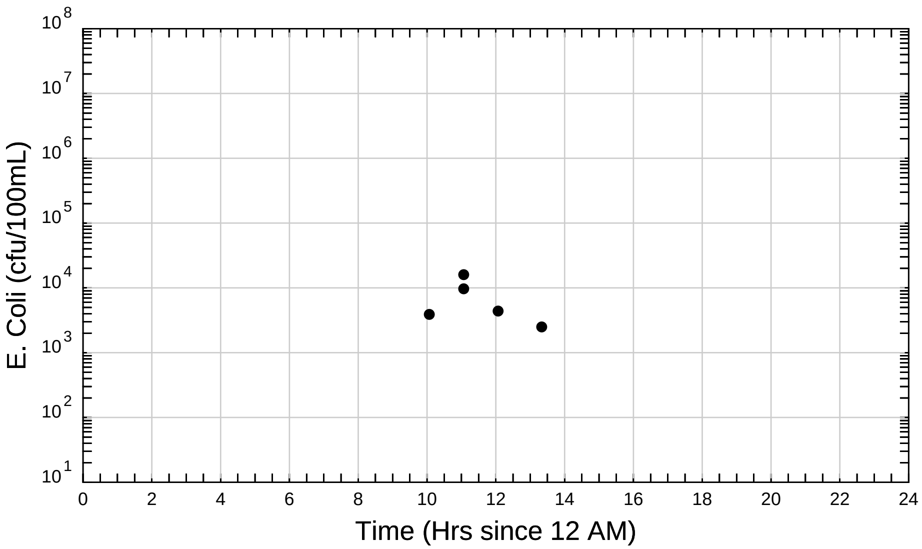
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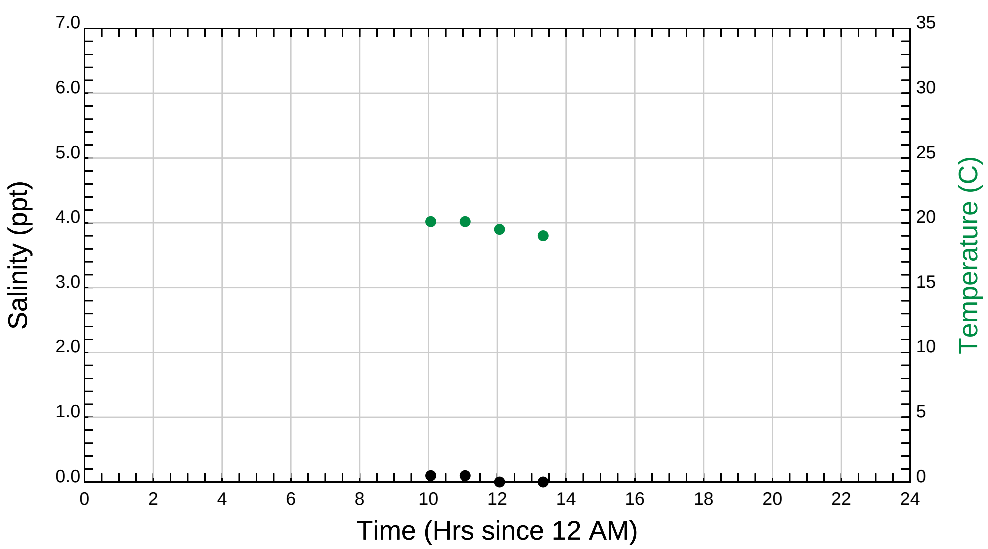
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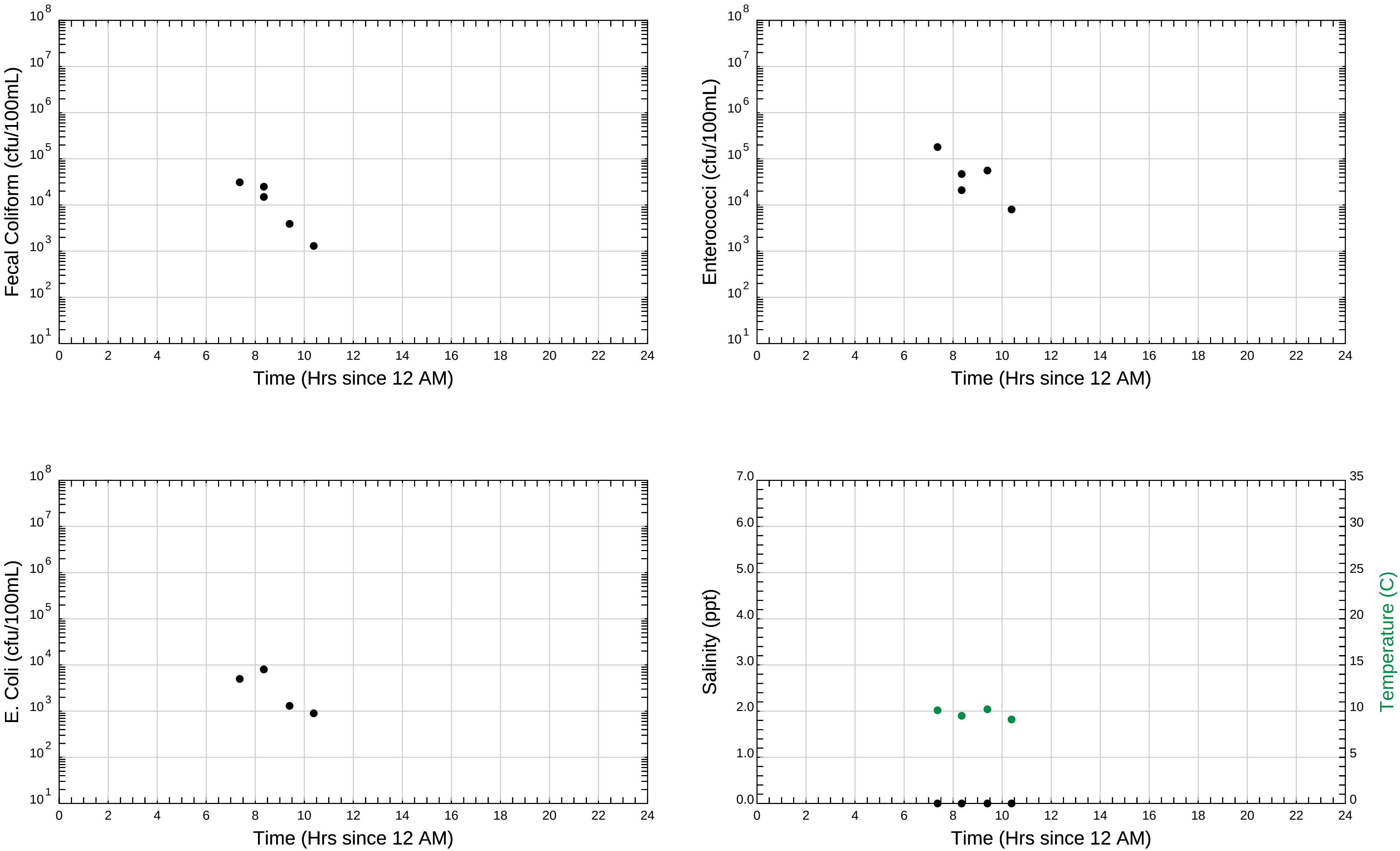
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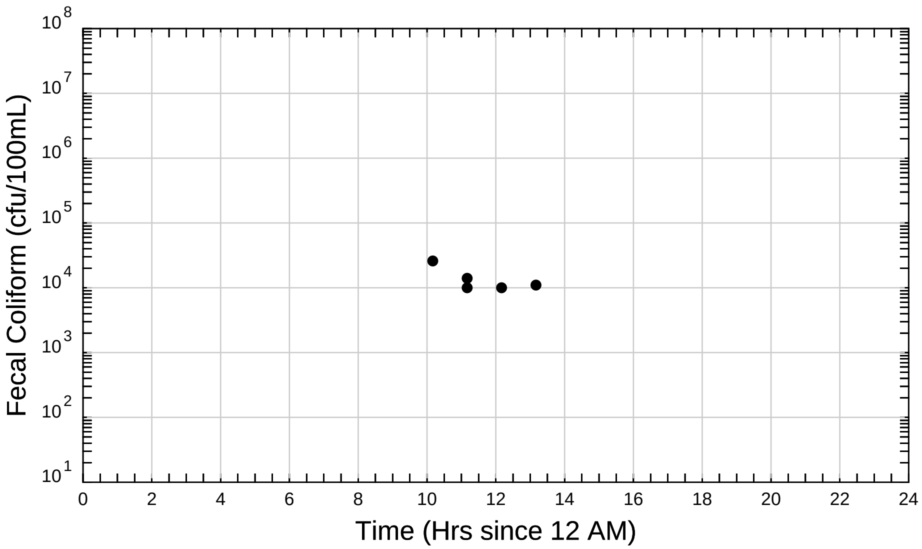
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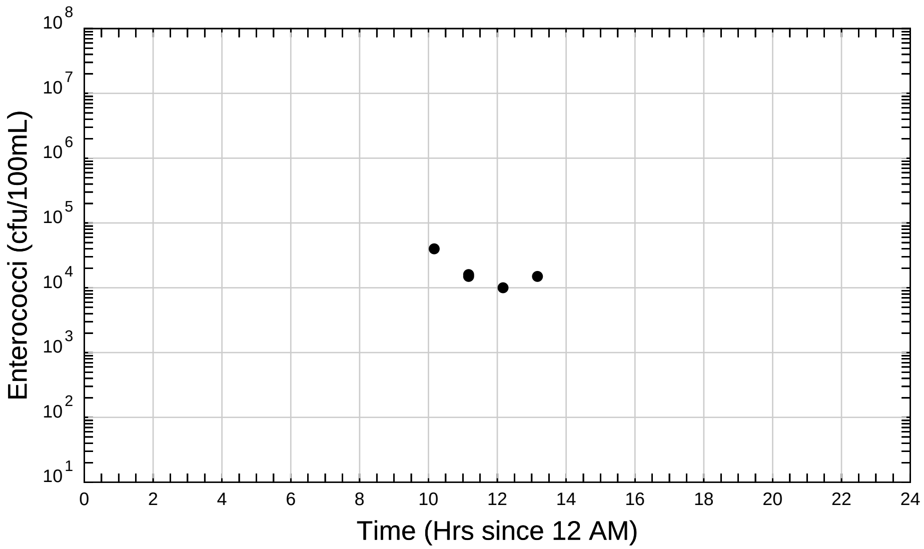
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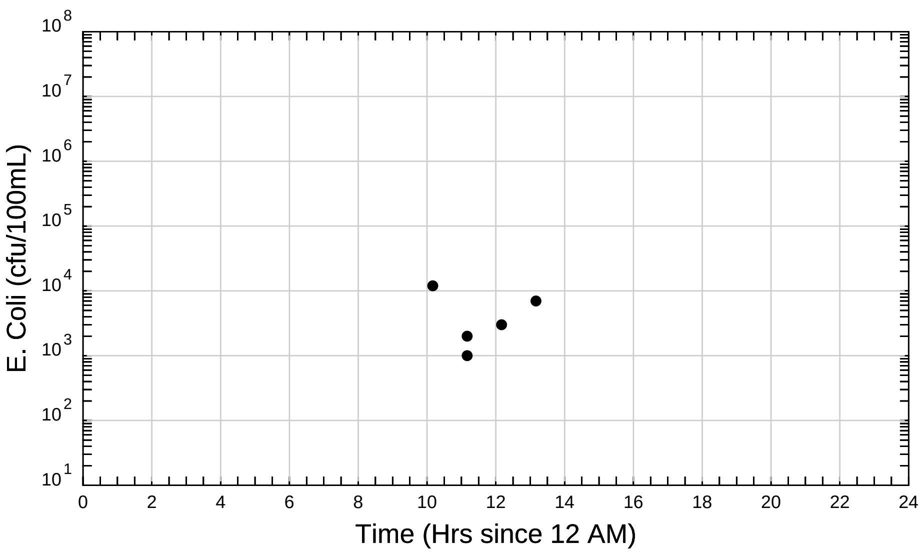
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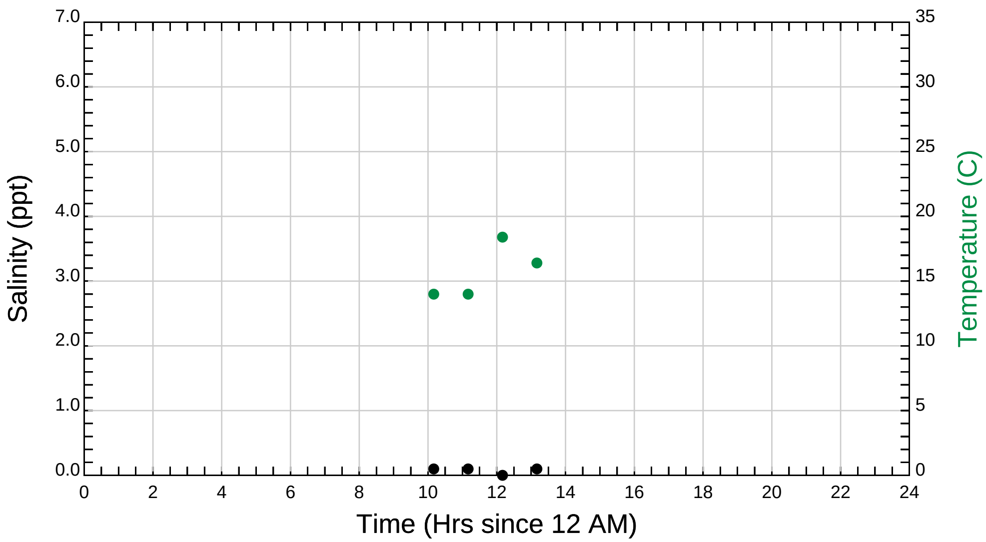
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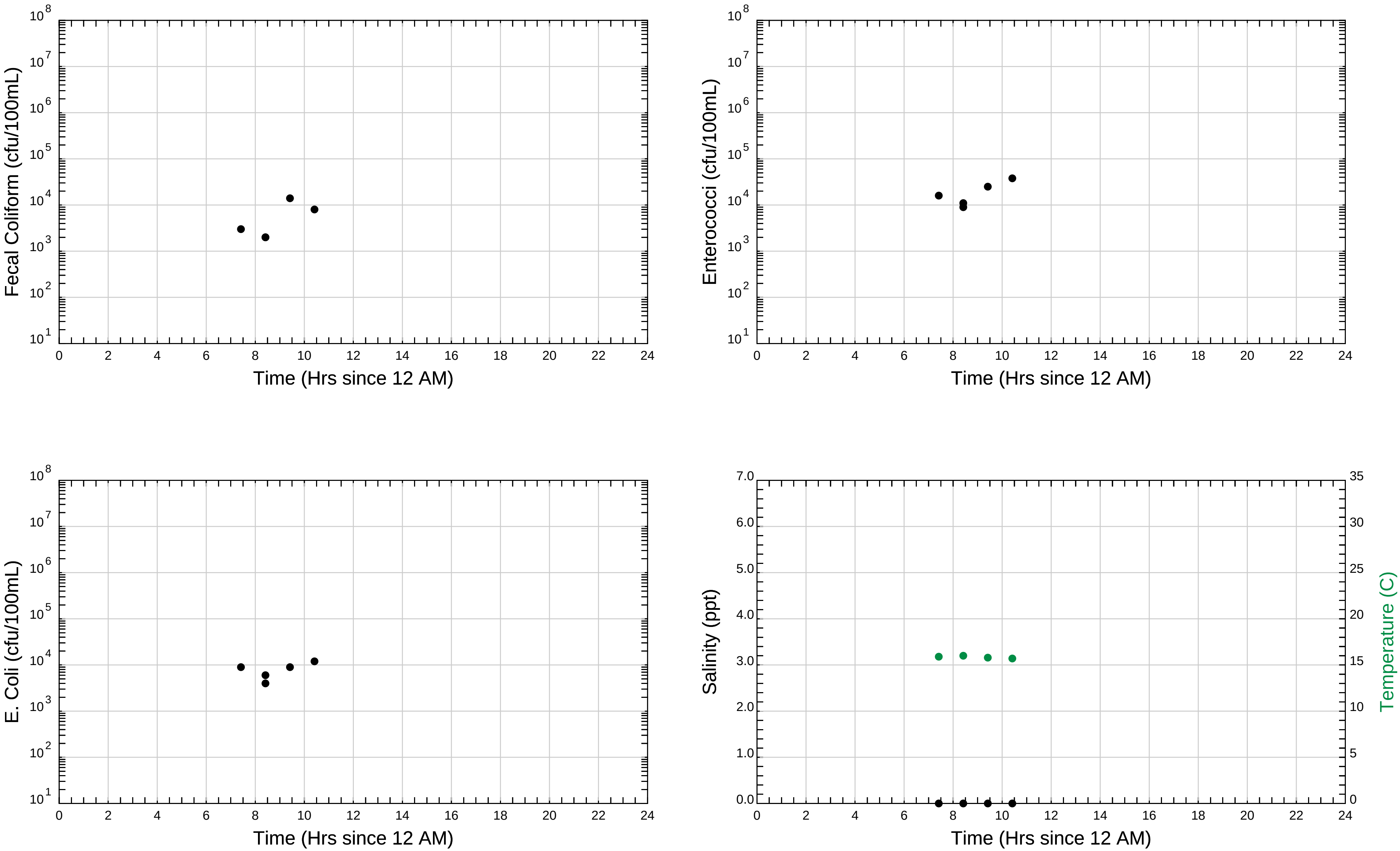
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Salinity (ppt)
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Wet-Weather Event 7.29.2016.

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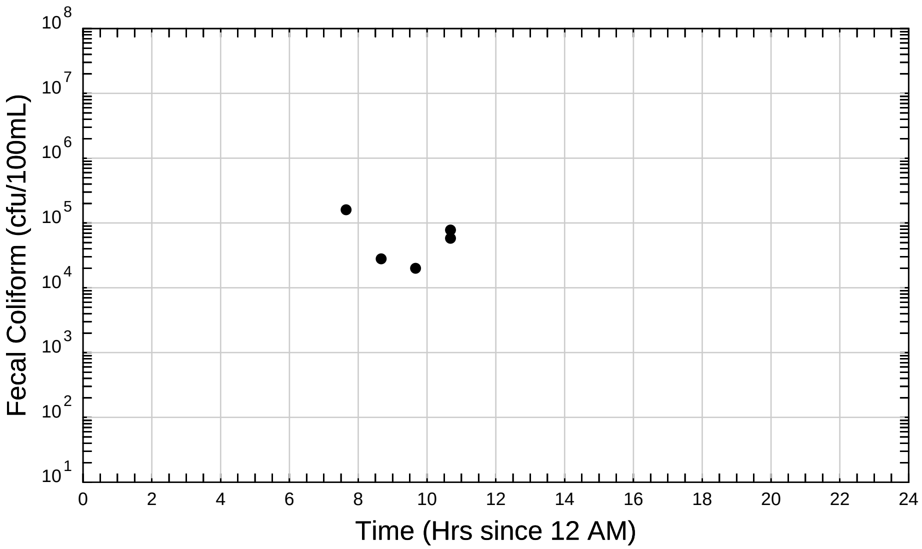

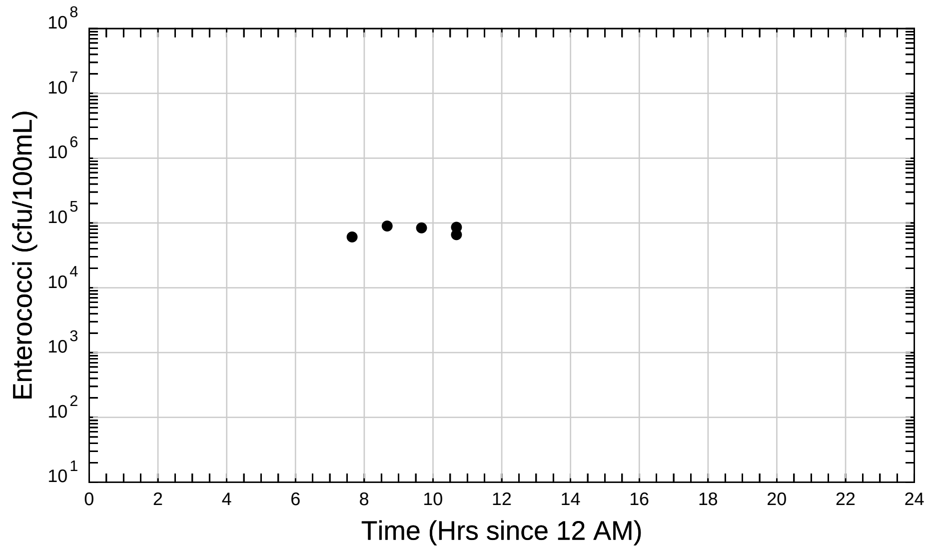

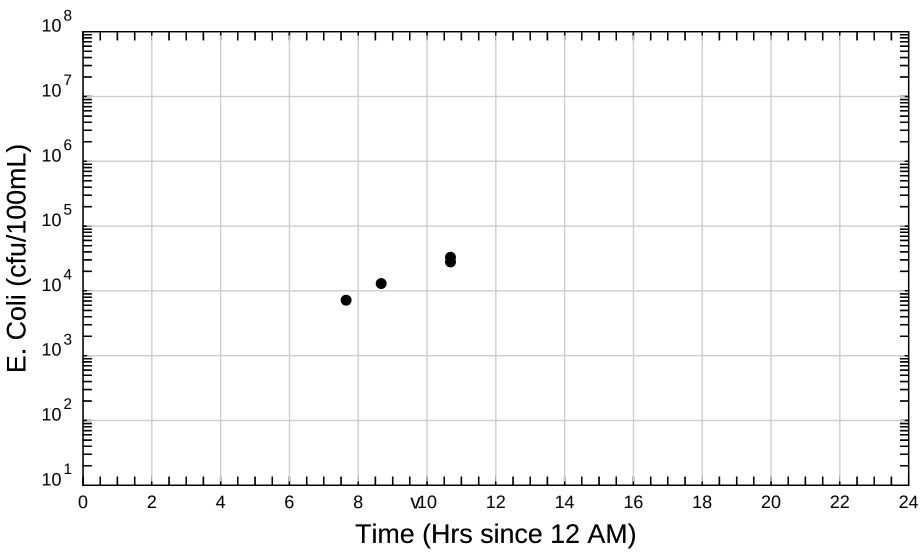

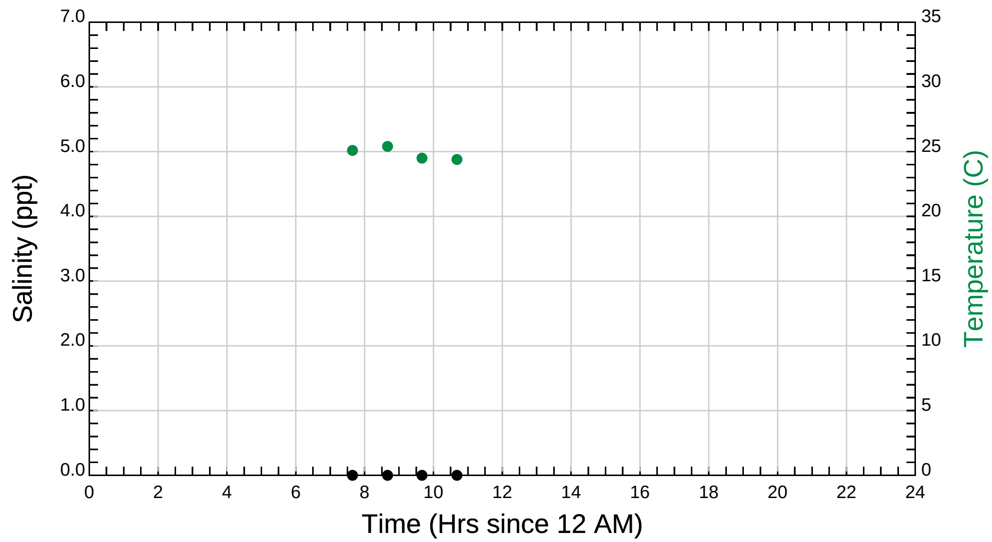

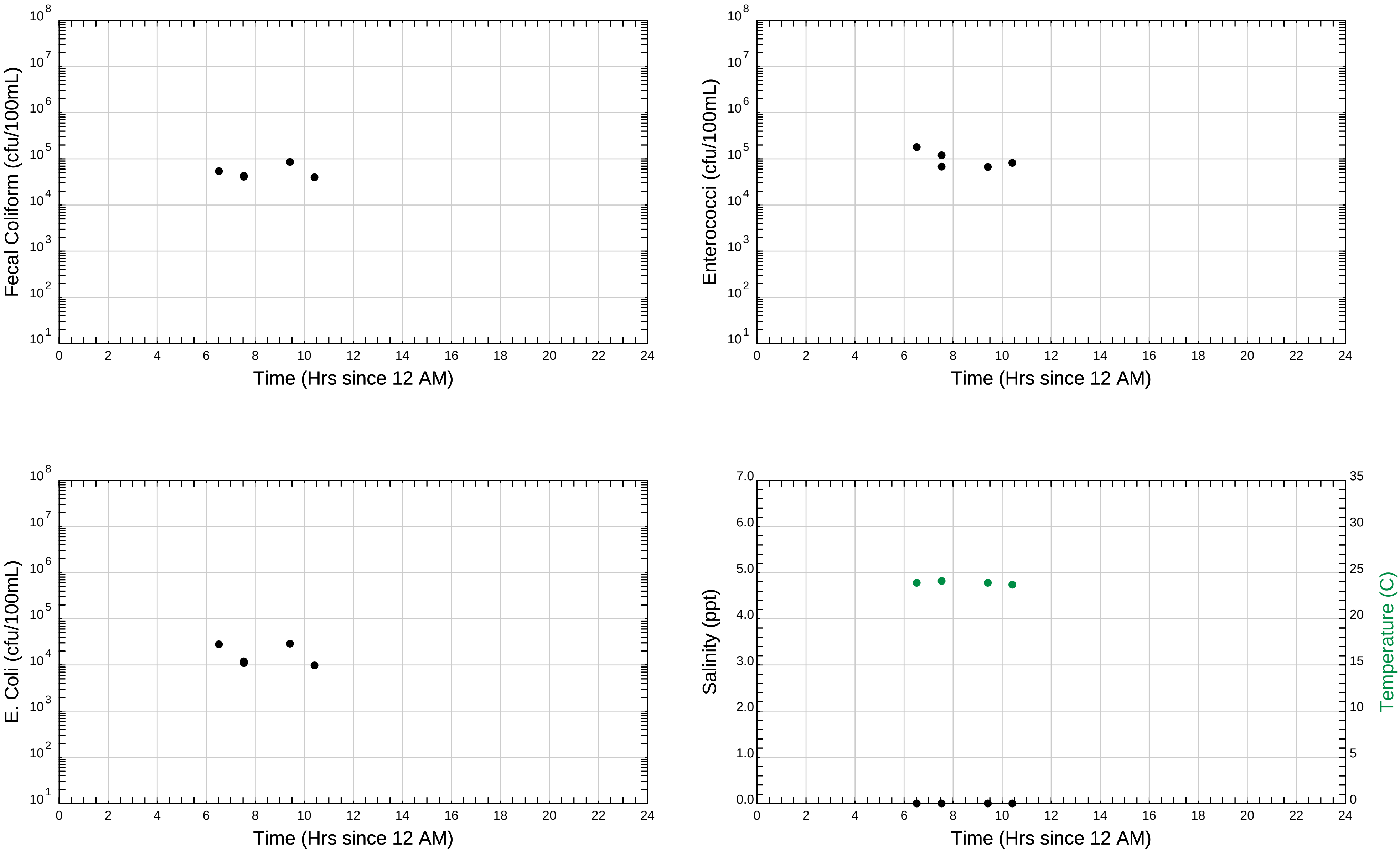
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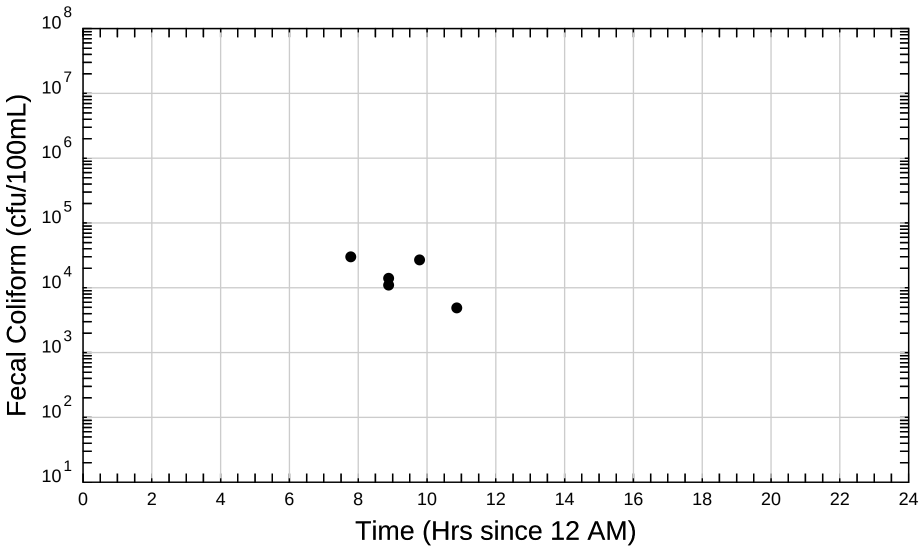

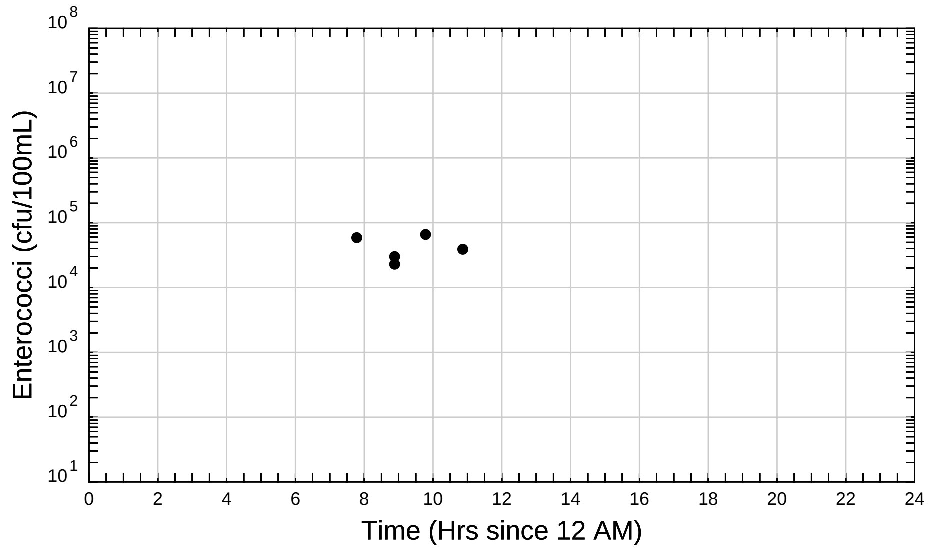

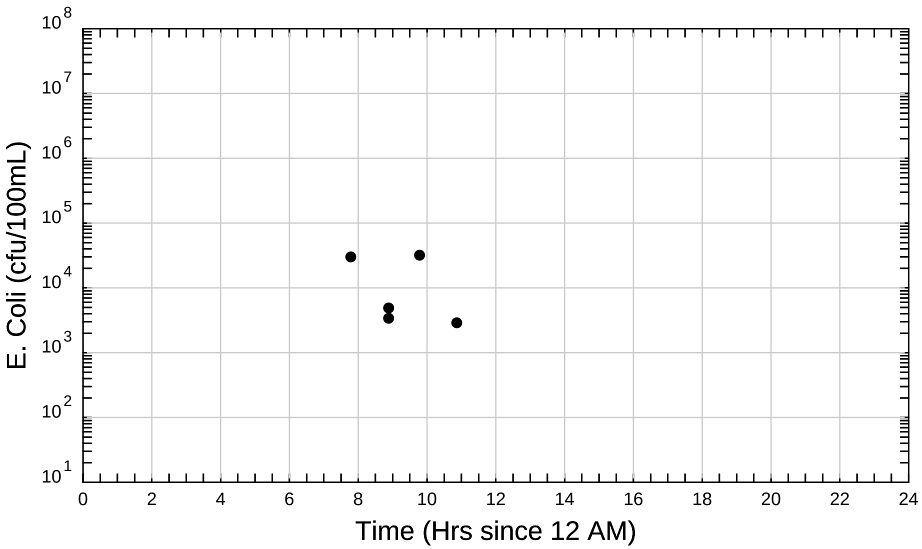

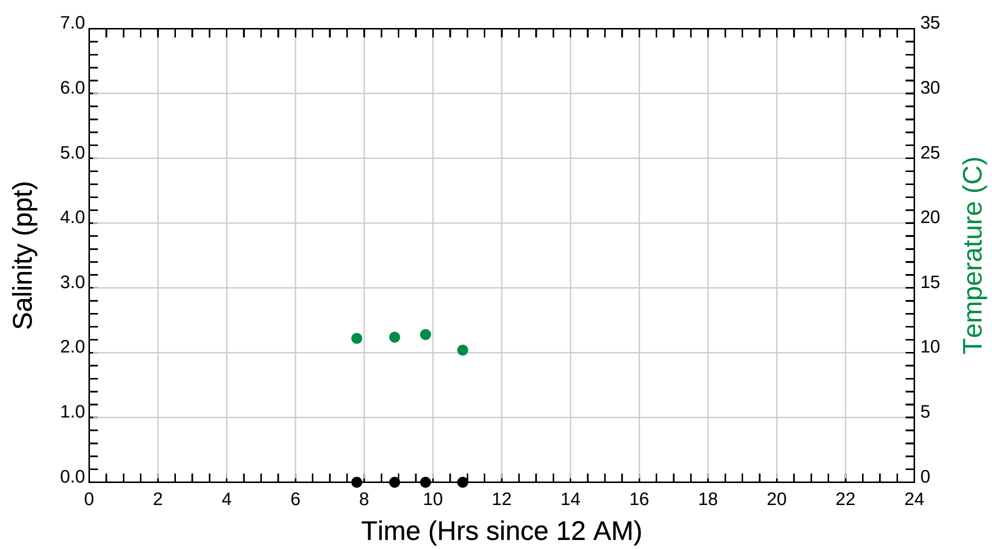

APPENDIX B

MEG Model Evaluation Group (MEG) Group Meeting Summary with comments, MEG -Memorandum, and Presentations for the following sessions: and Comments:

MEG Meeting 1- February 5, 2016
MEG Meeting 2 – March 17, 2017
MEG Meeting 3 – September 15, 2017
MEG Meeting 4 – December 5, 2018

March 7, 2016 Meeting Summary
PVSC Model Evaluation Group (MEG)
Session 1 Notes

Memorandum

To: *PVSC Long Term Control Plan Team*

From: *PVSC Model Evaluation Group: Alan Blumberg, Steve Chapra, Wayne Huber*

Date: *March 7, 2016*

Subject: *Model Evaluation Group – Session 1 Summary*

The PVSC Model Evaluation Group held an initial meeting at the offices of PVSC on February 5, 2016. CDM Smith, Greeley and Hansen, and HDR presented an overview of monitoring and modeling that will be implemented for the PVSC Long-Term Control Plan project. The MEG submits the following comments based on discussion at the meeting and our review of the monitoring and modeling QAPPs.

Responses to MEG comments from the project team are shown in italics following each comment.

Monitoring

General

1. We endorse use of data collected by NYC DEP and other reputable groups even though they do not use NJ-approved QAPPs. These data should be compared with data collected in this project to ensure consistency.

   Agreed.

2. Storm event monitoring is the most critical element of the program. How will we be assured that the program will obtain wet weather data? Timing sampling to capture events is often difficult.

   The sampling QAPP indicates that three wet weather events will be measured at each intensive wet weather sampling station. The team has planned for up to six sampling events to capture the three wet weather events. A project scientist will monitor the weather so that appropriate resources are ready to sample when needed.

3. All collected data should be analyzed and presented as soon as possible.

   Collected data and its analysis will be presented to the MEG at the next meeting subsequent to a sampling event or as soon as practical thereafter.

4. The data should be made available to the public so that others have the chance to use it and possibly discover problems.

We will discuss this issue with PVSC.

5. The role of historical data collected over the last two decades was not adequately discussed. If land use and system configuration haven't changed much, then these data remain valuable for landside modeling. Conversely, deepening of channels in the Kills and other bathymetric changes affect receiving water dynamics.

Agreed.

6. The MEG inquired whether conservative tracers (e.g. select inorganic ions) that could help characterize sewage loads would be monitored and modeled, but the question was not answered.

We will not monitor or model inorganic ions.

Landside

7. We understand that there will be continuous water level monitoring at several stations along the main interceptor and at key CSO locations. This will be important for hydrologic/hydraulic model calibration and verification. Water levels alone are very useful when hydraulics are modeled dynamically.

Agreed.

8. It might be useful to sample sediment in the interceptor if it has sedimentation issues. This would help address the issue of possible first-flush effects. There seemed to be a variety of opinions offered about the first-flush concept at the meeting.

We will not sample sediment quality in sewers, but will measure sediment depths at flow metering sites.

9. Sampling within the collection system was not discussed. How clean is the upstream collection system? Additionally, interceptor geometry is critical for hydraulic grade line determination.

Sediment conditions in the community sewer systems likely vary widely. They have been incorporated to some extent into the existing collection system models. Newark and Bayonne (as well as Jersey City, which is conducting its own collection system study) already have reasonably detailed local collection system models; detail will be added for other communities as needed for assessing CSO. The existing local models and the PVSC interceptor model represent geometry adequately in all major pipes. The integrated PVSC model will incorporate good representation of the geometry of all pipes downgradient of CSO regulators.

10. Infiltration/inflow (I/I) was discussed, but monitoring of sanitary sewers was not adequately described. Will I/I just get merged with downstream sanitary sewage for estimating bacteria concentrations?

PVSC already monitors incoming flows from each of its communities. The modeling can thus discretely represent sanitary flow and I/I. Bacteria concentrations will be separately assigned to each flow component and tracked through the collection system model.

Receiving Water

11. Water quality sampling at predetermined intervals along with a few storm events in detail will provide a start for bacteria calibration, but see comments 15 and 16 below concerning modeling dry-weather bacteria concentrations.

12. Lateral sampling is important; more is needed, especially for bacteria. Stations should be added near the Statue of Liberty, Governors Island, and on the eastern side of Staten Island, perhaps near 455 Front Street, Staten Island.

See Item 12 discussion below.

Summary: The monitoring program will serve the needs of the study with the caveat that the sampling should be designed to characterize the predominant loads. The proposed metering for sewer system hydraulics should be adequate.

Modeling

13. The charge to the MEG (QAPP page 10) should mention review of the model grid prior to running simulations, and should include assessing the validity of calibration and sensitivity simulations.

Agreed.

14. The MEG should be given the chance to evaluate plans for the projection cases and the outcomes.

Agreed.

15. Bacteria are notoriously difficult to quantify from both a precision and accuracy standpoint; an order of magnitude agreement between measurements and the models will be an accomplishment.

We believe that statistical comparisons still have general merit. We will seek further guidance from the MEG, statistical experts, and scientific literature as to what values best represent "central tendency" and "variance" when comparing bacteria concentrations.

16. It is unclear how bacteria loadings will be generated for the model. Probably the most significant contribution will be from sanitary sewage. If most loading is from sanitary sewers, the most useful data will be both influent and effluent strength at the treatment plant, with influent strength used for estimating concentration in CSO during wet weather. Is bacteria concentration at the WWTP monitored regularly?

Bacteria concentration is not monitored at the WWTP. We expect to rely on dry weather sewer system sampling included in the planned field program and prior system characterization.

17. The stormwater contribution will need to be calibrated, as we are unaware of consistent loading rates (e.g., MPN/acre) for stormwater. However, it could turn out that during an overflow, the dominant bacteria load is due to the sanitary contribution even though stormwater quantity might be greater. Both sewage and stormwater mass flux (flowrate times concentration) magnitudes will be important.

Bacteria loads for the calibration will be generated by the following methodology:

<u>CSO</u> flows will be based on permittee/NYC DEP InfoWorks or SWMM model. Concentrations will be assigned based on the mass balance approach in which InfoWorks determines the fraction of sanitary and stormwater flow. Sanitary flow concentrations will be based on system-specific data collected during the monitoring program. Stormwater concentrations will be based on literature-derived concentrations based on land use supplemented by site-specific stormwater sampling. A constant concentration, based on geometric mean of the data, will be assigned to the sanitary and stormwater flow components. These concentrations may be spatially variable, depending on the sampling data.

<u>Stormwater</u> flows will be based on a rainfall-runoff model. Stormwater concentrations will be obtained from literature-derived concentrations based on land-use supplemented by site specific stormwater sampling.

Flows from <u>external rivers</u> entering the model domain at the boundary will be based on USGS gauge flow or flow ratios based on gauged and ungauged drainage areas. Flow versus concentration curves will be developed based on sampling data.

<u>Internal rivers</u> will be based on data collected at source sampling stations.

<u>Illicit dry-weather sources</u> will be identified based on dry-weather sampling data. Loads will be estimated via trial and error to match available water quality data. Depending on the required size of the dry weather source, flows may or may not be added to the model, as flow volumes may be trivial.

<u>Ocean boundary conditions</u> are likely to be inconsequential to driving the model solution; they will set to low bacteria concentrations.

The approach to developing <u>projection condition loads</u> may differ from the calibration process. The MEG will participate in the decision process for developing projection conditions. Decisions will need to be made as to whether illicit dry weather loads are part of the projection analysis, and what river and meteorological conditions will be appropriate to use.

18. Sensitivity analysis was not adequately discussed. For instance, will receiving water concentrations be most sensitive to load, hydrodynamics (transport processes), or decay rate?

It is likely that the degree of sensitivity will vary within the model domain. Non-tidal freshwater sections will probably be more sensitive to transport processes, while some tidal areas may be more sensitive to the decay rate. Peak concentrations may be more sensitive to the load. In some places, illicit dry weather loads may mask these processes.

The intensive storm event sampling data should inform the spatial bacteria loss rate: transport + decay + other (e.g. settling). The calibrated hydrodynamic model will allow us to estimate the transport component of the loss by executing the water quality model with no decay rate. Previous model experience will allow us to bound expected die-off rates. If additional loss mechanisms are required, the effect of solar radiation and/or settling can be examined. Peak concentrations that are too high or too low will require us to reassess how loads were developed. Since bacteria concentrations range over orders of magnitude, factors that affect concentrations by a factor or two or so may be difficult to assess in terms of how much those factors influence model calibration.

19. What is the frequency of sanitary sewer overflow (SSO) across the system?

No SSO has been reported by the communities.

20. Was it stated that there is not a significant groundwater infiltration contribution to the sewer system, or just that it will not be dynamically modeled? How leaky are the regional sewers?

Base flow in regional streams typically varies from 1.5 cfs per square mile (cfsm) in spring to less than 0.5 cfsm in fall; regional sewers can be expected to exhibit similar variation in groundwater-driven infiltration flows. For areas where such seasonality has not already been incorporated into the collection system models, monthly infiltration factors will likely be developed to represent this flow variation based on long-term flow data already collected by PVSC. We will compile long-term flow data for the wastewater treatment plant and key permanent monitoring locations to establish seasonal infiltration factors. (While not directly pertinent to the issue of infiltration in sewers, it is noteworthy that flow in the Hackensack River does not conform to the regional norm. It is strongly regulated by in-line reservoirs and water supply withdrawals; base flow near its mouth averages 0.2 cfsm.)

21. Good coordination with the municipalities will be important if they want to use the landside model for internal analysis of their systems.

Agreed.

Item 12 Discussion

DEP (Marco Alebus): Although the model encompasses the core area of NY/NJ Harbor, the focus of the model calibration/validation should be on New Jersey waters. In addition, given the uncertainty in quantifying the loadings from NYC, detailed calibration of the model in open waters is not a primary objective of this effort. Thus, event sampling at these stations, although useful for the overall model, may not be critical to demonstrating model fitness in most NJ waters. For the purpose of establishing a baseline condition, does NYC sample at or near these locations? Station B28 is located along the shipping channel. Given that this is also an event sampling station, please explain how the sampling location will not jeopardize obtaining the required number of samples during an event sampling.

SJL (Sheldon Lipke Environmental Consultants): Please further explain the MEG's rationale for the additional sampling sites. It would be useful to know why the MEG chose the Governors Island and Statue of Liberty sites, which are relatively close to each other, and the B21 site, which is on the same confined waterbody (the Narrows) as B21A and B21B.

NYC sampling locations are not close to the additional stations suggested by the MEG. We don't see shipping interfering with sampling as an issue; we can move out of the way if a ship is coming by. We only need to be on station for 10 to 15 minutes to collect samples and make measurements.

Background information questions from MEG

Timothy J. Groninger from HDR is identified as Project Manager, but was not at the meeting, while Bill Leo, also from HDR, is not mentioned in the QAPP but participated in the meeting. Please clarify.

The project's consultant team consists of Greeley and Hansen, CDM Smith, and HDR. Greeley and Hansen is the contractual lead and responsible for landside analysis. CDM Smith is the program manager and coordinates modeling efforts. HDR is responsible for water quality sampling and receiving water analysis. Tim Groninger is HDR's project manager; Bill Leo is a senior vice president at HDR with extensive knowledge of the firm's previous work.

Why are pathogens in the receiving waters the emphasis of the study? We understand it is for an NPDES permit, but for what water quality standard? Fishable-swimmable or water contact locally (harbor areas)? Water contact at distant beaches? Shellfish? Is there a TMDL or other standard to be met?

Pathogens have been defined by NJ DEP as the water quality constituent of concern for the LTCP. There is no approved pathogen TMDL. Pathogen water quality standards will be existing NJ DEP standards. In the area of interest, the majority of the waters are secondary contact waters, but the region does contain primary contact waters in areas away from the CSOs. Beaches and shellfish areas also exist within the Harbor but they are in Raritan Bay and are far from any NJ CSOs.

In SSCWP QAPP PART 1.pdf, pp. 57-58, there is a memo from HDR "Modeled CSOs vs. Rainfall." The figures are examples of common rainfall frequency analyses in which it is demonstrated that small storms (by depth) occur much more frequently and contribute more to total annual rainfall depth than do big storms. How was a storm event defined? Event definition is typically done by specifying a minimum inter-event time (MIT, hours) between "independent" events. MIT can be determined probabilistically, although it seldom is. Instead, a number like 6 hours is often used. MIT definition influences the plots and thus the conclusions drawn from the plots. How was an event defined?

The minimum inter-event time was defined as 4 hours in the analyses noted. However, for the purpose of the LTCP, analyses will be continuous simulations using 15 minute to one hour time steps (yet to be determined). In continuous simulation modeling, MIT does not have to be defined.

PASSAIC VALLEY SEWERAGE COMMISSION

Long Term Control Plan

MEG Meeting
February 5, 2016 9:00 A.M. - 3:00 P.M.
PVSC WWTP, OEM Main Conference Room

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4	Sheldon Lipke	SJL Environmental Con. 32 Tanglewood Drive Livingston, NJ 07039	(201) 532-1715	slipke@SJLConsultants.com
5	Michael Hope	Greeley and Hansen 1700 Market Street Philadelphia, PA 19103	(215) 553-7917	mhope@greeley-hansen.com
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10	Signature: [signature] Print: STEVE CHAPRA	Name: TUFTS UNIV Address: Medford, MA	Phone: 617 627 3654 Fax:	steven.chapra@tufts.edu
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Meeting Summary

PVSC Model Evaluation Group (MEG)

Session 2

March 17, 2017

Stevens Institute of Technology

Attendees: See Sign-In Sheet

Introduction

The PVSC Long Term Control Plan (LTCP) Model Evaluation Group (MEG) held their second meeting at Stevens Institute of Technology on March 17, 2017. Greeley and Hansen, CDM Smith, and HDR presented status updates on the progress of the monitoring and modeling programs being performed for the PVSC Long-Term Control Plan project. The following is a summary of the meeting topics and discussions.

Opening Remarks

- Dr. Alan Blumberg welcomed the members of the MEG, PVSC, NJDEP, the engineering consultants, and other observers to Stevens Institute of Technology.
- The meeting attendees introduced themselves and their affiliation with the project
- Mike Hope provided an overview of the program status:
  - All the NJPDES QAPPS have been submitted to NJDEP and approved by NJDEP
  - The 12-week temporary flow monitoring program is complete
  - The water quality sampling programs are approximately 90% complete
  - The wet-weather sampling program is slightly behind schedule due to the lack of rainfall in 2016.

Flow Monitoring Program – Presented by Yuan Fang

- Yuan Fang provided an overview of the temporary flow monitoring program:
  - 21 temporary flow meters were in place from April 2016 through August 2016
    - 13 of the meters are monitoring flow in an outfall
    - 7 of the meters are monitoring flow in a regulator influent
    - 1 of the meters is monitoring flow on the interceptor (Paterson)

  - The flow monitoring data was analyzed to determine the period when close to all of the meters appear to be functioning properly so that model calibration events can be identified. The period between May 15th and August 5th.
- Yuan Fang provided an overview of the PVSC permanent flow meter locations.
- Yuan Fang provided an overview of available precipitation records for the proposed model calibration periods:
  - Sub-hourly data is available from Newark Airport, but there is a deficit in the total volume recorded in June 2017 as compared with the hourly and daily data.
  - Bridget McKenna stated that PVSC has a rain gage that might be able to supplement the missing airport information.
  - Tim Dupuis stated that we can also supplement the data by disaggregating the hourly data from the airport.

Water Quality Monitoring Program – Presented by Tim Groninger

- Tim Groninger provided an overview of the sampling programs:
  - The Routine Sampling program is 95% complete and is on schedule.
  - The Intensive Sampling program is 72% complete and is on schedule. One more boat intensive survey remains.
  - The System Characterization Stormwater Sampling program is 79% complete and is nearly on schedule.
  - The System Characterization CSO Sampling program is 12% complete and is behind schedule due to a lack of precipitation in 2016.
- Marco Alebus asked the MEG whether they felt it was critical to complete the CSO sampling program, since they aren't going to be used directly by the models. The models will be applying concentrations based upon the relative mix of stormwater and sanitary flow in the overflow, as predicted by the model.
  - Dr. Wayne Huber responded that the CSO sampling is important since the CSO load will be the largest bacterial source to the receiving waters.
- Tim Groninger presented a summary of the sample data quality, based on the number of laboratory qualified and estimated values:
  - Tim Groninger explained that the laboratory reports estimated values if the bacterial plate count is outside of the range of 20-60 colonies. The laboratory did provide the actual plate count with the sample data if the value was estimated due to being outside of this range.
  - Marco Alebus asked how the estimated values will be used:
    - Tim Groninger responded that we plan to utilize the qualified data for the model calibration, and note the qualifications.
    - Tim Dupuis stated that this is an area where we would like to receive input from the MEG.
      - Dr. Steven Chapra stated that he doesn't have concerns with utilizing the qualified data.

        - Biswarup Guha requested additional information on the upper quantification limit. He suggested that the upper quantification limit be included when reporting the data.
        - Marco Alebus asked whether a site-specific correlation can be established between the bacteria indicators, and if it could be used to help evaluate the estimated values.
            - Tim Groninger replied that it is something that would be looked at.

Typical Year – Presented by Mike Hope

- Mike Hope presented the selection criteria utilized for identifying a "typical year".
    - The method is a statistical approach based on multiple rainfall (Newark Airport) and river flow (Passaic River) criteria
    - This method has been used and accepted elsewhere by USEPA
    - Based on the applied ranking methodology, 2004 was ranked #1
        - 2008, the NYC typical year, was ranked as #8
            - New York City utilizes the rain gage at JFK Airport
    - The model was simulated for 20 years to evaluate the relative annual overflow volumes and number of events:
        - 2004 is approximately 1.5% over the average overflow volume, and 6.7% over the average number of overflow events.
    - Selecting a year other than 2008 will require additional coordination with NYC, but this additional coordination has been discussed with NYC and NYC seems to be willing to provide the required model outputs. In turn, PVSC will provide the required model outputs for 2008 to facilitate NYC's LTCP program.
- Biswarup Guha asked whether New York City utilized a similar method for selecting their typical year:
    - Tim Groninger responded that the New York City analysis utilized the same methodology that was previously used to select the JFK 1988 typical year. This included five unweighted statistics at JFK Airport, Newark Airport, LaGuardia Airport, and Central Park.
    - Dr. Steve Chapra suggested that the JFK data be run through the PVSC typical year selection criteria weight to see how 2008 ranks.
- Marco Alebus stated that the perception at NJDEP may be that 2008 is less stringent than the prior typical year (JFK 1988).
- Marco Alebus stated that USEPA may want to utilize 2008 anyway to be consistent with the shared waters.
- Biswarup Guha stated that intensity is critical for selecting critical year:
    - Biswarup Guha requested that a chart or figure be developed showing intensities for each year.
    - Biswarup Guha requested that temporal plots of the actual rainfall be developed for records from Newark Airport and other gages, including JFK Airport.

- Tim Dupuis stated that the number of back to back rainfall events is one of the critical parameters, and that 2008 was well above the annual average in the number of back to back events. The number of back to back events will impact the effectiveness of green infrastructure in reducing CSO impacts since the capacity will not have time to recover between storms.
    - Biswarup Guha requested a graphical representation on the number of back to back events
- Biswarup Guha stated that updated standards that introduce a Statistical Threshold Value (STV) are being developed for SE1 waters.
    - EPA is also pushing to upgrade the downgraded waters as well.
    - This won't happen before the LTCP plan is done
    - New York City has updated their LTCPs based on the new standards, and upgraded some of the shared waters to primary contact.
- Susan Rosenwinkel suggested that an official approval of the typical year report would be useful.
    - Mike Hope agreed, and asked whether the comparison of 2004 and 2008 should be included.
        - Dr. Steve Chapra stated that the analysis should be done for a range of years, but the comparison of 2004 and 2008 shouldn't be presented.
        - Susan Rosenwinkel suggested that a narrative be included on why the New York City typical year wasn't used by default.
        - Tim Dupuis stated that the planned approach was to submit a document to NJDEP for approval.
- Biswarup Guha requested that a comparison between the PVSC rain gage and the Newark Airport rain gage be performed.
- Nicholas Kim suggested that the Lodi/Saddle River streamflow gage may be more appropriate to look at in comparison to rainfall instead of the Passaic River.
- Marco Alebus requested that timeseries plots of river flow be developed for 2004 and 2008.
- Marques Eley stated that the September 8, 2008 storm was Hurricane Hannah, which was nearly 8". The National Weather Service said that 2008 was one of the driest years on record at that time, prior to that storm.

Regional Drainage Model – Presented by Mitch Heineman

- Mitch Heineman explained that that Regional Drainage Model is needed to simulate continuous flows and loads from the drainage areas not included in the CSO areas.
    - Stream flow records from 7 USGS gages were loaded directly into the model to account for flows from areas upstream of those gages.
    - Rainfall-runoff was simulated in areas downstream of those 7 USGS gages utilizing the SWMM non-linear reservoir method in InfoWorks.
    - Several downstream USGS gages were used for model calibration.

Hydrologic and Hydraulic Model – Presented by Yuan Fang

- Yuan Fang provided an update on the hydrologic and hydraulic model development.
  - The PVSC, Bayonne, and North Bergen models have been combined into a single integrated model.
  - A simplified Jersey City model was developed to convey flows from North Bergen and to account for the Jersey City flows.
    - Tim Dupuis informed the group that another consultant is working on the Jersey City modeling, and that the PVSC consulting team coordinates with them.
  - Regulator settings were checked and updated.
  - Delineations were updated, particularly in Paterson.
    - Susan Rosenwinkel asked whether Paterson Outfall O-28 is included in the model as a CSO. NJDEP recently confirmed that it is a CSO.
      - Yuan Fang replied that it is being modeled as a CSO.
  - Separately sewered areas were added to the model.
  - Wet-weather operating rules were added at the Newark CSO regulators and the primary storage tanks at PVSC.
- Wet weather calibration events have been identified as:
  - 5/29/16-5/30/16
  - 7/25/16
  - 7/29/16-8/1/16 (back to back storm at 7/29/16 and 7/31/16)
- Biswarup Guha asked whether in-pipe sedimentation is being considered.
  - Yuan Fang responded that sedimentation is not being included in the model.
  - Tim Dupuis stated that CDM Smith is inspecting the PVSC lines as part of another contract and that the information will be provided to the LTCP modeling team as it becomes available.

Hydrodynamic Model – Presented by Nicholas Kim

- Nicholas Kim provided an overview of the hydrodynamic receiving water model.
  - The model calibration period is 2009-2016.
  - The model calibration involves: elevation; currents; temperature; salinity
  - Tidal marsh area was added to account for the required storage volume of the large tidal flux.
  - An overview of the modified grid mesh was shown.
- Marco Alebus asked how "Dundee Lake", the water behind Dundee Dam, was handled in the model.
  - Nicholas Kim responded that the flow recorded at the USGS Little Falls gage is discharged over Dundee Dam.

- Dr. Alan Blumberg asked about bathymetry, and how the dredging program has been accounted for.
    - Nicholas Kim responded that approximately 90% of the dredging program was complete by 2009 and 2010. It was assumed that the dredging project was complete for the calibration period.
- Nicholas Kim presented model calibration timeseries plots of tide data, temperature, and salinity.
    - Dr. Alan Blumberg asked whether the model calibration will be evaluated in any sort of statistical manner.
        - Nicholas Kim stated that will be done and included in the report.
    - Marco Alebus requested that a statistical means for quantifying the error in the calibration be included.
- Biswarup Guha stated that BCUA collected salinity data that might be useful.
    - Bridget McKenna stated that BCUA is a participant on this project and she will request the data from BCUA.

Water Quality Modeling – Presented by Richard Isleib

- Richard Isleib provided a summary of the receiving water quality data collected between April 2016 and early January 2017.
    - The stormwater sampling results for the Hawthorne low density residential and Paterson commercial/industrial sampling locations are unexpectedly high. Additional investigation on these locations may be required.
    - Dr. Wayne Huber asked whether the industrial and commercial stormwater sampling locations are representative of the all industrial and commercial land uses.
        - Marques Eley stated that the Paterson Commercial/Industrial site may be near a slaughter house in Paterson.
- Dr. Steven Chapra suggested that light be included as a modeling parameter.
- Charlie Dujardins suggested that some of the remaining CSO sampling effort be diverted towards additional stormwater sampling.

Closing Remarks

- The group discussed a schedule for the next MEG meeting(s).
    - Dr. Steven Chapra requests that any information on the receiving water quality model be sent in advance of the next MEG meeting so that the MEG has time to review.
    - Tim Dupuis suggested that two more MEG meetings be held; one prior to the receiving water quality model validation and one afterwards.
    - Biswarup Guha requested that materials be shared with NJDEP ahead of the next meeting.

- The group decided that the next meeting will be targeted for August 2017.

Attachments

-Agenda
-Sign-in sheet

PASSAIC VALLEY SEWERAGE COMMISSION

Long Term Control Plan

Modeling Evaluation Group - Session 2
March 17, 2017, 9:00 A.M. - 3:00 P.M.
Stevens Institute of Technology, Babbio Center, 5th Floor

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Meeting Summary

PVSC Model Evaluation Group (MEG)

Session 3

September 15, 2017

Stevens Institute of Technology

Attendees: See Sign-In Sheet

Introduction

The PVSC Long Term Control Plan (LTCP) Model Evaluation Group (MEG) held their third meeting at Stevens Institute of Technology on September 15, 2017. Greeley and Hansen, CDM Smith, and HDR presented status updates on the progress of the monitoring and modeling programs being performed for the PVSC Long-Term Control Plan project. The following is a summary of the meeting topics and discussions.

Opening Remarks

- The meeting attendees introduced themselves and their affiliation with the project
- Mike Hope provided an overview of the program status:
    - The program is in the System Characterization Phase.
    - The collection system model calibration is almost complete.
    - The water quality sampling program is complete with the exception of the CSO sampling program.

Water Quality Monitoring and Modeling Program Overview – Presented by Richard Isleib

- Surface water quality sampling program:
    - There are 72 surface water monitoring locations.
    - The applicable water quality standards and waterbody classifications were reviewed.
    - There are locations upstream of the CSOs where the sample results approach or exceed the single sample maximum.
    - The Second River shows some of the highest bacteria concentrations.
        - Sheldon Lipke states that prior investigations on the Second River have shown that both dry and wet weather concentrations can be out of compliance.

  - The Elizabeth River also shows high bacteria concentrations.
  - Dr. Blumberg requests that maps of the sample locations be added to the sample results slides in future presentations.
  - Tim Groninger stated that the surface water sample data scatter plots will be distributed to the NJ CSO Group along with a memorandum explaining the sampling program and results.
  - Sheldon Lipke asked that Richard Isleib email him the figures shown in the presentation.
  - Sheldon Lipke suggested that distinguishing between dry-weather and wet-weather samples on the plots may be useful.
  - Richard Isleib asked NJDEP whether the State was considering upgrading any of the waterbodies.
    - Biswarup Guha stated that EPA wants the States to update their standards for primary contact waterbodies.
    - For SE1 and SC waters, NJDEP is going to update the criteria to match the EPA standards
    - For downgraded waters, NJDEP might consider the results of the LTCPs to determine whether to modify the standards.

- Stormwater sampling program:
  - There are 8 stormwater sampling locations.
  - There are 18 CSO sampling locations.
  - The stormwater sampling program is complete.
  - The stormwater sampling results were compared with tributary area land use, but definitive distinctions were not found. Therefore, a single stormwater concentration will be utilized.
  - Richard Isleib explained the mass balance approach for to determine the fraction of sanitary and stormwater flow in the overflow using a tracer, and calculating the overflow concentrations based on the percentage of each in the overflow.

- CSO sampling program:
  - Mike Hope stated that the CSO sampling program is the only portion of the overall sampling program that is not yet complete.
    - To date 18 CSO sampling events have been completed, which is 1/3rd of the CSO Sampling Program. 36 additional sampling events are required.
    - 10 of the 18 sampling stations have been sampled at least once.
    - Weather conditions have been a challenge
    - Continuing the current course of the CSO sampling program will negatively impact of the schedule for completing the System Characterization Report.

        - We are considering collecting additional stormwater sample data in lieu of collecting additional CSO sample.
    - Charlie Dujardins asked whether a difference in CSO concentration was found from location to location, or based on tributary area land use.
        - Richard Isleib stated that there is variability between locations, but there is also variability at the same station when it has been sampled multiple times.
    - Dr. Steven Chapra asked whether the CSO sample concentrations have been normalized to something like the size of the tributary area.
        - Richard Isleib responded that the data was no normalized to the area, but that is something that we can look at.
    - Susan Rosenwinkel stated that NJDEP would like to see all of the data before making a decision to allow a change to the sampling program.
    - Richard Isleib that the results of the InfoWorks model would be used to evaluate how well the model is predicting the existing CSO sample dataset, and then a decision can be made about whether additional CSO sampling data would be required.
    - Marco Alebus asked that a comparison of the results predicted by the model against the data collected be sent.

- Dry and Wet Weather Loads to the Receiving Water Model:
    - Richard Isleib explained the proposed Monte-Carlo regression of using dry weather river flow and bacteria concentration.
        - Dr. Steven Chapra suggested that the actual data be used instead of assuming a geometric distribution for sites with many observations.
    - Richard Isleib explained an approach using a linear regression of concentration vs. precipitation for events above 0.2" to determine a concentration to add to the dry weather concentrations.
        - Dr. Steven Chapra suggested that the slope of the regression be tested to determine whether it is statistically significant, or whether a constant wet weather concentration should be used instead.
        - Dr. Wayne Huber agrees that the significance of the regression slope needs to be confirmed.
    - Richard Isleib stated that the load from the upstream Hudson River will be applied just upstream of the area of interest, instead of trying to model the loads from Albany down to the area of interest.
        - The MEG agrees that this approach is reasonable.
    - Richard Isleib explained the pathogen model kinetics.
        - Dr. Chapra suggests that HDR's knowledge on NYC and available local data be used to determine the loss rate.

        - Dr. Chapra also suggests that the settling velocity can be used as a calibration knob.

Collection System Model Calibration Results – Presented by Yuan Fang

- Yuan Fang provided an overview of the collection system model and the individual CSO communities.
- The group discussed the impacts of not having the detailed Jersey City collection system model in the regional InfoWorks model.
    - Yuan Fang explained that the Jersey City collection system is currently represented as a simplified system.
    - Jersey City is performing their own modeling independently.
    - Bridget McKenna stated that PVSC has requested the Jersey City model, but it hasn't been received yet.
    - Mitch Heineman stated that we currently have a reasonably working model to simulate the flows, but not the detailed model.
- Yuan Fang presented timeseries and scatter plots showing how the collection system model flow predictions compare with the monitored flow data.
    - The model performs best on the interceptor and trunk sewer meters.

Final Discussion

- The group discussed holding another MEG meeting prior to final calibration of the receiving water quality model, most likely in the first quarter of 2018.
- The group discussed the overall project schedule.

Long Term Control Plan

Modeling Evaluation Group - Session 3
September 15, 2017, 9:00 A.M. - 3:00 P.M.
Stevens Institute of Technology, Babbio Center, 5th Floor

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Meeting Summary

PVSC Model Evaluation Group (MEG)

Session 4

December 5, 2018

Location: **CDM Smith Edison, NJ Office**
Attendees: **See Sign-In Sheet**

Introduction

The PVSC Long Term Control Plan (LTCP) Model Evaluation Group (MEG) held its fourth meeting on December 5, 2018. Greeley and Hansen and HDR presented status updates of the monitoring and modeling programs being performed for the PVSC Long-Term Control Plan project. This memorandum summarizes the meeting topics and discussion.

Opening Remarks

- Meeting attendees introduced themselves and their affiliation with the project
- Michael Hope provided an overview of the program status and schedule.
- Mr. Hope requested that the MEG provide a memorandum summarizing their participation in the project and their conclusions.
    - Susan Rosenwinkel agreed that this would be useful. She suggested the memo include an introduction with MEG meeting dates, background on the members, and conclusions.

Hydrologic and Hydraulic Model Overview – Presented by Dr. Yuan Fang

- Dr. Fang provided an overview of the collection system model and the individual CSO communities. She described wet weather operating rules implemented in the model, which include utilizing primary clarifier storage and closing regulator gates when influent flow rate to PVSC from the west exceeds 350 mgd.
    - Marques Eley confirmed that the rules implemented in the model match current standard operating procedures.
- Dr. Fang presented model calibration and validation results
    - Dr. Steven Chapra suggested that the flow monitoring data should be adjusted to eliminate questionable spikes, and then the calibration plots should be updated.

- Dr. Alan Blumberg suggested that performance statistics, such as root mean square error, should be included.
- Dr. Blumberg requested that monitored vs. modeled scatter plots be developed which show all metered events at all locations; the group agreed that these scatter plots would be useful in evaluating the calibration
- Marzooq (Marco) Alebus acknowledged that calibration was performed, but asked whether an independent validation was also performed using separate storm events.
  - Mitch Heineman responded that collection system models typically have limited data from which calibration and validation can be performed, so it is typical to perform a single calibration/validation.
  - Dr. Chapra stated that validation was performed since calibration results from the four events are based on a single set of model input parameters. Each event thus validates the others. Dr. Chapra stated that this is excellent engineering in terms of considering one's available data, and that he has confidence in the methodology; Charles DuJardin agreed with Dr. Chapra.
- NJDEP suggested that the System Characterization Report be retitled "Calibration/Validation", instead of "Calibration and Validation".
- The MEG requested that scatter plots with all the monitored vs. modeled results be developed, color coded by event.
- Susan Rosenwinkel stated that a 45-day extension would be granted for submission of the revised System Characterization Reports so that MEG comments could be addressed and incorporated.

Hydrodynamic Modeling – Presented by Nicholas Kim

- Mr. Kim provided an overview of the hydrodynamic model. He explained the model input parameters and model domain, and presented salinity and temperature calibration results at various monitoring locations within the model domain.
- Dr. Wayne Huber stated that the model results are generally in good agreement with the monitoring data.
- Mr. Alebus requested that all graphs be presented in the final report; Dr. Blumberg suggested that the main report should contain representative plots, with the remainder relegated to an appendix
- Rich Isleib stated that for the purposes of the water quality model, the hydrodynamics perform as required.
- Mr. DuJardin requested that some level of spatial plots be developed to show how salinity varies along the Hudson River, Passaic River, and Hackensack River.

Water Quality Modeling Update – Presented by Rich Isleib

- Mr. Isleib provided an overview of the receiving water quality model, beginning with model kinetics and pathogen sources.
- Mr. Isleib presented the monitored stormwater and sanitary bacteria concentrations obtained from the monitoring programs.
    - The results of the stormwater sampling program did not reveal a statistically significant difference in bacteria concentrations in runoff from different land use types. The variation within a land use type was as wide as the variation among land use types.
    - All the monitoring data was thus combined. Uniform fecal coliform (41,000 cfu/100 ml), enterococci (110,000 cfu/100 ml), and E. coli (38,000 cfu/100 ml) concentrations were applied to runoff regardless of land use type.
- Mr. Isleib explained that CSO loadings were determined based upon the fraction of sanitary and stormwater flows in the hydraulic models, multiplied by respective dry and wet weather concentrations. Calculated CSO concentrations were compared with monitored CSO concentrations and found to be in good agreement.
- Mr. Isleib presented the WWTP influent monitored pathogen concentrations.
    - Dr. Chapra asked about the seasonal pattern in bacteria concentration at the WWTP.
    - Mr. Isleib responded that it may be the result of dilution from I&I
- The group discussed the ratio of E. coli: enterococci in sanitary and stormwater data
- Mr. Isleib presented the methodology for assigning river boundary loads using a Monte Carlo approach for dry weather, and maximum likelihood estimation for wet weather.
    - The water quality monitoring data suggest the presence of additional dry-weather loads from sources other than those initially modeled.
    - To check the reasonability of the additional dry weather loads being input into the model, a "person-equivalent" approach was used assuming an average sanitary flow concentration and 150 gallons per day wastewater per capita.
        - The group discussed the person-equivalent approach.
        - Dr. Chapra suggested that it might be a good discussion for an appendix.
- Mr. Isleib presented WWTP, stormwater, baseflow, and Hudson River boundary loads that were applied to the model.
    - Mr. Alebus asked about using a WWTP effluent enterococci concentration of 100 cfu/100 ml even though WWTPs have limits of 35 cfu/100 ml.
        - Mr. Isleib responded that he didn't think the WWTP concentration was that sensitive.
        - Ms. Rosenwinkel responded that she doesn't believe the contributing WWTPs have enterococci limits.
        - Mr. Alebus suggested that an explanation of the 100 cfu/100 ml should be included in the report.

- Mr. Isleib presented NJ pathogen criteria for primary and secondary contact recreation, followed by model calibration results.
  - Mr. Hope asked if Mr. Isleib's interpretation of evaluating geomean compliance with the model is to use a rolling 30-day geomean.
    - Mr. Isleib responded that this is his interpretation and explained how he performed those calculations.
  - Dr. Chapra asked what model adjustments had to be made for this study as compared to prior studies.
    - Mr. Isleib responds that the base die-off rate for fecal coliform was set to 0.2/day instead of 0.8/day and that temperature adjustments were also made
  - Dr. Chapra stated that in his opinion the model is the best that it can be given the state of knowledge.
  - Mr. DuJardin stated that he would like to see a calculated depth-average solar radiation decay rate in the Hudson River vs. the Passaic River, or other locations.
  - Dr. Huber asked that the report address the sensitivity analysis of all key parameters, not just the die-off coefficient.

Final Discussion

- Dr. Huber suggested that a sensitivity analysis be performed for each model.
- The MEG requested that one additional MEG meeting be held.
- Mr. Hope discussed the next steps
  - Possibly hold another MEG meeting
  - Memo from the MEG
- Dr. Blumberg stated that the System Characterization Report needs a conclusion on the model's performance.

Long Term Control Plan

Modeling Evaluation Group - Session 4
Oct. ~~November~~ 5, 2018, 10:00 A.M. - 3:00 P.M.
CDM Smith, 110 Fieldcrest Avenue, Edison, New Jersey 08837

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PVSC LTCP
Model Evaluation Group (MEG)
Memorandum dated February 15, 2019

Memo:

February 15, 2019

To: PVSC Consulting Team

From: PVSC MEG: Steve Chapra, Alan Blumberg, Wayne Huber

Re. Comments re. MEG4 meeting of December 5, 2018 and PVSC Characterization Report, revised as of January 19, 2019

Overall Summary

1. The MEG has enjoyed presentations on the overall approach to modeling and its support data for the PVSC Combined Sewer Overflow mitigation efforts for the past three years. We are in broad general agreement with the approach and techniques used for the development of modeling tools to address pathogen receiving water impacts of PVSC CSO discharges. We feel that the consulting Team's efforts have been well conceived and executed within practical limits of budget and technology. In particular, the H&H modeling is very extensive and well done. The MEG is in accord with the direction of the Team to date in developing tools to address PVSC mitigation strategies. The Team is "on track".
   RESPONSE: Acknowledged.

2. The MEG is missing strategies and pathways leading to overall PVSC mitigation efforts, drawn from the modeling to date. We look for H&H modeling conclusions (such as discussed in our Addendum) related to CSO discharges and their impacts. We understand that there will be a sequence of reports dealing with important results such as receiving water impacts of mitigation strategies, e.g., time series and spatial distributions of pathogen concentrations in New Jersey and New York estuaries. We feel that it is incumbent on us to review and comment on results developed in the next phases of this project regarding the effectiveness and use of these strategies to reduce pathogen concentrations. Therefore, we strongly request another opportunity to evaluate these forthcoming efforts.
   RESPONSE: Acknowledged.

Addendum: Comments related to detailed review of PVSC System Characterization Report, Revised 1/2/19. Specific report sections addressed are in response to direction from M. Hope and M. Finizio.

Most comments are editorial in nature. More significant comments:

Section E, comments 2, 3, 6.

Section I, comments 7, 8, 9, 10, 14, 15, 16, 19, 22, 23.

Section G, comment 2.

Section E Collection of Precipitation and Sewer Flow Monitoring Data

1. P. 87. Red revisions delete number of meters for each category. Flow meter locations are summarized in Table E.1. Are we losing any information that we need to know by losing the number in each category? Maybe not, in which case disregard this comment.
   RESPONSE: The category for each meter is included in Table E-1. No information was lost.

2. A huge amount of data was recorded by hundreds of meters. Does the report highlight or give a sense of the relative percentage (or other metric) of regulator and outflow volume that was covered by flow monitoring relative the total CSO and PVSC discharges at the downstream end of its system during the time the monitors were active? The monitors include temporary ones here in Section E, and permanent ones. For example, can we say X % of regulator inflow (to the main trunk sewer) volume was measured? Or maybe a different perspective-type number would be the percentage of project cities' land area (or population or?) that was monitored for contributing inflows to the PVSC trunk and stormwater discharges?
   RESPONSE: Temporary flow meters were installed at eleven (11) outfalls. Based on the results of the typical year model simulation, these 11 outfall locations discharge approximately 30% of the total annual CSO volume. Quantifying the percentage of the monitored regulator influent would be more difficult. However, large CSO drainage basins were targeted for the temporary flow metering.

3. Regarding missing temporary flow meter data (Figure E-2), was there ever a need to infill such data by other than the model that is not indicated in the reports?
   RESPONSE: Figure E-2 in intended to show that all but two of the meters had available metering data from 5/20/2016 through 8/5/2016. That was the period that was selected for model calibration/validation. Records from the two meters located on the Newark 009/010 South and North outfalls were partially missing during this period. No infill of flow data was performed during this period.

4. Data and approaches to diurnal variations, peaking factors, screening of data – all seem good to me. A commendable and huge effort.
   RESPONSE: Acknowledged.

5. Section E.7 Rainfall Frequency Analysis. In the big picture, precision on the return period of the selected calibration events probably doesn't matter. But we point out that intensity-duration-frequency curves (IDF curves), here represented by depth-duration-frequency curves, are not an appropriate way to estimate a return period for individual events. IDF curves are not based on independent events but from some d-hour duration segment of real storms, which may be much longer than for the data point used to construct the contours. Specifically, they represent conditional probabilities that a certain intensity will occur given a duration. The right way is to perform a conventional frequency analysis on the period of record from the gages that contains the candidate events (Table E-4). This would be performed on the long-term period of record for the various the rain gages, by separating the record into likely-independent events by the minimum interevent time chosen, here 6 hours, a common choice. For example, SWMM5 can perform this analysis; it isn't arduous. It may be that only the Newark Airport has a long enough record here, which is fine. Then the events of 2016 could be identified from this separation with their return period or exceedance frequency.

This all seems to have been done in Section H ! Could not the analysis look ahead to tables such as H-2 and do a better (as in more precise and theoretically justified) job of assigning return periods here?

Having said all this, it is still obvious from Figure E-9 that all the chosen events are of high frequency with low return periods. That is the main point of the discussion, and the data are well presented. This is not a "mission critical" analysis. Perhaps the report could include a brief insertion on p. 99: "Newark Airport rainfall was compared to the NOAA's Precipitation Frequency Table to *provide an approximate* estimate *of* the return frequency of these events (Figure E-9)."
RESPONSE: The suggested text has been inserted into Section E.7.

6. Re. Section E.7, has the report stated what time steps are used in the simulations? 15-min? We have very good quality (i.e., 5 to 15-min) rainfall data here.
   RESPONSE: Precipitation is input at a 5-minute time step. This is first stated in Section I.3.1 of the Report and repeated in Section I.6. The model is run at a 1-minute time step and reported at a 5-minute time step.

7. Re. overall Section E, I believe we all understand the difficulty and expense of monitoring such a huge complex area and finding a group of monitored events that will serve for model calibration. We think the team has done a fine job here.
   RESPONSE: Acknowledged.

Section I Hydrologic and Hydraulic Modeling

1. This review will focus on highlights and the H&H modeling presentations.
   RESPONSE: Acknowledged.

2. The PVSC Interceptor Model covers a very large area of primarily old, established cities. Hence, assumptions about constant land use over time should be OK, maybe unless some huge new industrial or other development has occurred or will occur.
   RESPONSE: Acknowledged.

3. Pp. 165 and nearby: text is understandable, but with some awkward grammar, e.g., "…is corresponded to…"
   RESPONSE: The text was modified for grammar.

4. MEG comments and Table I-5 are discussed in a separate section below.
   RESPONSE: Acknowledged.

5. Re. Section I.3, H&H Model Components and inputs, the MEG has enjoyed several presentations on this work. The amount of spatial detail is enormous (e.g., Section I.4), with thousands of SWMM subcatchment parameters provided. Having so much impervious area in the study area helps with parameter choices. Rainfall data are taken from the best available options. Newark Airport data are good for the long-term simulations.
   RESPONSE: Acknowledged.

6. Hydraulic data for the combined sewers and regulators have been reviewed (P. 186) by the Team. We don't see how any better model representation could be constructed without unreasonable, large extra expense.
RESPONSE: Acknowledged.

7. At the MEG Session 1 (2/5/16, Table I-5) the MEG was assured that interceptor geometry was represented adequately. Does the Characterization Report mention what field surveys were conducted to ensure this? What is the range of dates for PVSC in-situ drawings for pipes and regulators, e.g., paragraph I.3.6?
RESPONSE: Field surveys were not conducted as part of the current project to confirm the interceptor geometry. The interceptor representation in the model was inherited from prior modeling efforts. Regulator configurations were confirmed using drawings dated from 1997 through 2008.

8. P. 189, re. RDII: Roughly what percentage of flow consists of RDII? Since there are three RDII components, just an average or total is all we request. We are just wondering how important is RDII to overall CSO volumes?
RESPONSE: The total typical year influent volume to the PVSC collection system is estimated to be 83,500 MG, of which approximately 600 MG is RDII.

9. Section I.4. The report should list the model time step for event calibration runs (short runs?) and long-term simulations (annual). Are the event calibration runs (Section I.5) run over a longer real time period, e.g., to establish antecedent conditions? Or are they just run over a period of several hours? Or maybe there's one long run for 2016 from which these four event simulations are extracted? Please explain.
RESPONSE: The same time steps were used for the calibration period simulations and the typical year simulations. Precipitation is input at a 5 minute time step. The model is run at a 1 minute time step and reported at a 5 minute time step. The calibration runs were done using two time periods. The simulation for the May 29th calibration event was started on May 27th to establish the antecedent conditions. The simulation for the July 25th through 30th events were started on July 23rd to establish the antecedent conditions.

10. Of course, these reports and all models will be passed along to the PVSC and its consultants for future application. Of more than just geeky interest is information about time steps and run times for individual events (e.g., the calibration events) and annual simulations as well as the computing platforms used. What kind of simulation times are encountered? Did the team or InfoWorks develop post-processers to aid in the analysis? If this information is already included somewhere, please point to it in, say, an appendix. Else, please do include it, at least briefly.
RESPONSE: The typical year model simulation takes approximately 3 hours without water quality tracers included, 8 to 9 hours with the water quality tracers included. Post processing was performed in Excel.

11. P. 197 re. modeling criteria: It is definitely more important to match volumes than peaks, although both matter, because pathogen loads are driven by volume. Hence, it is good to have a more

stringent goal (-10% - +20%) for volumes than for peaks. In terms of overflows to receiving waters, upstream timing at individual locations mostly gets smeared out in the summation. Hence, overflow volume summary figures are very important. I would expect fits of model vs. monitor volumes to be better than flows in any event, because of the flow integration involved. This is reflected in the useful new Nash-Sutcliffe Efficiency (NSE) plots shown in Section I.5.3 (volume matches have higher R2).

Re. the many, predominantly impressive calibration plots comparing hydrograph flows and volumes, Figures I-27 – I-54:
RESPONSE: Acknowledged.

12. Display of the same hydrograph and scatter plots all on one page, with a separate page showing the hydrographs on larger plots, is a good way to present these analyses.
RESPONSE: A prior version of the report did include the four hydrograph and two scatter plots for each calibration location together on a single page. DEP commented that the figures were too small so they were separated into the separate pages for the scatter plots and the hydrographs.

13. Is there some duplication of figures in Figs. I-27 and I-28? The hydrographs and model-monitoring scatter plots look the same.
RESPONSE: The redline version of the document that the MEG reviewed can be confusing when it comes to replacing figures. As described in the response to Comment #12 above, the prior version of the System Characterization Report included the hydrographs and scatter plots on a single page, in this case that would have been Figure I-27 as found on page 200 of the document. Page 200 is being removed (redlined) and replaced with pages 199 and 201. Figure I-27 now contains only the scatter plots and the site location map. Figure I-28 contains only the hydrograph plots.

14. P. 221, Fig. I-42, errant meter data in the top figure have been smoothed out or in-filled in the lower figure. The text might mention this process somewhere.
RESPONSE: The screening and smoothing/filling of meter data is mentioned in Section E.5. The process has been explained in the updated version.

15. But not at all locations: Fig. I-46 retains the missing (we assume) monitor flows on both sets of hydrographs. That would certainly account for overestimation of volumes by the model for this location and events. Likewise Fig. I-51 for NE_15A. Volumes are not comparable for three of the four events.
RESPONSE: The missing monitored flow data for this meter occurred over a long period of time, making it impossible to interpolate between adjacent data points with any confidence in the resultant timeseries.

16. Yet for location NE_15A_II, Fig. I-52, the missing or no-flow monitoring data are believed. Maybe monitors could be identified as more or less reliable?
RESPONSE: For location NE_15A, which is an overflow meter, the recorded flow during this event was zero. The meter appears to have been operating properly. It is possible that the precipitation used in the model for this particular event didn't occur within the contributing area, or that the

model is simulating an overflow event as a response to a rainfall event that didn't trigger an actual overflow event.

17. Re. Section I.5.3 and NSE, NSE values are very high, and, as noted in the report, well above the threshold (~0.5-0.75) heuristically characterized as a "good fit." Unlike the traditional R2, we don't believe there is a significance test for the NSE. We do note slightly higher NSE-R2 for volume than for peaks.
RESPONSE: Acknowledged.

18. Figures I-63 – I-65 graphs re. overflow statistics, it would help to have "frequency" include units of #/year, as in Table I-11.
RESPONSE: The units of #/year have been added to the figures.

19. In the context of comment 11 above, while a few locations/storm events show inferior fits, the large majority of model-monitor fits are good and within the project percentage criteria. But where do/will we see the summary total overflow volume from all outfalls, modeled vs. monitored, shown at the end of the MEG4 H&H modeling presentation (slide 65)? That is an essential figure, needful of inclusion and discussion.
RESPONSE: This referenced figure and a discussion of the figure has been added to Section I.5.2.

20. The overflow statistics and simple Table I-12 at the end are useful.
RESPONSE: Acknowledged.

Section I ends abruptly, with no summary. We understand from discussion with Team staff that future reports will present more pertinent (to the goal of reducing receiving water pathogens) results, such as receiving water analyses.
RESPONSE: Acknowledged. The intent of this report was to characterize the existing collection system. Future reports will address alternatives for reducing combined sewer overflows, pathogens discharged to the receiving waters, and receiving water quality.

A few additional comments:

21. Sanitary sewer overflows, SSOs: This question may have been addressed earlier, but at this point, it isn't found in prior summations. What is the importance of SSOs in modeling and overall pathogen inputs to the receiving waters? They are not mentioned in the Characterization Report.
RESPONSE: There are no known SSOs within the PVSC service area.

22. We are still missing a sensitivity analysis or discussion of key H&H calibration parameters? With thousands of individual H&H variables, i.e., for specific subcatchments and pipes, what were the main variables actually used to calibrate the overall H&H model and subarea models? What are the "key model parameters" mentioned at the beginning of Section I.5, p. 195? A good discussion of the various SWMM modeling parameters is given in Section I.3.2, but there had to be some watershed-wide (or sub-watershed or city-wide) parameter adjustments at some time. What global

parameters were typically adjusted? To what parameters was the SWMM model most sensitive to in this highly urbanized area?

RESPONSE: The routing coefficient (RC) for combined sewersheds was the principal calibration parameter for the PVSC model. This parameter controls directly-connected impervious area, and is the principal factor determining total wet weather runoff into the collection system. Other important calibration parameters were subcatchment width (hydrograph shape), sanitary sewershed infiltration/inflow (I/I) coefficients ("R"), and Manning's N in the PVSC interceptor. However, the routing coefficient was by far the most important parameter adjusted.

The model's hydrology was adjusted differently for sanitary and combined sewersheds.

For sanitary sewersheds, the unit hydrograph parameters (known as the RTK method) were adjusted. Three R parameters control total I/I. Overall average R coefficient was calibrated at 0.5 percent for 62,000 acres (97 mi^2) of separate service area (PVSC Model Summary and Update Procedures, April 2018, p. 5). Sanitary collection system I/I typically ranges from 0.1 to 5 percent of rainfall. I/I from sanitary sewersheds affects flow in the PVSC interceptor along the reach between Paterson and Newark, but has minor overall impact on total flow in the collection system, as demonstrated below.

For combined sewersheds, imperviousness (I) was generally computed directly using the National Land Cover Database (System Characterization Report, p. 179), while the routing coefficient was calibrated to match observed runoff rates. Effective imperviousness (EI) can be expressed as EI = I x (1-RC). As shown in Table I-7 of the report, the combined service area comprises 23,200 acres (36 mi^2), averaging 70 percent impervious and a calibrated value of 41 percent effective impervious (corresponding with RC equal to 41 percent).

For 1-month peak rainfall of 0.4 inches per hour, the rational method (Q = CIA) may be used to estimate runoff from both the sanitary and combined service areas, with the assumption of a typical one-hour time of concentration in much of the collection system. For the separate service areas, peak runoff is 0.5% x 0.4"/h x 62000 ac = 124 cfs (80 mgd). For the combined service area, peak runoff is 41% x 0.4"/h x 22000 ac = 3600 cfs (2300 mgd). The combined area runoff greatly exceeds the collection system's wet weather capacity of approximately 300 mgd (550 mgd total conveyance/treatment minus 250 mgd dry weather flow). Combined runoff greatly exceeds sanitary runoff, which is thus relatively inconsequential for overall system performance. Even in small storms or non-peak rainfall, combined runoff can exceed total system conveyance/treatment capacity (e.g. 600 mgd at 0.1"/h rainfall).

The calibrated 41 percent effective imperviousness is lower than would be expected based on the range of values suggested by Sutherland (1995) and presented in the EPA SWMM Hydrology Manual (Rossman and Huber, 2015). Sutherland's method suggests that an area with 70 percent total impervious should have between 49 and 60 percent effective imperviousness. The PVSC project team has found that the low end of this range is typical in northeastern US communities. The fact that the PVSC value is below the end of Sutherland's proposed range is not surprising, as it is common to find that some areas identified as having combined sewers instead drain to open waterways.

The routing coefficient in the combined service area was thus the principal determinant of total system runoff. It is also the key determinant of CSO volume; while parameters such as subcatchment width affect the timing of hydrographs, runoff across the PVSC combined communities has overland flow distances of at most a few hundred feet, and the timing of hydrographs from individual subcatchments cannot vary across a wide enough range to significantly influence the duration over which the collection system is stressed above its conveyance capacity.

References
PVSC LTCP Consultant Team, Memorandum to PVSC CSO Districts, dated April 24, 2018. PVSC Model Summary and Update Procedures.
Rossman, L. and W. Huber. Storm Water Management Model Reference Manual Volume I, Hydrology. US EPA Office of Research and Development, Washington, DC, EPA/600/R-15/162A, 2015.
Sutherland, R.C. (1995). Methodology for Estimating the Effective Impervious Area of Urban Watersheds. Watershed Protection Techniques 2(1): 47–51.

Section G.3 Overview of Sewer System Quality Monitoring Program and G.4 Sewer System Quality Results

1. A good CSO and stormwater sampling program, with help that the PVSC Water Resources Recovery Facility (WRRF) has continuous monitoring. Given the enormity of the watershed/sewershed, the monitoring seems adequate for model development and calibration.
   RESPONSE: Acknowledged.

2. Two or three representative photographs of monitoring sites, e.g., at/within a CSO location or regulator, would give the reader a sense of the difficulties of CSO monitoring, here or in Section D. The Team provided these on a PPT in one set of responses to MEG comments.
   RESPONSE: Acknowledged. Two representative photos are provided below.

PATTERSON - 025A

GUTTENBERG 01A

Table I.5 and Appendix B re. MEG comments and meeting reviews

1. To the extent of memory and notes, the MEG reviews are adequately characterized. MEG member comments have been addressed other than as noted above. We believe our summary comments have been uniformly positive and supportive of ongoing activities and see no reason why the report might not mention this if desired.
   RESPONSE: Acknowledged.

2. Pp. 173-174 re. MEG affiliations, Huber would prefer his affiliation to be “Oregon State University, emeritus.”
   RESPONSE: This report has been updated to reflect Dr. Huber’s affiliation.

PVSC LTCP
MEG Meeting 1, 2, 3 and 4 Presentations

PVSC Long Term Control Plan

Model Evaluation Group – Session 1

February 5, 2016

GREELEY AND HANSEN
CDM Smith
HDR

Agenda

- Introductions
- MEG Mission
- MEG Scope
- Regulatory Drivers
- Site Information/Background
- Long Term Control Plan Process
- Specific Modeling Components
- Discussion/Next Steps

GREELEY AND HANSEN CDM Smith HDR

CDM Smith

Introductions

- PVSC
  - Bridget McKenna
  - Marques Eley
  - Sheldon Lipke (SJL Environmental)
  - Charles Dujardin (GLEC)
- MEG
  - Alan Blumberg, Stevens Institute of Technology
  - Steve Chapra, Tufts University
  - Wayne Huber, Oregon State University
- LTCP Consultant Team
  - Greeley & Hansen
  - CDM Smith
  - HDR
- NJDEP
  - Marzooq Alebus
  - Susan Rosenwinkel
  - Chang Wu

MEG Mission

"The Model Evaluation Group (MEG) will review all significant technical aspects of the PVSC Long Term Control Plan model development. Model development will consist of three distinct components: Landside, Hydrodynamic, and Water Quality. The goal is to ensure that these model components are technically viable for use by the engineering team in the assessment of engineering alternatives and with withstand regulatory and public scrutiny.

The MEG will provide guidance, where appropriate, to improve or enhance the approaches and methodologies that lead to model development. The MEG will judge, individually and jointly, the technical acceptability of the major model components. If a component is deemed unacceptable, the MEG will outline steps to improve the technical acceptability of the model components. All findings will be summarized in interim progress reports and a final report."

Scope of the MEG

- Work Items (separate handout)
  - Review modeling workplans for landside, hydrodynamic and water quality models
  - Review proposed existing data sources
  - Review proposed sampling plans
  - Respond to requests for opinions
  - Provide guidance during sampling, model development and calibration phases
  - Prepare summary report
- Constraints
  - LTCP must stay within NJPDES permit schedule
  - Reasonable balance of new data and cost
  - Models are the "tools" to develop/evaluate CSO control alternatives for the LTCP

Regulatory Drivers

- CSO Long Term Control Plan
  - Required under NJPDES permits pursuant to Clean Water Act and CSO Policy
    - "Approvable" plan to be developed within 5-year timeframe
    - PVSC developing one coordinated LTCP for PVSC and 8 CSO municipalities
  - Goal is to identify appropriate CSO controls needed to achieve or not preclude attainment of waterbody-specific water quality standards
- NJDEP-Required Submittals
  - Sewer System Characterization – QAPP and Report – July 1, 2018
    - Major components - rainfall, CSS characterization, CSO monitoring, model and sensitive areas
  - Baseline Compliance Monitoring Program – QAPP and Report – July 1, 2018
    - Major components – ambient monitoring, CSO discharge, rainfall
  - Public Participation Report – July 1, 2018
  - Consideration of Sensitive Areas Plan – July 1, 2018
  - Development and Evaluation of Alternatives Report – July 1, 2019
  - Selection and Implementation of Alternatives Report – June 1, 2020

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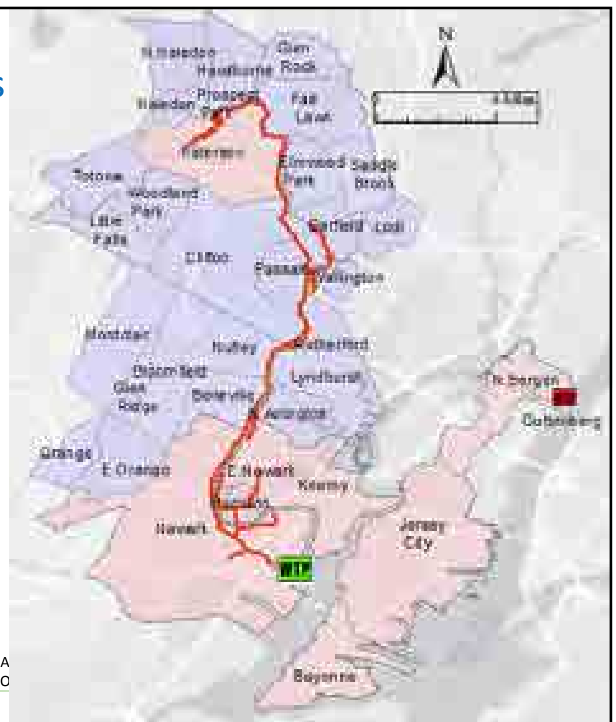
Sewer Systems

- Passaic Valley Sewerage Commission
  - 48 municipalities in Bergen, Essex, Hudson, Union and Passaic Counties
  - 1.5 million residents
  - 147 mi² service area
  - 22 mile interceptor sewer
  - 330 mgd WWTP
- PVSC combined service area
  - 8 municipalities
  - 0.9 million residents
- NBMUA
  - 2 CSO municipalities

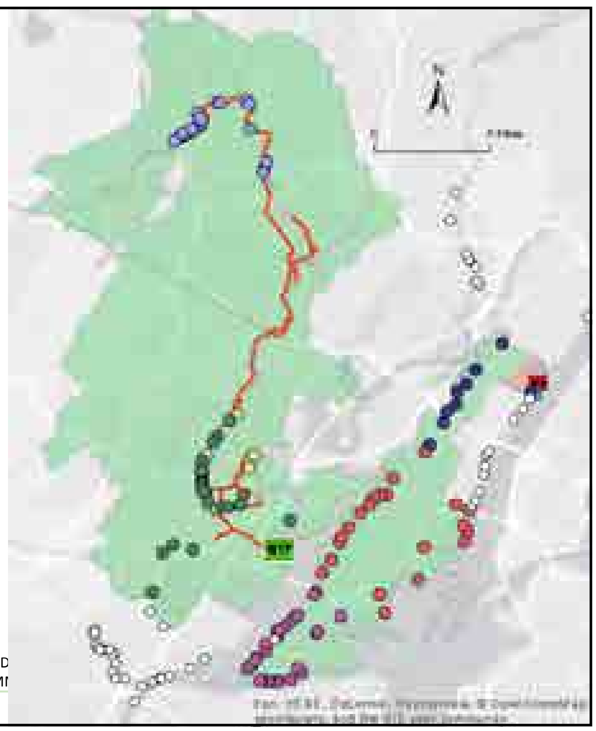
PVSC Communities



Passaic River Watershed

9

CSOs



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10 GREELEY AND HANSEN CDM Smith FDR

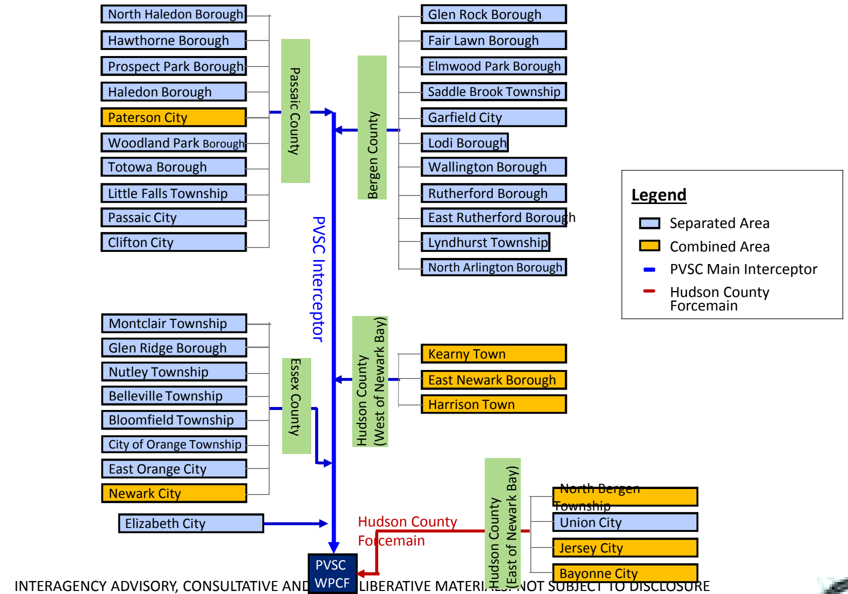
CSO Communities

Municipality	WWTP	Population	Area (mi²)	Sewerage (miles)	CSOs
Bayonne	PVSC	63,000	5.8	94	30
East Newark		2,400	0.1	2	1
Harrison		13,600	1.3	18	7
Jersey City		247,600	14.8	230	21
Kearny		40,700	6.5	52	5
Newark		277,100	22.3	579	18
North Bergen		52,600	4.5	59	7
Paterson		146,200	8.7	164	23
Guttenberg	NBMUA	11,200	0.2	5	1
North Bergen		8,200	0.7	8	1
Total		862,600	84	1,211	114

Previous Monitoring and 2016 QAPP

Municipality	WWTP	Previous Study	Internal Flow Meters		CSO Flow Meters		CSO WQ Sampling	
			Previous	***QAPP***	***Previous***	***QAPP***	***Previous***	***QAPP***
Bayonne	PVSC	2005	5	0	3	2	3	3
East Newark		1997	1	0	1	0	1	0
Harrison		1997	7	1	1	0	1	2
Jersey City		2005	59	-	4	-	2	-
Kearny		1997	9	0	2	1	2	1
Newark		2005	32	2	22	5	8	4
North Bergen		2005	10	0	3	2	2	2
Paterson		1997	27	1	7	2	7	5
Guttenberg	NBMUA	2005	0	0	0	1	0	0
North Bergen		2005	1	2	1	0	1	1
Total			**151**	**6**	**44**	**13**	**27**	**18**

PVSC Schematic



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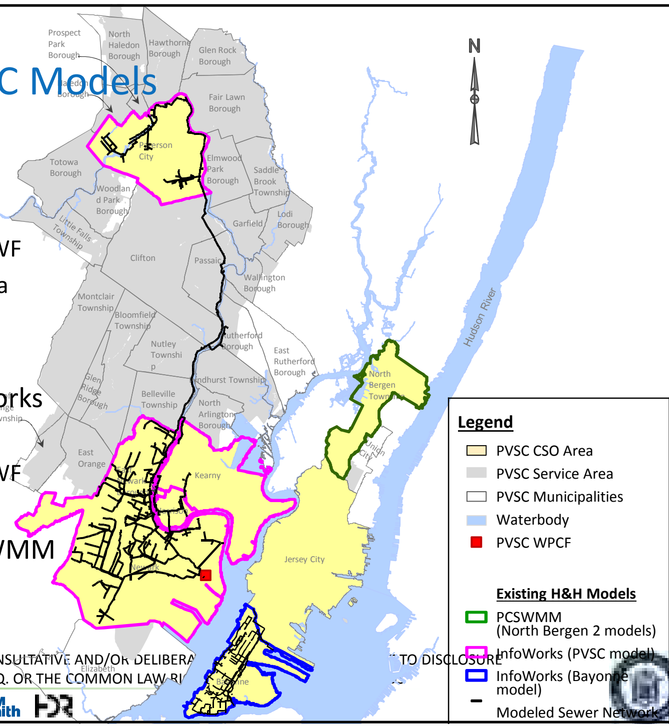
Existing PVSC Models

- PVSC InfoWorks
  - CSO area
  - Runoff and DWF
  - Separated area
  - DWF
  - No RDII
- Bayonne InfoWorks
  - CSO area
  - Runoff and DWF
  - No RDII
- N. Bergen PCSWMM
  - Two models



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Baseline Compliance Monitoring Program QAPP

Table

Station		Waterbody	Coordinates		Sa…
			Lat	Lon	Baseline
Passaic River & Tributaries	PAS-C	Passaic River	40.88217	-74.34000	PVSC
	POM-A	Pompton River	40.91442	-74.27100	PVSC
	PAS-B	Passaic River	40.89700	-74.27300	PVSC
	PAS-A	Passaic River	40.88773	-74.24700	PVSC
	1	Passaic River	40.90416	-74.20066	PVSC
	B24	Passaic River	40.91521	-74.18198	Contractor
	2	Passaic River	40.92120	-74.17550	Contractor
	3	Passaic River	40.94130	-74.14820	PVSC
	B22	Passaic River	40.91816	-74.13024	Contractor
	4	Passaic River	40.90266	-74.11500	PVSC
	5	Passaic River	40.87950	-74.12066	PVSC
	6	Saddle River	40.88900	-74.08166	PVSC
	7	Passaic River	40.84149	-74.12275	PVSC
	S7	Third River	40.82598	-74.13506	
	8	Passaic River	40.78616	-74.14733	PVSC
	9	Second River	40.78350	-74.16150	PVSC
	10[a]	Passaic River	40.75120	-74.16530	PVSC
	11	Passaic River	40.73566	-74.15566	Contractor
	B8	Franks Creek	40.74632	-74.13747	Contractor
	B6	Passaic River	40.74148	-74.13632	Contractor
	12	Passaic River	40.71983	-74.12183	PVSC
	13	Hackensack River	40.95610	-74.02880	PVSC

System Characterization and Landslide Modeling QAPP

PVSC System Characterization and Landside Modeling, Part 1 and Part 2 QAPP

Part 1:
- East Newark
- Harrison
- Kearny
- Newark
- Paterson

Part 2:
- Bayonne
- North Bergen (portion)

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East Newark

Baseline Compliance Monitoring Program

Harrison

Baseline Compliance Monitoring Program

System Characterization Wastewater Quality Sampling Stations

Kearney

Baseline Compliance Monitoring Program

System Characterization Wastewater Quality Sampling Stations

Newark

Baseline Compliance Monitoring Program

System Characterization Wastewater Quality Sampling Stations

Paterson

Baseline Compliance Monitoring Plan

System Characterization Wastewater Quality Sampling Stations

Bayonne

Baseline Compliance Monitoring Program

System Characterization Wastewater Quality Sampling Stations

North Bergen (PVSC)

Baseline Compliance Monitoring Program

System Characterization Wastewater Quality Sampling Stations

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North Bergen Woodcliff WWTP

- 477 acres serving 368 acres in North Bergen and all of Guttenberg (109 acres)
- 1 permitted CSO to Hudson River
- 3 mgd Woodcliff WWTP
- North Bergen MUA and Guttenberg cooperatively develop a CSO LTCP. Communities have requested PVSC's LTCP Engineer to develop the System Characterization and Landside Modeling Program on behalf of these permittees

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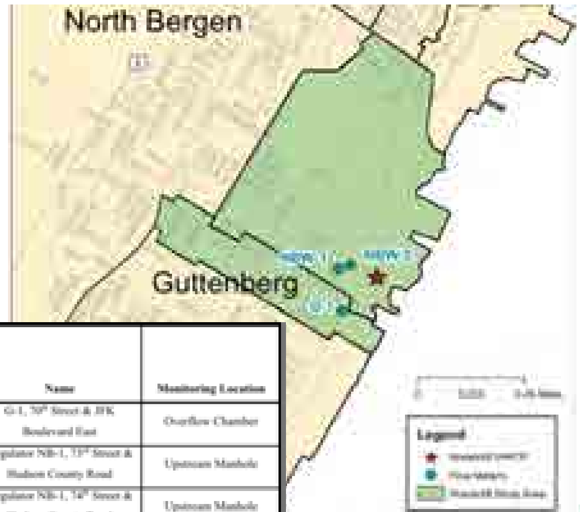
North Bergen Woodcliff WWTP Proposed Temporary Flow Meter Locations

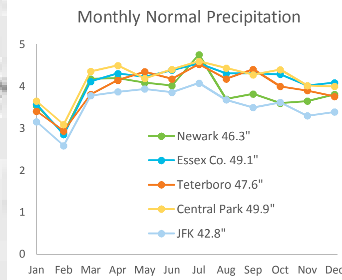


Flow Meter ID	Municipality	NJPDES Permit No.	Name	Monitoring Location
G-1	Guttenberg	001A	G-1, 70th Street & JFK Boulevard East	Overflow Chamber
NBW-1	North Bergen	004A	Regulator NB-1, 73rd Street & Hudson County Road	Upstream Manhole
NBW-2	North Bergen	004A	Regulator NB-1, 74th Street & Hudson County Road	Upstream Manhole

North Bergen Woodcliff WWTP System Characterization Wastewater Quality Sampling Stations

NJPDES Permit No.	Permittee	Location of Sampling Stations
001A	Guttenberg	G-1, 70th Street & JFK Boulevard East
004A	North Bergen	Regulator NB-1, 72nd Street & JFK Boulevard East

NOAA and USGS Rain Gauges



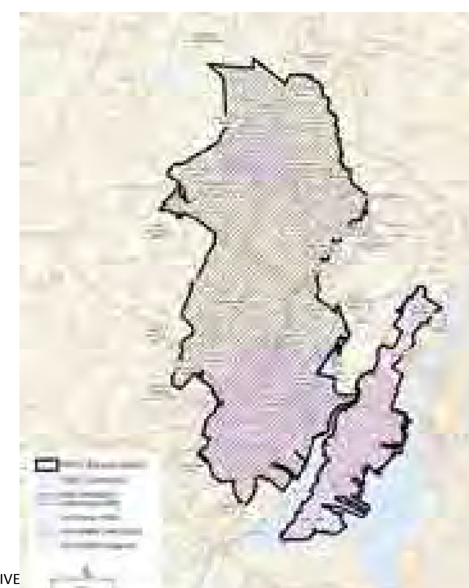
Landside Modeling

Landside Modeling

- System Review
  - Overview of PVSC Service Area Models
    - North Bergen
    - Bayonne
    - Jersey City
    - PVSC Main Interceptor
- PVSC Interceptor Model Development History
- Current and Historical Data Availability
- Previous Model Status and Ongoing Model Update
- Potential Model Improvement

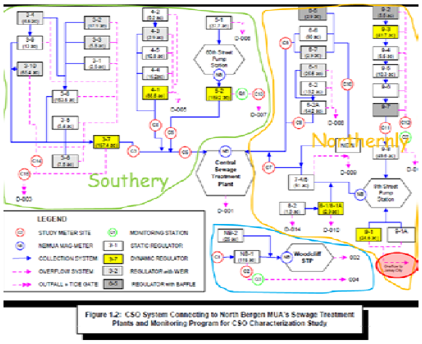
PVSC Service Area

- Service Area : ~100 mi²
  - Combined 13K ac
  - Separated 57K ac
  - 48 municipalities
    - 8 CSO communities
  - 1.5 million population
- Plant Flow
  - 330 mgd permitted & design
  - Average day 210 mgd



Non-PVSC Models

- North Bergen
  - Najarian Associates
  - PCSWMM
  - LTCP Team has model
  - Converted to EPA SWMM for CSO Alert System



Non-PVSC Models

- Bayonne
  - HDR
  - InfoWorks
  - LTCP Team has model
  - Used for CSO Alert System

Non-PVSC Models

- Jersey City
  - ARCADIS
  - XPSWMM
  - LTCP Team does not have model
  - Model results provided by ARCADIS for CSO Alert System

PVSC Main Interceptor Model

- Large, Complex System
  - Main interceptor
  - Seven branch interceptors
  - Combined and separate sewers
  - Regulators
  - RTC
  - Pump stations
  - River crossings
  - Treatment plant

Development History

- NJPDES General Permit for Combined Sewer Systems – 2003 Interceptor Modeling and CSO Characterization Study
  - XPSWMM schematic model
  - Main and branch interceptors
  - Regulators in Paterson, East Newark, Kearny and Harrison
  - Temporary flow and rainfall monitoring
  - Model calibration
  - Event mean concentration development for CSO loads

Development History

- 2007 Long Term Control Plan
  - Converted From XPSWMM to InfoWorks
    - Still schematic
  - Integrated Newark and PVSC interceptor models
    - Newark XPSWMM model developed in 2005 by LMS Engineers
    - Converted to InfoWorks by LMS in 2006-2007
    - Newark portion of model is geo-referenced
  - Verified model with data used in 2003 study and additional interceptor data from 2005-2006

Development History: Domain and Level of Detail

- Interceptors and Branch Interceptors
  - Not all manholes included in model
  - Continuous sewers with same size and slope without inflows are simplified as one link in model
  - Ground elevations from as-built drawings in 1940s
- Paterson, East Newark, Kearny and Harrison
  - Included regulators and one pipe section upstream of regulators
  - Combined sewers not modeled
  - Model subcatchments are regulator based, no sub-delineation of regulator drainage areas
  - Runoff parameters such as imperviousness from reported values

Development History: Domain and Level of Detail

- Newark
  - Combined sewers up to 24” are included
  - Drainage areas are subdivided to subcatchments
- Separately Sewered Area
  - Modeled as dry weather point inflows to interceptor
  - No I&I representation except for Union Outlet
  - Groundwater Infiltration not modeled
- Hudson County Force Main Service Areas
  - Not included

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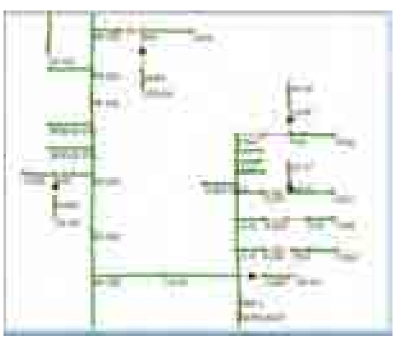
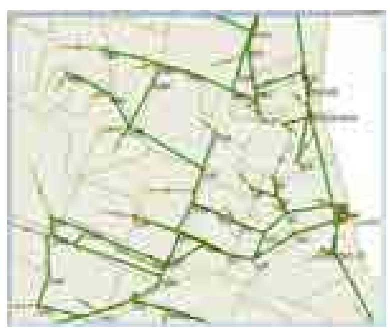
Development History

- Geographic Layout - Mixed
  - Newark
    - Sewers laid out per relative geographic location (accuracy unknown, i.e. not survey quality)
    - Subcatchments delineated as polygons
  - Other areas schematic in nature , not geo-referenced
- Suitability
  - Planning level flow and interceptor capacity analysis
  - Not enough detail outside Newark for combined sewer capacity analysis and alternative evaluation, surface flooding analysis or GI evaluation
  - Not applicable for asset management

Development History: Layout and Level of Detail



Non-Newark



Newark

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Development History

- Recent Applications
  - Analysis for responses to EPA questions
  - Interceptor plug and release study for REDZONE inspection
  - Interceptor lining capacity analysis
  - PVSC CSO alert system website development

Development History

- 2015 updates
  - Georeference entire model
  - Calibrate interceptor HGL using data collected May – Oct 2015

Current and Historic Data Availability

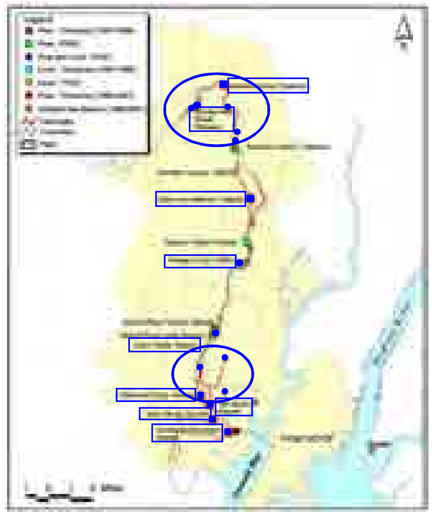
- Permanent In-System Monitoring
- Historic Flow Monitoring and Model Calibrations
- New Level Monitoring Data
- Proposed Flow Metering

Permanent In-system Monitoring Historically Used For Calibration

- Flow
  - Plant flow & Hudson County force main
  - 3 venturi meters
- Level
  - Two level meters
- Rain
  - At plant

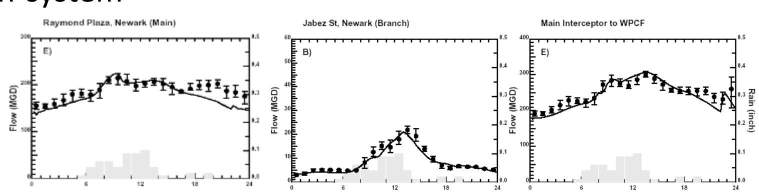
Historic Flow Monitoring and Calibration

- 1997-1998 Interceptor Monitoring
  - Flow and level
  - Calibration: 4 dry and 4 wet events
- 1999-2001 CSO Monitoring Program
  - Overflow and concentration at major outfalls
  - Calibration: 3 wet events for each group
- Permanent Meters
  - Verification: 5 wet events in 2005-2006

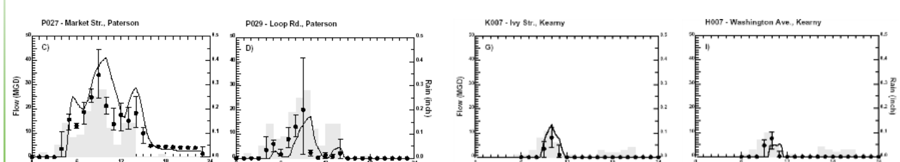


Historical Calibration Example

- In-system



- Overflow



Notes on Previous Calibration

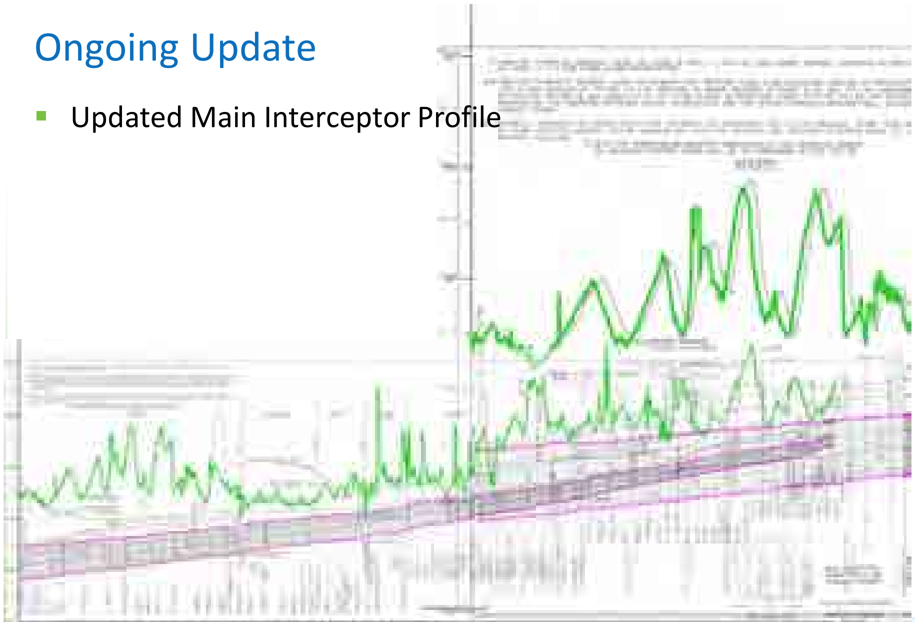
- Changes occurred in system, model has been updated but has not been recalibrated
  - Water conservation and dry weather flow changes
  - Market Street regulator and South Side interceptor gates no longer in operation
  - Regulator reconfiguration, area separation
  - Interceptor relining
- In-system monitoring and overflow monitoring did not occur concurrently for the same events, giving limited view of system-wide flow balance
- HGLs were not focus of previous work; level data collected were very limited

Ongoing Update

- Geo-referenced main and branch interceptors, regulator and outfall locations
- Refined interceptor and branch interceptor representation by including all manholes
- Updated main and branch interceptor manhole invert and ground elevations with survey data
- Updated from interceptor ground elevations with best available topography
- Development of non-Newark area subcatchment boundaries

Ongoing Update

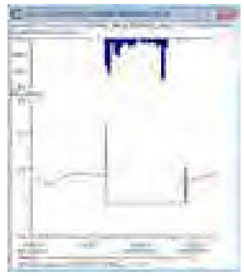
- Updated Main Interceptor Profile



Current Characteristics

- InfoWorks CS 10.5; can be converted to ICM
- 1666 Nodes
  - 75 outfalls
- 1547 Links
  - 7 pumps
  - 71 orifices/sluices
  - 10 Newark gate + plant gate RTCs
- 473 Subcatchments

Current Characteristics



- Automated Gate Operations
  - Main Plant Gates and Regulator Gates in Newark
  - Use Real Time Controls
    - Time-based RTC rules (operational logs) for events
    - General flow based rules (operational criteria) for continuous simulation

CSO REGULATORS

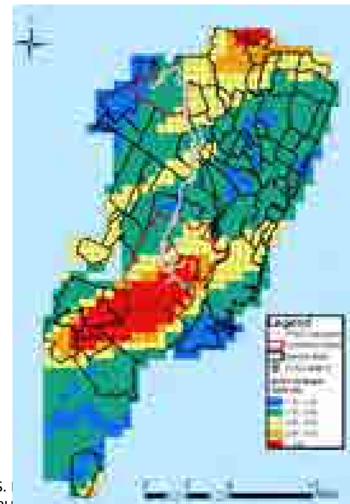
OUTLETS	OUT OF SYSTEM	OUT DATE	OUT TIME	COMPUTER AUTO OPER.	LINE CREW MANUAL	IN DATE	IN TIME	AUTO OPER.	LINE CREW MANUAL
CLAY ST.	X	05/31/15	16:35	X		06/02/15	9:30		X
VERONA	X	05/31/15	16:34	X		06/01/15	18:32	X	
HERBERT	X	05/31/15	16:35	X		06/01/15	18:31	X	
4TH AVE.	X	05/31/15	16:33	X		06/01/15	18:32	X	
CITY DOCK	X	05/31/15	16:30	X		06/01/15	18:30		X
JACKSON	x	05/31/15	19:30	X		06/01/15	18:30	X	
POLK	x	05/31/15	19:29	X		06/01/15	18:29	X	
FREEMAN	x	05/31/15	19:30	X		06/01/15	18:30	X	
SAYBROOK	X	05/31/15	16:34	X		06/01/15	18:30	X	
RECTOR	X	05/31/15	16:36	X		06/01/15	18:33	X	

Current Characteristics

- Boundary Condition
  - Upstream of Dundee Dam
    - River elevation
  - Downstream Tidal Area
    - Tidal elevation
  - Internal Overflows
    - Free discharge

2015 Calibration - Rain

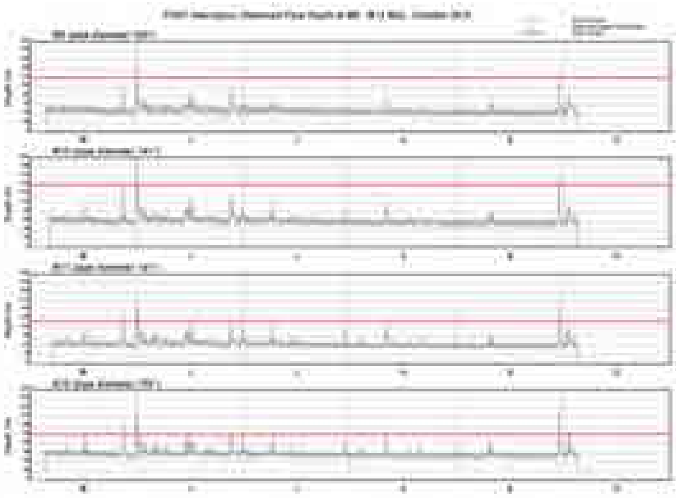
- Gauge Adjusted Radar Rainfall Collected (GARR)
  - Long interceptor system, spatial rainfall differences exists between upstream and downstream drainage areas
  - 2015 radar rainfall
    - 5-min
    - hourly



2015 Calibration - Metering

- Flow Assessment Level Monitoring
  - 18 level (1 with flow) meters along main interceptor
  - May 8th - Oct 10th, 2015
  - 5-minute data
- PVSC Permanent Meters
  - Flow
  - Level

2015 Calibration: Flow Assessment Levels



Sample Level Data

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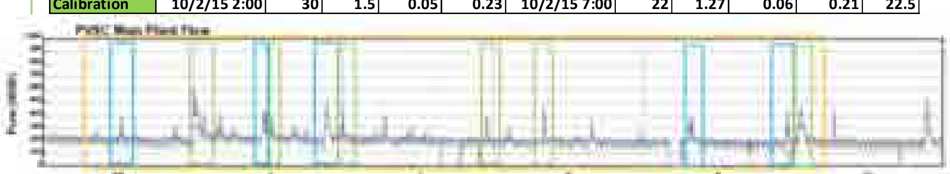
2015 Calibration: Events

- Selection of Calibration and Validation Events

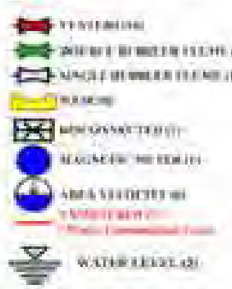
Station	EWR					TEB					
Calibration/Val	Start time	Duration (hrs.)	Volume (in.)	Ave inten (in./hr.)	Max inten (in./hr.)	Start time	Duration (hrs.)	Volume (in.)	Ave inten (in./hr.)	Max inten (in./hr.)	Delta (hrs.)
Validation	5/16/15 19:00	6	0.67	0.11	0.45	5/16/15 19:00	9	0.18	0.02	0.07	15
Calibration	5/31/15 14:00	23	2.68	0.12	0.74	5/31/15 15:00	14	1.86	0.13	0.53	98
Validation	6/14/15 21:00	9	0.77	0.09	0.24	6/14/15 22:00	7	0.82	0.12	0.39	146
Calibration	6/15/15 14:00	4	0.66	0.17	0.33	6/15/15 14:00	4	0.38	0.1	0.26	14.5
Validation	6/27/15 15:00	15	1.37	0.09	0.28	6/27/15 16:00	16	1.25	0.08	0.19	150.5
Calibration	7/1/15 4:00	1	0.99	0.99	0.99	7/1/15 4:00	1	0.99	0.99	0.99	76.5
Calibration	7/30/15 14:00	3	0.84	0.28	0.54	7/30/15 13:00	4	0.35	0.09	0.3	294.5
Calibration	8/11/15 5:00	6	0.96	0.16	0.38	8/11/15 5:00	6	0.84	0.14	0.37	172
Validation	9/10/15 3:00	17	0.98	0.06	0.19	9/10/15 1:00	9	0.45	0.05	0.16	717.5
Validation	9/29/15 23:00	11	1.31	0.12	0.77	9/29/15 22:00	9	1.5	0.17	0.73	394
Calibration	10/2/15 2:00	30	1.5	0.05	0.23	10/2/15 7:00	22	1.27	0.06	0.21	22.5

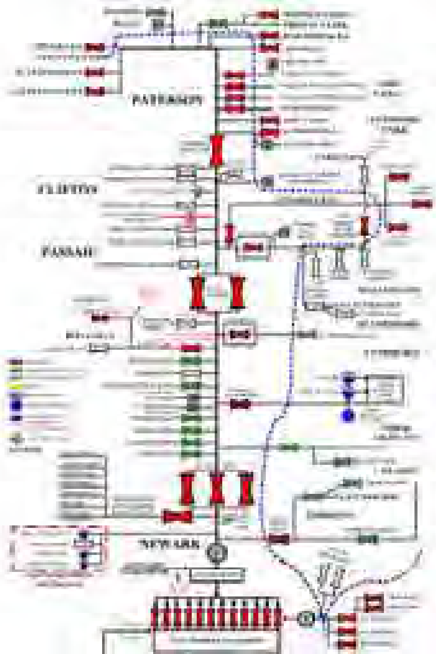


CDM Smith

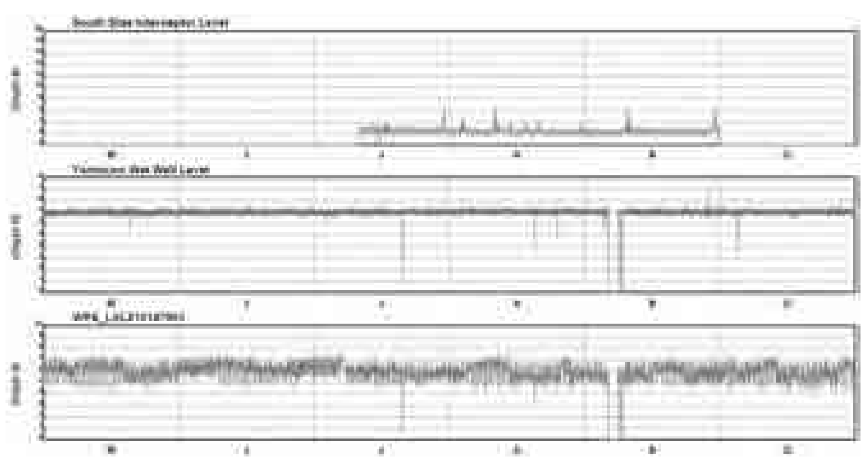
2015 Calibration: PVSC Permanent Meters

- Flow
- Level



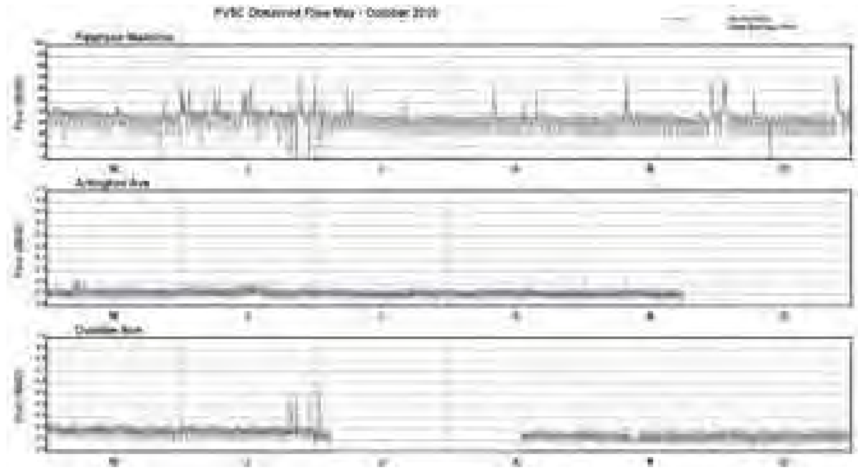


2015 Calibration: PVSC Data



Sample Level Data

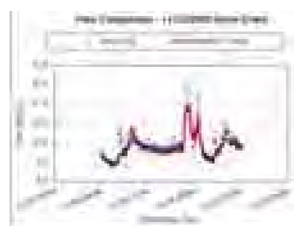
2015 Calibration: PVSC Data

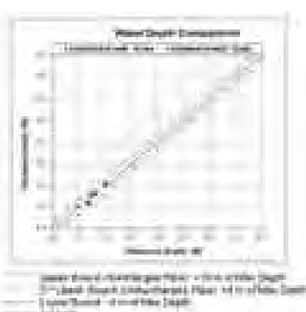


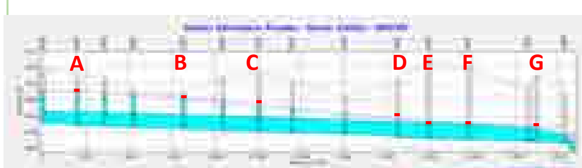
Sample Flow Data

2015 Calibration: – Example Results

- Hydrograph Comparison
- Profile Comparison
- Goodness-of-fit Comparison







Potential Improvements

- Expand and Build-out
  - Current model does not include detailed combined sewer network in areas outside Newark (Subcatchments at regulators)
  - Data Required
    - Field survey and development of GIS database of major sewer network
    - Development of drainage area maps for subcatchments delineations, along with other data such as: imperviousness, landuse, population, slope, etc.
    - Additional flow monitoring within municipalities
  - Benefits
    - Asset management, municipality level sewer capacity analysis, alternatives evaluation (storage, GI, etc.)

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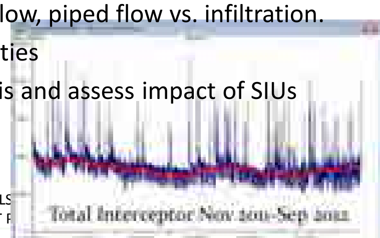
Potential Improvements

- Update base flow and include GI and I&I characterization
  - Currently GWI and I&I not modeled, base dry-weather flow distributions based on 1990s data
  - Requirements
    - Updated water usage/billing info for modeled flow distribution and identifying SIU (significant industrial users)
    - Monitored flow from separate sanitary areas for I&I calculation
    - Expanded to include subcatchments from separate areas
  - Benefits
    - Better characterize dry flow vs. wet flow, piped flow vs. infiltration.
    - Quantify I&I from non-CSO communities
    - Conduct infiltration reduction analysis and assess impact of SIUs



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Potential Improvements

- Update Calibration with Built-out Network
  - Recently collected data does not include outfall monitoring
  - Requirement
    - Additional flow and level data in combined system, interceptor and outfalls (Part of CSO Characterization)
  - Benefit:
    - Verify changes made to model
    - Verify modeled flow components (storm runoff, infiltration, plant flow, outfall flow)
    - Verify HGLs for flooding analysis and assessing system capacity
    - Evaluate plan alternatives (rehabilitation, storage, flow control, GI, etc.)

Hydrodynamic Modeling

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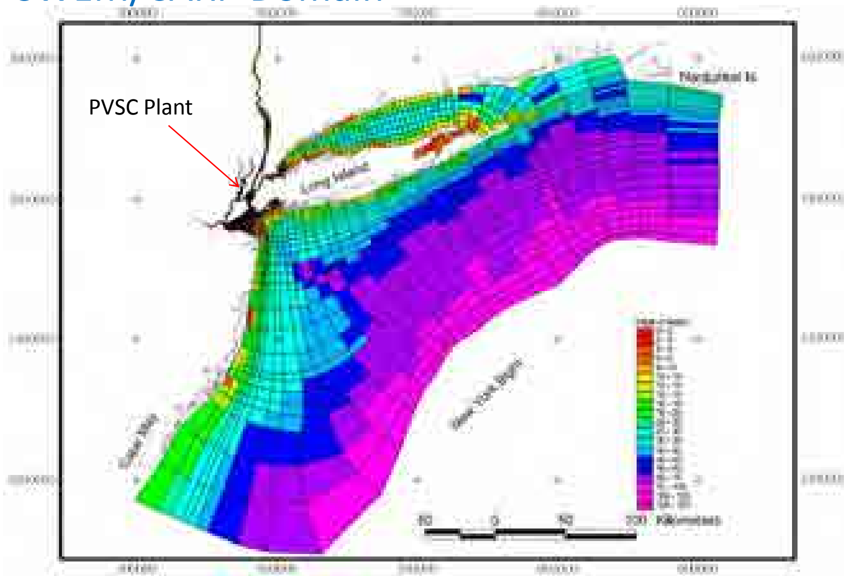
Hydrodynamic Modeling

- History of NY-NJ Models
- Proposed Model Grid
- Model Summary
- Calibration Data
- Challenges

Overview of NY-NJ Harbor Models

- Early 1990s – Inner and Outer Harbor CSO Studies for NYCDEP
- Mid 1990s – System Wide Eutrophication Model (SWEM)
- Early 2000s – NY-NJ Pathogen TMDL, CARP (Contamination Assessment and Reduction Project)
- 2005 to Present: Lower Passaic River/ Newark Bay EPA Superfund Studies

SWEM/CARP Domain



SWEM/CARP: NY-NJ Harbor Area

SWEM/CARP: NJ LTCP Area

- Coarse resolution in:
  - Lower Passaic River (~1-2 km)
  - Hackensack River (~1-2 km)
  - No Meadowlands
  - Newark Bay: single grid (7 grid cells of 2 km size)
  - Arthur Kill & Kill van Kull: single grid cells
  - Hudson River and Upper Bay (~300x1500 m)

2015 Refined Grid

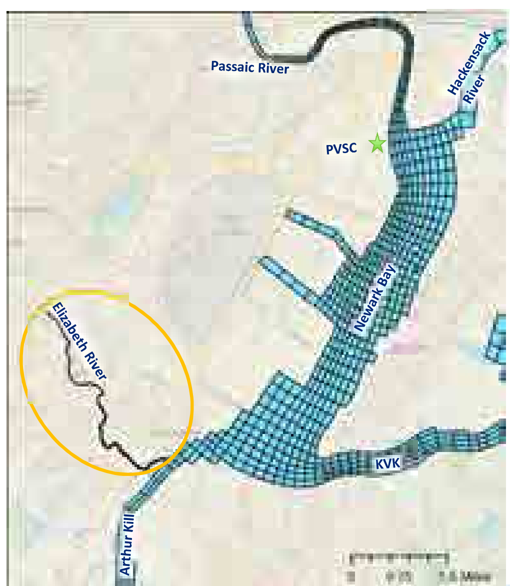
- Improved Resolution
  - Lower Passaic River (200-500 m)
  - Hackensack River (200-500 m)
  - NJ Meadowlands
  - Newark Bay (100x200 m)
  - Arthur Kill & Kill van Kull: 3-5 lateral cells (100x250 m)
  - Hudson River and Upper Bay (200x600 m)
- Expanded Domain
  - Dundee Dam to Little Falls
  - Overpeck Creek (100x300 m)
  - Elizabeth River (40x150 m)

2015 Refined Grid

- Expanded Domain
  - Dundee Dam to Little Falls
  - Overpeck Creek

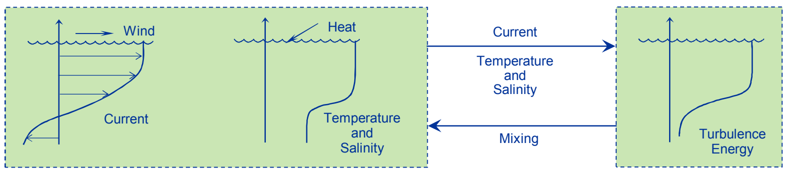
2015 Refined Grid

- Improved Resolution
  - Lower Passaic River
  - Newark Bay
  - Arthur Kill & Kill van Kull
- Expanded Domain
  - Elizabeth River

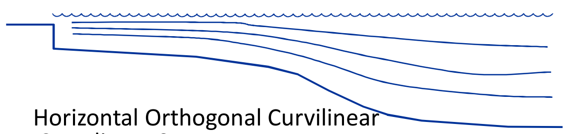


ECOMSED Features

- 3D Hydrodynamic Model
  - Current
  - Temperature
  - Salinity
  - Water Levels
- Turbulence Model



- Sigma (σ) Coordinate System: 10 layers for PVSC model



$$\sigma = \frac{z - h}{H + h}$$

- Horizontal Orthogonal Curvilinear Coordinate System

Inputs

- Tidal Forcing
  - Mid-Atlantic Bight
- Freshwater
  - Rivers
  - CSOs
  - Stormwater outfalls & direct drainage
  - Wastewater treatment plants
- Thermal Loads
  - Power plants
- Meteorological Forcing
  - Winds
  - Air temperature
  - Barometric pressure
  - Solar radiation

Available Calibration Data

- NYC DEP Harbor Survey Program: T/S
- NOAA/USGS/Hudson River Environmental Conditions Observing System (HRECOS) monitoring data: tides, T/S
- NJ Harbor Dischargers Group: T/S
- Meadowlands Environmental Research Institute (MERI): T/S
- Rutgers: 2008 – 2009 (ADCP, T/S)
- Tierra Solutions: 2010 – 2011 (ADCP, T/S)
- NJ LTCP WQ Sampling Program: 2016 (T/S)

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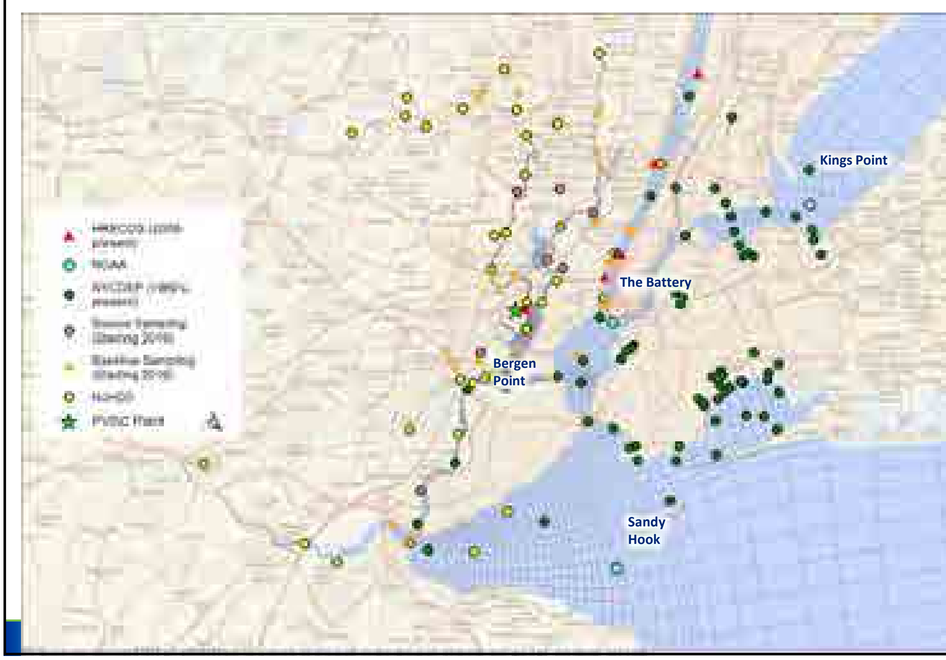
Available Calibration Data



CDM Smith

Meadowlands Environmental Research Institute Water Quality Monitoring Network

- 2004 – present

2008 - 2011 ADCP & Temperature/Salinity

- ADCP: Acoustic Doppler Current Profiler
- Note: These data were collected during USACE NY District Harbor Deepening Projects

Sampling Location Modifications

- Lateral stations in Hudson River
- Some locations based on field recon
- Additional baseline and event stations in Upper Passaic River
- Additional source stations
  - Frank's Creek
  - Third River
  - Woodbridge Creek
- Additional station in Kill van Kull
- Additional stations at The Narrows

Sampling Stations

- 32 Baseline
- 7 Source
- 22 Intensive Event
- Sampling frequency
  - Baseline and Source
    - Jan-Apr: Monthly
    - May-Jun: Bi-weekly
    - Jul-Sept: Weekly
    - Oct-Dec: Monthly
  - Intensive event
    - 3 events
    - 3 days/event
    - Sampled twice a day

Calibration Objectives

- Accurate Volume Exchange in the Meadowlands:
  - Total: 8,400 acres (~13 mi^2) vs. Wet Areas: 3,500 acres (~5.5 mi^2)
  - Needed for proper tidal dynamics (amplitude and phases)
  - Potential importance of groundwater seepage (~100 cfs)
- Correct net fluxes through the Kills (counter-clockwise)
- Correct net fluxes through the East River
- Proportion of fresh and saline areas in the Meadowlands

Meadowlands

Photo by Doc Searls

Hackensack River (Looking East)

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Photo by Doc Searls

Hackensack River in Winter (Looking East)

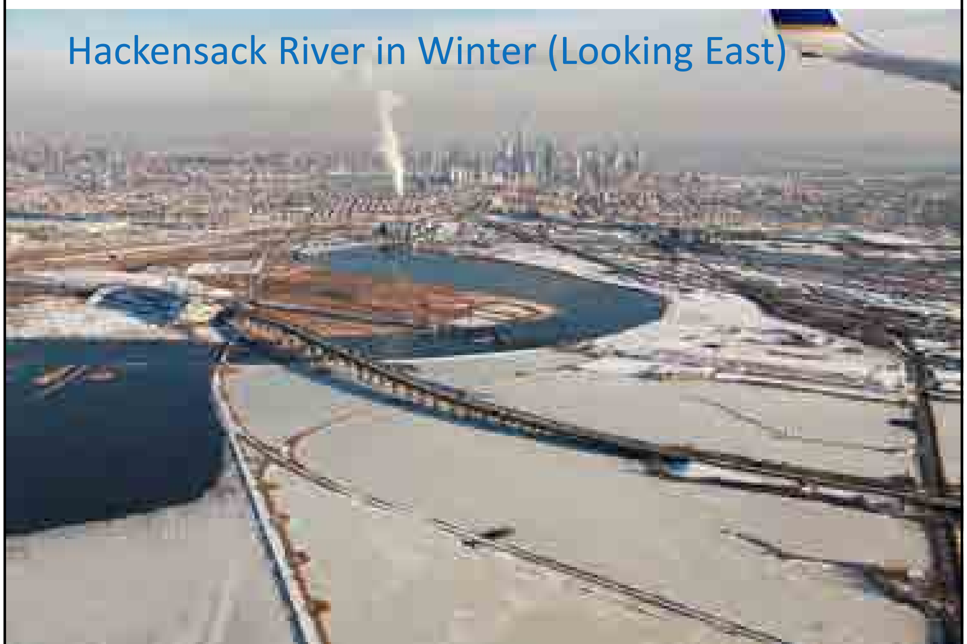

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Photo by Doc Searls

CDM Smith

Water Quality Modeling

Water Quality Modeling

- Previous work (Pathogen TMDL)
- Proposed bacteria model
- Inputs
- Calibration
- Projections

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Water Quality Modeling Approach

- Use Pathogen TMDL work as starting point
- Update landside modeling from RAINMAN to InfoWorks for NJ CSO Communities
- Update NYC landside modeling using RAINMAN and IW loads
- Refine water quality model segmentation in key areas
- Recalibrate WQ model using
  - 2016-2017 New Jersey Harbor Dischargers Group (NJHDG) data
  - 2016-2017 Baseline monitoring sampling data
  - 2016-2017 Event-based WQ sampling data

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Pathogen TMDL Modeling

- Work conducted 2005-2007
- Endpoints (attainment)
  - Total coliform
  - Fecal coliform
  - Enterococci
- MEG reviewed original work
- TMDL not finalized

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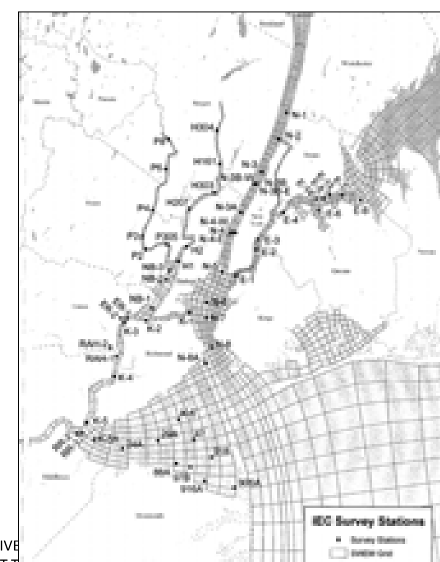
Basis of Pathogen TMDL Loading

- CSO loadings by RAINMAN
  - Cross-calibrated to SWMM or IW for NJ
  - RAINMAN for NYC
  - Loads based on a mass balance approach
- Stormwater loadings by RAINMAN

Pathogen TMDL Calibration

- WQ Model
- Calibration
  - Periods in 2002 and 2003
  - Total coliform
  - Fecal coliform
  - Enterococci
- No intensive wet-weather data available

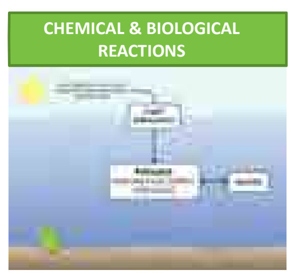


Program Enhancements

- Upgrade from RAINMAN to InfoWorks for NJ-based sources
- Add source sampling locations to provide better accounting of source loads
- Add receiving water sampling stations and wet-weather event sampling to provide additional data for model re-calibration
- Enhance model grid resolution
- Model skill assessment as outlined in draft QAPP

Bacteria Model

- RCA (Row-Column AESOP)
- State variables
  - Salinity
  - Tracer
  - E. coli
  - Fecal coliform
  - Enterococci



WATER QUALITY MODEL

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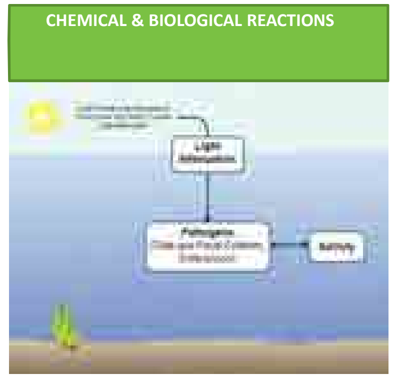
Bacteria Model Kinetics

$$N = N_0 \exp(\quad KBt)$$

K_B = [0.8 + 0.006(%seawater)]$1.07^{(T-20)}$
+ $\alpha I_0(t)/K_eH[1-\exp(-K_eH)]$
+ V_s/H
(Mancini, 1978)



N = Bacteria concentration
K_B = Bacteria loss rate
T = Temperature (°C)
α = proportionality constant (~1)
I_0 = Surface solar radiation
t = time
K_e = Extinction coefficient (1/m)
H = Depth (m)
V_s = Net settling rate (m/d)

Required Inputs

- Hydrodynamics
- Loads
  - CSOs
  - Storm drains
  - Direct drainage
  - Dry-weather sources
  - WWTPs
- Boundary Conditions
  - Rivers
  - Ocean
- Constants and Parameters
  - Die-off rates
  - Additional constants or parameters as necessary

Input Development

- CSO Flows and Volumes
- Generate NJ CSOs with InfoWorks
- Use 2008 Characterization Study models
- Convert SWMM to InfoWorks as necessary
- PVSC InfoWorks Model
  - Paterson, Newark, Kearny, Harrison, East Newark
  - Bayonne, North Bergen to be added
- Other local CSO municipalities (provided by others)
  - Elizabeth, Ridgefield Park, Hackensack, Fort Lee, Guttenberg, Perth Amboy, North Hudson Sewerage Authority, Jersey City

Sources of CSO Flow/Volumes

- Greeley and Hansen
  - PVSC/NBMUA communities
    - Paterson
    - Newark
    - Kearny
    - Harrison
    - East Newark
    - Bayonne
    - North Bergen
    - Guttenberg
- Arcadis
  - Hackensack
  - Jersey City (PVSC)
- CDM Smith
  - Perth Amboy
- Hatch Mott
  - Elizabeth
  - Ridgefield Park
- CH2M
  - North Hudson
- AECOM and H&S
  - NYC
- HDR
  - Fort Lee

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Approaches to CSO Loading

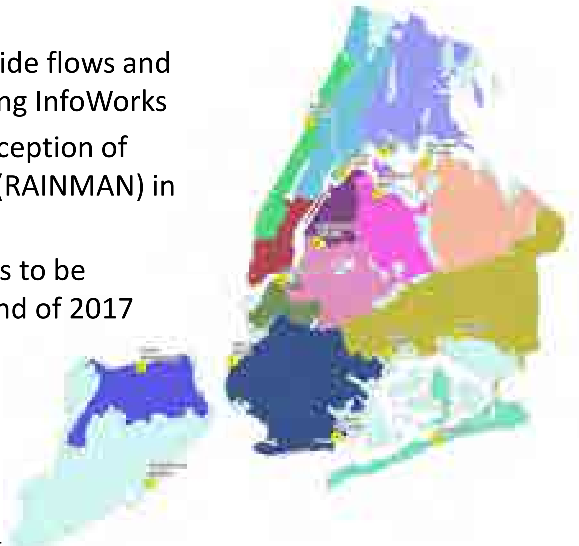
- Event Mean Concentration: Constant concentrations
    - Pros: simple, commonly used
    - Cons: does not represent observed variability
- ✓ Mass Balance : Constant sanitary and stormwater concentrations mixed based on IW calculations
    - Pros: simple, consistent, predictive
    - Cons: less variability, IW-dependent
- Monte Carlo: Concentrations from a generated probability distribution based on observed data
    - Pros: reproduces observed magnitude and variability of data
    - Cons: requires site specific data, random, non-predictive
- Hybrid Mass Balance/Monte Carlo: Mass Balance with concentrations generated by Monte Carlo
    - Pros: reproduce observed data while including predictive capabilities
    - Cons: data requirements, IW-dependent, untested

Proposed CSO Loading Approach – NJ

- Use IW/SWMM flows provided by consultants
- Use 2008 CSO Characterization Study measured data
- Supplement with LTCP 2016 data as necessary
- Bacteria concentrations
- Mass balance (approach used for Pathogen TMDL)

Proposed CSO Modeling Approach – NYC

- NYCDEP will provide flows and loads using existing InfoWorks
- All areas, with exception of Oakwood Beach (RAINMAN) in InfoWorks
- InfoWorks models to be recalibrated by end of 2017

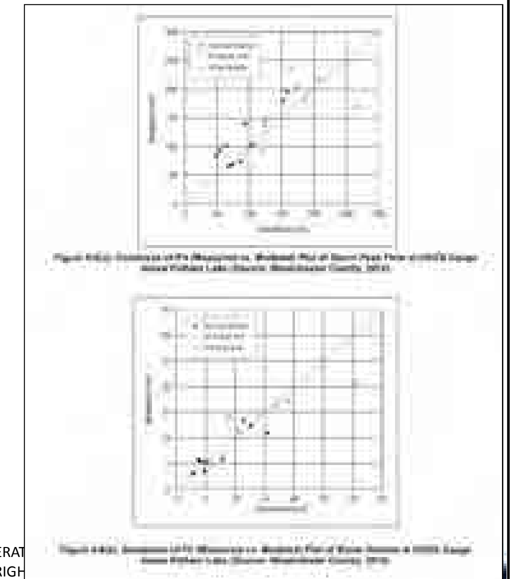


Proposed Approach to Stormwater Loads

- Use InfoWorks or gauged flow regression
- Calibrate to gauge data and 2016-2017 measurements
- Bacteria concentrations based on literature values for land uses, supplemented with 2016-2017 stormwater monitoring results
  - Geometric mean concentrations
  - Constant in time
  - Spatially varying depending on literature/sampling data

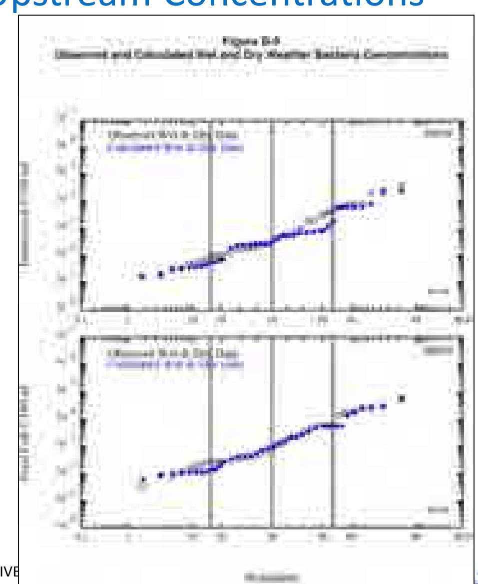
Proposed Approach to Upstream Flows

- Use available flow data from USGS gauges
  - Hackensack River
  - Saddle River
  - Elizabeth River
  - Second River
  - Third River
- Develop runoff using InfoWorks or methodologies used for Passaic River Superfund Project for other tributaries



Proposed Approach to Upstream Concentrations

- Develop functional relationships based on 2016-2017 sampling data and historical data
  - NJHDG
  - Third party



Data for Water Quality Calibration/Validation

- Calibration
  - 2016-2017 NJHDG data
    - Weekly (July-September)
    - Every other week (May, June)
    - Monthly (January-April, October-December)
  - 2016-2017 LTCP Baseline Compliance Monitoring data
    - Same frequency as NJHDG
  - 2016-2017 Intensive Sampling Event data
    - Three 3-day events
  - Other: NYCDEP Harbor Survey, Citizens, etc.
- Validation
  - Historical NJHDG, NYCDEP, IEC, Meadowlands Research Institute data

Calibration Assessment

- Graphical Comparisons
  - Spatial transect plots of model output versus observed
  - Graphical time-series plots of observed and predicted data
  - Comparisons between observed and calculated probability distributions
  - Scatter plots of observed versus predicted values
- Statistical Comparisons (geometric means)
  - Mean error
  - Absolute
  - Relative error

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Projection Simulations

- Baseline
- Gap Analysis (100% CSO Removal)
- Component Analysis
  - NYC sources
  - NJ CSOs
  - NJ non-CSOs
  - Upstream/downstream boundary conditions
- CSO Control Alternatives
  - Permittee-related
  - Area-wide
  - Final selected plan

Discussion / Next Steps

PVSC – Long Term Control Plan
Modeling Evaluation Group – Session 2
Hydrologic and Hydraulic Model

Greeley and Hansen LLC
March 17, 2017

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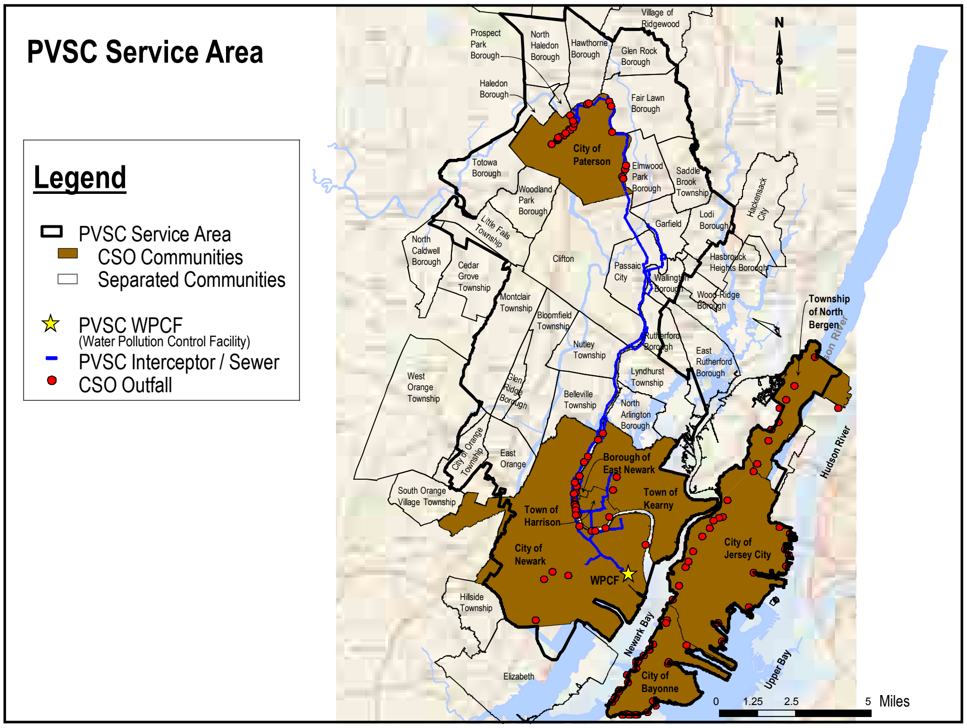
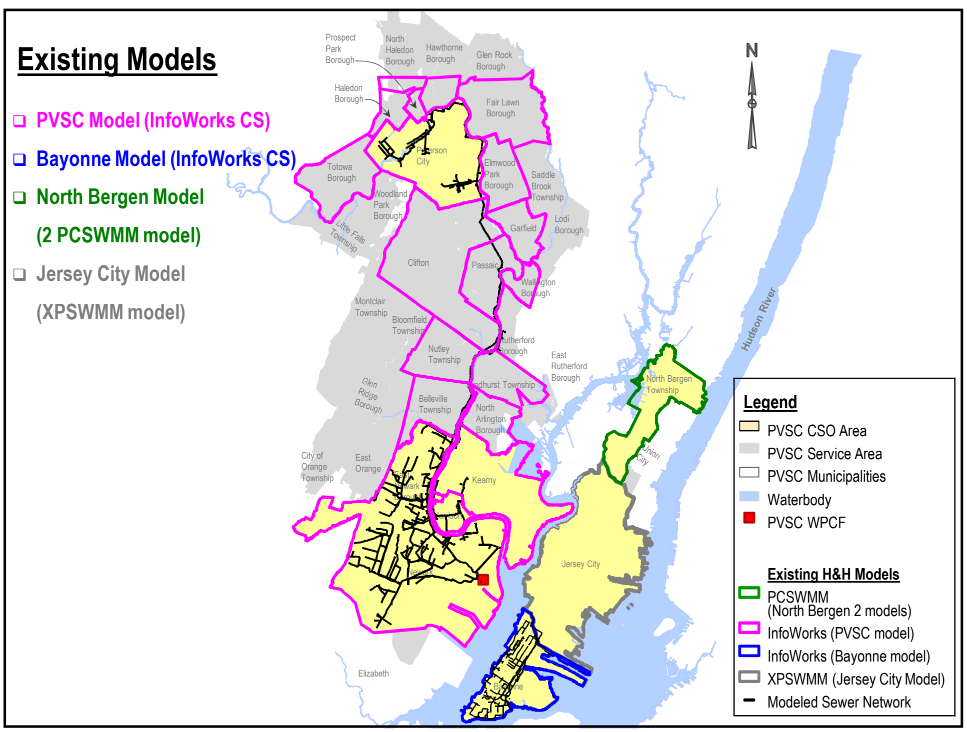
Outline

- Hydrologic and Hydraulic (H&H) Model Update
  - Model Integration
  - Regulator Update
  - Paterson Re-delineation
  - Separated Service Area
  - Wet Weather Operating Rules
- Next Step


PVSC Service Area
Legend
PVSC Service Area
CSO Communities
Separated Communities
PVSC WPCF
(Water Pollution Control Facility)
PVSC Interceptor / Sewer
CSO Outfall
City of Paterson
Borough of East Newark
Town of Kearny
Town of Harrison
City of Newark
City of Jersey City
City of Bayonne
Township of North Bergen
WPCF
Newark Bay
Upper Bay
Hudson River
N
0 1.25 2.5 5 Miles


Existing Models
PVSC Model (InfoWorks CS)
Bayonne Model (InfoWorks CS)
North Bergen Model
(2 PCSWMM model)
Jersey City Model
(XPSWMM model)
N
Hudson River
Legend
PVSC CSO Area
PVSC Service Area
PVSC Municipalities
Waterbody
PVSC WPCF
Existing H&H Models
PCSWMM
(North Bergen 2 models)
InfoWorks (PVSC model)
InfoWorks (Bayonne model)
XPSWMM (Jersey City Model)
Modeled Sewer Network

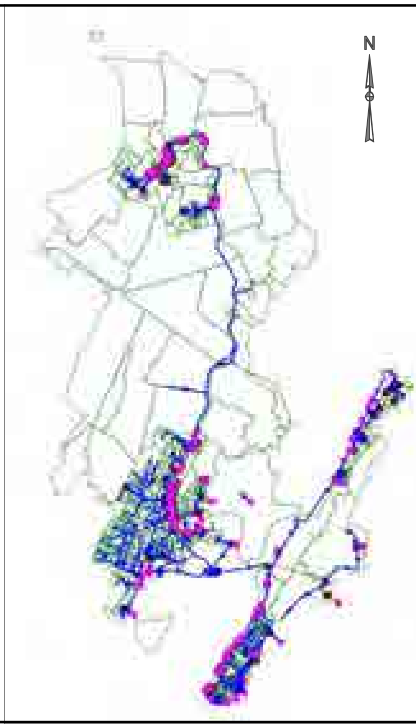
A Snapshot of Integrated Model…

- ❑ **48 PVSC communities**
- ❑ **8 CSO communities**
  - ✓ Paterson
  - ✓ Newark
  - ✓ East Newark
  - ✓ Harrison
  - ✓ Kearny

  (Above 5 discharge to interceptor by gravity to WPCF)

  - ✓ Bayonne
  - ✓ Jersey City
  - ✓ North Bergen

  (Above 3 discharge to Hudson County Forcemain to WPCF)

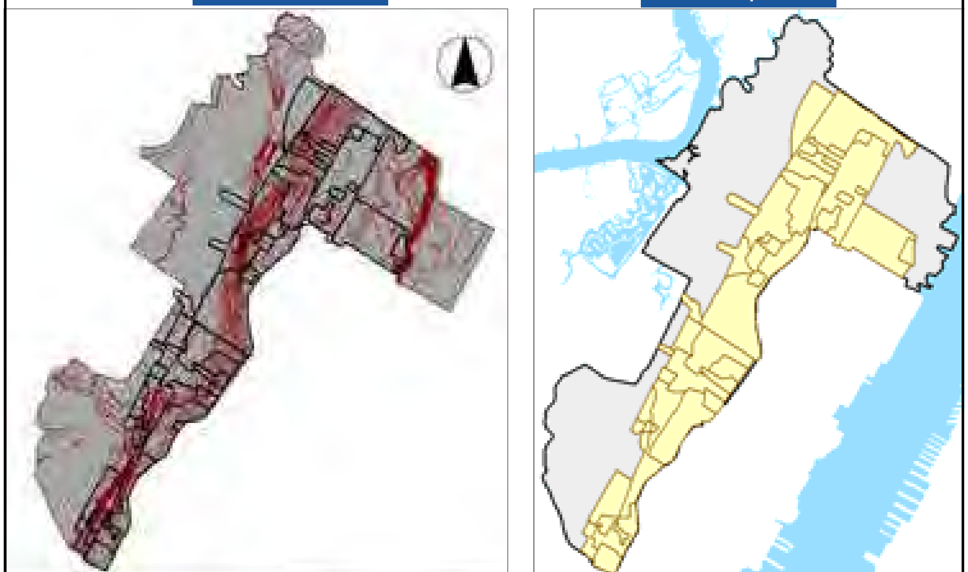


Model Integration

Recreate North Bergen Model from PCSWMM

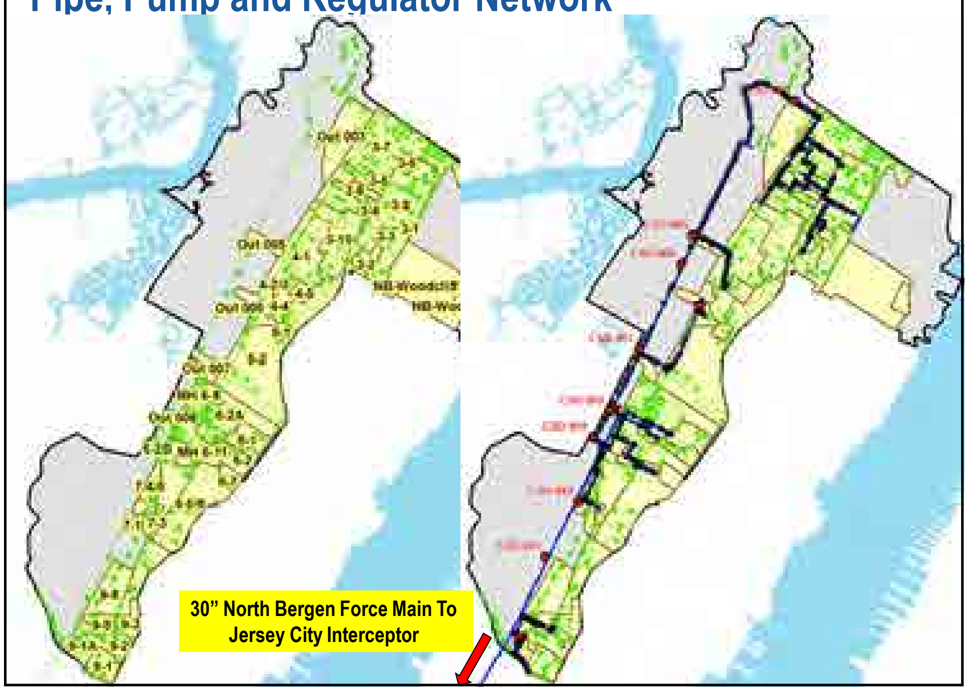
NB Delineation

Paper Copy → GIS Shapefile

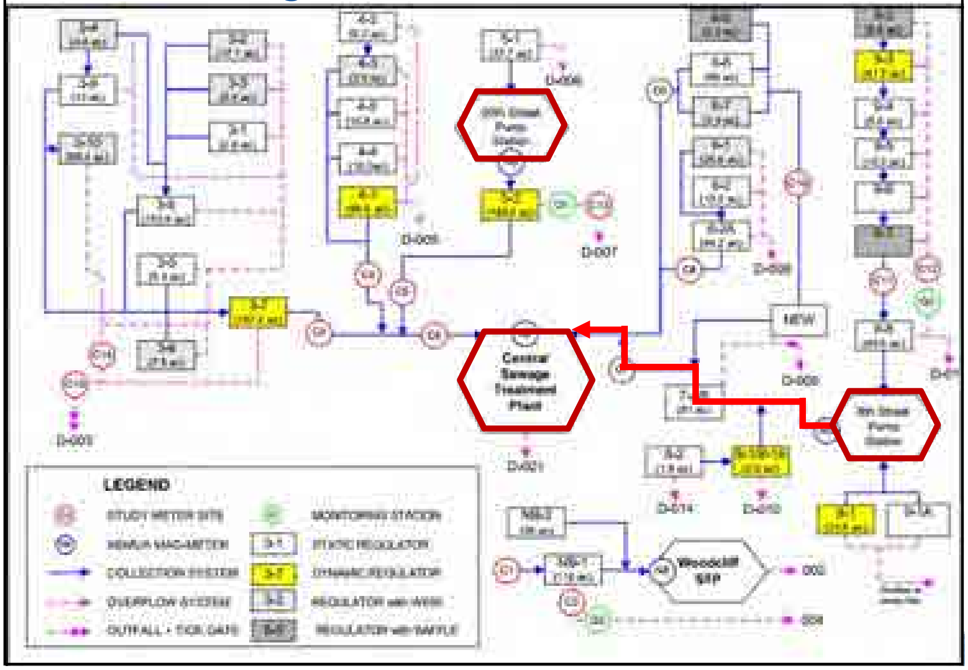


❑ *Digitize model subcatchment based on paper copy*

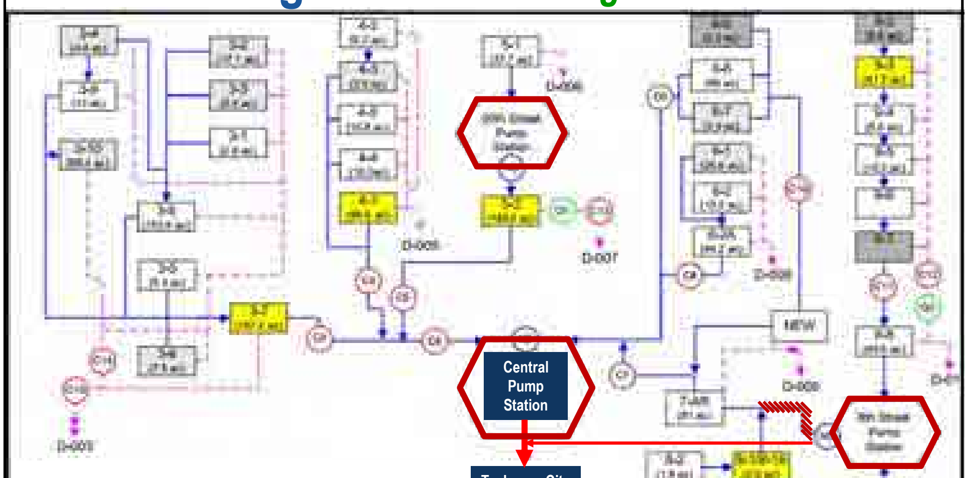
Pipe, Pump and Regulator Network



Model Integration/*North Bergen Model*



Model Integration/*North Bergen Model*



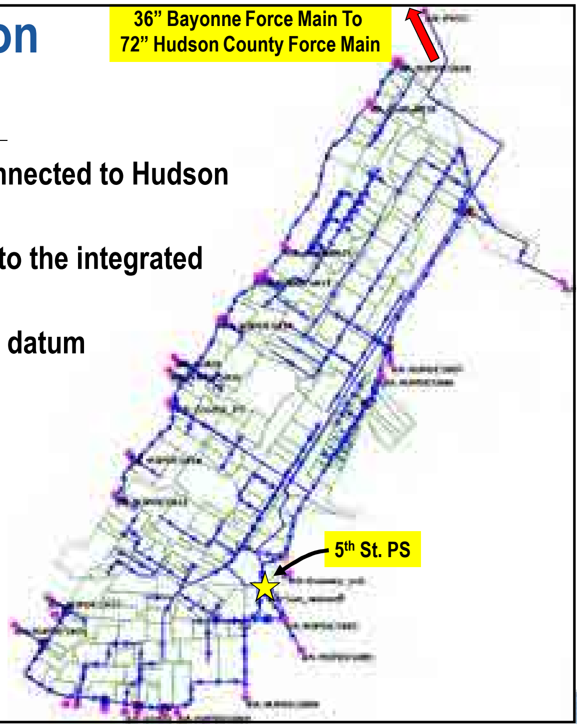
- Updated to PVSC Datum (100 ft above Mean Sea Level (MSL))
- Pump Capacity Current

Flow to Jersey City =	Central PS +	8th St. PS
Max: 18.6 MGD	16 MGD	2.6 MGD

Model Integration

Bayonne Model

- Bayonne force main Connected to Hudson County Force Main
- 11 RTC rules appended to the integrated model
- Datum updated to PVSC datum



Model Integration

Jersey City Model

- Simplified model network to
  - represent Jersey City flow
  - connect North Bergen and Bayonne models to the PVSC model

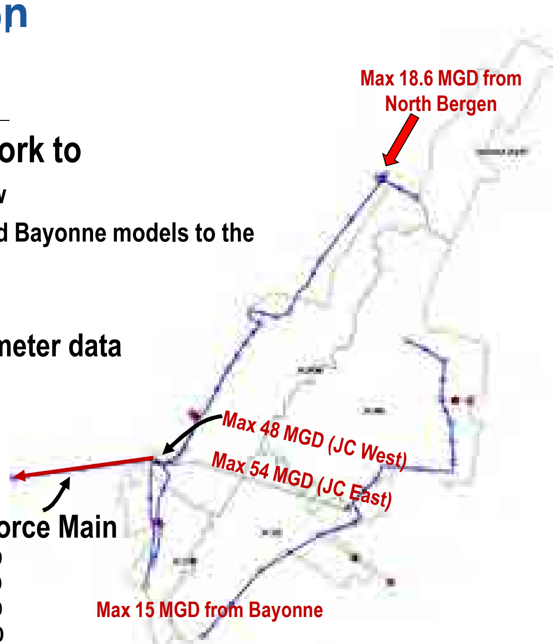
Max pump rate based on meter data

Jersey City East: Peak 54 MGD
Jersey City West: Peak 48 MGD

Flows in Hudson County Force Main

- Jersey City East: Peak 54 MGD
- Jersey City West: Peak 48 MGD
- Bayonne: Peak 15 MGD

Total Maximum: 117 MGD



Model Integration

Force Mains

- Hudson County Force Main was extended to the PVSC WPCF based on drawing
- South Kearny PS 30" force main was created and tied into the Hudson County Force Main

South Kearny Pump Station Service Area

- Kearny Meadowlands District
- South Kearny District
- Both Separated

South Kearny Pump Station

- Capacity: 17.5 MGD
- DWF: 1.6 MGD

GREELEY AND HANSEN

Regulator Update

Regulator Modification

Regulator	Overflow Weir				Regulating Sluice Gate / Orifice					
	Drawing		Original Model		Drawing			Original Model		
	Crest	Width	Crest	Width	Invert	Width	Height	Invert	Width	Height
P_015A (S.U.M. Park)	152.9	2.5	152.9	2.5	151.87	1.25		151.87	1.25	
P-001A (Curtis Pl.)	146.9	3.83	146.9	3.83	143.94	3	1	143.94	2.25	
P-003A (West Broadway)	139.5	4	139.5	4	137.4	1.25		137.4	1.25	
P-005A (Bridge St.)	133.4	5	136.71	5	131.7	0.833	1.667	131.7	1.25	
P-006A (Montgomery St.)	134.2	8.0	135.25	8	129.53	2		129.53	2	
P-007A (Straight St.)	133.8	6	133.8	5	130.1	1.83	3	130.1	1.25	
P-009A (Keen St.)	135.4	4	135.4	4	133.44	1.67	0.83	133.44	1.25	
P-010A (Warren St.)	133.85	4	135.21	3						
P-016A (Northwest St., modified)	138.8	8	140.94	8.5	136.25	2.5		136.25	2.5	
P-017A (Arch St.)	135.7	4.5	135.69	3.67	132.6	1		132.6	1	
P-032A (Hudson St.)	135.2	4	135.2	4						
P-022A (Short St.)	132.6	4.5	132.6	4.5	130.63	2		130.63	2	
P-021A (Bergen St.)	132.7	4.5	132.7	4.5	130.75	1		130.75	1	
P-013A (East Eleventh St.)	133.4	4.83	133.4	4.83	131.7	1.67	0.83	131.7	1.25	
P-014A (Fourth Ave.)	140.9	4.5	140.9	3	137.76	1.67	0.83	137.76	1.25	
P-023A (Second Ave.)	129.8	5	130.56	5	127.4	Not available	Not available	127.4	1.25	
P-024A (Third Ave.)	130.3	4.5	130.3	5	128.2	1.67	0.83	128.2	1.25	
P-025A (East 33rd Ave.)	128.9	8.58	129.87	8.58	127.07	3	1	127.07	2	
P-026A (East 20th Ave.)	129.2	5.5	128.92	5.5	126.95	1.67	0.83	126.95	1.66	0.83
P-027A (Market St.)	131.1	7.11	131.1	4.0	129.6	3.5	1.167	129.6	3.5	2.0
					129.6	3.5	1.167	129.6	3.5	0.0

Regulator Modification

Regulator	Overflow Weir				Regulating Sluice Gate / Orifice					
	Drawing		Original Model		Drawing			Original Model		
	Crest	Width	Crest	Width	Invert	Width	Height	Invert	Width	Height
N-002A (modified, Verona)	110.43	41	103	6	102.65	2.5	2.5	99.33	2	2
N-004A/005A (modified, Herbert Pl.)	114.34	41	105.55	6.667	107.06	2	2	103.6	1.5	1.5
N-008A (4th Ave.)	103.5	6	103.5	6	100.7	1.5	1.5	100.7	1.5	1.5
N-009A (Passaic St.)	103.24	4	103.24	4	102.4	1.66	0.83	102.4	1.66	0.83
N-010A (Clay St.)	105.12	8.42	105.12	8.42	101.24	6	3	101.24	6	3
	105.12	8.42	105.12	8.42	101.24	6	3	101.24	6	3
	105.12	8.42	105.12	8.42						
N-014A (Rector St., modified)	102.56	5.5	103.66	5.5	99.97	1.5	1.5	101.07	1.5	1.5
N-014A (Saybrook Pl., modified)	102.33	7	103.43	7	99.02	2	2	100.12	2	2
N-015A (City Dock, modified)	98.67	14	98.67	14	95.67	3.5	2.5	95.67	3.5	2.5
N-016A (Jackson St.)	97.62	7	97.62	4.5	96	1.5	1.5	96	1.33	1.33
N-017A (Polk St.)	97.8	8	97.8	7	95.2	1.5	1.5	95.35	1.33	1.33
N-018A (Freeman St.)	100.26	4	100.26	4	99	2	2	99	2	2
N-022A (Roanoke Ave.)	98.93	6	98.93	6						
N-027A/029A	102	4.5	102	4.5	96.4	4	2.33	96.4	4	2.33
N-025A (Peddie St.)	98.6	8	98.6	8	93	4	2.33	93	4	2.33
	98.6	8	98.6	8						
	98.6	8	98.6	8						
	98.6	8	98.6	8						
N-030A	102.32	10	102.32	10	99.04	4	3	99.04	4	3
N-023A	98.54	7	98.54	7						

Regulator Modification

Regulator	Overflow Weir				Regulating Sluice Gate / Orifice					
	Drawing		Original Model		Drawing			Original Model		
	Crest	Width	Crest	Width	Invert	Width	Height	Invert	Width	Height
K-001A (Stewart Ave.)	120.85	4.5	120.27	1.5	119.07	1		119	1	
K-004A	107.9	1.5	108	1.5	106.9	1		107	1	
K-006A (Johnston Ave.)	99.9	5	100.9	10	98.7	1.5		98.2	1.5	
	99.9	5								
K-007A	103	9	103	9	100.2	3	1	100.2	3	1
K-010A (Duke St.)	102.5	4	102.5	4.5	98.84	1	1	100.45	1	
E-001A	101.6	4	101.6	4	99.2	1.25		99.2	1.25	
H-001A	101.2	4	101.2	4	99.8	1.25		99.8	1	
H-002A	102.2	4	102.2	4	101	1		101.2	1	
H-003A	103.9	4	103.9	4	101.4	1.25		101.4	1.25	
H-004A (Dey St.)	102.2	4	102.2	3.5	100.58	1		100.58	1	
H-005A	100.8	3.5	100.8	3.5	99.1	1		99.1	1	
H-006A	99.9	4	99.9	4	97.9	1		97.9	1	
H-007A	102.4	4.5	102.4	4.5	101.2	1		101.2	1	

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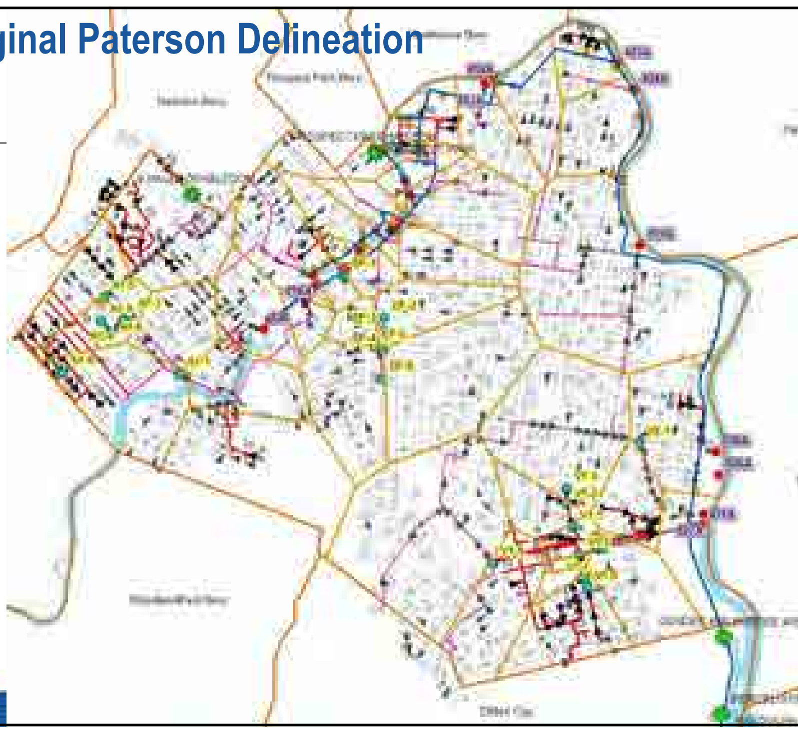
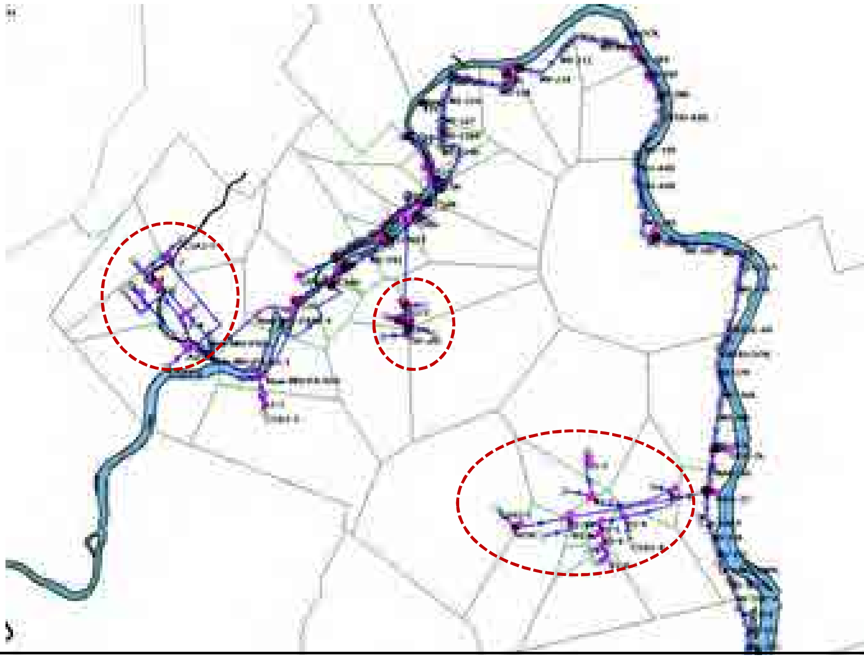
Paterson Update

Original Paterson Delineation



Paterson Internal Regulator

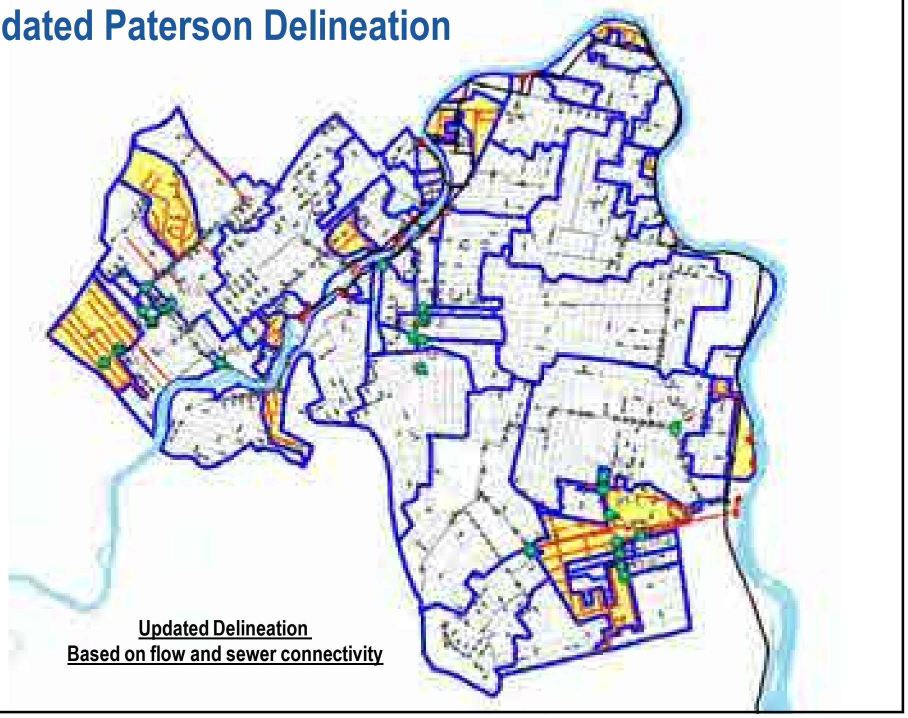


Paterson Internal Regulator Connectivity

Regulator #	Normal Flow Connection	Overflow Connection
A1-1 to A1-9 (8)	P_001A Regulator	P_028A
EF-2 to EF-6 (5)	P_006A Regulator	P_029A
V2-1	P_027A Regulator	P_030A
V1-1 to V1-9 (9)	P_027A Regulator	P_031A
EF-1	PVSC Interceptor MH 243	P_033A

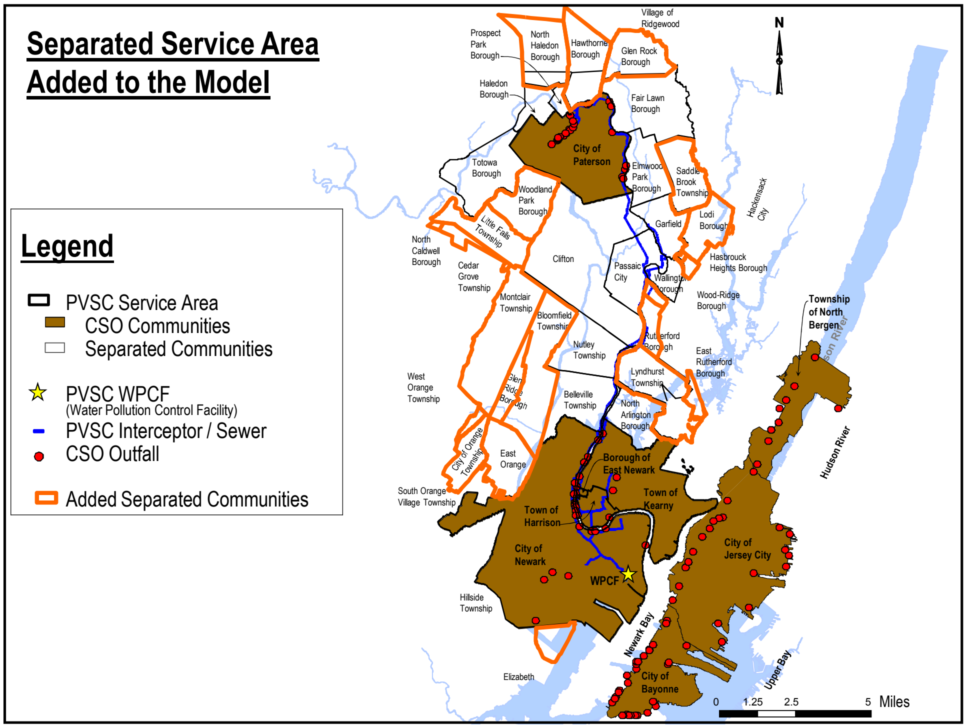
1/7/2019

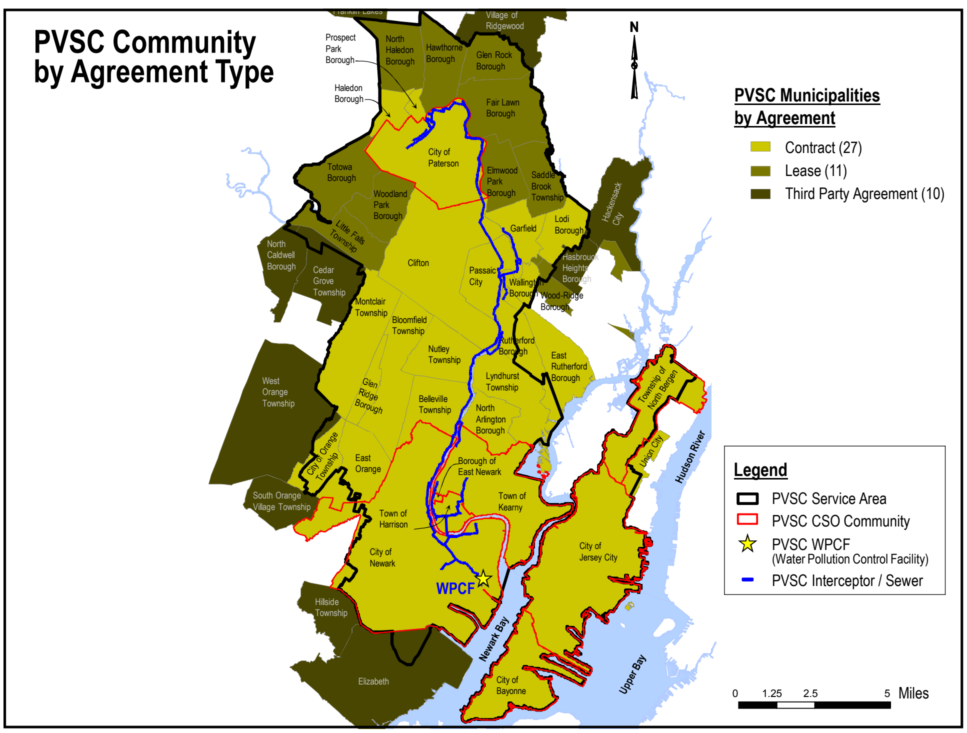
Updated Paterson Delineation



GREELEY AND HANSEN

Separated Service Area


Separated Service Area
Added to the Model
Legend
PVSC Service Area
CSO Communities
Separated Communities
PVSC WPCF
(Water Pollution Control Facility)
PVSC Interceptor / Sewer
CSO Outfall
Added Separated Communities
City of Paterson
Clifton
Passaic City
Town of Harrison
City of Newark
WPCF
Town of Kearny
Borough of East Newark
City of Jersey City
City of Bayonne
Township of North Bergen
Hudson River
Newark Bay
Upper Bay
Elizabeth
N
0 1.25 2.5 5 Miles


PVSC Community
by Agreement Type
PVSC Municipalities
by Agreement
Contract (27)
Lease (11)
Third Party Agreement (10)
Legend
PVSC Service Area
PVSC CSO Community
PVSC WPCF
(Water Pollution Control Facility)
PVSC Interceptor / Sewer
WPCF
Hudson River
Newark Bay
Upper Bay
N
0 1.25 2.5 5 Miles

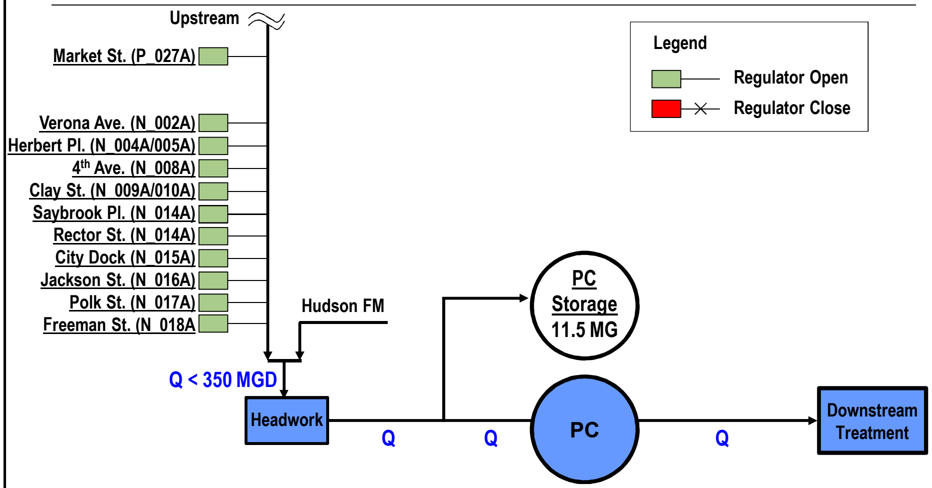
Municipality	Type of Agreement	Lease/ Contract Date	Agreed Average Daily Flow (MGD)	Agreed Max Rate of Flow (MGD)	Comments
Passaic County					
Township of Little Falls	Lease	9/29/1986	2.2		
Borough of Woodland Park	Lease	4/25/1984	2	2	
Borough of Totowa	Lease	1/7/1986	2.4	2.4	
Borough of North Haledon	Lease	8/13/1980	1	1.8	
Borough of Hawthorne	Lease	3/23/1944	2	3	
Bergen County					
Township of South Hackensack	Lease	4/5/2010	0.05	0.1	
Borough of Hasbrouck Heights	Third Party Agreement				Via Lodi
City of Garfield	Contract	1/1/1965	16.11	16.11	
Borough of Lodi	Contract	8/8/1960	4.5	4.5	
City of Hackensack	Third Party Agreement				Via Lodi
Township of Saddle Brook	Lease	11/10/1960	2	2	
Borough of Elmwood Park	Lease	10/20/1943	1	1.5 (max day)	
Borough of Wood-Ridge	Lease	11/15/2006	0.25		Lodi & Wood Ridge
Village of Ridgewood	Third Party Agreement				Via Glen Rock & Hawthorne
Borough of Franklin Lakes	Third Party Agreement				Via North Haledon
Borough of Fair Lawn	Lease	1/3/1945	2.25	2.5 (max day)	
Borough of Glen Rock	Lease	10/23/1944	1	1.5 (max day)	
Essex County					
Township of Cedar Grove	Third Party Agreement				Via Little Falls and Montclair
Borough of North Caldwell	Third Party Agreement				Via Little Falls
Township of West Orange	Third Party Agreement				Via Orange
Township of South Orange Village	Third Party Agreement				Via Orange
Hudson County					
City of Bayonne	Contract	11/25/1986	11	17.6	
Township of North Bergen	Contract	3/9/2006	10	16	
City of Union City	Contract	9/25/1985	1.5	2.4	
City of Jersey City	Contract	9/24/1985	50	80	
Union County					
City of Elizabeth	Third Party Agreement				Via Airport / Port Newark to South Side Interceptor @ Waverly
Township of Hillside	Third Party Agreement				Via Newark South Side Interceptor

GREELEY AND HANSEN

Wet Weather Operating Rules

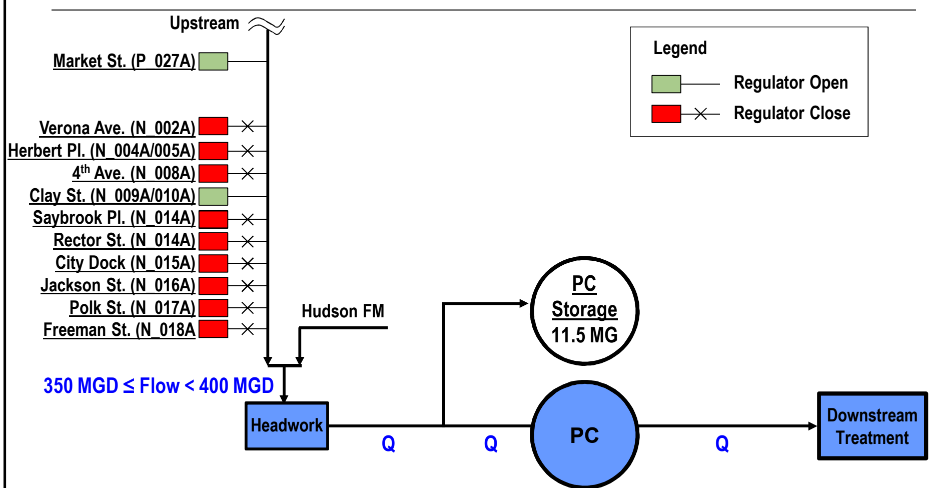
Wet Weather SOP

Flow < 350 MGD

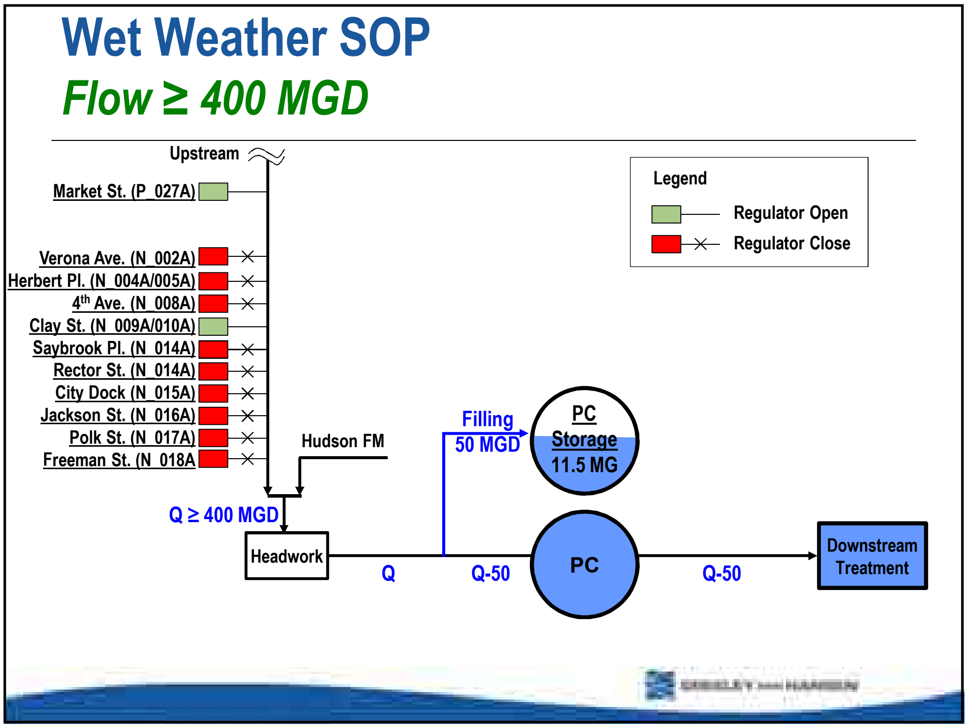


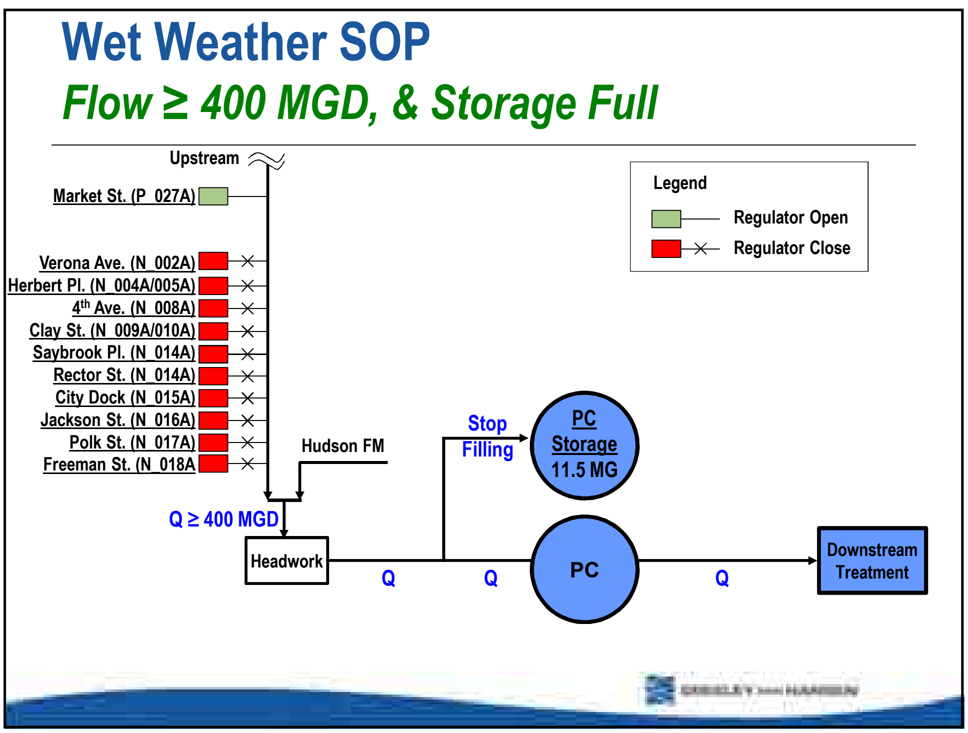
Wet Weather SOP

350 MGD ≤ Flow < 400 MGD



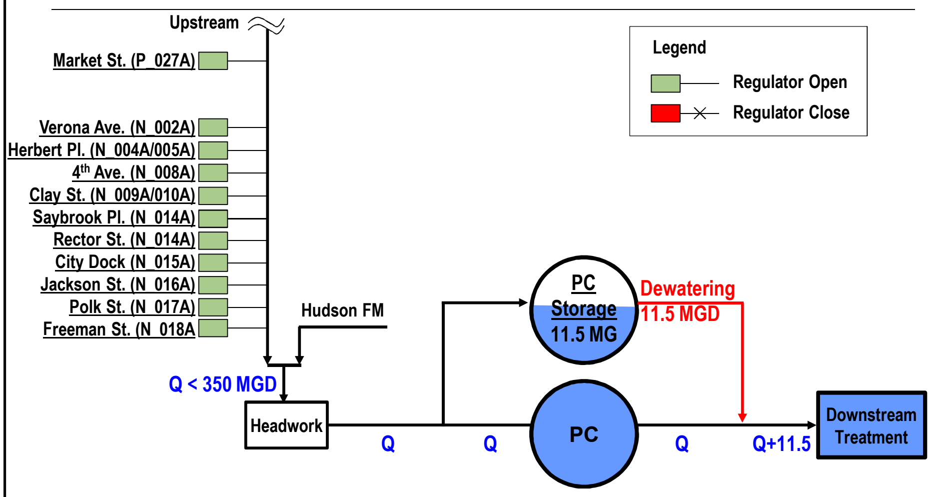
Note: During 10/7/15 to 7/7/16, CSOs were put in use at plant flow 400 MGD.


Wet Weather SOP
Flow ≥ 400 MGD
Upstream
Market St. (P_027A)
Verona Ave. (N_002A)
Herbert Pl. (N_004A/005A)
4th Ave. (N_008A)
Clay St. (N_009A/010A)
Saybrook Pl. (N_014A)
Rector St. (N_014A)
City Dock (N_015A)
Jackson St. (N_016A)
Polk St. (N_017A)
Freeman St. (N_018A
Hudson FM
Q ≥ 400 MGD
Headwork
Q
Q-50
Filling
50 MGD
PC
Storage
11.5 MG
PC
Q-50
Downstream
Treatment
Legend
Regulator Open
Regulator Close

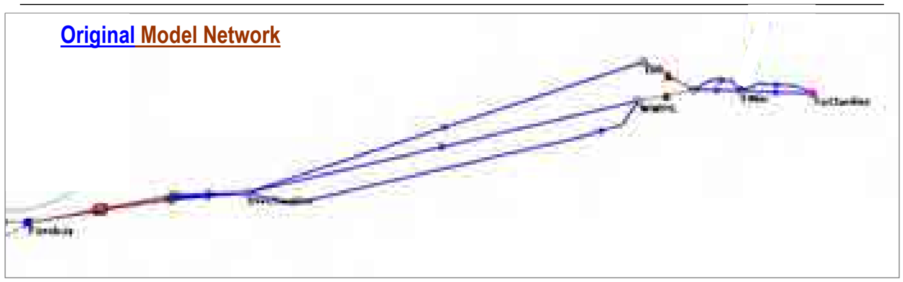

Wet Weather SOP
Flow ≥ 400 MGD, & Storage Full
Upstream
Market St. (P_027A)
Verona Ave. (N_002A)
Herbert Pl. (N_004A/005A)
4th Ave. (N_008A)
Clay St. (N_009A/010A)
Saybrook Pl. (N_014A)
Rector St. (N_014A)
City Dock (N_015A)
Jackson St. (N_016A)
Polk St. (N_017A)
Freeman St. (N_018A
Hudson FM
Q ≥ 400 MGD
Headwork
Q
Q
Stop
Filling
PC
Storage
11.5 MG
PC
Q
Downstream
Treatment
Legend
Regulator Open
Regulator Close

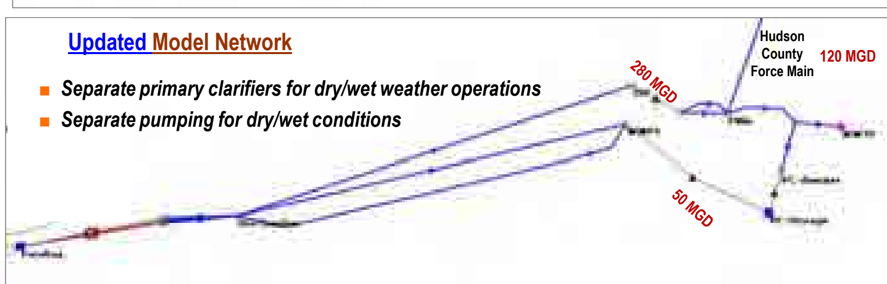
Wet Weather SOP

Flow Drops to 350 MGD



Model Network around PVSC Wastewater Facility





Next Step

Model Calibration/Validation Approach

- Dry Weather Flow Calibration
  - DWF distribution based on metershed
  - Weekday/Weekend Diurnal
- Wet Weather Flow Calibration
  - 2-3 storm events
  - CSO area runoff
  - Separated area RDII (RTK)
  - Wet weather flow peak and volume

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End

PVSC – Long Term Control Plan Modeling Evaluation Group – Session 2
Flow Metering Data

Greeley and Hansen LLC
March 17, 2017

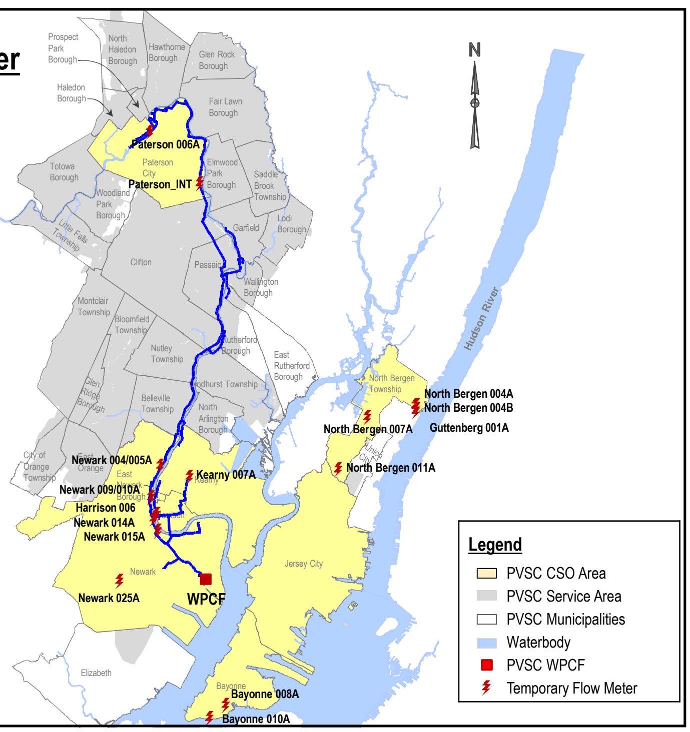
Outline

- Flow Monitoring Data
  - Temporary Flow Meter
  - Permanent Meter Data
- Rainfall Data
  - Rainfall Stations
  - Rainfall Data Analysis
- Calibration Event

Temporary Flow Meter

Temporary Flow Meter

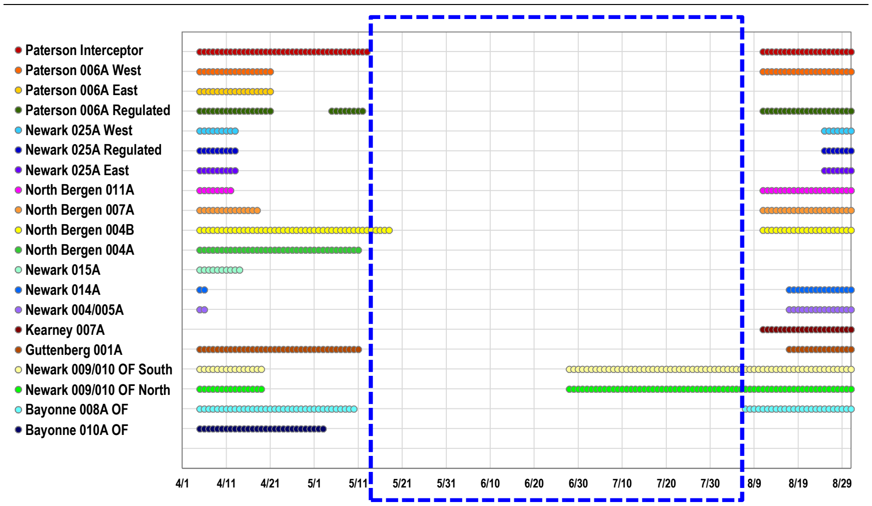
- 21 Flow Meters
- 3 Inclinometers



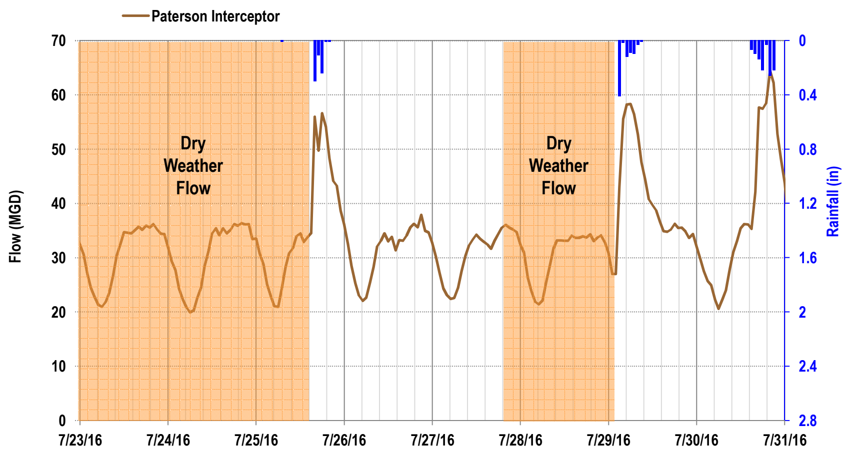
Meter Summary Table

Meter ID	Municipality	Location	Category
Bayonne 008A OF	Bayonne	East 5th and Ingham Ave	Outfall
Bayonne 010A OF	Bayonne	W 1st and Avenue C	Outfall
Guttenberg 001A	Guttenberg	70th and JFK Blvd	Outfall
Harrison 006 Influent	Harrison	Bergen and Dey	Regulator Influent
Kearny 007A	Kearny	King and Ivy Street	Outfall
Newark 004/005A	Newark	Herbert Place under elevated Hwy	Outfall
Newark 009/010 OF North	Newark	Clay Street - inside facility	Outfall
Newark 009/010 OF South	Newark	Clay Street - inside facility	Outfall
Newark 015A	Newark	City Dock	Outfall
Newark 014A	Newark	Saybrook in pull off	Outfall
Newark 025A East	Newark	Peddie - access through parking, near railroad	Regulator Influent
Newark 025A West	Newark	Peddie - access through parking, near railroad	Regulator Influent
Newark 025A Regulated	Newark	Peddie - access through parking, near railroad	Regulator Effluent
North Bergen 004A	North Bergen	73td and Hudson County 693	Outfall
North Bergen 004B	North Bergen	Near 74th and Hudson County in grassy lot	Outfall
North Bergen 007A	North Bergen	53rd and Tonnelle Ave in Concrete Plant driveway	Outfall
North Bergen 011A	North Bergen	1101 Tonnelle Ave	Outfall
Paterson 006A East	Paterson	Montgomery and River St	Regulator Influent
Paterson 006A West	Paterson	Montgomery and River St	Regulator Influent
Paterson 006A Regulated	Paterson	Montgomery and River St	Regulator Effluent
Paterson_INT	Paterson	McLean Boulevard at Cemetary entrance	Interceptor

Missing Data Period for Each Flow Meter

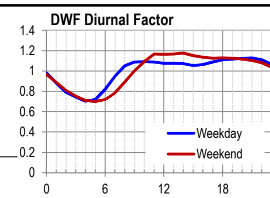


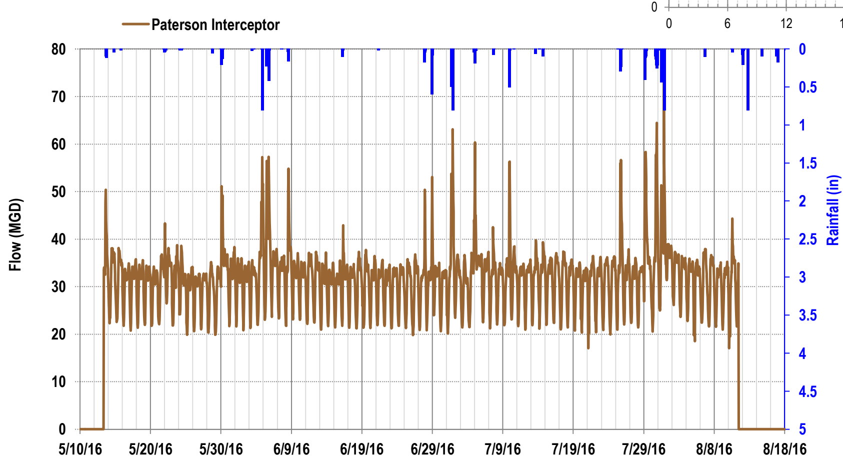
Dry Weather Flow Analysis



Hydrograph

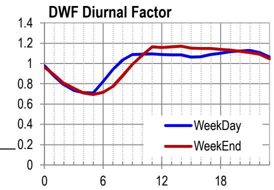
Paterson Interceptor

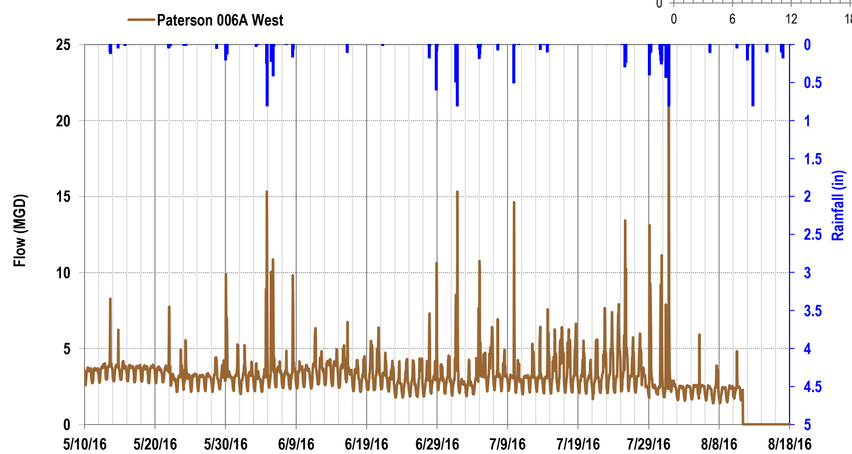




Hydrograph

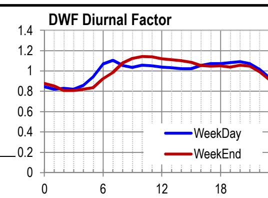
Paterson 006A West

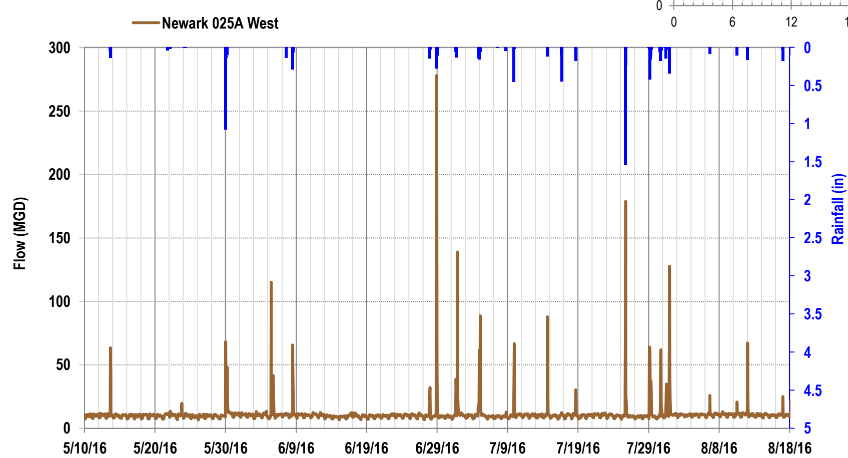




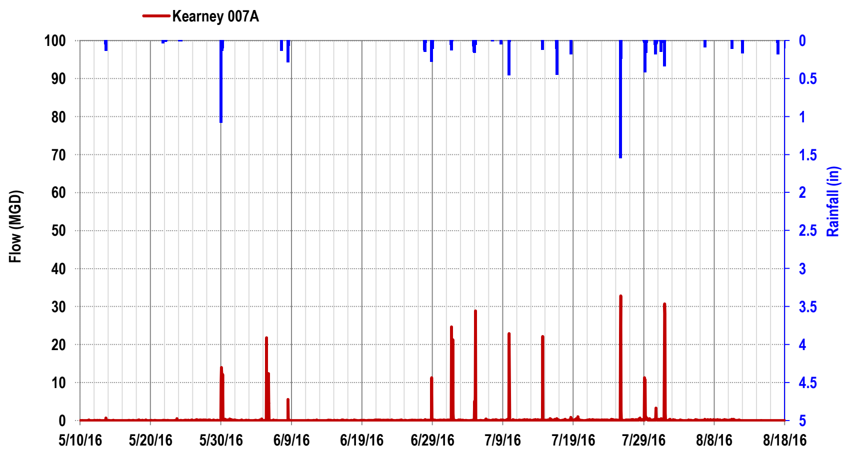
Hydrograph

Newark 025A West

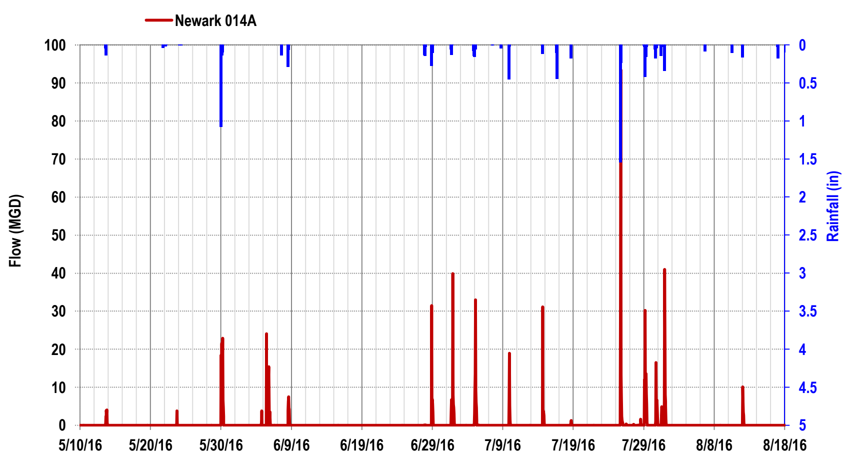




Hydrograph
Kearny 007A Overflow



Hydrograph
Newark 014A Overflow

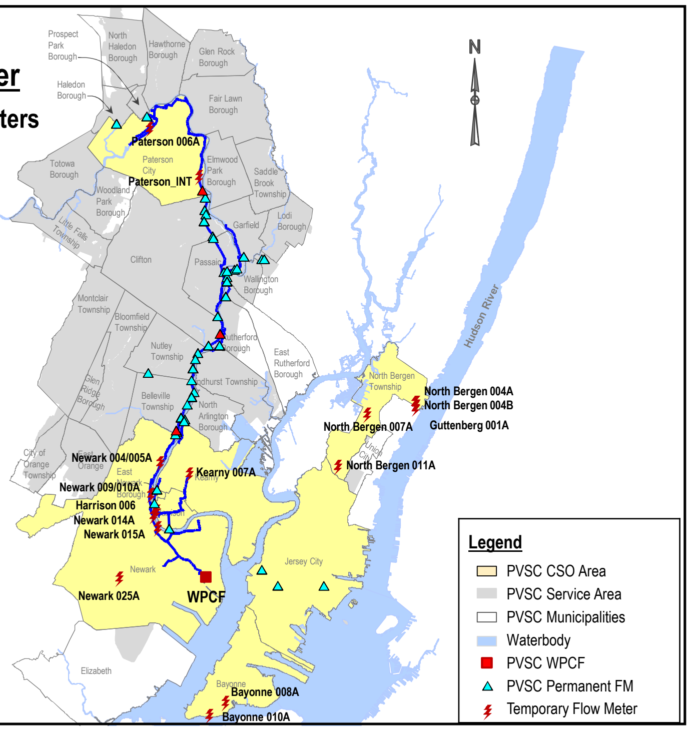


GREELEY AND HANSEN

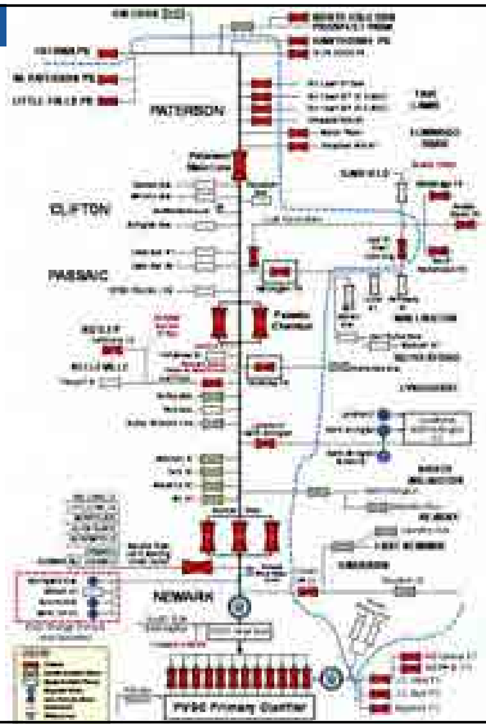
Permanent Flow Meters

PVSC Map
Permanent Flow Meter

- Over 70 permanent meters
- 58 analyzed for DWF

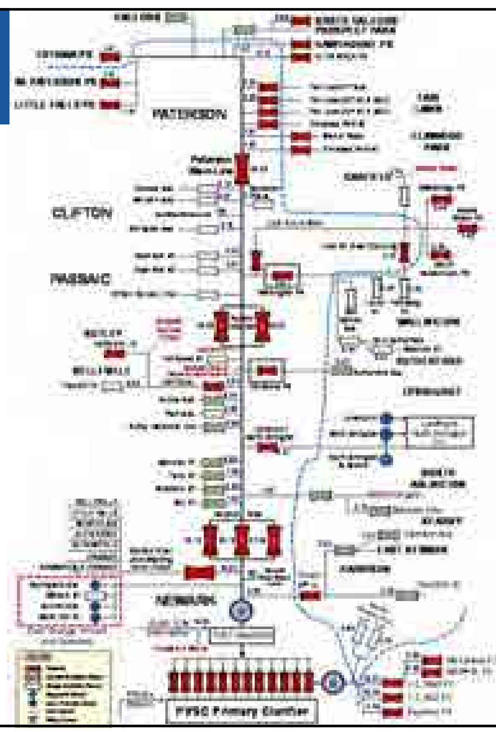


Flow Meter Diagram



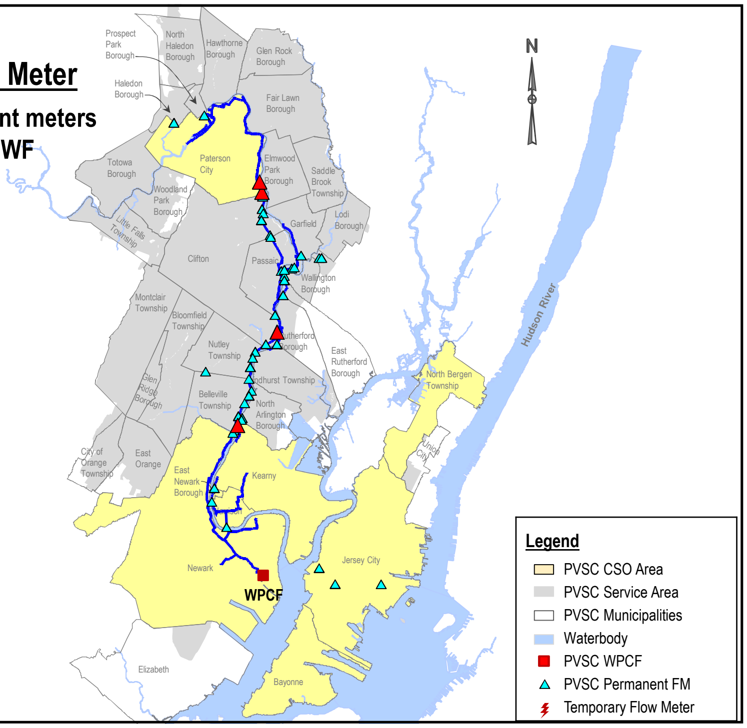
Flow Meter Diagram

Dry Weather Flow (MGD)

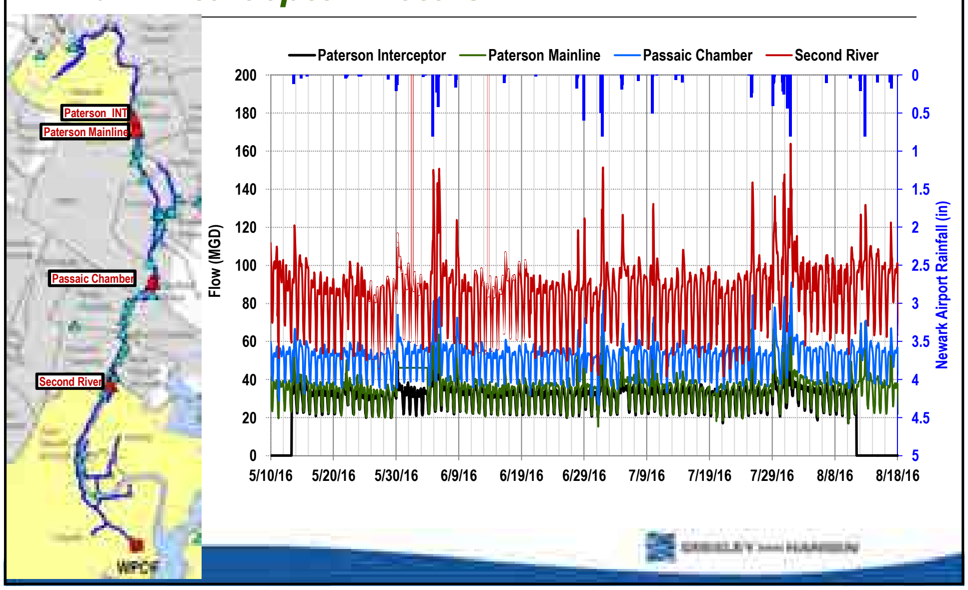


PVSC Map
Permanent Flow Meter

- Over 70 permanent meters
- 58 analyzed for DWF

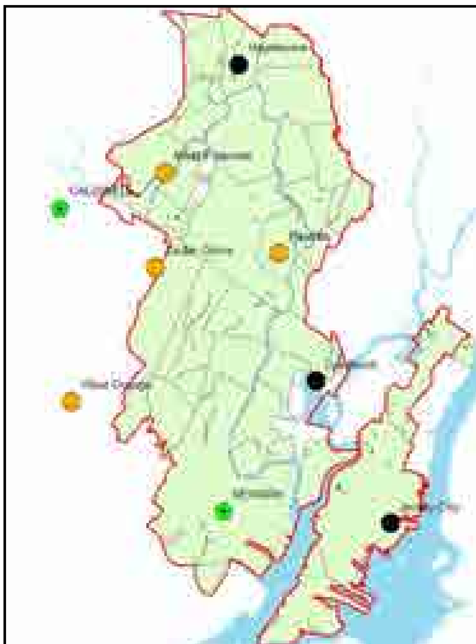


Hydrograph
Main Interceptor Meters

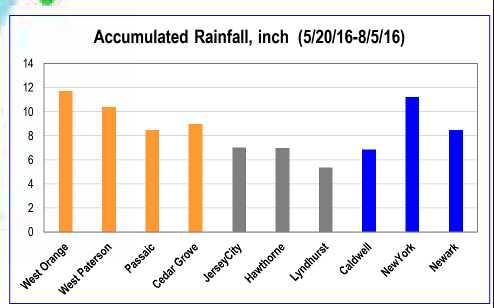


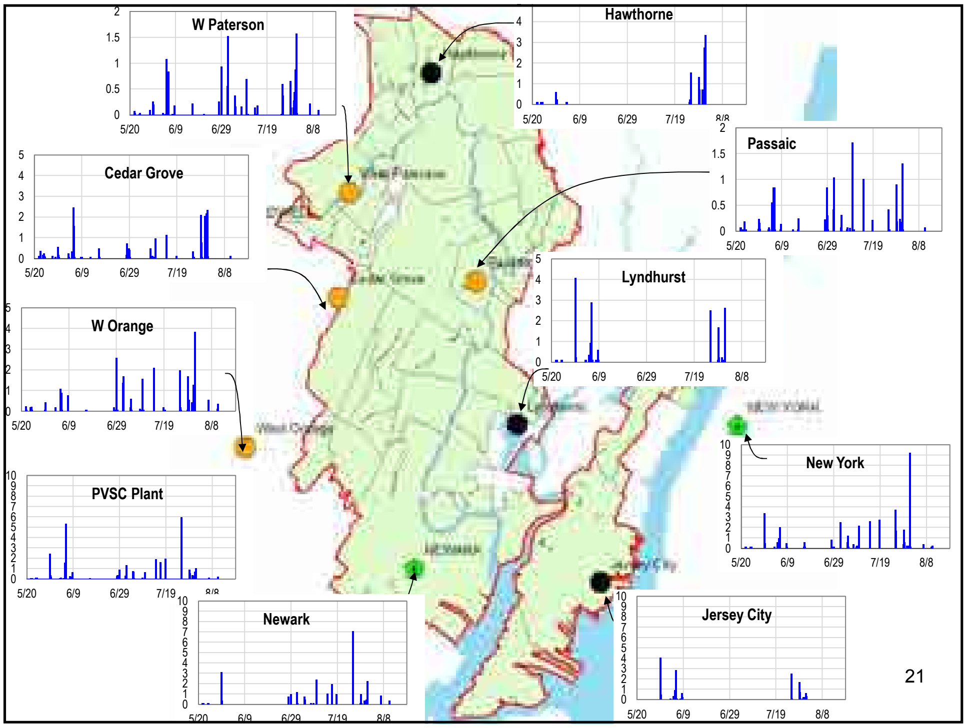
GREELEY AND HANSEN

Rainfall Data Analysis



Rain Gauge Summary			
Source	RG ID	Data Time Interval (Min.)	Total Rainfall (5/20/16-8/05/16)
NJ Weather	Hawthorne	5	6.97
NJ Weather	Lyndhurst	5	5.39
NJ Weather	jersey City	5	7.04
CWOP	West Paterson	30	10.4
CWOP	Passaic	15	8.46
CWOP	Cedar Grove	10-50	8.98
CWOP	West Orange	10	11.72
NWS ASOS	Caldwell	1	6.84
NWS ASOS	New York	1	11.23
NWS ASOS	Newark	1	8.47





Candidate Storm Events for Calibration

Rain Start	Rain End	Duration (hr)	Depth (in)	Max Intensity (in/hr)	Average Intensity (in/hr)
7/25/16 16:05	7/25/16 18:50	2.75	**1.81**	1.68	0.66
5/29/16 23:50	5/30/16 5:20	5.50	**1.6**	1.09	0.29
7/29/16 0:20	7/29/16 8:35	8.25	**0.85**	0.42	0.10
5/2/16 22:40	5/3/16 9:50	11.17	**0.7**	0.17	0.06
7/31/16 8:35	7/31/16 22:35	14.00	**0.69**	0.49	0.05
7/4/16 19:20	7/5/16 2:50	7.50	**0.63**	0.23	0.08
5/6/16 2:30	5/6/16 12:25	9.92	**0.6**	0.19	0.06
7/16/16 14:50	7/16/16 15:35	0.75	**0.56**	0.75	0.75
6/8/16 11:25	6/8/16 14:10	2.75	**0.49**	0.3	0.18
7/9/16 21:30	7/9/16 22:05	0.58	**0.48**	0.82	0.82
4/4/16 7:45	4/4/16 17:00	9.25	**0.43**	0.12	0.05

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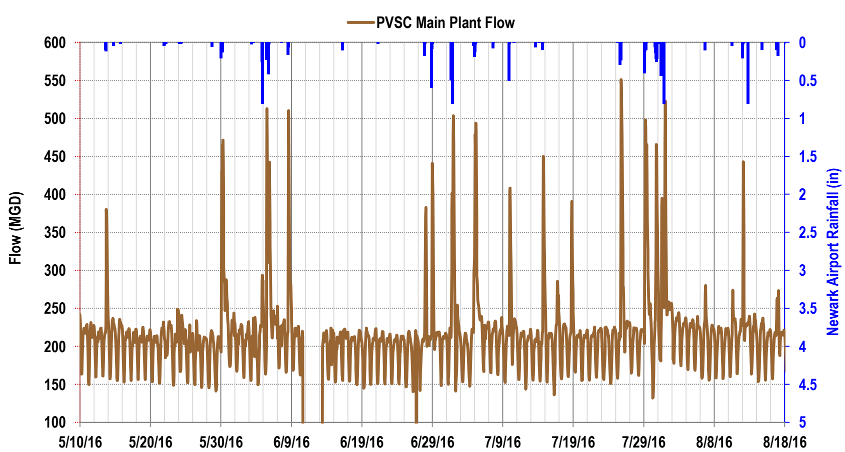
Discussion

Hydrograph

PVSC Main Plant Flow



GREELEY AND HANSEN

PVSC – Long Term Control Plan
Modeling Evaluation Group – Session 3

Hydrologic and Hydraulic Model Update and Calibration

Greeley and Hansen LLC
September 15, 2017

INTERAGENCY ADVISORY, CONSULTATIVE AND/OR DELIBERATIVE MATERIALS. NOT SUBJECT TO DISCLOSURE UNDER N.J.S.A 47:1A-1 ET SEQ. OR THE COMMON LAW RIGHT TO INSPECT PUBLIC RECORDS

Agenda

- Background: PVSC Sewer System
- PVSC Hydrologic and Hydraulic (H&H) Model Snapshot
- H&H Model Update
- H&H Model Calibration and Validation
- Summary & Next Step

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Background

Sewer Systems

- Passaic Valley Sewerage Commission
  - 48 municipalities
    - 8 CSO municipalities (0.9 million residents)
  - 1.5 million residents
  - 147 mi² service area
  - 22 mile interceptor sewer
  - 330 mgd WPCF
- NBMUA Woodcliff WWTP
  - 2 CSO municipalities
  - 3 mgd Woodcliff WWTP
  - 477 acres (368 acres in North Bergen)

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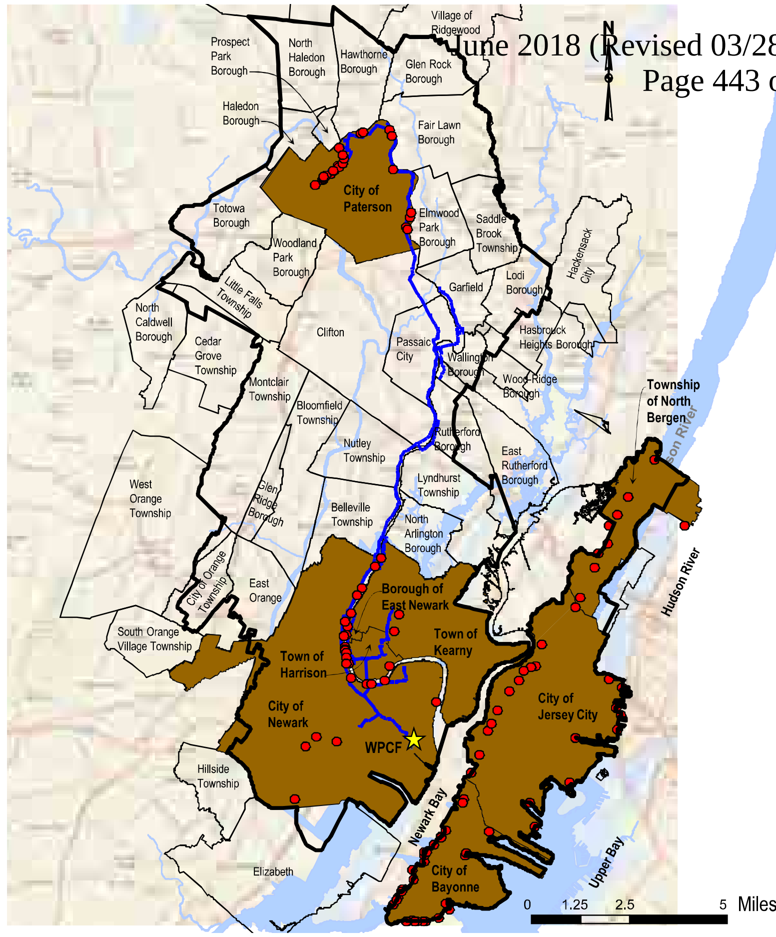
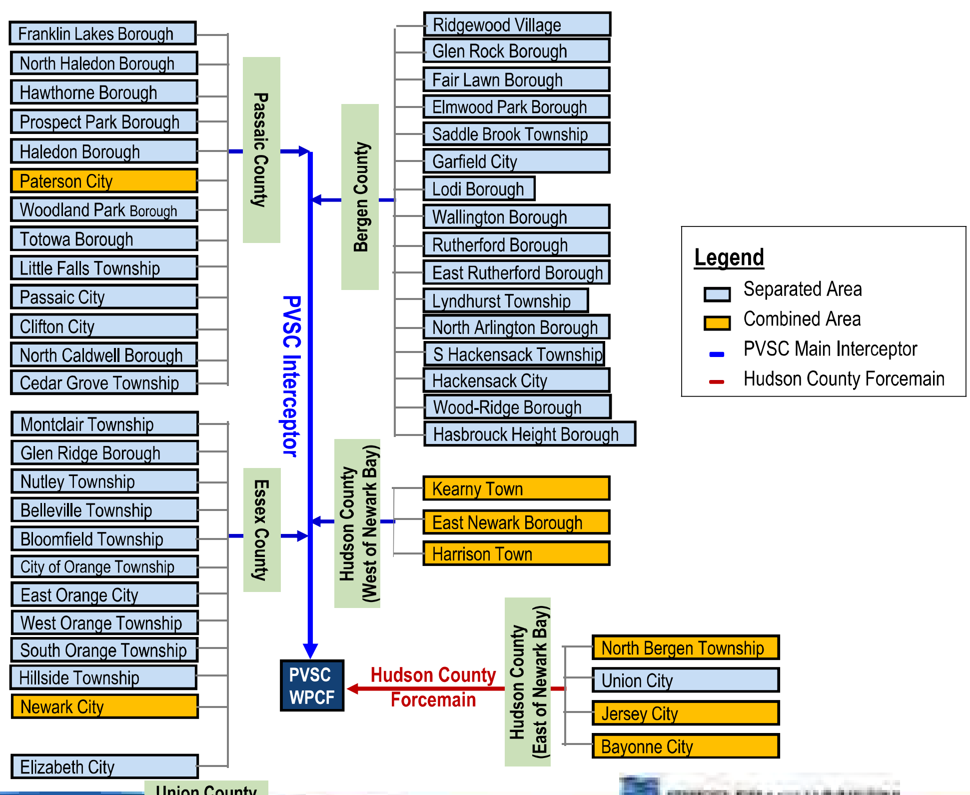
PVSC Service Area

Legend

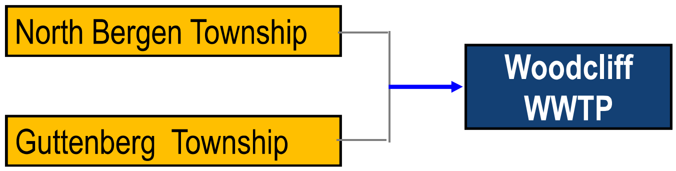
- PVSC Service Area
- CSO Communities
- Separated Communities
- PVSC WPCF (Water Pollution Control Facility)
- PVSC Interceptor / Sewer
- CSO Outfall



PVSC WPCF Schematic



NBMUA Woodcliff WWTP Schematic



CSO Communities

Municipality	WWTP	Population	Area (mi²)	Sewerage (miles)	CSOs
Bayonne	PVSC	63,000	5.8	94	30
East Newark	PVSC	2,400	0.1	2	1
Harrison	PVSC	13,600	1.3	18	7
Jersey City	PVSC	247,600	14.8	230	21
Kearny	PVSC	40,700	6.5	52	5
Newark	PVSC	277,100	22.3	579	18
North Bergen	PVSC	52,600	4.5	59	7
Paterson	PVSC	146,200	8.7	164	23
Guttenberg	NBMUA	11,200	0.2	5	1
North Bergen	NBMUA	8,200	0.7	8	1
Total		**862,600**	**84**	**1,211**	**114**

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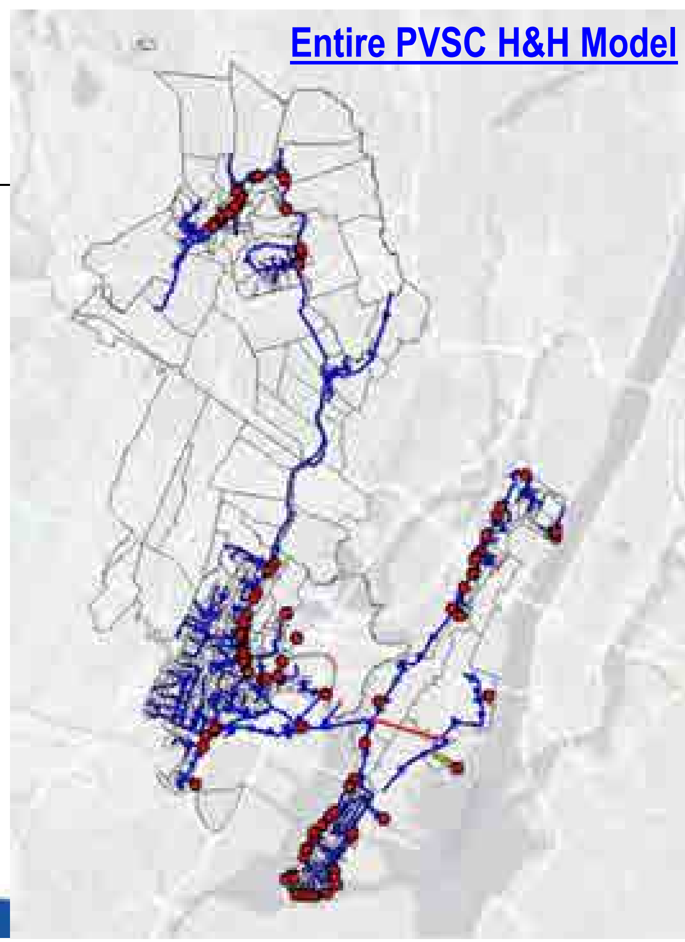
Current H&H Model Snapshots

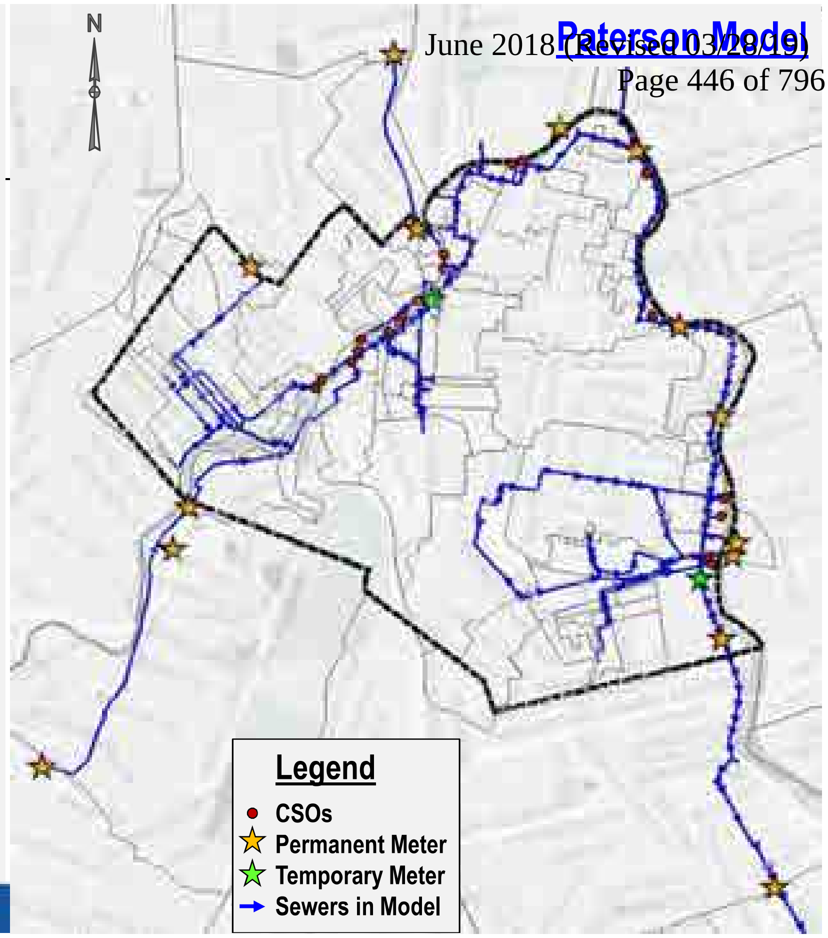
Entire PVSC H&H Model

- Subcatchment: 732
- Nodes (2735)
  - Manhole: 2621
  - Outfall: 103
  - Storage: 11
- Link (2873)
  - Conduit: 2567
  - Flap Valve: 82
  - Orifice: 33
  - Pump: 14
  - Sluice: 74 (30 variable)
  - Weir: 103



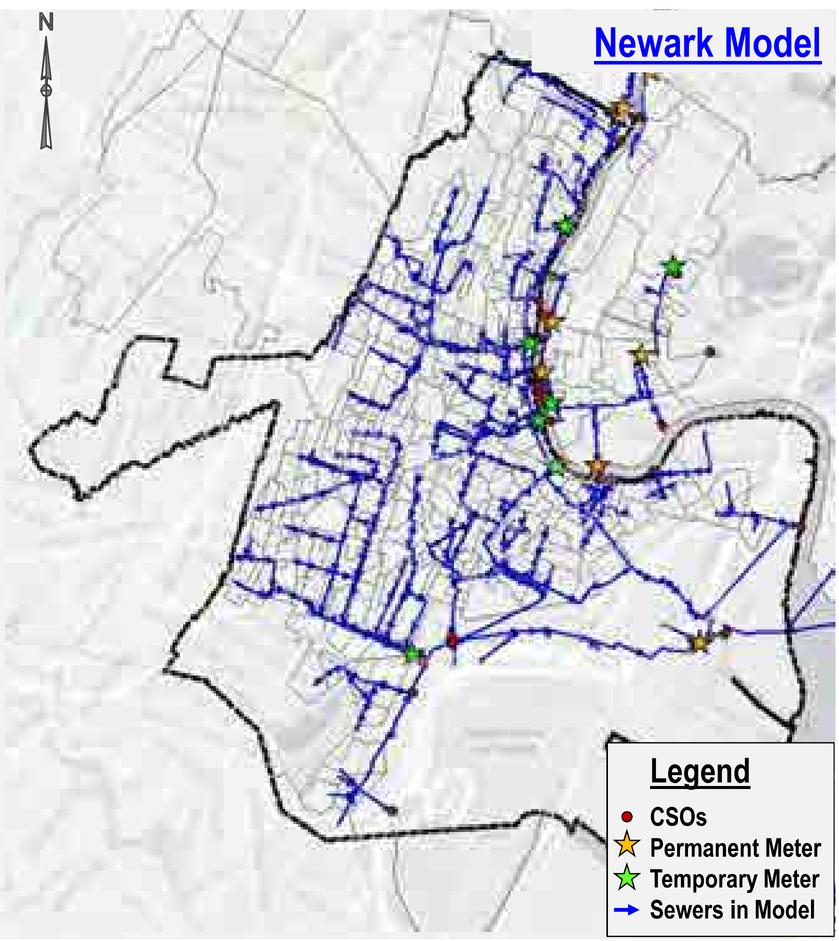
Paterson Model

- Subcatchment: 67
- Nodes (585)
  - Manhole: 562
  - Outfall: 23
  - Storage: 0
- Link (657)
  - Conduit: 503
  - Flap Valve: 82
  - Orifice: 14
  - Pump: 0
  - Sluice: 16 (2 variable)
  - Weir: 42



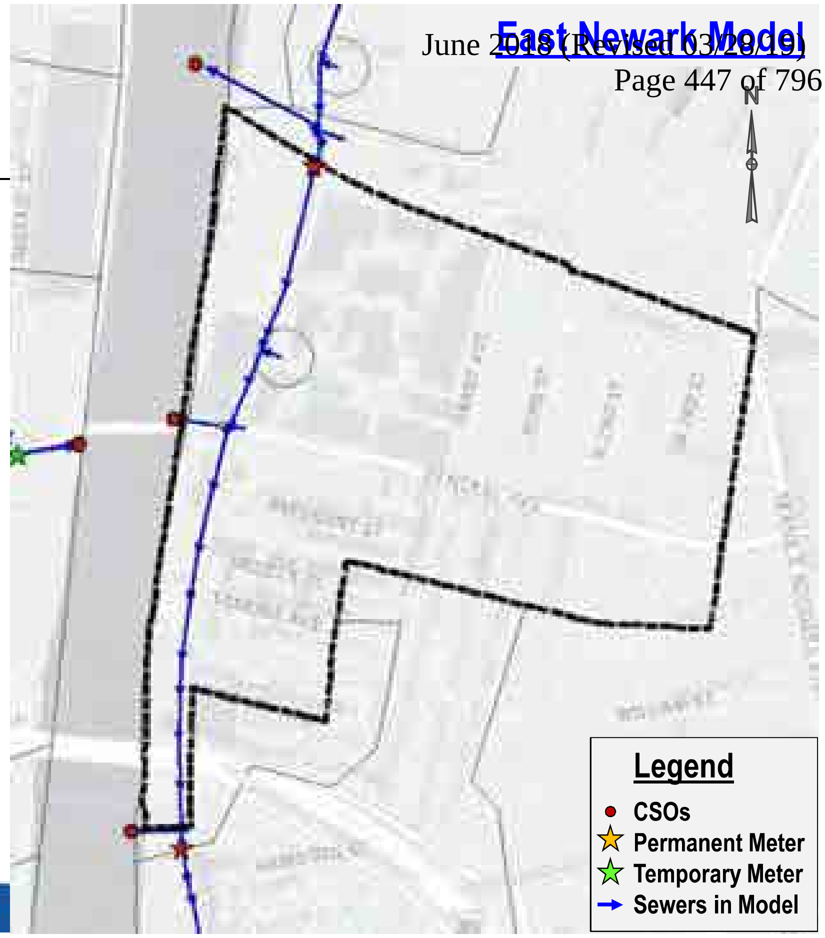
Newark Model

- Subcatchment: 310
- Nodes (758)
  - Manhole: 738
  - Outfall: 18
  - Storage: 2
- Link (819)
  - Conduit: 746
  - Flap Valve: 17
  - Orifice: 3
  - Pump: 3
  - Sluice: 27 (17 variable)
  - Weir: 23



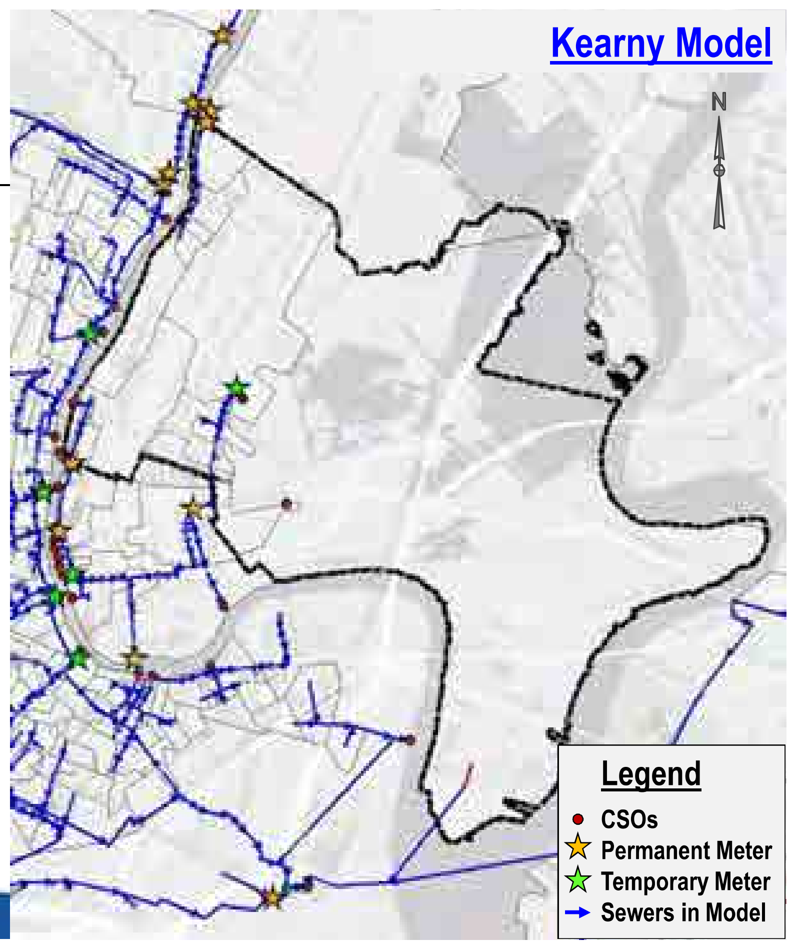
East Newark Model

- Subcatchment: 1
- Nodes (22)
  - Manhole: 21
  - Outfall: 1
  - Storage: 20
- Link (22)
  - Conduit: 19
  - Flap Valve: 1
  - Orifice: 1
  - Pump: 0
  - Sluice: 0
  - Weir: 1



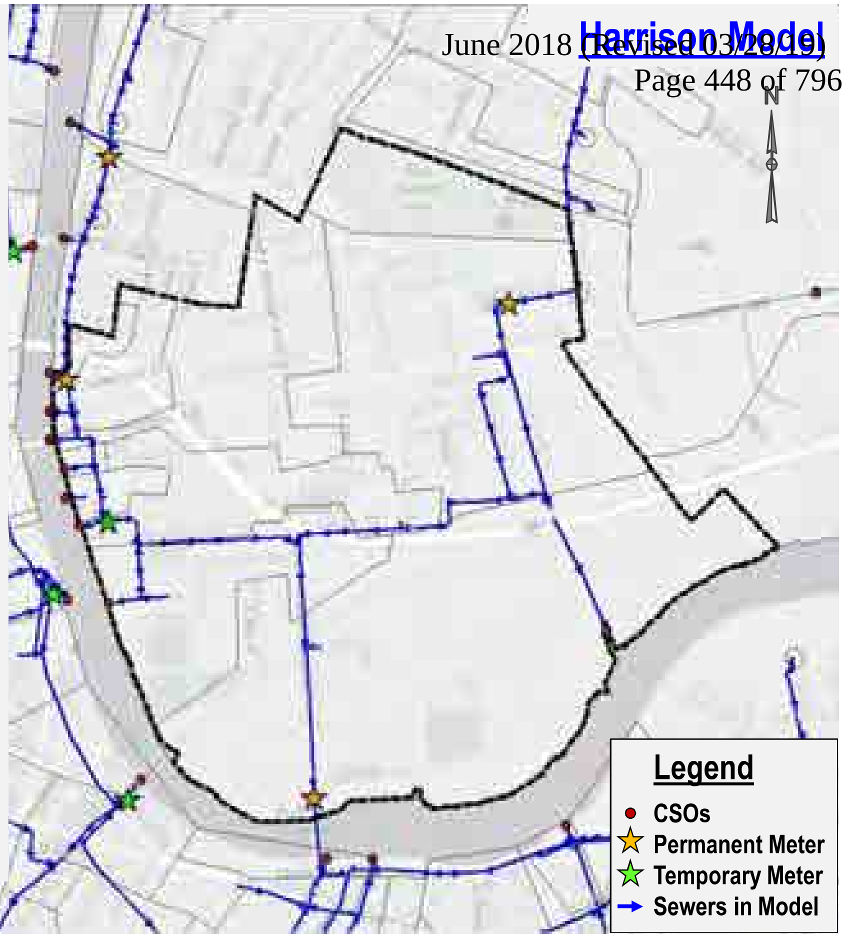
Kearny Model

- Subcatchment: 16
- Nodes (97)
  - Manhole: 91
  - Outfall: 5
  - Storage: 1
- Link (97)
  - Conduit: 78
  - Flap Valve: 5
  - Orifice: 7
  - Pump: 1
  - Sluice: 1
  - Weir: 5



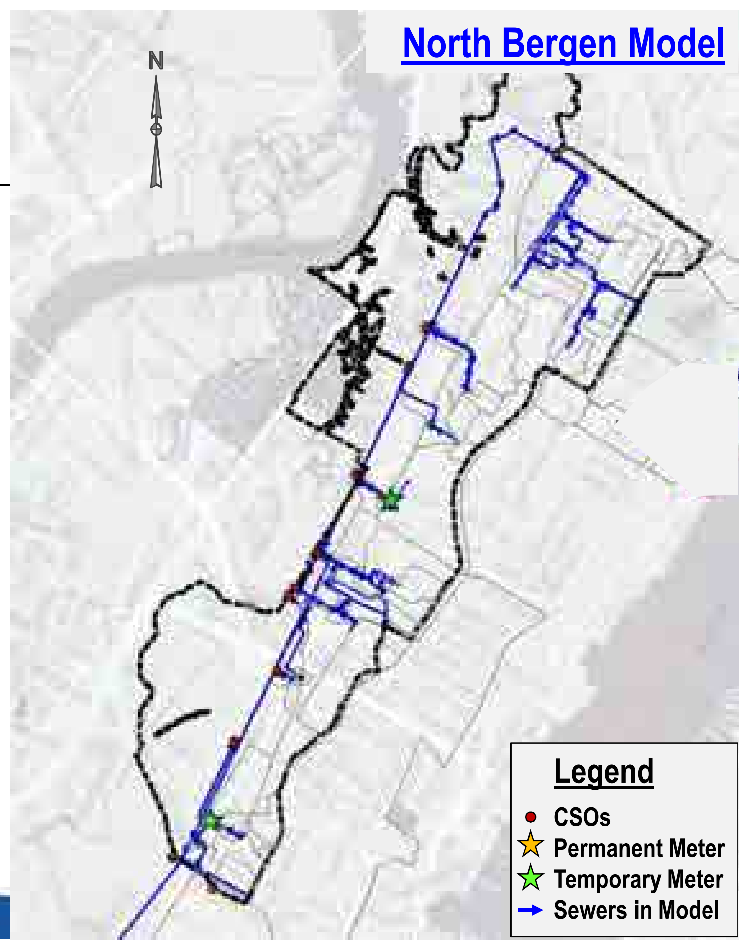
Harrison Model

- Subcatchment: 16
- Nodes (117)
  - Manhole: 110
  - Outfall: 7
  - Storage: 0
- Link (118)
  - Conduit: 97
  - Flap Valve: 7
  - Orifice: 7
  - Pump: 0
  - Sluice: 0
  - Weir: 7



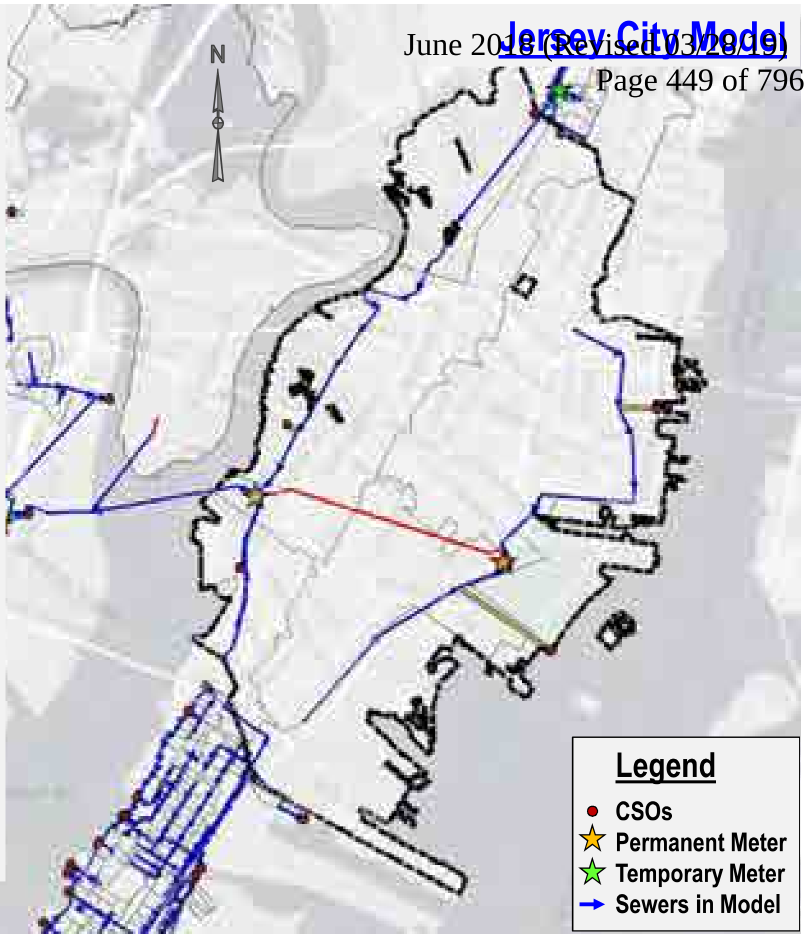
North Bergen Model

- Subcatchment: 41
- Nodes (178)
  - Manhole: 166
  - Outfall: 9
  - Storage: 3
- Link (199)
  - Conduit: 183
  - Flap Valve: 0
  - Orifice: 0
  - Pump: 3
  - Sluice: 5
  - Weir: 8



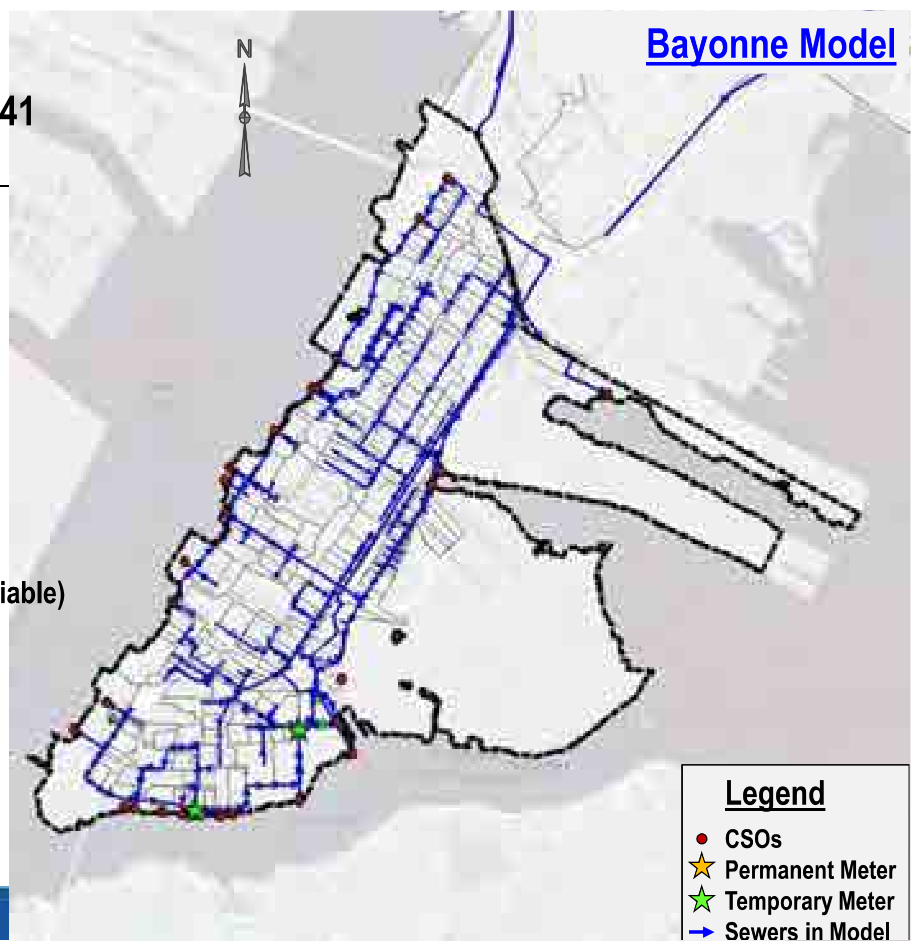
Jersey City Model

- Subcatchment: 5
- Nodes (34)
  - Manhole: 29
  - Outfall: 5
  - Storage: 0
- Link (36)
  - Conduit: 24
  - Flap Valve: 5
  - Orifice: 0
  - Pump: 2
  - Sluice: 5
  - Weir: 0



Bayonne Model

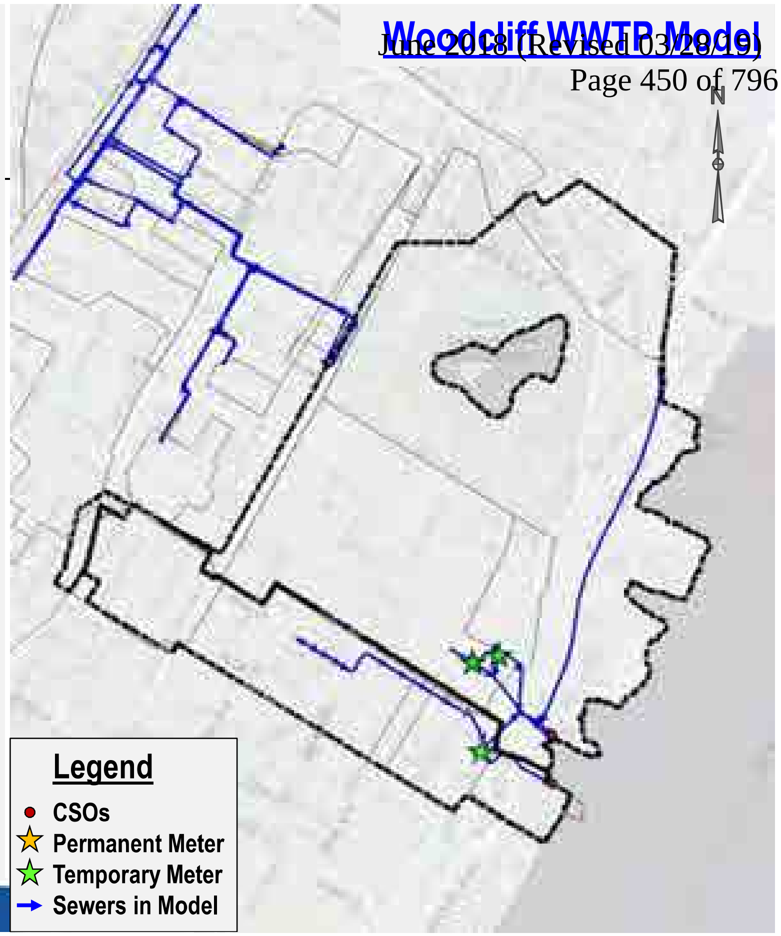
- Subcatchment: 41
- Nodes (685)
  - Manhole: 651
  - Outfall: 29
  - Storage: 5
- Link (712)
  - Conduit: 648
  - Flap Valve: 27
  - Orifice: 0
  - Pump: 5
  - Sluice: 20 (11 variable)
  - Weir: 12



Woodcliff WWTP Model

Woodcliff WWTP Model

- Subcatchment: 5
- Nodes (38)
  - Manhole: 35
  - Outfall: 2
  - Storage: 1
- Link (39)
  - Conduit: 37
  - Flap Valve: 0
  - Orifice: 0
  - Pump: 0
  - Sluice: 1
  - Weir: 1



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Model Update

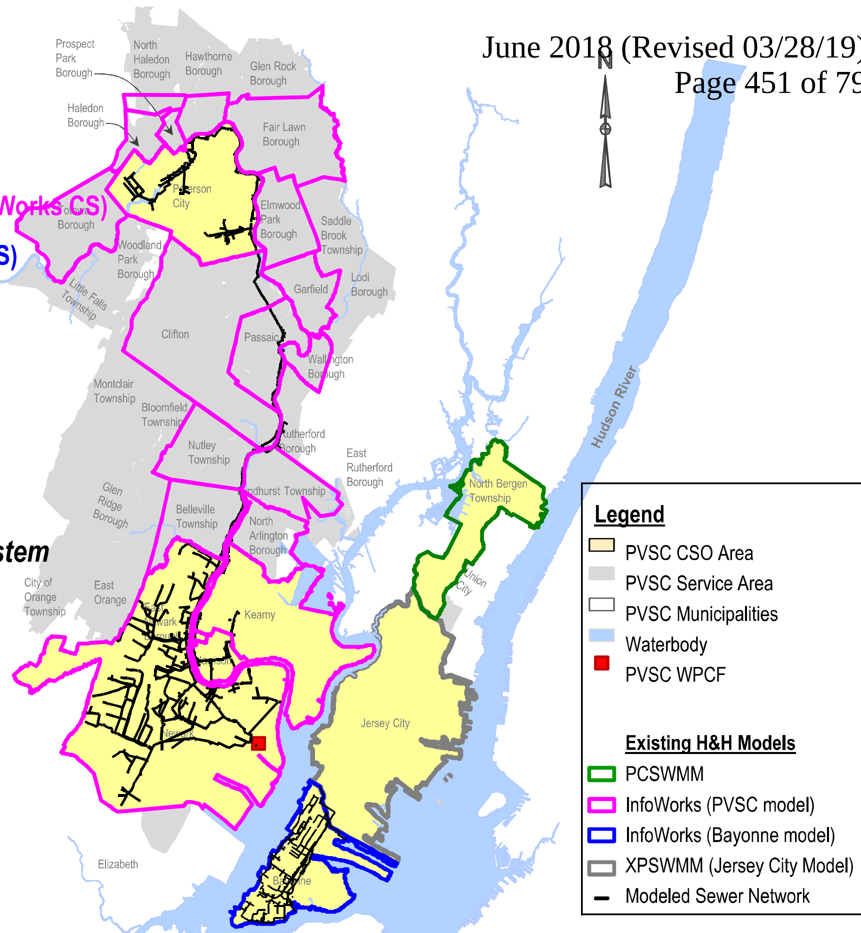
Existing Models

PVSC WPCF System

- PVSC Interceptor Model (InfoWorks CS)
- Bayonne Model (InfoWorks CS)
- North Bergen Model
  (2 PCSWMM model)
- Jersey City Model
  (XPSWMM model)

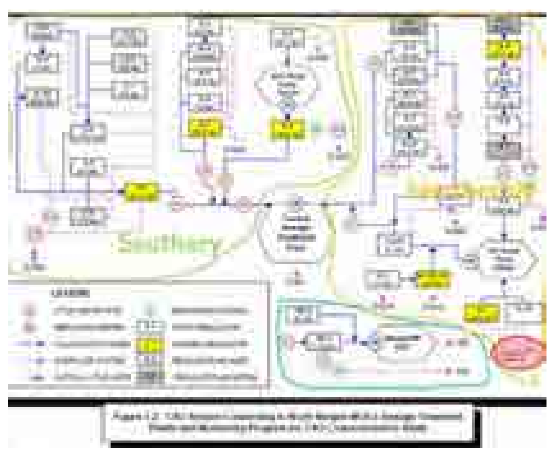
NBMUA Woodcliff WWTP System

- North Bergen Model
  (1 PCSWMM model)
- Guttenberg Model
  (1 PCSWMM model)



North Bergen Models

- North Bergen
  - Najarian Associates
  - 3 PCSWMM Models
  - LTCP Team has model
  - Converted to EPA SWMM for CSO Alert System



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Bayonne Models

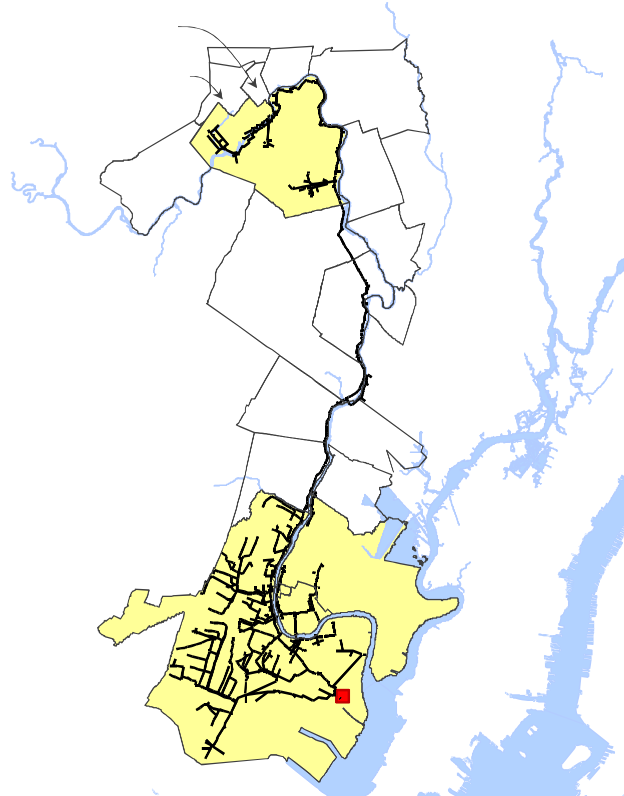
- Bayonne
  - HDR
  - InfoWorks CS
  - LTCP Team has model
  - Used for CSO Alert System

Jersey City Models

- Jersey City
  - ARCADIS
  - XPSWMM
  - LTCP Team does not have model
  - Model results provided by ARCADIS for CSO Alert System

PVSC Main Interceptor Model

- **Large, Complex System**
  - Main interceptor
  - Seven branch interceptors
  - Combined and separate sewers
  - Regulators
  - RTC
  - Pump stations
  - River crossings
  - Treatment plant



A Snapshot of Integrated Model…

Entire PVSC H&H Model

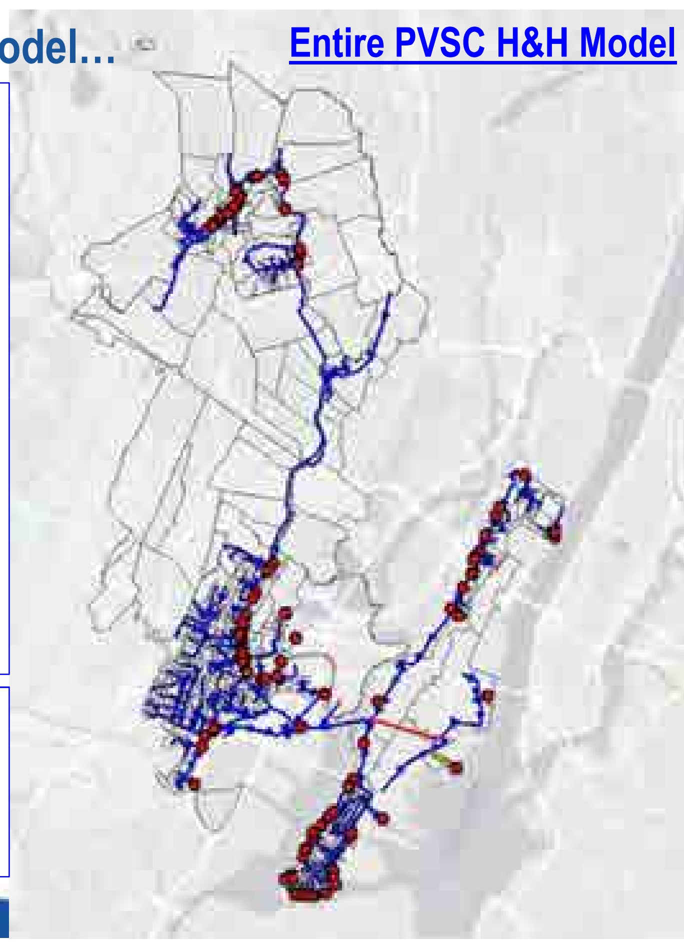
- 48 PVSC communities
- 8 CSO communities
  - ✓ Paterson
  - ✓ Newark
  - ✓ East Newark
  - ✓ Harrison
  - ✓ Kearny

  (Above 5 discharge to interceptor by gravity to WPCF)

  - ✓ Bayonne
  - ✓ Jersey City
  - ✓ North Bergen

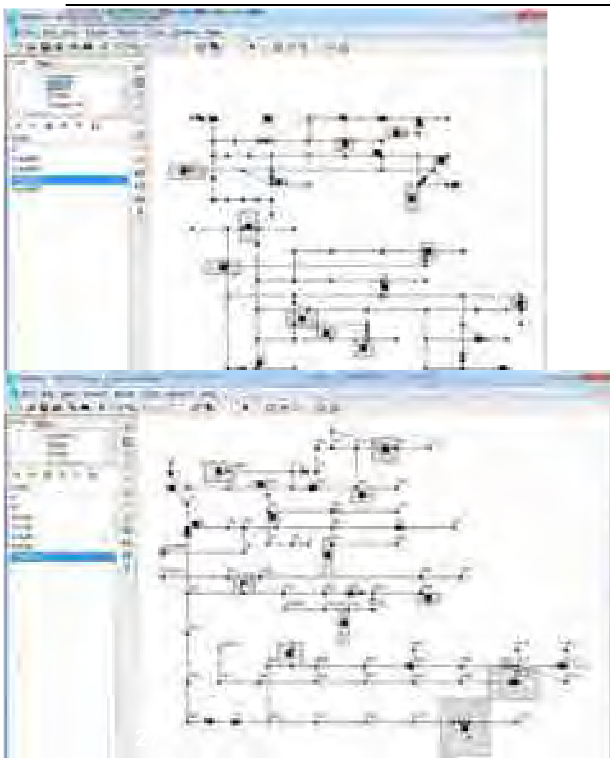
  (Above 3 discharge to Hudson County Forcemain to WPCF)

- 2 NBMUA Woodcliff WWTP CSO communities
  - ✓ North Bergen
  - ✓ Guttenberg



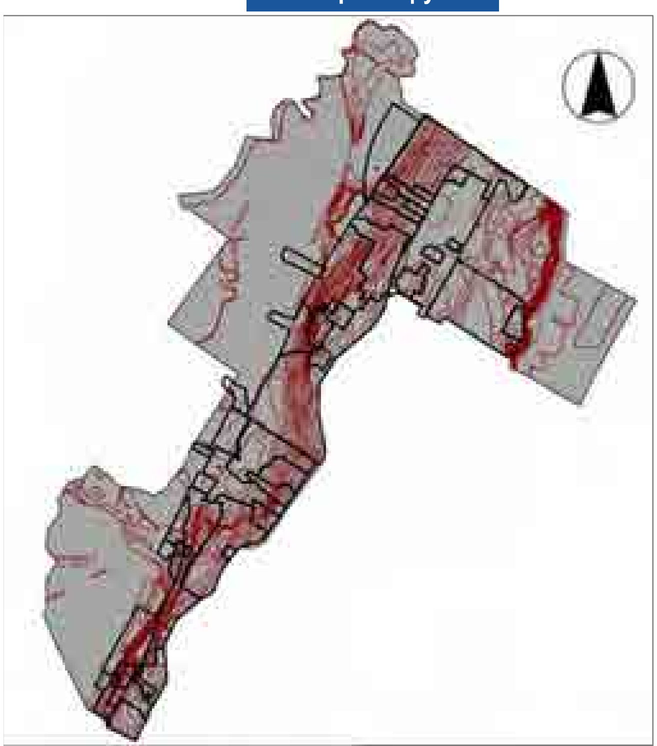
Model Integration

Recreate North Bergen Model from PCSWMM



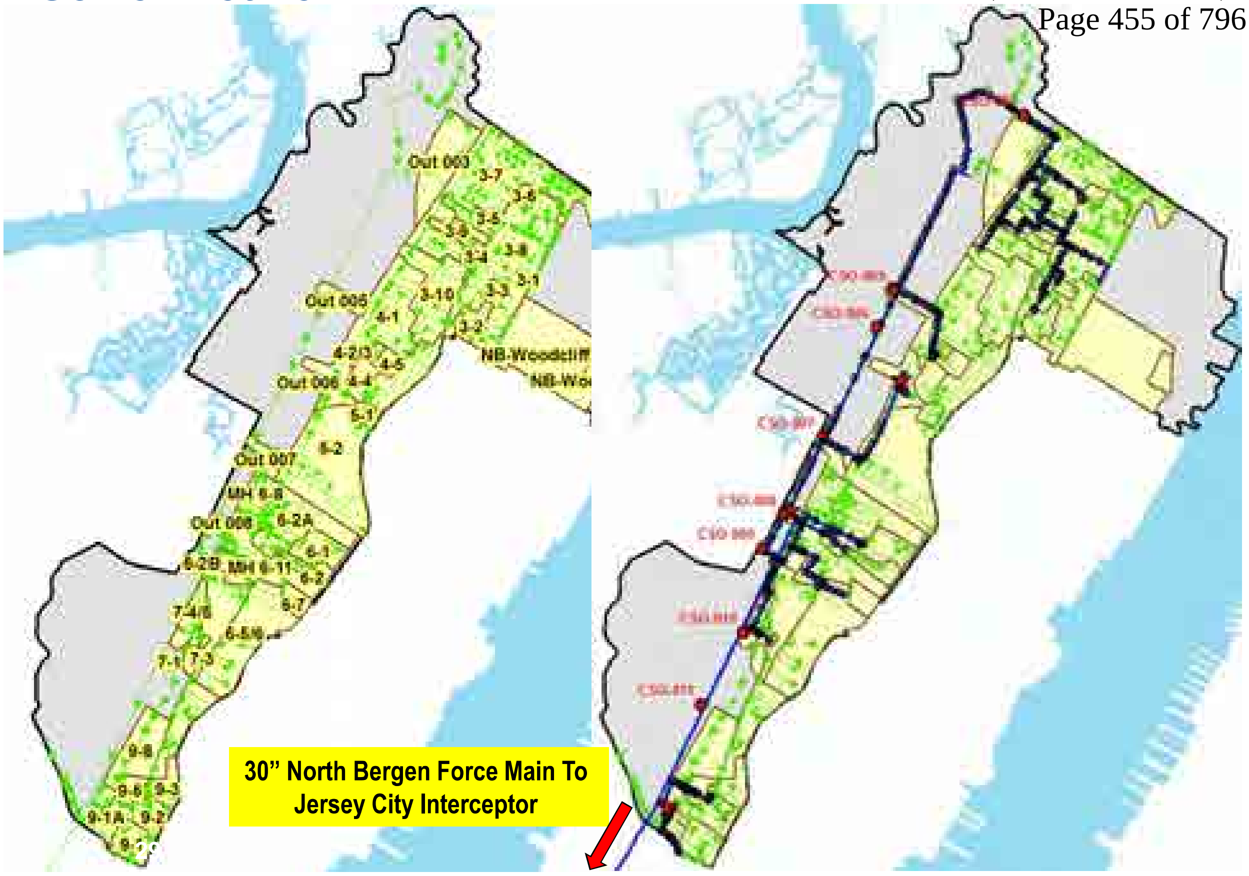
NB Delineation

Paper Copy → **GIS Shapefile**

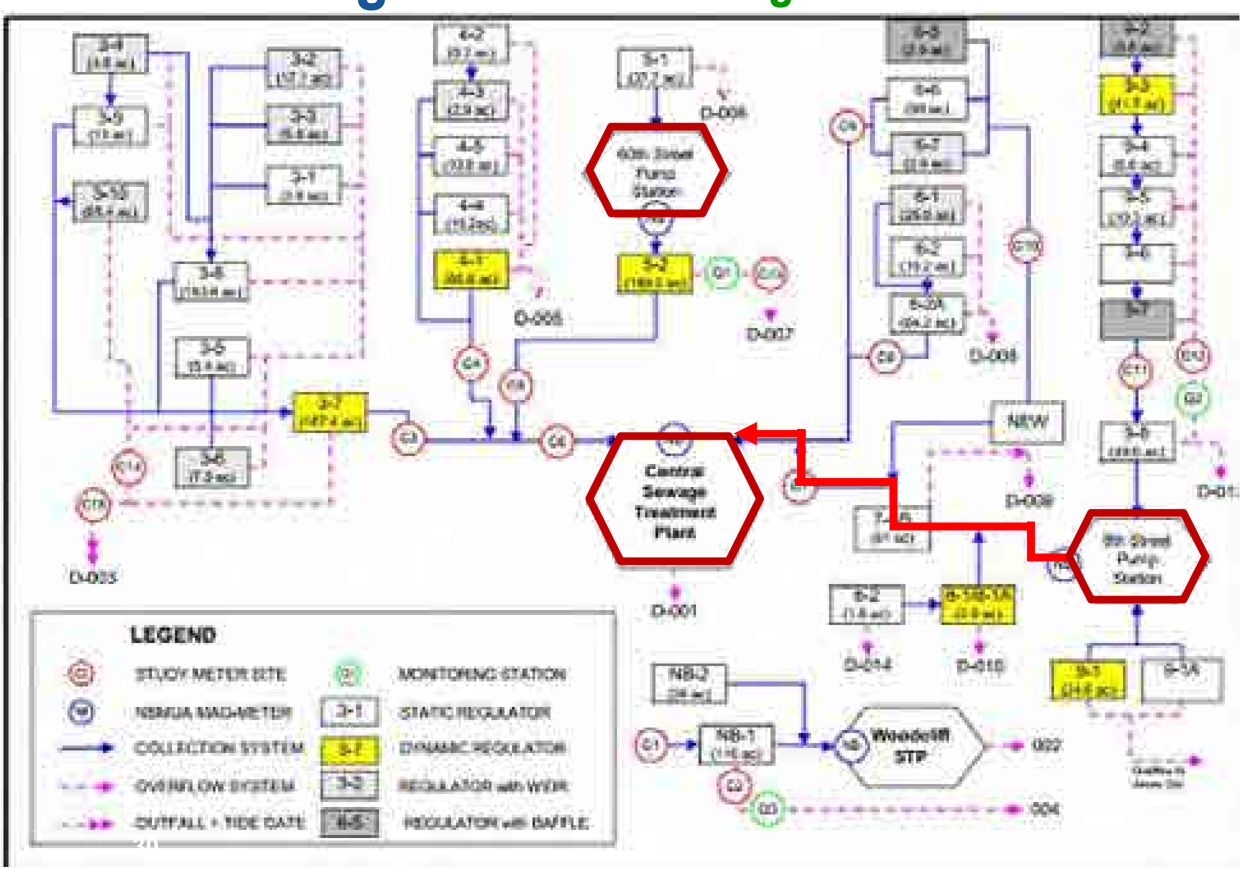


- *Digitize model subcatchment based on paper copy*

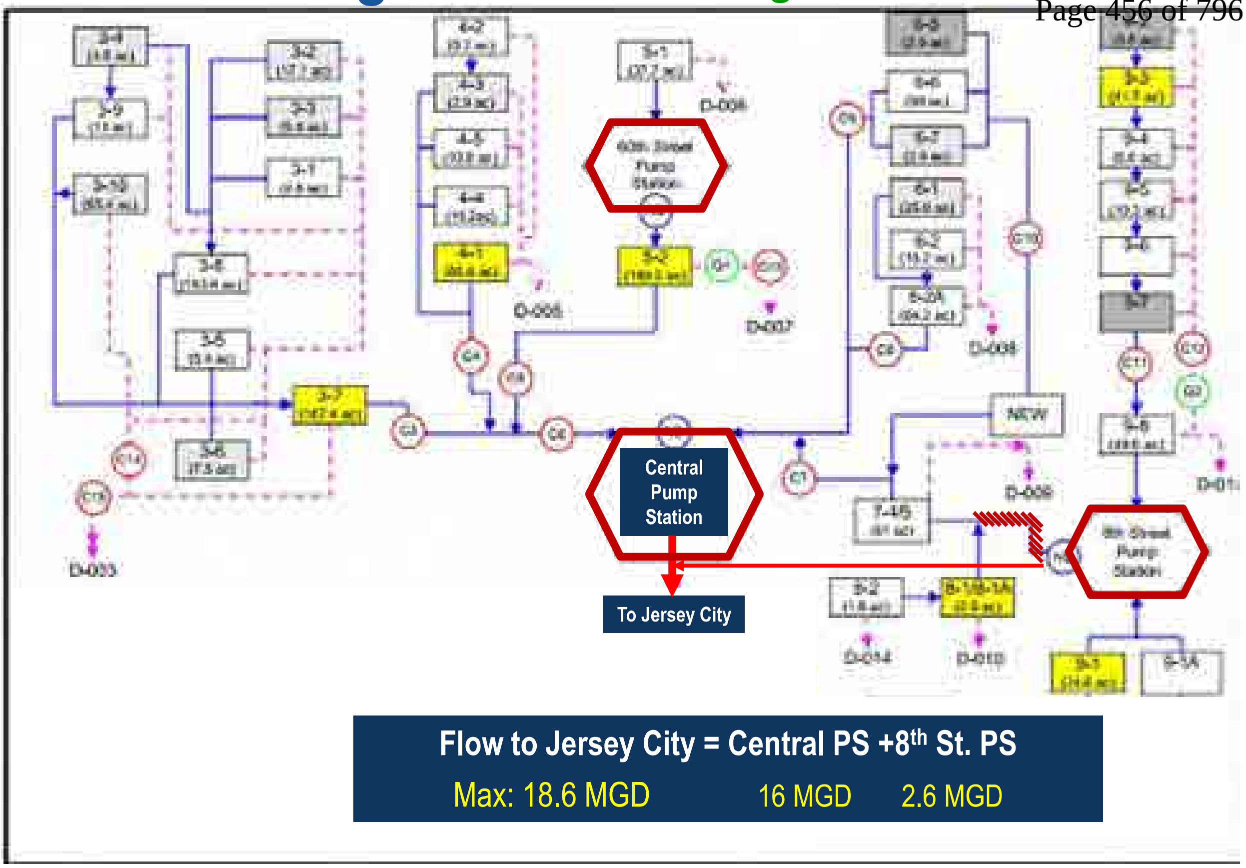
Sewer Network



Model Integration/*North Bergen Model*



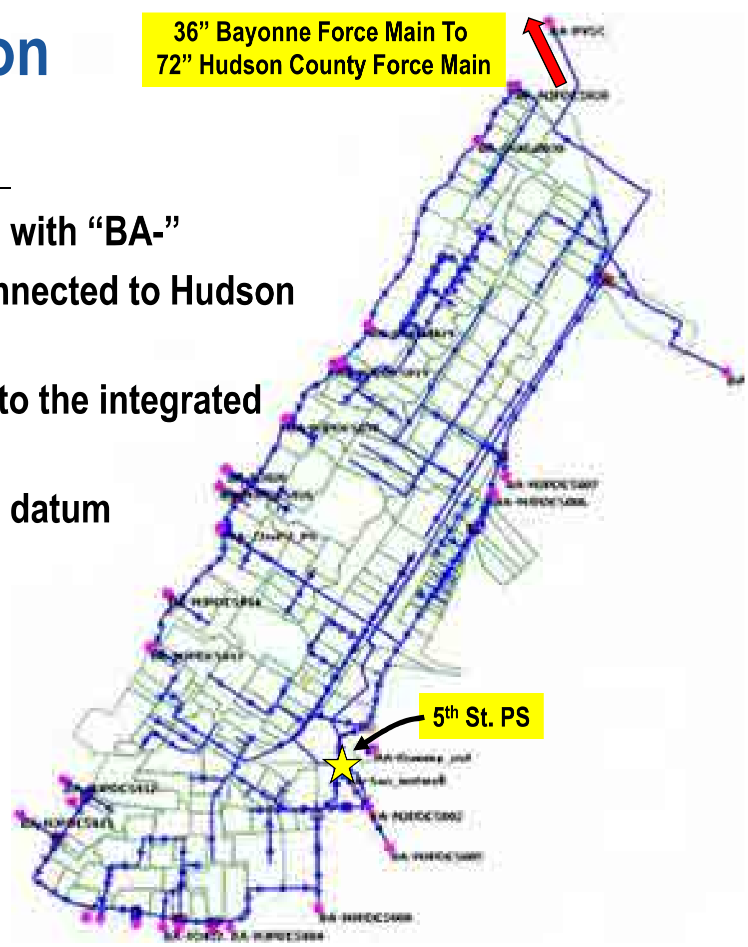
Model Integration/*North Bergen Model*



Model Integration

Bayonne Model

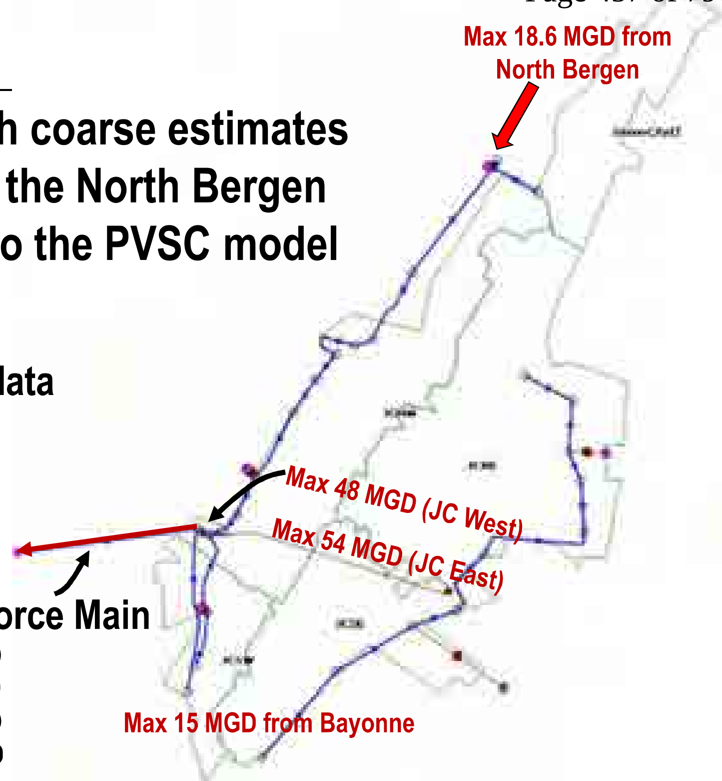
- With unique IDs starting with “BA-”
- Bayonne force main Connected to Hudson County Force Main
- 11 RTC rules appended to the integrated model
- Datum updated to PVSC datum



Model Integration

Jersey City Model

- **Model was created with coarse estimates to allow connection of the North Bergen and Bayonne models to the PVSC model**



Max pump rate based on data

Jersey City East:	Peak 54 MGD
Jersey City West:	Peak 48 MGD

Flows in Hudson County Force Main

- Jersey City East:	Peak 54 MGD
- Jersey City West:	Peak 48 MGD
- Bayonne:	Peak 15 MGD
Total Maximum:	**117 MGD**

Model Integration

Force Mains

- **Hudson County Force Main was extended to the PVSC WPCF based on drawings**
- **South Kearny PS 30" force main was created and tied into the Hudson County Force Main**

South Kearny Pump Station Service Area

- Kearny Meadowlands District
- South Kearny District
- Both Separated

South Kearny Pump Station

- Capacity: 17.5 MGD
- DWF: 1.6 MGD

Source: Mott MacDonald

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Regulator Update

Regulator Modification

Regulator	Overflow Weir				Regulating Sluice Gate / Orifice					
	Drawing		Original Model		Drawing			Original Model		
	Crest	Width	Crest	Width	Invert	Width	Height	Invert	Width	Height
P_015A	152.9	2.5	152.9	2.5	151.87	1.25		151.87	1.25	
P-001A	146.9	3.83	146.9	3.83	143.94	3	1	143.94	2.25	
P-003A	139.5	4	139.5	4	137.4	1.25		137.4	1.25	
P-005A	133.4	5	136.71	5	131.7	0.833	1.667	131.7	1.25	
P-006A	134.2	8.0	135.25	8	129.53	2		129.53	2	
P-007A	133.8	6	133.8	5	130.1	1.83	3	130.1	1.25	
P-010A	135.4	4	135.4	4	133.44	1.67	0.83	133.44	1.25	
P-010A	133.85	4	135.21	3						
P-016A (modified)	138.8	8	140.94	8.5	136.25	2.5		136.25	2.5	
P-017A	135.7	4.5	135.69	3.67	132.6	1		132.6	1	
P-032A	135.2	4	135.2	4						
P-022A	132.6	4.5	132.6	4.5	130.63	2		130.63	2	
P-021A	132.7	4.5	132.7	4.5	130.75	1		130.75	1	
P-013A	133.4	4.83	133.4	4.83	131.7	1.67	0.83	131.7	1.25	
P-014A	140.9	4.5	140.9	3	137.76	1.67	0.83	137.76	1.25	
P-023A	129.8	4.5	130.56	5	127.4	Not available	Not available	127.4	1.25	
P-024A	130.3	4.5	130.3	5	128.2	1.67	0.83	128.2	1.25	
P-025A	128.9	8.58	129.87	8.58	127.07	3	1	127.07	2	
P-026A	129.2	5.5	128.92	5.5	126.95	1.67	0.83	126.95	1.66	0.83
P-027A	131.1	7.11	131.1	4.0	129.6	3.5	1.167	129.6	3.5	2.0
					129.6	3.5	1.167	129.6	3.5	0.0

Regulator Modification

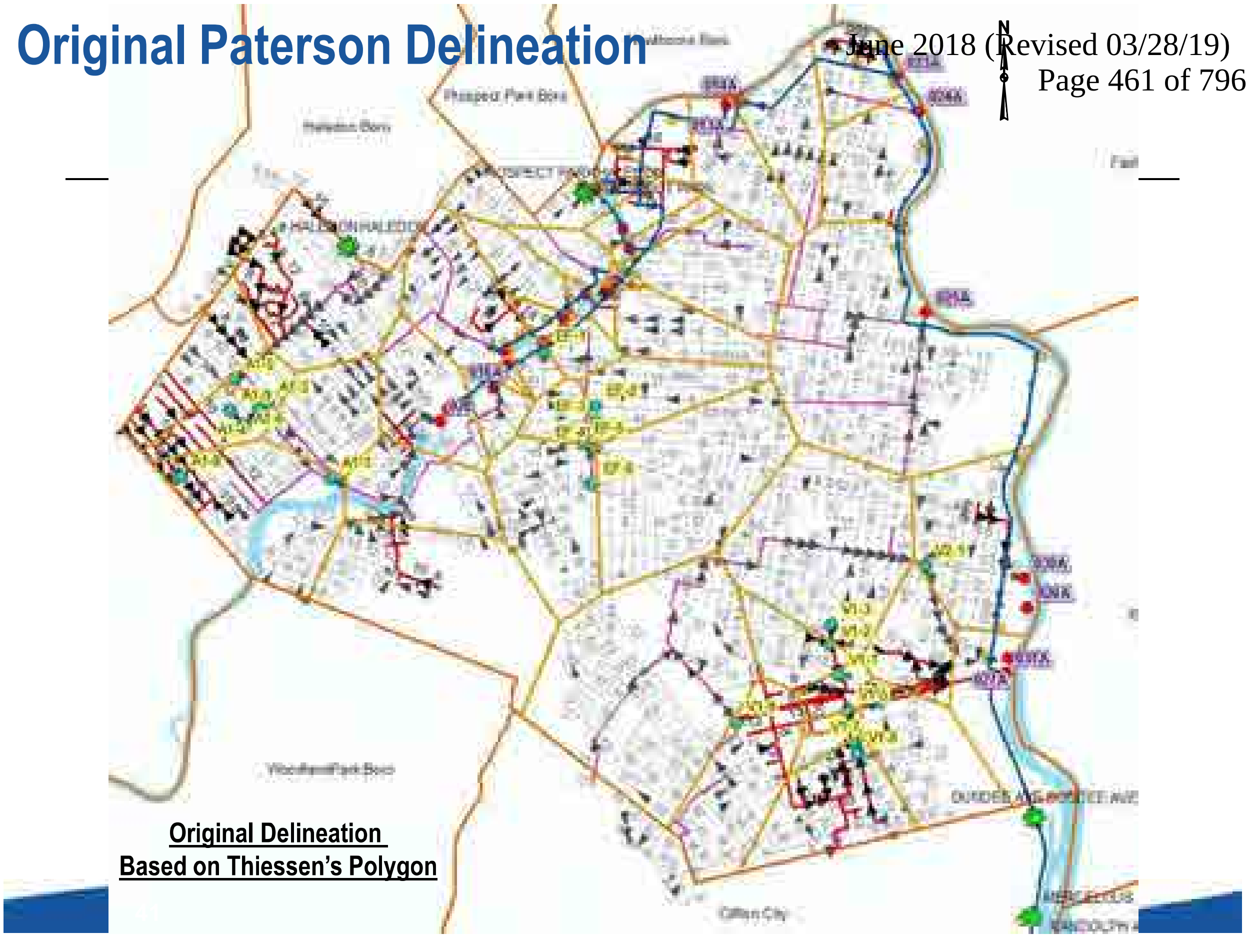
Regulator	Overflow Weir				Regulating Sluice Gate / Orifice					
	Drawing		Original Model		Drawing			Original Model		
	Crest	Width	Crest	Width	Invert	Width	Height	Invert	Width	Height
N-002A (modified, Verona)	110.43	41	103	6	102.65	2.5	2.5	99.33	2	2
N-004A/005A (modified, Herbert Pl.)	114.34	41	105.55	6.667	107.06	2	2	103.6	1.5	1.5
N-008A	103.5	6	103.5	6	100.7	1.5	1.5	100.7	1.5	1.5
N-009A	103.24	4	103.24	4	102.4	1.66	0.83	102.4	1.66	0.83
N-010A	105.12	8.42	105.12	8.42	101.24	6	3	101.24	6	3
	105.12	8.42	105.12	8.42	101.24	6	3	101.24	6	3
	105.12	8.42	105.12	8.42						
N-014A (modified, Rector)	102.56	5.5	103.66	5.5	99.97	1.5	1.5	101.07	1.5	1.5
N-014A (modified, Saybrook)	102.33	7	103.43	7	99.02	2	2	100.12	2	2
N-015A (modified)	98.67	14	98.67	14	95.67	3.5	2.5	95.67	3.5	2.5
N-016A	97.62	7	97.62	4.5	96	1.5	1.5	96	1.33	1.33
N-017A	97.8	8	97.8	7	95.2	1.5	1.5	95.35	1.33	1.33
N-018A	100.26	4	100.26	4	99	2	2	99	2	2
N-022A	98.93	6	98.93	6						
N-027A/029A	102	4.5	102	4.5	96.4	4	2.33	96.4	4	2.33
N-025A	98.6+	6	98.6	8	93	4	2.33	93	4	2.33
	98.6+	8	98.6	8						
	105.85	5	98.6	8						
	105.85	5	98.6	8						
N-030A	102.32	10	102.32	10	99.04	4	3	99.04	4	3
N-023A	98.54	7	98.54	7						

Regulator Modification

Regulator	Overflow Weir				Regulating Sluice Gate / Orifice					
	Drawing		Original Model		Drawing			Original Model		
	Crest	Width	Crest	Width	Invert	Width	Height	Invert	Width	Height
K-001A	120.85	4.5	120.27	1.5	119.07	1		119	1	
K-004A	107.9	1.5	108	1.5	106.9	1		107	1	
K-006A	99.9	5	100.9	10	98.7	1.5		98.2	1.5	
	100.1	5								
K-007A	103	9	103	9	100.2	3	1	100.2	3	1
K-010A	102.5	4	102.5	4.5	98.84	1	1	100.45	1	
E-001A	101.6	4	101.6	4	99.2	1.25		99.2	1.25	
H-001A	101.2	4	101.2	4	99.8	1.25		99.8	1	
H-002A	102.2	4	102.2	4	101	1		101.2	1	
H-003A	103.9	4	103.9	4	101.4	1.25		101.4	1.25	
H-004A	102.2	4	102.2	3.5	100.58	1		100.58	1	
H-005A	100.8	3.5	100.8	3.5	99.1	1		99.1	1	
H-006A	99.9	4	99.9	4	97.9	1		97.9	1	
H-007A	102.4	4.5	102.4	4.5	101.2	1		101.2	1	

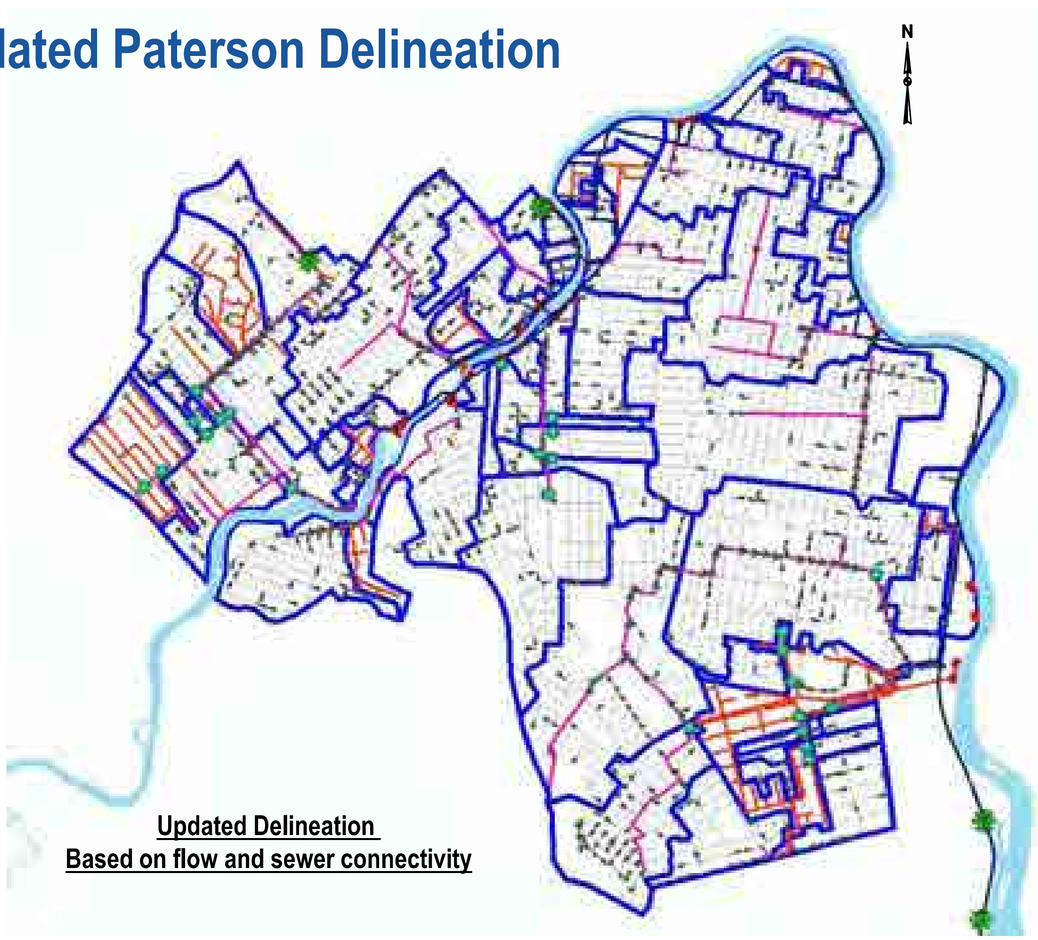
Paterson Update

Original Paterson Delineation



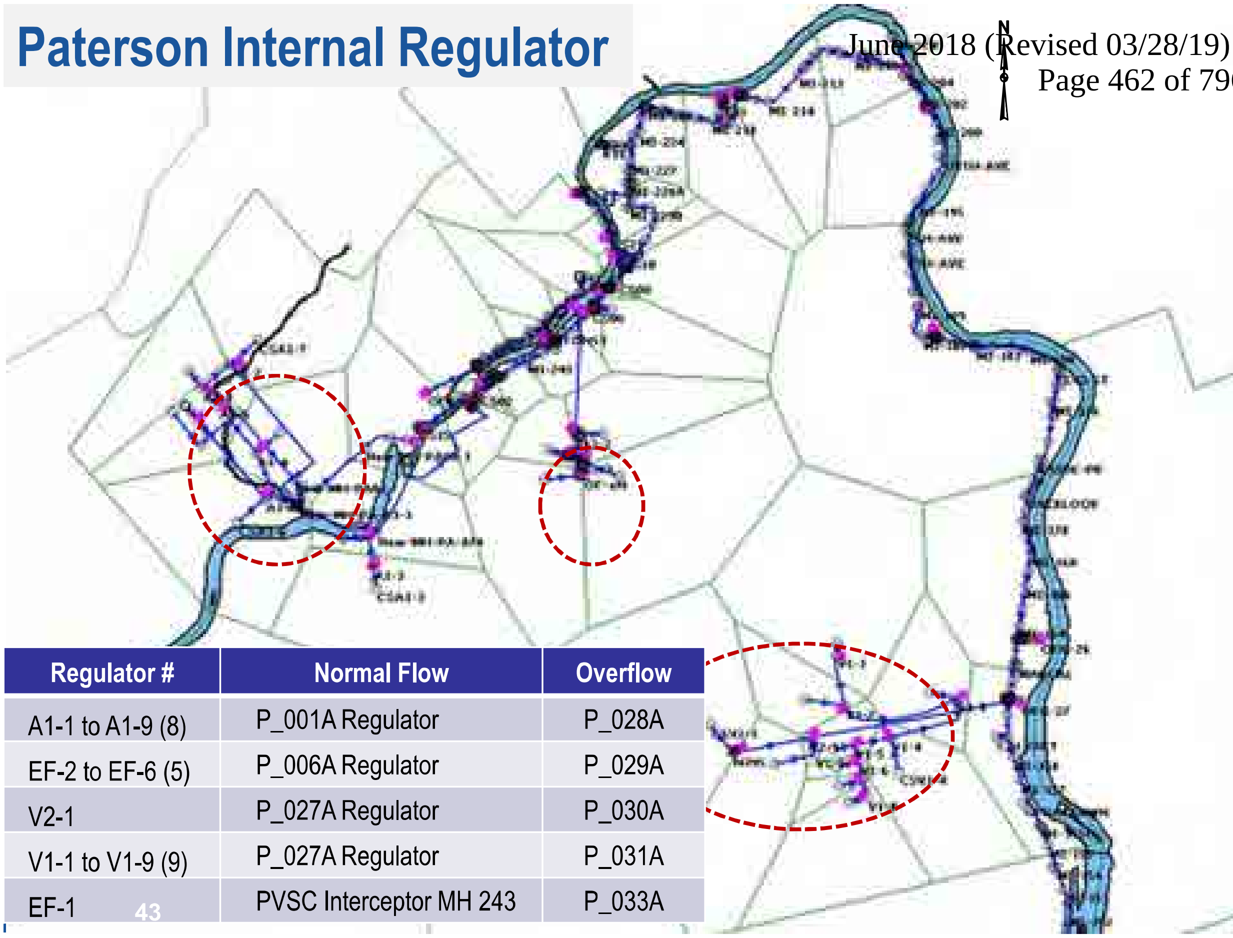
Original Delineation
Based on Thiessen's Polygon

Updated Paterson Delineation



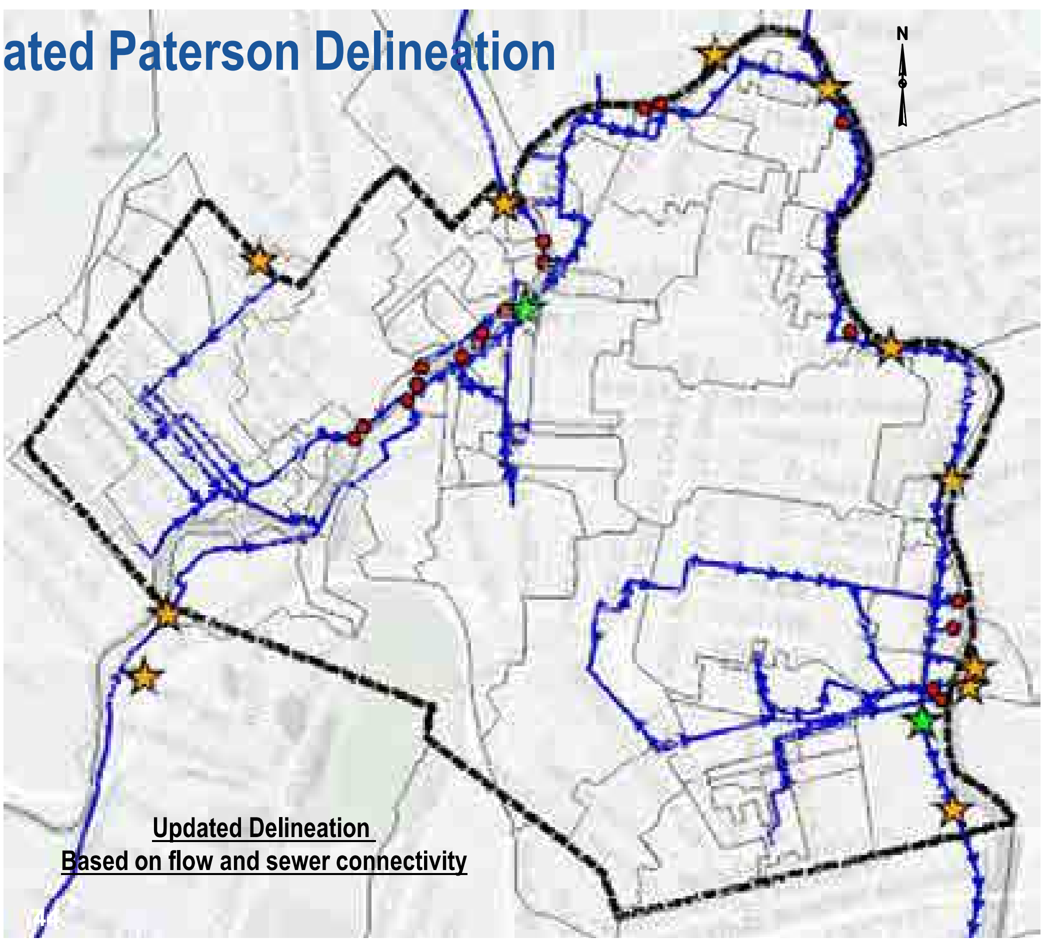
Updated Delineation
Based on flow and sewer connectivity

Paterson Internal Regulator



Regulator #	Normal Flow	Overflow
A1-1 to A1-9 (8)	P_001A Regulator	P_028A
EF-2 to EF-6 (5)	P_006A Regulator	P_029A
V2-1	P_027A Regulator	P_030A
V1-1 to V1-9 (9)	P_027A Regulator	P_031A
EF-1	PVSC Interceptor MH 243	P_033A

Updated Paterson Delineation



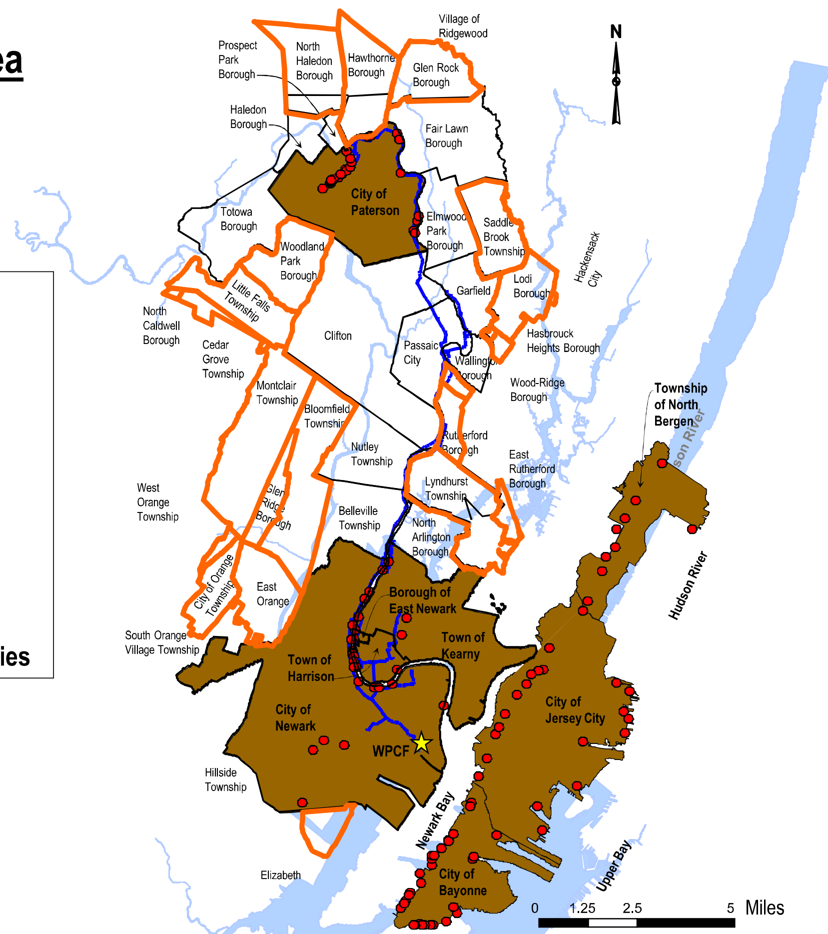
GREELEY AND HANSEN

Separated Service Area

Separated Service Area Added to the Model

Legend

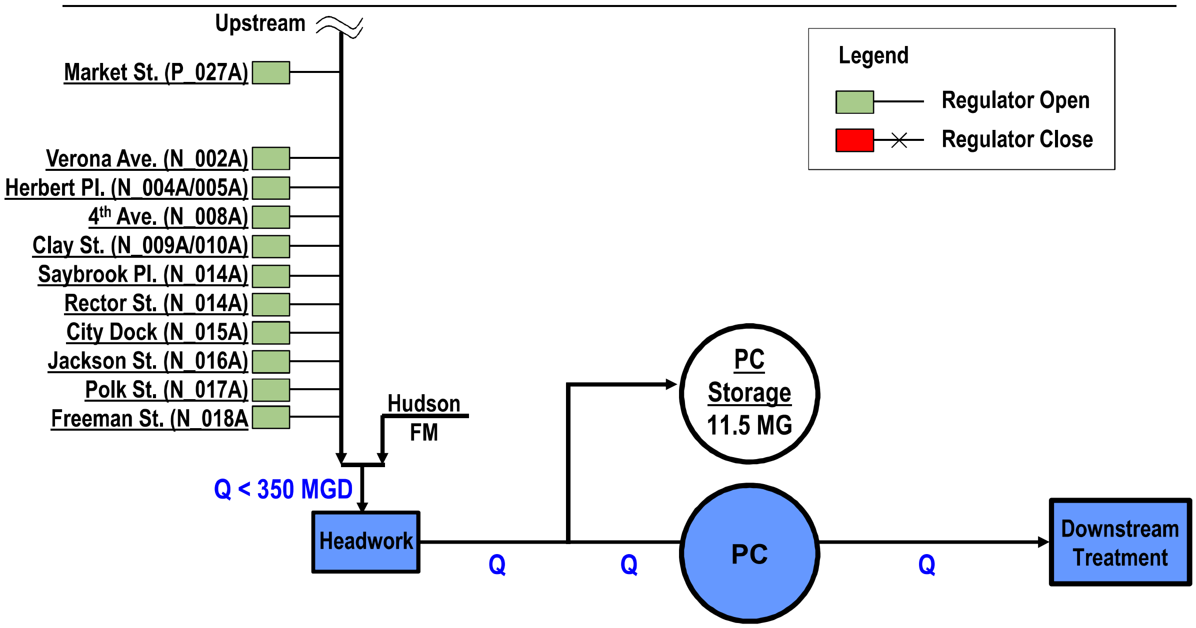
- PVSC Service Area
- CSO Communities
- Separated Communities
- PVSC WPCF (Water Pollution Control Facility)
- PVSC Interceptor / Sewer
- CSO Outfall
- **Added Separated Communities**



Wet Weather Operating Rules

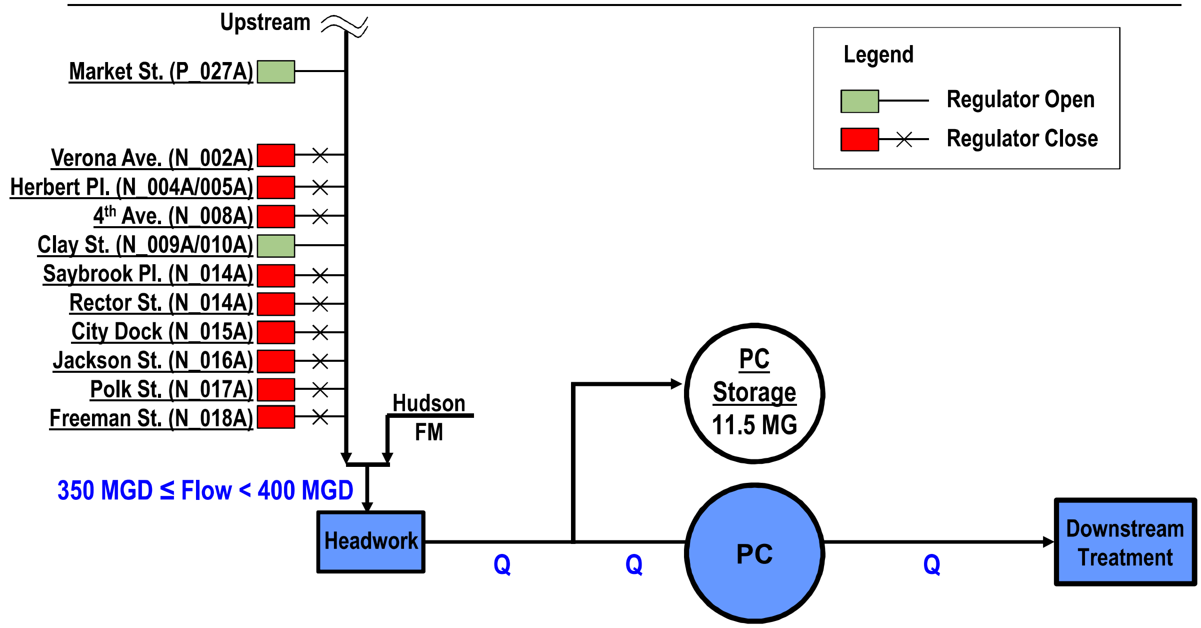
Wet Weather SOP

Flow < 350 MGD



Wet Weather SOP

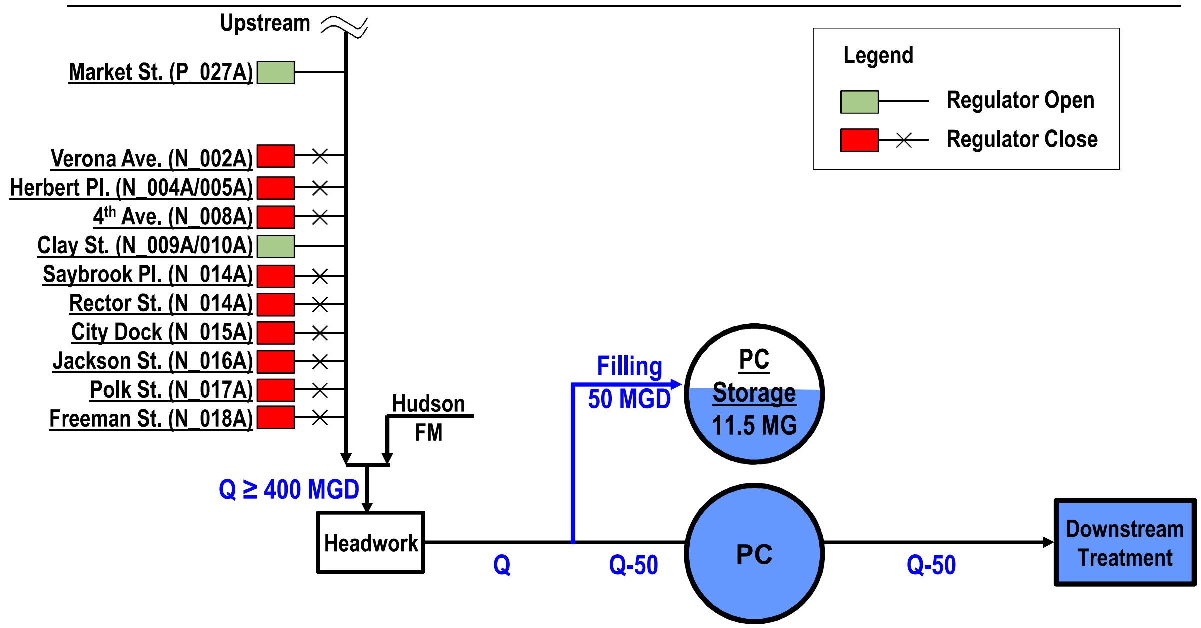
350 MGD ≤ Flow < 400 MGD



Note: During 10/7/15 to 7/7/16, CSOs were put in use at plant flow 400 MGD.

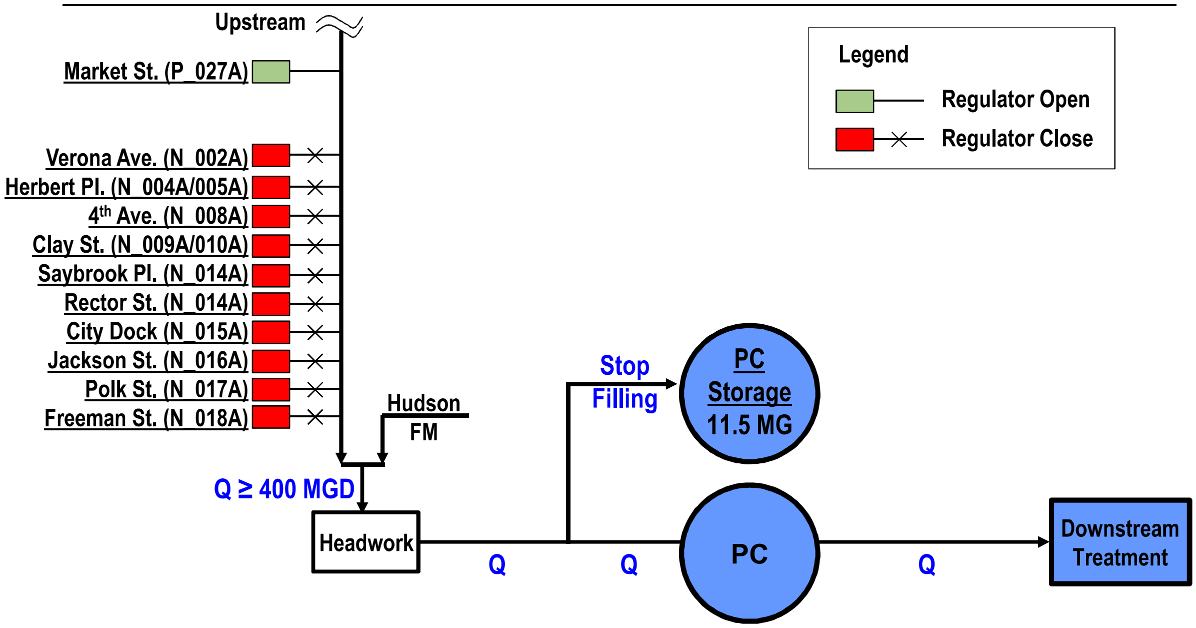
Wet Weather SOP

Flow ≥ 400 MGD



Wet Weather SOP

Flow ≥ 400 MGD, & Storage Full



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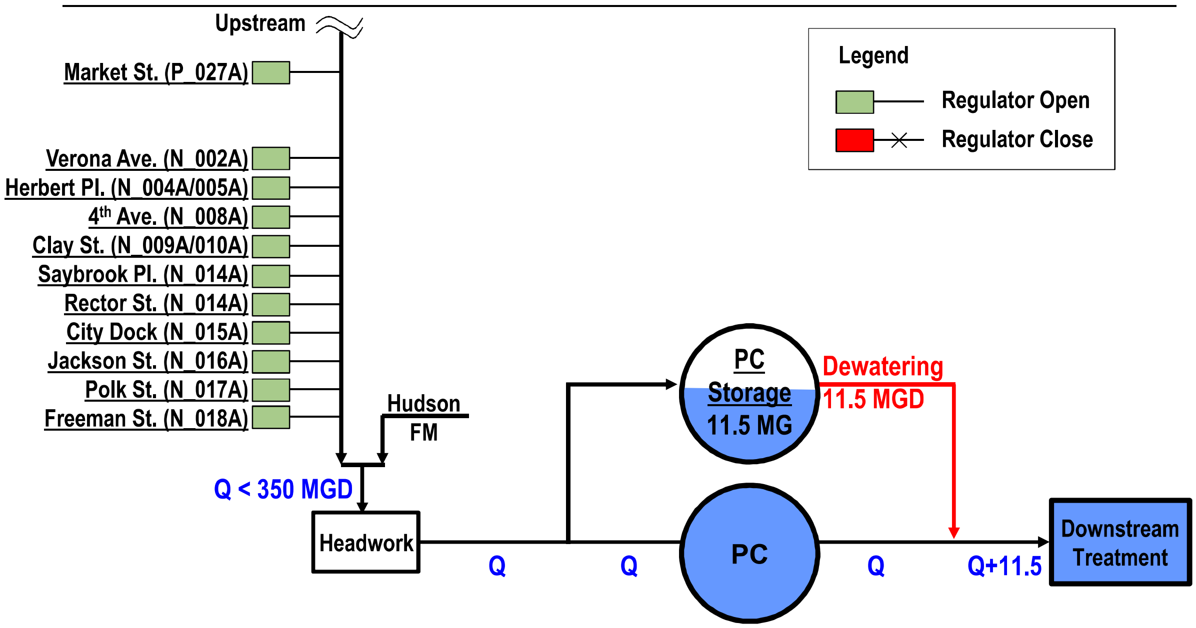
Wet Weather SOP

Flow Drops to 350 MGD



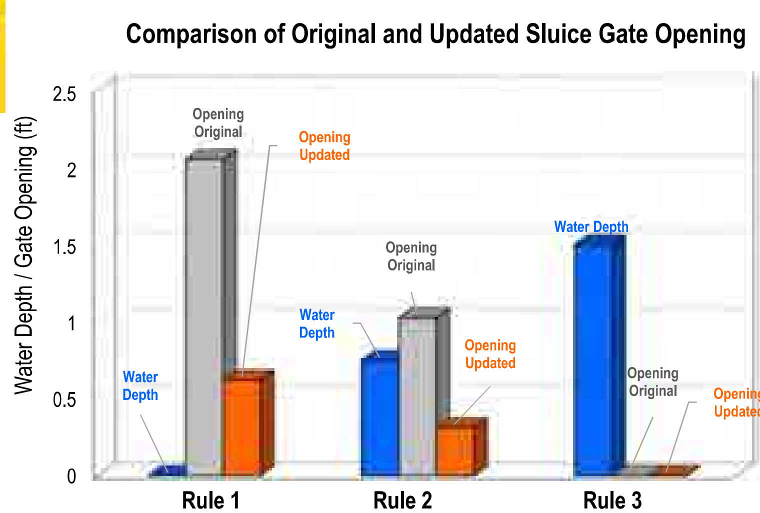
GREELEY AND HANSEN

Bayonne Real Time Control Rule Update

एक फुट = 0.3048 मीटर
एक मीटर = 3.28 फुट

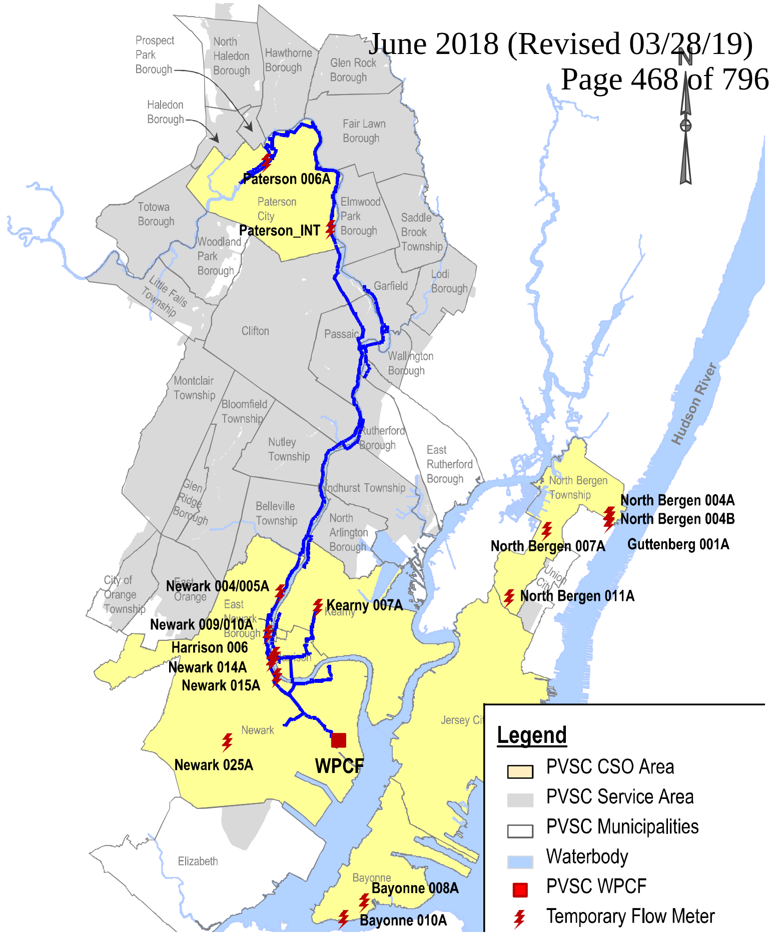
Original RTC Closing Table		
	Input ft	Output
Rule 1	0	0.625
Rule 2	0.751	0.313
Rule 3	1.499	0

Updated RTC Closing Table		
	Input ft	Output
Rule 1	0	0.190
Rule 2	0.751	0.095
Rule 3	1.499	0



PVSC H&H Model Calibration and Validation

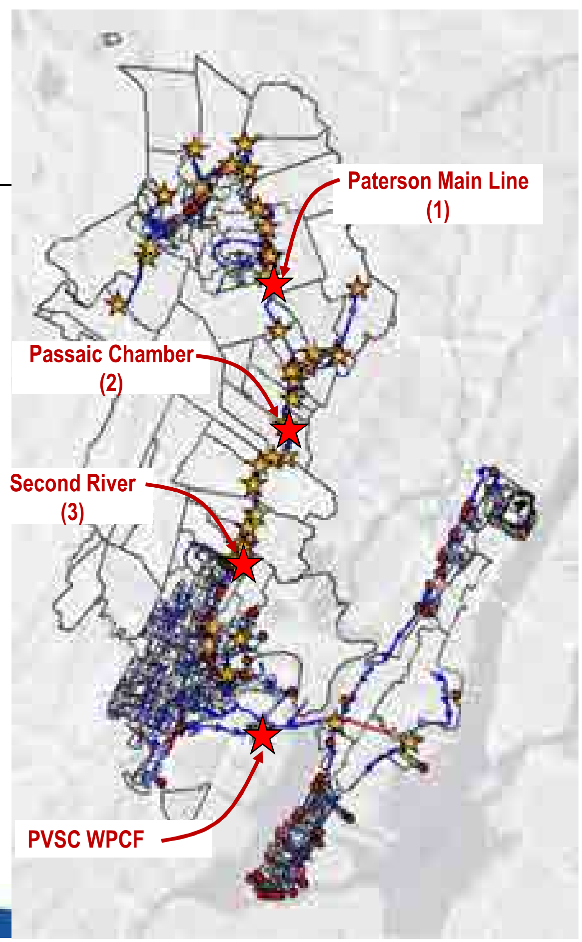
Temporary Flow Meter



21 Flow Meters

- 13 outfall pipe
- 5 regulator influent
- 2 regulator effluent
- 1 interceptor

PVSC Permanent Flow Meters



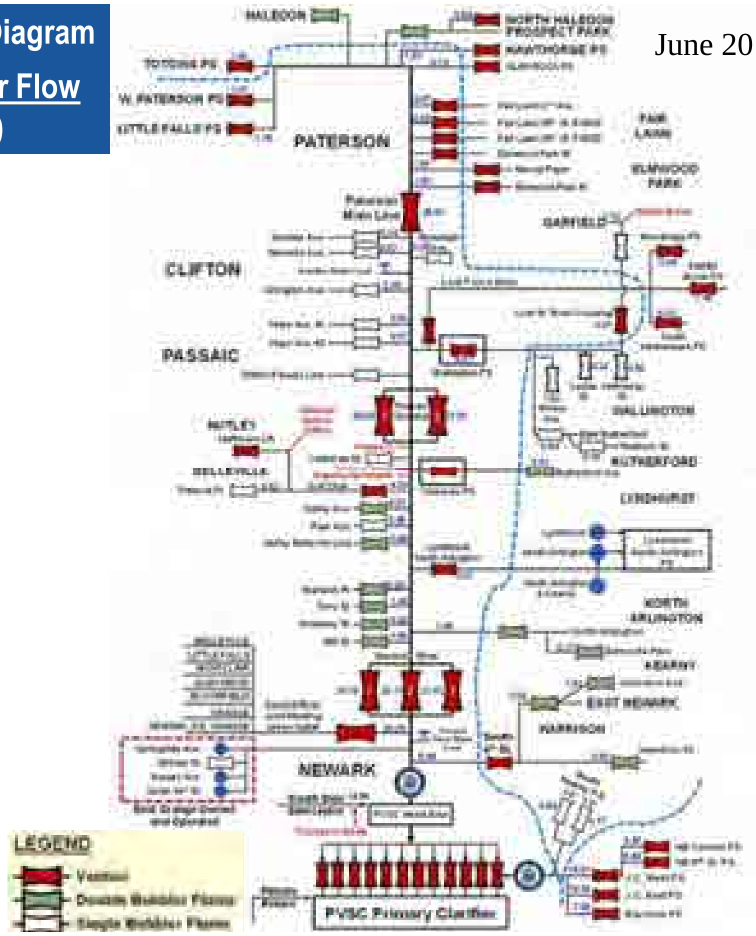
Over 70 Flow Meters, 55 was analyzed for DWF and model calibration

- PVSC Interceptor: 6
- Pump Station: 6
- Combined area: 5
- Separated Area: 38

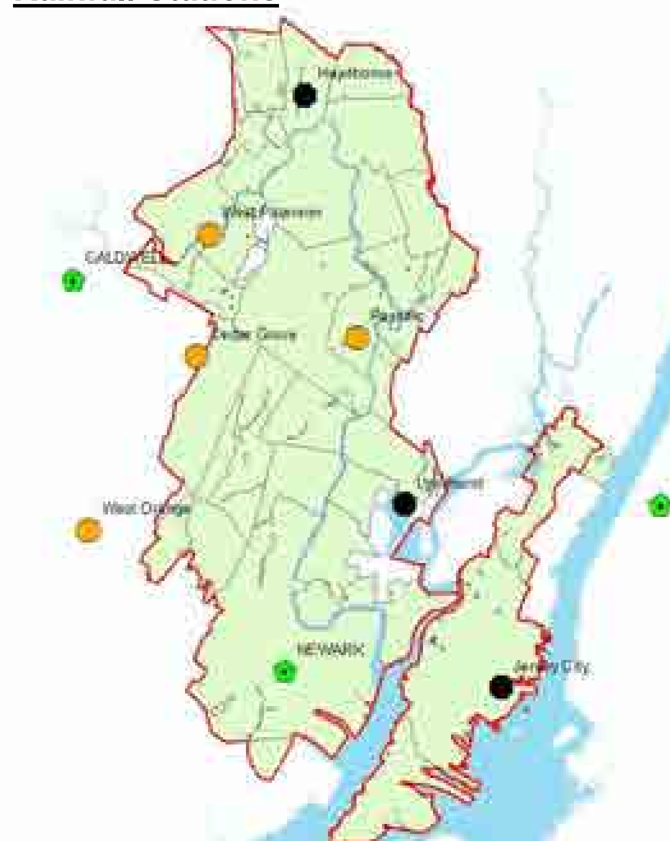
Flow Meter Diagram

Dry Weather Flow

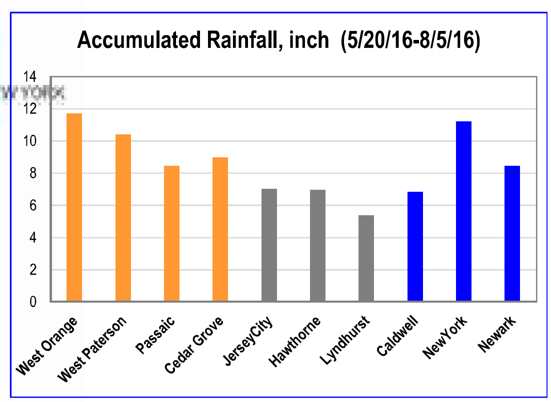
(MGD)



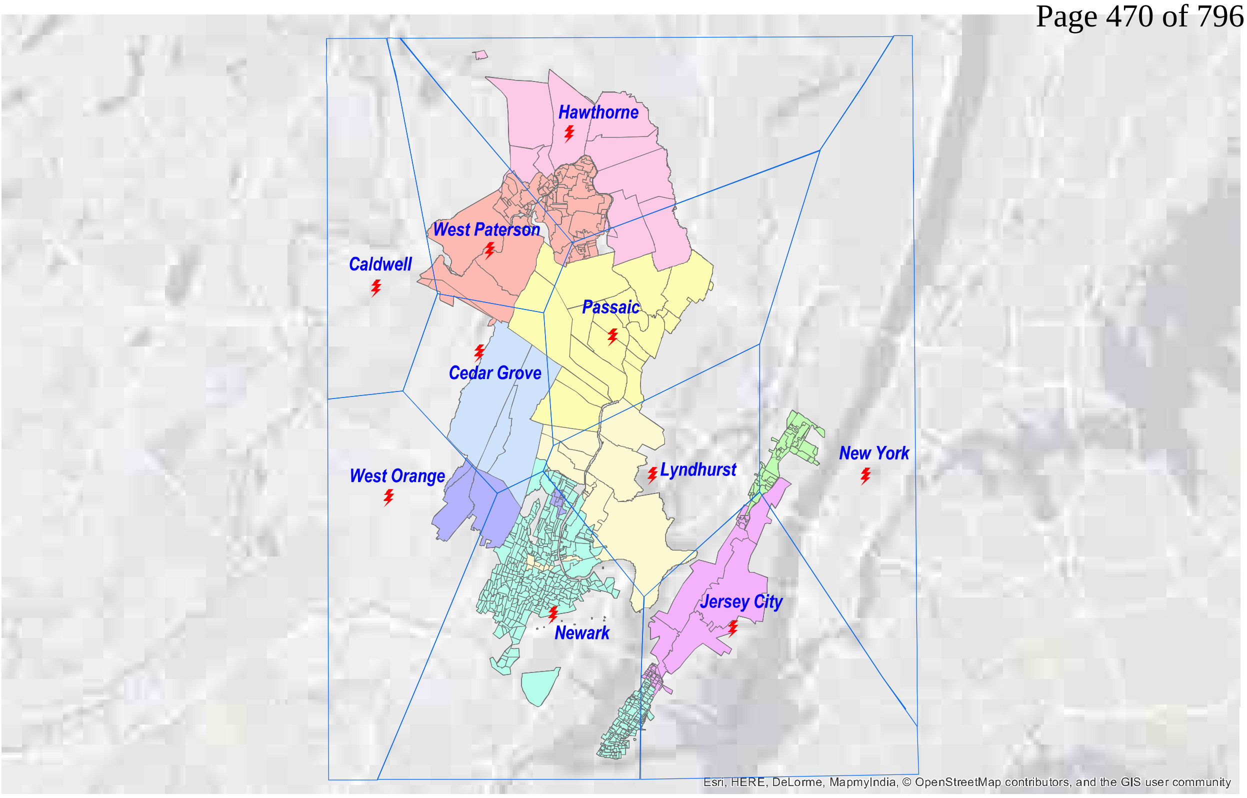
Rainfall Stations



Rain Gauge Summary			
Source	RG ID	Data Time Interval (Min.)	Total Rainfall (5/20/16-8/05/16)
NJ Weather	Hawthorne	5	6.97
NJ Weather	Lyndhurst	5	5.39
NJ Weather	jersey City	5	7.04
CWOP	West Paterson	30	10.4
CWOP	Passaic	15	8.46
CWOP	Cedar Grove	10-50	8.98
CWOP	West Orange	10	11.72
NWS ASOS	Caldwell	1	6.84
NWS ASOS	New York	1	11.23
NWS ASOS	Newark	1	8.47



Rainfall Station Assignment



Candidate Storm Events for Calibration

Rainfall Based on Newark

Rain Start	Rain End	Duration (hr)	Depth (in)	Max Intensity (in/hr)	Average Intensity (in/hr)
7/25/16 16:05	7/25/16 18:50	2.75	**1.81**	1.68	0.66
5/29/16 23:50	5/30/16 5:20	5.50	**1.6**	1.09	0.29
7/29/16 0:20	7/29/16 8:35	8.25	**0.85**	0.42	0.10
5/2/16 22:40	5/3/16 9:50	11.17	**0.7**	0.17	0.06
7/31/16 8:35	7/31/16 22:35	14.00	**0.69**	0.49	0.05
7/4/16 19:20	7/5/16 2:50	7.50	**0.63**	0.23	0.08
5/6/16 2:30	5/6/16 12:25	9.92	**0.6**	0.19	0.06
7/16/16 14:50	7/16/16 15:35	0.75	**0.56**	0.75	0.75
6/8/16 11:25	6/8/16 14:10	2.75	**0.49**	0.3	0.18
7/9/16 21:30	7/9/16 22:05	0.58	**0.48**	0.82	0.82
4/4/16 7:45	4/4/16 17:00	9.25	**0.43**	0.12	0.05

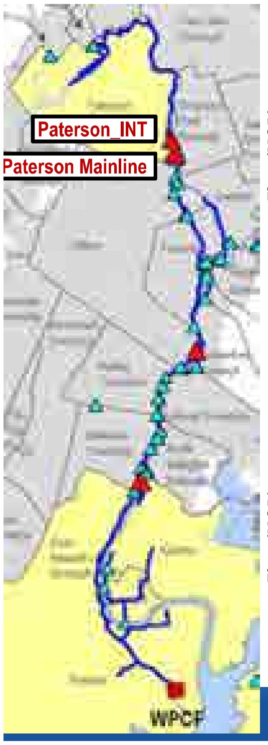
GREELEY AND HANSEN

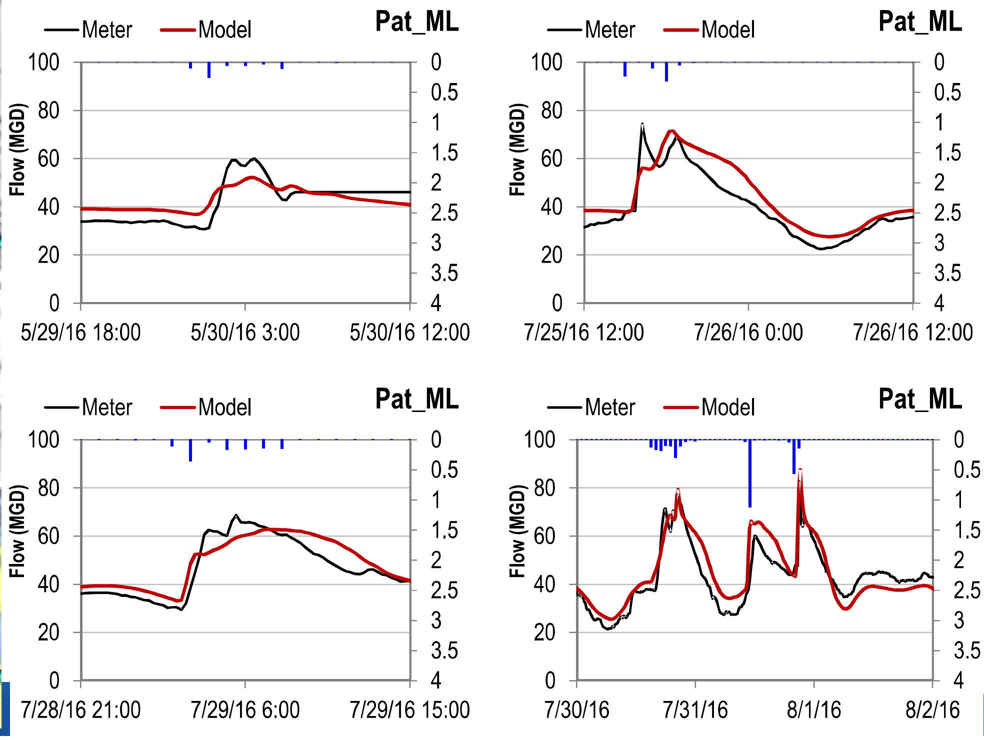
Model Calibration and Validation Goals

- Visual match
- +/- 20% volume and
- +25%/-15% peak

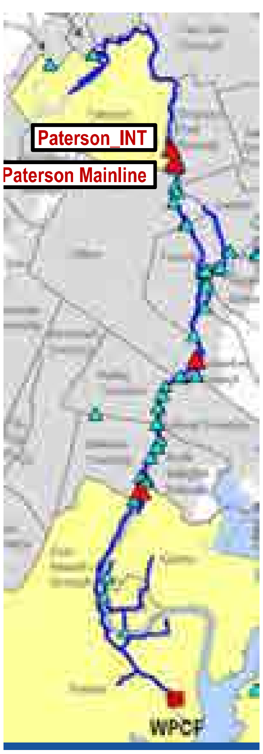
Major Interceptor

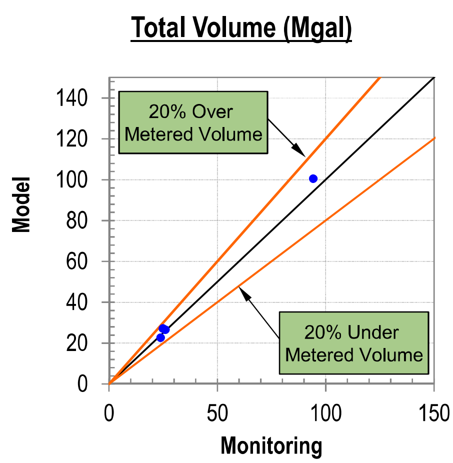
Calibration Results – Main Interceptor
Paterson Main Line

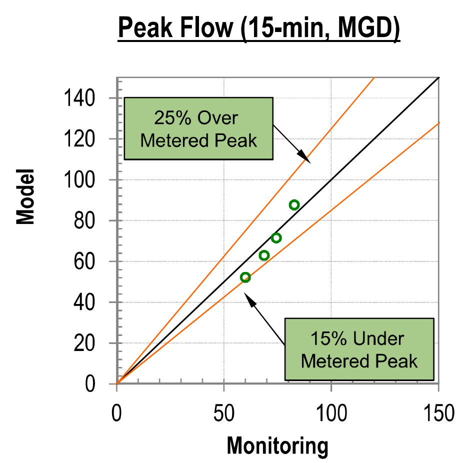




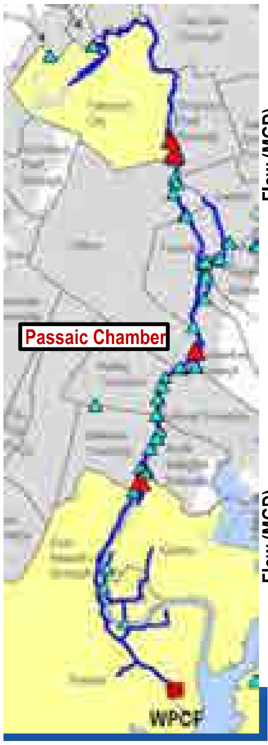
Calibration Results – Main Interceptor
Paterson Main Line: Goodness-of-Fit

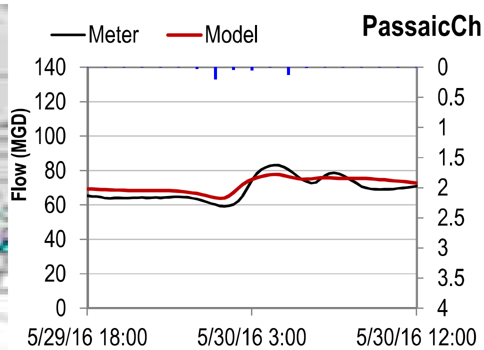


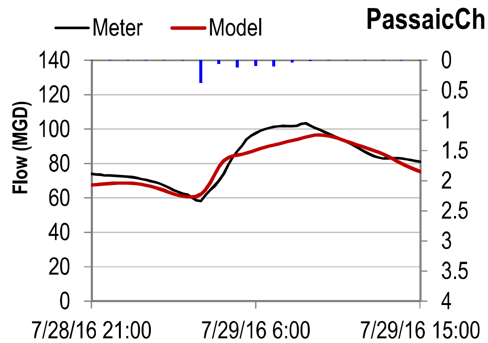


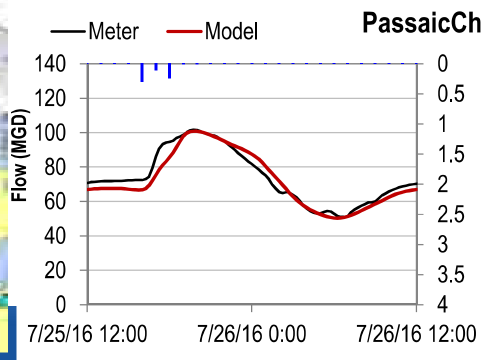


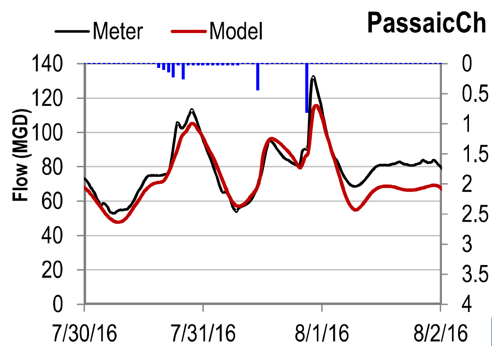
Calibration Results – Main Interceptor
Passaic Chamber



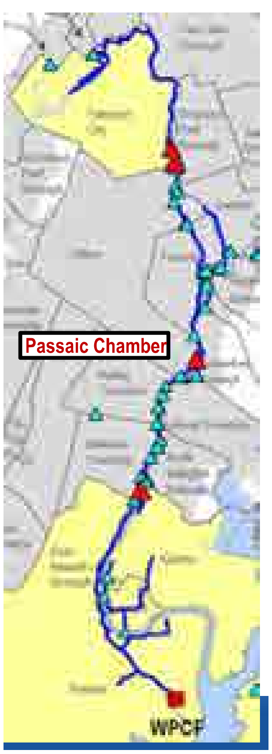


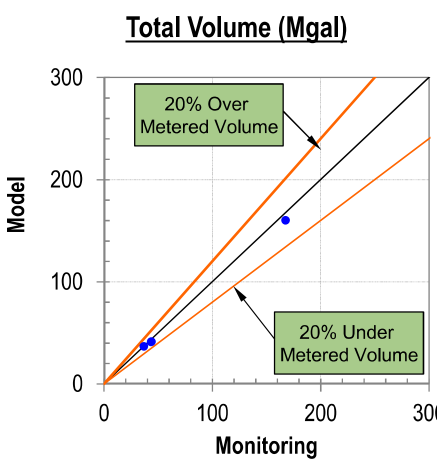


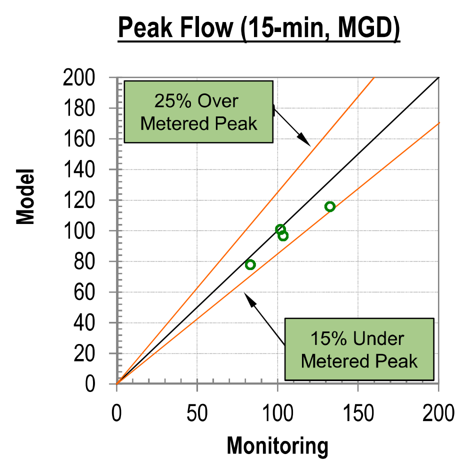




Calibration Results – Main Interceptor
Passaic Chamber: Goodness-of-Fit

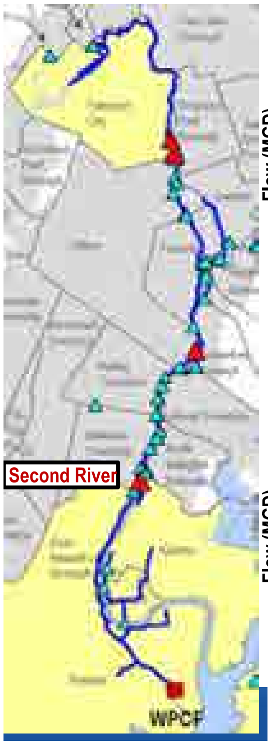


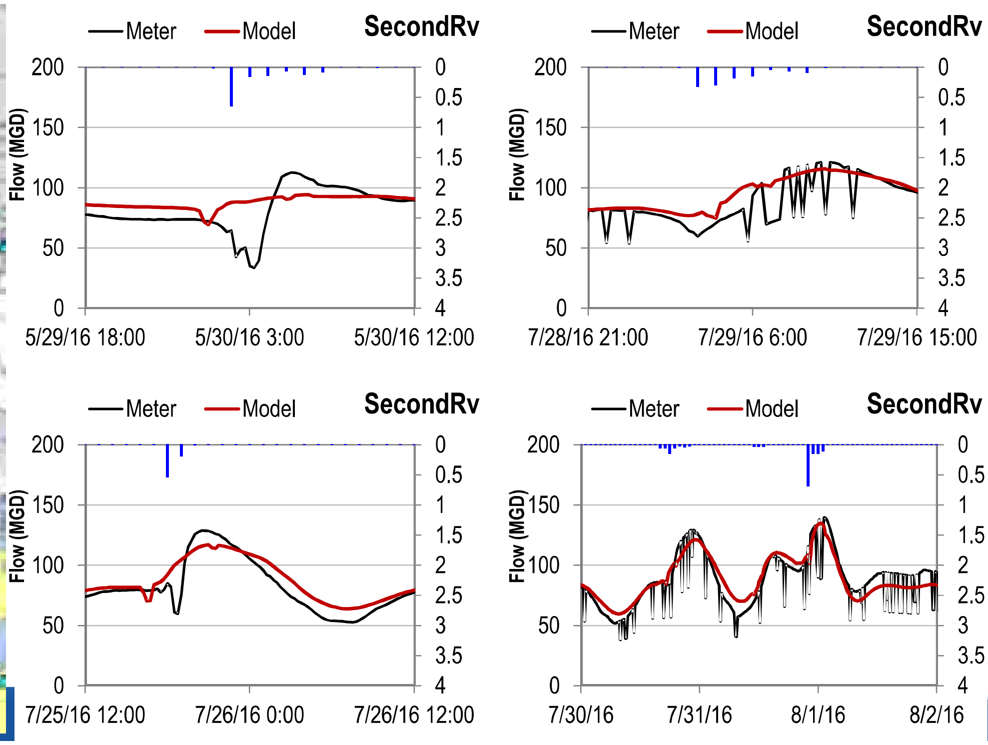




Calibration Results – Main Interceptor

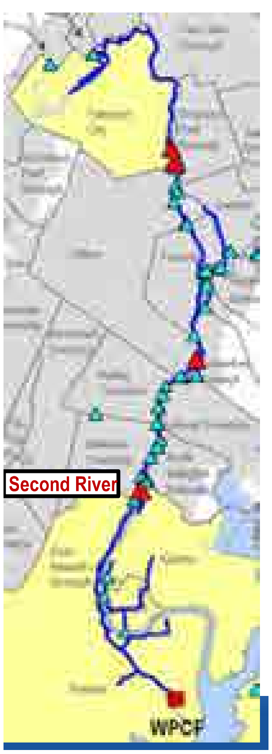
Second River Crossing

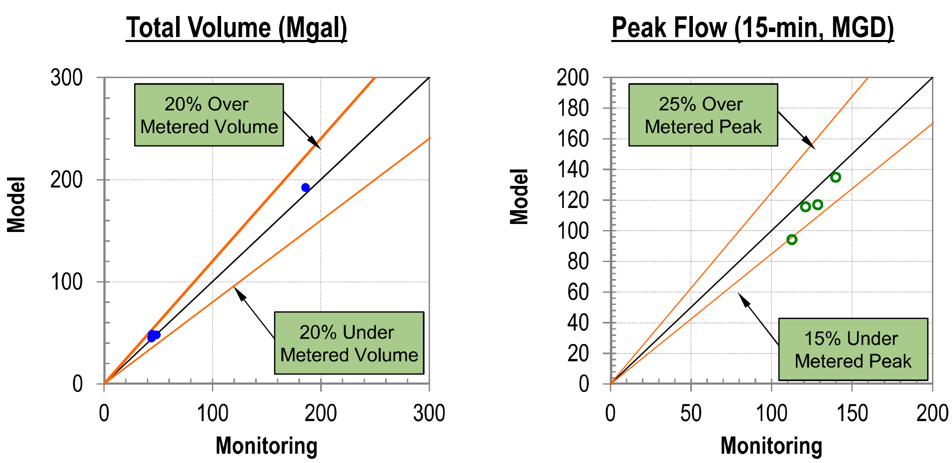




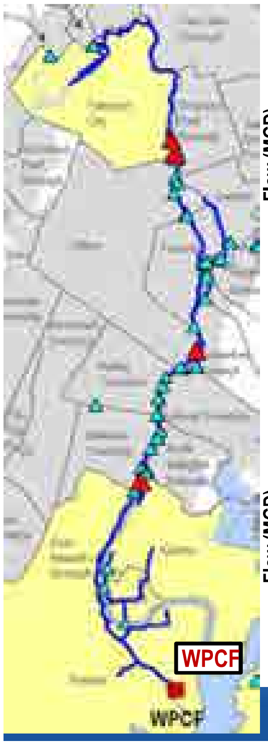
Calibration Results – Main Interceptor

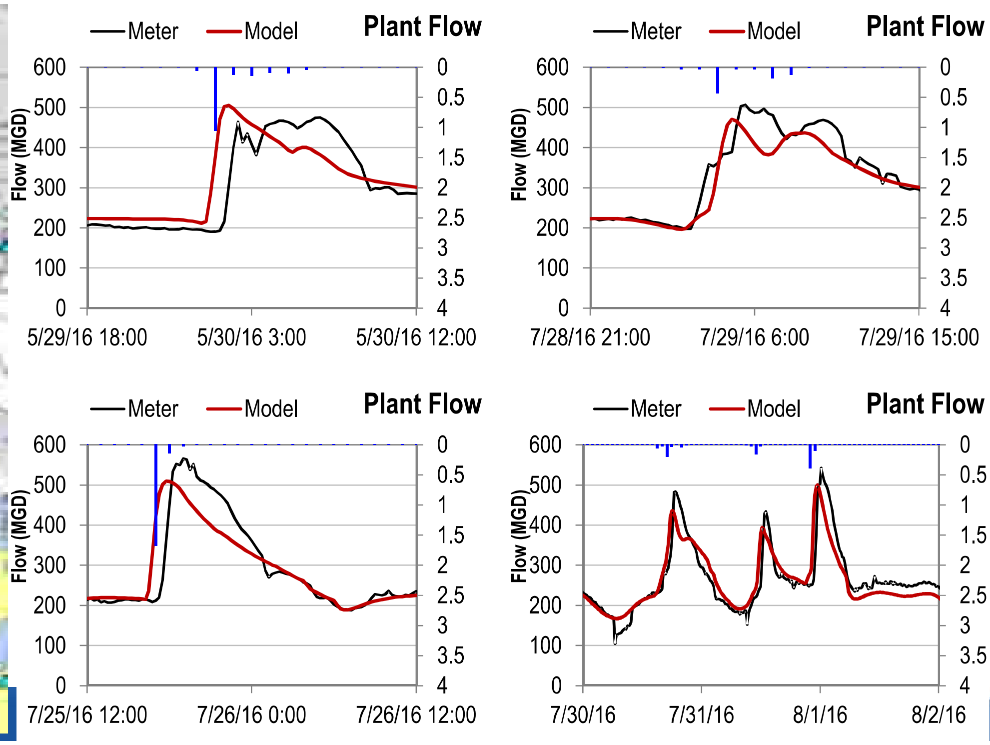
Second River Crossing: Goodness-of-Fit



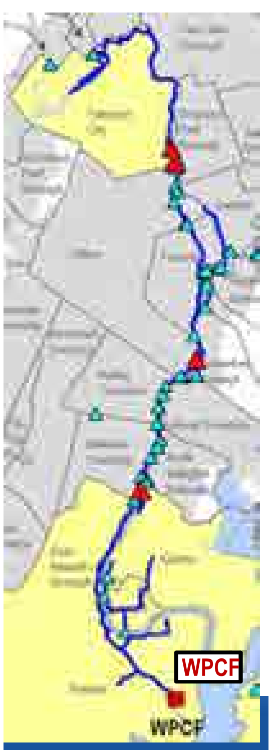


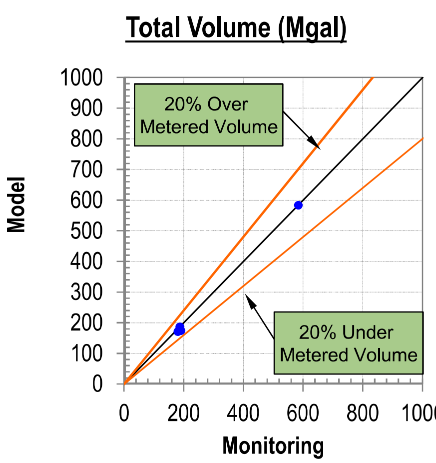
Calibration Results – Main Interceptor
PVSC WPCF

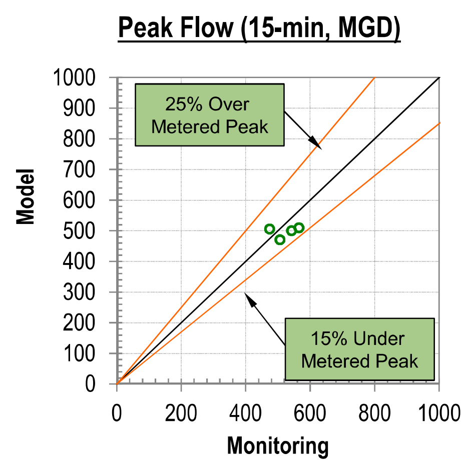




Calibration Results – Main Interceptor
PVSC WPCF: Goodness-of-Fit

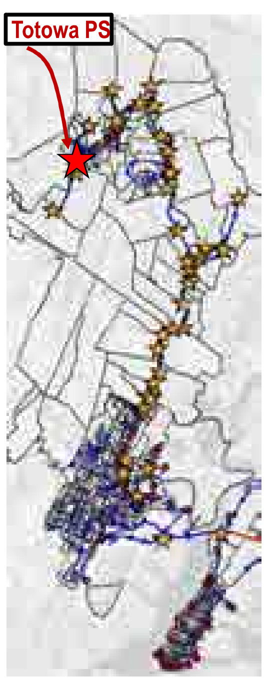


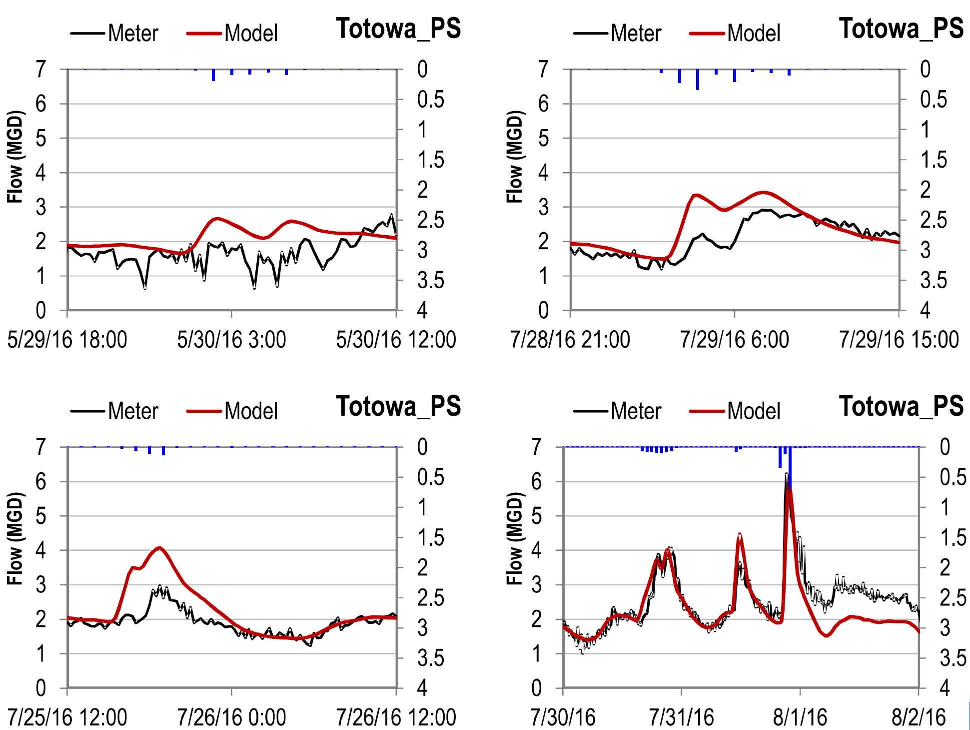




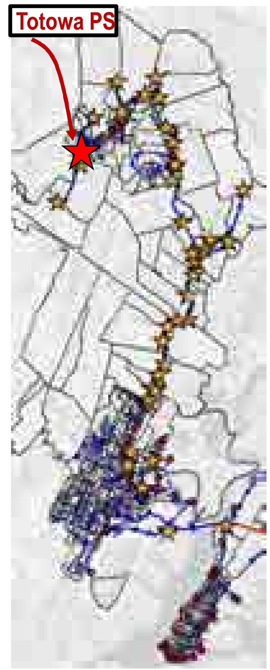
Separated Area

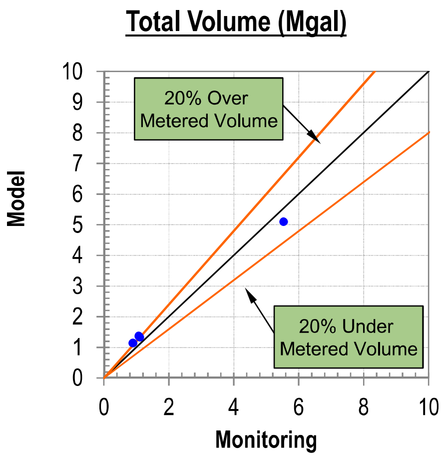
Calibration Results – Separated Area
Totowa PS

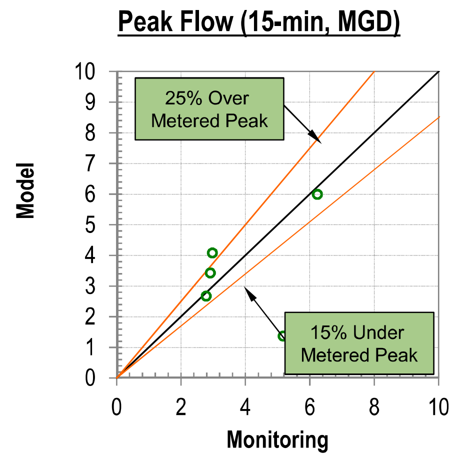




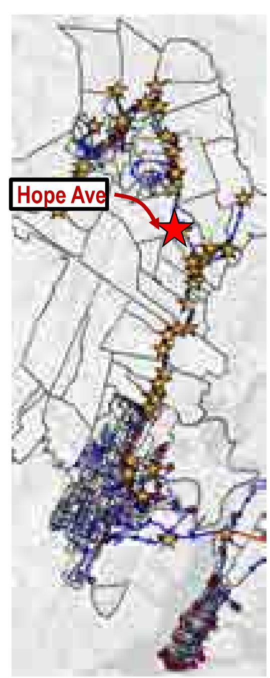
Calibration Results – Separated Area
Totowa PS: Goodness-of-Fit

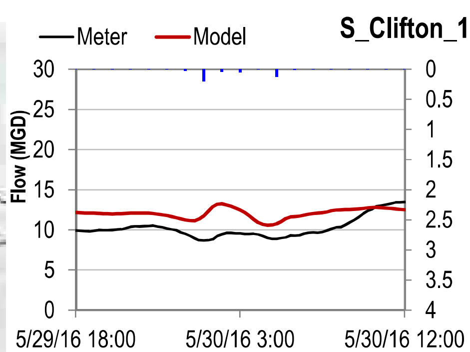


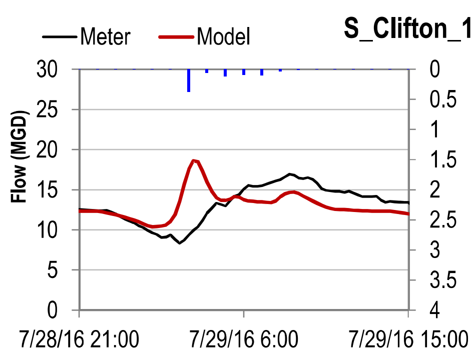


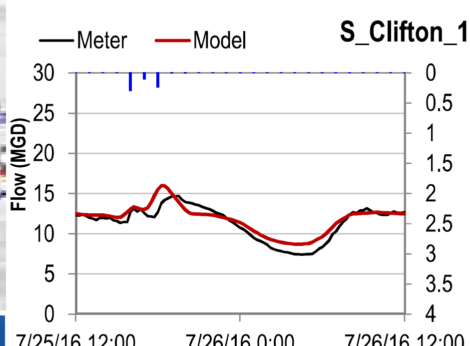


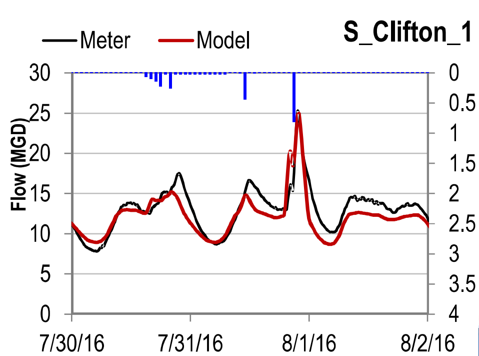
Calibration Results – Separated Area
Hope Ave





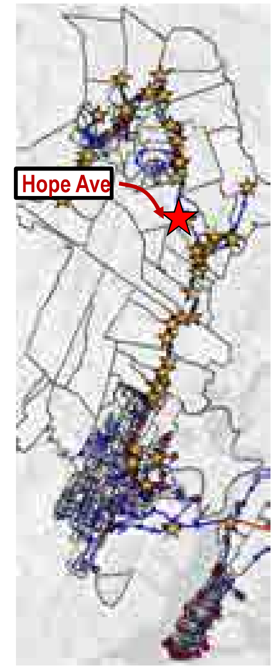


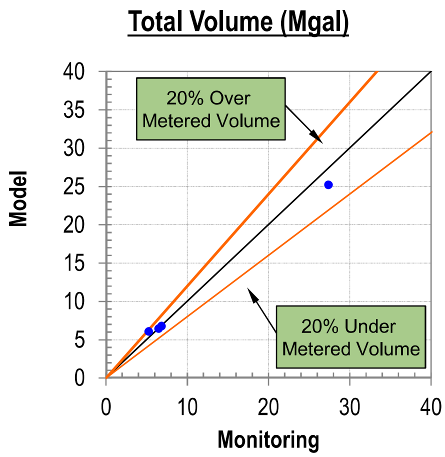


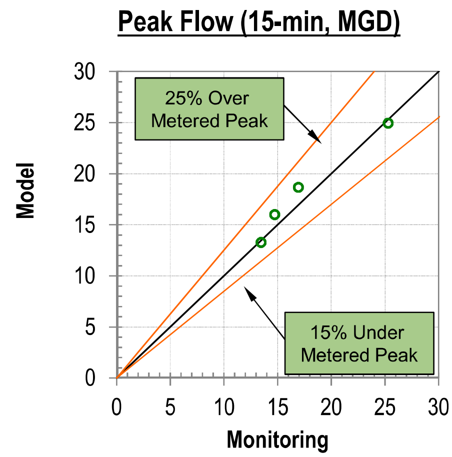


Calibration Results – Separated Area

Hope Ave: Goodness-of-Fit

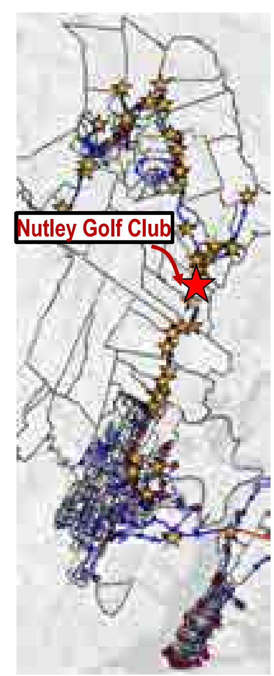


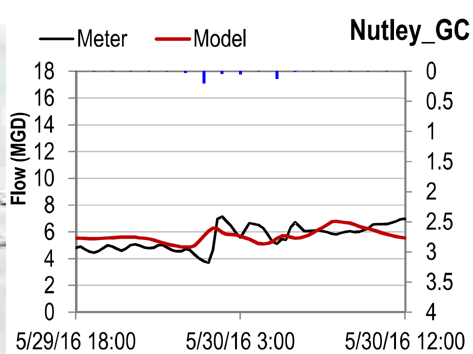


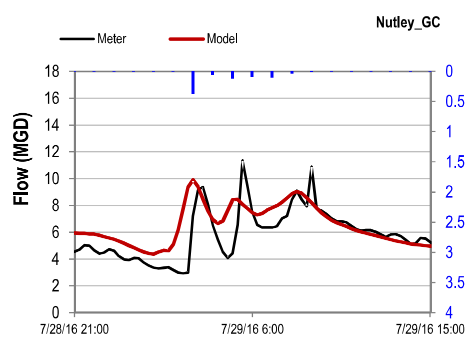


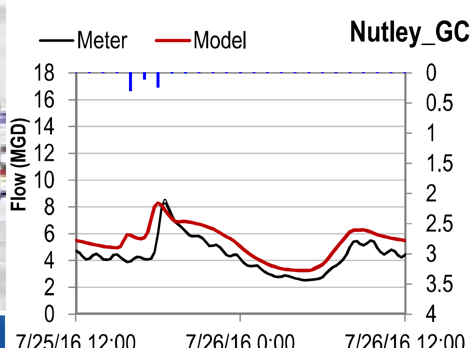
Calibration Results – Separated Area

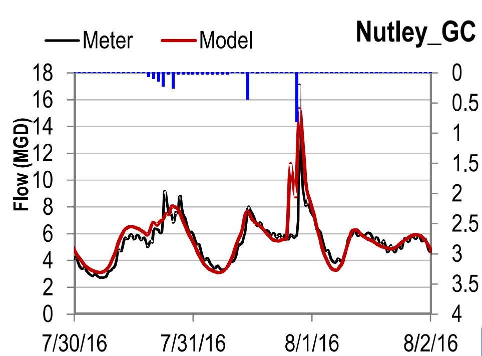
Nutley Golf Club



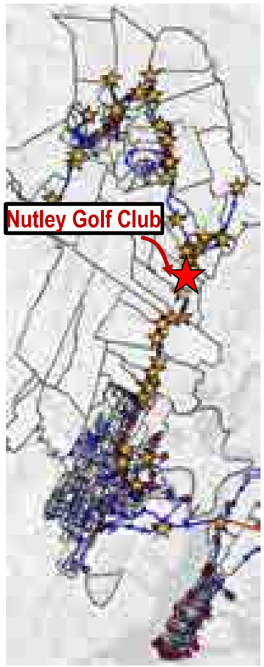


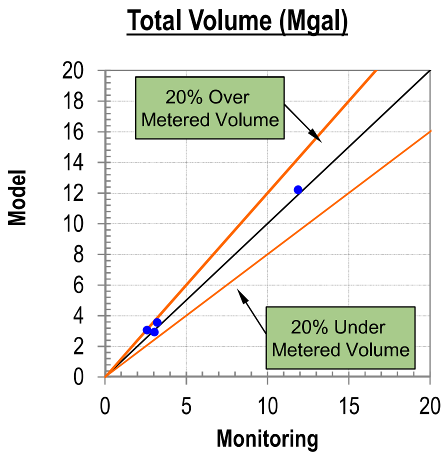


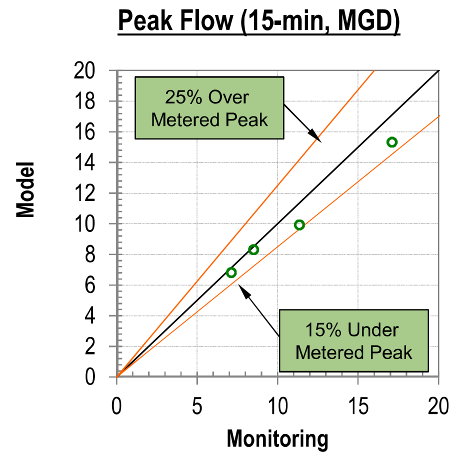




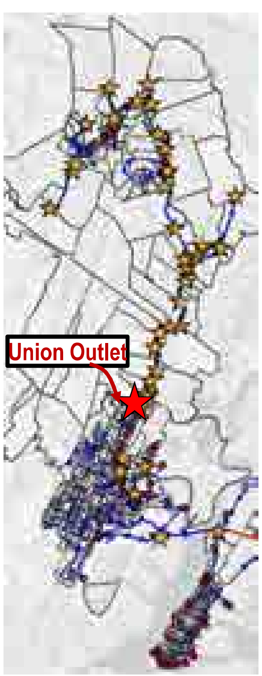
Calibration Results – Separated Area
Nutley Golf Club: Goodness-of-Fit

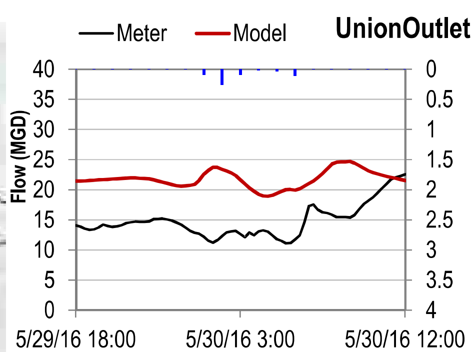


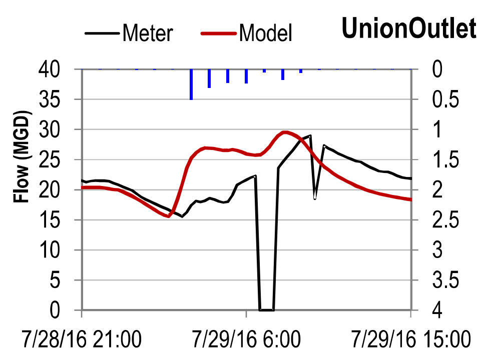


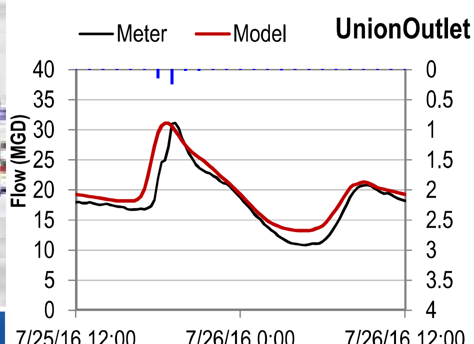


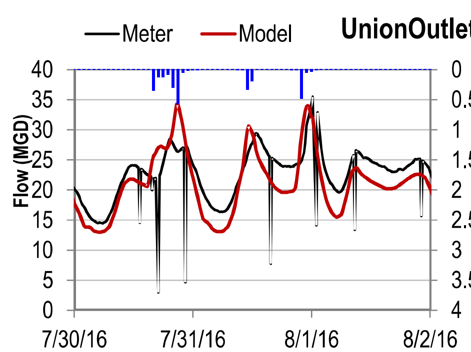
Calibration Results – Separated Area
Union Outlet



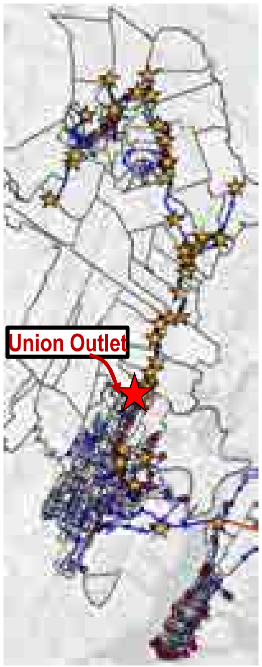


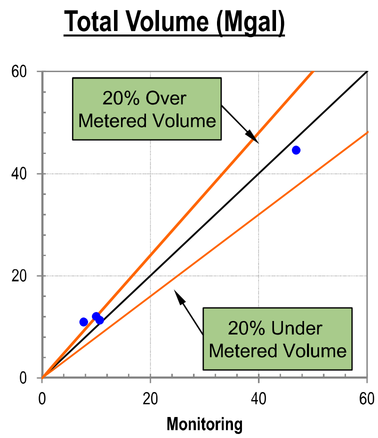


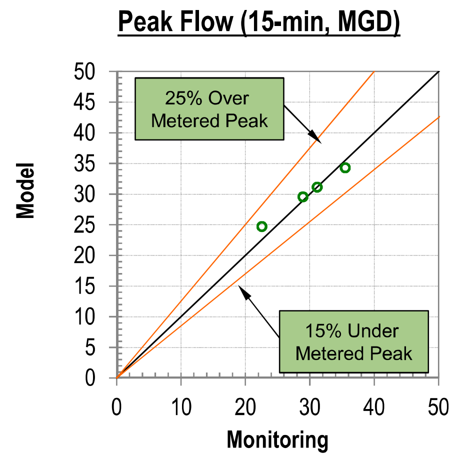




Calibration Results – Separated Area
Union Outlet





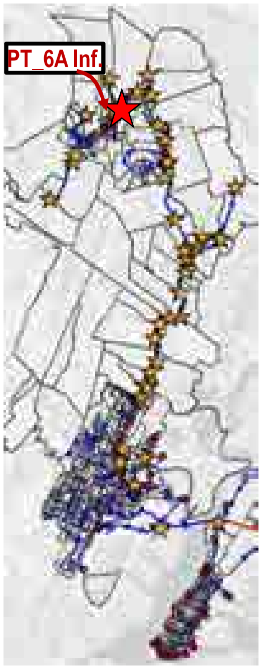


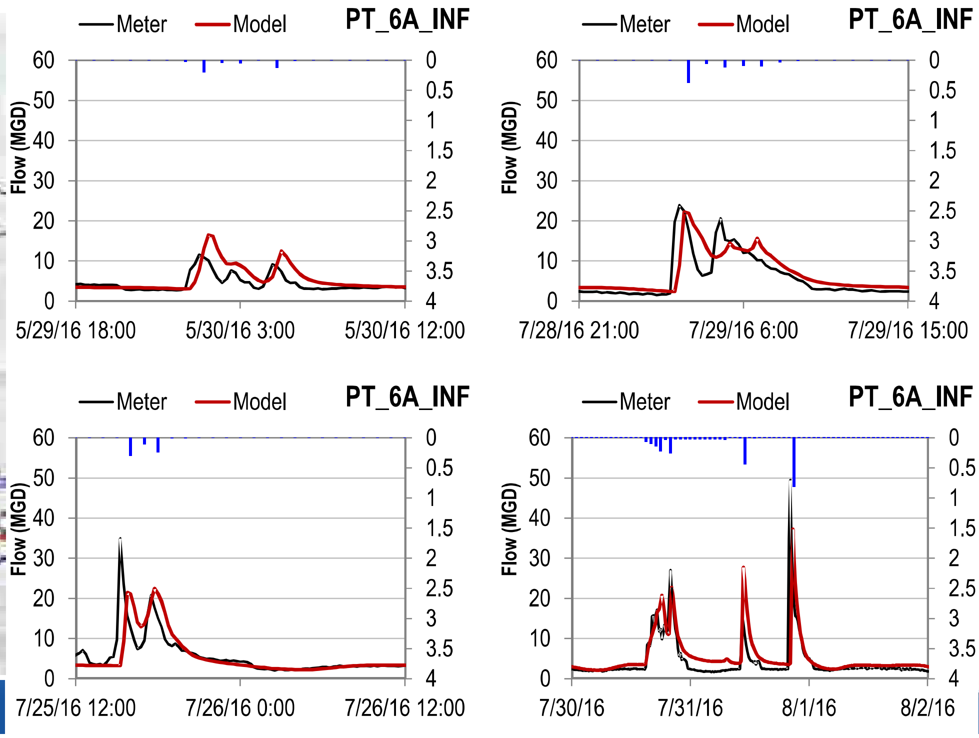
GREELEY AND HANSEN

Combined Area

Calibration Results – Combined Area

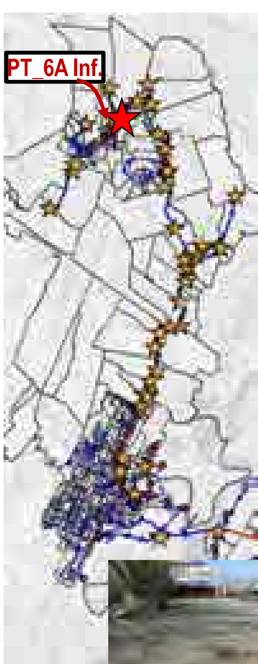
Paterson 6A Influent

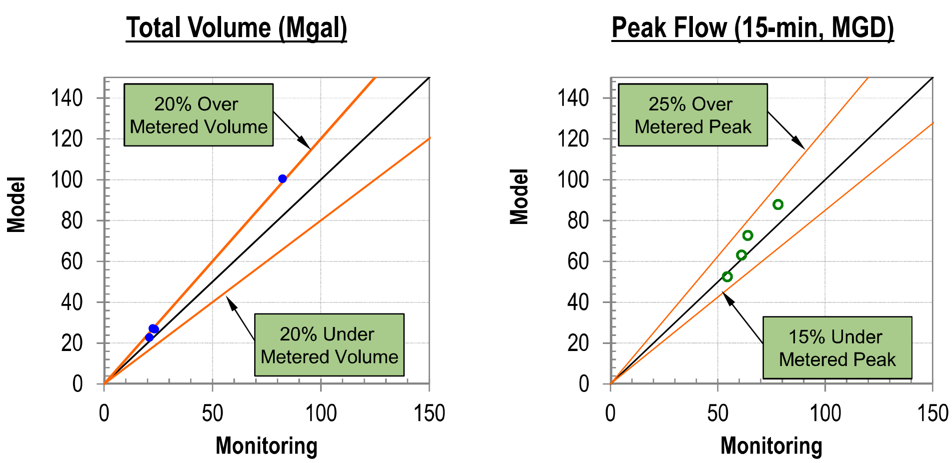


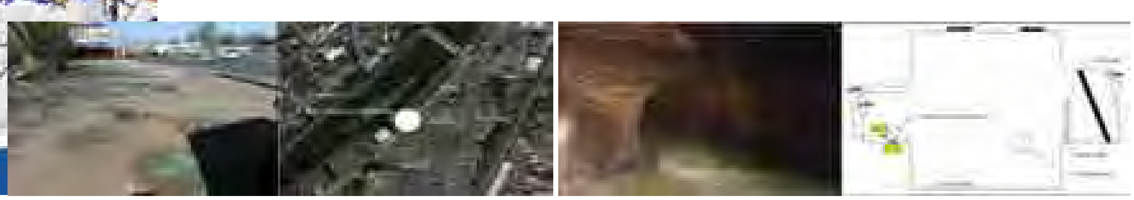


Calibration Results – Combined Area

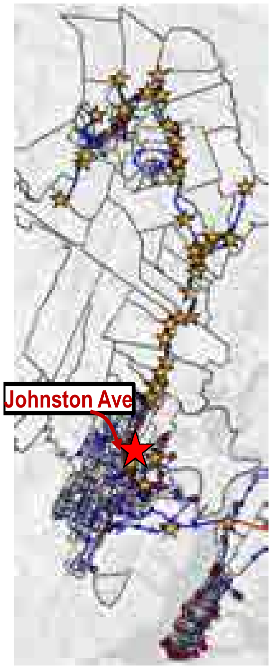
Paterson 6A Influent

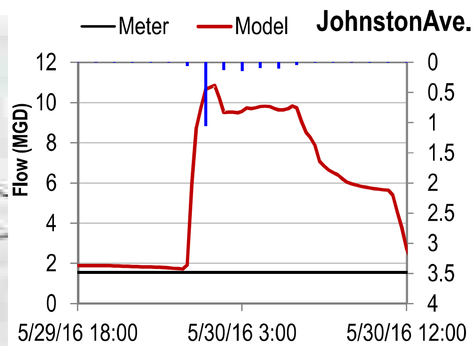


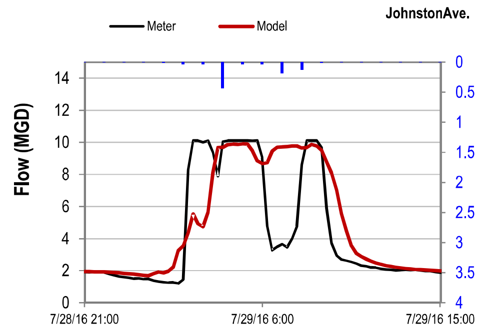


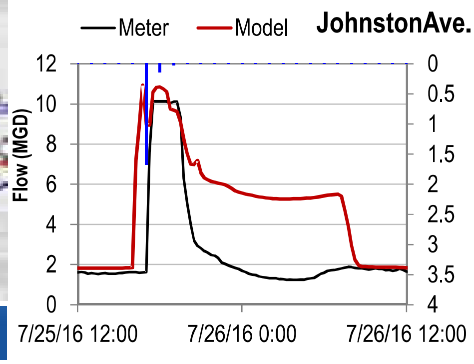


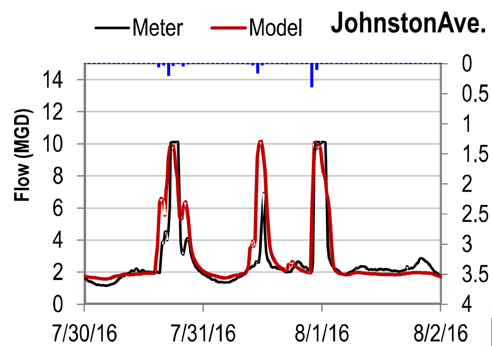
Calibration Results – Combined Area
Johnston Ave.



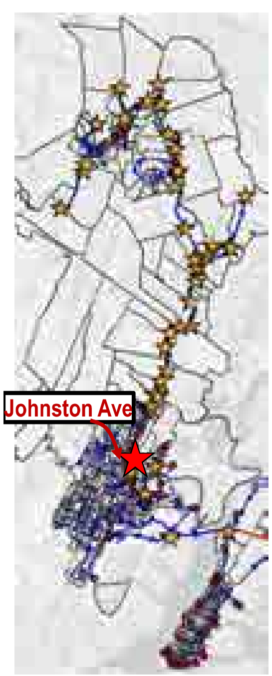


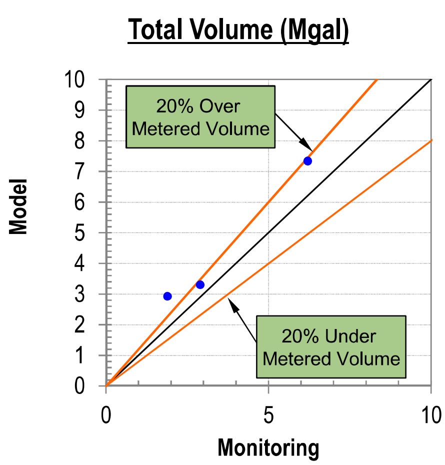


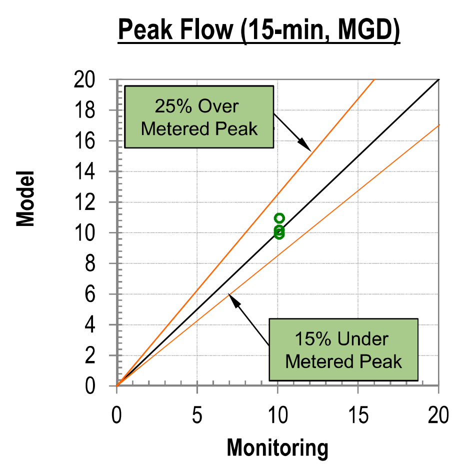




Calibration Results – Combined Area
Johnston Ave.

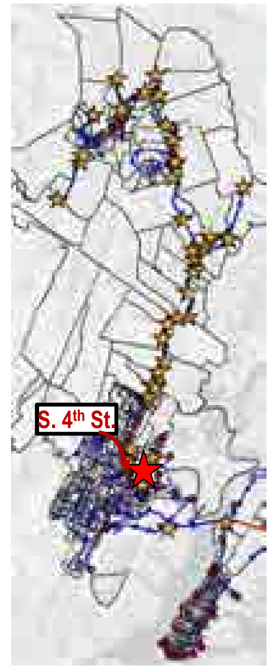


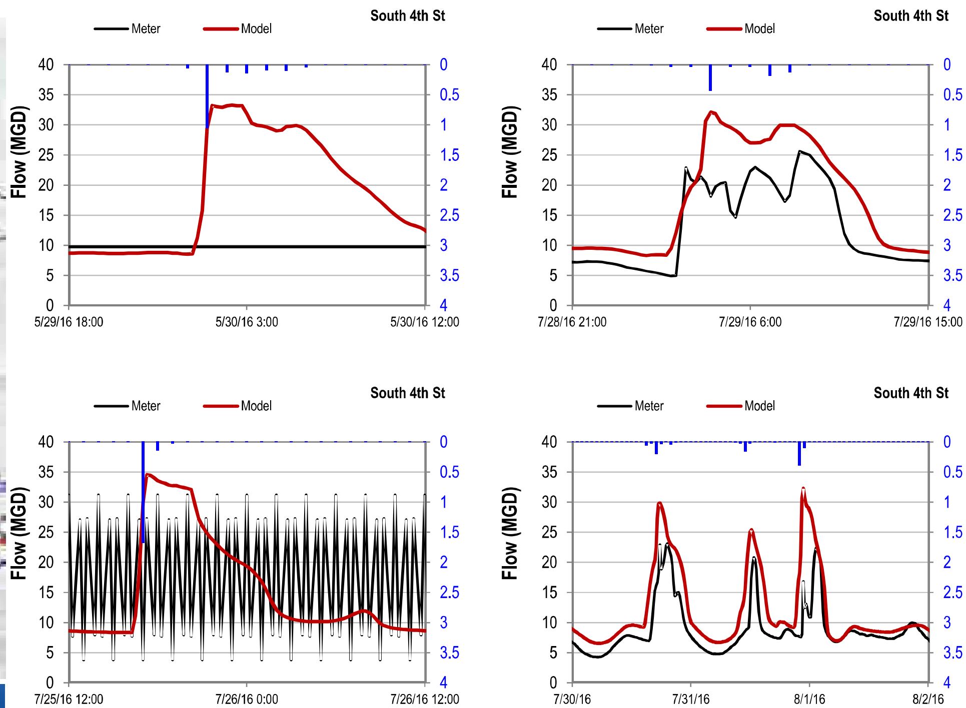




Calibration Results – Combined Area

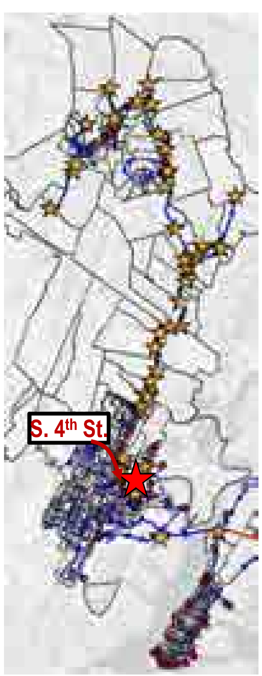
South 4th St.

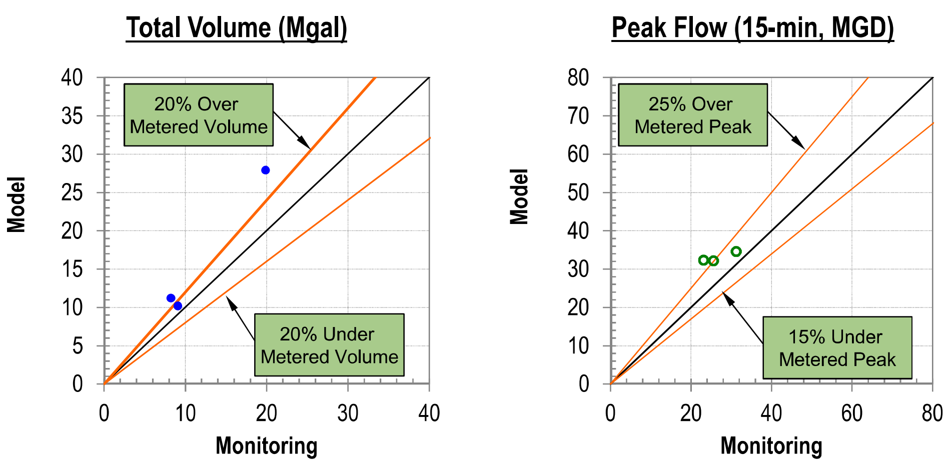




Calibration Results – Combined Area

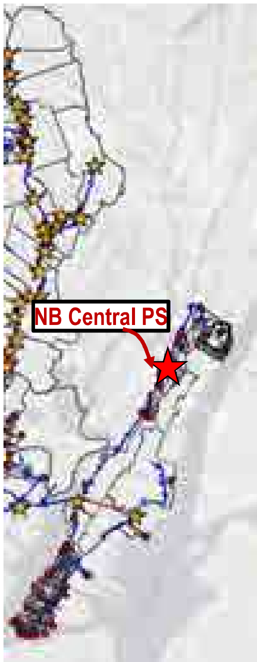
South 4th St.

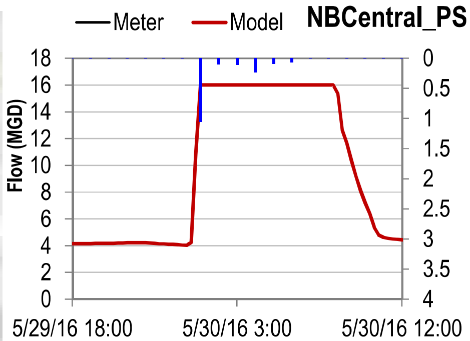


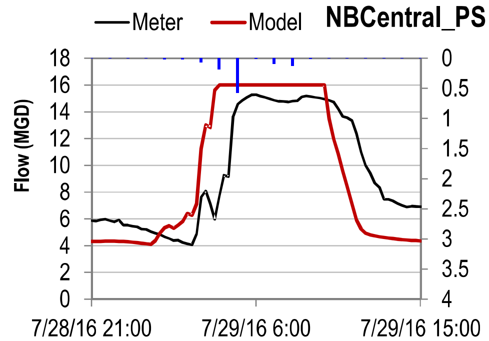


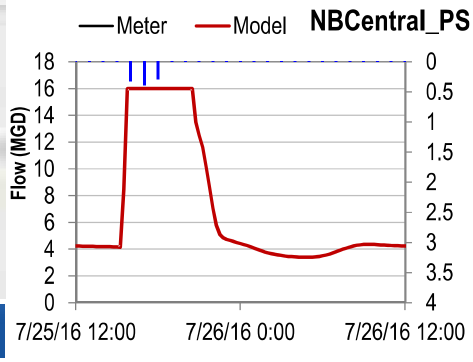
Calibration Results – Combined Area

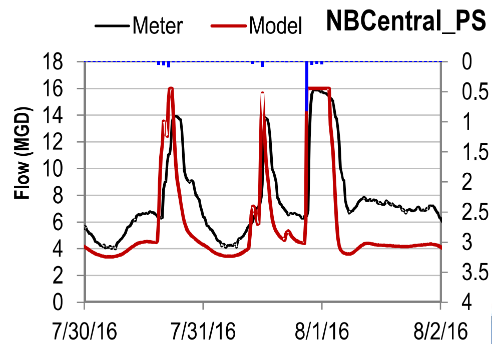
NB Central PS.





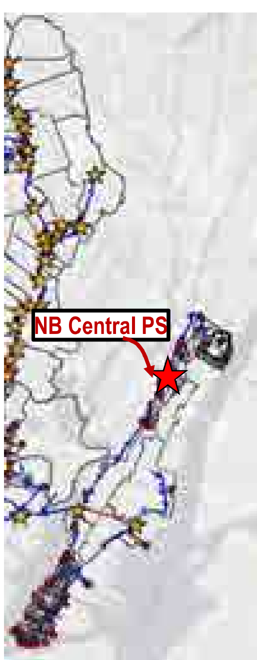


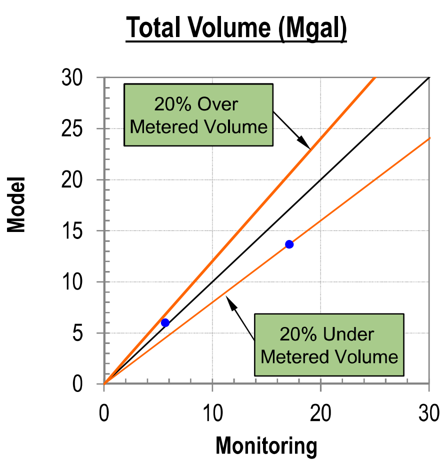


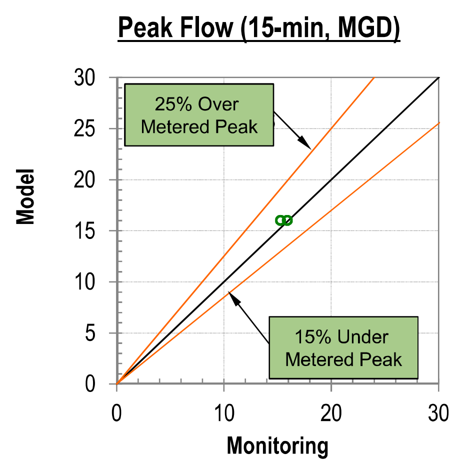


Calibration Results – Combined Area

NB Central PS.





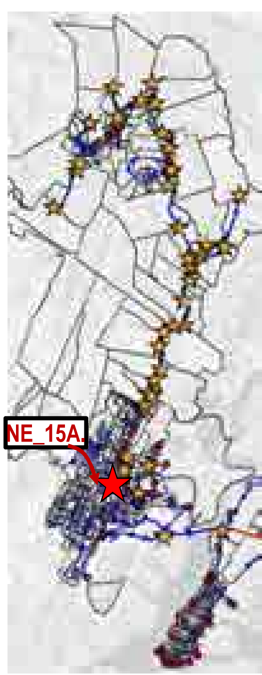


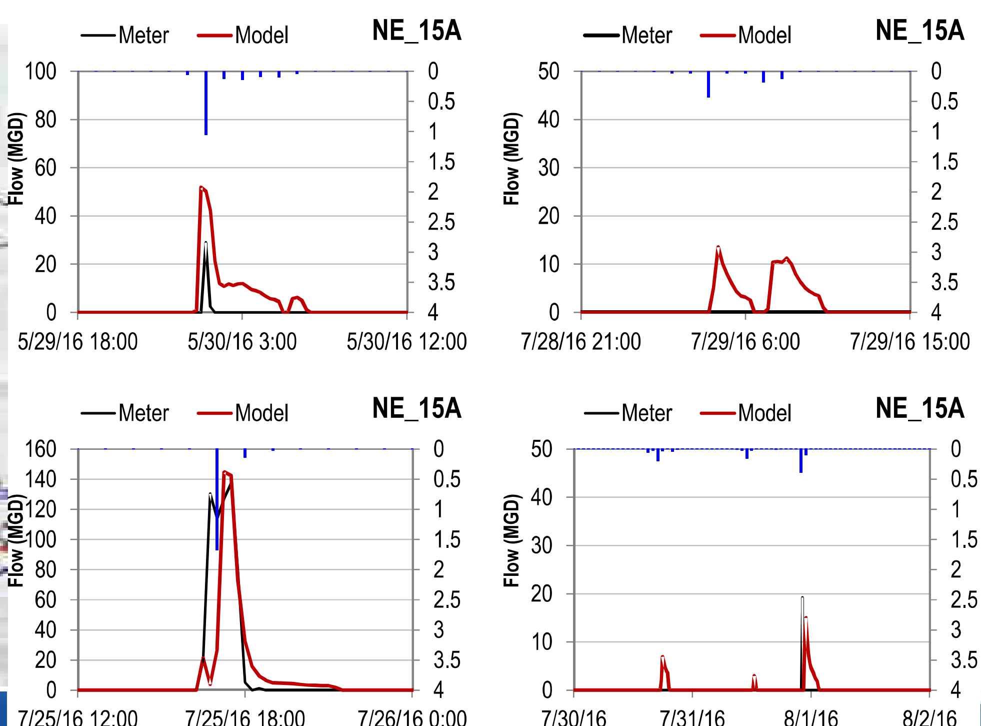
GREELEY AND HANSEN

CSO Meters

Calibration Results – CSO Overflow

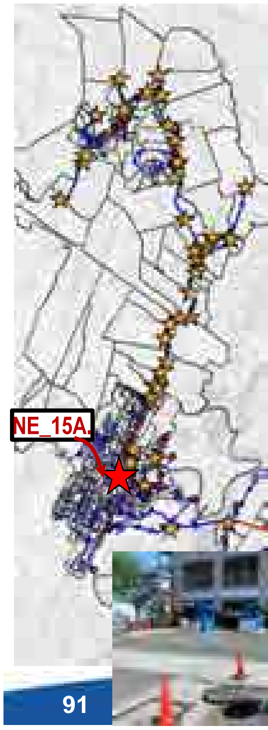
NE_15A

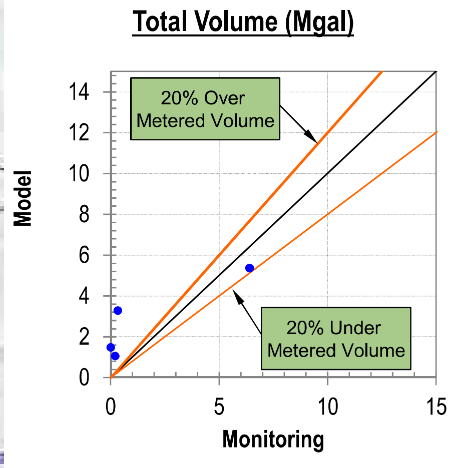


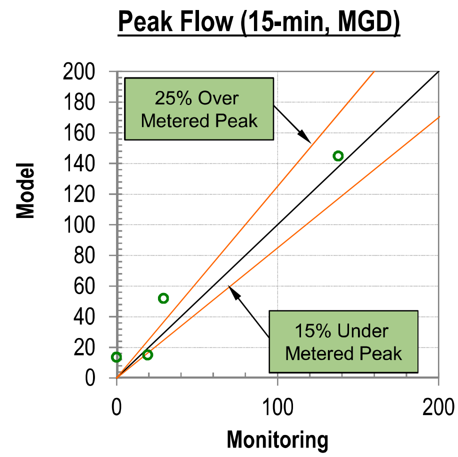


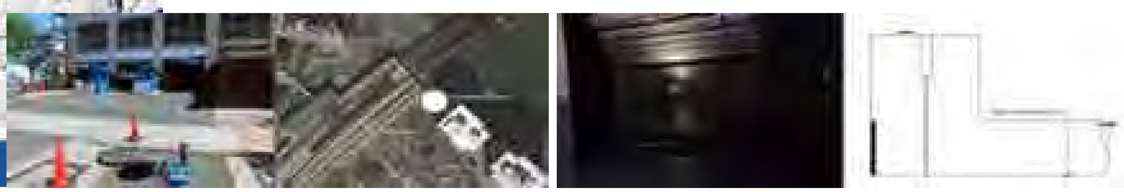
Calibration Results – CSO Overflow

NE_15A



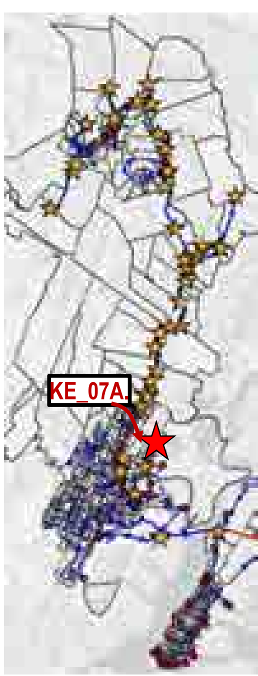


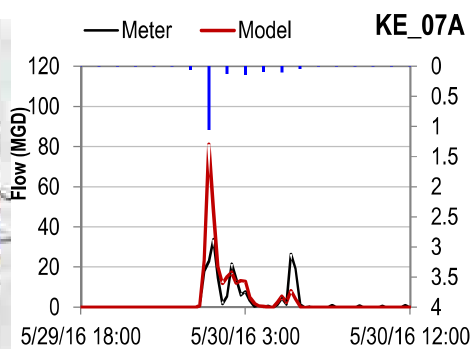


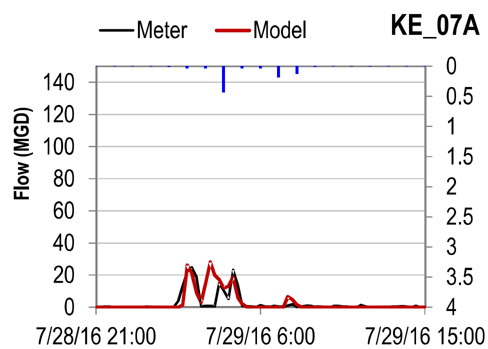


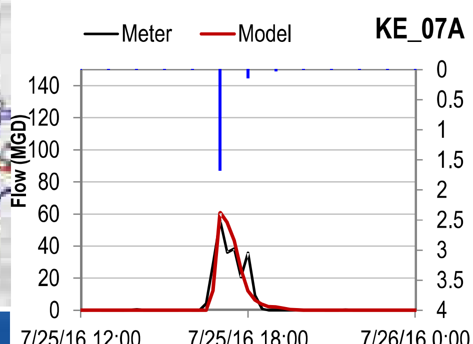
Calibration Results – CSO Overflow

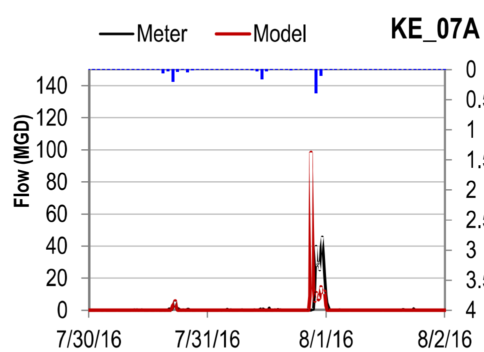
KE_07A





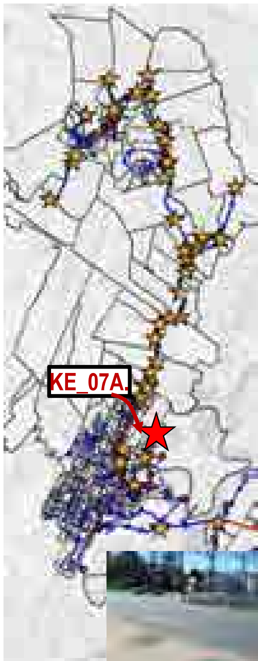


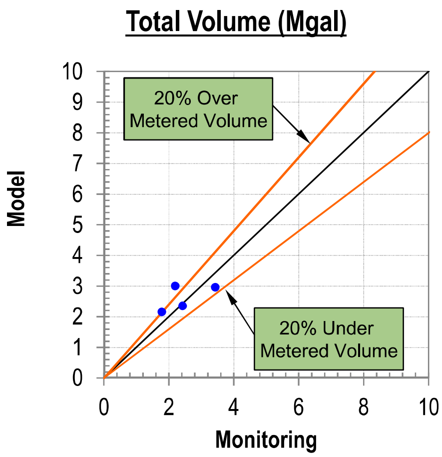


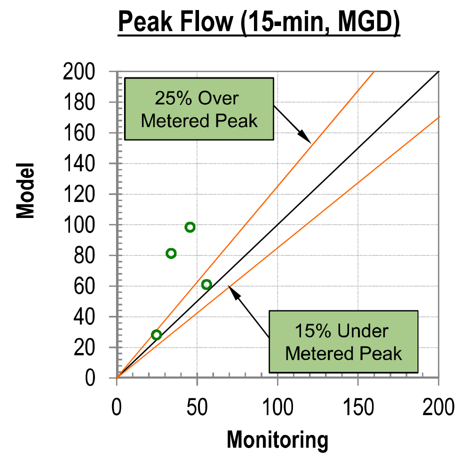


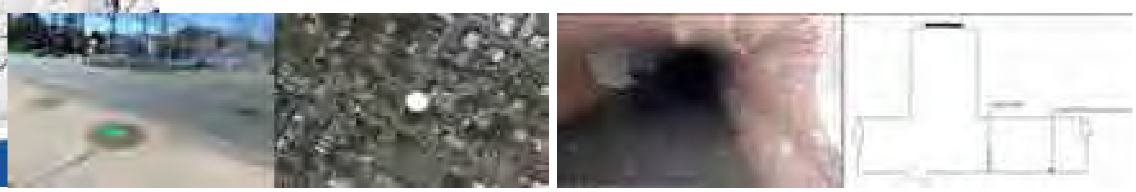
Calibration Results – CSO Overflow

KE_07A



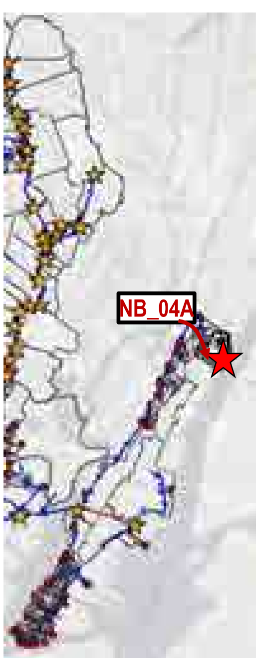


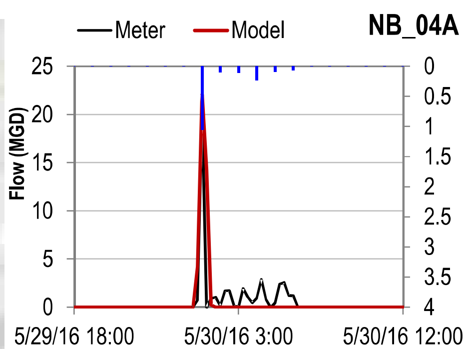


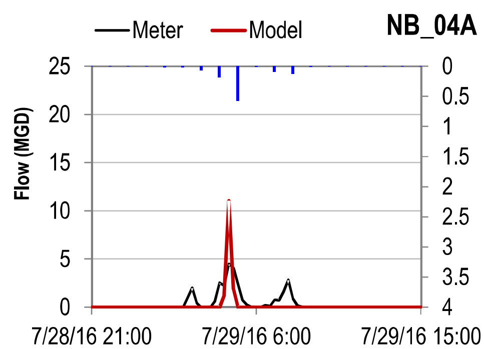


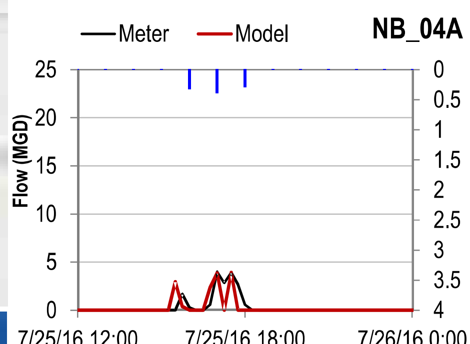
Calibration Results – CSO Overflow

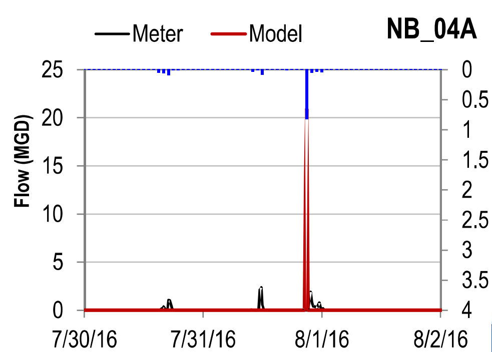
NB_04A



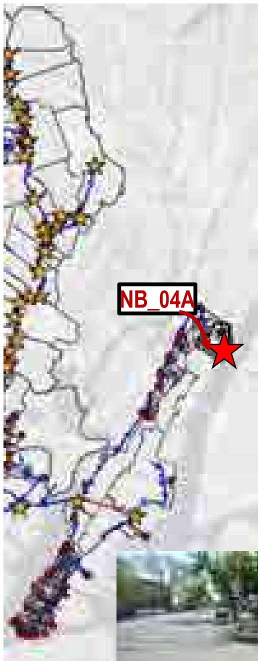


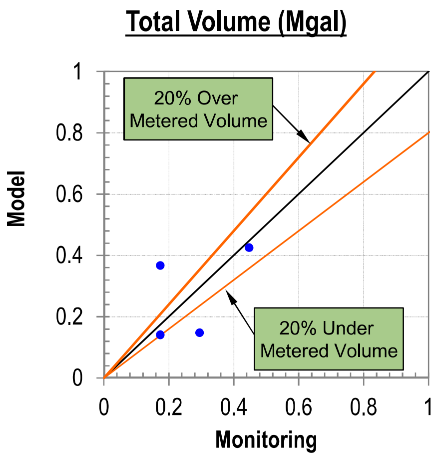


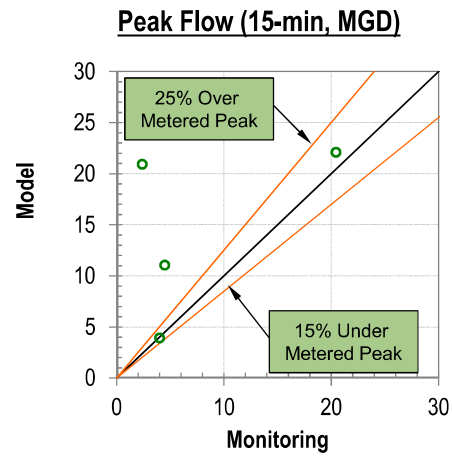


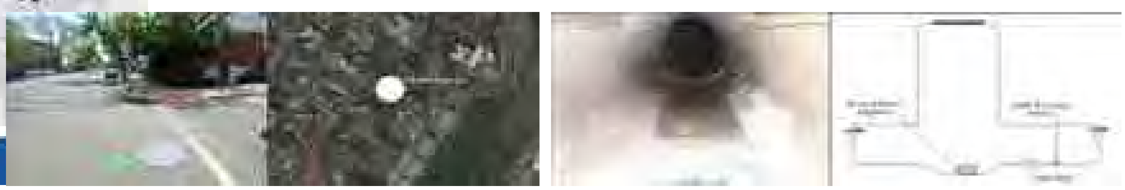


Calibration Results – CSO Overflow
NB_04A

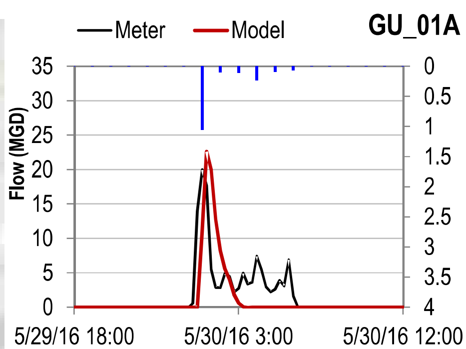


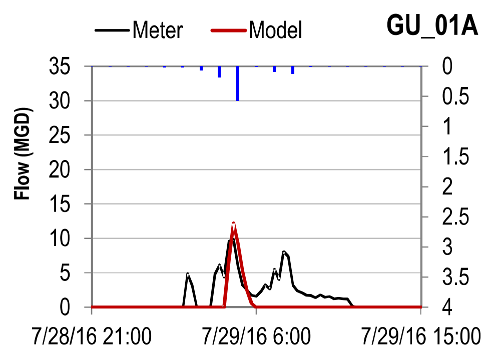


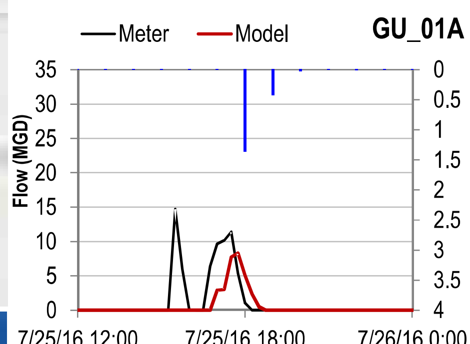


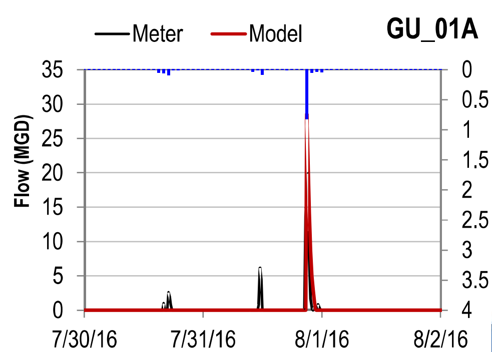


Calibration Results – CSO Overflow
GU_01A

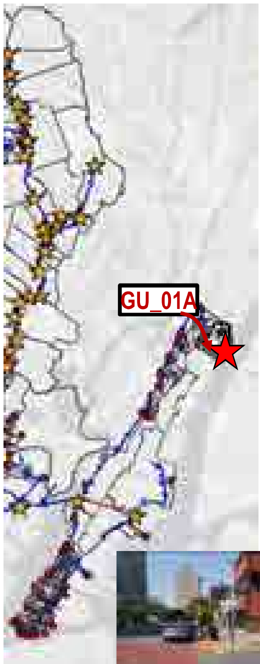


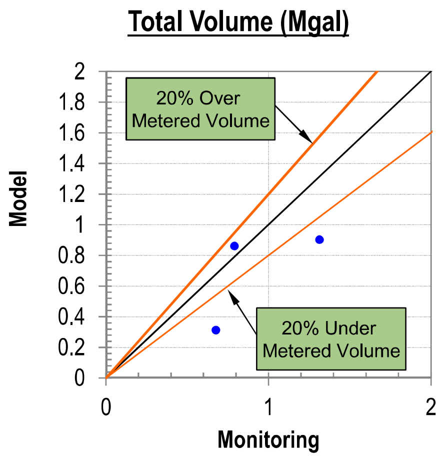


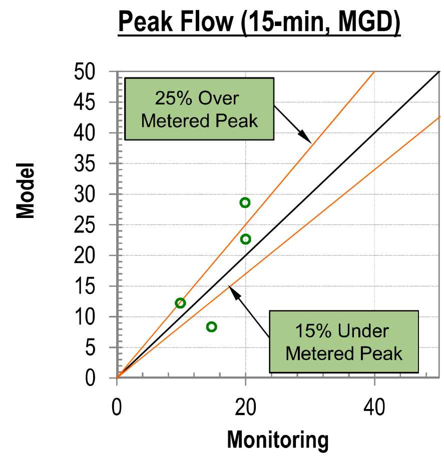


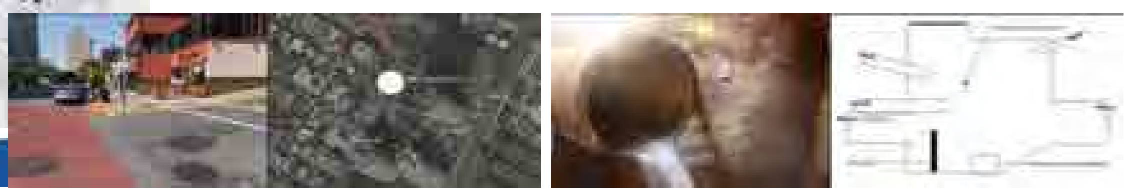


Calibration Results – CSO Overflow
GU_01A





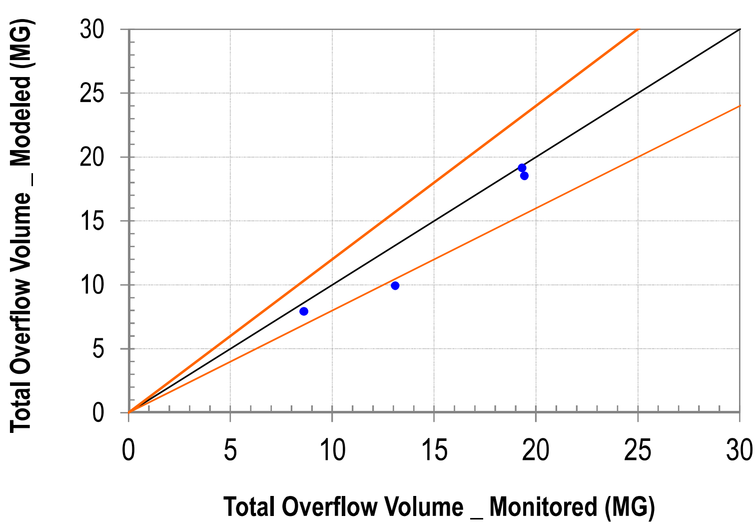




Total Overflow Volume

NE_04&05, NE_09&10, NE_14A , NE_15A , KE_07A , BA_08A , BA_10A ,NB_11A , NB_07A, NB_04A, NB_04B, GU_01A

Total Overflow Volume from Sampling Locations



Summary & Next Step

Summary

- The updated PVSC H&H model includes
  - 48 municipalities served by the PVSC WPCF
  - 2 municipalities served by the NBMUA Woodcliff WWTP
  - Dry weather flow based on 2016 flow monitoring data
  - Wet weather flow simulated as runoff from the combined areas and RDII from the separated areas
  - Current PVSC WPCF wet weather operating rules
- The model is calibrated and validated to 2016 flow monitoring data

Next Step

- Finalize model
- Address comments received
- Generate CSO flows for WQ model
- Distribute model to CSO permittees

The End

Water Quality Modeling Update

Model Evaluation Group – Session 3

Rich Isleib, HDR

September 15, 2017

Agenda

- Receiving Water Data Summary
- Source Loading Approach
  - Stormwater
  - CSO
  - Rivers
- Model Calibration
- Next Steps

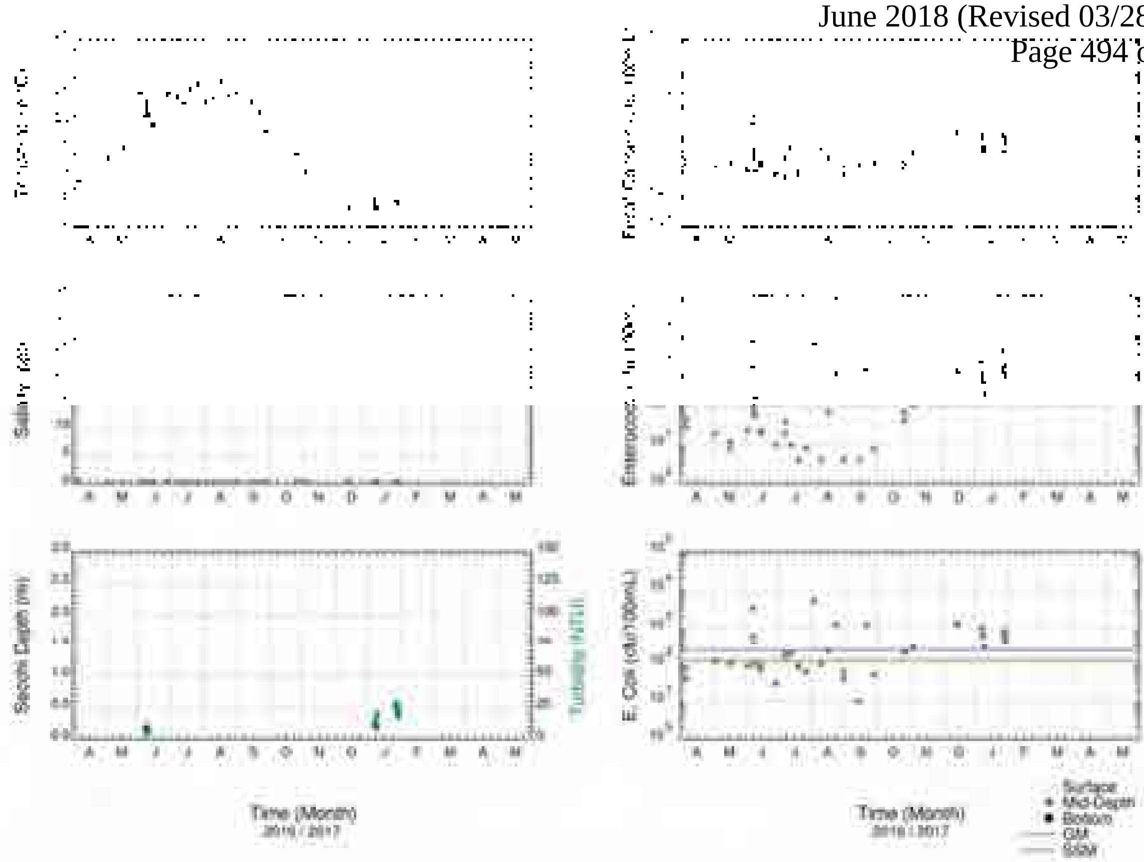
Receiving Water Sampling Locations

NJ Pathogen Criteria

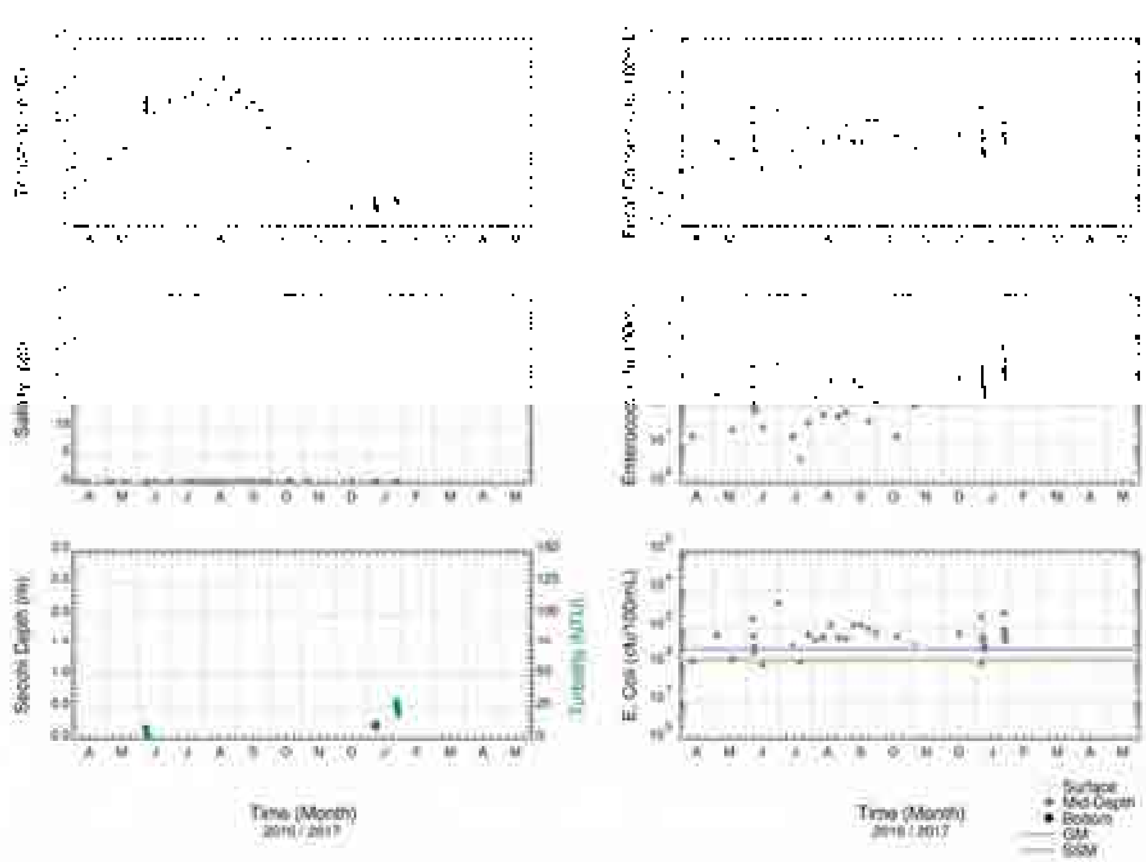
- Primary Contact Recreation:
  - Enterococci levels shall not exceed a geometric mean of **35/100 ml**, or a single sample maximum of **104/100 ml**. (SE1 and SC)
    - Hackensack R. (upper), Hudson R. (north of Harlem R.), Raritan R., Raritan Bay
  - E. coli levels shall not exceed a geometric mean of **126/100 ml** or a single sample maximum of **235/100 ml**. (All FW2)
    - Elizabeth R., Passaic R., Raritan R.

- Secondary Contact Recreation:
  - Fecal coliform levels shall not exceed a geometric mean of **770/100 ml**. (SE2)
    - Arthur Kill (lower), Hackensack R. (mid), Hudson R., Passaic R. (mid), Rahway R.
  - Fecal coliform levels shall not exceed a geometric mean of **1500/100ml**. (SE3)
    - Arthur Kill (upper), Elizabeth R., Hackensack R. (lower), Kill Van Kull, Newark Bay, Passaic R. (lower)

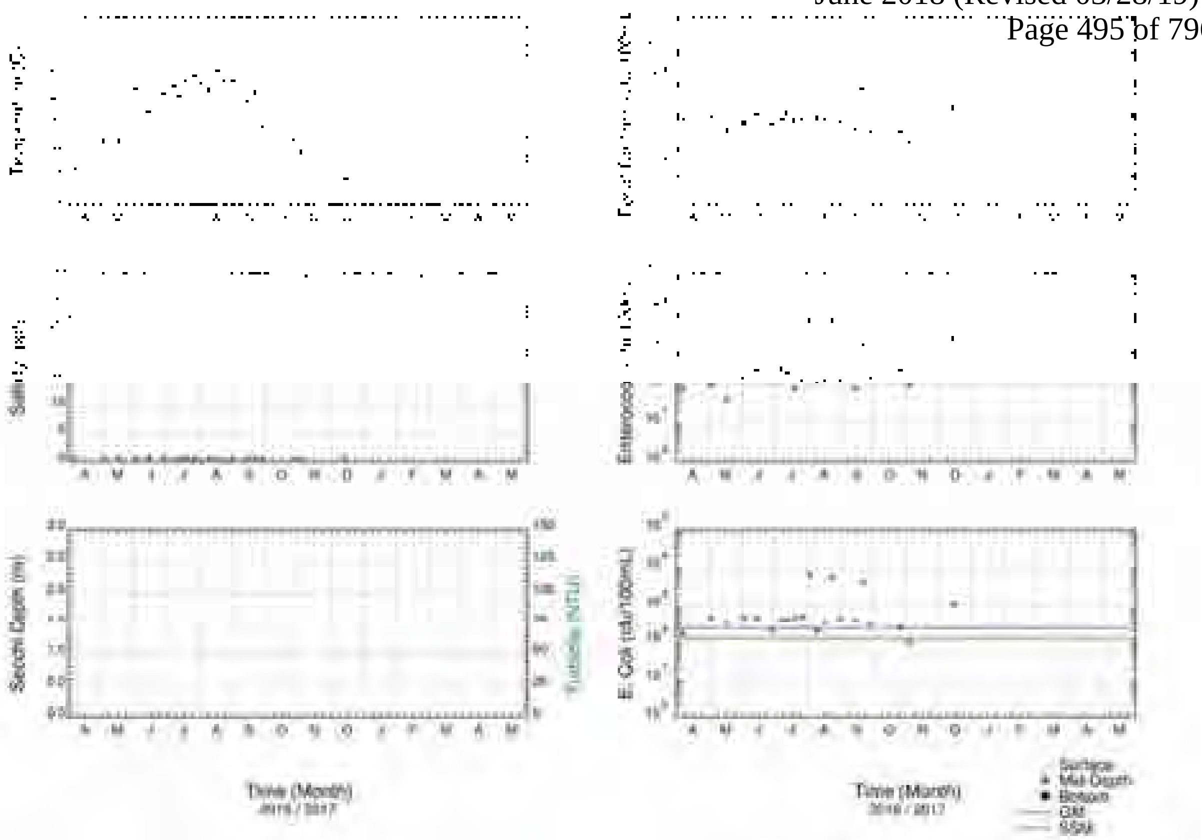
Passaic River & Tributaries, Passaic River, 1 (FW2)



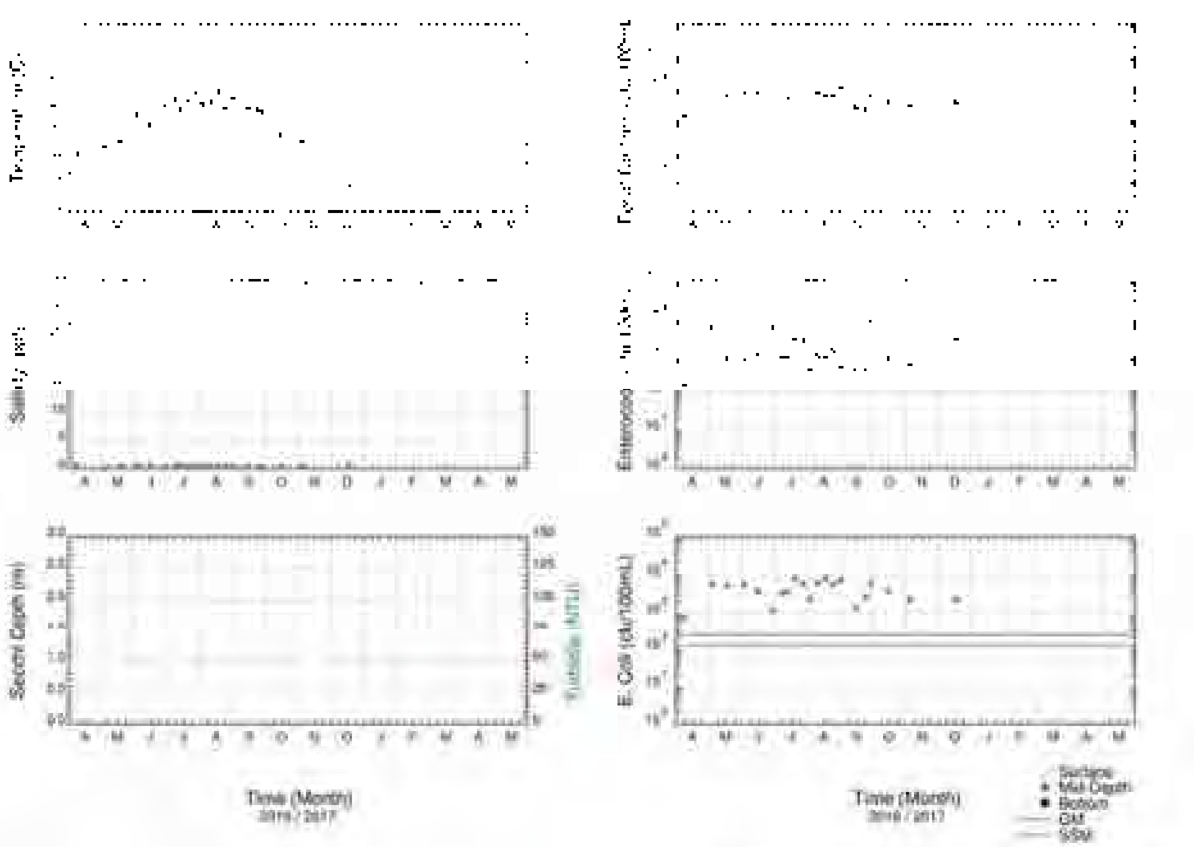
Passaic River & Tributaries, Passaic River, 3 (FW2)



Passaic River & Tributaries, Saddle River, 6 (FW2)



Passaic River & Tributaries, Second River, 9 (FW2)



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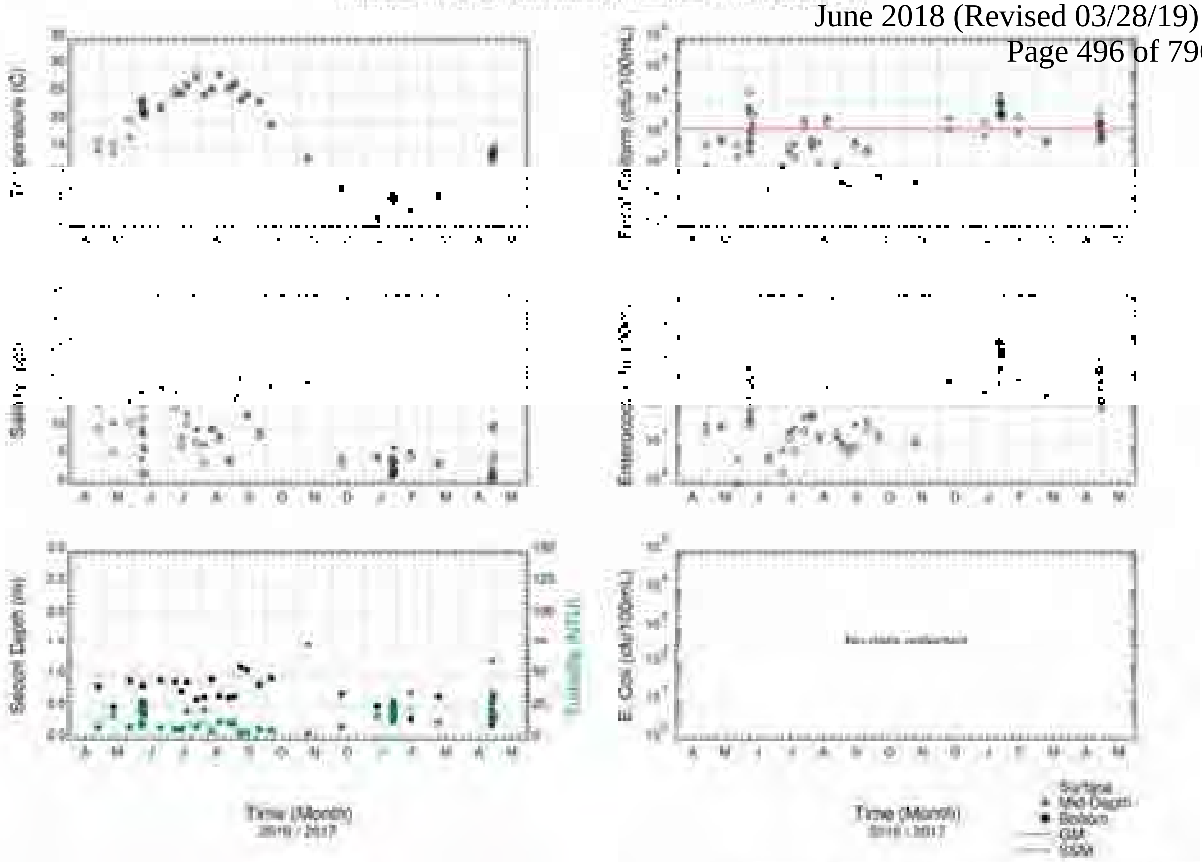
OR THE COMMON LAW RIGHT TO INSPECT PUBLIC RECORDS.

Passaic River & Tributaries, Passaic River, B6, (SE3)



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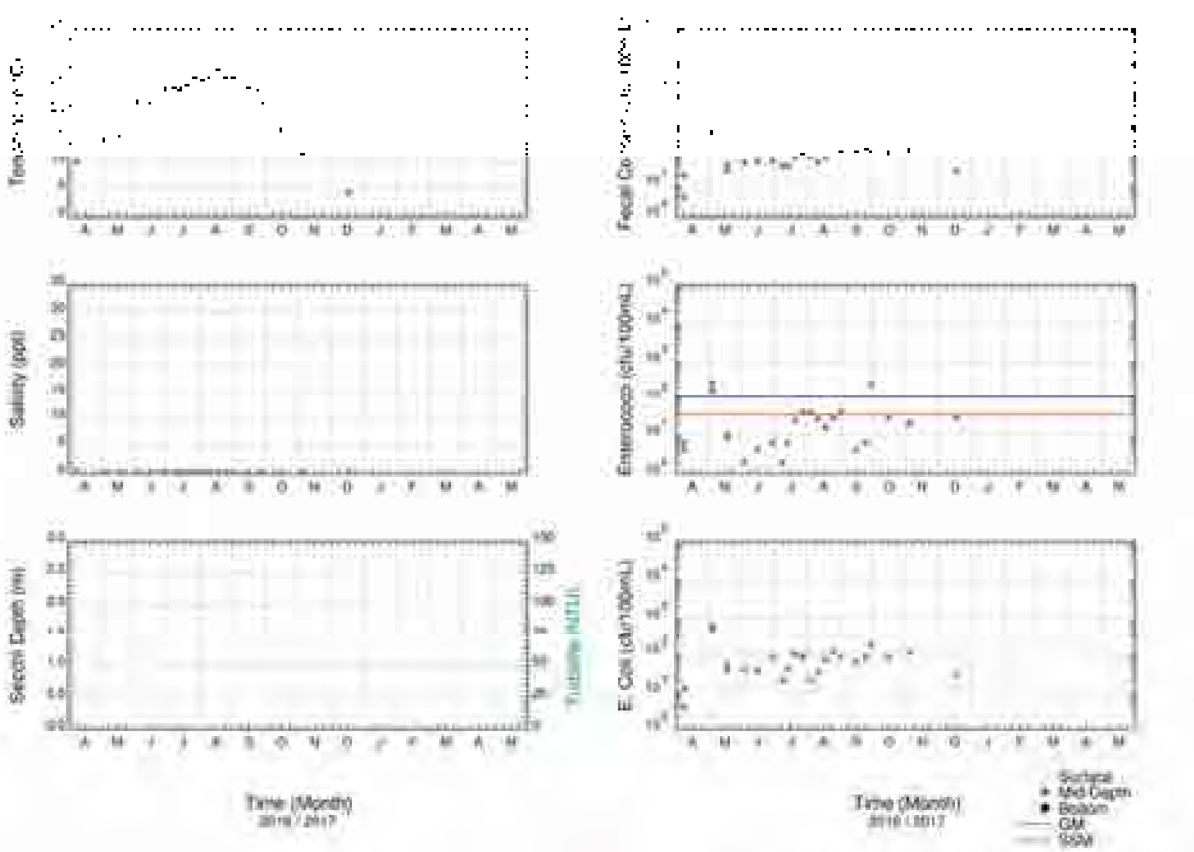
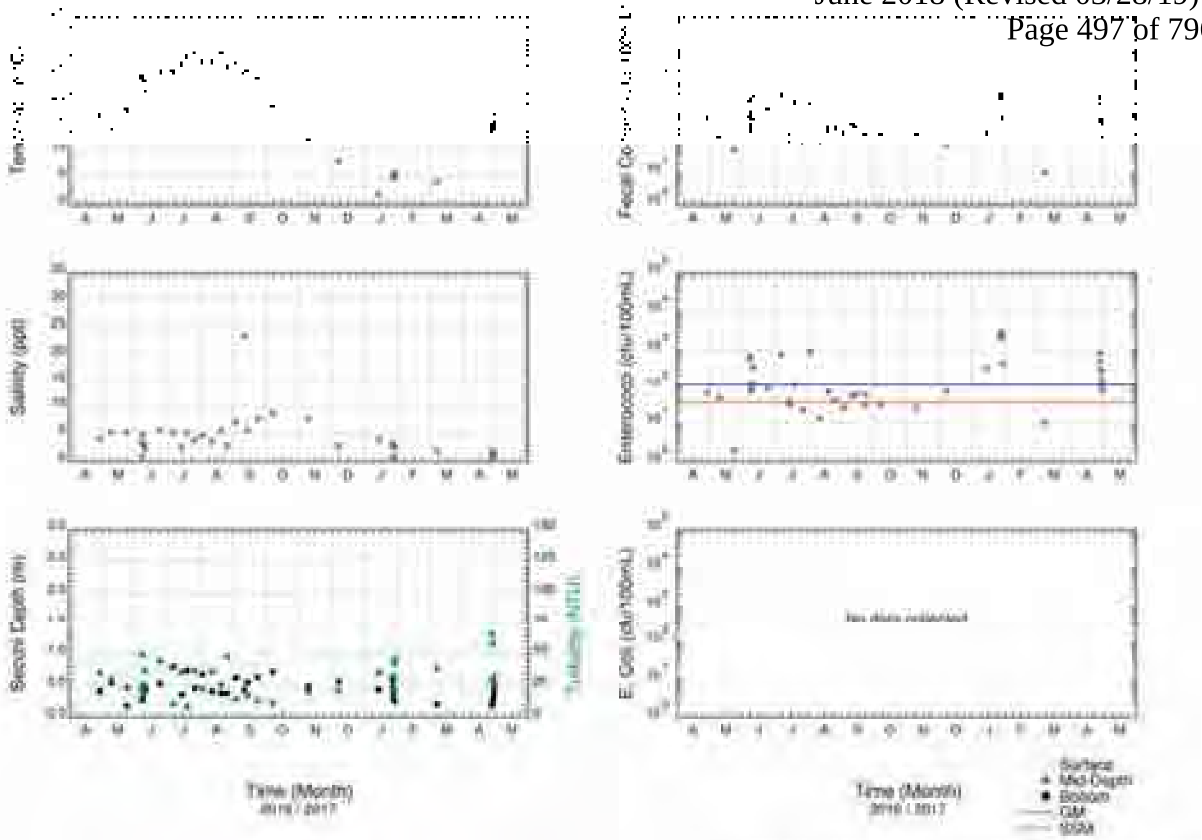
Hackensack River & Tributaries, Hackensack River, 10, (SE1)



CDM Smith FDR

Hackensack River & Tributaries, Hackensack River, 82, (SE1)



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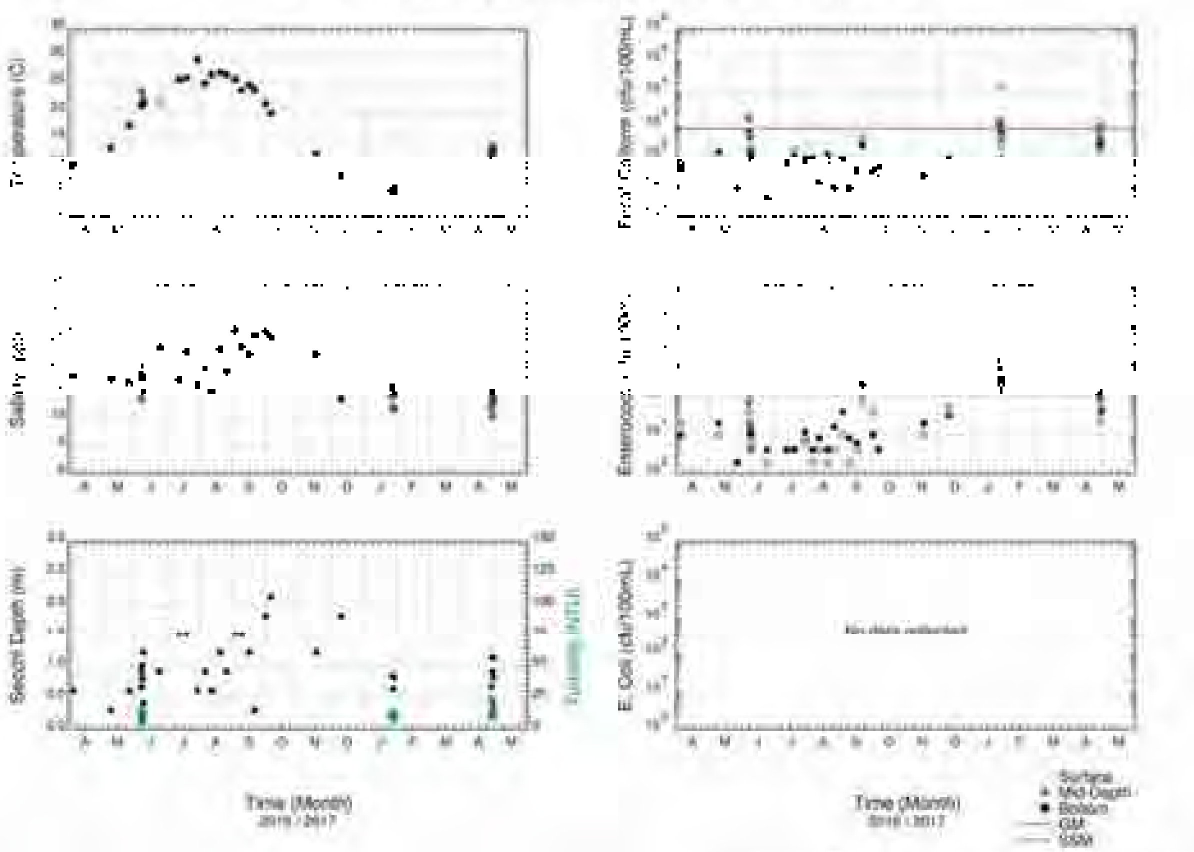
Hackensack River & Tributaries, Hackensack River, 15, (SE2)



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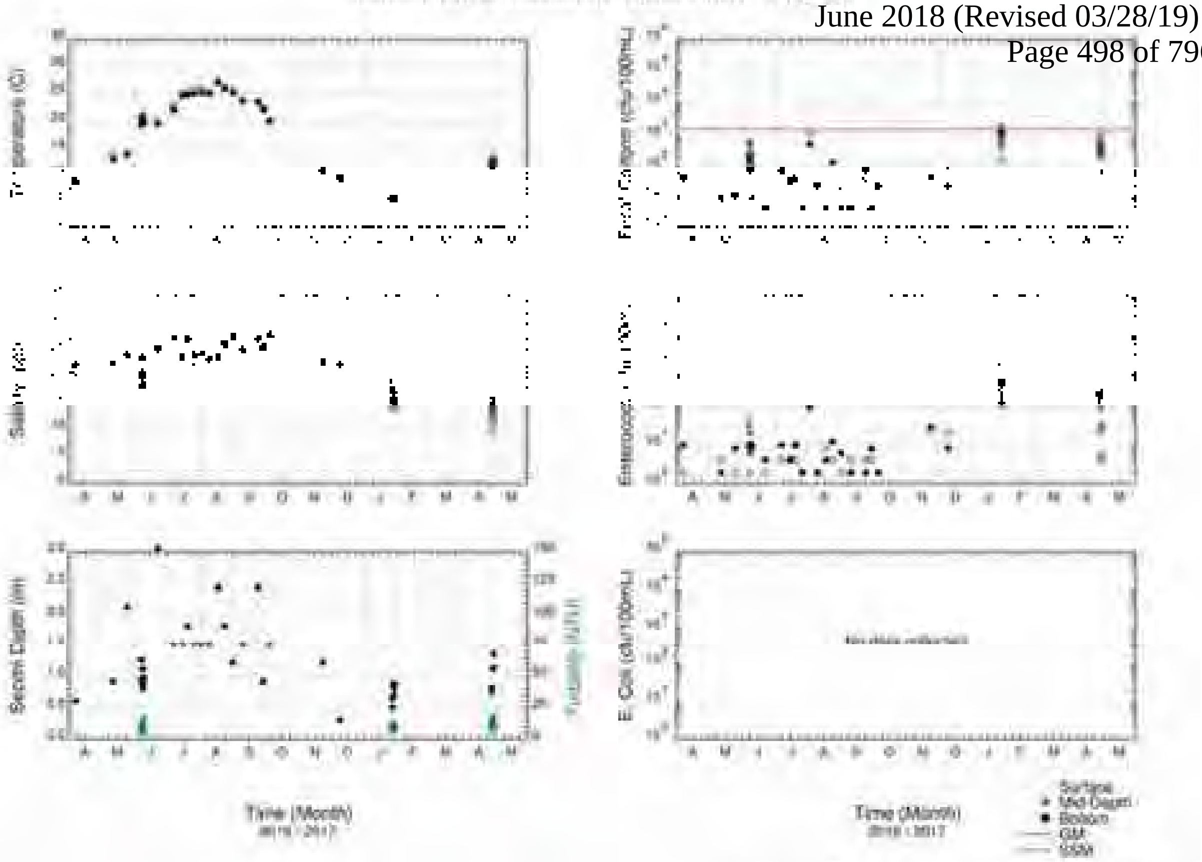
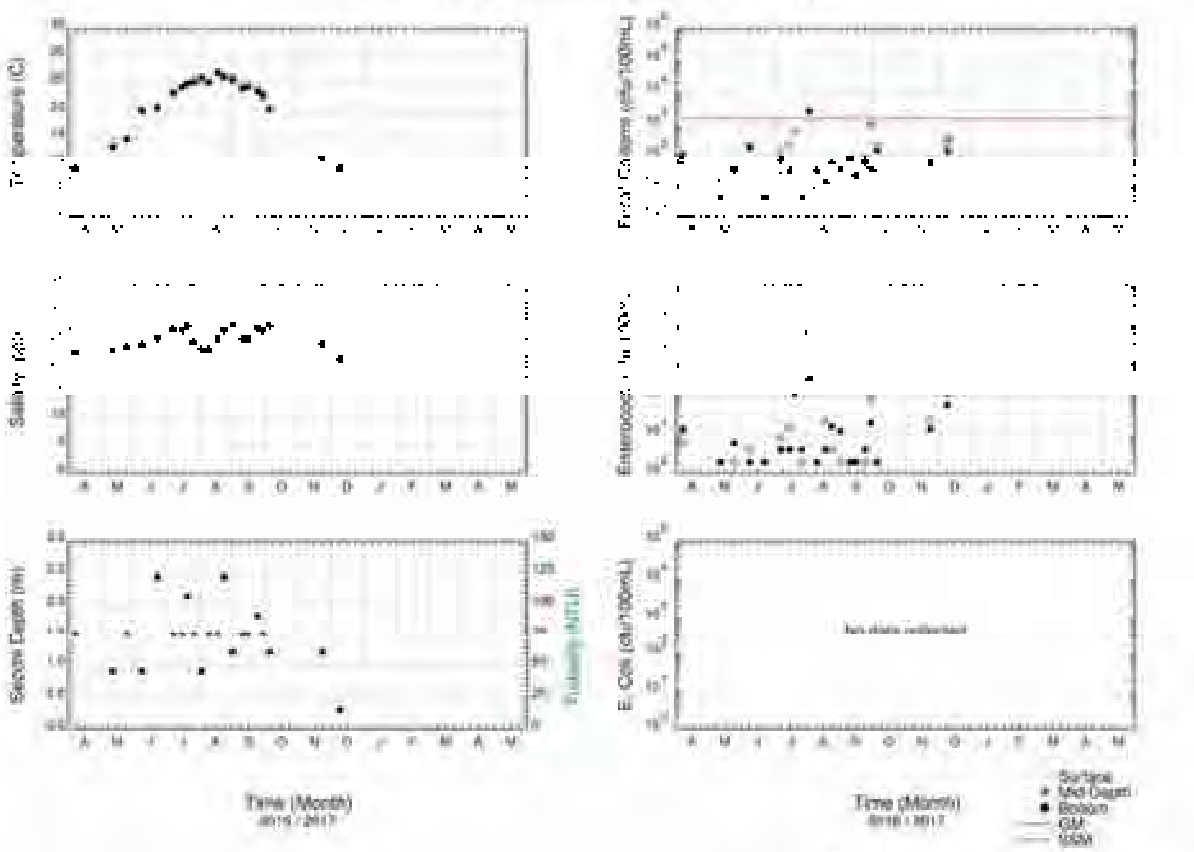
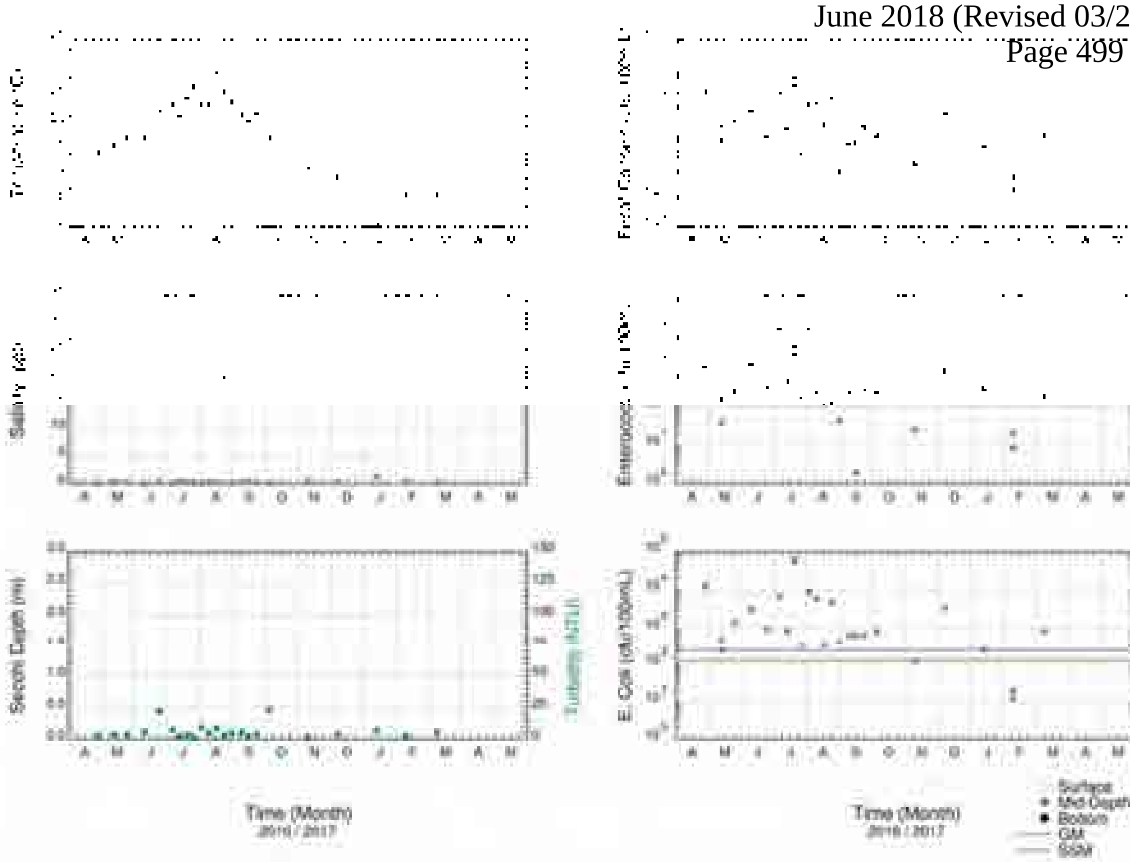
Newark Bay & Tributaries, Newark Bay, 17, (SE3)



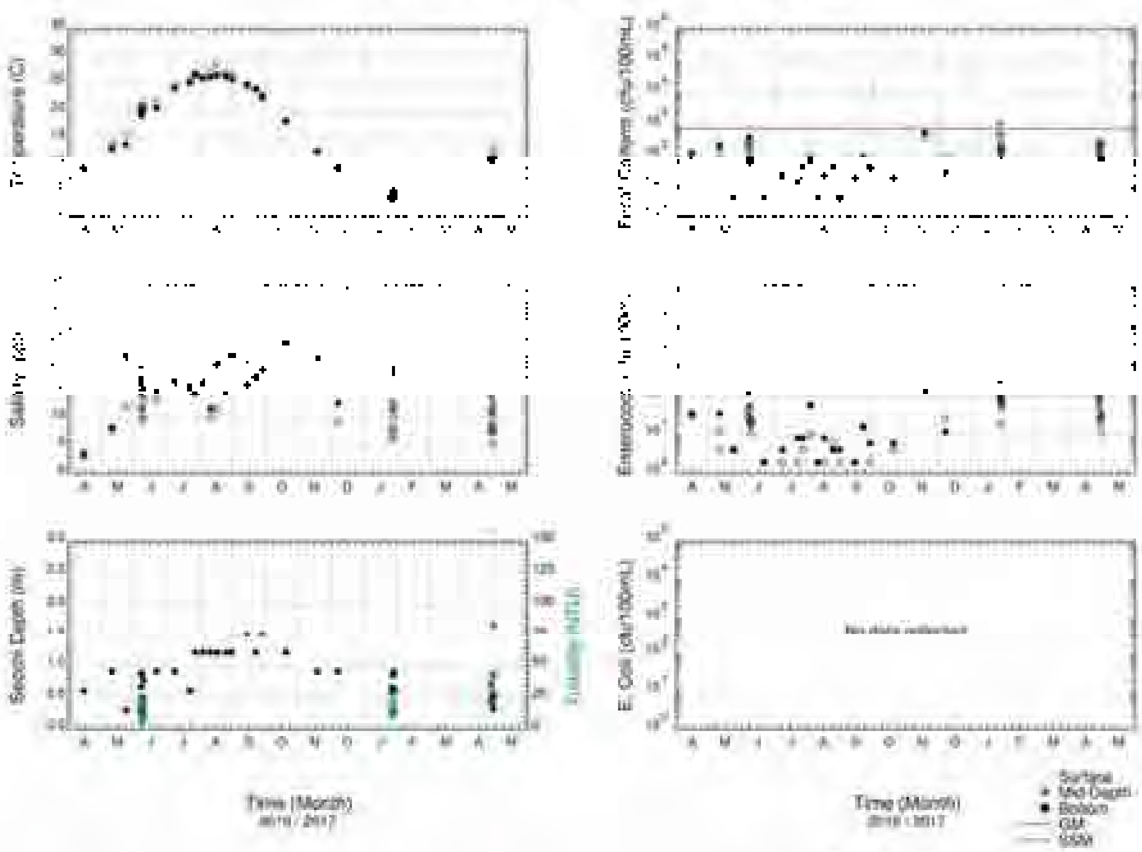
Newark Bay & Tributaries, Arthur Kill, 21, (SE3)



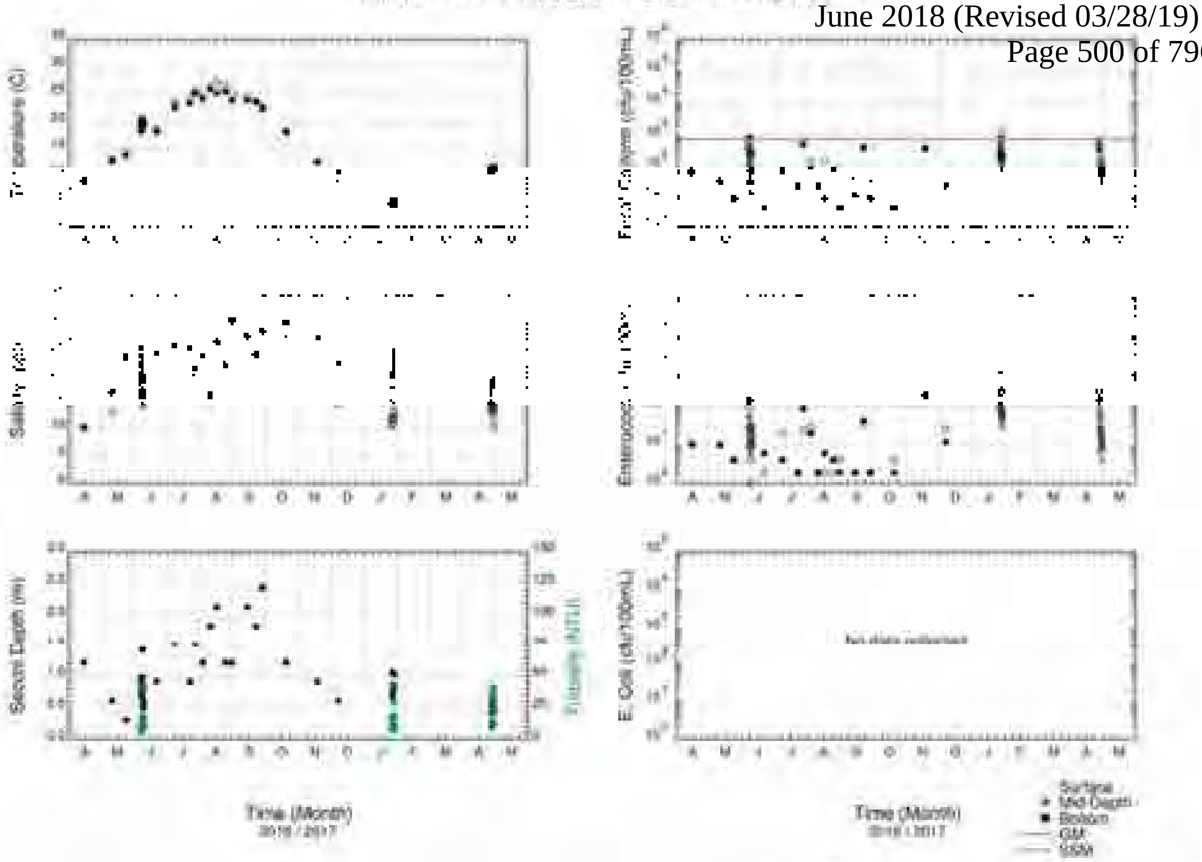
Newark Bay & Tributaries, Elizabeth River, R16, (FW2)



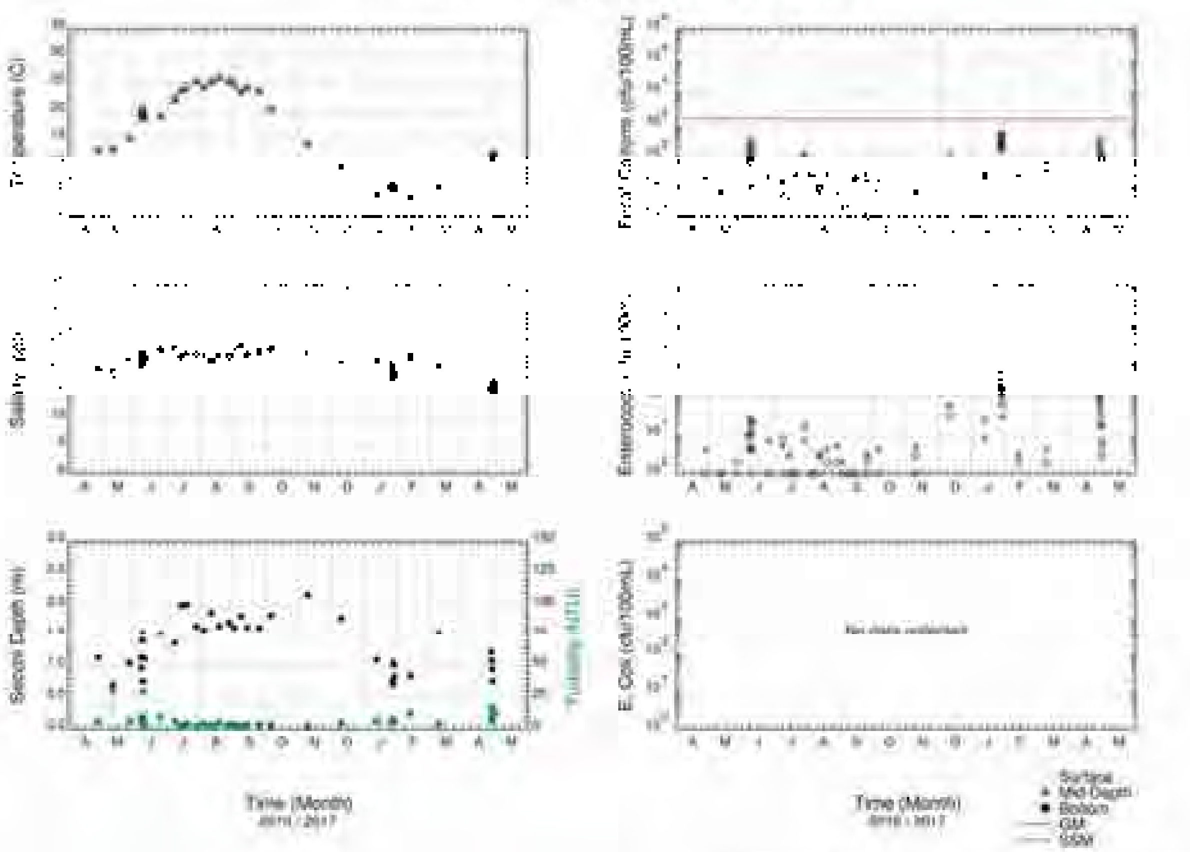
Hudson River: Upper Bay, Hudson River, 31, (SE2)



Hudson River: Upper Bay, Hudson River, 33, (SE2)



Hudson River: Upper Bay, Kill Van Kull, B12, (SE3)



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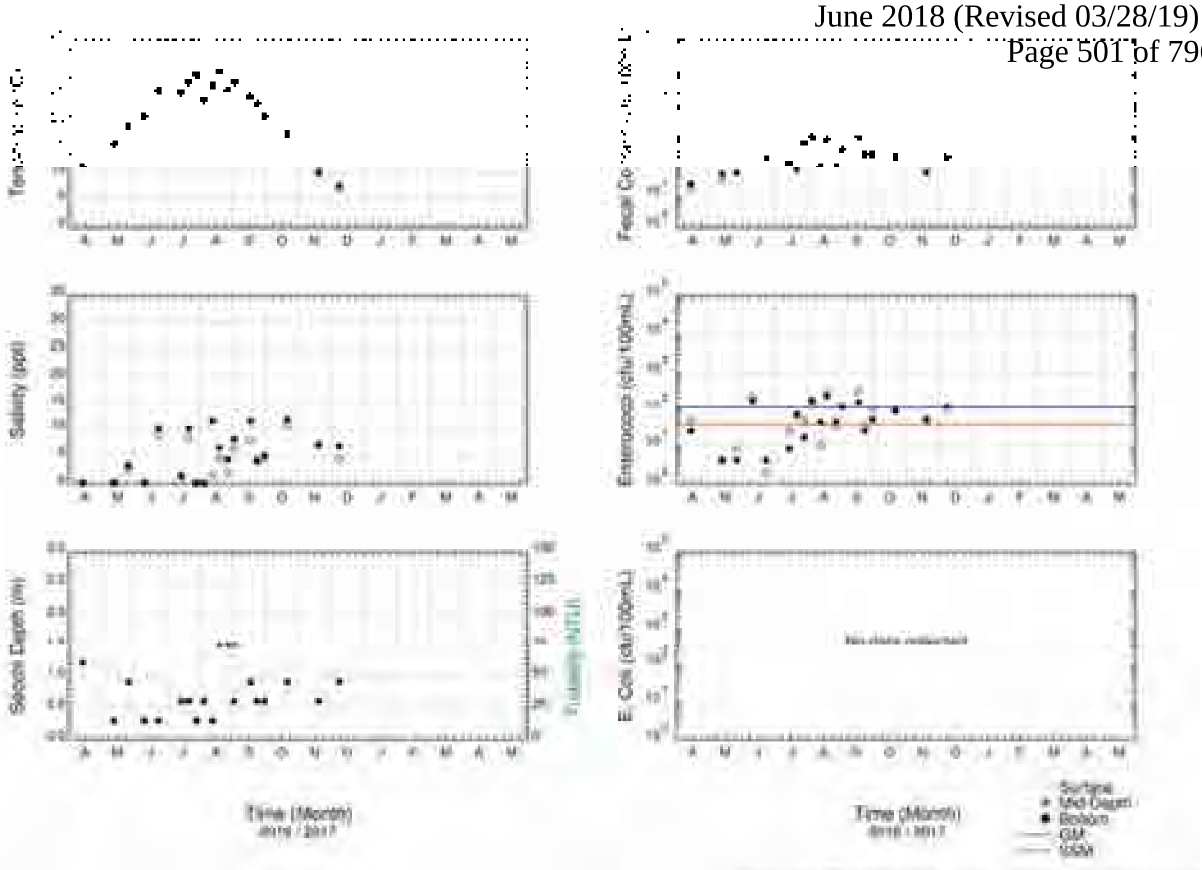
Annex K – Raritan River Bay & Tributaries, Raritan River 20 (SE1)



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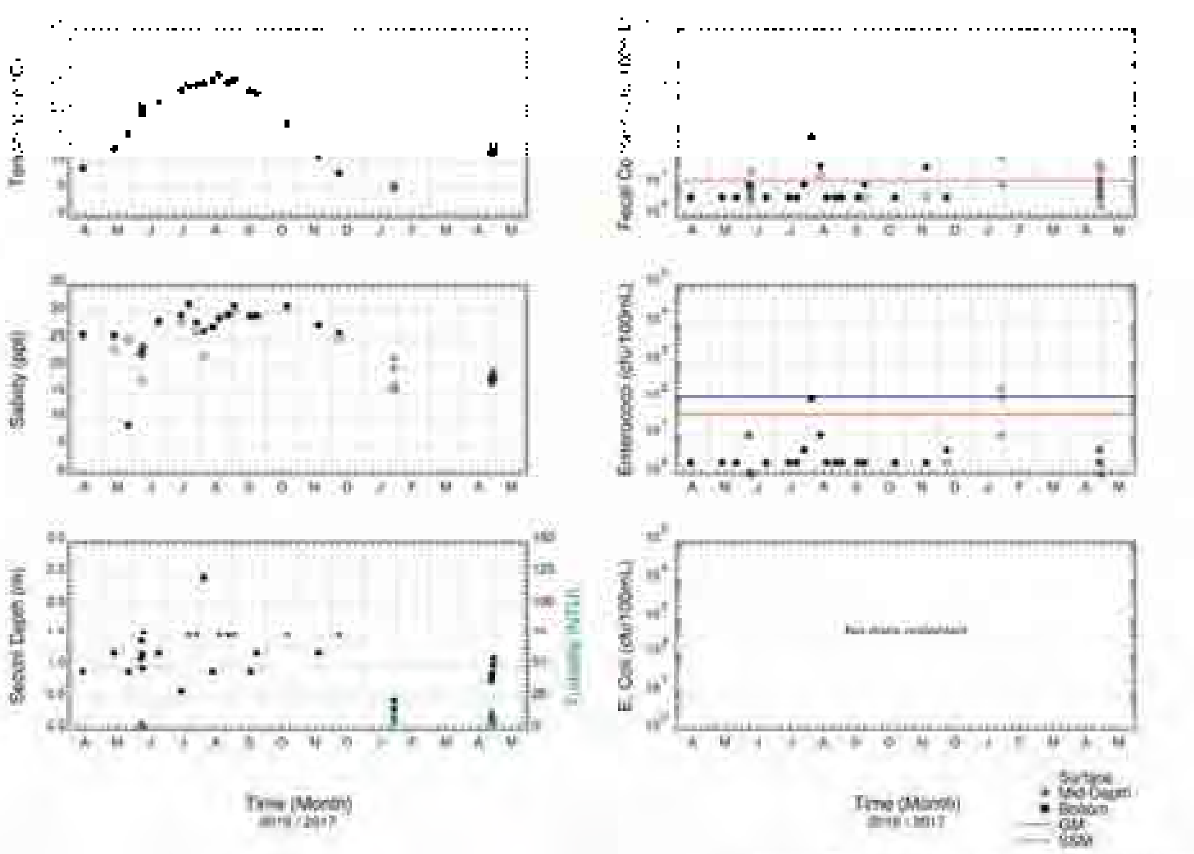
Annex K – Raritan River Bay & Tributaries, Raritan Bay 23 (Shellfish)



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