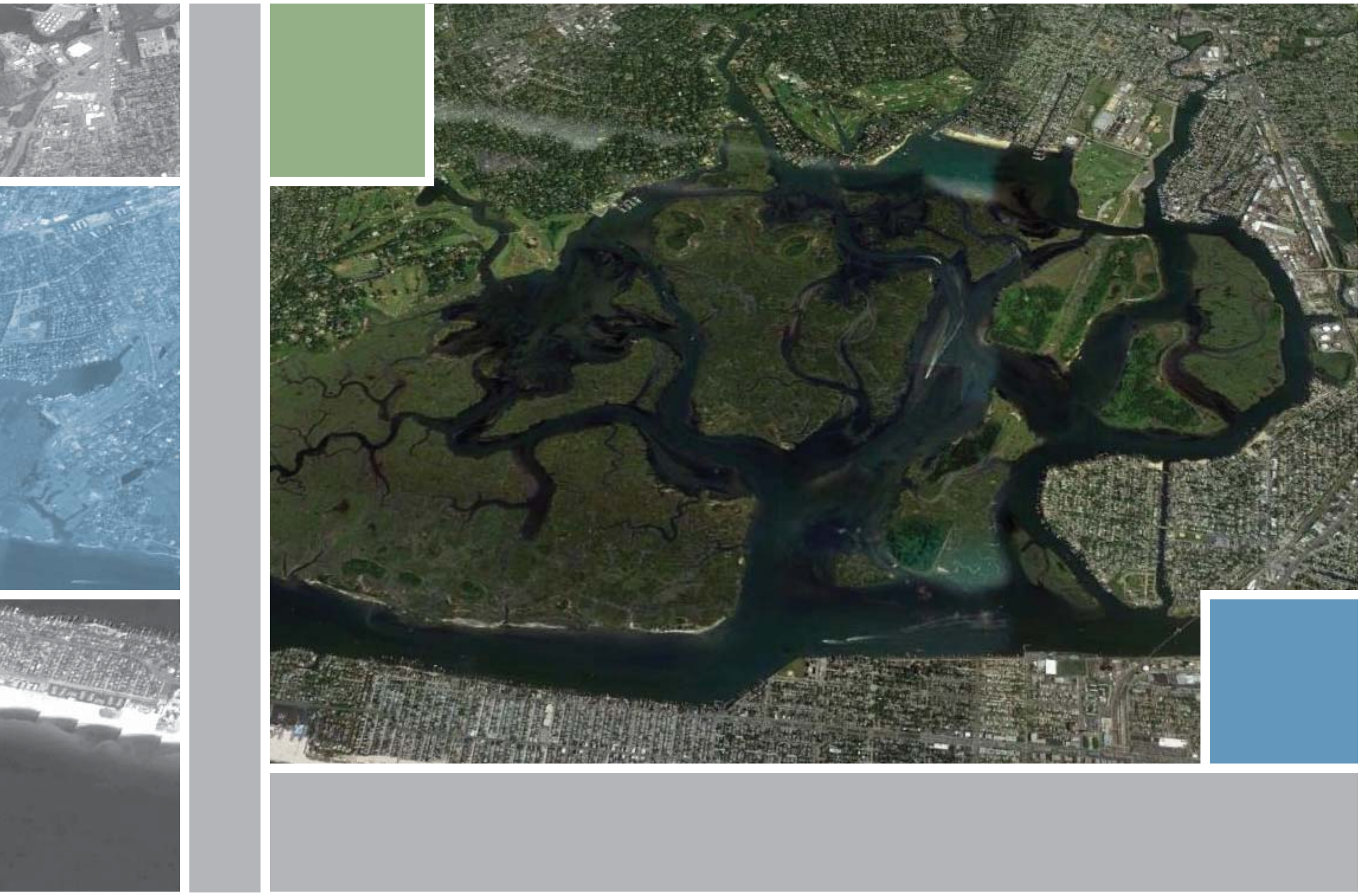
Nassau County
Department of Public Works



Water Quality Assessment of the Impact of the

Bay Park Sewage Treatment Plant

in the Days After Hurricane Sandy

February 2013

HDR | HydroQual

Table of Contents

Section Page

EXECUTIVE SUMMARY ES-1

1. INTRODUCTION 1-1

2. BAY PARK STP 2-1

2.1 PERMIT 2-1

2.3 INFLUENT AND EFFLUENT QUALITY DATA 2-3

3. SAMPLING PROGRAM 3-1

4. WATER QUALITY 4-1

5. SEDIMENT 5-1

6. COMPUTER MODELING 6-1

7. DISCUSSION/CONCLUSIONS 7-1

8. LITERATURE CITED 8-1

APPENDIX A TRC ANALYSIS

APPENDIX B FIELD SHEETS

APPENDIX C LABORATORY SHEETS

List of Figures

Figure | Page

Figure 1-1. Study Area ... 1-2
Figure 2-1. Bay Park STP Influent/Effluent Flow, TSS and BOD – 2012 ... 2-4
Figure 2-2. Bay Park STP Effluent Flow, TSS and BOD Percent Removal – 2012 ... 2-5
Figure 2-3. Bay Park STP Total and Fecal Coliform – 2012 ... 2-6
Figure 2-4. Bay Park STP Effluent Temperature and DO– 2012 ... 2-8
Figure 2-5. Bay Park STP Volume of Chlorination and Dechlorination Agents and Resulting Effluent TRC ... 2-9
Figure 3-1. Macy Channel Sampling Stations ... 3-7
Figure 3-2. Thixton Creek Sampling Stations ... 3-8
Figure 3-3. Grand Canal Sampling Stations ... 3-9
Figure 3-4. Mill River Sampling Stations ... 3-10
Figure 3-5. Parsonage Creek Sampling Stations ... 3-11
Figure 3-6. East Rockaway Channel Sampling Stations ... 3-13
Figure 3-7. West Hempstead Bay Sampling Stations ... 3-14
Figure 4-1. Water Quality Classifications ... 4-2
Figure 4-2. Rainfall Record at JFK International Airport – October 2012 – January 2013 ... 4-5
Figure 4-3. Temperature Data in Macy Channel, Thixton Creek and Grand Canal ... 4-6
Figure 4-4. Temperature Data in Mill River and Parsonage Creek ... 4-7
Figure 4-5. Salinity Data in Macy Channel, Thixton Creek and Grand Canal ... 4-9
Figure 4-6. Salinity Data in Mill River and Parsonage Creek ... 4-10
Figure 4-7. TSS Data in Macy Channel, Thixton Creek and Grand Canal ... 4-11
Figure 4-8. TSS Data in Mill River and Parsonage Creek ... 4-12
Figure 4-9. BOD_5 Data in Macy Channel, Thixton Creek and Grand Canal ... 4-13
Figure 4-10. BOD_5 Data in Mill River and Parsonage Creek ... 4-14
Figure 4-11. DO Data in Macy Channel, Thixton Creek and Grand Canal ... 4-16
Figure 4-12. DO Data in Mill River and Parsonage Creek ... 4-17
Figure 4-13. DO Percent Saturation Data in Macy Channel, Thixton Creek and Grand Canal ... 4-18
Figure 4-14. DO Percent Saturation Data in Mill River and Parsonage Creek ... 4-19
Figure 4-15. Total Coliform Data in Macy Channel, Thixton Creek and Grand Canal ... 4-20
Figure 4-16. Total Coliform Data in Mill River and Parsonage Creek ... 4-21
Figure 4-17. Fecal Coliform Data in Macy Channel, Thixton Creek and Grand Canal ... 4-23
Figure 4-18. Fecal Coliform Data in Mill River and Parsonage Creek ... 4-24
Figure 4-19. Enterococci Data in Macy Channel, Thixton Creek and Grand Canal ... 4-25
Figure 4-20. Enterococci Data in Mill River and Parsonage Creek ... 4-26
Figure 4-21. Lead Data in Macy Channel, Thixton Creek and Grand Canal ... 4-27
Figure 4-22. Lead Data in Mill River and Parsonage Creek ... 4-28

Figure 4-23. Zinc Data in Macy Channel, Thixton Creek and Grand Canal ... 4-29
Figure 4-24. Zinc Data in Mill River and Parsonage Creek ... 4-30
Figure 4-25. Temperature Data in West Hempstead Bay ... 4-32
Figure 4-26. Temperature Data in Reynolds Channel ... 4-33
Figure 4-27. Salinity Data in West Hempstead Bay ... 4-34
Figure 4-28. Salinity Data in Reynolds Channel ... 4-35
Figure 4-29. TSS Data in West Hempstead Bay ... 4-40
Figure 4-30. TSS Data in Reynolds Channel ... 4-41
Figure 4-31. BOD_5 Data in West Hempstead Bay ... 4-42
Figure 4-32. BOD_5 Data in Reynolds Channel ... 4-43
Figure 4-33. DO Data in West Hempstead Bay ... 4-44
Figure 4-34. DO Data in Reynolds Channel ... 4-45
Figure 4-35. DO Percent Saturation Data in West Hempstead Bay ... 4-46
Figure 4-36. DO Percent Saturation Data in Reynolds Channel ... 4-47
Figure 4-37. Total Coliform Data in West Hempstead Bay ... 4-49
Figure 4-38. Total Coliform Data in Reynolds Channel ... 4-50
Figure 4-39. Fecal Coliform Data in West Hempstead Bay ... 4-51
Figure 4-40. Fecal Coliform Data in Reynolds Channel ... 4-52
Figure 4-41. Enterococci Data in West Hempstead Bay ... 4-54
Figure 4-42. Enterococci Data in Reynolds Channel ... 4-55
Figure 4-43. Lead Data in West Hempstead Bay ... 4-56
Figure 4-44. Lead Data in Reynolds Channel ... 4-57
Figure 4-45. Mercury Data in West Hempstead Bay ... 4-58
Figure 4-46. Mercury Data in Reynolds Channel ... 4-59
Figure 4-47. Zinc Data in West Hempstead Bay ... 4-60
Figure 4-48. Zinc Data in Reynolds Channel ... 4-61
Figure 4-49. Comparison of Town of Hempstead and Bay Park Salinity Sampling Data ... 4-70
Figure 4-50. Comparison of Town of Hempstead and Bay Park Temperature Sampling Data ... 4-71
Figure 4-51. Comparison of Town of Hempstead and Bay Park DO Sampling Data ... 4-72
Figure 4-52. Comparison of Town of Hempstead and Bay Park Total Coliform Sampling Data ... 4-73
Figure 4-53. Comparison of Town of Hempstead and Bay Park Fecal Coliform Sampling Data ... 4-74
Figure 4-54. Comparison of Town of Hempstead and Bay Park Total Coliform Probability Distributions ... 4-75
Figure 4-55. Comparison of Town of Hempstead and Bay Park Fecal Coliform Probability Distributions ... 4-76
Figure 5-1. Sediment TOC and Percent Moisture Data ... 5-4
Figure 5-2. Sediment Arsenic and Barium Data ... 5-5
Figure 5-3. Sediment Cadmium and Chromium Data ... 5-6

Figure 5-4. Sediment Copper and Nickel Data 5-7
Figure 5-5. Sediment Iron and Lead Data 5-8
Figure 5-6. Sediment Selenium and Silver Data 5-9
Figure 5-7. Sediment Zinc and Mercury Data 5-10
Figure 5-8. Sediment Acenaphthylene and Dibenzo(ah)anthracene Data 5-11
Figure 5-9. Sediment Benzo(a)anthracene and Benzo(a)pyrene Data 5-12
Figure 5-10. Sediment Fluorene and Chrysene Data 5-13
Figure 5-11. Sediment Anthracene and Fluoranthene Data 5-14
Figure 5-12. Sediment Naphthalene and Phenanthrene Data 5-15
Figure 5-13. Sediment Pyrene Data 5-16
Figure 5-14. Sediment Benzo(b)fluoranthene and Benzo(ghi)perylene Data 5-17
Figure 5-15. Sediment Benzo(k)fluoranthene and Indeo(123-cd)pyrene Data 5-18
Figure 6-1. SUNY FVCOM Model Domain for the Great South Bay Model 6-2
Figure 6-2. SUNY FVCOM Model Segmentation in West Hempstead Bay 6-3
Figure 6-3. SUNY FVCOM Model Segmentation in northern West Hempstead Bay Including Macy Channel and East Rockaway Channel 6-4
Figure 6-4. Flushing Analysis using Particle Tracking in Macy Channel 6-6
Figure 6-5. Flushing Analysis using Particle Tracking in East Rockaway Channel 6-7
Figure 6-6. Flushing Analysis using Particle Tracking in Parsonage Creek 6-9

List of Tables

Table — Page

Table ES-1. Percent of Mass Remaining after 1, 3 and 7 days ES-5
Table 2-1. Bay Park STP Effluent Limits 2-1
Table 2-2. Bay Park Process Recovery Schedule 2-2
Table 3-1. Summary of Number of Parameters Analyzed 3-4
Table 3-2. Water Quality and Sediment Sampling Schedule 3-5
Table 3-3. Laboratory Methods 3-6
Table 4-1. Waterbody Classes 4-1
Table 4-2. Water Quality Standards 4-3
Table 4-3. Summary Statistics for Creek Stations 4-36
Table 4-4. Summary Statistics for Bay Stations 4-63
Table 4-5. Summary Statistics for Surface Coliform and Enterococci Data 4-65
Table 4-6. Summary Statistics for Mid-depth Coliform and Enterococci Data 4-66
Table 4-7. Enterococci Statistics Using 5 no./100 mL for Measurements less than the Detection Limit 4-67
Table 4-8. Comparison of Average Monthly DO concentrations between the Bay Park and Town of Hempstead Datasets for November and December 4-69
Table 5-1. Sediment Guidelines for Metals 5-2
Table 5-2. Sediment Guidelines for Organic Compounds 5-2
Table 6-1. Percent of Mass Remaining after 1, 3 and 7 days. 5-8
Table 7-1. Chlorine toxicity thresholds for estuarine fish and invertebrates commonly found in the Hempstead Bays - South Oyster Bay ecosystem. Source: USEPA (1985) 5-5

EXECUTIVE SUMMARY

The Bay Park Sewage Treatment Plant (STP) is located in East Rockaway, NY in the Town of Hempstead, and is operated by the Nassau County Department of Public Works. Under normal operating conditions, this STP discharges approximately 50 MGD of secondary treated effluent through a diffuser structure located in Reynolds Channel in West Hempstead Bay. West Hempstead Bay and its creeks are classified by NYSDEC as either SA, SB, or SC waterbodies.

On October 29, 2012, Hurricane/Superstorm Sandy slammed into the coast of New Jersey near Atlantic City. The wind and storm surge associated with this storm severely affected the Town of Hempstead and disrupted the operation of the Bay Park STP. The storm surge overwhelmed the STP knocking out its primary generators and backup generators, resulting in a complete loss of power to the STP's equipment. As a consequence, the STP could not receive or treat wastewater from its sewershed for approximately two and a half days.

As an emergency measure, portable pumps were set up to pump sewage out of the Bay Park interceptor and into local waterways. These portable pumps ran for approximately 48 hours, after which some power was restored to the STP, and sewage could be accepted by the plant. During the early portion of the repairs, the pumps required to force effluent out to the Reynolds Channel outfall during high tide were not yet operational, so a portion of the STP effluent flow was discharged at high tide through an emergency auxiliary outfall to the East Rockaway Channel near the STP. As a result, partially treated effluent was discharged to both East Rockaway Channel and Reynolds Channel. The STP was unable to provide full secondary treatment for approximately six to eight weeks after the storm.

Untreated or partially treated sewage introduced to a waterbody has the potential to impact human health and aquatic resources. In order to assess the potential impact of the discharge from the Bay Park STP, a water quality sampling and assessment program was rapidly put into place. The sampling program consisted of water quality and sediment constituents collected from 13 tributary stations and 17 bay stations during the period of November 6, 2012 through January 8, 2013. These data as well as STP influent and effluent data were used during November and December by Nassau County to assess potential impacts to the local residents. These data are presented herein to assess the potential impact of the effluent on the bay. In addition, hydrodynamic and particle tracking modeling was conducted with a pre-existing model by State University of New York (SUNY) Stony Brook's School of Marine and Atmospheric Sciences (SoMAS). This modeling was used to estimate flushing time of the effluent in various sections of the bay.

Repairs to the Bay Park STP started immediately after Sandy's surge waters receded, so that the plant could begin treating sewage as quickly as possible. Raw sewage pumps, influent screens, disinfection and temporary effluent pumping were up and running by November 1, 2012. The last of the treatment processes were operating by mid- to late-December. Disinfection began on

November 1, when the STP began accepting flow again, so the Bay Park STP never discharged high levels of coliform and enterococci. However, during a short period of time, high levels of pathogens entered the bay during the period when the temporary pumps were in operation. Primary settling tanks began operation on November 13 to more effectively remove solids and BOD. Dechlorination began on November 15 to reduce the effluent levels of chlorine being discharged by the STP. On November 23, the STP discontinued discharging effluent through the auxiliary outfall into the East Rockaway Channel, which ended the local effects of that discharge.

During the period from January through October 28, 2012 the STP removal efficiency was approximately 97 percent for TSS and 94 percent for BOD. During November after Hurricane Sandy, the removal efficiency was approximately 68 percent for TSS and 49 percent for BOD. By December, the STP had returned to its minimum 85 percent removal efficiency with 89 percent removal efficiency for TSS and 86 percent removal efficiency for BOD.

During the period of January through October 2012, the monthly median total coliform effluent concentration ranged from 80 to 325 no./100 mL, and the fecal coliform monthly geometric mean ranged from 6 to 39 no./100 mL. Soon after Hurricane Sandy, personnel at the Bay Park STP began manually disinfecting the wastewater. During November, the median total coliform concentration was less than 2 no./100 mL, and the fecal coliform geometric mean was less than 3 no./100 mL. As operations at the STP moved closer to normal during December, the median total coliform concentration was 9 no./100 mL, and the fecal coliform geometric mean was less than 3 no./100 mL.

The usage of NaOCl for disinfection and $NaHSO_3$ for dechlorination was disrupted in the weeks after Hurricane Sandy. During the first three-quarters of the year, disinfection and dechlorination was effective at reducing the effluent coliform to low levels and the chlorine levels to near 0 μg/L. After Hurricane Sandy, disinfection was handled manually and usage of $NaHSO_3$ declined to zero, resulting in higher effluent TRC during November. The effluent TRC concentrations increased to about 5 mg/L, but were as high as 13 mg/L during November. Effluent TRC levels returned to normal in December.

In order to assess the potential impact of these discharges, a sampling program was developed and implemented to quantify water quality and sediment conditions within the bay. Sampling included: temperature, salinity, pH, five-day biochemical oxygen demand (BOD_5), total suspended solids (TSS), dissolved oxygen (DO), metals and PAHs. Sampling stations were divided into 13 creek stations and 17 bay stations. The creek locations included tributaries that received raw sewage discharges (Macy Channel, Grand Canal, Mill River and Parsonage Creek) as well as one tributary that did not receive any discharge (Thixton Creek), which served as a reference site. The creek stations were used to assess the impact of the 48-hour discharge of raw sewage into the creeks. The bay stations were used to assess the longer-term discharge of partially treated effluent through the auxiliary outfall near the STP and the Reynolds Channel outfall. Receiving water sampling was conducted between November 6, 2012 and January 8, 2013.

The water quality data collected after Hurricane Sandy showed that water quality was somewhat adversely affected by the storm. The discharge of untreated and partially treated wastewater from the Bay Park STP could have contributed to the impact, but allocation of the contribution of impact to Bay Park cannot be made at this time. The data also shows that the impact was short-lived and that West Hempstead Bay and its tributaries returned to normal conditions by mid- to late-December. DO levels were below the 4.8 mg/L chronic NYS water quality standard on occasion in some of the tributaries during November including the reference tributary Thixton Creek. DO levels in the Creeks never went below the 3.0 mg/L acute NYS water quality standard. Coliform and enterococci concentrations exceeded standard concentrations during November, but were significantly lower during December.

In the bay, DO concentrations were above the DO standard for the entire sampling period at all of the locations that were visited. As the NYSDEC dissolved oxygen standards are set to be protective of biota in all life stages and measured dissolved oxygen concentrations were in compliance with those standards, although possibly somewhat depressed for a period, it is not be expected that there would have been any short or long term impacts on biota.

Coliform and enterococci concentrations exceeded standards during November, but were significantly lower during December. Enterococci geometric means continued to be above 35 no./100 mL during December. Bay Park STP effluent data indicate that chlorination was effective during December, which suggests elevated bacteria levels were from a source other than the STP. Pathogen standards are typically set for two reasons: protection of humans against contact with infectious organisms and protection of humans from consuming shellfish contaminated from the uptake of pathogenic organisms. For the periods of time, pathogen concentrations were observed to be elevated above allowable NYSDEC standards, it would not be expected that local residents would have been exposed to them from swimming or secondary contact recreation because of (a) the fact the storm occurred well outside of the summer recreational period and (b) the other impacts of the hurricane (lack of power to homes, damage to homes, damage to recreation vessels, etc.) generally kept residents out of the impacted waters. With respect to the issue of consumption of contaminated shellfish, residents were not observed by the field sampling crews to be out in the creeks and/or bay shellfishing for the same reasons that residents were not using the waters for recreation.

TRC was not measured in the bay or creek as part of the sampling program. Only after reviewing the STP effluent data did it become apparent that TRC could have potentially impacted water quality and aquatic biota post-Sandy. To protect organisms from TRC toxicity, NYSDEC has promulgated TRC criteria for New York State based on Ambient Water Quality Criteria for Chlorine (USEPA 1985). A chronic standard of 7.5 μg/L and an acute standard of 13 μg/L have been chosen by the NYSDEC using guidance from EPA research. The Bay Park STP effluent chlorine residual concentration that was measured to be between approximately 2-10 mg/L during November, with occasional measurements above this range, represents a concentration that was more than a factor of 10 greater than the permit limits for the facility. Assuming a 10:1 dilution through the outfall or within East Rockaway Channel, it is estimated that the concentration of residual chlorine as it entered the receiving waters of Hempstead Bay or TRC during the critical monitoring period was in the range of 0.2 - 1 mg/L, or 200 to 1,000 μg/L. Although the field sampling crews did not observe any obvious impacts of these elevated residual chlorine concentration on biota during the time they were in the field, impacts could be expected.

The timing of the storm and subsequent Bay Park STP failure was, to some degree, fortuitous with regard to impacts to estuarine organisms. Most fish and shellfish in temperate estuaries spawn approximately between April and July. Thus, the likelihood of very sensitive early life stages (larvae and post-larvae) of most fish and shellfish present in the area of the elevated chlorinated effluent discharge was remote. Furthermore, adult finfish have the ability to move away from areas of poor water quality; larvae and early juveniles lack the motility of adults. However, sessile invertebrates (e.g., mussels, oysters, clams, scallops) are only able to avoid potentially toxic water quality conditions by cessation of feeding (filtration) activity. In addition, estuarine/marine organisms are more sensitive to chorine produced oxidants when subjected to elevated temperatures (thermal stress). Had the Bay Park STP failure occurred during mid-summer, the potential for increased toxicity to early life stages as well as adult fish and invertebrates in Hempstead Bay would have been much greater.

In addition, to direct sampling of water quality within the creeks and bay, mathematical computer modeling is a valuable tool in assessing the impacts of pollutant sources on water quality. Although a fully calibrated mathematical water quality model does not exist for the waters impacted by the Bay Park STP discharge, the SUNY School of Marine and Atmospheric Sciences (SoMAS) has a hydrodynamic model of the Great South Bay coastal lagoonal system of Long Island. The model is particularly suited to applications where the advection and mixing of salt, heat, nutrients, and biological constituents are important issues. An existing hydrodynamic model simulation was used as part of this impact assessment to provide insight to the potential impacts of the discharge of poorly treated Bay Park STP sewage through the assessment of flushing times. The model was applied for a series of screening level simulations to provide additional information beyond what the sampling program provided.

In portions of the bay, particles were released into the model at locations of known discharges, and tracked to assess flushing time. To simulate the discharge of raw sewage into the tidal creeks, particles were released for 36 hours and then tracked to determine how long it takes for the particles to leave the tributary. This modeling was conducted in Macy Channel, East Rockaway Channel (Mill River), and Parsonage Creek. Table ES-1 summarizes the fraction of particles (or mass) remaining after the cessation of raw discharge. These estimates are all approximate since the tributaries are not perfectly represented by the model, the tidal and weather conditions are not the same as the post-storm tides, and the temperature changes over time, which affects the decay and die-off rates. It is also possible that more flushing occurred after Hurricane Sandy due to the extreme water levels during the storm.

For Macy Channel, the calculations suggest that within a week of the cessation of the raw sewage, the vast majority of the BOD and bacteria had been flushed out or decayed away. Thus, any impact from the discharge was short-lived. For Mill River, the model indicates that approximately two-thirds of a theoretical conservative substance that was in the tributary at the end of the 36-hour discharge period would remain in the tributary after a week. Since BOD associated with raw sewage and bacteria have high decay and die-off rates, less than 10 percent of these substances would be expected to remain in the tributary after seven days. In Parsonage Creek, the particles exit the tributary quite rapidly. At the end of the 36-hour discharge period, the majority of the particles have been flushed out. Over the next 24-hour period, nearly three-quarters of the particles that had remained were flushed out. After three days the particles dissipate very slowly. The modeling suggests that once the discharge raw sewage reached the mouth of Parsonage Creek, it was flushed away rapidly.

Table ES-1. Percent of Mass Remaining after 1, 3 and 7 days.

		Percent remaining after 1, 3, 7 Days								
		Macy Channel			**East Rockaway Channel**			**Parsonage Creek**		
Substance	Rate (/d)	1	3	7	1	3	7	1	3	7
Conservative		73	55	34	93	80	66	27	11	8.2
BOD	0.275	55	24	5	70	35	9.7	20	4.7	1.2
Coliform	0.68	37	7.1	0.3	47	10	0.6	14	1.4	0.07
Enterococci	0.62	39	8.5	0.4	50	12	0.9	14	1.7	0.1

The results of these model simulations show that within a few days of the cessation of a discharge into the local creeks, pathogen concentrations would be reduced significantly through the process of flushing by tide water and the natural decay of these organisms in the salt water environment. Depending on the waterway, pathogen concentrations would be expected to be reduced by a factor of more than 100:1 seven days after the end of the discharge of sewage into the creek.

Based on the data collected, it does not appear that there is any need for any remedial actions to improve water quality as a result of discharges from the Bay Park STP during and right after Hurricane Sandy. Impacts to water quality after Hurricane Sandy were short-lived and caused by a number of factors. These factors include: the discharge of untreated and partially treated sewage, stormwater runoff, the resuspension of bay and creek sediments, and runoff associated with the storm's tidal surge. Based on the December water quality data, water quality has returned to normal conditions.

SECTION 1

INTRODUCTION

The Bay Park Sewage Treatment Plant (STP) is located in East Rockaway, NY in the Town of Hempstead, and is operated by the Nassau County Department of Public Works (County). This STP serves approximately 40 percent of Nassau County and is permitted at a dry-weather capacity of 70 MGD. Under normal operating conditions, the STP discharges secondary treated effluent through a diffuser structure located in Reynolds Channel in West Hempstead Bay.

West Hempstead Bay (Figure 1-1) is a shallow tidal embayment along the southern coast of Long Island. The bay includes sheltered shallow bays and salt marsh islands connected by interconnected channels and tidal creeks. There are no sizable freshwater tributaries entering the bay. The portion of Hempstead Bay of interest for this project is West Hempstead Bay which includes: Brosewere Bay in the west, Hewlett Bay in the north, East Rockaway Channel to the east and Reynolds Channel to the south. East Rockaway Inlet connects West Hempstead Bay with the Atlantic Ocean on its western end.

On October 29, 2012, Hurricane/Superstorm Sandy slammed into the coast of New Jersey near Atlantic City. Winds greater than 90 mph were reported. The storm produced a tidal surge as high as 13 ft in some areas. The storm surge overwhelmed the STP disrupting operations and ultimately causing the STP to shutdown. As a consequence, the STP could not receive or treat wastewater from its sewershed.

As an emergency measure, portable pumps were set up to pump sewage away from the Bay Park interceptor and subsequently discharging into local waterways. By pumping from the interceptor the County was attempting to prevent or limit sewage from backing into homes and overflowing into streets. Beginning at midnight on October 31, these portable pumps ran for approximately 48 hours, after which power was restored to the STP, and sewage could be accepted by the plant. After 48 hours, the plant could accept sewage, but the STP could not treat wastewater at the level achieved before the storm. Additionally, the pumps required to force effluent out to the Reynolds Channel outfall during high tide were not yet operational, so a portion of its flow was discharged at high tide through an auxiliary outfall to the East Rockaway Channel near the STP. As a result partially treated effluent was discharged to both East Rockaway Channel and Reynolds Channel.

Untreated or partially treated sewage introduced to a waterbody has the potential to impact human health and aquatic resources. In order to assess the potential impact of the discharge from the Bay Park STP, a water quality sampling and assessment program was created. The sampling program consisted of water quality and sediment constituents collected from 13 tributary stations

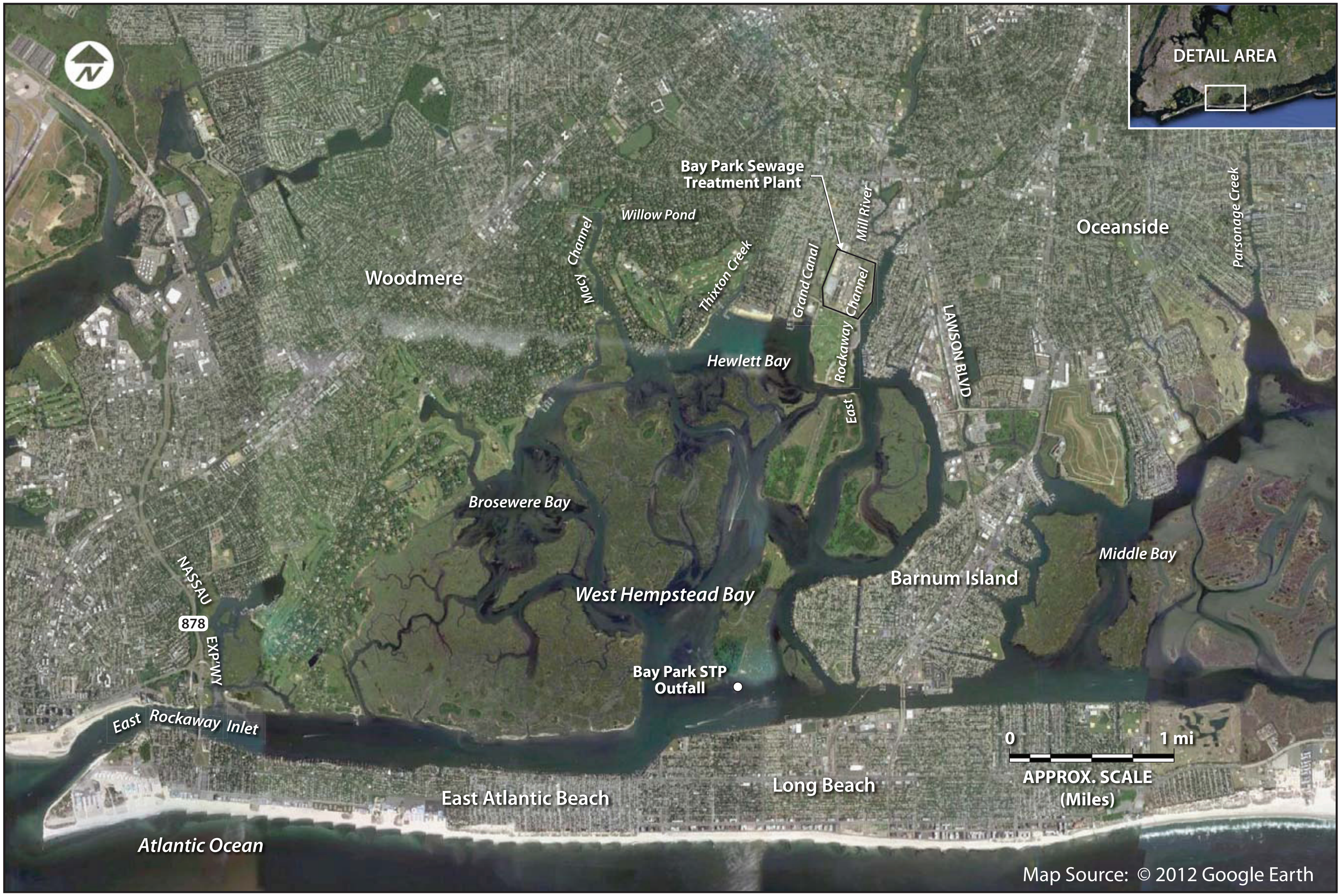


Figure 1-1. Study Area

and 17 bay stations during the period of November 6, 2012 through January 8, 2013. These data as well as STP influent and effluent data were used to assess the potential impact of the effluent on the bay. In addition, hydrodynamic and particle tracking modeling was conducted with a pre-existing model by State University of New York (SUNY) Stony Brook's School of Marine and Atmospheric Sciences (SoMAS). This modeling was used to estimate flushing time of the effluent in various sections of the bay.

This report presents the results of the sampling program as well as conclusions that were developed based on the data and modeling results.

SECTION 2

BAY PARK STP

2.1 PERMIT

The Bay Park STP operates under SPDES permit number NY-002-6450. The permit limits the STP to a monthly average flow of 70 MGD, and limits effluent TSS and $CBOD_5$ to 15 percent of the influent concentration. Effluent disinfection is required year round and the maximum total residual chlorine (TRC) effluent limit is 0.5 mg/L. The minimum allowable DO concentration in the effluent is 2.0 mg/L. Table 2-1 presents a subset of the STP's effluent limits. Under normal operating conditions the STP discharges to a diffuser in the Reynolds Channel at 40° 35' 45" N latitude and 73° 40' 34" W longitude.

Table 2-1. Bay Park STP Effluent Limits

Parameter	Type	Effluent Limit			
		Limit	Units	Limit	Units
Flow	Monthly Avg	70	mgd		
$CBOD_5$	Monthly Avg	25	mg/l	15,000	lb/d
$CBOD_5$	7 Day Avg	40	mg/l	23,000	lb/d
BOD_5	6 cons hr sample mean	50	mg/l		
Solids, Suspended	Monthly Avg	30	mg/l	18,000	lb/d
Solids, Suspended	7 Day Avg	45	mg/l	26,000	lb/d
Solids, Suspended	6 cons hr sample mean	50	mg/l		
Coliform, Fecal	30 Day Geometric Mean	200	No./100 ml		
Coliform, Fecal	7 Day Geometric Mean	400	No./100 ml		
Chlorine, Total Residual	Daily Max	0.5	mg/l		
Coliform, Total	Monthly median	700	No./100 ml		
Coliform, Fecal	6 hr geometric mean	800	No./100 ml		
Coliform, Fecal	Individual sample	2400	No./100 ml		
Copper, Total	Daily Max	24	lb/day		
Mercury, Total	Daily Max	200	ng/l		

2.2 REPAIR TIMELINE

The tidal surge associated with Hurricane Sandy left six feet of floodwaters at the STP, damaging much of the plant's infrastructure. Repairs to the Bay Park STP started immediately after Sandy's surge waters receded, so that the plant could begin treating sewage as quickly as possible. Table 2-2 presents a timeline of the process recovery schedule. Raw sewage pumps, influent screens, disinfection and temporary effluent pumping were up and running by November 1, 2012. The last of the treatment processes were operating by mid- to late-December. During the two month period from November through December, the STP could not treat incoming sewage to the level that was achieved before the storm.

Disinfection began on November 1 when the STP began accepting flow again, so the Bay Park STP never discharged high levels of pathogens.. However, during a short period of time, high levels of pathogens entered the bay during the period when the temporary pumps were in operation. Primary settling tanks began operation on November 13 to more effectively remove solids and BOD. Dechlorination began on November 15 to reduce the effluent levels of chlorine being discharged by the STP. On November 23, the STP discontinued discharging effluent through the auxiliary outfall to the East Rockaway Channel, which ended the local effects of that discharge.

Table 2-2. Bay Park Process Recovery Schedule

Date	Process Area of Equipment
November 1, 2012	Raw Sewage Pumps
November 1, 2012	Influent Screens
November 1, 2012	Disinfection (Manual/Gravity)
November 1, 2012	Temporary Effluent Pumping System
November 5, 2012	Central Heating Facility/Boilers
November 6, 2012	Aeration Tanks/Process Air Blowers
November 12, 2012	Temporary Sludge Dewatering Facility (Synagro)
November 12, 2012	Sludge Storage Tanks; Sludge Circulation Pumps/HX; Gas Compressors
November 12, 2012	Primary Digestors
November 12, 2012	Secondary Digestors
November 13, 2012	Primary Settling Tanks/Primary Sludge Pumping
November 14, 2012	Grit Collection
November 15, 2012	Dechlorination (Manual Control/Pumped)
November 15, 2012	Return Activated Sludge Pumping /WAS
November 20, 2012	Effluent Tide Pump (Tide Pump #2)
November 21, 2012	Final Settling Tanks (#2, 3 and 4)
November 23, 2012	Last Recorded Discharge to East Rockaway Channel

Table 2-2. Bay Park Process Recovery Schedule

Date	Process Area of Equipment
November 26, 2012	Sludge (Waste Activated Sludge) Thickening/Temporary GBTs (Synagro)
November 30, 2012	6-10 Final Clarifiers in Full Service
December 4, 2012	10 Final Clarifiers Running 44-50 Collectors
December 10, 2012	Effluent Screens Operational but waiting for EW?
December 16, 2012	10 Final Clarifiers Operational; All Collector Drives
December 20, 2012	2 Effluent Screens in Operation

2.3 INFLUENT AND EFFLUENT QUALITY DATA

Flow, BOD and TSS

The damage to the Bay Park STP suffered from Hurricane Sandy, and the subsequent repairs had an impact on the STP's treatment levels and effluent quality. Figure 2-1 presents the Bay Park daily average effluent flow, influent and effluent TSS concentrations, and influent and effluent BOD concentrations during the calendar year 2012. (Note: BOD and TSS concentrations greater than 500 mg/L are not shown.) The impact of Hurricane Sandy is readily apparent. During the first 10 months of the year, the STP operated at a flow of approximately 50 MGD and achieved high levels of TSS and BOD removal. After the storm impacted the STP, flows increased, influent BOD and TSS concentrations decreased presumably due to infiltration. A few days later when the flow returned to normal levels effluent TSS and BOD concentrations increased. As the STP became more operational during November and December, flows and effluent TSS and BOD concentrations returned to pre-Sandy levels by the end of December. Figure 2-2 presents the TSS and BOD STP data in terms of percent removal. During the period from January through October 28, 2012 the STP removal efficiency was approximately 97 percent for TSS and 94 percent for BOD. During November, the removal efficiency was approximately 68 percent for TSS and 49 percent for BOD. By December, the STP had returned to its minimum 85 percent removal efficiency with 89 percent removal efficiency for TSS and 86 percent removal efficiency for BOD.

Total and Fecal Coliform

The Bay Park STP flow and effluent concentrations for total and fecal coliform during 2012 are presented in Figure 2-3. During the period of January through October 2012, the monthly median total coliform effluent concentration ranged from 80 to 325 no./100 mL, and the fecal coliform monthly geometric mean ranged from 6 to 39 no./100 mL. Soon after Hurricane Sandy, personnel at the Bay Park STP began manually disinfecting the wastewater. During November, the median total coliform concentration was less than 2 no./100 mL, and the geometric mean was less

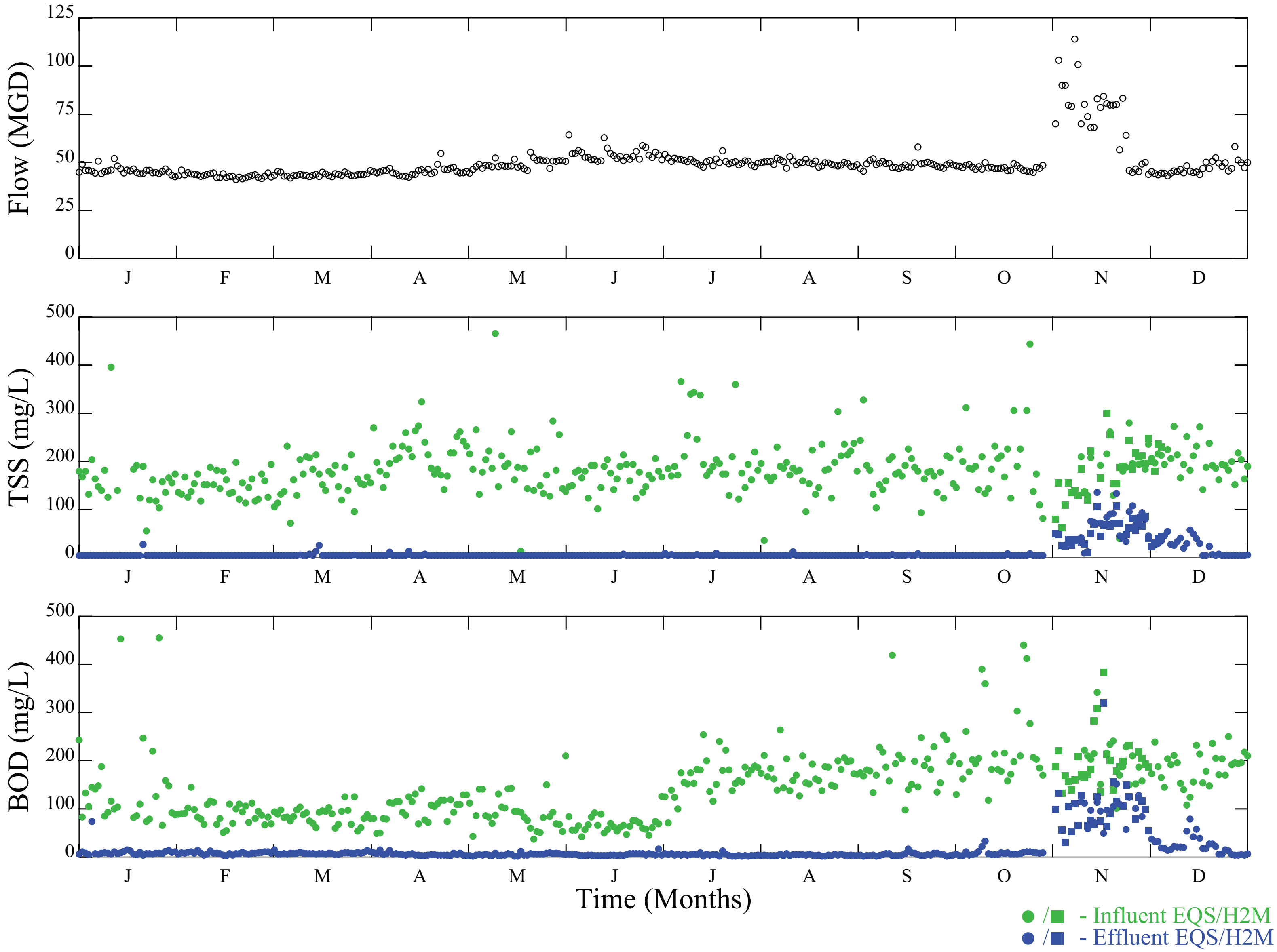


Figure 2-1. Bay Park STP Influent/Effluent Flow, TSS and BOD - 2012

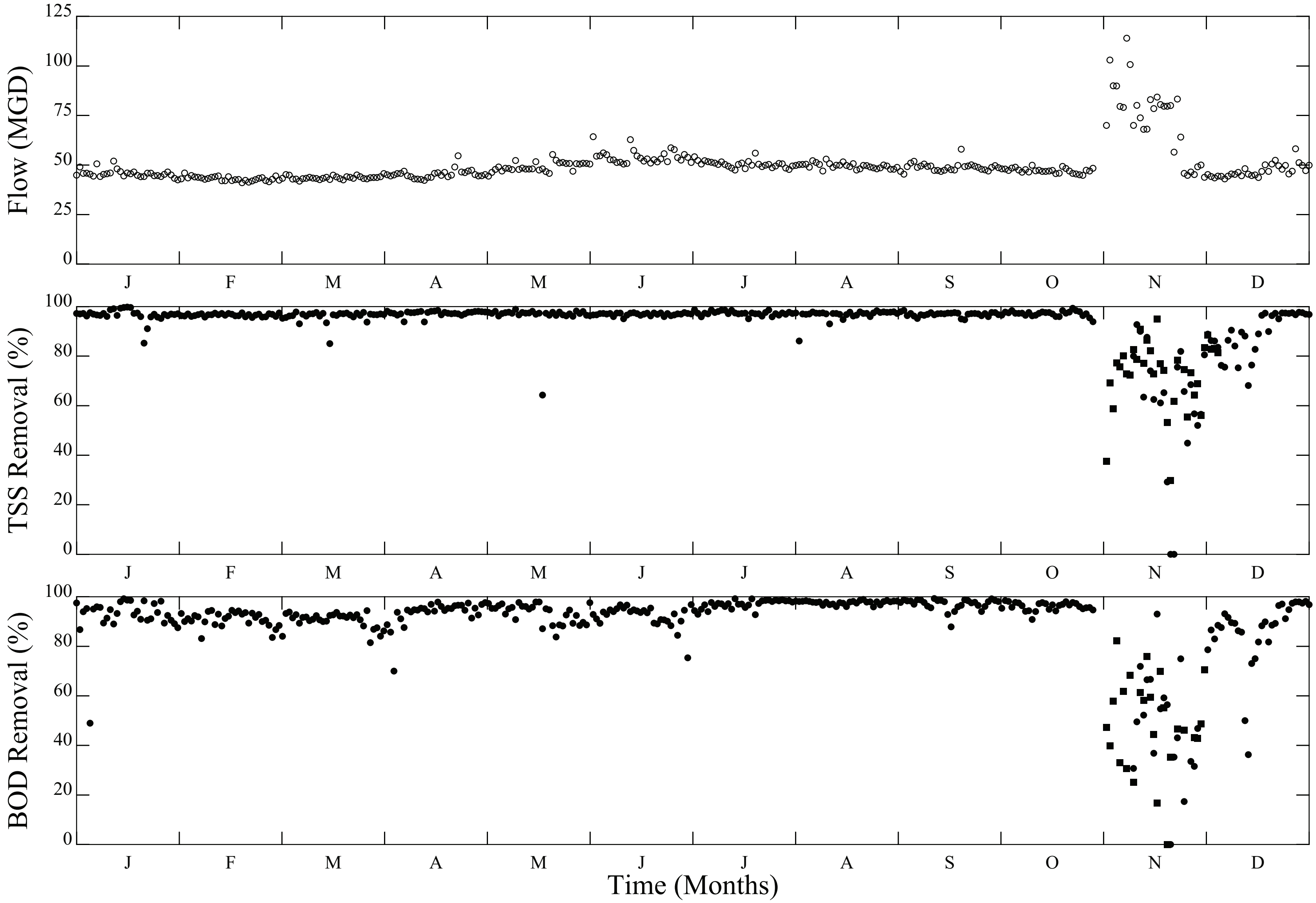


Figure 2-2. Bay Park STP Effluent Flow, TSS and BOD Percent Removal - 2012

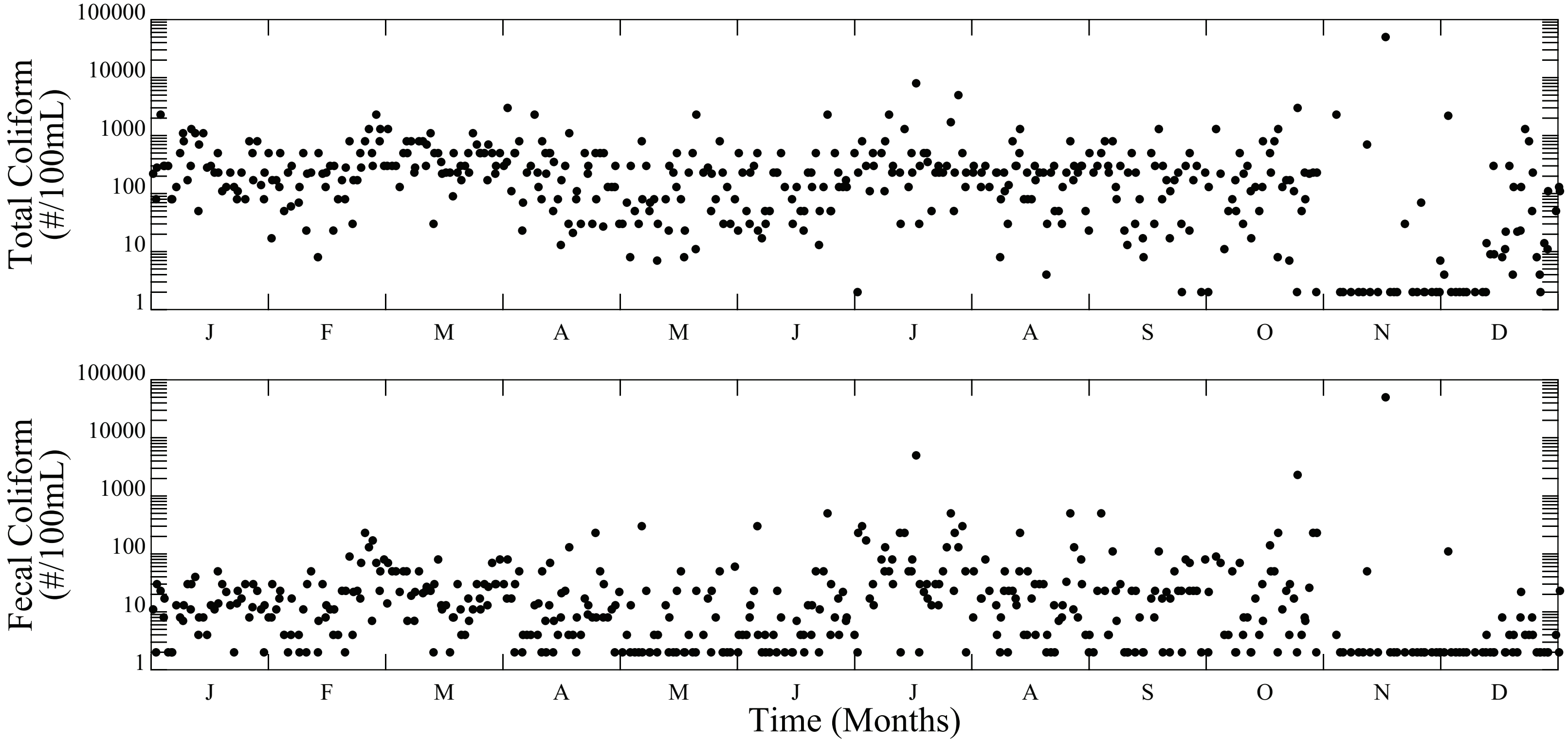


Figure 2-3. Bay Park STP Total and Fecal Coliform - 2012

than 3 no./100 mL. As operations at the STP moved closer to normal during December, the median total coliform concentration was 9 no./100 mL, and the fecal coliform geometric mean was less than 3 no./100 mL.

There was some question as to whether or not the effluent coliform levels were actually as low as reported during November, or if the effluent samples continued to be disinfected in the sample container due to high chlorine dosing, a lack of dechlorination at the STP, or potentially inadequate dechlorination of the sample itself. Based on a review of the sampling and testing procedures, it appears that the coliform levels were as low as reported. The lab uses Nasco Whirl-Pak sample bags, and each 100 ml sample bag contains 30 mg active sodium thiosulfate to neutralize chlorine. These bags meet the National Environmental Laboratory Accreditation Conference (NELAC) standard for sampling waste water treated with 15 mg/l of chlorine, which appears to be enough to meet the demand created by the effluent chlorine for the vast majority of cases.

So aside from the 48-hour when emergency portable pumps were being used it appears that the treatment plant was able to effectively disinfect its effluent.

Temperature and Dissolved Oxygen (DO)

Effluent temperature and DO during 2012 for the Bay Park STP are presented in Figure 2-4. The temperature results are unremarkable and show a slight decrease during November relative to the overall annual trend in temperature. DO levels show more variability after Hurricane Sandy than before it, but the effluent DO concentrations remained above the permit requirement of 2 mg/L for the entire year. Figure 2-5 presents the actual dosages of sodium hypochlorite (NaOCl) used for disinfection and sodium bisulfite ($NaHSO_3$) used for dechlorination in gallons per day, and the resulting daily average TRC effluent concentration. The number of gallons of NaOCl used daily remains relatively constant through the first half of the year and then increases during July. After Hurricane Sandy, the dosage of NaOCl becomes more variable and often higher during November. Dosage rates return to pre-Sandy levels during December. The application of $NaHSO_3$ is variable during the first three-quarters of the year, but is effective at reducing the chlorine levels to near 0 μg/L. After Hurricane Sandy knocked out the dechlorination facility, usage of $NaHSO_3$ declined to zero during November and the effluent TRC concentration increased. The effluent TRC concentrations increased to about 5 mg/L, but were as high as 13mg/L for most of November. Effluent TRC levels returned to normal in December.

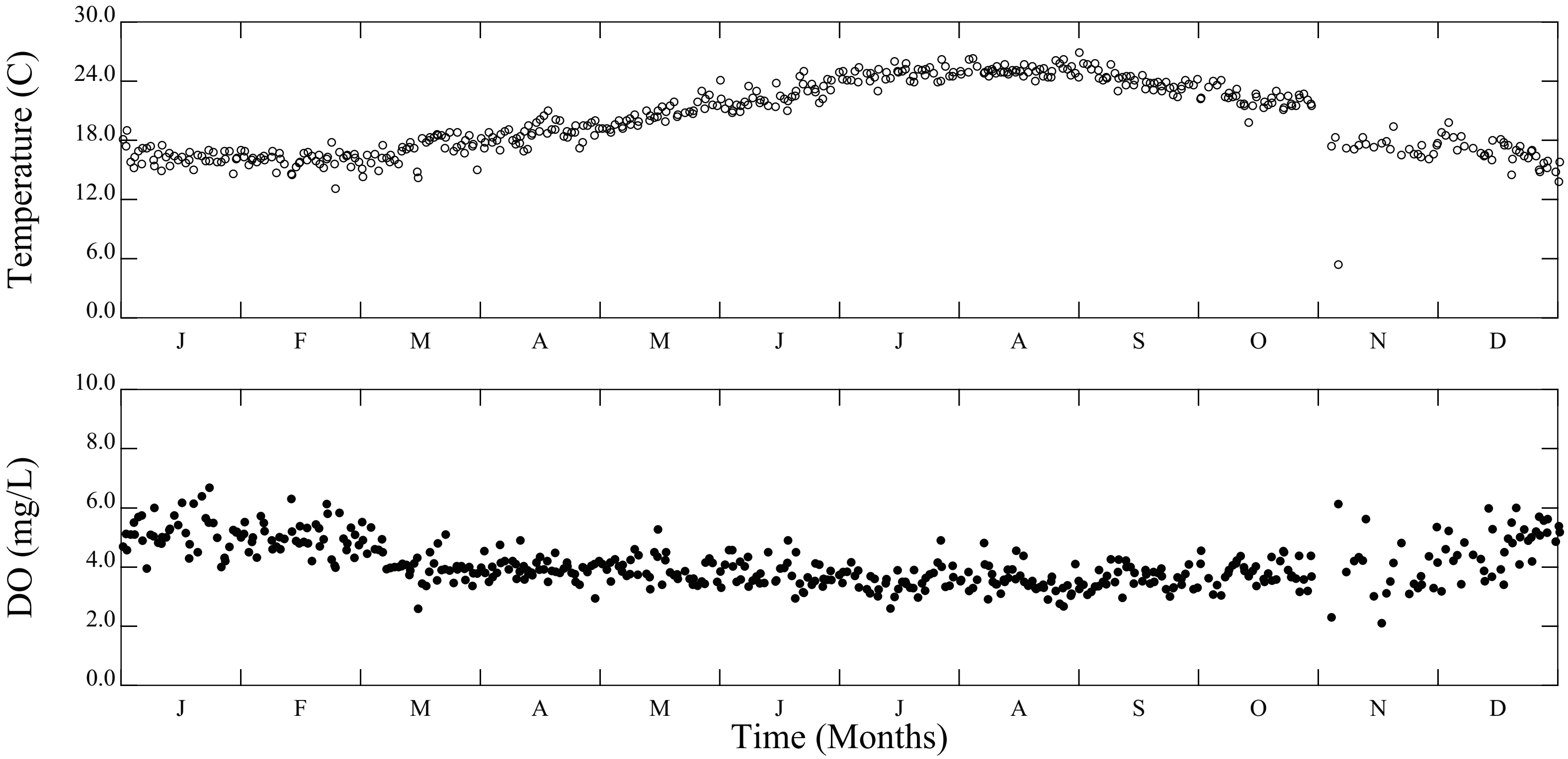


Figure 2-4. Bay Park STP Effluent Temperature, DO and TRC - 2012

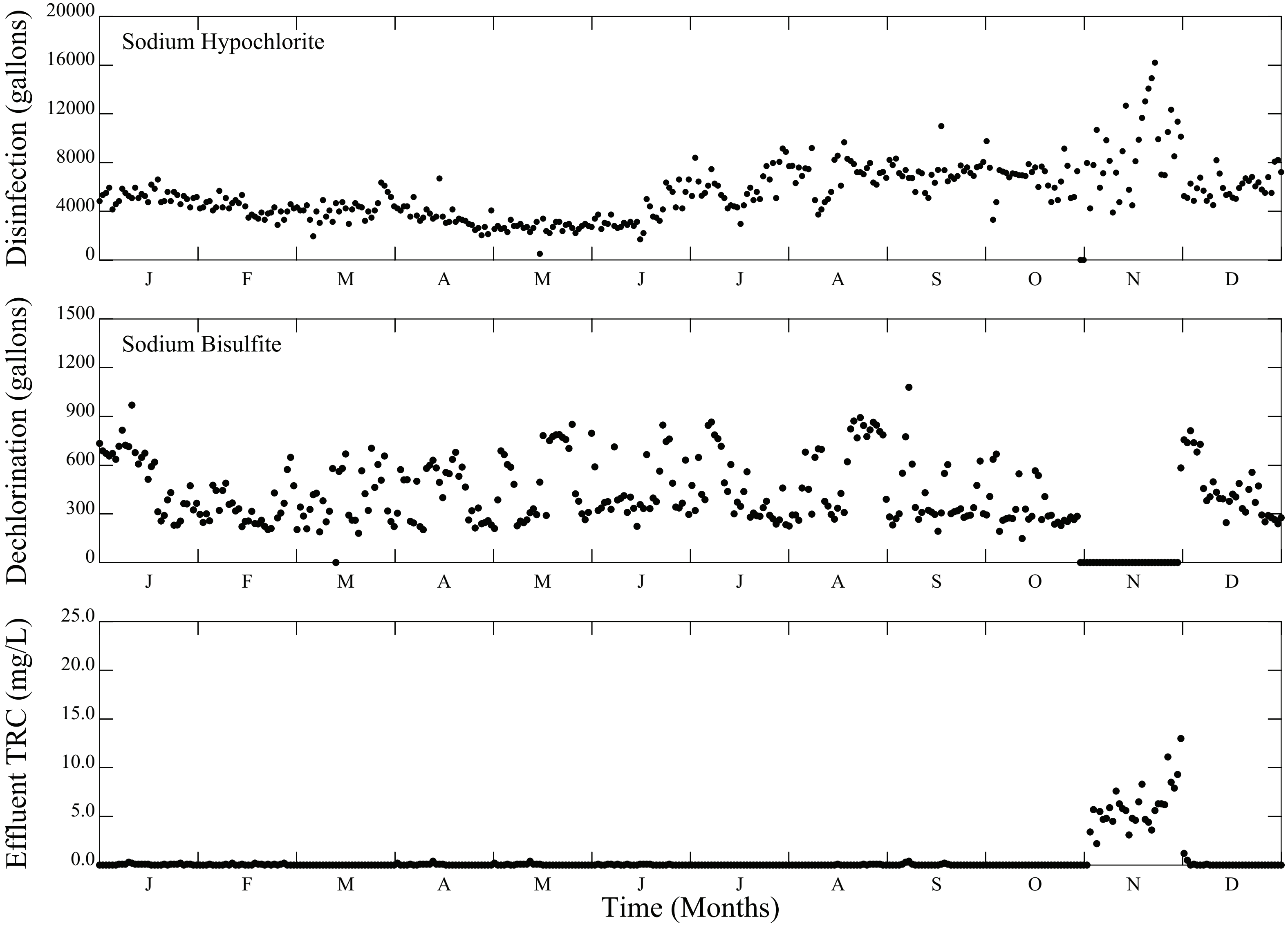


Figure 2-5. Bay Park STP Volume of Chlorination and Dechlorination Agents and Resulting Effluent TRC

Metals and PAHs

The Bay Park STP has permit limits for two metals: copper (24 lb/d) and mercury (200 ng/L), as well as action levels for cadmium, nickel, lead, zinc and chromium. There are also monitoring action levels for several polycyclic aromatic hydrocarbons (PAH). The STP is not designed to remove metals and PAHs, but is able to remove some of these constituents that adhere to suspended solids in the settling processes. A review of the 2012 data indicates that the effluent limit for copper was exceeded on November 15 and 20, 2012. These exceedances were related to a combination of unusually high daily flows (78.5 MGD and 80.0 MGD) and higher than normal effluent concentrations (37 and 78 μg/L). All the other metal effluent concentrations were below the limits or action levels.

Four PAHs: benzo(a)anthracene, benzo(k)fluoranthene, diethyl phthalate, and pentachlorophenol, were listed as exceeding the permit limit during November, but this appears to be entirely due to limits of detection that were four times higher during this month than any other month. All of these PAHs were measured below the detection limit. To obtain the effluent load, the detection limits were multiplied by the flow and the appropriate conversion factor. There were no other reports of PAHs exceeding the permit limits during 2012.

SECTION 3

SAMPLING PROGRAM

Raw and partially treated sewage was discharged into West Hempstead Bay and some of its tributaries in the aftermath of Hurricane Sandy. In order to assess the potential impact of these discharges, a sampling program was developed and implemented to quantify water quality and sediment conditions within the bay. Sampling stations were divided into 13 creek stations and 17 bay stations. The creek stations were used to assess the impact of the 48-hour discharge of raw sewage into the creeks. The bay stations were used to assess the longer-term discharge of partially treated effluent through the auxiliary outfall near the STP and the Reynolds Channel outfall. Receiving water sampling was conducted between November 6, 2012 and January 8, 2013.

Sampling Parameters

The following is a list of parameters used to assess water quality and sediment conditions in the creeks and bay. The parameters were chosen to assess whether there were potential exceedances of water quality standards. The chosen parameters were not meant to be an exhaustive list of all possible standard exceedances, only those that had a greater likelihood.

Field Measurements (surface, mid-depth and bottom):

- Temperature
- Salinity
- Dissolved Oxygen
- pH

Laboratory Measurements – Water Quality (surface and mid-depth)

- BOD_5
- TSS
- Total coliform
- Fecal coliform
- Enterococci
- Metals
  - Cadmium
  - Chromium
  - Copper
  - Lead
  - Mercury
  - Nickel
  - Silver
  - Zinc

- PAHs
    - 2-Methylnaphthalene
    - Acenaphthene
    - Acenaphthylene
    - Anathracene
    - Benzo(a)anthracene
    - Benzo(b)pyrene
    - Benzo(b)fluoranthene
    - Benzo(g,h,i)perylene
    - Benzo(k)fluoranthene
    - Chrysene
    - Dibenzo(a,h) anthracene
    - Fluoranthene
    - Fluorene
    - Indeo(1,2,3,cd)pyrene
    - Naphthalene
    - Phenathrene
    - Pyrene

Laboratory Measurements – Sediment (surface 1 cm)

- Total organic carbon (TOC)
- Metals
    - Cadmium
    - Chromium
    - Copper
    - Lead
    - Mercury
    - Nickel
    - Silver
    - Zinc
- PAHs
    - 2-Methylnaphthalene
    - Acenaphthene
    - Acenaphthylene
    - Anathracene
    - Benzo(a)anthracene
    - Benzo(b)pyrene
    - Benzo(b)fluoranthene

- Benzo(g,h,i)perylene
- Benzo(k)fluoranthene
- Chrysene
- Dibenzo(a,h)anthracene
- Fluoranthene
- Fluorene
- Indeo(1,2,3,cd)pyrene
- Naphthalene
- Phenathrene
- Pyrene

Table 3-1 presents a list of the number of samples taken for each constituent in the creeks and in the bay. Table 3-2 presents the schedule for the sampling events

Lab Methods

Table 3-3 presents the laboratory methods used to measure the chosen constituents. The field measurements for DO, temperature, and salinity were collected via Yellow Springs, Inc. (YSI) handheld meters, model # 85 and model # Pro2030. pH was taken with a separate meter, the Oakton pH pen model # pHTestr10.

Table 3-1. Summary of Number of Parameters Analyzed

	Water Column Samples											
Week	**Creek Sites (13)**	**Field**	**Pathogens**	**BOD & TSS**	**Metals**	**PAHs**	**Bay Sites (16) + Discharge**	**Field**	**Pathogens**	**BOD & TSS**	**Metals**	**PAHs**
Wk 1 (Nov 5)	13	1	1	1	1	1	16	1	1	1	1	1
Wk 2 (Nov 12)	13	1	1	1	1	1	16	2	2	2	2	2
Wk 3 (Nov19)							16	1	1			
Wk 4 (Nov 26)							17	2	2			
Wk 5 (Dec 3)							17	2	2			
Wk 6 (Dec10)	13	1	1	1	1		17	1	1	1		
Wk 7 (Dec 17)							17	2	2	1	1	1
Wk 8 (Dec 24)							12	1	1	1	1	1
Wks 9-10 (Dec 31, Jan 7)	13	1	1				5	1	1	1	1	1
Total Events		**4**	**4**	**3**	**3**	**2**		**12**	**12**	**6**	**5**	**5**
Total Samples		**140**	**96**	**72**	**72**	**48**		**585**	**390**	**188**	**154**	**154**

Total Samples includes surface, mid-depth and bottom when appropriate

	Sediment Samples							
Week	**Creek Sites (13)**	**TOC**	**Metals**	**PAHs**	**Bay Sites (16) + Discharge**	**TOC**	**Metals**	**PAHs**
Wk 10 (Jan 7)*	13	1	1	1	17	1	1	1
Total Events		**1**	**1**	**1**		**1**	**1**	**1**
Total Samples		**13**	**13**	**13**		**17**	**17**	**17**

*Creek sediment samples done on January 8, 2012. Bay sediment samples done on January 3, 2013 along with 5 missing Bay water col samples.

Table 3-2. Water Quality and Sediment Sampling Schedule

Sampling Date	Creek Sites (13)													Bay Sites (16+1)																
	MC-1	MC-2	MC-3	TX-1	TX-2	C-1	C-2	C-3	MR-1	MR-2	P-1	P-2	P-3	ERC-1	ERC-2	ERC-3	ERC-4	TH-3	TH-4	TH-6	TH-6A	TH-7	TH-10	B-2B	B-3A	B-3B	B-4A	B-4B	B-6C	Discharge
11/6/2012	x	x		x	x	x	x	x																						
11/7/2012			x						x	x																				
11/9/2012											x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	
11/13/2012														x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	
11/15/2016	x	x	x	x	x	x	x	x	x	x	x	x	x																	
11/16/2012														x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	
11/20/2012														x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	
11/27/2012														x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
11/29/2012														x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
12/4/2012														x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
12/6/2012														x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
12/11/2012														x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
12/13/2012	x	x	x	x	x	x	x	x	x	x	x	x	x																	
12/18/2012														x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
12/20/2012														x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
12/27/2012														x	x	x	x	x				x	x	x	x		x	x		x
1/3/2013																			x	x	x					x			x	
1/8/2013	x	x	x	x	x	x	x	x	x	x	x	x	x																	

Sediment Sampling

Sampling Date	Creek Sites (13)													Bay Sites (16+1)																
	MC-1	MC-2	MC-3	TX-1	TX-2	C-1	C-2	C-3	MR-1	MR-2	P-1	P-2	P-3	ERC-1	ERC-2	ERC-3	ERC-4	TH-3	TH-4	TH-6	TH-6A	TH-7	TH-10	B-2B	B-3A	B-3B	B-4A	B-4B	B-6C	Discharge
1/3/2013														x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
1/8/2013	x	x	x	x	x	x	x	x	x	x	x	x	x																	

x - Station Sampled
"Discharge" station was added on 11/27/12; station near main outfall discharge

Table 3-3. Laboratory Methods

Constituents	Test Method	Detection Limit	Reference
Heavy Metals –			
Cd	E200.7	0.005 mg/L	EPA
Cr		0.01	
Cu		0.02	
Pb		0.005	
Ni		0.04	
Ag		0.01	
Zn		0.02	
Heavy Metals – Mercury	E245.1	0.0002 mg/L	EPA
Total Coliform Bacteria	SM9221BE	2 MPN/100mL	Standard Methods
Fecal Coliform Bacteria	SM9221BE	2 MPN/100mL	Standard Methods
Enterococci	D6503-99	10 MPN/100mL	ASTM
BOD-5	SM5210B	2 mg/L	Standard Methods
Total Suspended Solids - TSS	SM2540D	10 mg/L	Standard Methods
Total PAH	SW8270C	10 μg/L	Solid Waste
Total Organic Carbon (TOC)	SW9060		Solid Waste

Creek Stations

The creek sampling locations are presented in Figures 3-1 through 3-5. Three sampling stations were placed in Macy Channel: one midway through the creek, one near where the raw sewage was discharged, and one in Willow Pond, which is connected to the channel via a culvert. Residents in this area were concerned that high tide levels pushed raw sewage from the channel up into the pond. Thixton Creek was chosen as a reference creek as it did not receive raw sewage but is in the same vicinity as the other creeks. Stations were placed at the head end and the mouth of the creek. In the Grand Canal, sewage was not pumped into the creek, but sewage was reported to have run down the street into the head end of the canal. Sampling stations were placed at the head end, mid canal and mouth of the canal. Two stations were placed in the Mill River, one near the point of sewage discharge and the other just north of East Rockaway Channel. Parsonage Creek was the last creek that was sampled. Stations were placed at the upstream point of discharge, the midway point of the creek, and near the mouth of the creek.

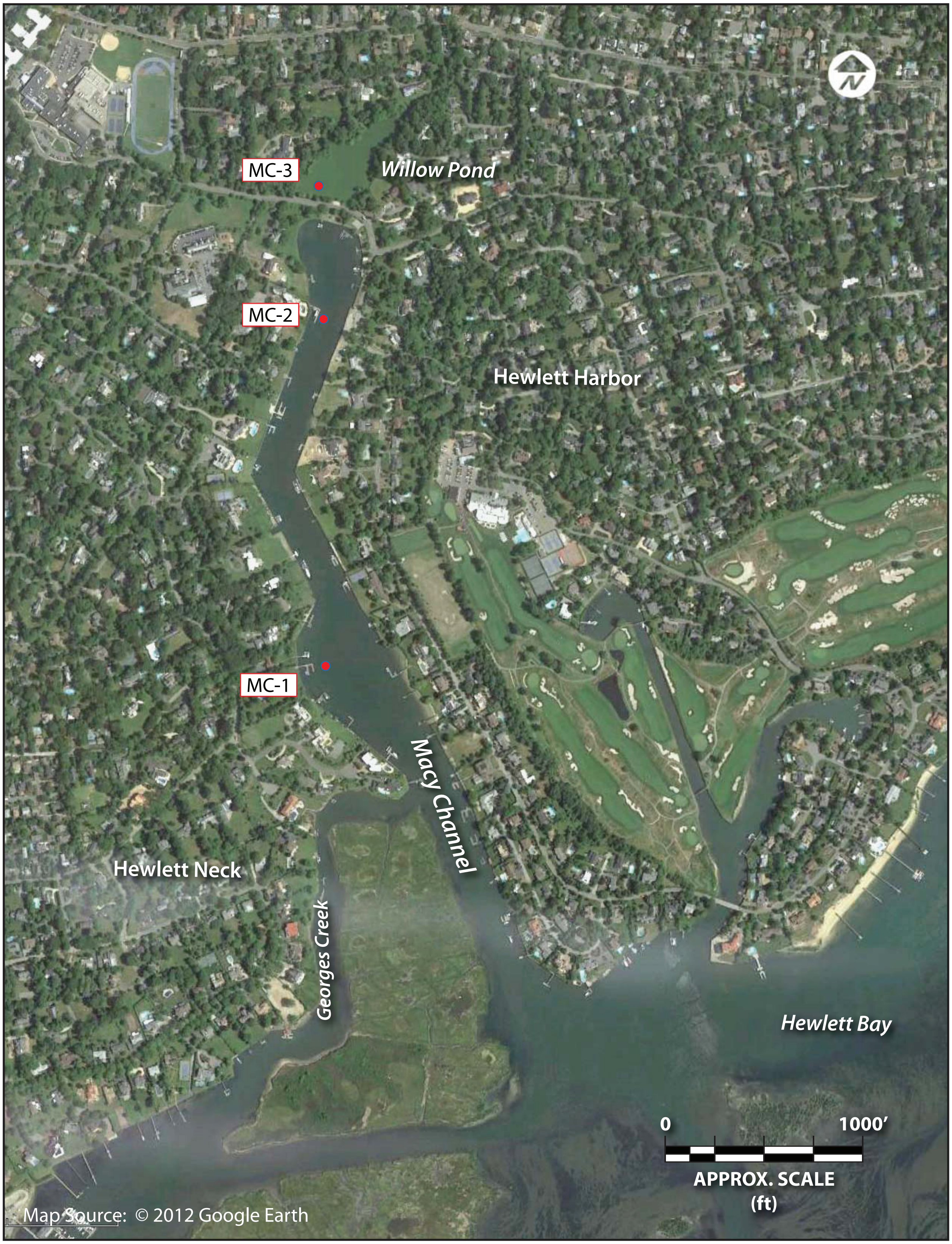


Figure 3-1. Macy Channel Sampling Stations

Figure 3-2.Thixton Creek Sampling Stations

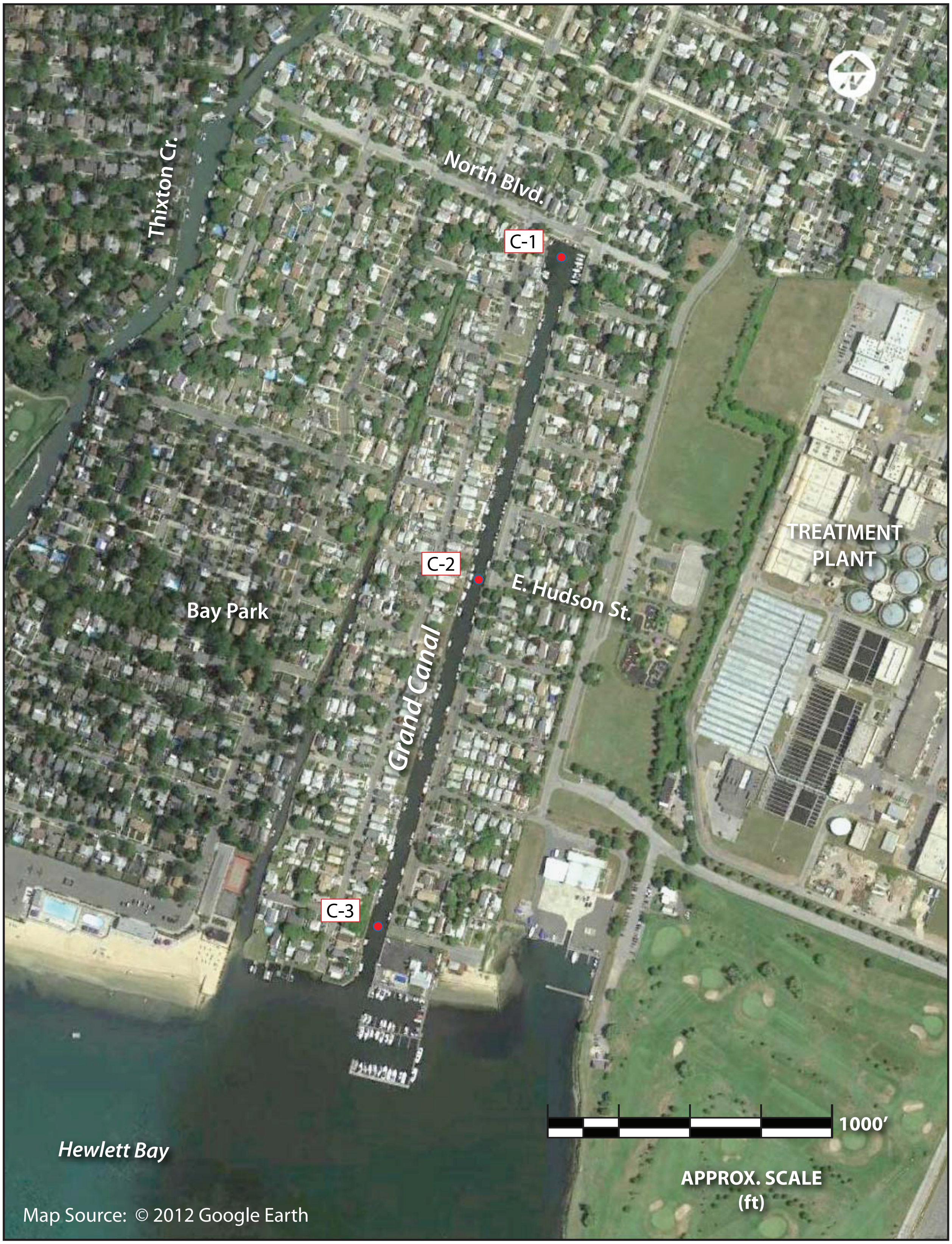


Figure 3-3. Grand Canal Sampling Stations

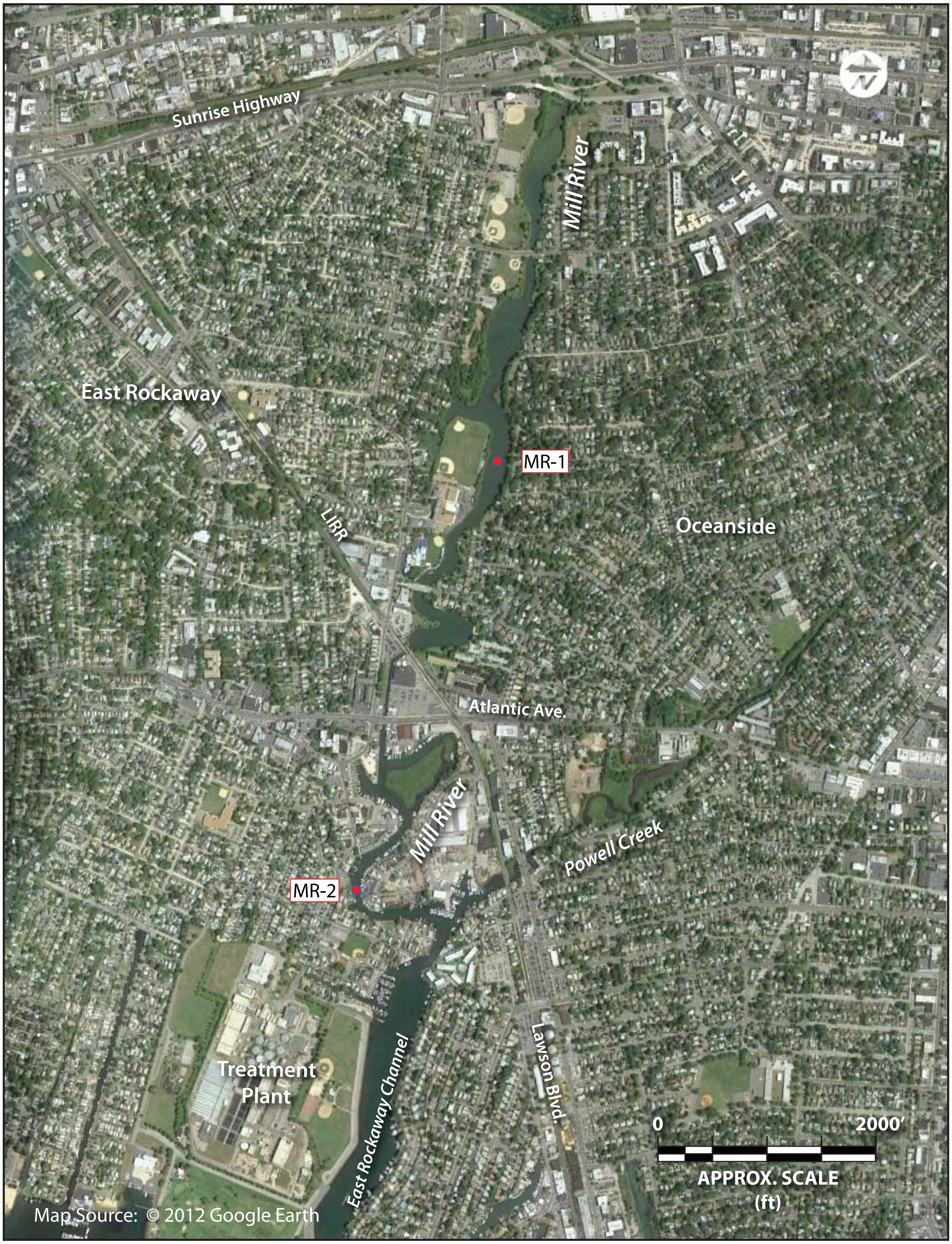


Figure 3-4. Mill River Sampling Stations

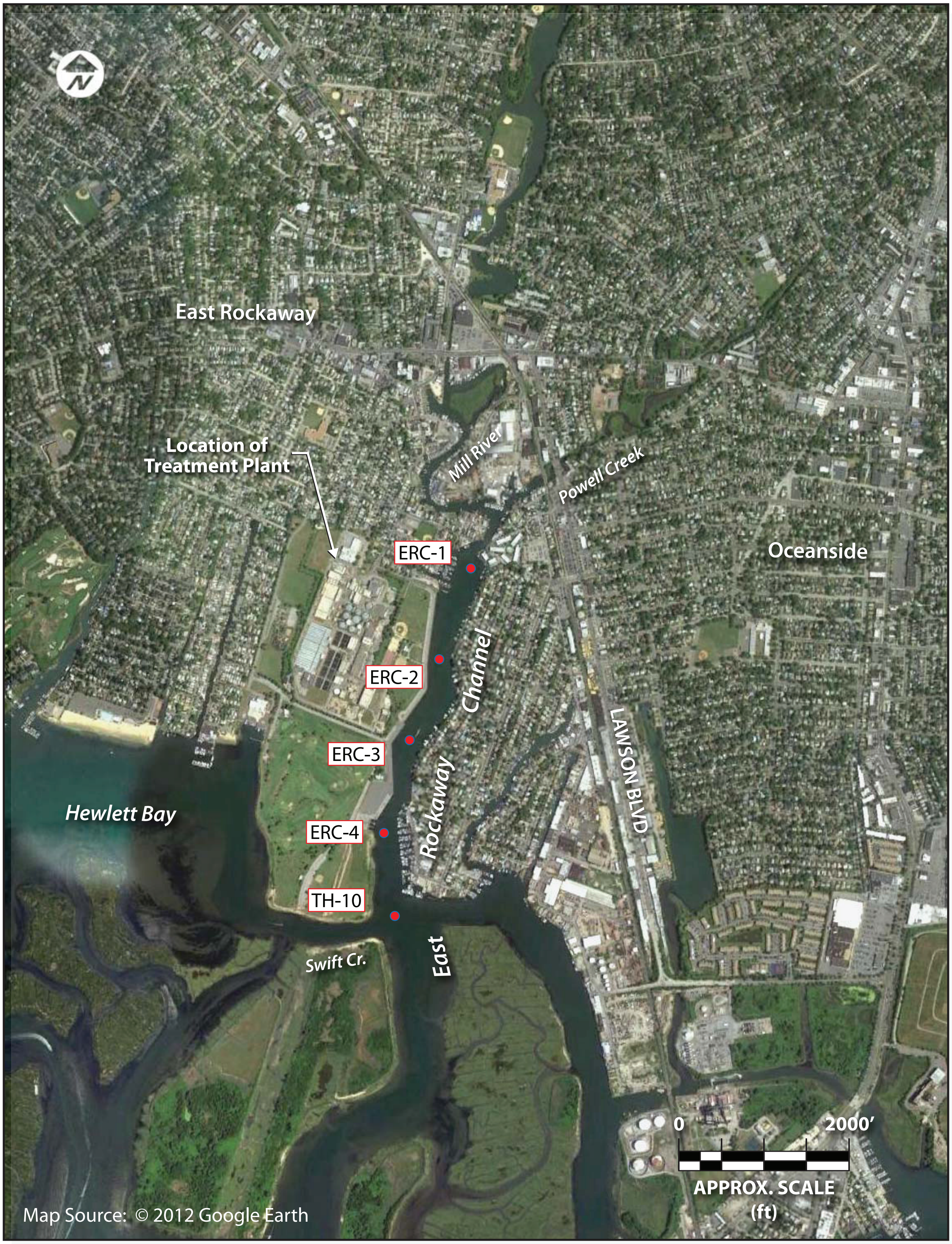


Figure 3-5. East Rockaway Channel Sampling Stations

Field measurements were taken at the near surface, mid-depth and near bottom of each of these sampling stations. Water samples were collected at near surface and mid-depth for sewage contaminant analysis since contaminants were more likely to be found in the buoyant freshwater associated with the discharges. In locations where the depths were shallow, only a surface measurement was taken. Four water quality surveys were conducted in the creeks: November 6 through November 9, November 15, December 13, 2012 and January 8, 2013. Not all laboratory measurements were taken during each of the surveys. For each survey data samples were shipped to H2M laboratories for analysis of the constituents noted in Table 3-3. A sediment survey was conducted on January 8, 2013 where surficial sediments were collected for analysis of these contaminants listed in Table 3-3.

Bay Stations

Bay sampling included 17 stations as shown in Figures 3-6 and 3-7. Sampling began with only 16 stations, but a 17th station was added in the Bay Park STP discharge plume in Reynolds Channel later in the sampling program. Four of the stations were located in East Rockaway Channel near the STP. Stations with a TH prefix were meant to coincide with stations that are sampled by the Town of Hempstead. Field measurements were taken at the near surface, mid-depth and near bottom. Water samples were collected at near surface and mid-depth for shipment to H2M Laboratories for analysis of the constituents noted in Table 3-3. Twelve water quality surveys were conducted between November 9, 2012 and January 3, 2013. Not all of the water quality parameters were measured during each of the surveys. The sediment survey was conducted on January 3, 2013.

Town of Hempstead Sampling

The Town of Hempstead routinely samples six stations in the bay on a monthly basis. The stations 3, 6, 6A, 7 and 10 correspond to the TH stations in Figure 3-7. Station 4 is closer to the discharge station than station TH-4. The sampling includes temperature, salinity, DO and coliform. Data from the period of January 2010 through September 2012 was obtained from the town to serve as a baseline condition before Hurricane Sandy. Coliform data was not provided by the town due to concerns with the accuracy of the data.

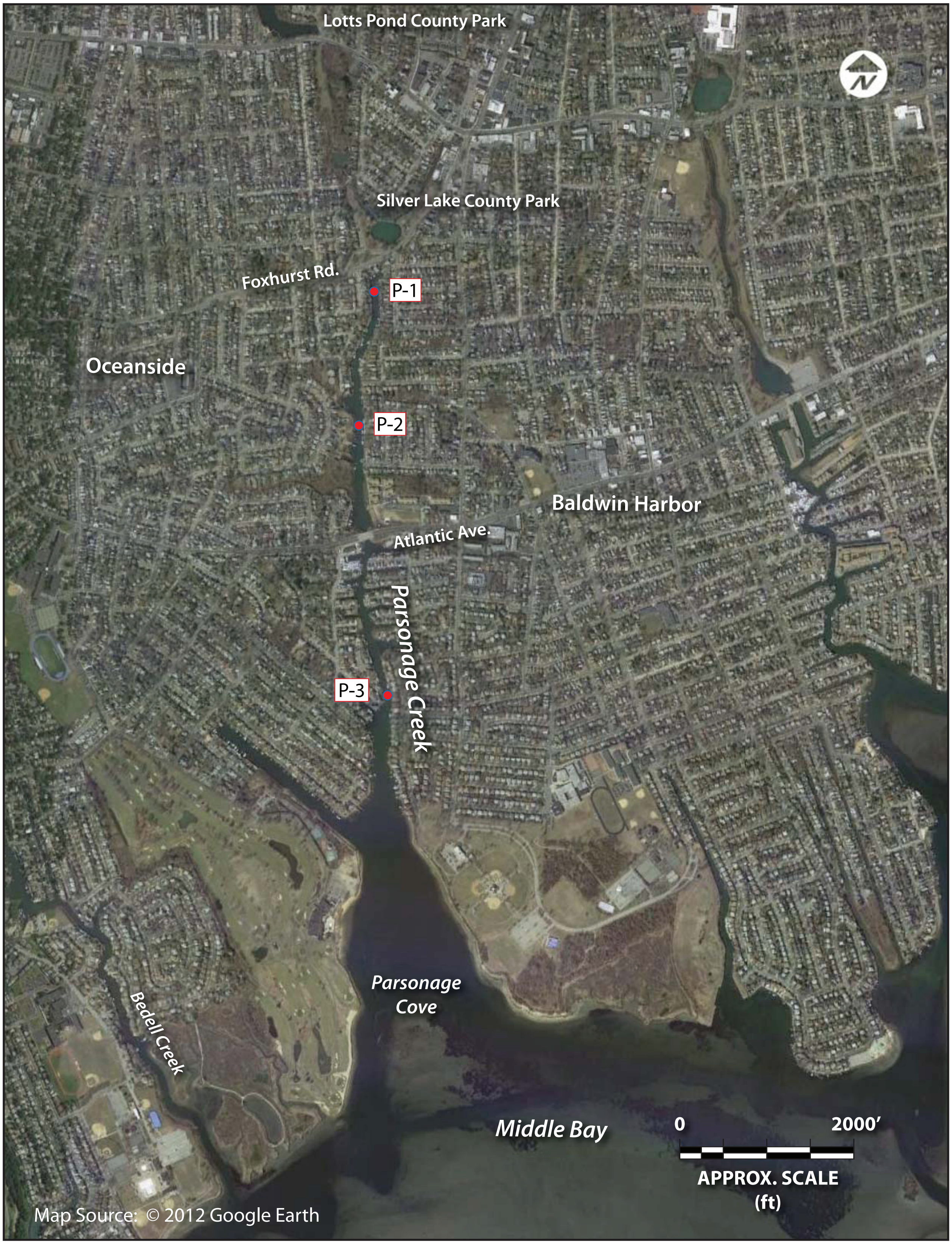


Figure 3-6. Parsonage Creek Sampling Stations

Figure 3-7. West Hempstead Bay Sampling Stations

SECTION 4

WATER QUALITY

Classifications and Standards

West Hempstead Bay and its creeks are classified by NYSDEC as either SA, SB, or SC waterbodies (Figure 4-1), with the exception of Willow Pond which is likely a class C waterbody. Table 4-1 presents the designated use for each classification and the sampling stations that fall into each class. Each waterbody class is assigned water quality standards so that the designated uses can be met. Table 4-2 presents some of the relevant standards for this project.

Table 4-1. Waterbody Classes

Class	Designated Use	Stations
SA	The best usages of Class SA waters are shellfishing for market purposes, primary and secondary contact recreation and fishing. These waters shall be suitable for fish, shellfish, and wildlife propagation and survival.	B-3B, TH-6, TH-6A, B-6C, TH-10
SB	The best usages of Class SB waters are primary and secondary contact recreation and fishing. These waters shall be suitable for fish, shellfish, and wildlife propagation and survival.	B-2B, TH-3, B-3A, TH-4, B-4A, B-4B, TH-7, Discharge
SC	The best usage of Class SC waters is fishing. These waters shall be suitable for fish, shellfish, and wildlife propagation and survival. The water quality shall be suitable for primary and secondary contact recreation, although other factors may limit the use for these purposes.	All creek stations including the ERC stations[A]

A – Willow Pond is likely a Class C waterbody and has the same uses as a Class SC waterbody

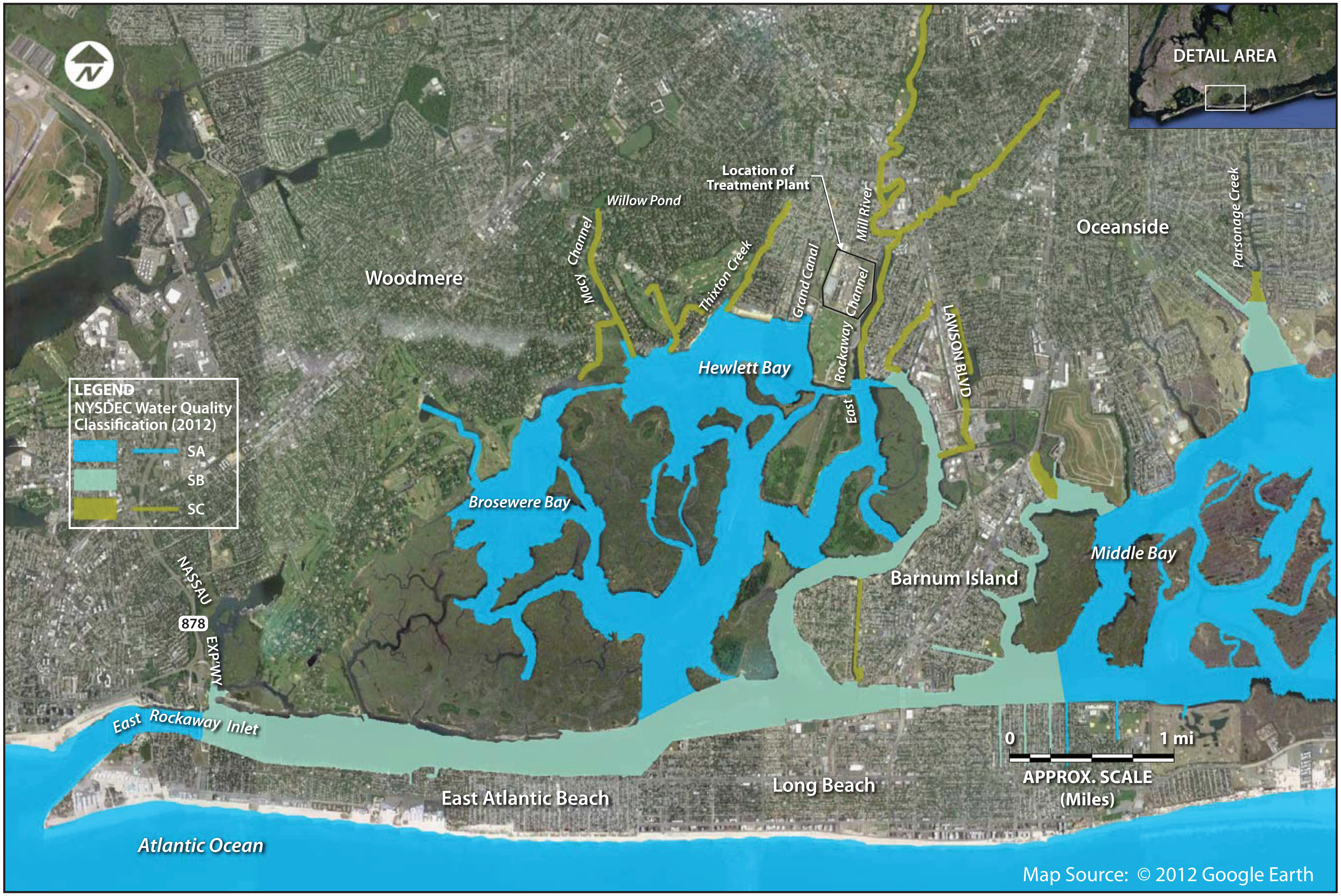


Figure 4-1. Water Quality Classifications

Table 4-2. Water Quality Standards

Parameter	Classification					
	SA			SB/SC		
	value	unit	type	value	unit	type
DO	3.0	mg/L	Never <	3.0[d]	mg/L	Never <
	4.8[a]	mg/L	Daily average	4.8[a,d]	mg/L	Daily average
Total coliform	70	MPN/100mL	Median[b]	2,400	MPN/100mL	Monthly median
				5,000	MPN/100mL	Monthly 80th percentile
Fecal coliform				200	MPN/100mL	Monthly geometric mean
Enterococci	35	MPN/100mL	Monthly geometric mean	35	MPN/100mL	Monthly geometric mean
Total residual chlorine	7.5	µg/L	Chronic	7.5	µg/L	Chronic
	13	µg/L	Acute	13	µg/L	Acute
Copper	3.4[c]	µg/L	Chronic	3.4[c]	µg/L	Chronic
	4.8[c]	µg/L	Acute	4.8[c]	µg/L	Acute
Mercury	0.77[c]	µg/L	Chronic	0.77[c]	µg/L	Chronic
	1.4[c]	µg/L	Acute	1.4[c]	µg/L	Acute
Cadmium	7.7[c]	µg/L	Chronic	7.7[c]	µg/L	Chronic
	21[c]	µg/L	Acute	21[c]	µg/L	Acute
Lead	8[c]	µg/L	Chronic	8[c]	µg/L	Chronic
	204[c]	µg/L	Acute	204[c]	µg/L	Acute
Nickel	8.2[c]	µg/L	Chronic	8.2[c]	µg/L	Chronic
	74[c]	µg/L	Acute	74[c]	µg/L	Acute

Table 4-2. Water Quality Standards

Parameter	Classification					
	SA			SB/SC		
	value	unit	type	value	unit	type
Zinc	66[c]	μg/L	Chronic	66[c]	μg/L	Chronic
	95[c]	μg/L	Acute	95[c]	μg/L	Acute

a The DO concentration may fall below 4.8 mg/L for a limited number of days
b The median most probable number value in any series of representative samples shall not be in excess of 70.
c Dissolved form
d Willow Pond has DO standards of daily average not less than 5.0 mg/L and an instantaneous minimum not less than 4.0 mg/L.

Rainfall

The Bay Park STP is not the only source of contaminants to West Hempstead Bay. Another important pollutant source is stormwater discharge that occurs during rainfall events. Figure 4-2 presents rainfall data from the John F. Kennedy International (JFK) Airport for the period of October 2012 through early-January 2013. Since stormwater can contain high levels of bacteria and other contaminants, sampling events that occur during or shortly after rain events will include impacts from not only the Bay Park STP, but stormwater as well. The sampling program included some relatively dry periods such as mid-November and relatively wet periods such as mid- to late-December. When interpreting the water quality data, the timing of precipitation should be considered.

Creek Results

This section of the report presents the results of the water quality sampling in the creeks. Figures are laid out such that they approximate the north-south direction of the creeks and the spatial distribution of the stations within the creeks. The creeks are presented from west to east. The data are represented as circles with colors corresponding to the depth of the sample. In cases were the data were below the detection limit, the data are presented as less than signs with colors corresponding to the sample depth.

The temperature data that were collected in the creeks are presented in Figures 4-3 and 4-4. In general, water temperature in the creeks after Hurricane Sandy was approximately 10 °C and decreased to less than 5 °C by January. The temperatures were within the normal range for this time of year. Macy Channel station 3 was located at the edge of Willow Pond, so it was more susceptible to changes in atmospheric temperature, and generally had lower temperatures than the other locations. Parsonage Creek was sampled three days later than the other creeks during the first survey, so the temperature during the first sampling event differs from the other creeks.

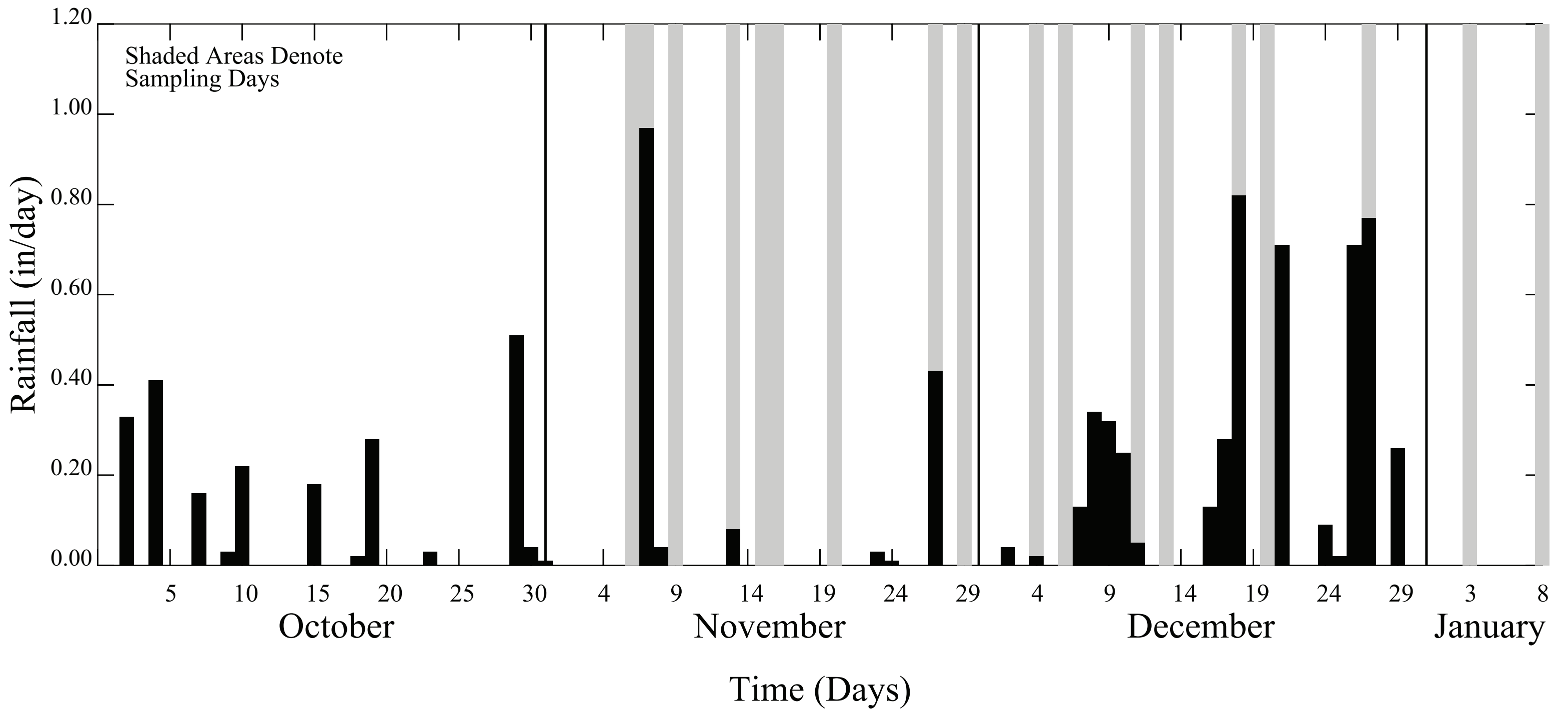


Figure 4-2. Rainfall record at JFK International Airport - October 2012 - January 2013

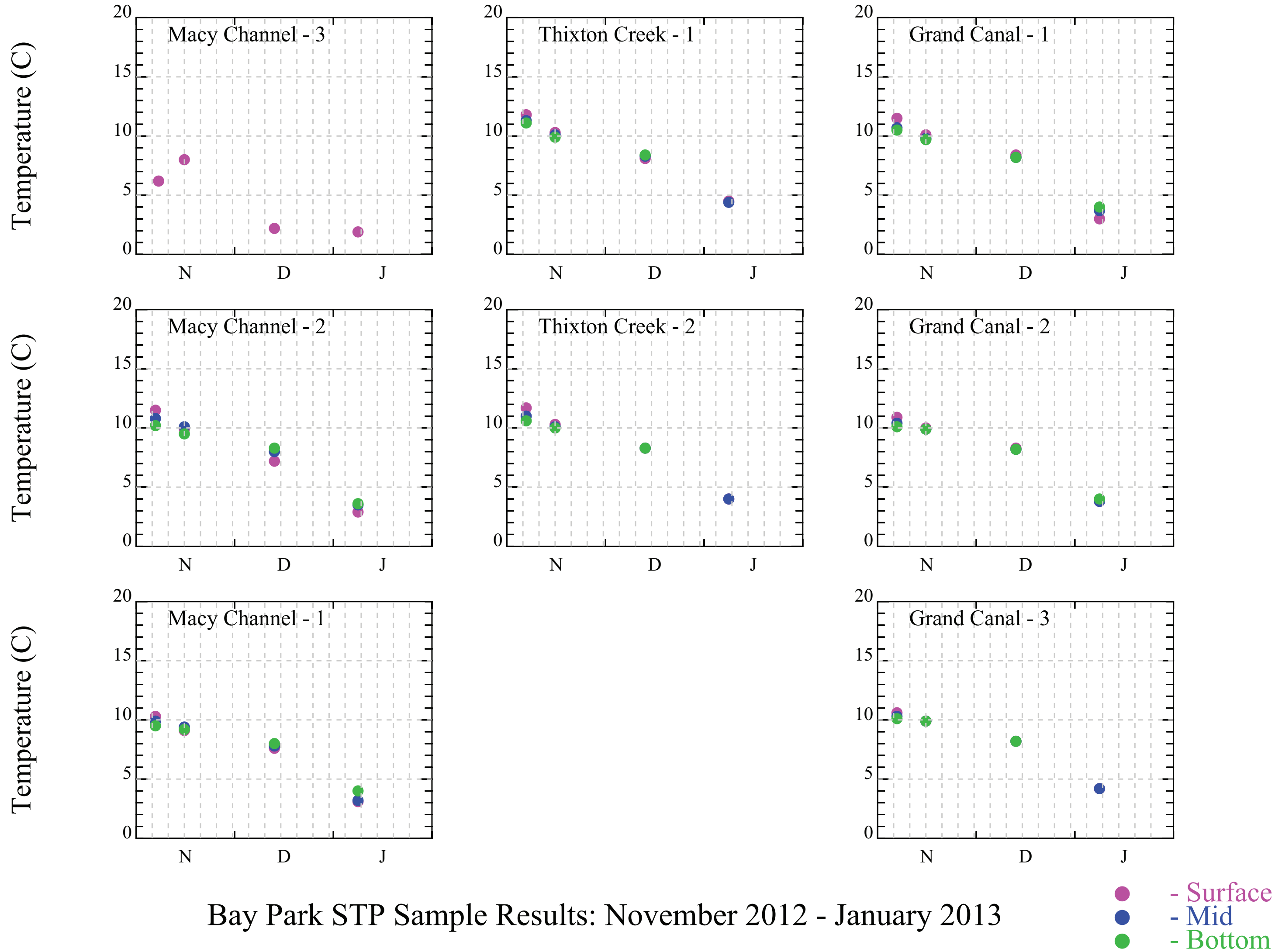


Figure 4-3. Temperature Data in Macy Channel, Thixton Creek and Grand Canal

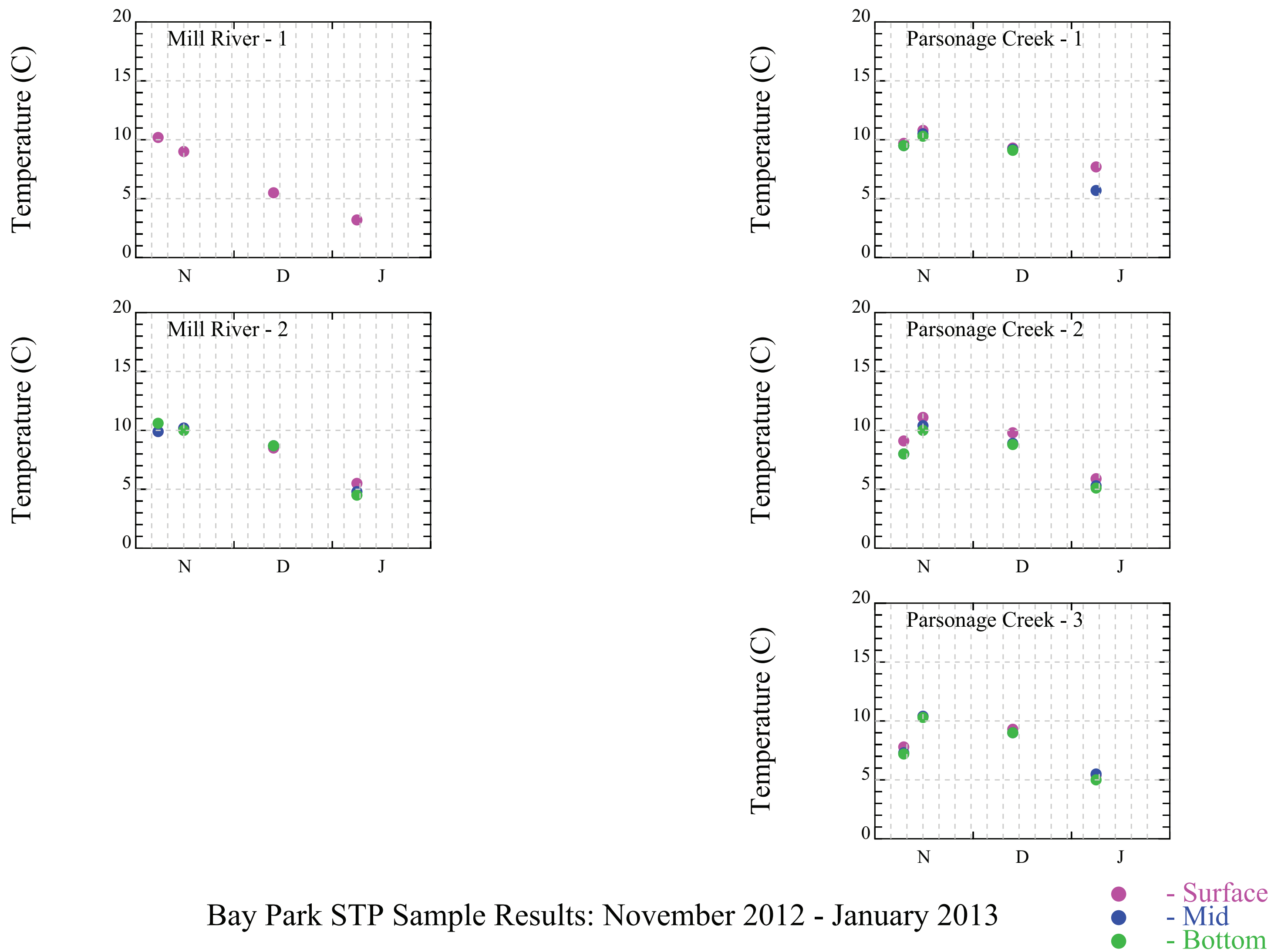


Figure 4-4. Temperature Data in Mill River and Parsonage Creek

Figures 4-5 and 4-6 present the creek salinity data collected during the sampling program. It appears that Willow Pond (MC-3) exhibited high salinity levels presumably associated with the impact of the sea water during Hurricane Sandy. These salinity levels have been slowly freshening since the storm. If the pond is normally fresh, it is possible that high salinity levels may have impacted biota in the pond. Of course this would be a result of the hurricane itself, not of actions by Nassau County. In the rest of Macy Channel, the salinity has increased slightly from the first sampling event, but remained relatively constant since the second sampling event. The channel appears to be well mixed during this period because the surface and bottom salinity is similar. Thixton Creek appears to have a small freshwater source as the surface and bottom salinity levels differ. Large amounts of freshwater entered the creek before the January sampling event to create more salinity stratification. The Grand Canal is similar to Macy Channel with little evidence of a freshwater source and relatively constant salinity throughout the sampling program.

The Mill River has an obvious freshwater source and station MR-1 is behaving over time in a similar way to Willow Pond. It is possible that an upstream source collected high salinity water and is freshening over time. Station MR-2 is less saline than the water at the stations in the other creeks. Surface to bottom salinity stratification changes over time related to the input of freshwater. Parsonage Creek also shows evidence of a freshwater source. The bottom salinity remained relatively constant over the sampling period and the surface salinity showed some variability.

Figure 4-7 presents the total suspended solids (TSS) data for Macy Channel, Thixton Creek and Grand Canal. Figure 4-8 presents the TSS data for Mill River and Parsonage Creek. Three sampling events are shown because TSS was not collected during the sediment survey. The surface data are represented by purple circles and the mid-depth data are presented by blue circles. The majority of the data are at or near the detection limit of 10 mg/L for the first two surveys, with the exception of MC-3 in Willow Pond and MR-1, the most northerly Mill River station, where the concentrations are higher. The highest TSS concentrations were measured in December, long after the discharge of raw sewage to the creeks. Samples collected at Thixton Creek, the reference creek, had similar TSS concentrations to the other creeks.

The results of the BOD_5 sampling in the creeks are presented in Figures 4-9 and 4-10. The majority of the data are at or near the detection limit of 2.0 mg/L. Some of the higher measurements occurred during mid-December at the same time the higher TSS concentrations were measured. Two areas where higher BOD_5 concentrations were measured were Willow Pond (MC-3) and MR-1. At MC-3 higher BOD_5 concentrations are observed during the period well after the storm, and are higher than the BOD_5 concentrations measured at the point of raw sewage discharge (MC-2). This suggests there is a local source of BOD_5 other than Macy Channel. The high BOD_5 concentration at MR-1 during the first sampling event could be related to the raw sewage discharge or and upstream source. High BOD_5 concentrations are not observed at MR-1 after the first sampling event.

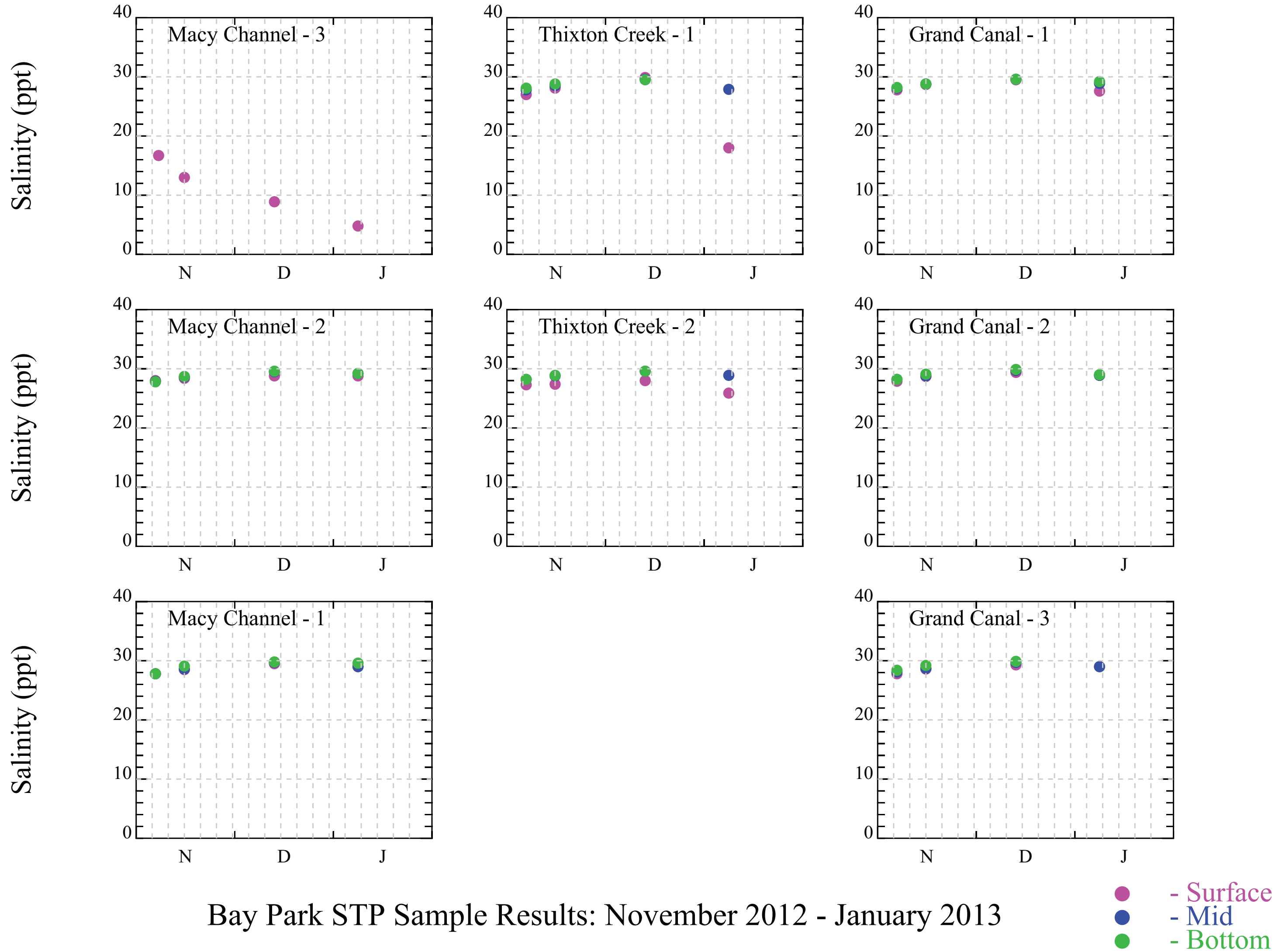


Figure 4-5. Salinity Data in Macy Channel, Thixton Creek and Grand Canal

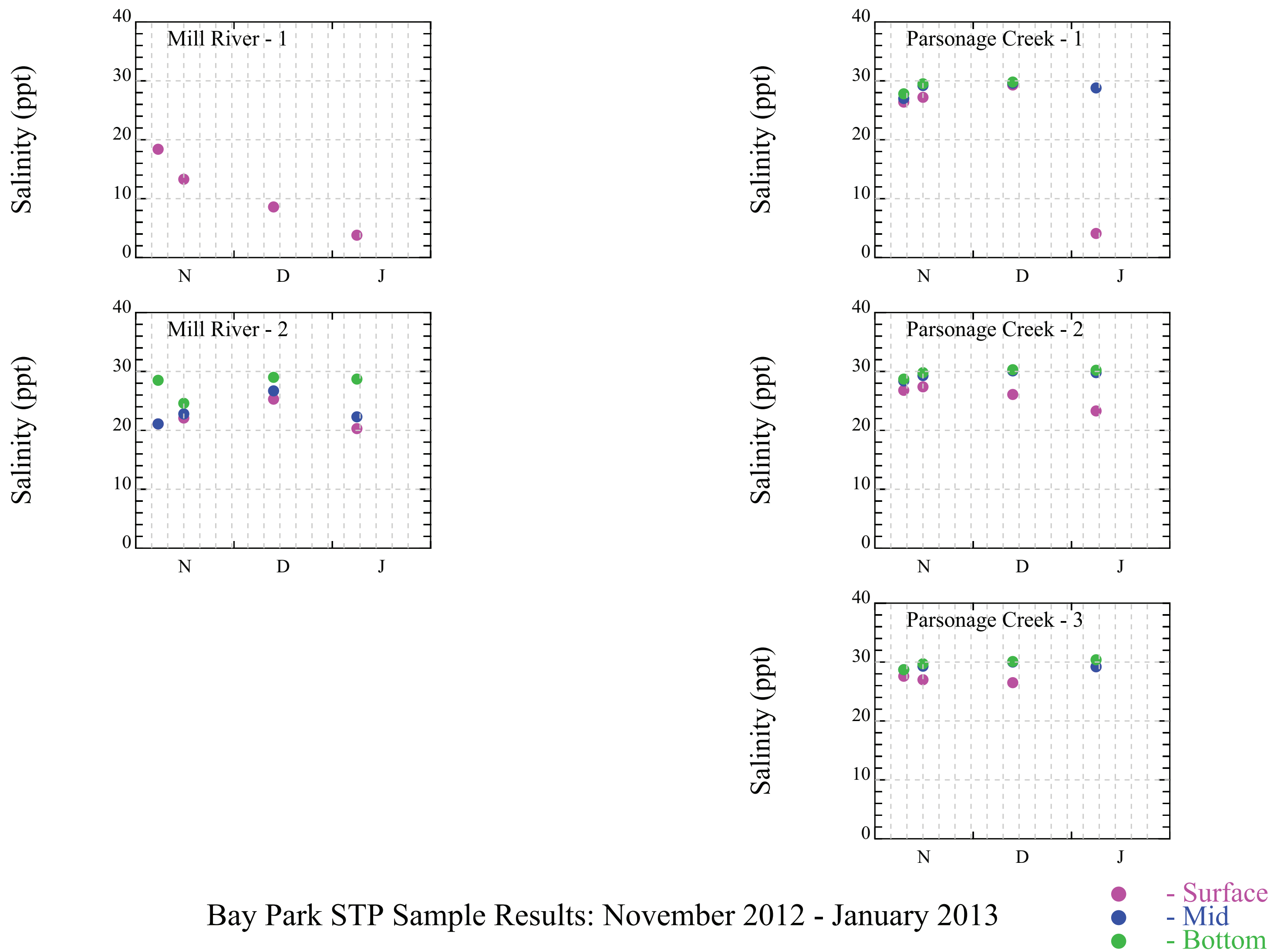


Figure 4-6. Salinity Data in Mill River and Parsonage Creek

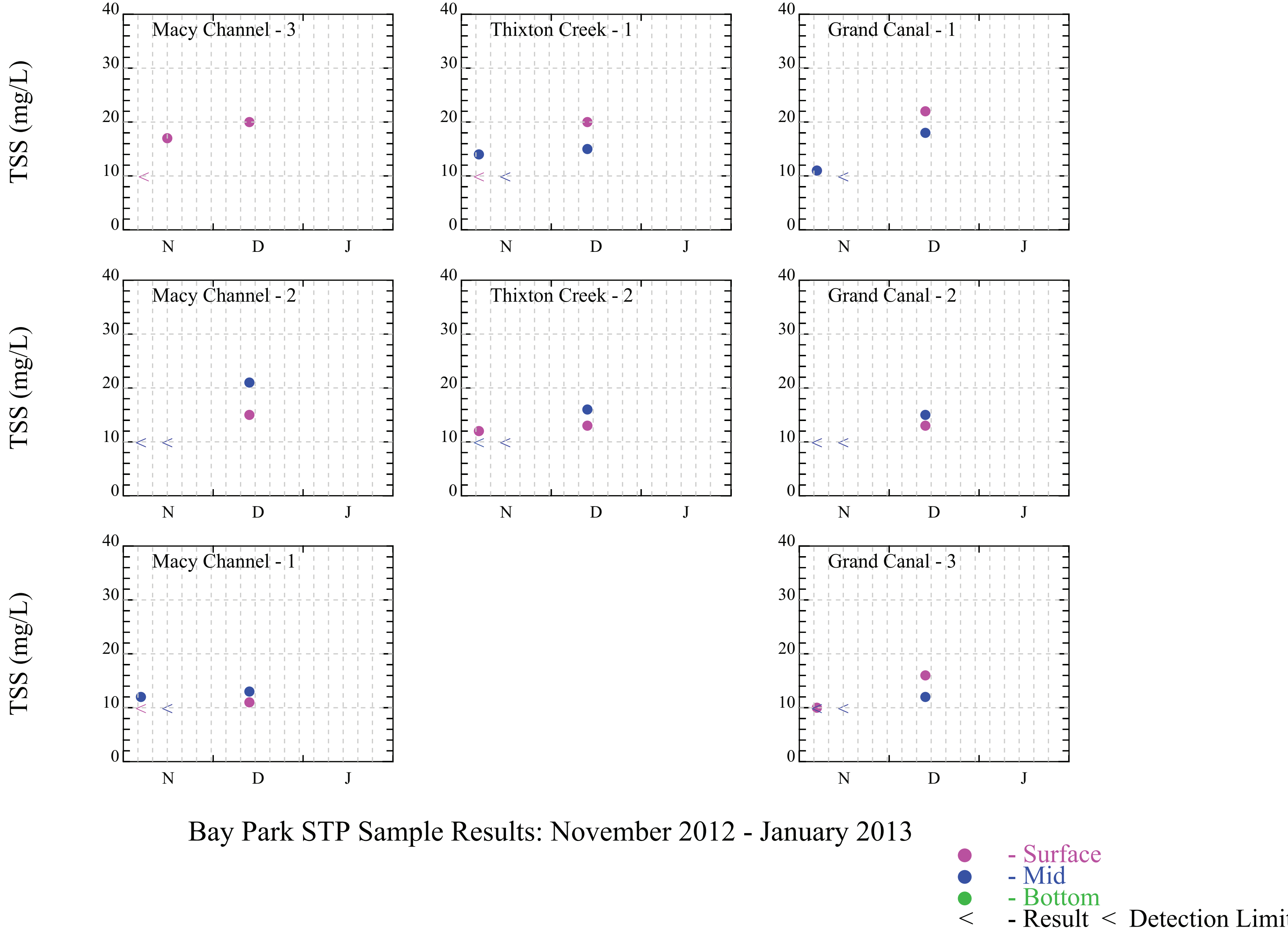


Figure 4-7. TSS Data in Macy Channel, Thixton Creek and Grand

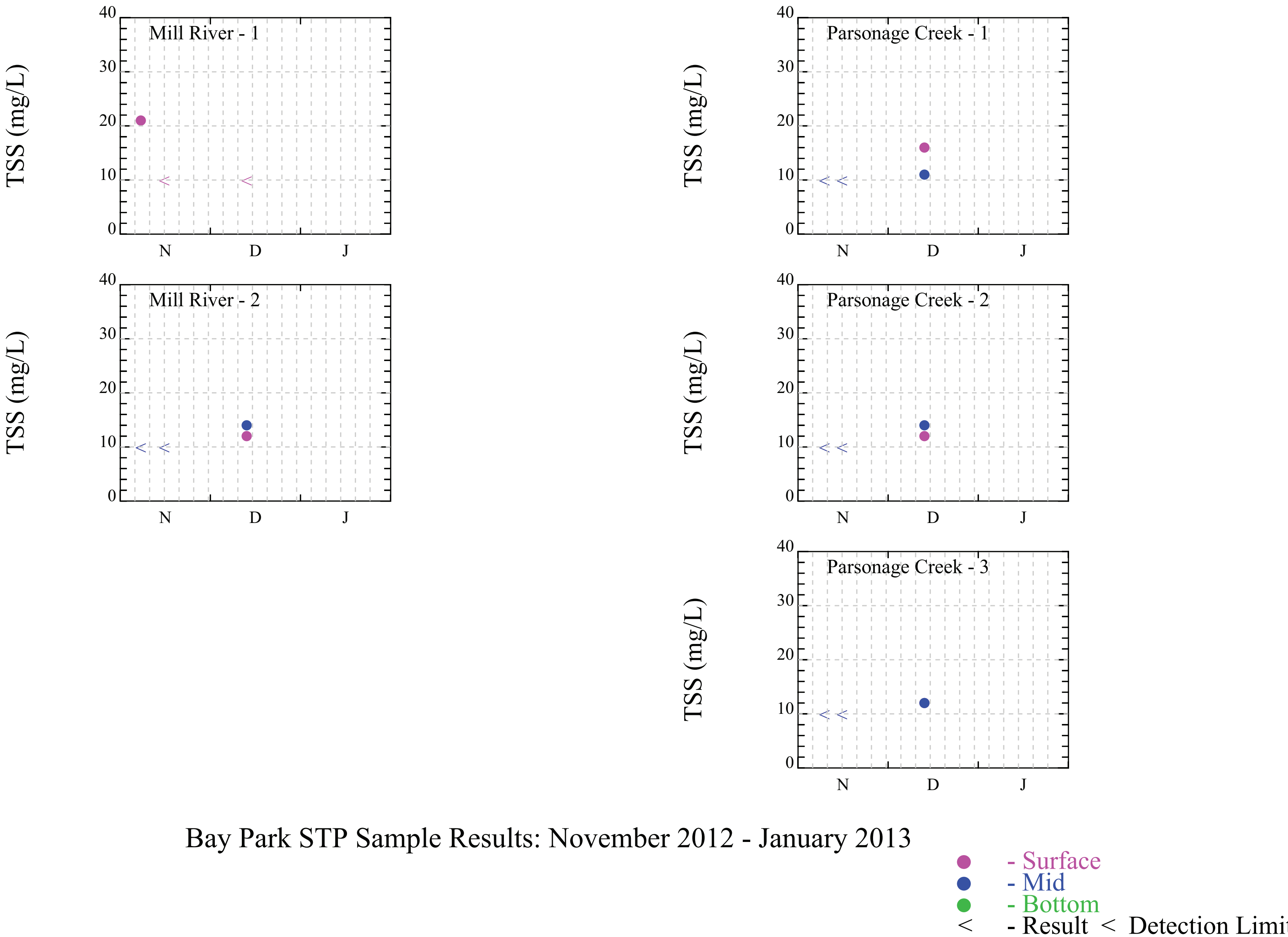


Figure 4-8. TSS Data in Mill River and Parsonage Creek

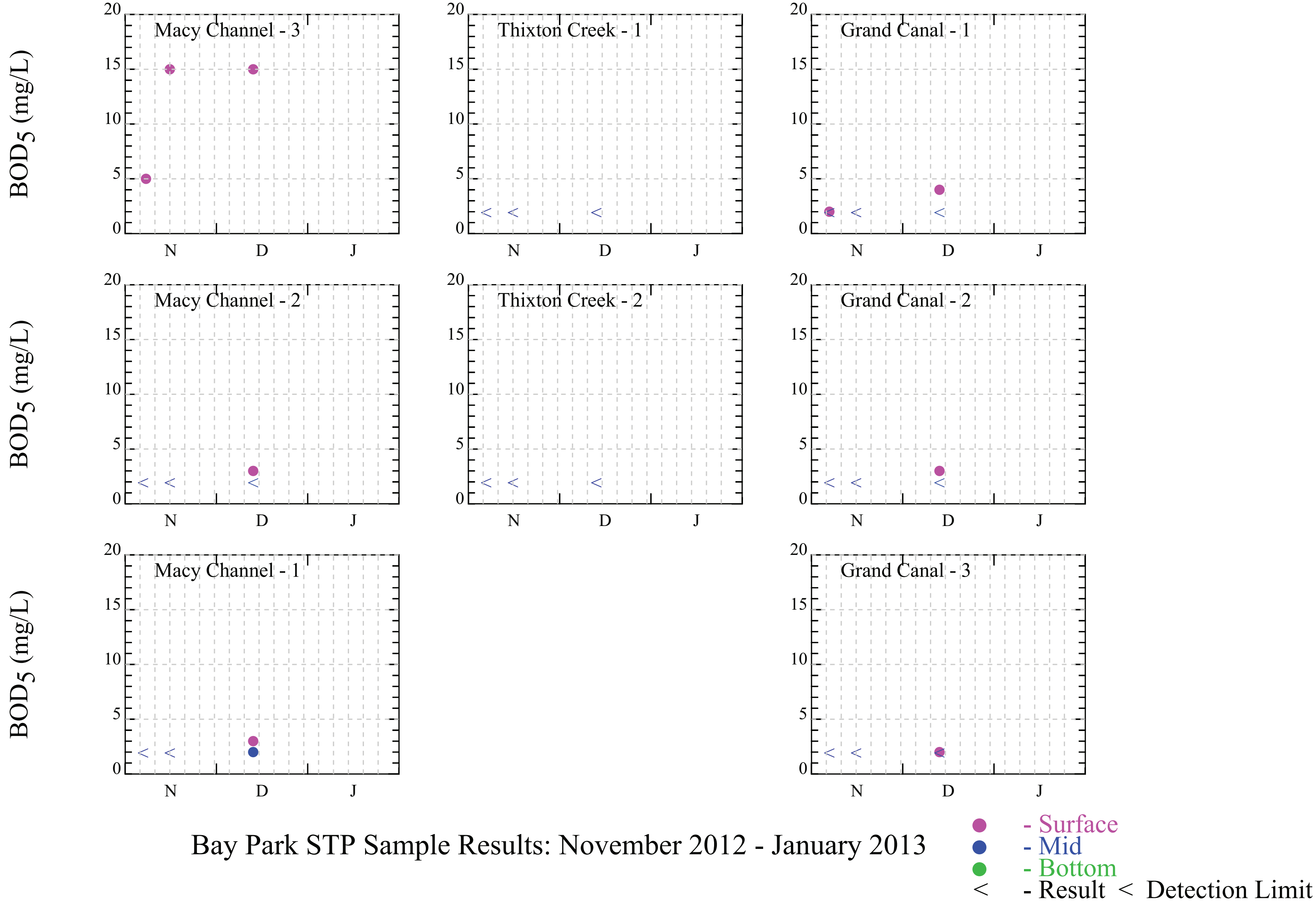


Figure 4-9. BOD_5 Data in Macy Channel, Thixton Creek and Grand Canal

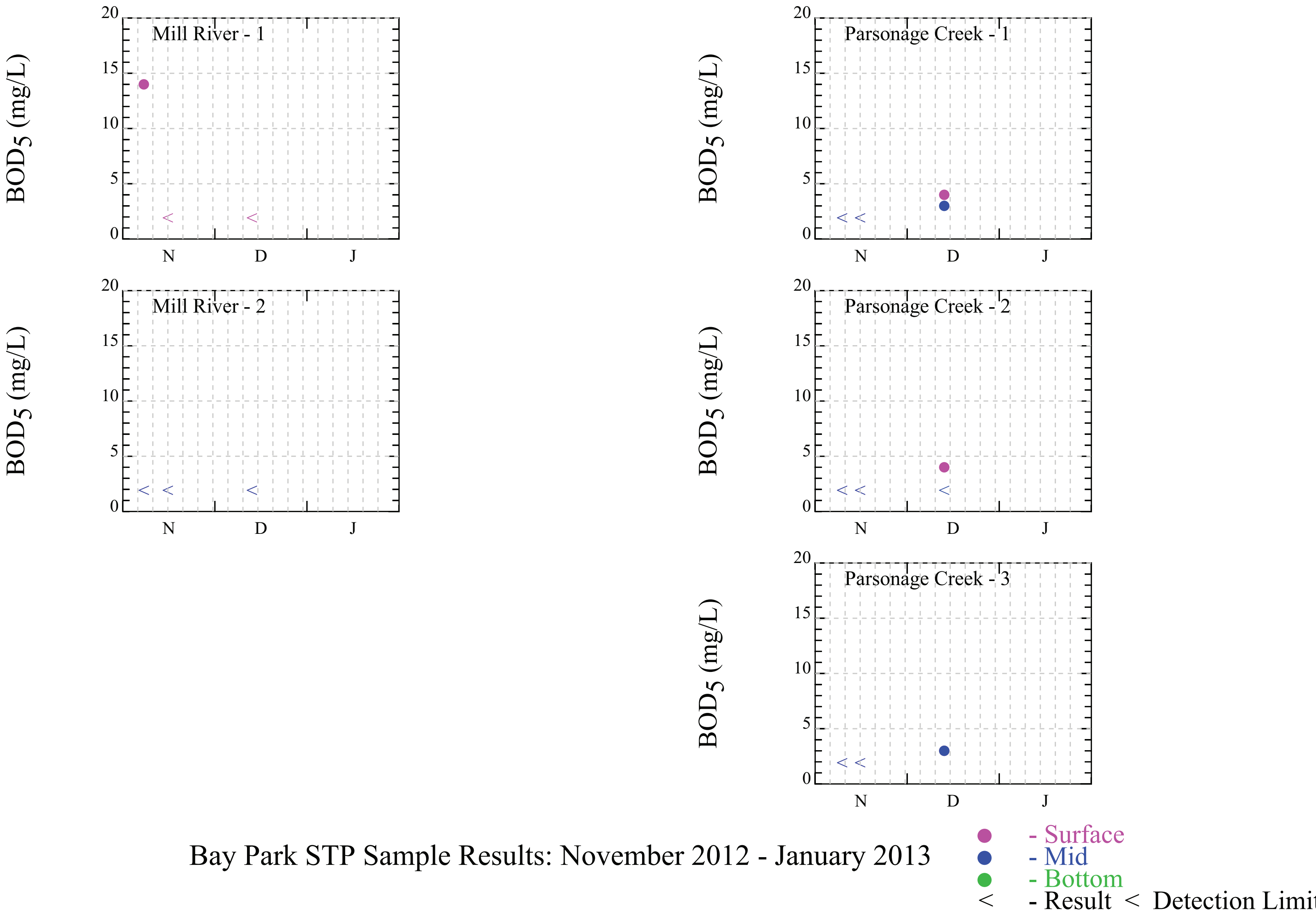


Figure 4-10. BOD_5 Data in Mill River and Parsonage Creek

Figures 4-11 and 4-12 present the results of the DO sampling in the creeks. Horizontal lines were added to these figures to show the daily average chronic standard (4.8 mg/L) and the never less than acute standard (3.0 mg/L). During the November surveys, stations C-1, C-2, C-3, MR-2, P-1, P-2, TX-1 and TX-2 all had measurements below 4.8 mg/L. Since these measurements are instantaneous grabs and not a daily average value it cannot be stated with certainty whether attainment with the DO standard was achieved, but there is the potential for exceedances. The lowest measured DO concentration was 3.8 mg/L at station P-1, so there were no measurements below the instantaneous minimum standard of 3.0 mg/L. In December and January, DO concentrations increased to well above the DO standards.

Some of the lowest DO measurements were obtained at the TX reference stations that were placed in a creek that did not receive a raw sewage discharge. Thus, the creeks that received a raw sewage discharge did not have appreciably worse DO levels than the reference creek.

Since DO concentrations naturally rise as water temperature decreases due to water's increased ability to dissolve oxygen at lower temperatures, it can be difficult to discern if rising DO concentrations are due to improving water quality, decreased temperatures or both. Figures 4-13 and 4-14 present the percent of DO saturation in the creeks during the sampling period. During November, percent DO saturation was generally between 40 and 70 percent. These levels indicate a fairly significant reduction in DO concentrations due to oxygen demand in the water column. By December the majority of stations had percent saturation greater than 80 percent, which indicates a reduction in the oxygen demand. The increase in percent DO saturation could be related to the dissipation of effects from Hurricane Sandy or also the reduction of biological activity with lower water temperatures resulting in a smaller oxygen demand on the water column.

Total coliform, fecal coliform and enterococci are indicator bacteria meant to show the presence of human waste. All three were measured as part of the sampling program. Figures 4-15 and 4-16 present the total coliform results for the creek stations. Solid horizontal lines are included that show the water quality standards of a median of 2,400 no./100 mL and the 80^{th} percentile standard of 5,000 no./100 mL. Although a minimum of 5 samples within a 30-day period are necessary to assess compliance with the standards, dashed lines are presented on the figures to show the monthly median and 80^{th} percentile values for the entire sampling period In general, the highest values were measured in November, many of which were individually higher than the monthly standards. Concentrations at the reference site were comparable to or higher than the other creeks. After the first sampling event, total coliform concentrations generally declined or leveled off to concentrations well below the standards. Two exceptions to this were stations MC-3 and MR-1. At these stations, total coliform concentrations remained relatively high, which is an indication of local sources unrelated to Hurricane Sandy or the Bay Park STP's discharge.

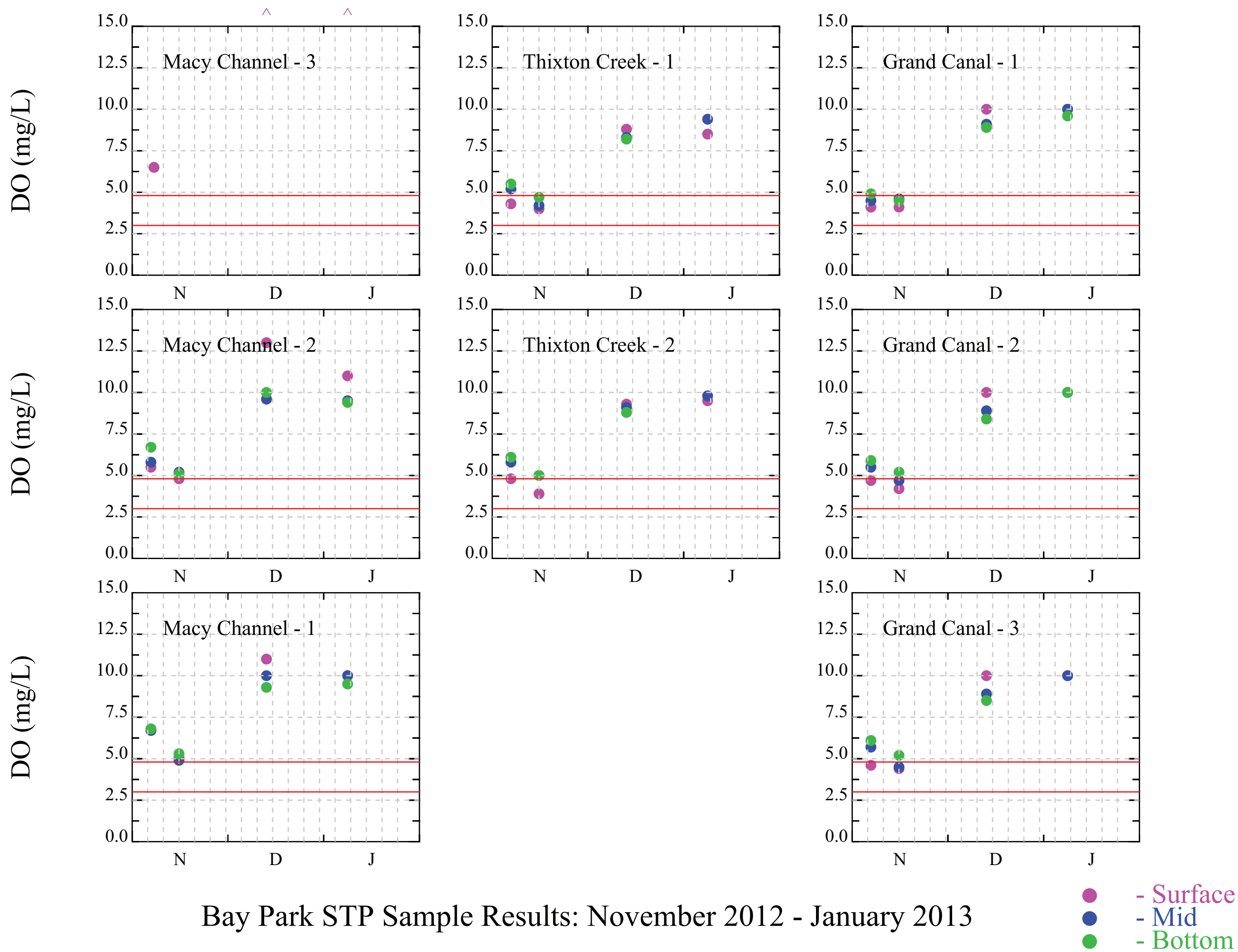


Figure 4-11. DO Data in Macy Channel, Thixton Creek and Grand Canal

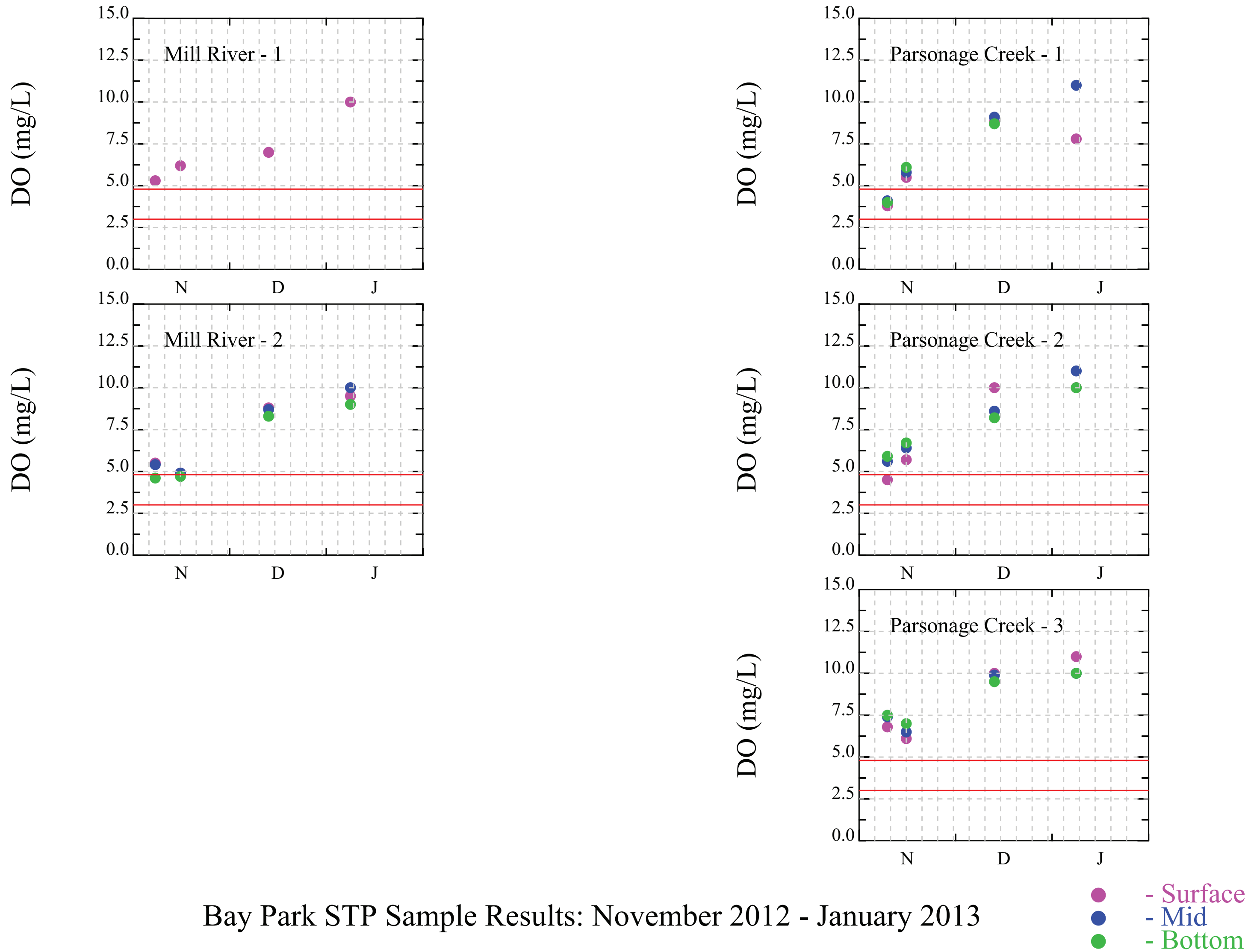


Figure 4-12. DO Data in Mill River and Parsonage Creek

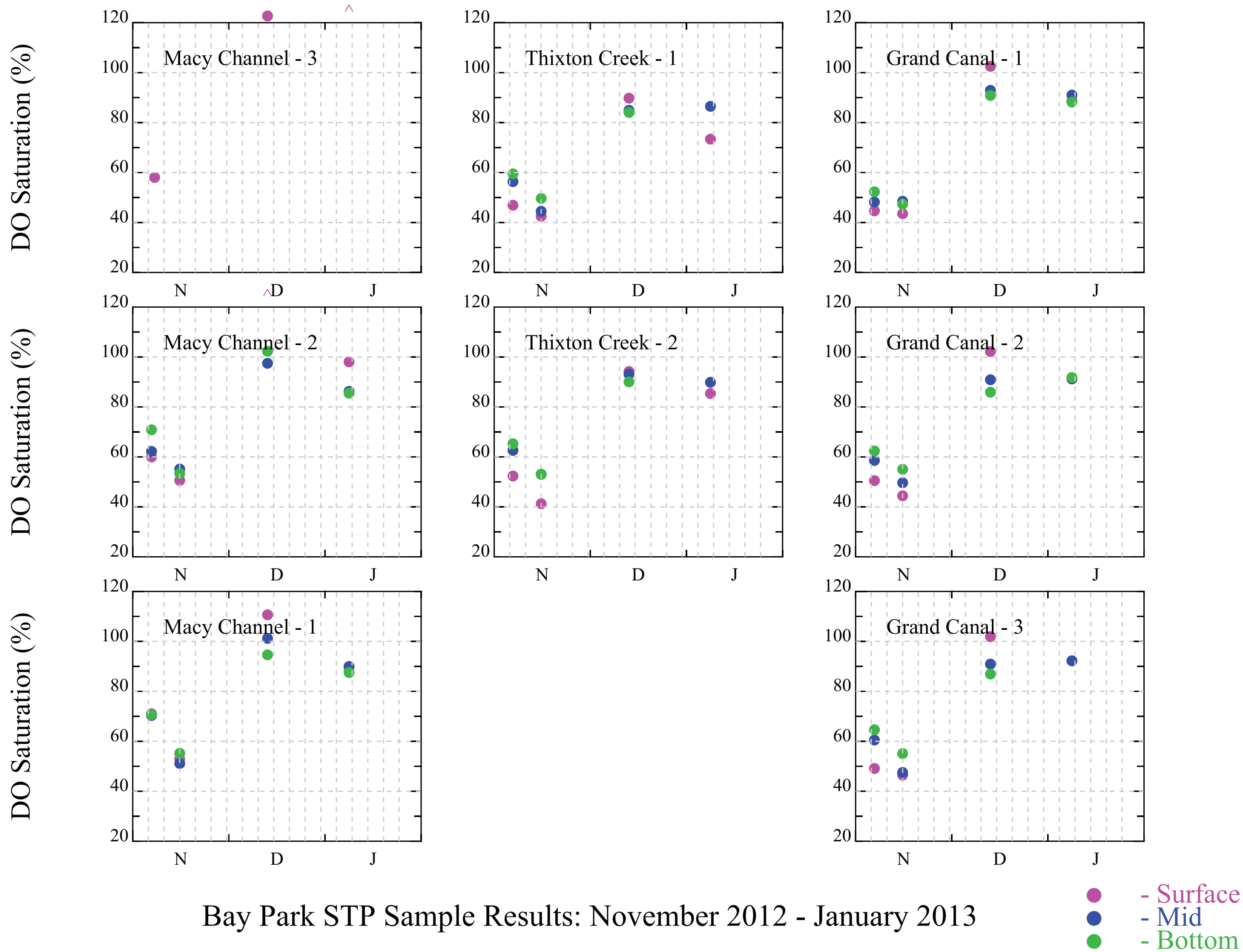


Figure 4-13. DO Percent Saturation Data in Macy Channel, Thixton Creek and Grand Canal

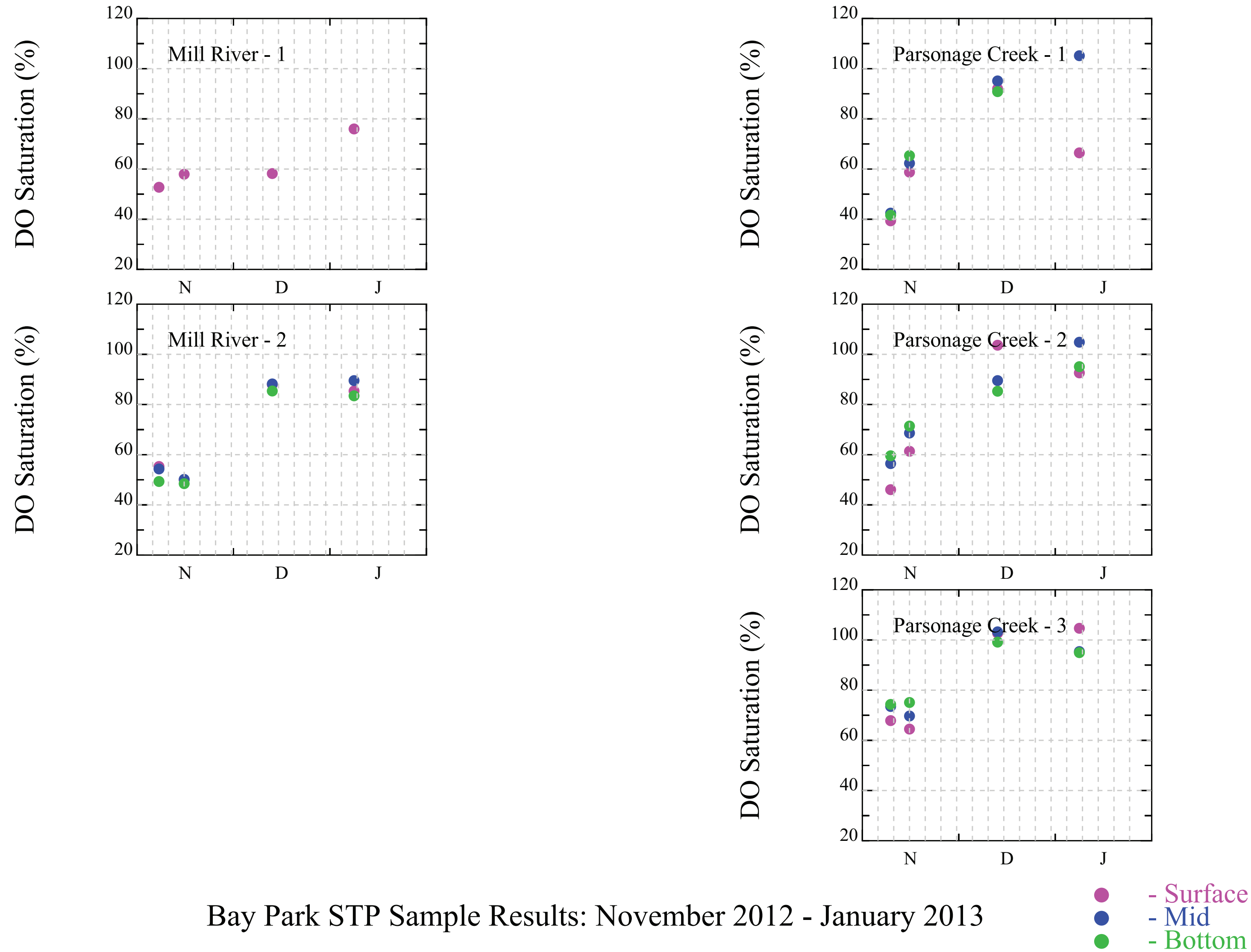


Figure 4-14. DO Percent Saturation Data in Mill River and Parsonage Creek

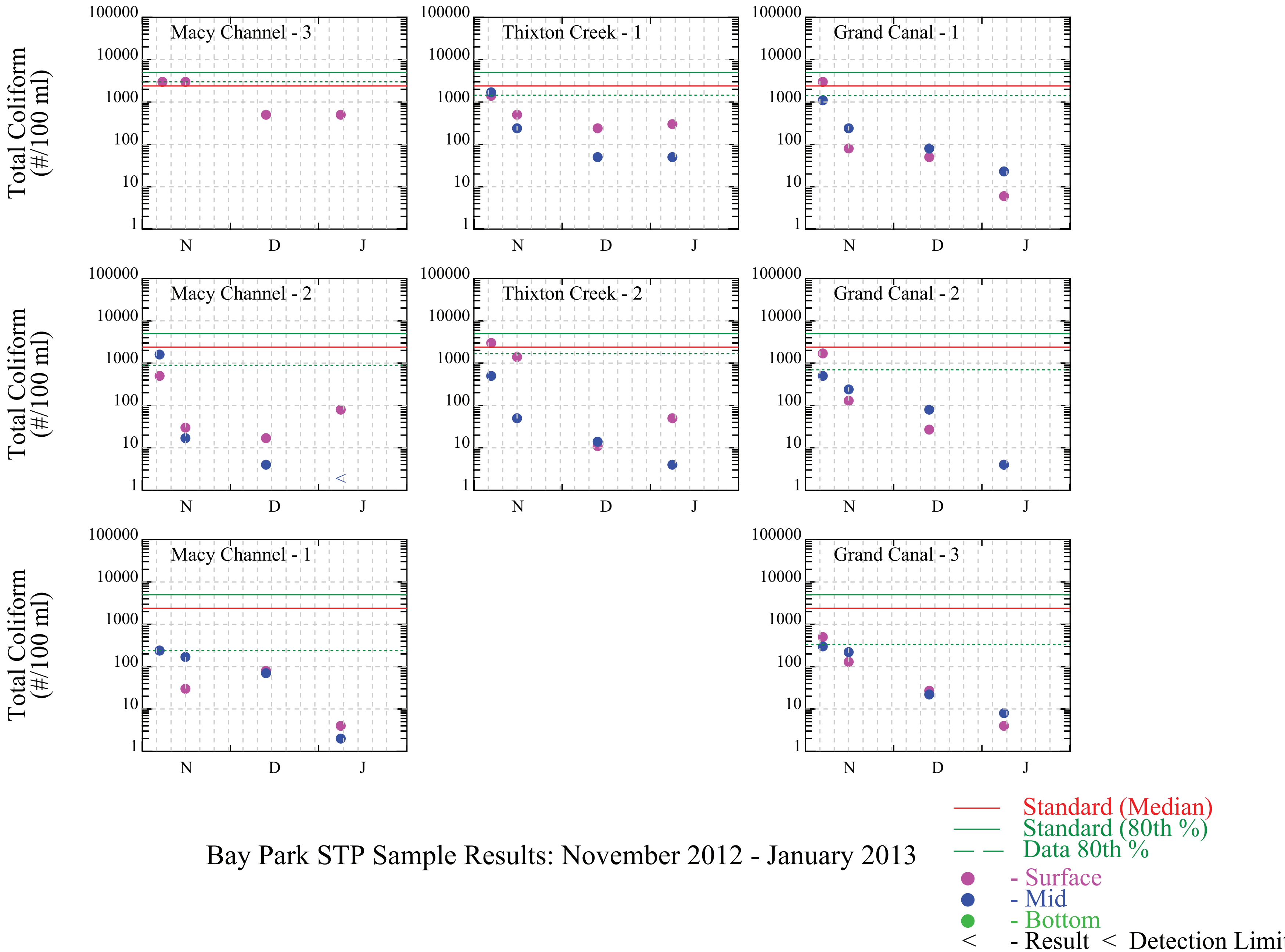


Figure 4-15. Total Coliform Data in Macy Channel, Thixton Creek and Grand Canal

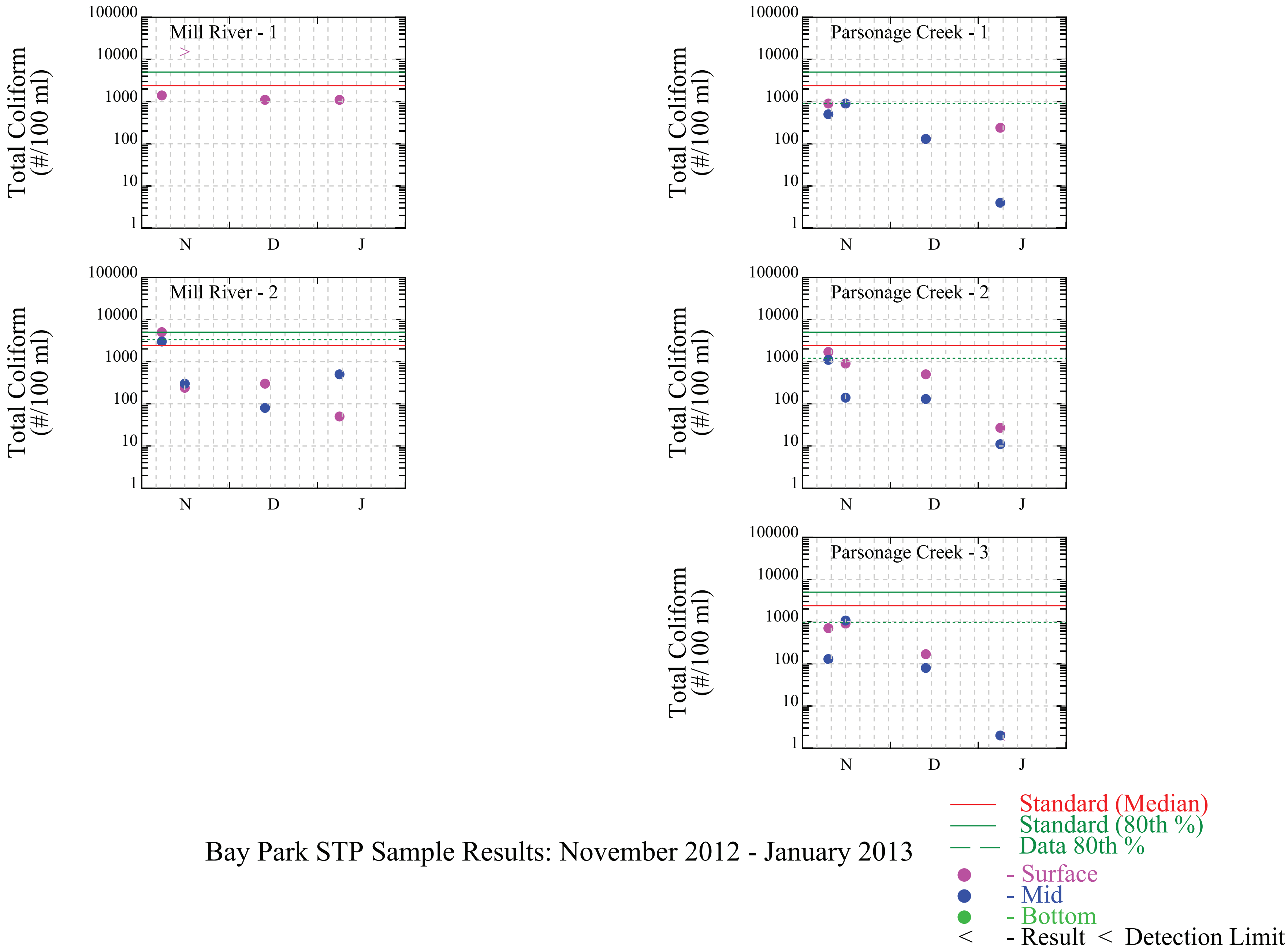


Figure 4-16. Total Coliform Data in Mill River and Parsonage Creek

The fecal coliform and enterococci data collected in the creeks is presented in Figures 4-17 through 4-20. The patterns are similar to those seen in the total coliform data. Higher concentrations were measured during the period after the storm and then decreased over time. Stations MC-3 and MR-1 show slower rates of decline.

Of the metals that were sampled in the creeks, only lead and zinc were detected in some samples. The results for lead are presented in Figures 4-21 and 4-22. During the first two surveys lead concentrations were either below the detection limit or below the chronic standard for lead. During the third survey, lead concentrations were significantly higher in all locations. The lab reviewed its results and found no errors. It is possible that the samples were somehow contaminated. If the lead measurements are accurate, the source of lead was not likely the STP as all of its discharge had returned to the Reynolds Channel outfall by this time.

Figures 4-23 and 4-24 present the zinc data collected in the creeks. Zinc concentrations were generally higher during the first survey and then declined over the following surveys. Zinc concentrations were below the acute and chronic standards with the exception of MC-3 during December. The concentration is likely due to a local source rather than from the STP because the highest concentrations are generally observed nearest the source and the STP was discharging into Reynolds Channel during this period of time.

The cadmium, chromium, copper, mercury, nickel, and silver measurements were all below the detection limit and are not shown.

All PAH measurements were below the detection limit.

Creek Water Quality Statistics

The previous section provided some temporal and spatial insight into the data collected in the creeks during the sampling program. Table 4-3 includes some statistics for the creek data with comparisons to some of the water quality standards. In the case of the bacteriological data, not enough samples were taken to assess compliance with the standards. The DO data show that there were periods when the DO concentrations were below the chronic standard, but Thixton Creek, the reference creek that did not receive a sewage discharge had similar or lower DO concentrations than the other creeks. BOD_5 concentrations were generally low with the highest concentrations associated with freshwater sources at MC-3 and MR-1. TSS concentrations were similar amongst the creeks; however, the high detection limit may mask some of the differences. High coliform and enterococci data at station MR-1 suggest a local source unrelated to the Bay Park STP. Some high lead concentrations were measured, but they all occurred during the mid-December sampling event and concentrations were high at all locations. Zinc concentrations were below the standard with the exception of Willow Pond (MC-3).

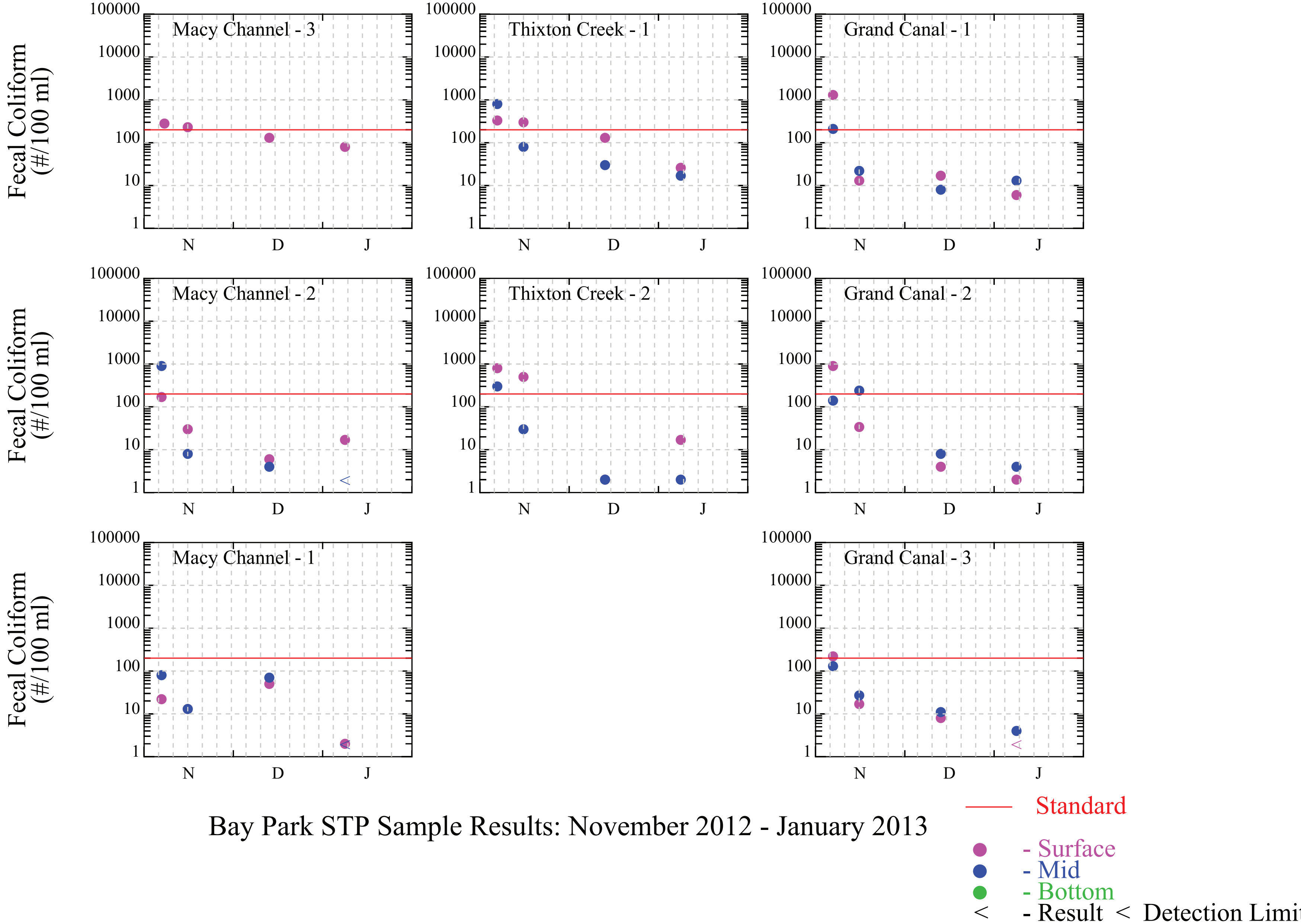


Figure 4-17. Fecal Coliform Data in Macy Channel, Thixton Creek and Grand Canal

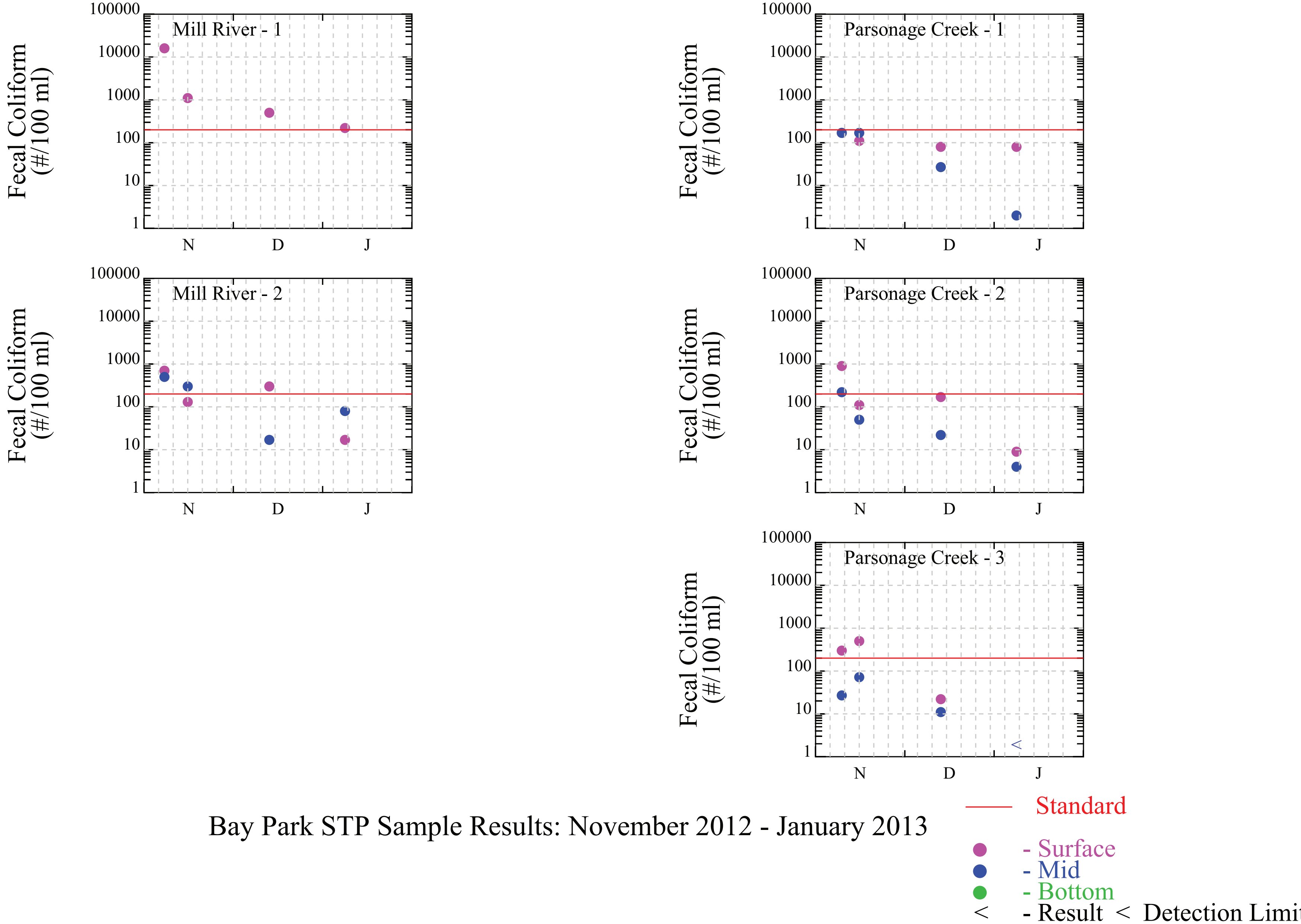


Figure 4-18. Fecal Coliform Data in Mill River and Parsonage Creek

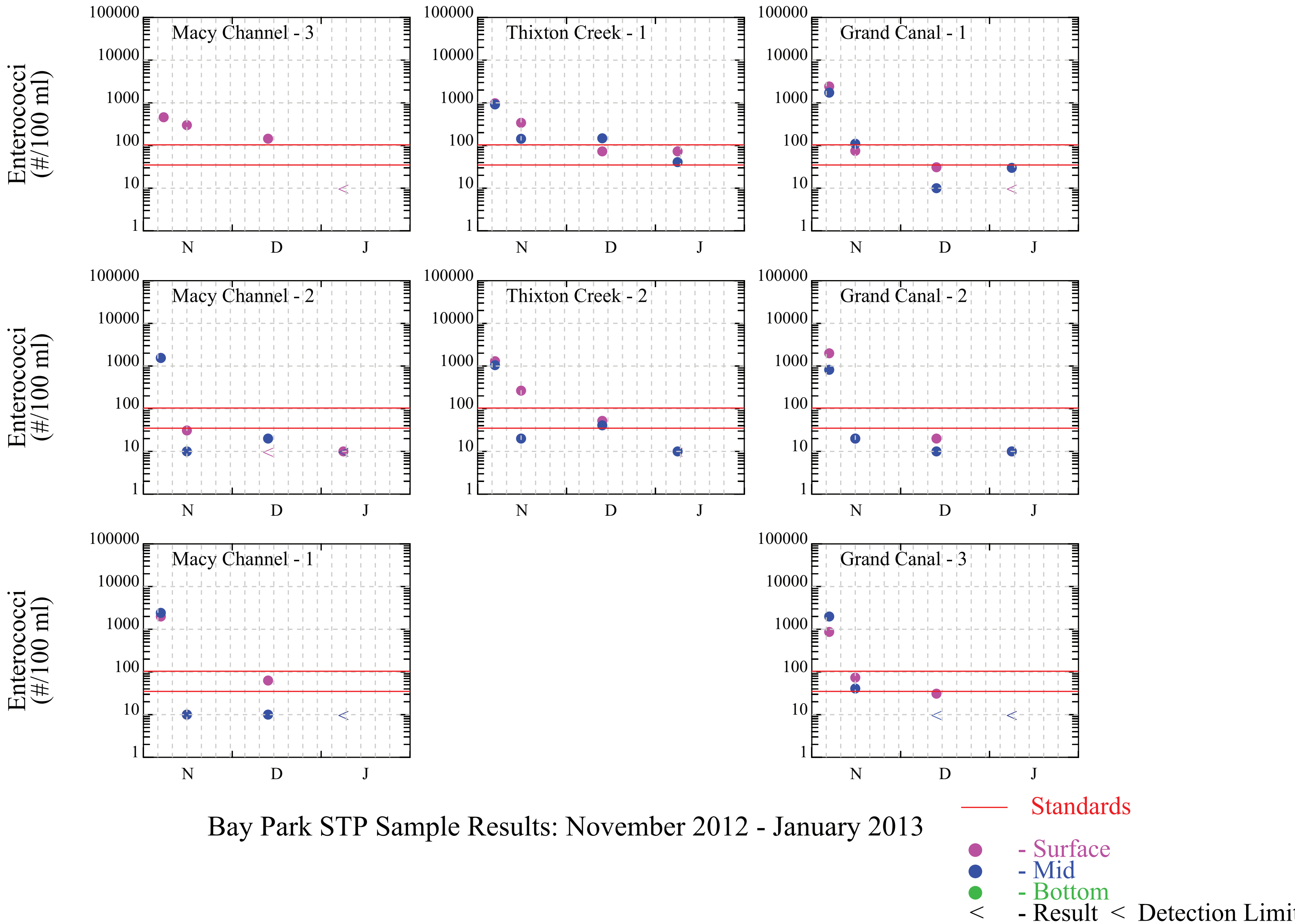


Figure 4-19. Enterococci Data in Macy Channel, Thixton Creek and Grand Canal

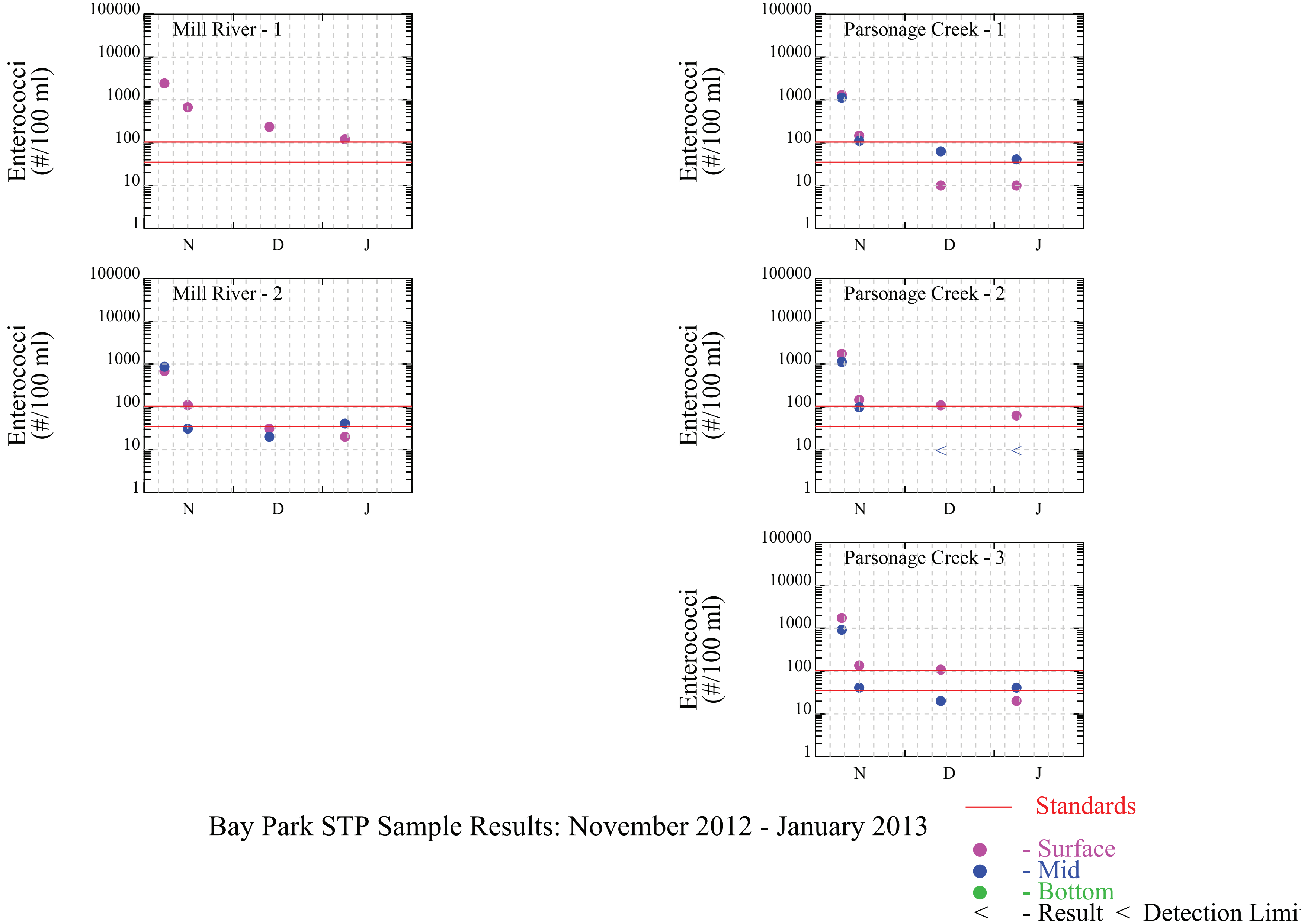


Figure 4-20. Enterococci Data in Mill River and Parsonage Creek

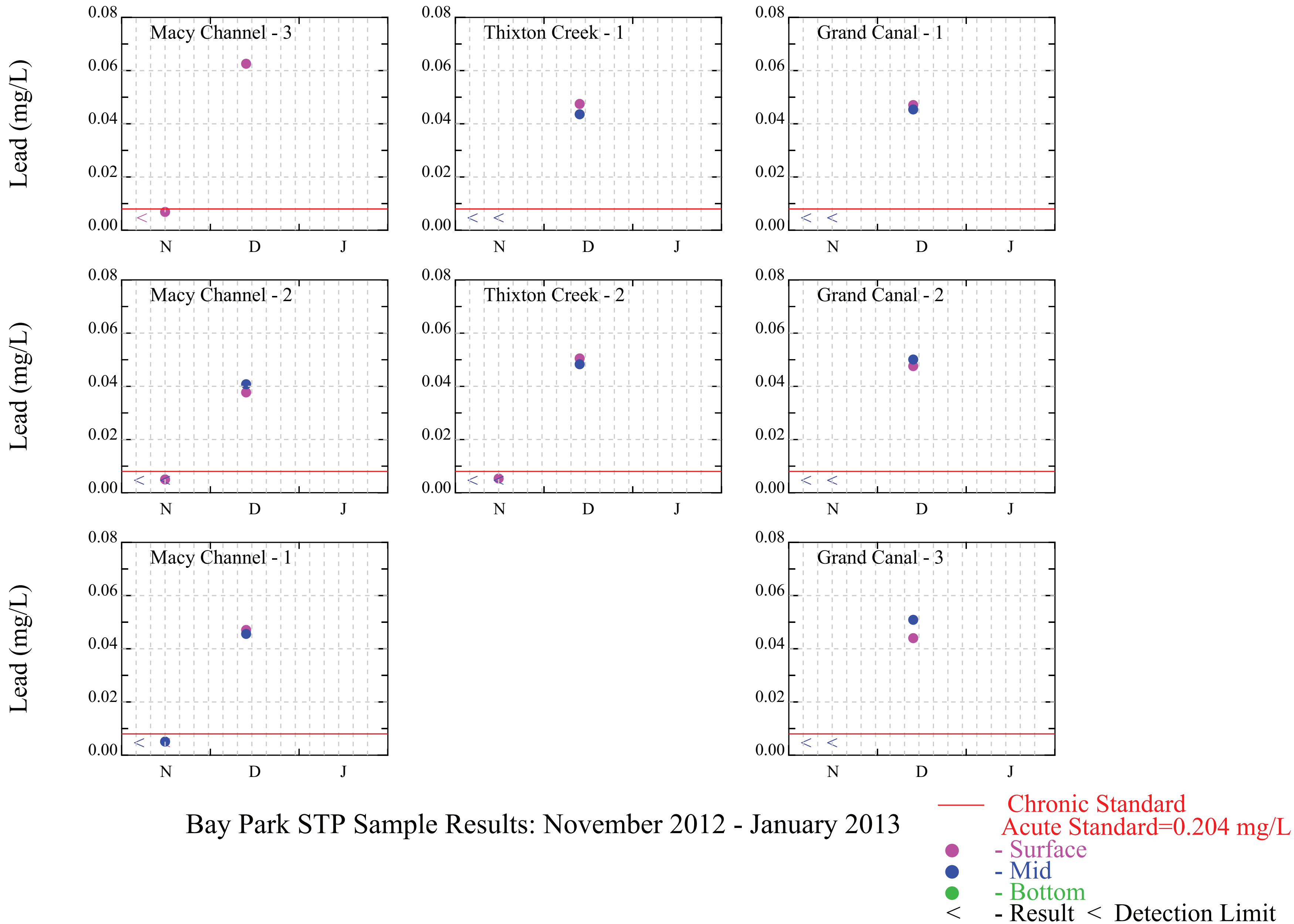


Figure 4-21. Lead Data in Macy Channel, Thixton Creek and Grand Canal

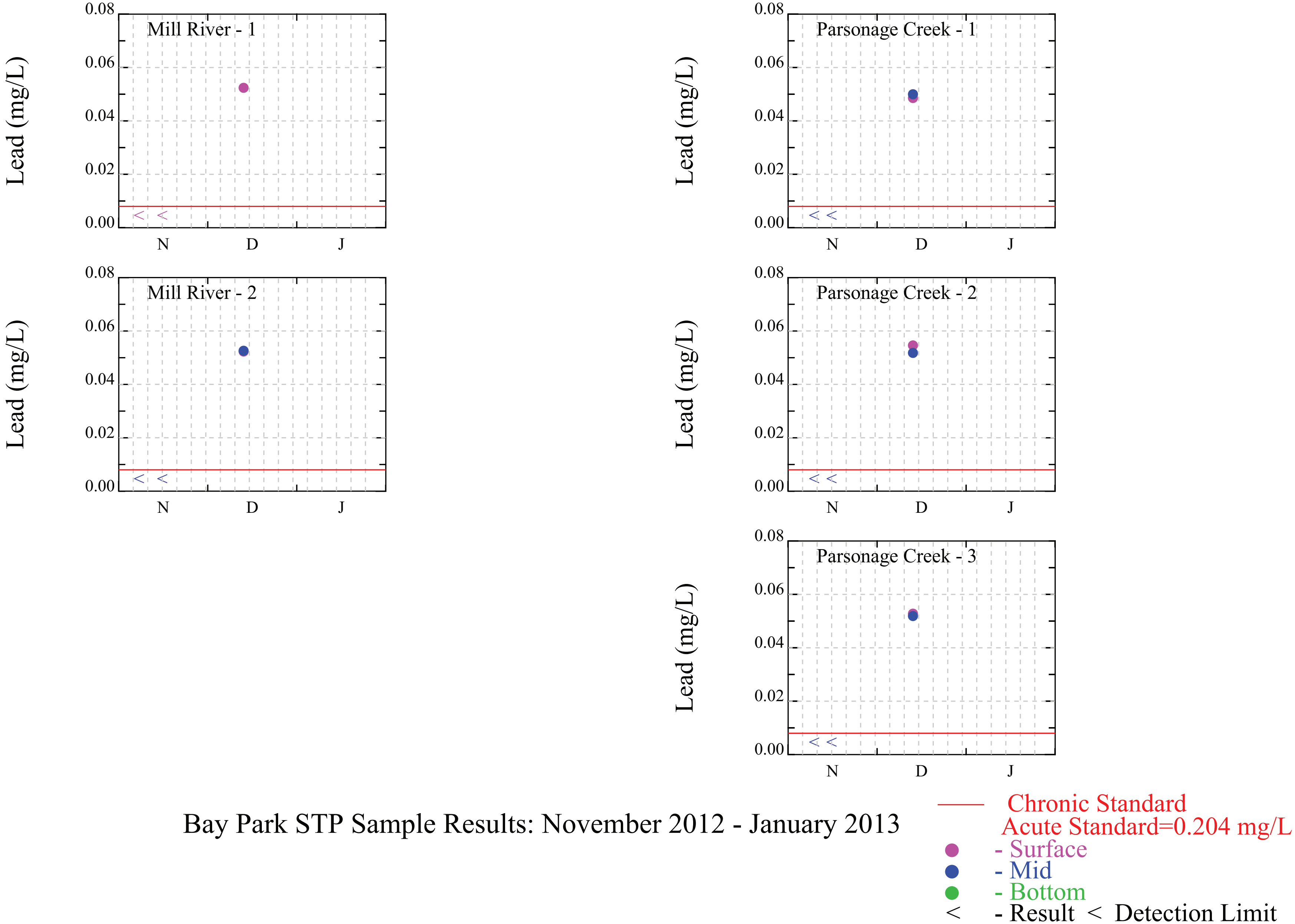


Figure 4-22. Lead Data in Mill River and Parsonage Creek

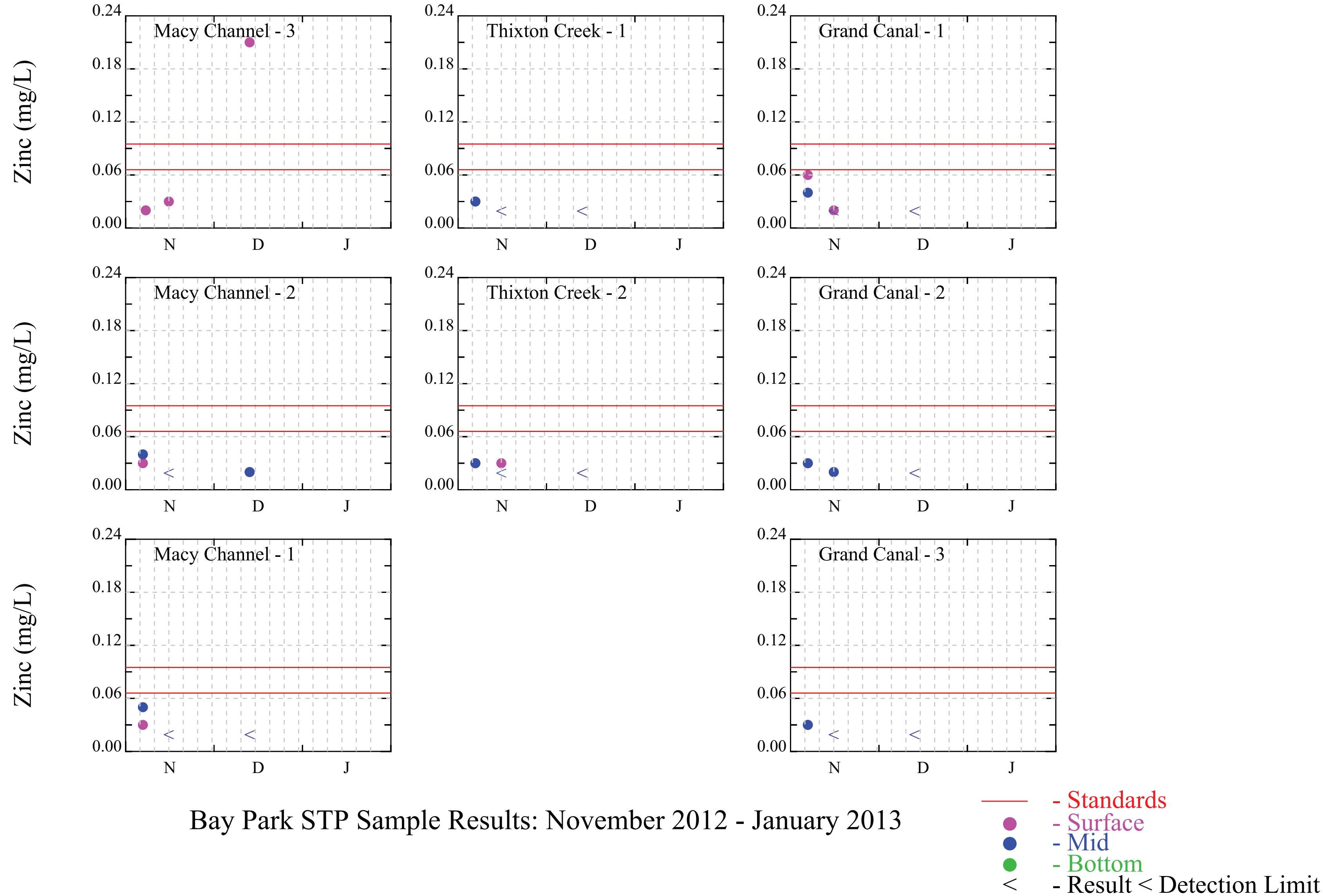


Figure 4-23. Zinc Data in Macy Channel, Thixton Creek and Grand Canal

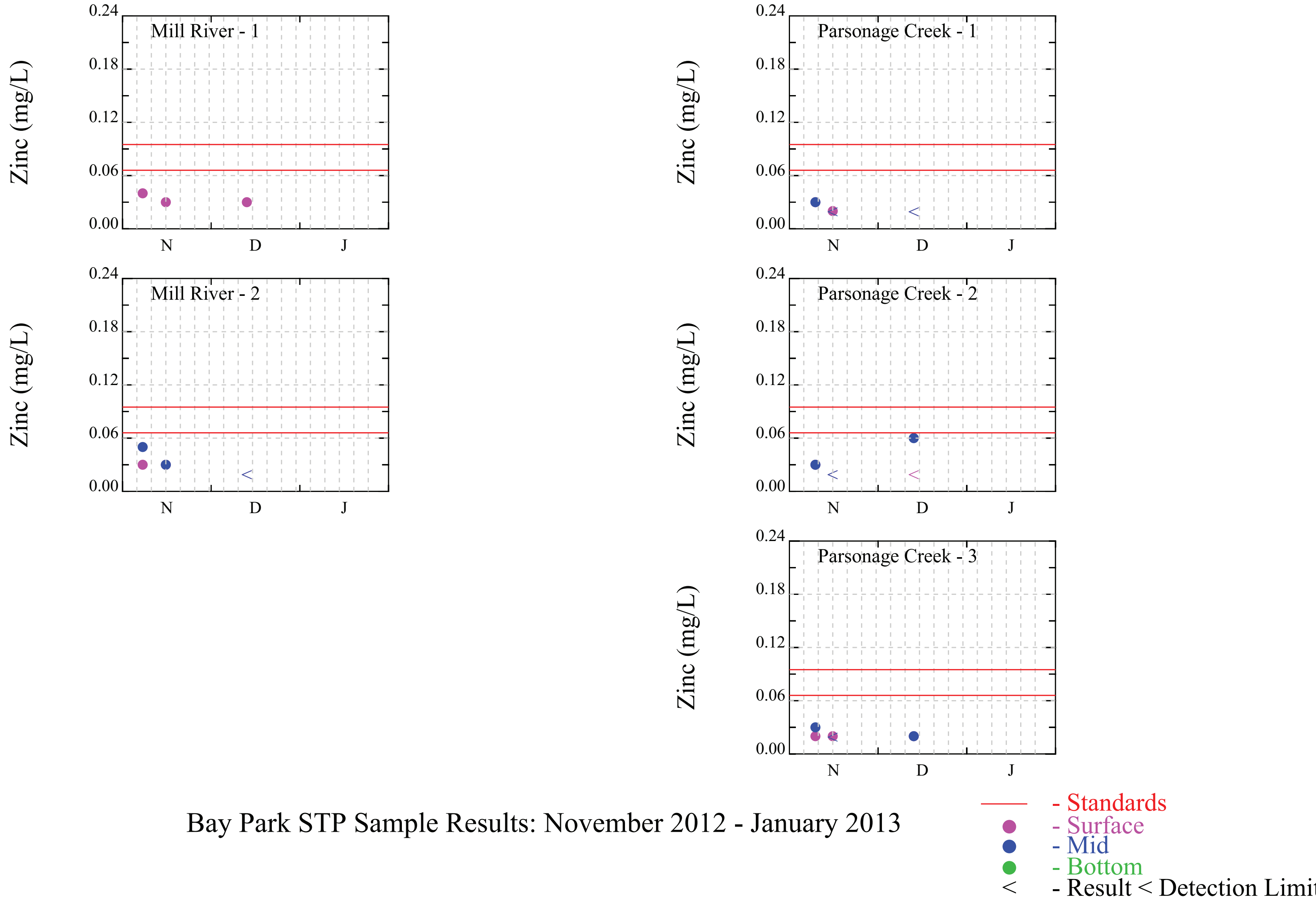


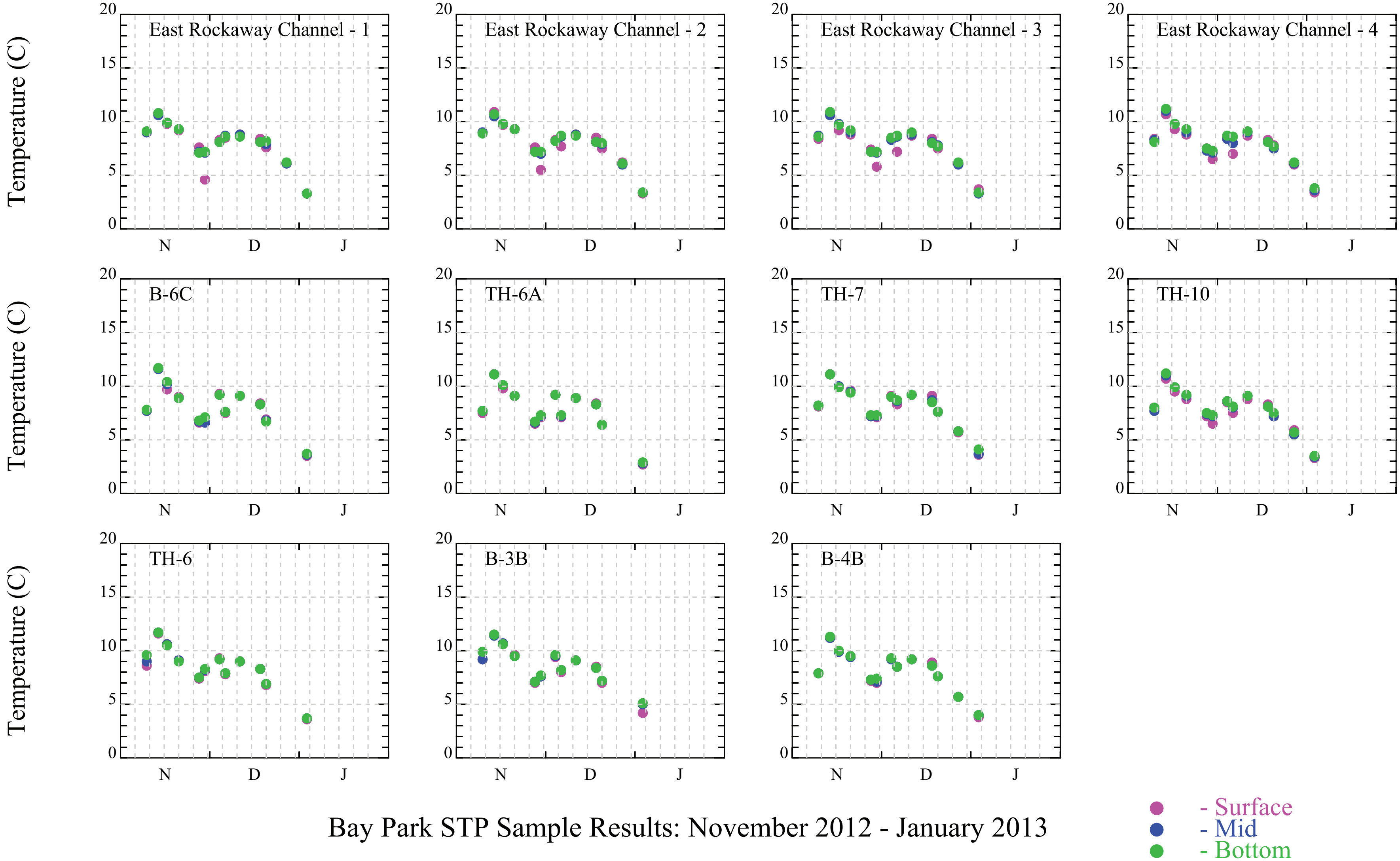
Figure 4-24. Zinc Data in Mill River and Parsonage Creek

Bay Results

This section will present the results of the water quality sampling in the bay. Figures are set up so that they approximate the distribution of the stations within the bay with the first page showing the more northerly stations and the second page showing the stations in or near Reynolds Channel.

The temperature data collected in the bay during the sampling program is presented in Figures 4-25 and 4-26. Temperatures in the northern portion of the bay were less than 10 °C in the beginning of November, but rose above 10 °C by mid-November. Temperatures then declined into the end of November then rose again in early December. By-mid December the temperatures again began to drop, almost linearly, into January. In the southern portions of the bay, the temperature fluctuations were more moderate as ocean water buffered the temperature changes.

Figures 4-27 and 4-28 present the salinity data collected in the bay during the period of November 2012 through early January 2013. The freshwater from the Mill River continues to be observed at the ERC stations and to station TH-10, which all show the surface water to have lower salinity concentrations. The influence of freshwater from the auxiliary outfall within ERC is not readily observed. The discharge ended on November 23 and it is not apparent that the salinity changed very much after that date. Further into the bay, the salinity stratification disappears with both surface and bottom salinity remaining near 30 to 32 ppt for the entire sampling period. Locations closer to the outfall (B-3A, Discharge and TH-4) show some evidence of the freshwater plume from the outfall. Differences between the surface and bottom salinity in the outfall plume vary between approximately 2 ppt to 5 ppt indicating that a 5:1 to 10:1 dilution occurs within close proximity of the outfall.



Bay Park STP Sample Results: November 2012 - January 2013

Figure 4-25. Temperature Data in West Hempstead Bay

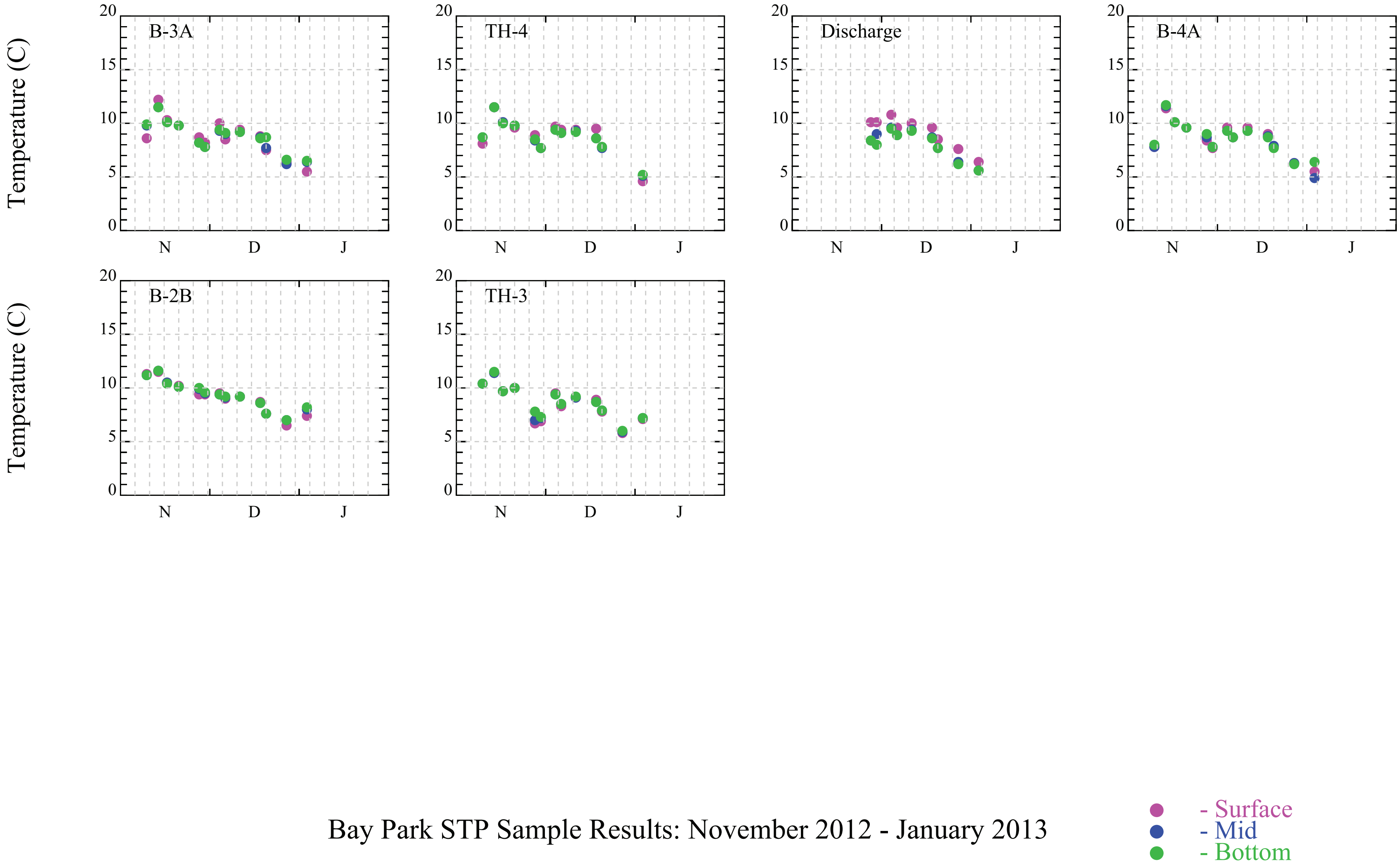


Figure 4-26. Temperature Data in Reynolds Channel

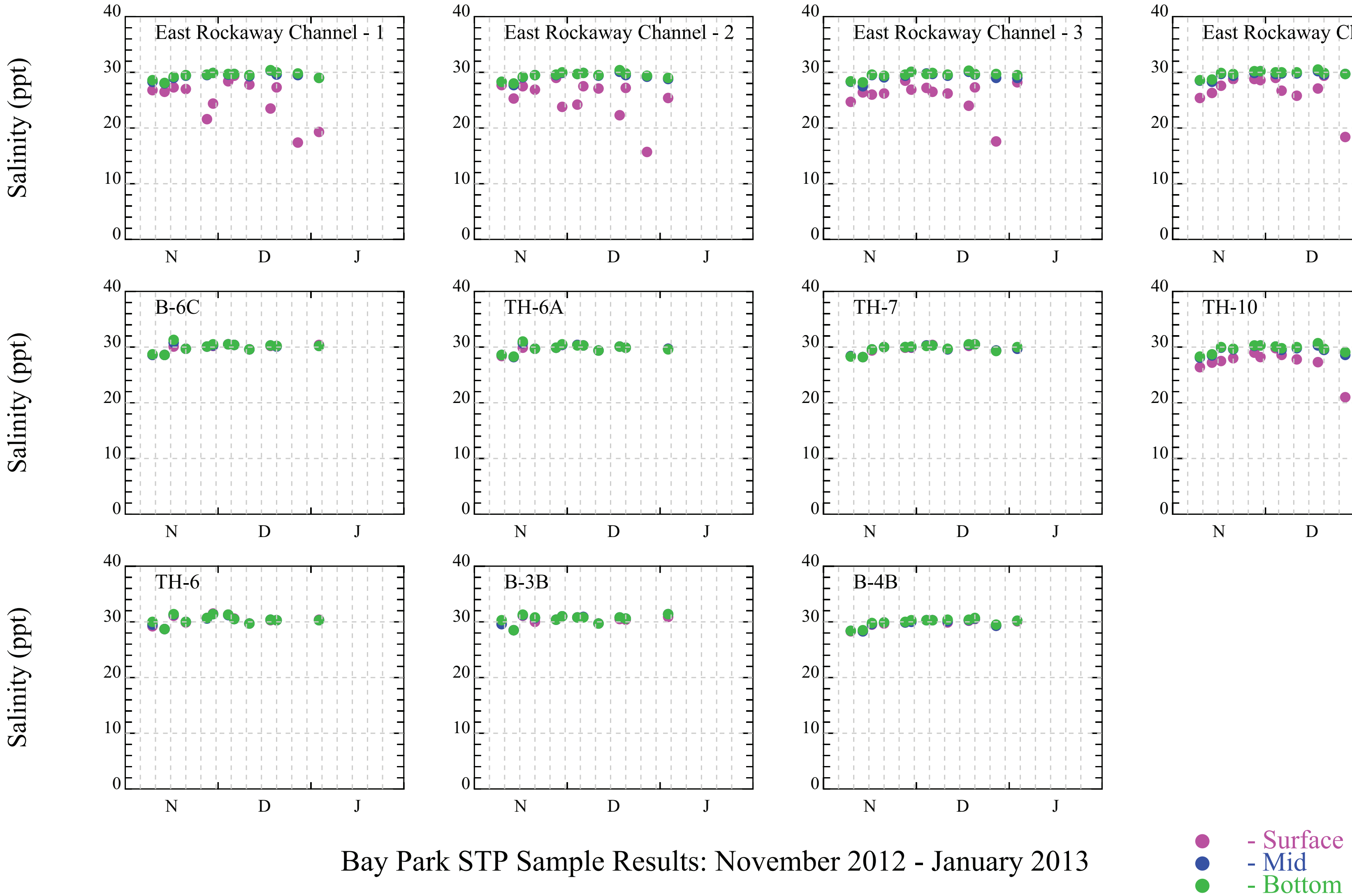
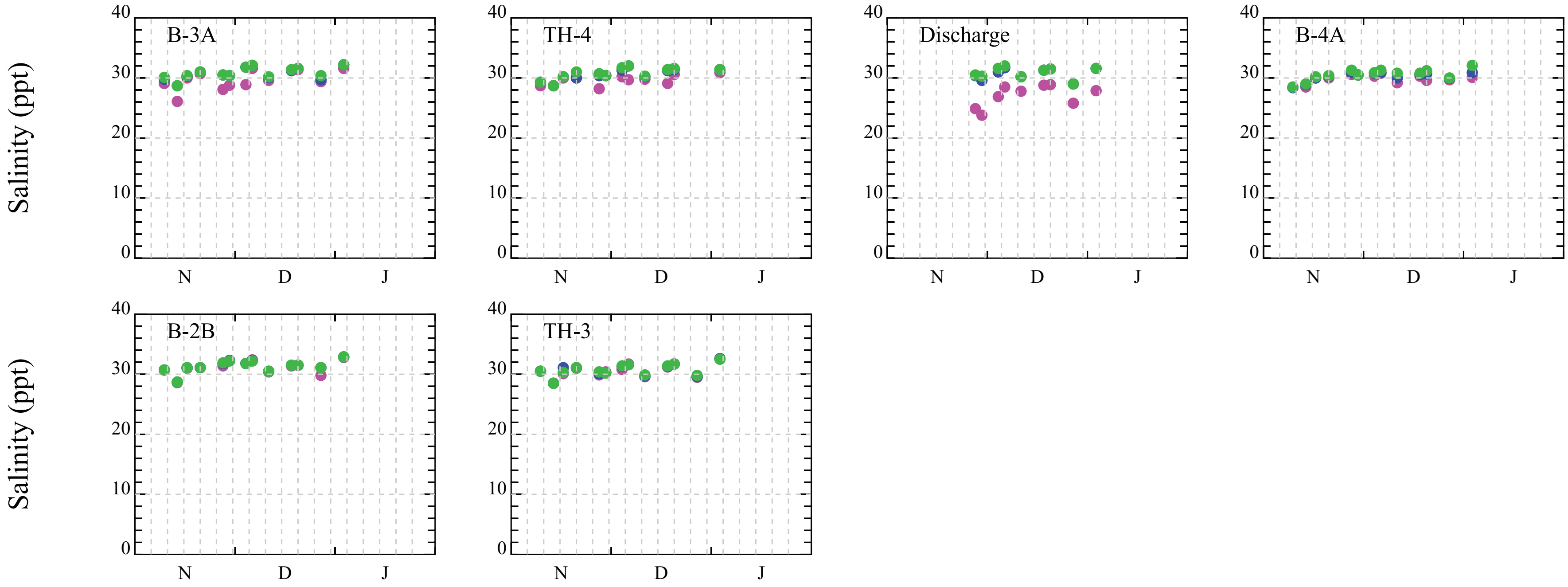


Figure 4-27. Salinity Data in West Hempstead Bay



Bay Park STP Sample Results: November 2012 - January 2013

Figure 4-28. Salinity Data in Reynolds Channel

Table 4-3. Summary Statistics for Creek Stations

		Creek Stations												
	Station	**MC-3**	**MC-2**	**MC-1**	**TX-1**	**TX-2**	**C-1**	**C-2**	**C-3**	**MR-1**	**MR-2**	**P-1**	**P-2**	**P-3**
	Class	**SC**	**SC**	**SC**	**SC**	**SC**	**SC**	**SC**	**SC**	**SC**	**SC**	**SC**	**SC**	**SC**
DO (mg/L)	**No. Samples**	3	12	12	11	11	12	12	11	4	12	11	12	12
	Maximum	19	13	11	9.4	9.8	10	10	10	10	10	11	11	11
	Minimum	6.5	4.8	4.9	4	3.9	4.1	4.2	4.4	5.3	4.6	3.8	4.5	6.1
	Mean	13.8	8.0	7.9	6.5	7.0	7.0	7.3	7.1	7.1	7.0	6.8	7.7	8.5
	No. <3.0	0	0	0	0	0	0	0	0	0	0	0	0	0
	No. <=4.8	0	1	0	4	2	5	3	3	0	2	3	1	0
BOD5 (mg/L)	**No. Samples**	3	6	6	6	6	6	6	6	3	6	6	6	6
	Maximum	15	3	3	2	2	4	3	2	14	2	4	4	3
	Minimum	5	2	2	2	2	2	2	2	2	2	2	2	2
	Mean	12	2	2	2	2	2	2	2	6	2	3	2	2
TSS (mg/L)	**No. Samples**	3	6	6	6	6	6	6	6	3	6	6	6	6
	Maximum	20	21	13	20	16	22	15	16	21	14	16	14	12
	Minimum	10	10	10	10	10	10	10	10	10	10	10	10	10
	Mean	16	13	11	13	12	14	11	11	14	11	11	11	11
Total Coli (#/100 ml)	**No. Samples**	4	8	8	8	8	8	8	8	4	8	8	8	8
	Maximum	3000	1600	240	1700	3000	3000	1700	500	16000	5000	900	1700	1070
	Minimum	500	2	2	50	4	6	4	4	1100	50	4	11	2
	Median-Nov													
	Median-Dec													
	Median-All													
	80th Percentile	3000	685	240	1451	1670	1420	702	334	16000	3337	900	1201	929
	No. >5000	0	0	0	0	0	0	0	0	1	0	0	0	0
	No. >2400	2	0	0	0	1	1	0	0	1	2	0	0	0
	No. >70	4	3	4	6	3	5	5	4	4	7	7	6	6
	Mon Median Exceed 2400	**Y**	N	N	N	N	N	N	N	**Y**	N	N	N	N
	Median Exceed 70	Y	N	Y	Y	N	Y	Y	Y	Y	Y	Y	Y	Y

Table 4-3. Summary Statistics for Creek Stations

		Creek Stations												
	Station	**MC-3**	**MC-2**	**MC-1**	**TX-1**	**TX-2**	**C-1**	**C-2**	**C-3**	**MR-1**	**MR-2**	**P-1**	**P-2**	**P-3**
	Class	**SC**	**SC**	**SC**	**SC**	**SC**	**SC**	**SC**	**SC**	**SC**	**SC**	**SC**	**SC**	**SC**
	80th % Exceed 5000	N	N	N	N	N	N	N	N	Y	N	N	N	N
Fecal Coli (#/100 ml)	**No. Samples**	4	8	8	8	8	8	8	8	4	8	8	8	8
	Maximum	280	900	80	800	800	1300	900	220	16000	700	170	900	500
	Minimum	80	2	2	17	2	6	2	2	220	17	2	4	2
	Geo Mean-Nov													
	Geo Mean-Dec													
	No. >200	2	1	0	3	3	2	2	1	4	4	0	2	2
	Geo Mean Exceed 200	**Y**	N	N	**Y**	**Y**	N	N	N	**Y**	**Y**	N	N	N
Enterococci (#/100 ml)	**No. Samples**	4	8	8	8	8	8	8	8	4	8	8	8	8
	Maximum	461	1550	2420	980	1300	2420	1990	1990	2420	866	1300	1730	1730
	Minimum	10	10	10	41	10	10	10	10	121	20	10	10	20
	Geo Mean-Nov													
	Geo Mean-Dec													
	No. >35	3	2	3	8	5	4	2	4	4	4	6	6	6
	No.>104	3	2	2	5	3	3	2	2	4	3	4	4	4
	Geo Mean Exceed 35	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**
	Geo Mean Exceed 104	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**
Lead (mg/L)	**No. Samples**	3	6	6	6	6	6	6	6	3	6	6	6	6
	Maximum	0.063	0.041	0.047	0.047	0.051	0.047	0.05	0.051	0.052	0.053	0.05	0.055	0.053
	Minimum	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005
	Mean	0.025	0.016	0.019	0.019	0.02	0.019	0.02	0.019	0.021	0.021	0.02	0.021	0.021
	No. >=0.008 (chr)	**1**	**2**	**2**	**2**	**2**	**2**	**2**	**2**	**1**	**2**	**2**	**2**	**2**
Zinc (mg/L)	**No. Samples**	3	6	6	6	6	6	6	6	3	6	6	6	6
	Maximum	0.21	0.04	0.05	0.03	0.03	0.06	0.03	0.03	0.04	0.05	0.03	0.06	0.03
	Minimum	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.03	0.02	0.02	0.02	0.02
	Mean	0.087	0.025	0.027	0.023	0.025	0.03	0.023	0.023	0.033	0.03	0.023	0.03	0.022

Table 4-3. Summary Statistics for Creek Stations

		Creek Stations												
	Station	**MC-3**	**MC-2**	**MC-1**	**TX-1**	**TX-2**	**C-1**	**C-2**	**C-3**	**MR-1**	**MR-2**	**P-1**	**P-2**	**P-3**
	Class	**SC**	**SC**	**SC**	**SC**	**SC**	**SC**	**SC**	**SC**	**SC**	**SC**	**SC**	**SC**	**SC**
	No. >=0.066 (chr)	**1**	0	0	0	0	0	0	0	0	0	0	0	0
	No. >=0.095 (acute)	**1**	0	0	0	0	0	0	0	0	0	0	0	0

Figures 4-29 and 4-30 present the TSS data collected in the bay during November 2012 through early January 2013. TSS data was not collected during every bay sampling event. The stations in East Rockaway Channel do not show the effect of the temporary auxiliary outfall as the TSS remain relatively constant over the sampling period and tend to be lower that TSS concentrations in the bay. The general trend in the data is that stations in the northern and eastern portions of the bay have the lowest TSS concentrations and the stations in Reynolds Channel have the highest TSS concentrations with B-2B having the highest concentrations. TSS concentrations may be related more to current velocity (resuspension) than to proximity to the Bay Park STP outfalls.

Times series figures for the BOD_5 data collected during the sampling program in the bay are presented in Figures 4-31 and 4-32. Most of the data are at or below the detection limit of 2.0 mg/L, with occasional measurements reaching as much as 5 mg/L. Two high BOD_5 measurements, at 10 mg/L to 11 mg/L, were observed at station B-3A, west of the Reynolds Channel outfall. There is no readily discernible effect of the auxiliary outfall discharge on the BOD_5 levels in East Rockaway Channel. The effect of the partially treated sewage on BOD_5 concentrations in the bay is not evident with the possible exception of station B-3A where high BOD_5 concentrations were measured briefly during mid-November. BOD_5 was not measured during every sampling event because the concentrations were low for the majority of the early sampling events, so it did not appear to be important to continue sampling for BOD_5.

The DO data collected in the bay during the sampling program is presented in Figures 4-33 and 4-34. All of the DO measurements were greater than 4.8 mg/L. In East Rockaway Channel and station TH-10, DO concentrations increased almost linearly from the first sampling event. Out in the bay, DO concentrations increased through November and then leveled off through December and January at approximately 8 to 10 mg/L. Overall, the measurements are in compliance with the NYS dissolved oxygen water quality standards.

The percent DO saturation for the bay stations is presented in Figures 4-35 and 4-36. The trends are similar to those observed in the creeks excepted the starting percentage is higher. In general, the bay stations had a percent DO saturation near 60 percent in November, while the East Rockaway Channel stations were closer to 50 percent. The percent DO saturation increased steadily into early December and then leveled off or showed some up and down variability all being between 90 and 100 percent of saturation. The data indicate a reduction in the impact of oxygen demand materials over the course of the sampling period.

Although DO concentrations and percent DO saturation are lowest in early November and increase steadily through the filed investigations, these data do not directly connect the lower DO concentrations in early November with the partially treated sewage discharged from Bay Park. With the myriad of other things that happened during the hurricane (resuspension of settled organic matter from within the bay and marsh, significant runoff of debris, oils, and other pollutants as

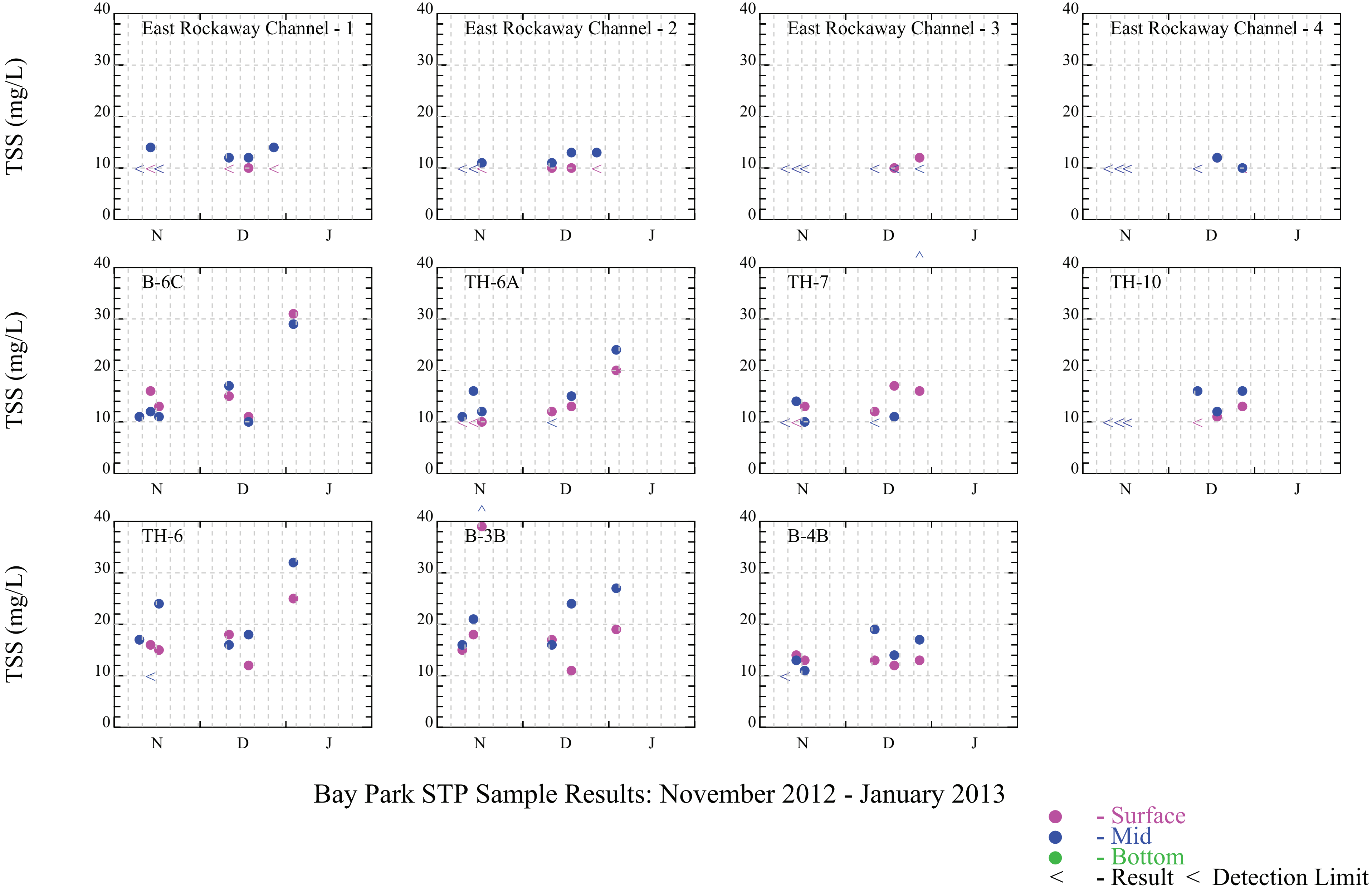


Figure 4-29. TSS Data in West Hempstead Bay

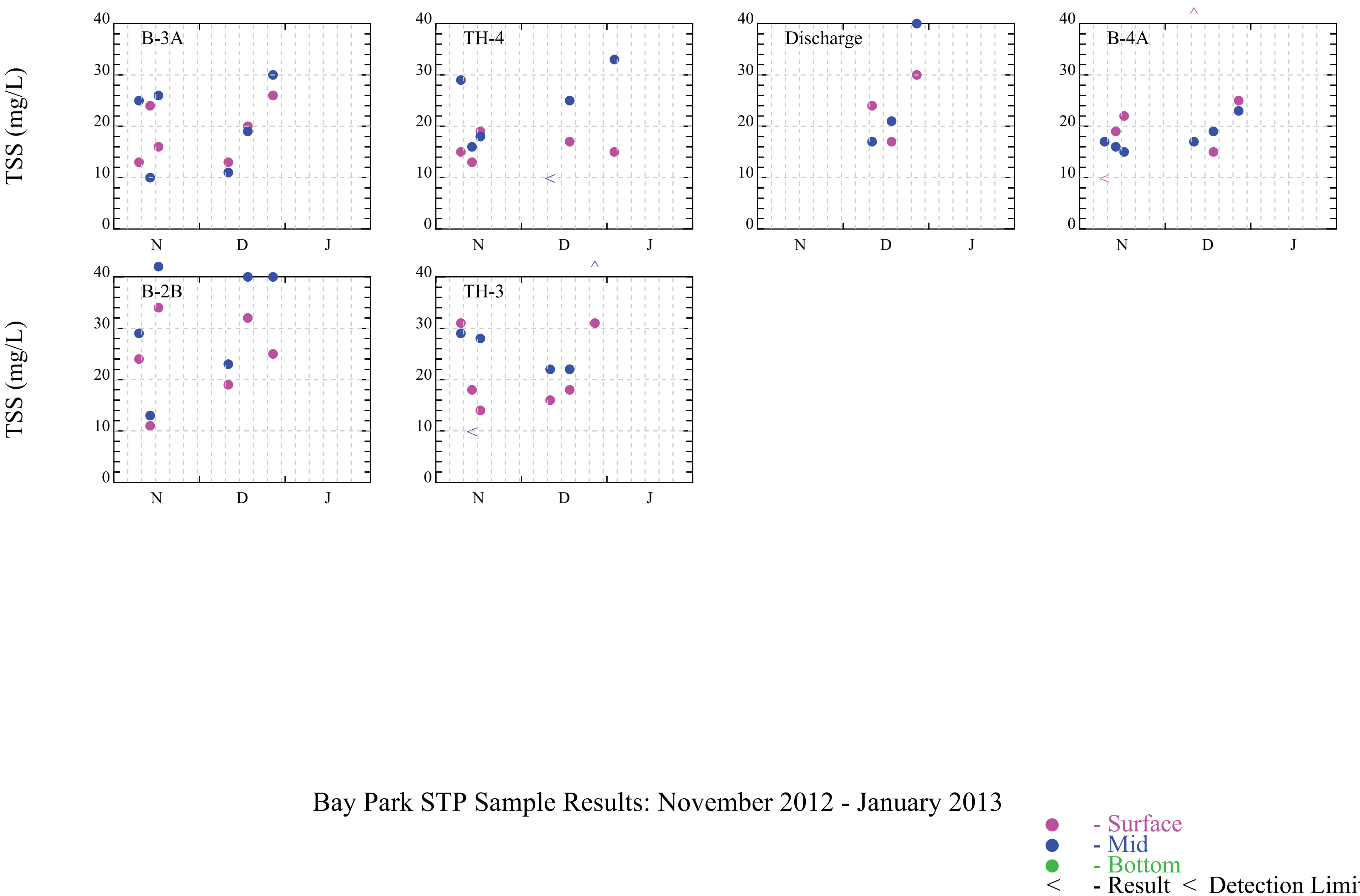


Figure 4-30. TSS Data in Reynolds Channel

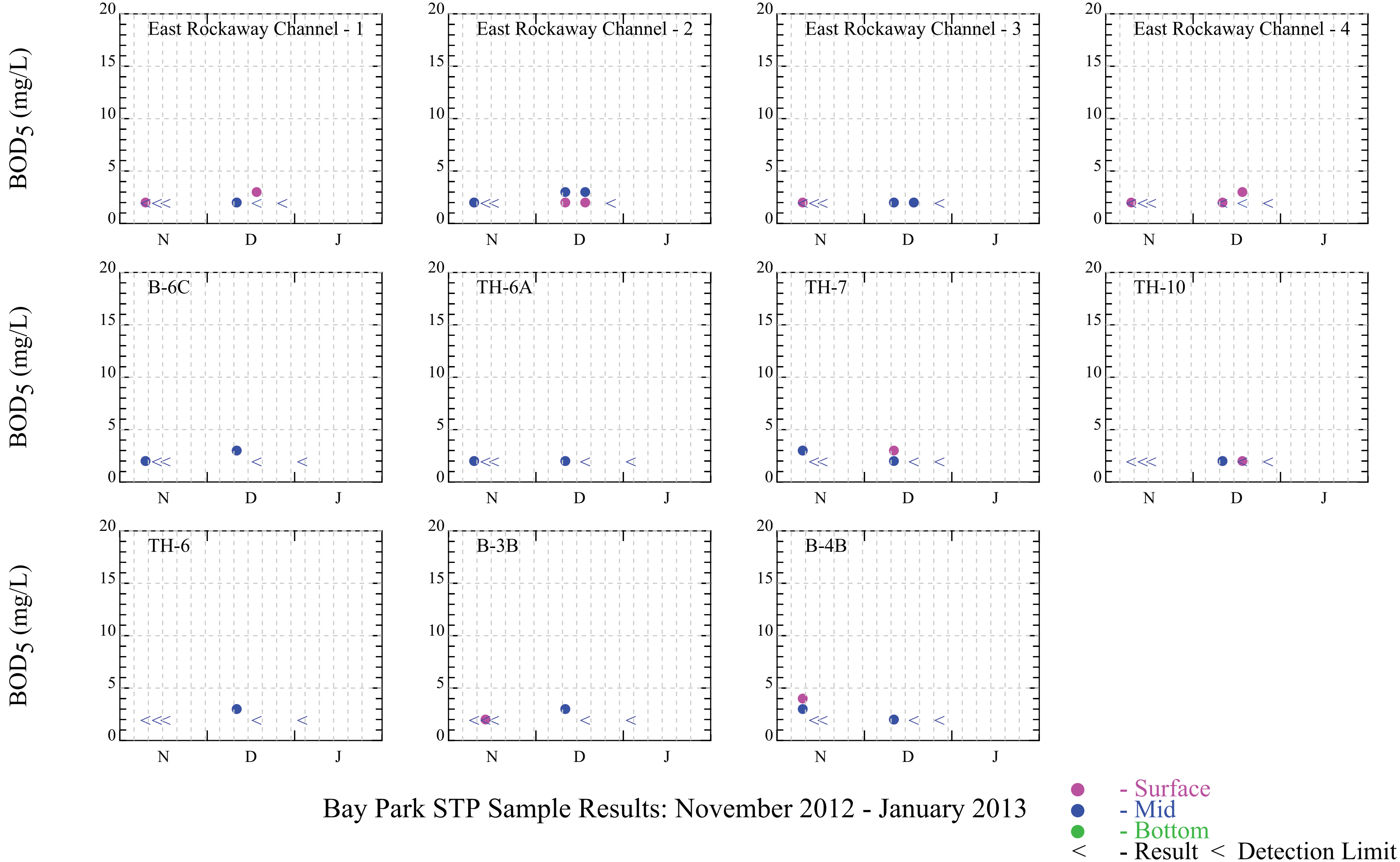


Figure 4-31. BOD_5 Data in West Hempstead Bay

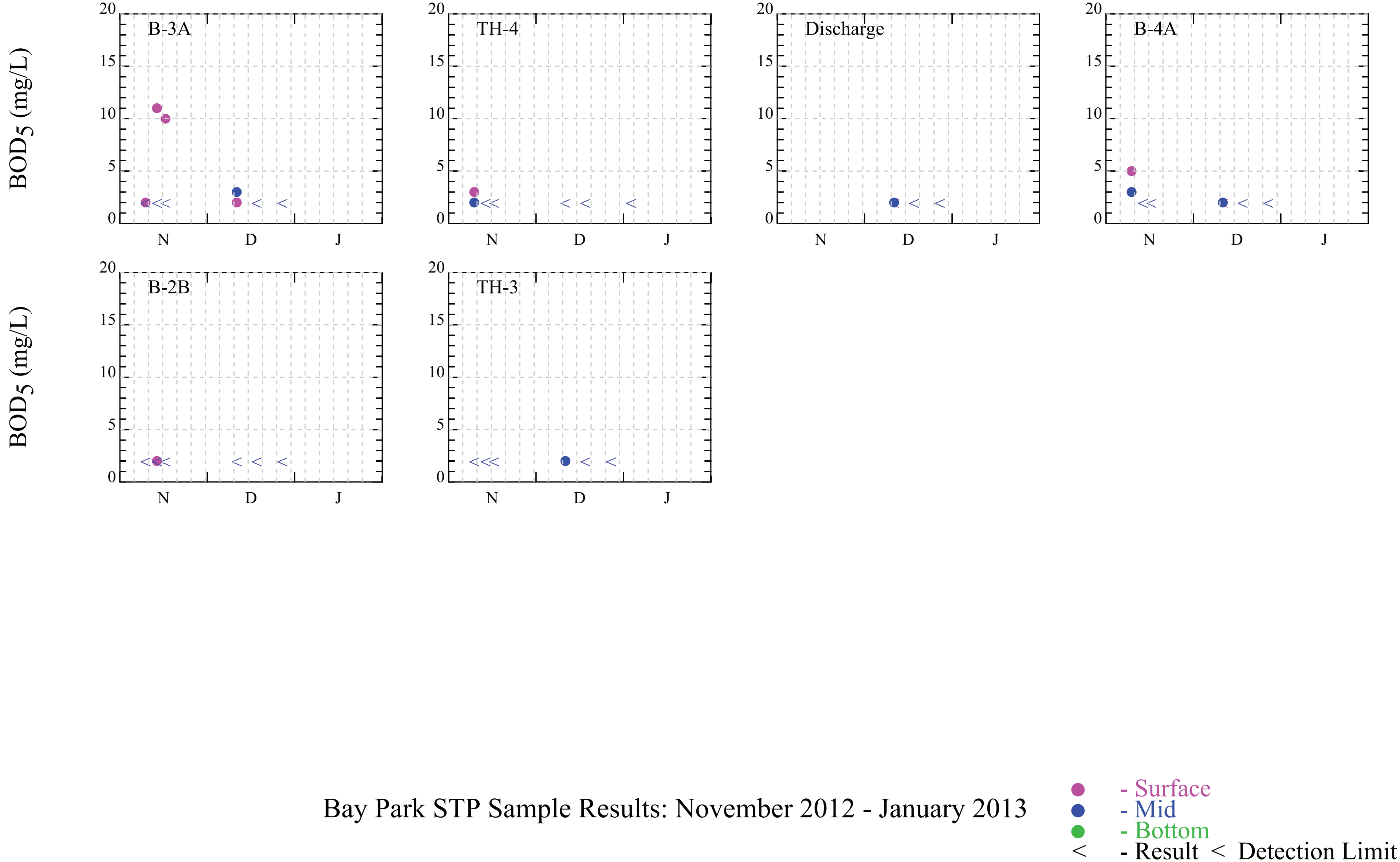


Figure 4-32. BOD_5 Data in Reynolds Channel

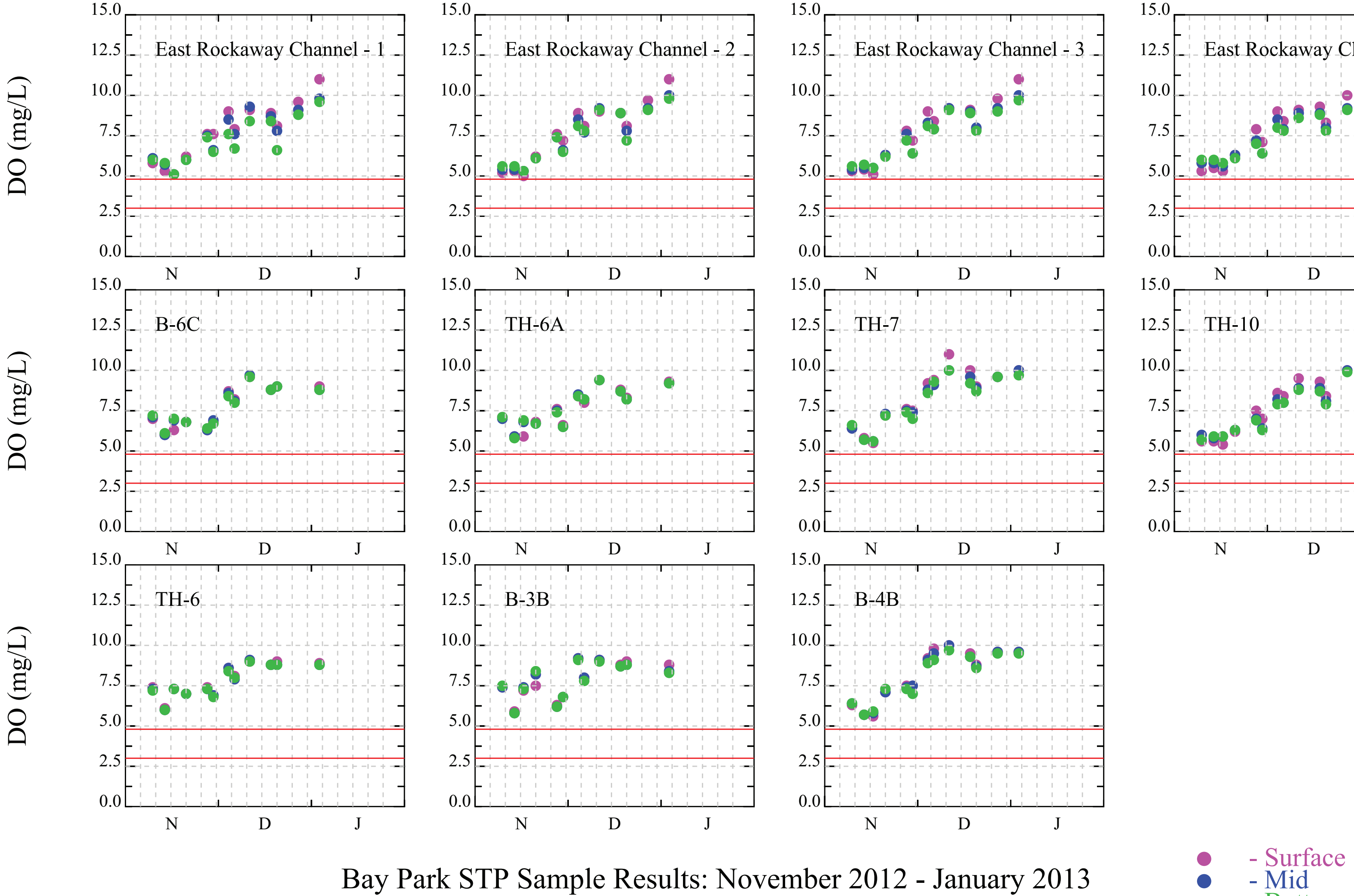


Figure 4-33. DO Data in West Hempstead Bay

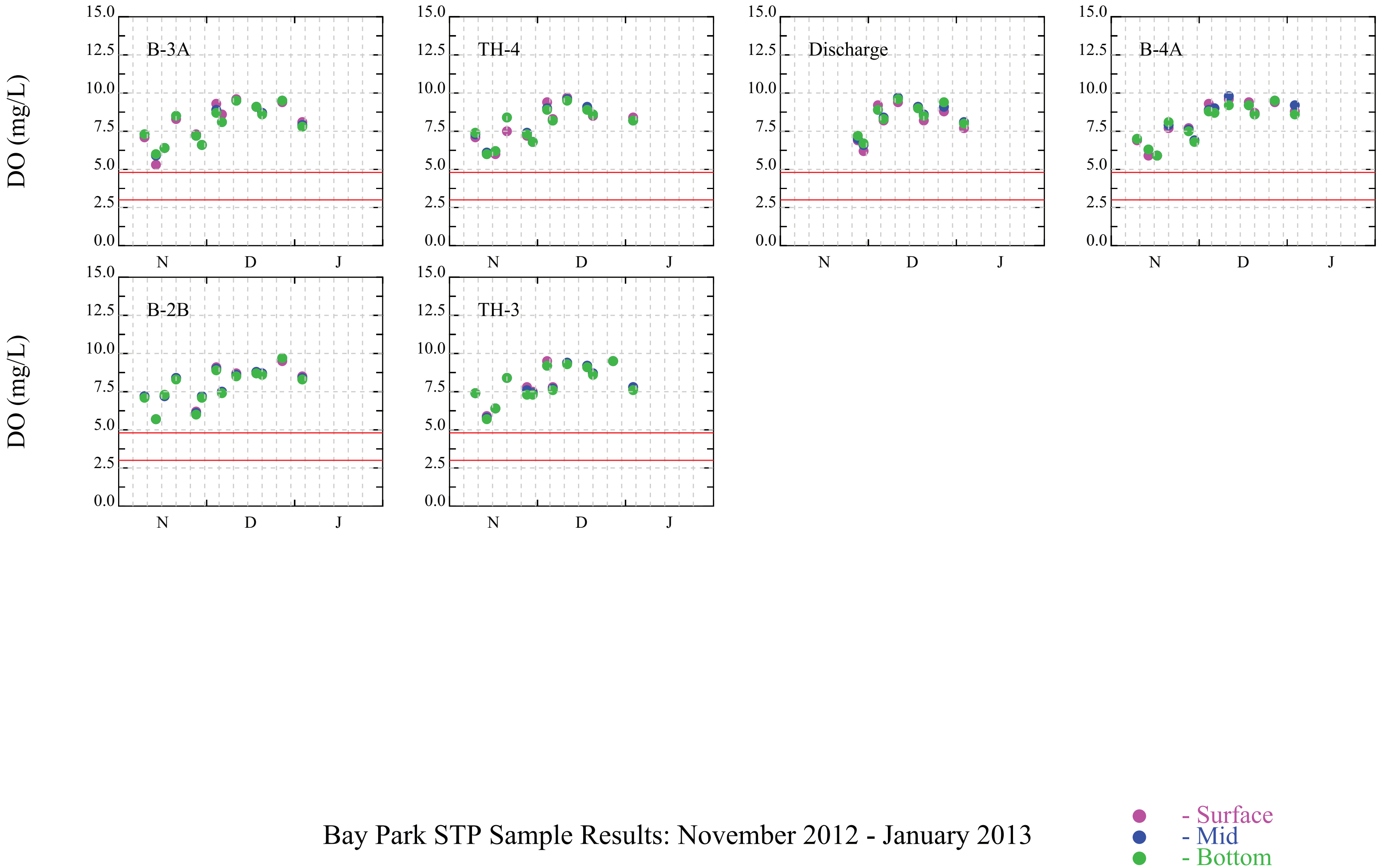


Figure 4-34. DO Data in Reynolds Channel

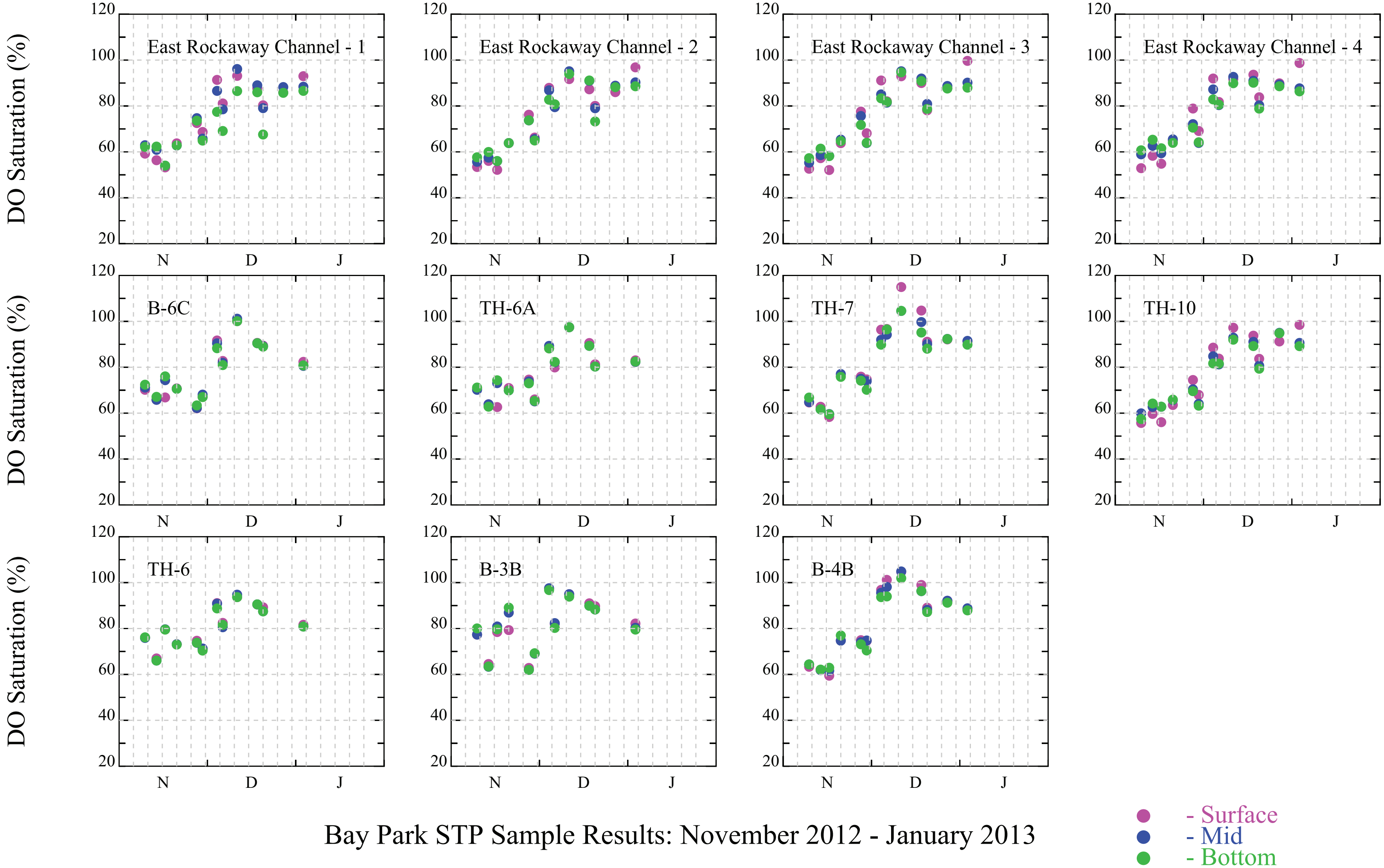
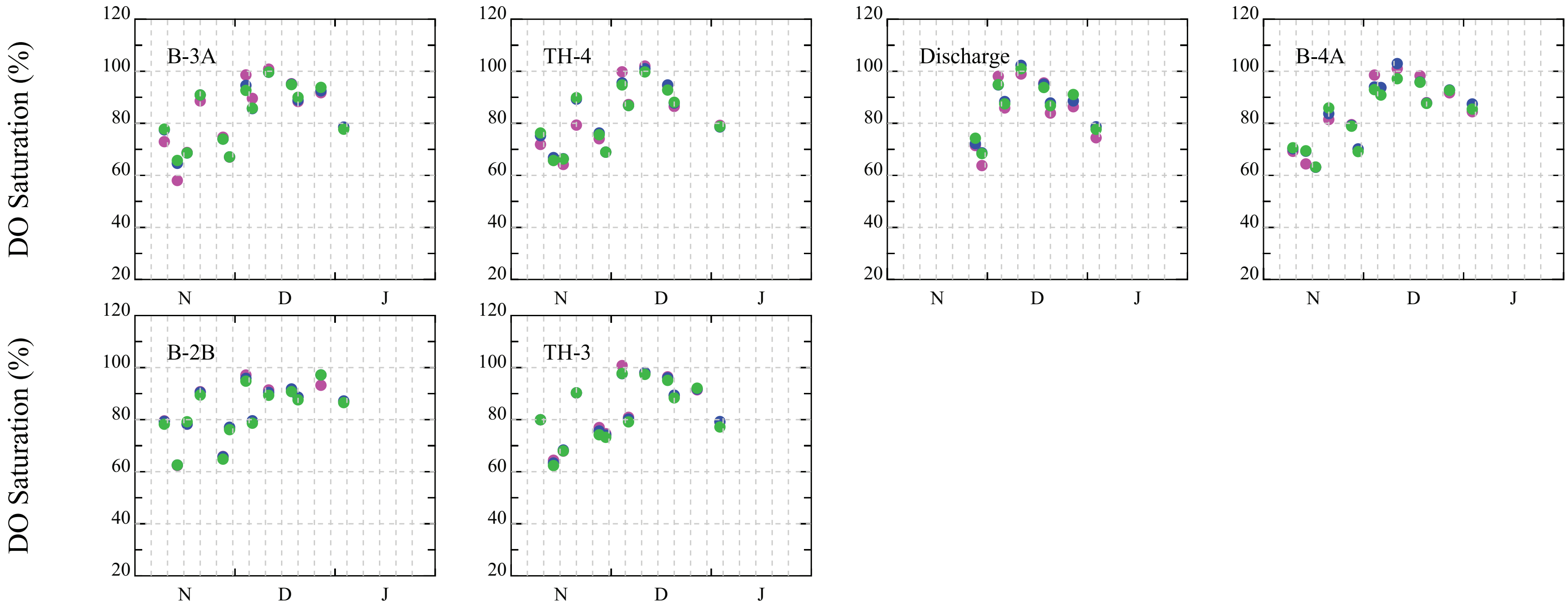


Figure 4-35. DO Percent Saturation Data in West Hempstead Bay



Bay Park STP Sample Results: November 2012 - January 2013

Figure 4-36. DO Percent Saturation Data in Reynolds Channel

floodwaters subsided, etc.), the Bay Park STP effluent impacts would be part of the cause of reduced DO levels. Attributing a portion of the DO reduction to Bay Park would take additional analysis including development and application of a water quality model.

Figures 4-37 and 4-38 present the total coliform concentrations measured in the bay during the sampling program. On some panels that correspond to locations in Class SA water, a horizontal line representing a geometric mean of 70 no./100 mL has been added to represent the water quality standard in these locations. Sampling in the bay occurred more often than in the creek. The data in the bay do not show the same trend as the creek stations. Since rainfall can heavily impact coliform levels, much of the variation observed in the data is likely do to rainfall rather than the Bay Park STP, especially since disinfection was restarted in early November.

In East Rockaway Channel, the surface total coliform concentrations remain relatively high over the sampling period, but this area is fed by the Mill River, which was observed to have elevated total coliform concentrations. Lower concentrations were measured in East Rockaway Channel at the more saline mid-depth. In the bay, high concentrations in early November are followed by a decline in total coliform levels. In general, after November 8, rainfall was low until November 27. December had several periods of higher rainfall, and this coincides with an increase in total coliform concentrations. Further from the northern shore of the bay, the southern stations show less impact from the December rain events.

The stations in the class SB/SC waters all had monthly median total coliform concentrations well below the standard of 2,400 no./100 mL during November and December. The highest median total coliform during November was at station B-3A, 195 no./100mL. During December, the highest total coliform medians were measured at the ERC stations, ranging from 175 no./100 mL to 370 no./100 mL. All of the 80th percentile total coliform concentrations were less than 5,000 no./100 mL, with the highest at 1,700 no./100 mL at station ERC-1. In the SA waters, stations TH-10, B-6C and TH-6 all had median total coliform levels greater the 70 no./100 mL during November with the highest median of 185 no./100 mL at station TH-10. By December, only station TH-10 had a monthly median total coliform concentration higher than 70 no./100 mL (130 no.100 ml).

The fecal coliform data collected in the bay are presented in Figures 4-39 and 4-40. The patterns are similar to the total coliform data. High fecal coliform were measured in the period after the storm. Higher concentrations were generally measured in the more northerly portions of the bay rather than in the Reynolds Channel area near the outfall. Fecal coliform concentrations declined during November at most stations except those near East Rockaway Channel. During December, fecal coliform levels leveled off or increased in some locations corresponding to periods of higher rainfall.

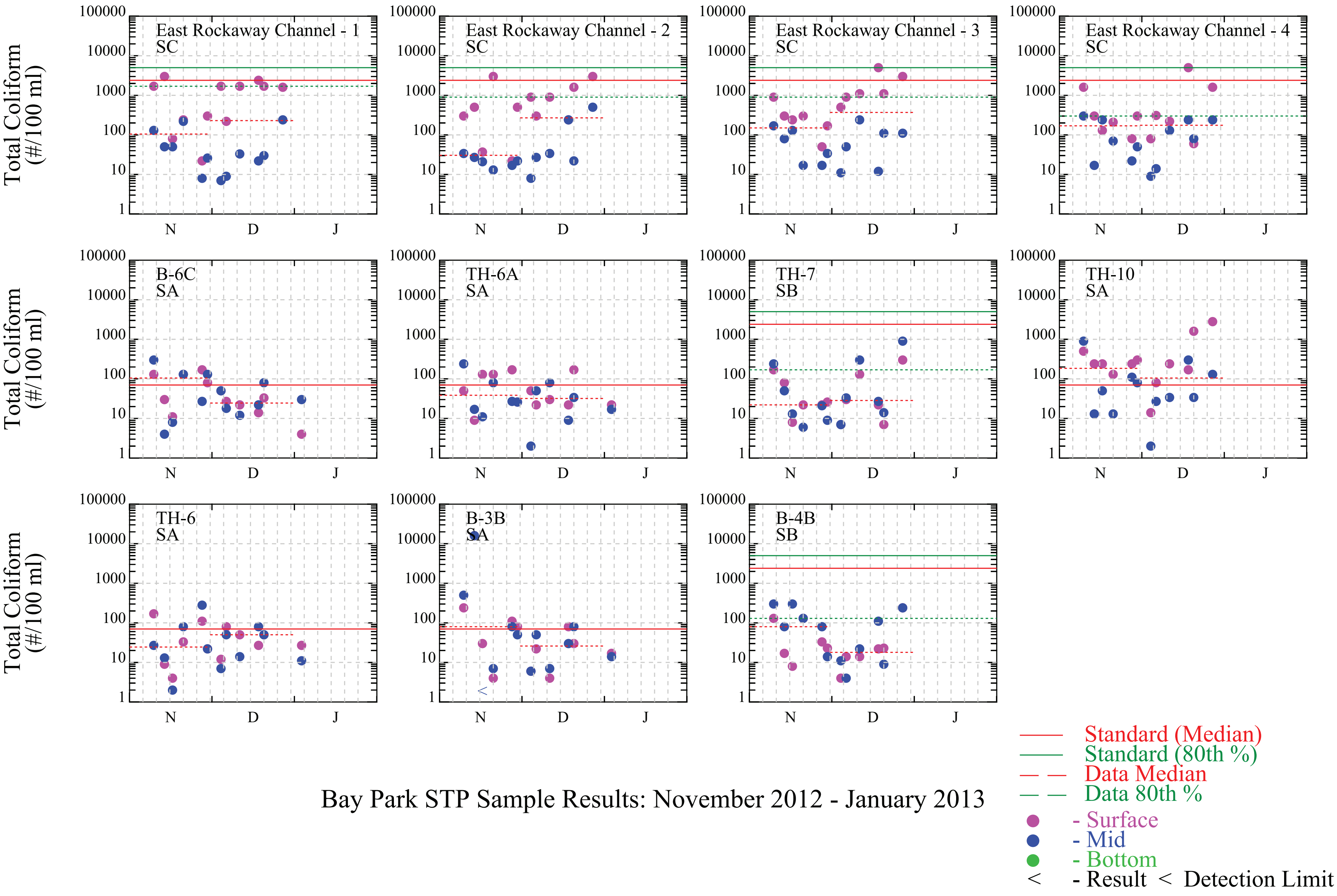
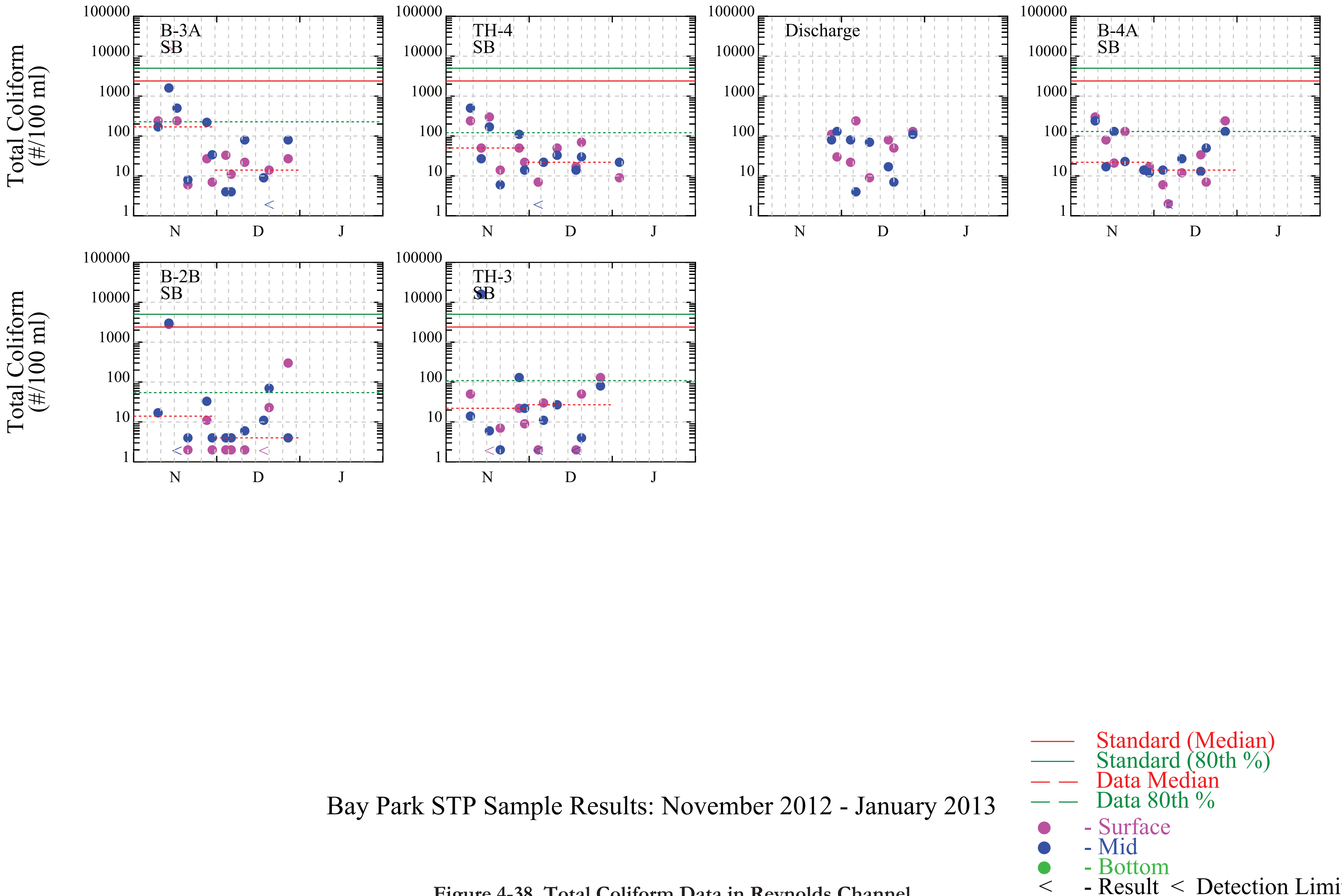


Figure 4-37. Total Coliform Data in West Hempstead Bay



Bay Park STP Sample Results: November 2012 - January 2013

Figure 4-38. Total Coliform Data in Reynolds Channel

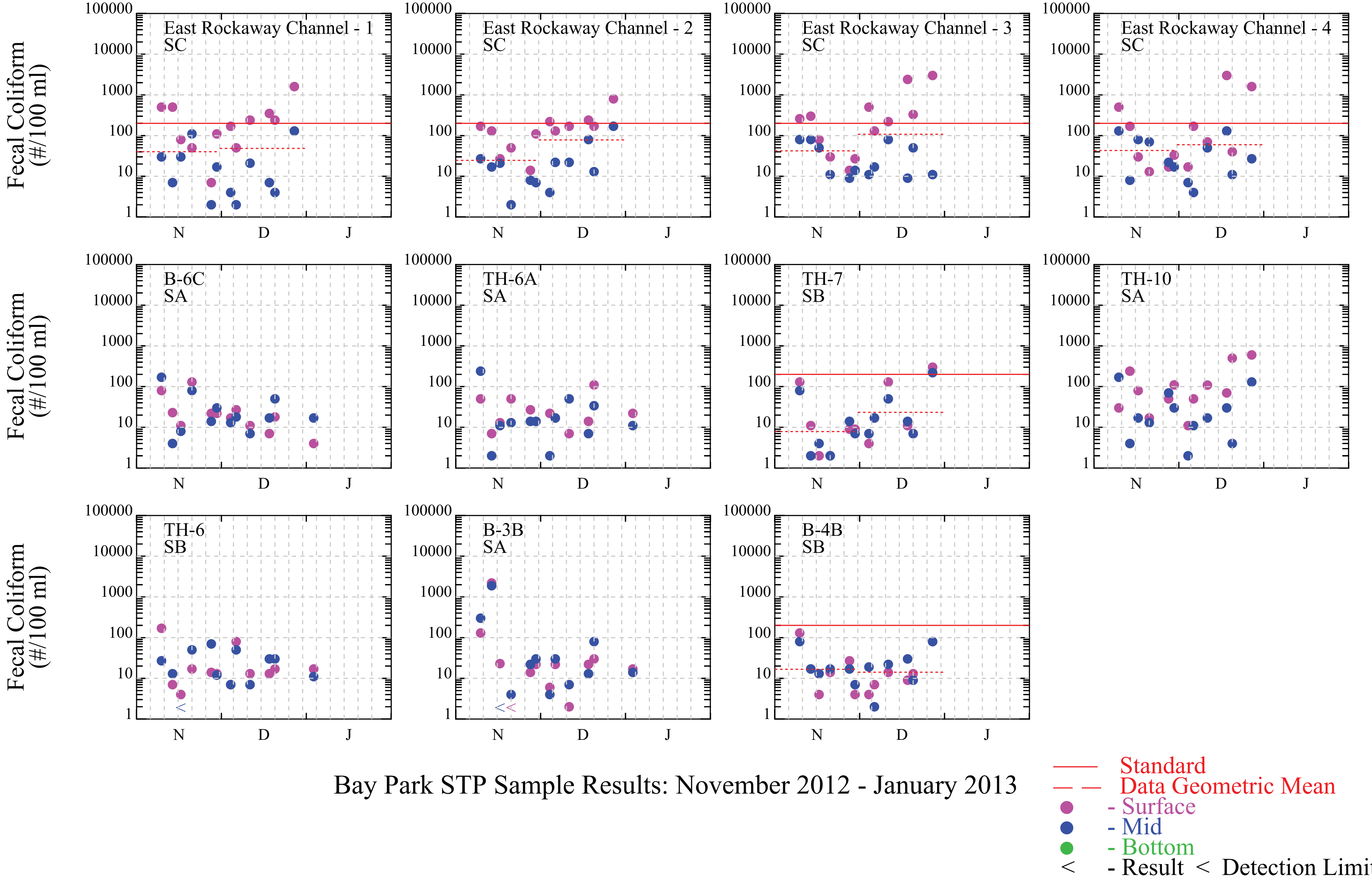


Figure 4-39. Fecal Coliform Data in West Hempstead Bay

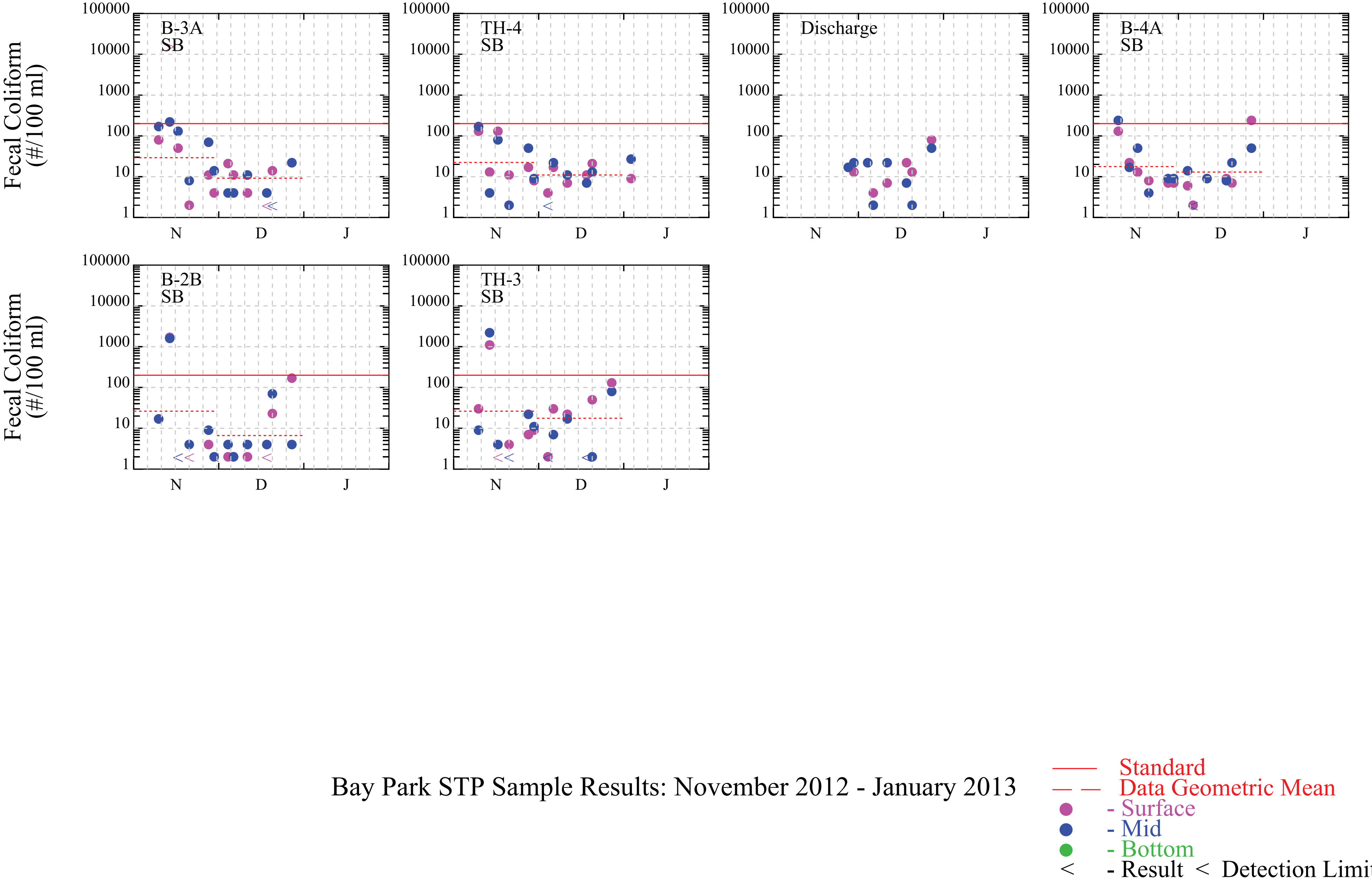


Figure 4-40. Fecal Coliform Data in Reynolds Channel

All of the fecal coliform monthly geometric means at each station were below the standard of 200 org./100 mL. The highest monthly geometric mean of 108 org./100 mL was measured at station ERC-3 during December. The highest monthly geometric mean measured at class SA station was 40 org./100 mL during November at station TH-10.

Figures 4-41 and 4-42 present the enterococci data collected in the bay. The enteroccoci levels where high when sampling began, which is similar to the coliform data. The enterococci concentrations show a more definitive decline during November than the coliform. In East Rockaway Channel and some of the northern bay stations, the enterococci data increase again during December. In the southern stations, after the initial decline, the concentrations level off, but remain at levels near the water quality standard.

The enterococci monthly geometric means during November were all above 35 no./100 mL ranging from 36 no./100 mL at station B-2B to 88 no./100 mL at station ERC-3. By December, only the ERC stations, and stations TH-10, TH-6A and B-3B had monthly geometric mean enterococci concentrations greater than 35 no./100 mL, which ranged from 37 no./100 mL to 108 no./100 mL.

Of the metals that were sampled in the bay, only lead, mercury and zinc were detected in some samples. The results for lead are presented in Figures 4-43 and 4-44. The data do not show very much temporal or spatial variation. Most of the concentrations are less than the chronic standard of 0.008 mg/L. There were occasionally measurements at or above 0.008 mg/L including in the discharge plume. However, the highest concentration was measured at the western most station in East Rockaway Inlet, station B-2B. Influent lead data to the Bay Park STP during 2012 ranged from less than 0.005 mg/L to 0.009 mg/L. As these influent sewage concentrations are typically lower than the water quality standards, it suggests the effluent would not commonly contain high levels of lead that would lead to exceedances of the water quality standard.

Figures 4-45 and 4-46 present the mercury data collected in the bay as part of the sampling program. The vast majority of the samples collected had concentrations below the detection limit. Stations ERC-4 and TH-10, which are next to one another, had measurable levels of mercury in late December well after the discharges at the auxiliary outfall had ceased. Station B-2B, which would be expected to be most diluted with ocean water of any of the stations, had a measurement above the detection limit in mid-December. All of the other concentrations were below the detection limit.

Zinc was measureable in a number of locations within the bay during the sampling period (Figures 4-47 and 4-48). The highest concentrations were measured in mid-November in East Rockaway Channel. Since influent zinc concentrations at the STP ranged from less than 100 μg/L to 205 μg/L it is possible that the short-term elevated zinc concentrations may have occurred due to effluent from the auxiliary outfall. Elevated zinc concentrations were also measured at station B-2B. In general, zinc concentrations were lower in December than in November.

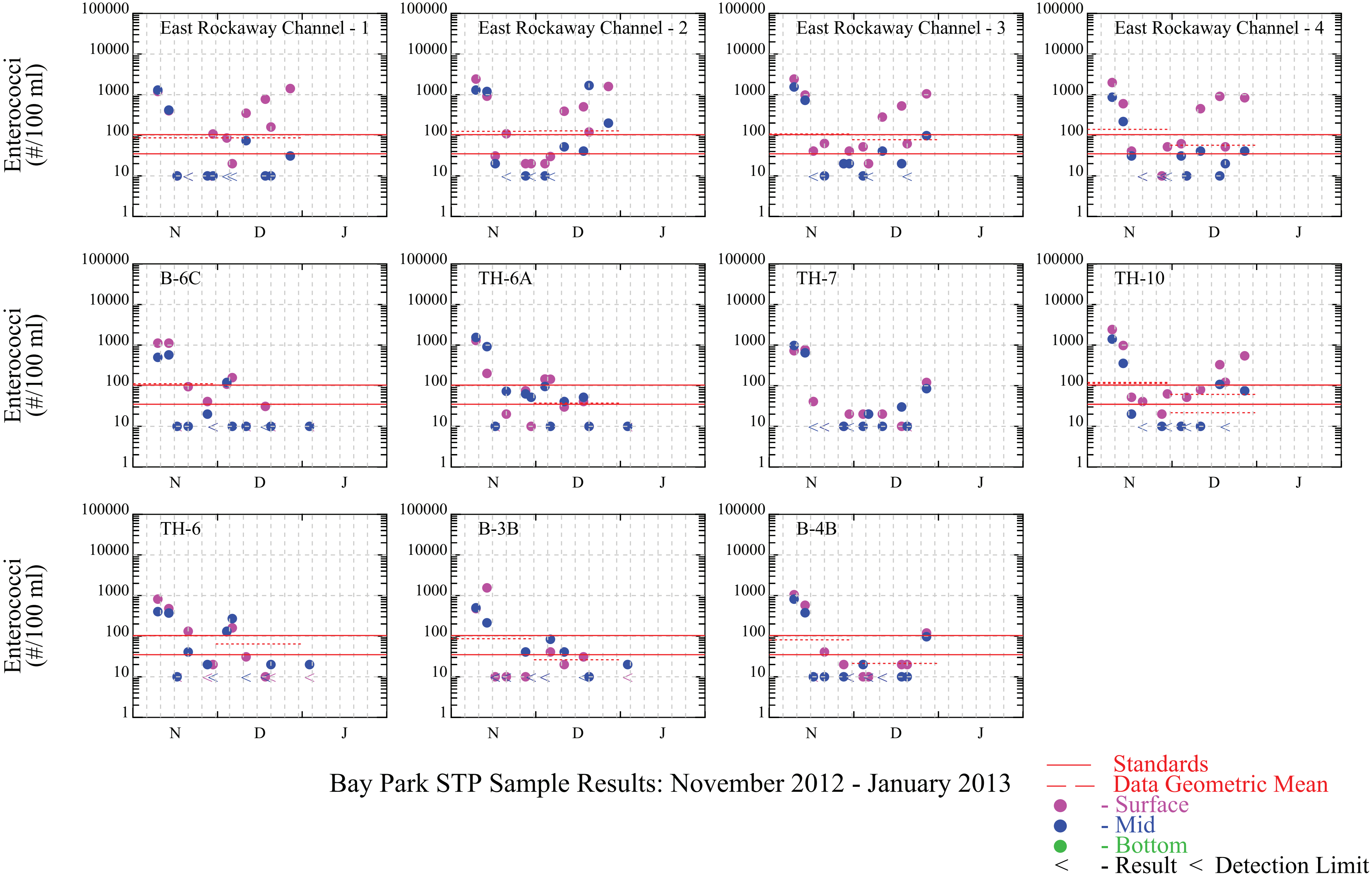


Figure 4-41. Enterococci Data in West Hempstead Bay

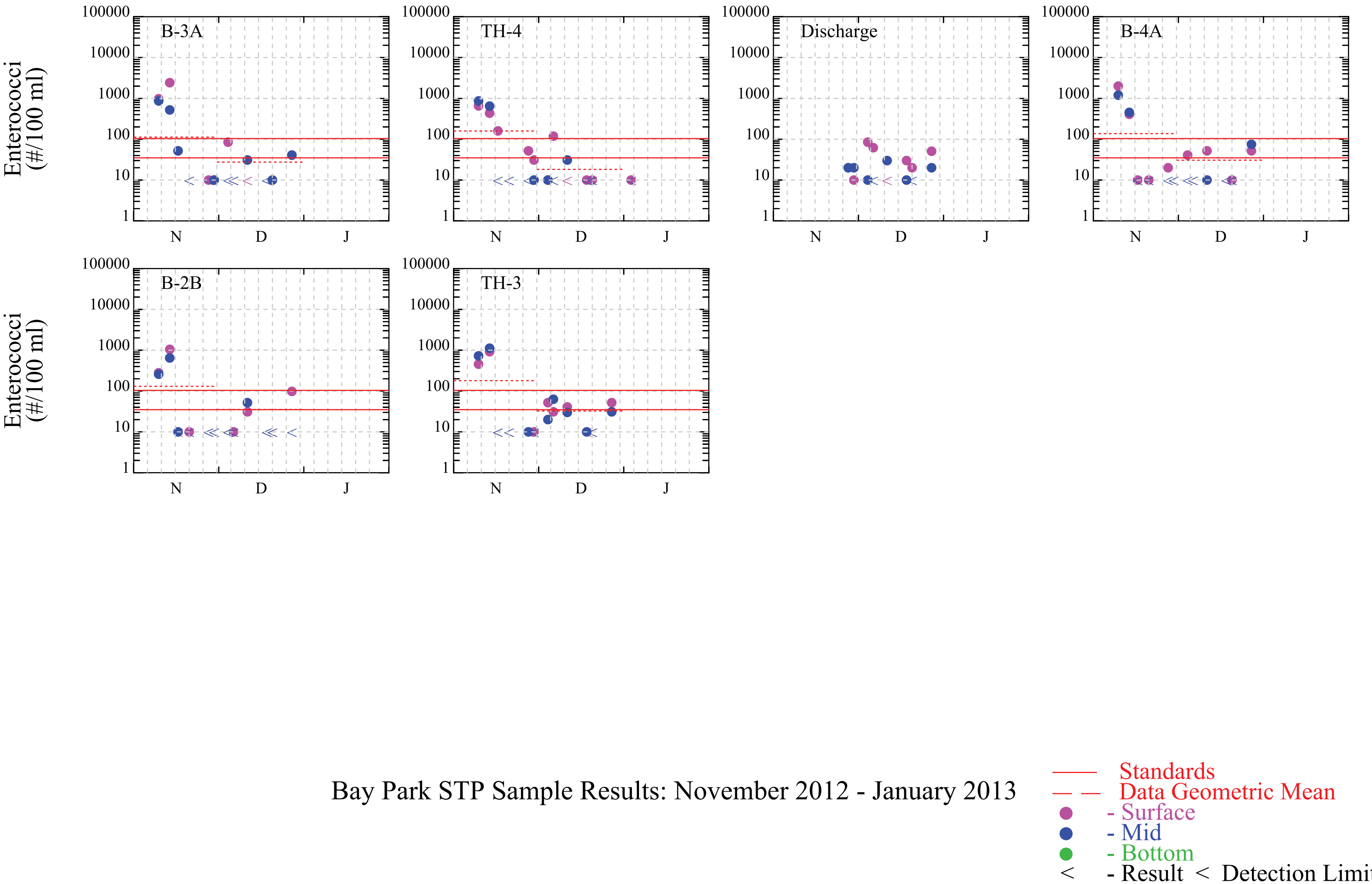


Figure 4-42. Enterococci Data in Reynolds Channel

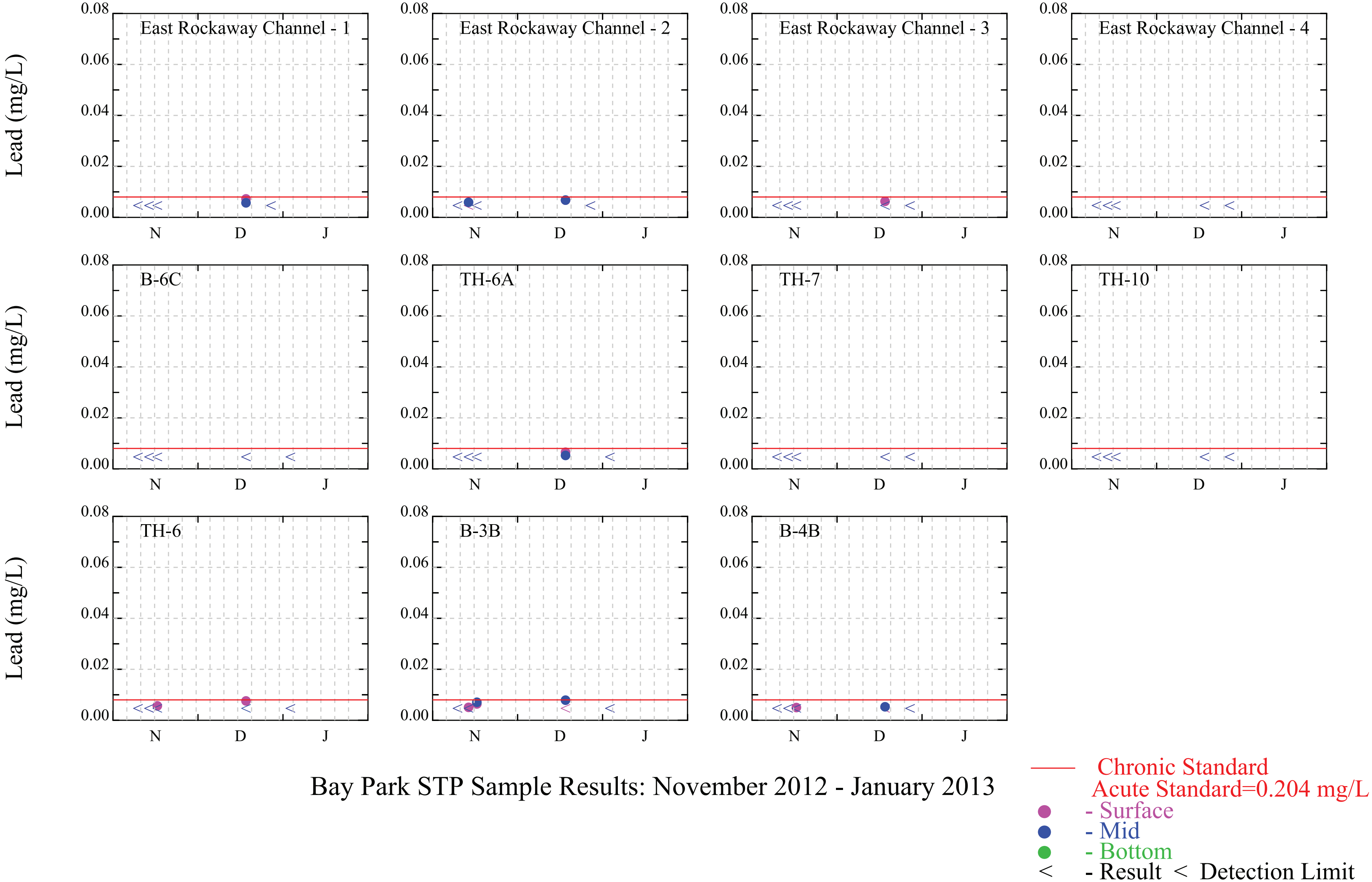


Figure 4-43. Lead Data in West Hempstead Bay

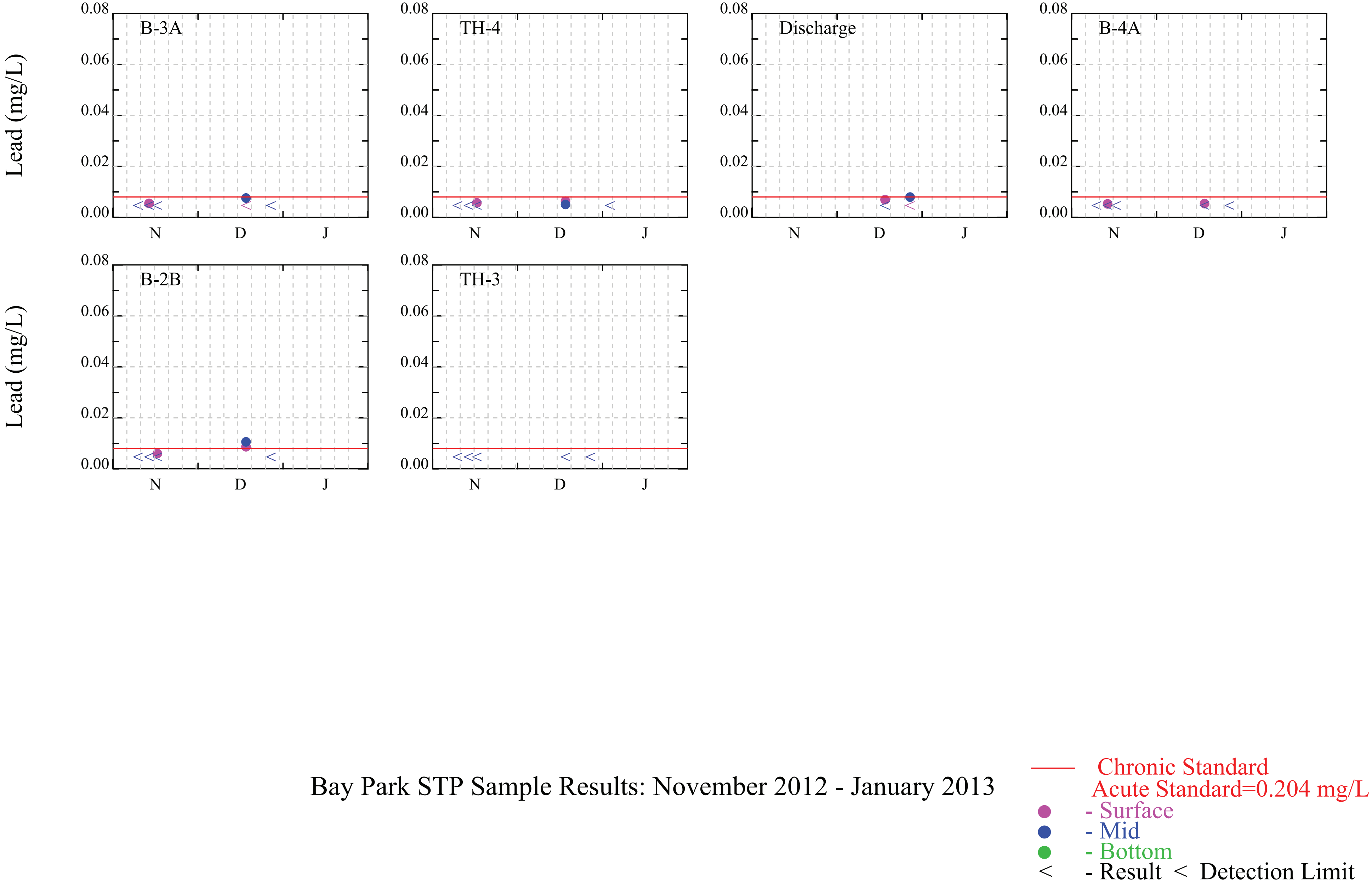


Figure 4-44. Lead Data in Reynolds Channel

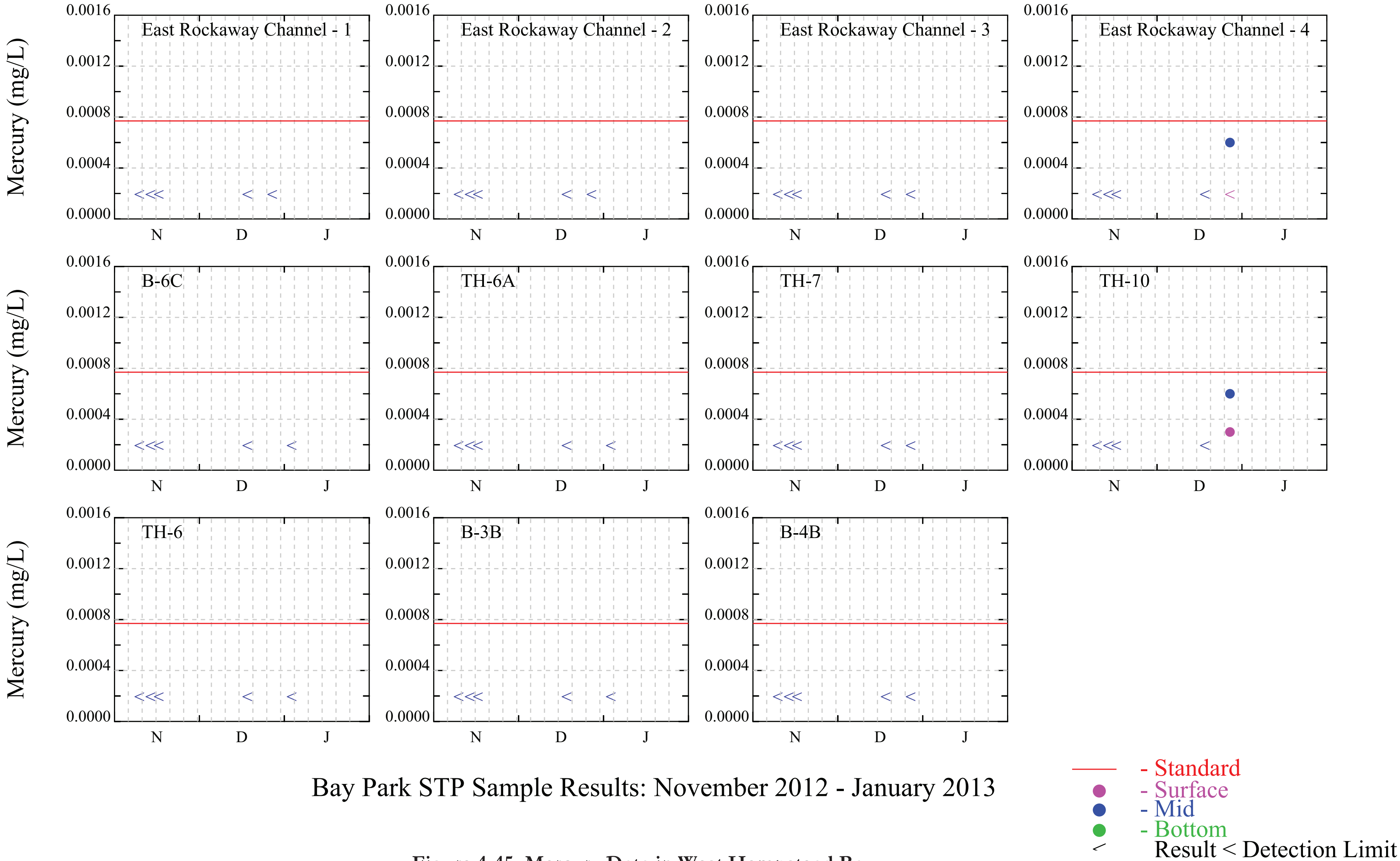
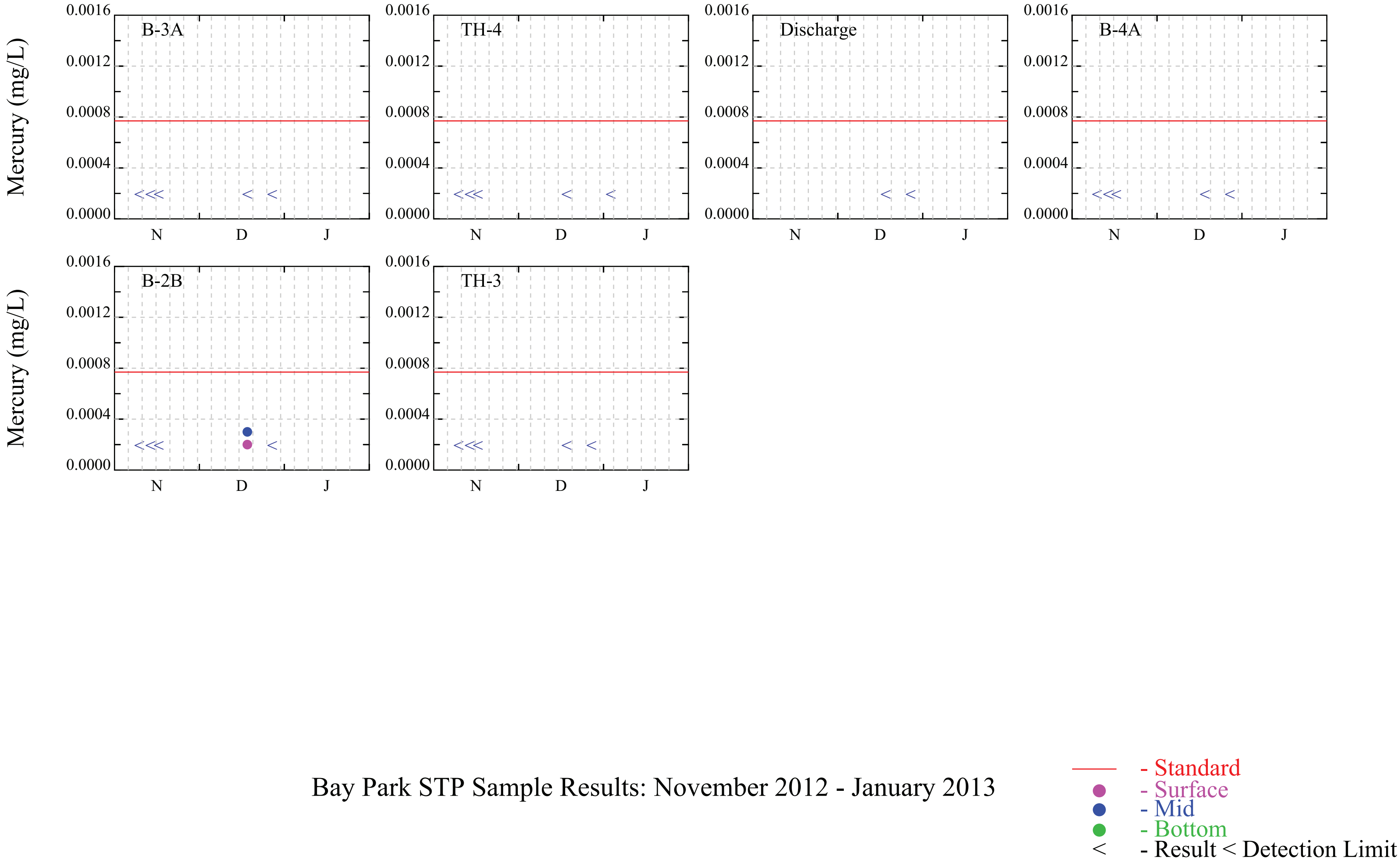


Figure 4-45. Mercury Data in West Hempstead Bay



Bay Park STP Sample Results: November 2012 - January 2013

Figure 4-46. Mercury Data in Reynolds Channel

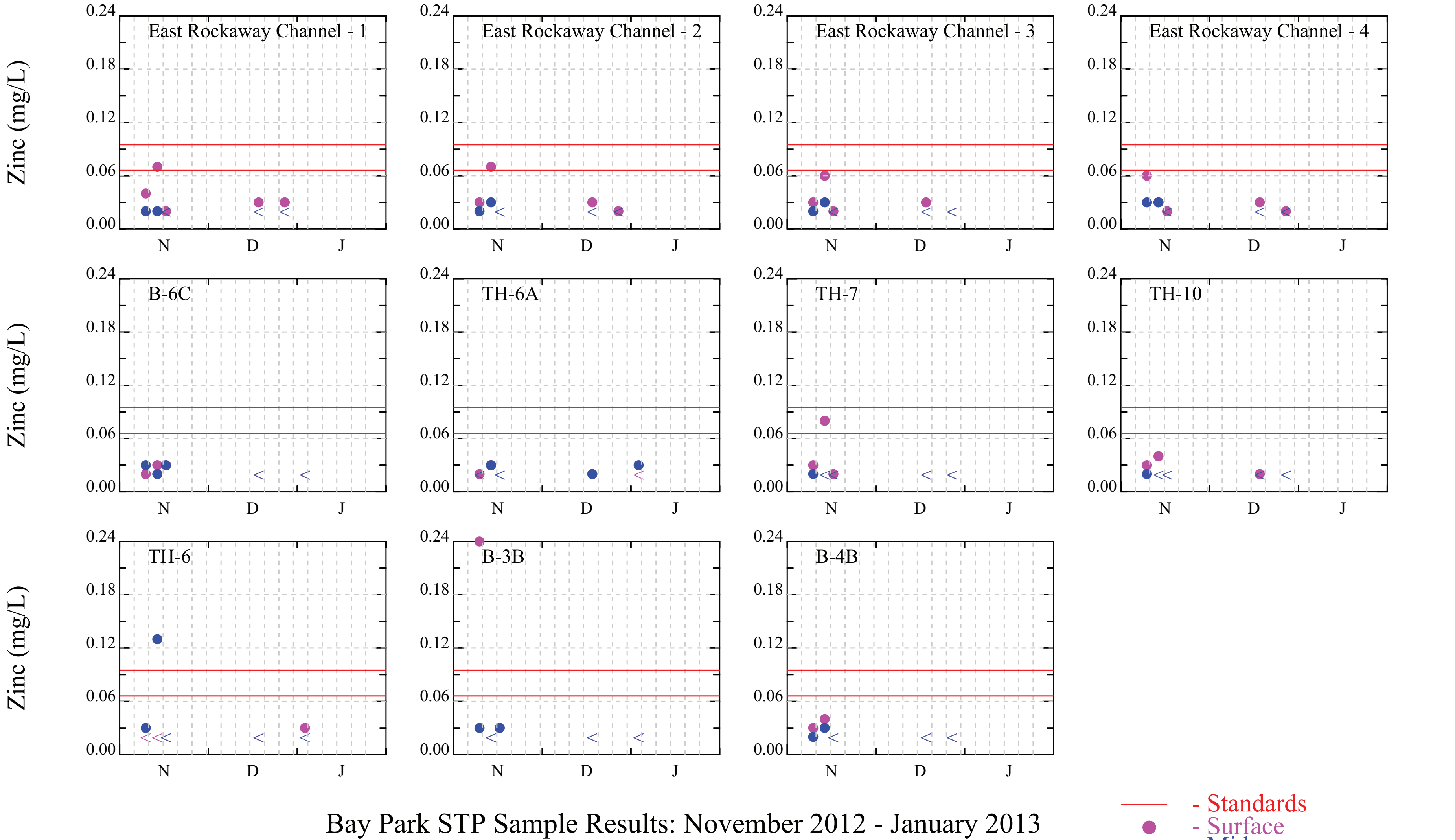


Figure 4-47. Zinc Data in West Hempstead Bay

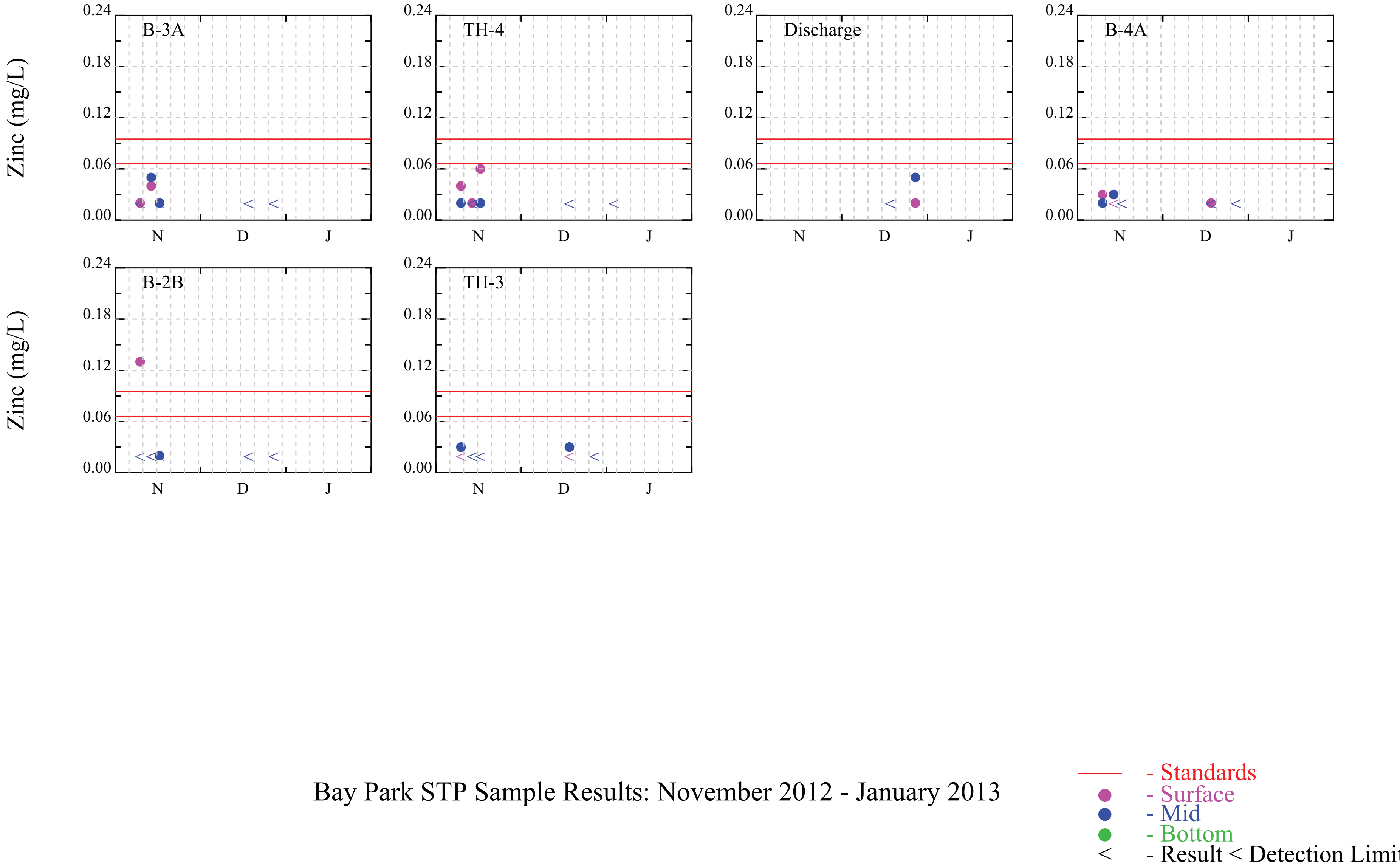


Figure 4-48. Zinc Data in Reynolds Channel

The cadmium, chromium, copper, nickel, and silver measurements were all below the detection limit and are not shown.

All PAH measurements were below the detection limit.

Statistics

Table 4-4 presents some monthly statistics for the bay data that were collected. This allows a more quantitative comparison of the data to applicable water quality standards than the time series figures. In this table, the surface and mid-depth data are combined to calculate the statistics. All of the DO concentration measurements were greater than the acute and chronic standards. BOD_5 concentrations were low throughout the bay. TSS concentrations were the highest in Reynolds Channel. The highest of these TSS concentrations were measured closest to the ocean. Total coliform concentrations in the class SB/SC waters meet the standards during November and December. Total coliform standards in the SA station TH-10 did not meet the total coliform standard in either November or December. The fecal coliform concentrations meet the SB/SC standards in the bay for November and December. The enterococci monthly geometric mean of 35 no./100 mL was exceeded at all stations during November, and stations ERC-1, ERC-2, ERC-3, ERC-4, TH-10, TH-6A and B-3B during December. The upstream source at station MR-1 probably contributes to exceedances at the ERC stations and station TH-10. Lead concentrations higher than the chronic standard were measured only in the inlet near the ocean. Higher zinc concentrations were measured near the ocean and in the middle of the bay away from any Bay Park STP outfall.

When calculating statistics for the surface data only or the mid-depth data only, the surface data show fecal coliform concentrations higher than the standard at stations ERC-1, ERC-2 and ERC-3 during December (Tables 4-5 and 4-6). The surface enterococci geometric mean was higher than 104 no./100 mL at stations ERC-2, ERC-3, and TH-10 during November and all of the ERC stations during December.

It should be noted that laboratory detection limits for enterococci was 10 no./100mL. For calculating the geometric means to compare the standard of 35, a value of 10 was assigned to all samples that were measured to be below detection limit. A sensitivity was conducted for the enterococci geometric mean using half of the method detection limit or 5 no./100 mL and is shown in Table 4-7. This sensitivity results in several stations no longer exceeding a geometric mean of 35 no./100 mL during the sampling period.

The field and lab sheets for all of the measurements are presented in Appendix A and B.

Table 4-4. Summary Statistics for Bay Stations

		Bay Stations																
	Station	ERC-1	ERC-2	ERC-3	ERC-4	TH-10	TH-7	B-4B	B-4A	TH-4	B-3A	TH-3	B-2B	B-6C	TH-6A	TH-6	B-3B	Discharge
	Class	SC	SC	SC	SC	SA	SB	SB	SB	SB	SB	SB	SB	SA	SA	SA	SA	
DO (mg/L)	No. Samples	39	39	39	39	39	39	39	39	36	39	39	39	36	36	36	36	27
	Maximum	11	11	11	11	11	11	10	9.8	9.7	9.6	9.5	9.7	9.7	9.1	9.2	9.4	9.7
	Minimum	5.1	5	5.1	5.3	5.4	5.5	5.6	5.9	6	5.3	5.7	5.7	6	6	5.8	5.8	6.2
	Mean	7.5	7.5	7.6	7.6	7.7	8.2	8.1	8.1	7.9	8.0	8.0	7.9	7.7	7.8	7.8	7.7	8.3
	No. <3.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	No. <=4.8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BOD5 (mg/L)	No. Samples	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	6
	Maximum	3	3	2	3	2	3	4	5	3	11	2	2	3	3	3	2	2
	Minimum	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
	Mean	2	2	2	2	2	2	2	2	2	3.5	2	2	2.167	2.167	2.167	2	2
TSS (mg/L)	No. Samples	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	6
	Maximum	14	13	12	12	16	45	19	87	33	30	53	42	31	32	43	24	40
	Minimum	10	10	10	10	10	10	10	10	10	10	10	11	10	10	11	10	17
	Mean	11	11	10	10	12	15	13	24	18	19	24	28	16	18	22	14	24.833
Total Coli (#/100 ml)	No. Samples	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	16
	Maximum	3000	3000	5000	5000	2800	900	300	300	500	16000	16000	3000	300	280	16000	240	240
	Minimum	7	8	11	9	2	6	4	2	2	2	2	2	4	2	2	2	4
	Median-Nov	105	31	150	170	185	22	80	22	50	195	18	8	105	25	80	39	95
	Median-Dec	230	270	370	175	105	29	18	14	22	13	19	4	25	50	26	32	60
	Median-All					130								30	27	30	29	75
	80th Percentile	1700	900	900	300	300	170	130	130	110	240	80	33	130	80	110	130	122
	No. >5000	0	0	0	0	0	0	0	0	0	1	2	0	0	0	2	0	0
	No. >2400	1	2	2	1	1	0	0	0	0	1	2	2	0	0	2	0	0
	No. >70	14	12	17	17	16	7	10	7	5	9	5	3	8	6	9	7	8
	Mon Median Exceed 2400	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	
	Median Exceed 70	Y	Y	Y	Y	Y	N	N	N	N	N	N	N	N	N	N	N	
	80th % Exceed 5000	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	
Fecal Coli (#/100 ml)	No. Samples	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	16
	Maximum	1600	800	3000	3000	600	300	130	240	170	16000	2200	1700	170	170	2200	240	80
	Minimum	2	2	9	4	2	2	2	2	2	2	2	2	4	2	2	2	2
	Geo Mean-Nov	40	25	42	43	40	8	17	18	22	49	17	11	28	17	39	18	17
	Geo Mean-Dec	48	78	108	60	37	23	14	11	9	7	10	6	16	18	13	17	12
	No. >200	6	3	7	3	3	2	0	2	0	2	2	2	0	0	3	1	0
	Geo Mean Exceed 200	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	
Enterococci (#/100 ml)	No. Samples	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	16
	Maximum	1420	2420	2420	1990	2420	980	1050	2000	866	2420	1120	1050	1120	816	1550	1550	85

Table 4-4. Summary Statistics for Bay Stations

		Bay Stations																
	Station	**ERC-1**	**ERC-2**	**ERC-3**	**ERC-4**	**TH-10**	**TH-7**	**B-4B**	**B-4A**	**TH-4**	**B-3A**	**TH-3**	**B-2B**	**B-6C**	**TH-6A**	**TH-6**	**B-3B**	**Discharge**
	Class	**SC**	**SC**	**SC**	**SC**	**SA**	**SB**	**SB**	**SB**	**SB**	**SB**	**SB**	**SB**	**SA**	**SA**	**SA**	**SA**	
	Minimum	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
	Geo Mean-Nov	51	82	88	58	80	51	48	46	63	61	42	36	61	57	42	85	17
	Geo Mean-Dec	61	104	55	57	45	20	18	18	14	17	24	15	24	37	20	37	21
	No. >35	11	13	14	13	14	7	7	8	7	9	8	6	9	10	8	14	3
	No.>104	9	11	7	7	8	5	5	4	6	4	4	4	7	9	4	6	0
	Geo Mean Exceed 35	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**	
	Geo Mean Exceed 104	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	
Lead (mg/L)	**No. Samples**	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	4
	Maximum	0.007	0.007	0.006	0.005	0.005	0.005	0.005	0.005	0.006	0.008	0.005	0.011	0.005	0.008	0.008	0.007	0.008
	Minimum	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005
	Mean	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.006	0.005	0.005	0.006	0.005	0.006
	No. >=0.008 (chr)	0	0	0	0	0	0	0	0	0	0	0	**2**	0	0	0	0	0
Zinc (mg/L)	**No. Samples**	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	4
	Maximum	0.07	0.07	0.06	0.06	0.04	0.08	0.04	0.03	0.06	0.05	0.03	0.13	0.03	0.13	0.24	0.03	0.05
	Minimum	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
	Mean	0.029	0.028	0.027	0.028	0.023	0.027	0.024	0.022	0.026	0.025	0.022	0.031	0.024	0.033	0.045	0.023	0.027
	No. >=0.066 (chr)	**1**	**1**	0	0	0	**1**	0	0	0	0	0	**1**	0	**1**	**1**	0	0
	No. >=0.095 (acute)	0	0	0	0	0	0	0	0	0	0	0	**1**	0	**1**	**1**	0	0

Table 4-5. Summary Statistics for Surface Coliform and Enterococci Data

		Bay Stations																
	Station	**ERC-1**	**ERC-2**	**ERC-3**	**ERC-4**	**TH-10**	**TH-7**	**B-4B**	**B-4A**	**TH-4**	**B-3A**	**TH-3**	**B-2B**	**B-6C**	**TH-6A**	**TH-6**	**B-3B**	**Discharge**
	Class	**SC**	**SC**	**SC**	**SC**	**SA**	**SB**	**SB**	**SB**	**SB**	**SB**	**SB**	**SB**	**SA**	**SA**	**SA**	**SA**	
Total Coli (#/100 ml)	**No. Samples**	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	8
	Maximum	3000	3000	5000	5000	2800	300	240	300	300	16000	16000	2800	170	170	16000	170	240
	Minimum	22	22	50	60	14	7	4	2	7	6	2	2	4	4	4	9	9
	Median-Nov	270	400	270	255	240	24	28	51	50	134	16	7	105	28	95	90	70
	Median-Dec	1700	900	1100	265	205	26	18	10	22	18	29	2	27	50	22	30	65
	Median-All					240								32	30	30	40	65
	80th Percentile	1960	2119	1805	1600	908	145	130	171	133	240	80	126	130	91	158	145	149
	No. >5000	0	0	0	0	0	0	0	0	0	1	1	0	0	0	1	0	0
	No. >2400	1	2	2	1	1	0	0	0	0	1	1	1	0	0	1	0	0
	No. >70	11	10	11	11	11	4	3	4	2	3	2	2	4	3	5	4	4
	Mon Median Exceed 2400	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	
	Median Exceed 70	Y	Y	Y	Y	**Y**	N	N	N	N	N	N	N	N	N	N	N	
	80th % Exceed 5000	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	
Fecal Coli (#/100 ml)	**No. Samples**	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	8
	Maximum	1600	800	3000	3000	600	300	130	240	130	16000	1100	1700	130	170	2200	110	80
	Minimum	7	14	14	13	11	2	4	2	4	2	2	2	4	4	2	7	4
	Geo Mean-Nov	96	60	64	51	61	9	15	16	26	42	16	10	33	16	40	21	15
	Geo Mean-Dec	255	233	569	184	104	24	12	11	10	9	16	6	14	17	11	21	16
	No. >200	6	3	7	3	3	1	0	1	0	1	1	1	0	0	1	0	0
	Geo Mean Exceed 200	**Y**	**Y**	**Y**	N	N	N	N	N	N	N	N	N	N	N	N	N	
Enterococci (#/100 ml)	**No. Samples**	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	8
	Maximum	1420	2420	2420	1990	2420	770	1050	2000	658	2420	920	1050	1120	816	1550	1300	85
	Minimum	10	20	20	10	10	10	10	10	10	10	10	10	10	10	10	10	10
	Geo Mean-Nov	61	120	131	80	136	60	61	50	95	71	40	38	89	68	44	58	14
	Geo Mean-Dec	218	168	147	149	99	21	19	22	16	18	26	18	35	36	19	48	34
	No. >35	8	7	10	9	10	4	4	5	5	5	5	3	6	5	3	6	3
	No.>104	7	7	5	5	5	3	3	2	4	2	2	2	4	5	2	4	0
	Geo Mean Exceed 35	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**	
	Geo Mean Exceed 104	**Y**	**Y**	**Y**	**Y**	**Y**	N	N	N	N	N	N	N	N	N	N	N	

Table 4-6. Summary Statistics for Mid-depth Coliform and Enterococci Data

		Bay Stations																
	Station	**ERC-1**	**ERC-2**	**ERC-3**	**ERC-4**	**TH-10**	**TH-7**	**B-4B**	**B-4A**	**TH-4**	**B-3A**	**TH-3**	**B-2B**	**B-6C**	**TH-6A**	**TH-6**	**B-3B**	**Discharge**
	Class	**SC**	**SC**	**SC**	**SC**	**SA**	**SB**	**SB**	**SB**	**SB**	**SB**	**SB**	**SB**	**SA**	**SA**	**SA**	**SA**	
Total Coli (#/100 ml)	**No. Samples**	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	8
	Maximum	240	500	240	300	900	900	300	240	500	1600	16000	3000	300	280	16000	240	130
	Minimum	7	8	11	9	2	6	4	2	2	2	2	2	4	2	2	2	4
	Median-Nov	50	22	57	60	65	17	105	20	69	195	18	11	79	25	65	27	105
	Median-Dec	26	31	80	105	34	30	17	21	22	7	8	5	22	50	30	34	44
	Median-All					42								29	25	40	27	75
	80th Percentile	163	110	145	240	193	262	262	130	132	324	99	47	130	80	236	80	113
	No. >5000	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0
	No. >2400	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	No. >70	3	2	6	6	5	3	7	3	3	6	3	1	4	3	4	3	4
	Mon Median Exceed 2400	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	
	Median Exceed 70	N	N	N	Y	N	N	Y	N	N	N	N	N	N	N	N	N	
	80th % Exceed 5000	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	
Fecal Coli (#/100 ml)	**No. Samples**	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	8
	Maximum	130	170	80	130	170	220	80	240	170	220	2200	1600	170	70	1890	240	50
	Minimum	2	2	9	4	2	2	2	2	2	2	2	2	4	2	2	2	2
	Geo Mean-Nov	17	10	28	36	26	7	18	20	19	58	18	13	24	18	38	15	19
	Geo Mean-Dec	9	26	20	19	13	22	16	11	8	6	7	6	17	19	15	13	9
	No. >200	0	0	0	0	0	1	0	1	0	1	1	1	0	0	2	1	0
	Geo Mean Exceed 200	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	
Enterococci (#/100 ml)	**No. Samples**	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	8
	Maximum	1300	1690	1550	866	1410	980	816	1200	866	866	1120	648	574	403	501	1550	30
	Minimum	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
	Geo Mean-Nov	42	56	60	42	46	43	38	42	42	54	45	34	42	48	40	123	20
	Geo Mean-Dec	17	64	21	22	21	19	16	14	13	15	22	13	16	37	20	29	13
	No. >35	3	6	4	4	4	3	3	3	2	4	3	3	3	5	5	8	0
	No.>104	2	4	2	2	3	2	2	2	2	2	2	2	3	4	2	2	0
	Geo Mean Exceed 35	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	Y	Y	Y	Y	
	Geo Mean Exceed 104	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	

Table 4-7. Enterococci Statistics Using 5 no./100 mL for Measurements less than the Detection Limit

DL values set to 5/100 ml		Bay Stations																
	Station	**ERC-1**	**ERC-2**	**ERC-3**	**ERC-4**	**TH-10**	**TH-7**	**B-4B**	**B-4A**	**TH-4**	**B-3A**	**TH-3**	**B-2B**	**B-6C**	**TH-6A**	**TH-6**	**B-3B**	**Discharge**
	Class	**SC**	**SC**	**SC**	**SC**	**SA**	**SB**	**SB**	**SB**	**SB**	**SB**	**SB**	**SB**	**SA**	**SA**	**SA**	**SA**	
Enterococci	**No. Samples**	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	16
(#/100 ml)	**Maximum**	1420	2420	2420	1990	2420	980	1050	2000	866	2420	1120	1050	1120	816	1550	1550	85
	Minimum	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
All	**Geo Mean-Nov**	43	73	83	46	71	40	40	34	50	52	30	26	52	48	34	80	17
	Geo Mean-Dec	54	98	49	57	40	19	15	12	11	12	20	10	20	30	16	37	18
	No. >35	11	13	14	13	14	7	7	8	7	9	8	6	9	10	8	14	3
	No.>104	9	11	7	7	8	5	5	4	6	4	4	4	7	9	4	6	0
	Geo Mean Exceed 35	Y	Y	Y	Y	Y	Y	Y	N	Y	Y	N	N	Y	Y	N	Y	
	Geo Mean Exceed 104	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	
Enterococci	**No. Samples**	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	8
(#/100 ml)	**Maximum**	1420	2420	2420	1990	2420	770	1050	2000	658	2420	920	1050	1120	816	1550	1300	85
	Minimum	5	20	20	5	10	5	5	5	5	5	5	5	5	5	5	5	5
Surface Only	**Geo Mean-Nov**	49	120	131	71	136	53	48	45	85	63	28	27	70	54	39	52	14
	Geo Mean-Dec	218	168	147	149	99	19	17	17	14	13	21	12	27	32	17	48	31
	No. >35	8	7	10	9	10	4	4	5	5	5	5	3	6	5	3	6	3
	No.>104	7	7	5	5	5	3	3	2	4	2	2	2	4	5	2	4	0
	Geo Mean Exceed 35	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	N	Y	Y	Y	Y	
	Geo Mean Exceed 104	Y	Y	Y	Y	Y	N	N	N	N	N	N	N	N	N	N	N	
Enterococci	**No. Samples**	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	8
(#/100 ml)	**Maximum**	1300	1690	1550	866	1410	980	816	1200	866	866	1120	648	574	403	501	1550	30
	Minimum	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	10	5
Mid Only	**Geo Mean-Nov**	37	45	53	30	37	30	34	26	30	43	32	24	38	43	29	123	20
	Geo Mean-Dec	13	57	16	22	17	19	13	9	8	11	20	7	14	28	15	29	11
	No. >35	3	6	4	4	4	3	3	3	2	4	3	3	3	5	5	8	0
	No.>104	2	4	2	2	3	2	2	2	2	2	2	2	3	4	2	2	0
	Geo Mean Exceed 35	Y	Y	Y	N	Y	N	N	N	N	N	N	N	Y	Y	N	Y	
	Geo Mean Exceed 104	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	

Green=change from using DL=10/100 ml

Town of Hempstead Data

The Town of Hempstead routinely monitors water quality at several stations in West Hempstead Bay. When designing the Bay Park sampling program, sixof the stations, designated by the TH prefix, were chosen based on an approximation of the Town of Hempstead sampling locations. Town of Hempstead Stations 3, 6, 6A, 7 and 10 correspond to stations TH-3, TH-6, TH-6A, TH-7 and TH-10 in the Bay Park sampling program. Station 4 corresponds more closely to the Bay Park outfall (discharge) station than to TH-4. These stations were chosen so that it would be possible to compare pre-Sandy conditions to the data collected post-Sandy in the same locations.

Salinity, temperature and DO data were obtained from the Town of Hempstead for the period of January 2010 through September 2012 and are presented in Figures 4-49, 4-50 and 4-51, respectively. These data are presented as filled circles. Data from the November through January Bay Park sampling program are plotted on these figures as well and presented as open circles. The long-term salinity data (Figure 4-49), shows that West Hempstead Bay is relatively saline with limited freshwater input. The salinity remains above 25 ppt the majority of the time, although station 10 shows some influence from the Mill River and station 4 shows variability due to the freshwater effluent plume from the Bay Park STP. The data collected during the Bay Park sampling program falls within the typical range of salinity measured during the previous two to three years. Figure 4-50 shows that the water temperatures measured during the Bay Park sampling program are not unusual when compared to November and December of 2010 and 2011.

The comparison of DO data in Figure 4-51 suggests that the DO concentrations in early November 2012 were lower than DO concentrations in the previous two years. The Bay Park 2012 sampling data shows that there was a rapid increase in the DO concentrations between early November 2012 and the end of the year such that late 2012 DO concentrations were similar to the previous years.

As noted previously, the lower DO data does suggest some potential impact of the hurricane on bay waters, but at this point no direct link can be made to the reduced levels of treatment at the Bay Park STP. Table 4-8 presents a comparison of the November and December average DO concentrations at each of the stations, as well as the number of samples used to compute the averages. In most cases there were only two measurements for the Town of Hempstead data, but more measurements were taken near the outfall. The surface mid-depth and bottom data were grouped for the Bay Park sampling, as it is expected that the water column is vertically well mixed during the late fall and early winter. Since there is a large difference in the number of samples within the data sets, only general comparisons can be made. With the exception of station 4, the difference in average DO concentrations between the two data sets during November is greater than 1.5 mg/L. During December the difference in average DO concentrations between the two data sets has diminished.

Table 4-8. Comparison of Average Monthly DO concentrations between the Bay Park and Town of Hempstead Datasets for November and December

	Average DO Concentrations (mg/L) (n # of Samples) November		Average DO Concentrations (mg/L) (n = # of Samples) December	
Station	Town of Hempstead	Bay Park	Town of Hempstead	Bay Park
3	8.74 (n=2)	7.16 (n=18)	9.99 (n=2)	8.95 (n=18)
4	8.22 (n=4)	6.76 (n=6)	9.22 (n=7)	8.91 (n=18)
6	8.76 (n=2)	6.97 (n=18)	10.29 (n=2)	8.65 (n=15)
6A	8.59 (n=2)	6.71 (n=18)	10.22 (n=2)	8.59 (n=15)
7	8.37 (n=2)	6.63 (n=18)	9.81 (n=2)	9.53 (n=18)
10	8.88 (n=2)	6.21 (n=18)	10.03 (n=2)	8.77 (n=18)

Recently, the FDA and NYSDEC conducted an audit of lab practices for the Town of Hempstead and found issues with their bacteriological results. The data were deemed to potentially underestimate the actual coliform levels. A decision was made to consider all of the data unreliable and not to be used for the purposes of assessing whether shellfish beds could be open. This lead to the closure of shellfish beds in the area. After some continued sampling and testing at the NYSDEC laboratory, a small area in eastern Hempstead Bay was reopened briefly, but then closed again after Hurricane Sandy. The data were obtained from NYSDEC for the period of 2010-2011, but since the data are of questionable quality only general comparisons to the Bay Park data will be made.

Figures 4-52 and 4-53 present a temporal comparison of total and fecal coliform data from the Town of Hempstead and Bay Park sampling programs of the period of 2010-2012. With the exception of one high measurement during the early part of November at station TH-3, the two data sets show similar ranges and variability, although the Bay Park data set is for a shorter period of time. Figures 4-54 and 4-55 compare the total and fecal coliform data as probability distributions. These figures allow a comparison of the medians and standard deviations between the two datasets as well as the general slopes of the distributions. The comparisons are between Town of Hempstead data for the calendar years of 2010 and 2011, and the Bay Park Sampling data for the November 2012 through December 2012. In most cases the Bay Park sampling program had similar or lower coliform concentrations than the Town of Hempstead data, with the exception of station TH-10 where the Bay Park sampling program measured higher coliform concentrations. It would be expected that the Town of Hempstead measured coliform concentrations would be lower since during the summer the die-off rate of coliform is higher due to higher temperatures. The comparison of the data sets suggest that the coliform concentrations in West Hempstead Bay during November and December 2012 were not unusual compared with recent years.

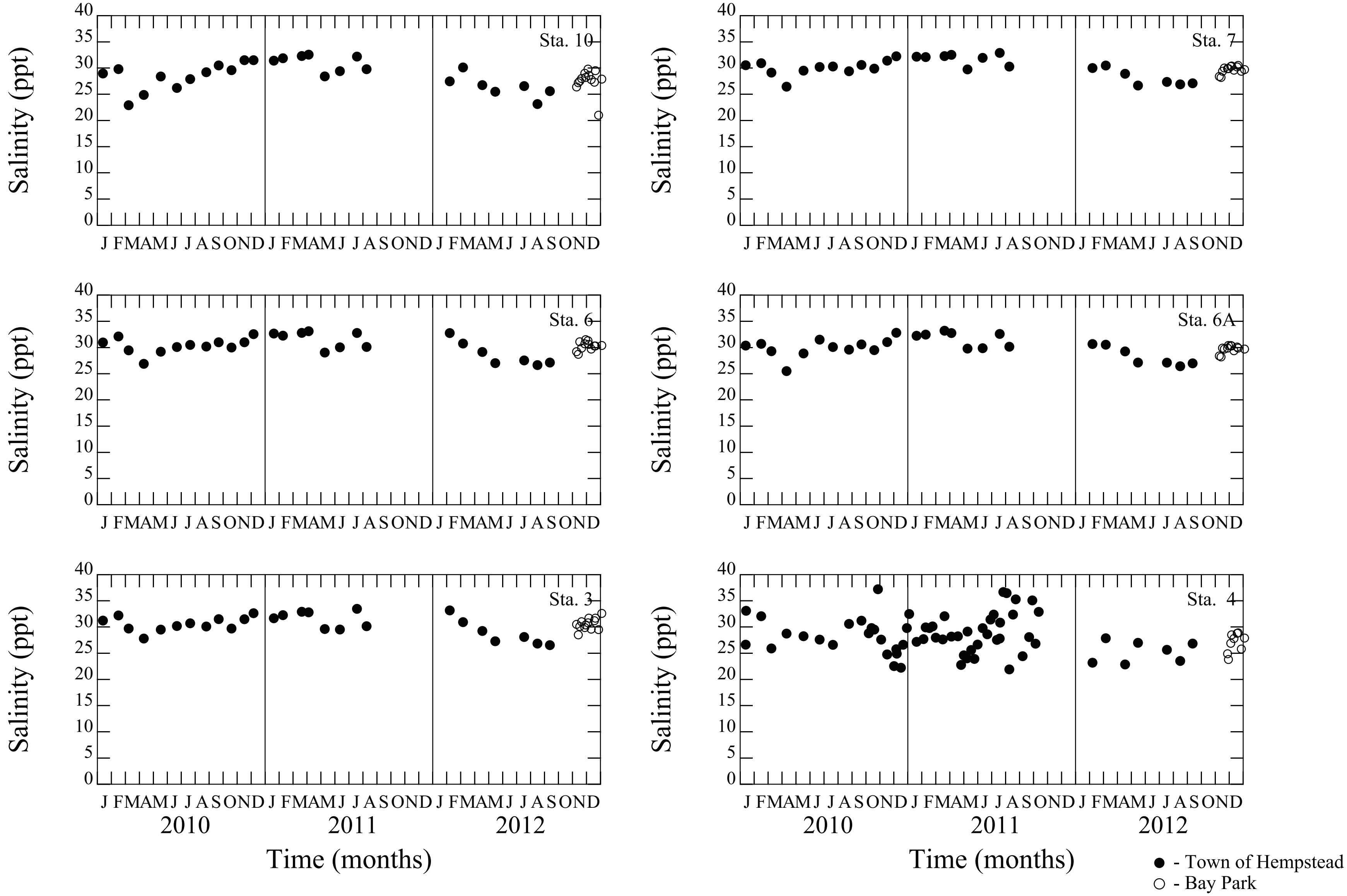


Figure 4-49. Comparison of Town of Hempstead and Bay Park Salinity Sampling Data

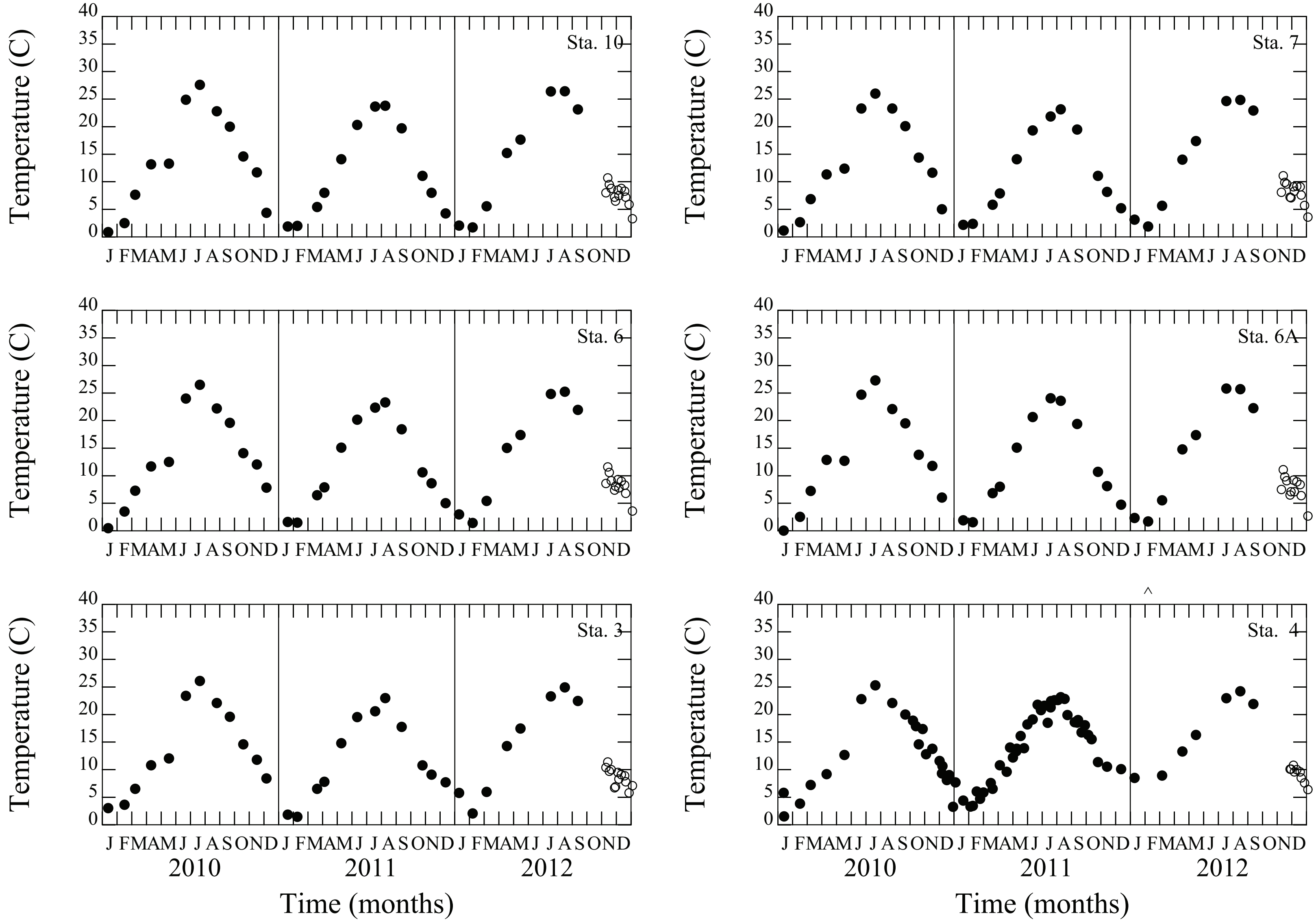


Figure 4-50. Comparison of Town of Hempstead and Bay Park Temperature Sampling Data

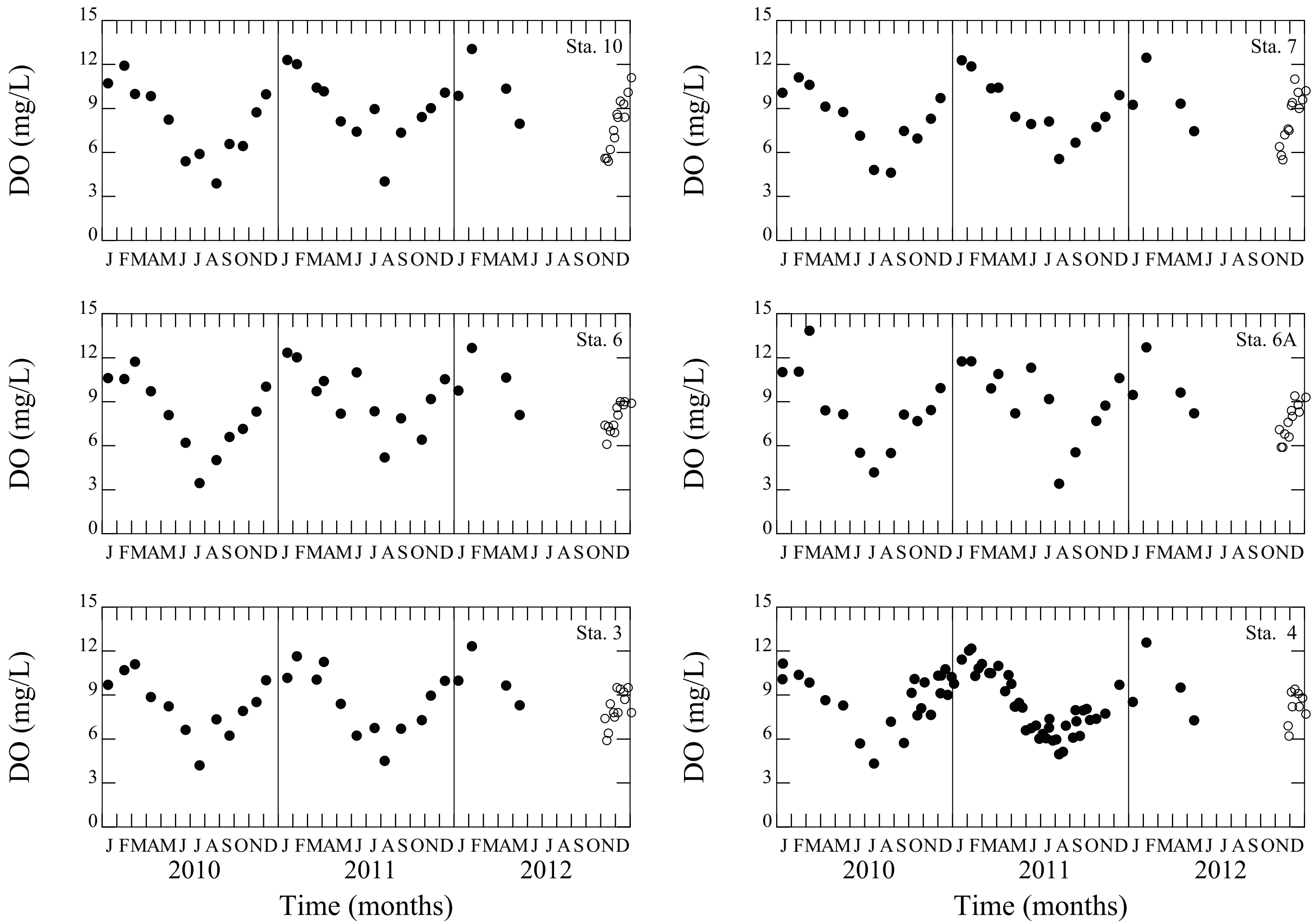


Figure 4-51. Comparison of Town of Hempstead and Bay Park DO Sampling Data

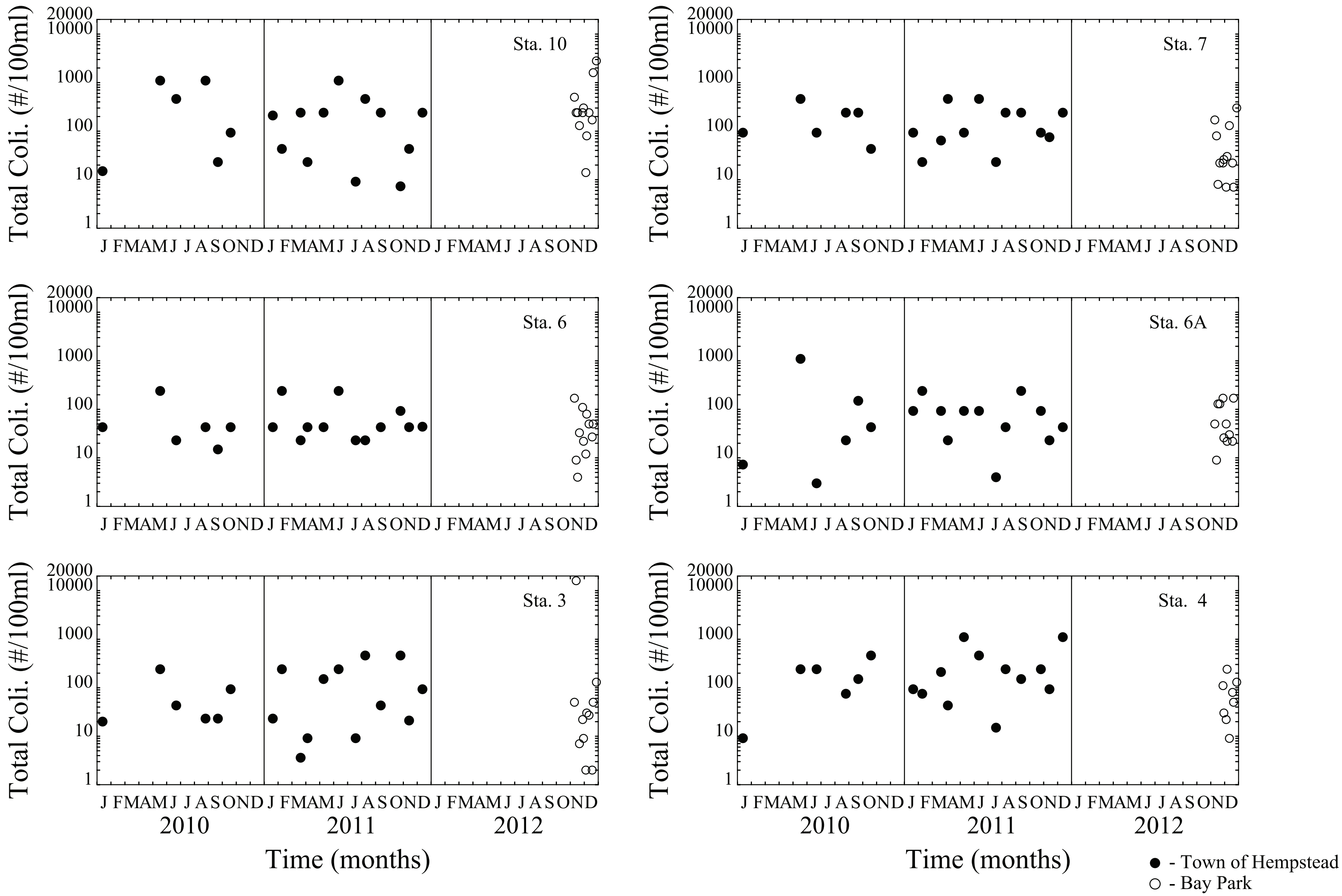


Figure 4-52. Comparison of Town of Hempstead and Bay Park Total Coliform Sampling Data

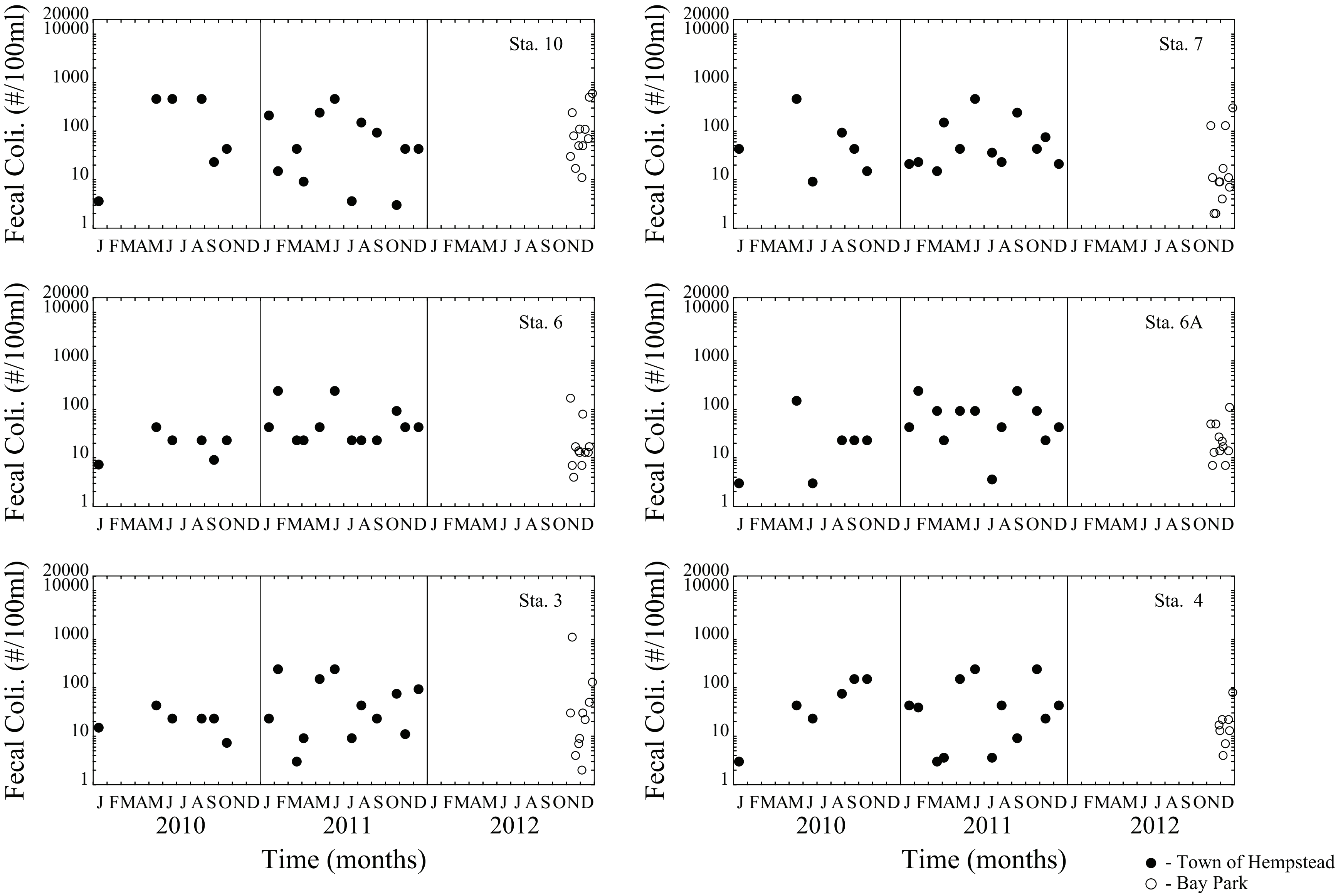


Figure 4-53. Comparison of Town of Hempstead and Bay Park Fecal Coliform Sampling Data

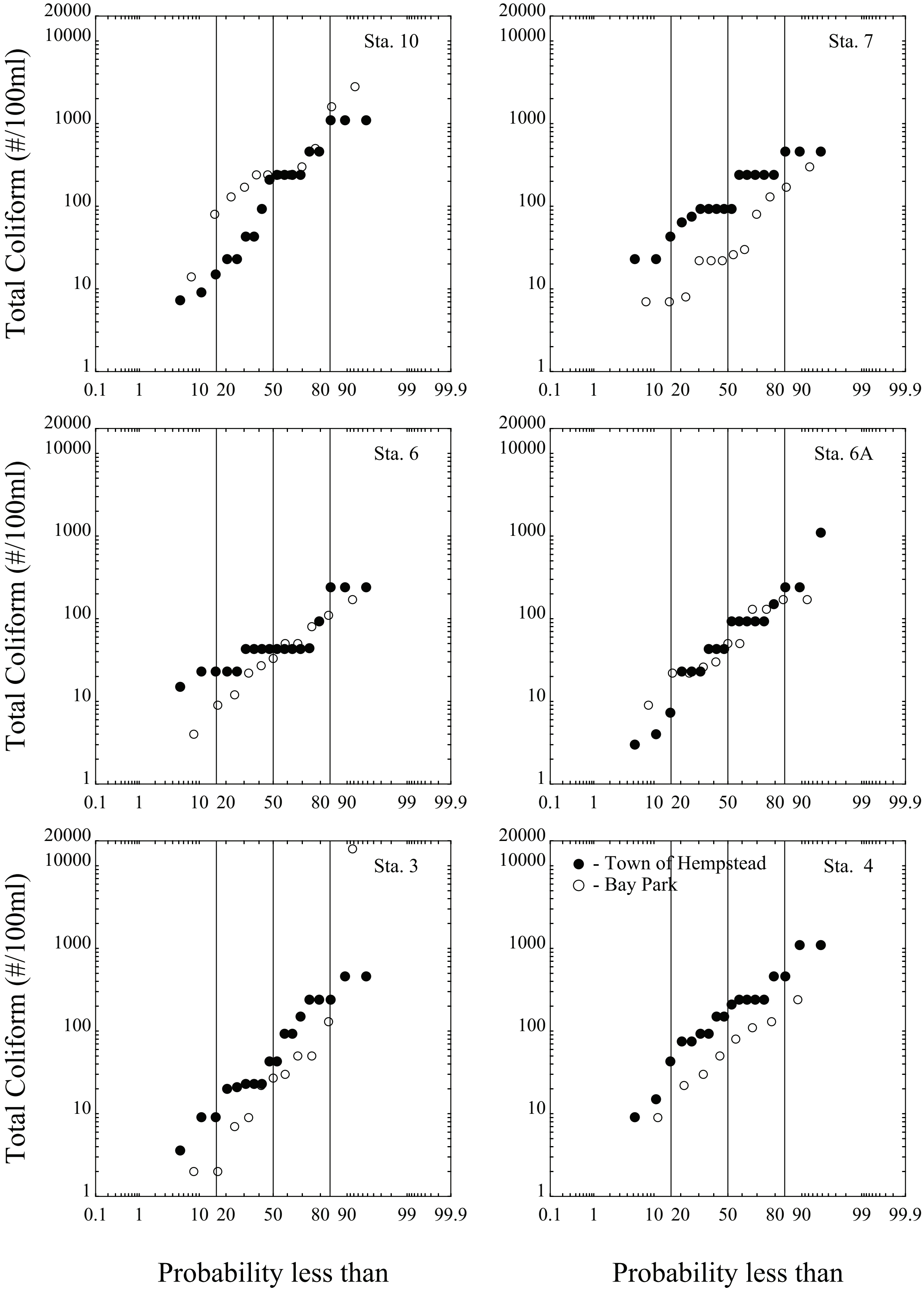


Figure 4-54. Comparison of Town of Hempstead and Bay Park Total Coliform Probability Distributions

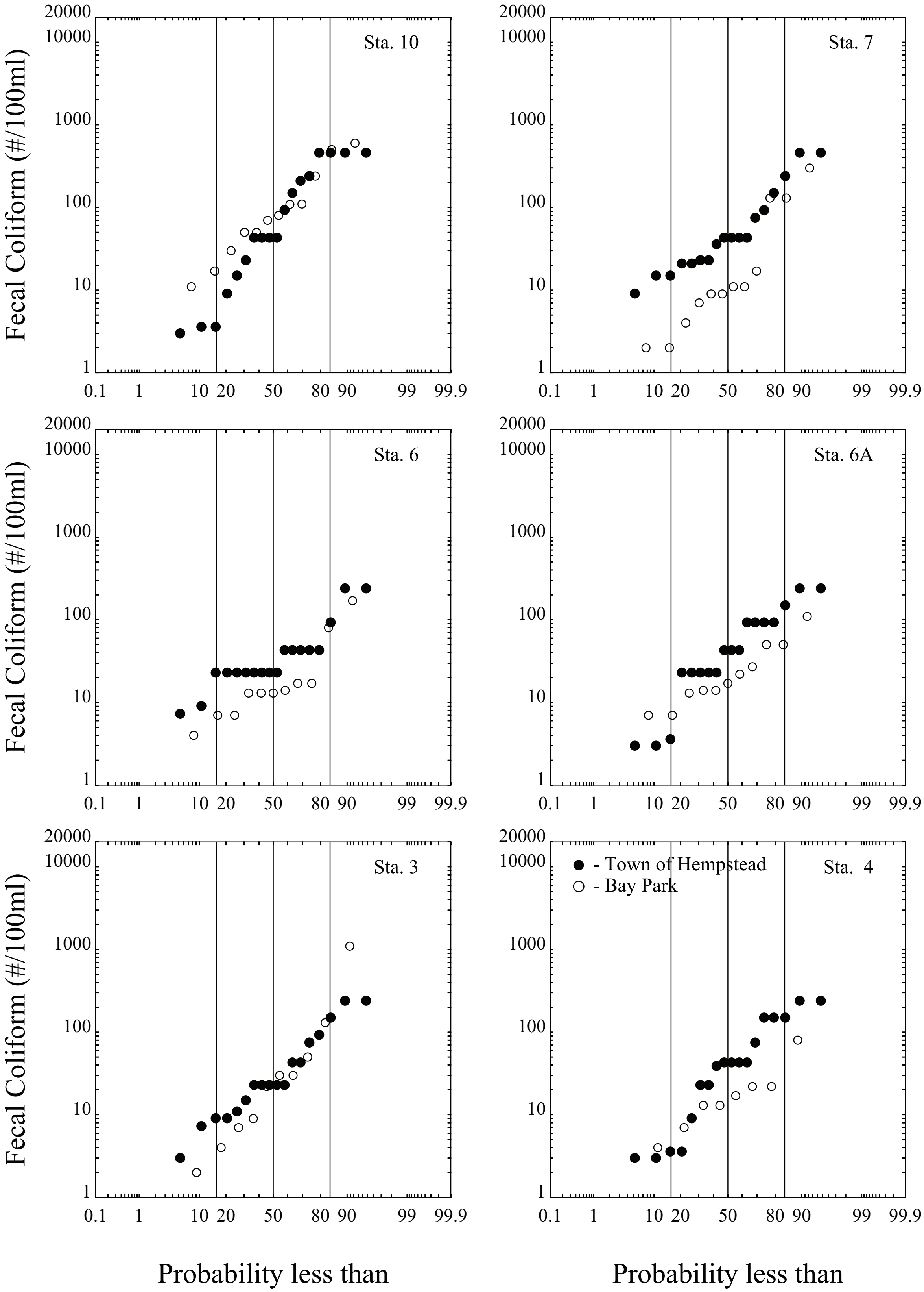


Figure 4-55. Comparison of Town of Hempstead and Bay Park Fecal Coliform Probability Distributions

SECTION 5

SEDIMENT

Sediment samples were collected at the creek and bay stations during the last sampling events. The measurements were meant to assess if sediment near where raw sewage was discharged or areas near the auxiliary or Reynolds Channel outfalls were different than other areas of the bay. The difficulty in interpreting these data is that there are no pre-Sandy measurements, and it is likely that many areas of the bay had highly disturbed sediment due to Hurricane Sandy. It is also difficult to discern the source of the contaminants because of the disturbances caused by Hurricane Sandy. The local tributaries are lined with personal watercraft and homes that could be sources of local contamination. Since only one sample was collected it is also difficult to determine how representative a single sample is for the area in which it was collected. The top 1 cm of the sediment was sampled in order to collect the most recent deposition, but even this depth of sediment could represent several years of deposition in low deposition areas.

There are no sediment criteria in the State of New York, but the state has developed some documents including: Technical Guidance for Screening Contaminated Sediments (1999), to provide guidance at the screening level to determine if sediments are contaminated. The document states that the purpose of sediment criteria for screening is to "identify areas of sediment contamination and to make a preliminary assessment of the risk posed by the contamination to human health and the environment." Tables 5-1 and 5-2 present some of the parameters of interest listed in the document. The table is broken into two columns: Effects Range Low (ERL) and Effects Range Median (ERM). ERL corresponds to the sediment concentration at which effects begin to be observed, and ERM corresponds to the concentration at which effects are almost always observed. These sediment concentrations are considered benchmarks that when exceeded have the potential to cause harm or risk to organisms in the environment. These levels were used to compare against the levels measured during the lone sediment survey conducted in January.

Table 5-1. Sediment Guidelines for Metals

Metal	ERL (µg/g)	ERM (µg/g)
Arsenic	8.2	70
Cadmium	1.2	9.6
Chromium	81	370
Copper	34	270
Iron	2.0%	4.0%
Lead	46.7	218
Mercury	0.15	0.71
Nickel	20.9	51.6
Silver	1	3.7
Zinc	150	270

Table 5-2. Sediment Guidelines for Organic Compounds

Chemical	ERL (µg/kg)	ERM (µg/kg)
Acenaphthene	16	500
Acenaphthylene	44	640
Anthracene	85.3	1100
Fluorene	19	540
2-Methylnaphthalene	70	670
Naphthalene	160	2100
Phenanthrene	240	1500
Benzo(a)anthracene	261	1600
Benzo(a)pyrene	430	1600
Chrysene	384	2800
Dibenzo(a,h)anthracene	63.4	260
Fluoranthene	600	5100
Pyrene	665	2600

In general, sediments with higher total organic carbon (TOC) and higher moisture content are more contaminated. Many chemicals adsorb to fine organic material which tends to settle out in low velocity, lower energy waters. In areas with higher currents, deposition is less likely to occur so the sediment is more sandy, which does not adsorb contaminants as well as organic material. Figure

5-1 presents the percent TOC and percent moisture data that were collected. The TOC content tends to be low, less than 1%. In the creeks, the reference site TX-1, and the upstream Parsonage Creek station, P-1, have the highest percent TOC. A few stations on the western side of the Reynolds Channel outfall (TH-3, B-3A, B-3B) have elevated TOC content in the bay, but with only one sample it is difficult to know whether these samples are representative of the area. The percent moisture follows the expect trend in the creeks with higher TOC sites having higher percent moisture. In the bay, the trend is reversed.

The metals results for the sediment are presented in Figures 5-2 through 5-7. Barium, cadmium, zinc, silver and mercury were all below the detection limit, although on occasion the detection limit was higher than the ERL. In the creeks, the highest metal concentrations do not always correspond to the point of raw sewage discharge. In Macy Channel, the highest metals concentrations are generally associated with MC-2, which is near the discharge point. However, the concentrations here are not significantly higher than the other locations and it is not surprising that the highest concentrations would be found at the head end of a dead end creek where material is most likely to settle. In Grand Canal, the concentrations are generally similar at all three stations. In the Mill River, station MR-2 generally has the highest metals concentrations, not MR-1 near the discharge point. In Parsonage Creek, the highest metals concentrations shift between P-1 and P-2. Interestingly, the reference station TX-1 generally has the highest or one of the highest metals concentrations, which suggests that the sewage discharges are not necessarily the sole source of the metals in the sediment.

In the bay, the highest metals concentrations were measured in the ERC station sediments, but these concentrations were generally lower than the upstream MR-2 station. The discharge sampling station sediment does not generally have higher metals concentrations than the stations around it. The lowest metals concentrations were found in the center of the bay and near the Rockaway Channel Inlet.

Many of the samples collected had concentrations higher than the ERLs in Table 5-1, and some of the measurements were greater than the ERM, which suggests that there is metals contamination in the creeks and bay. However, the data do not clearly indicate that the raw sewage discharge and Bay Park STP discharge are the sole or major source of the metals contamination.

The sediment results for the PAHs are presented in Figures 5-8 through 5-15. No PAHs were detected in the bay stations. PAHs in the creek sediments were found at stations: C-1, C-2, C-3, P-1, P-2, and TX-1 and TX-2. When high PAH concentrations were found, they generally occurred at stations C-2, P-1 and TX-1. Since PAHs were found at the reference site and not all of the discharge sites, it is likely that the raw sewage discharge was not the source of the PAH contamination. Personal watercraft docked along the edge of the tributaries could be a local source of PAH contamination. During Hurricane Sandy, many boat, cars and home heating systems were damaged and could be sources of PAH contamination.

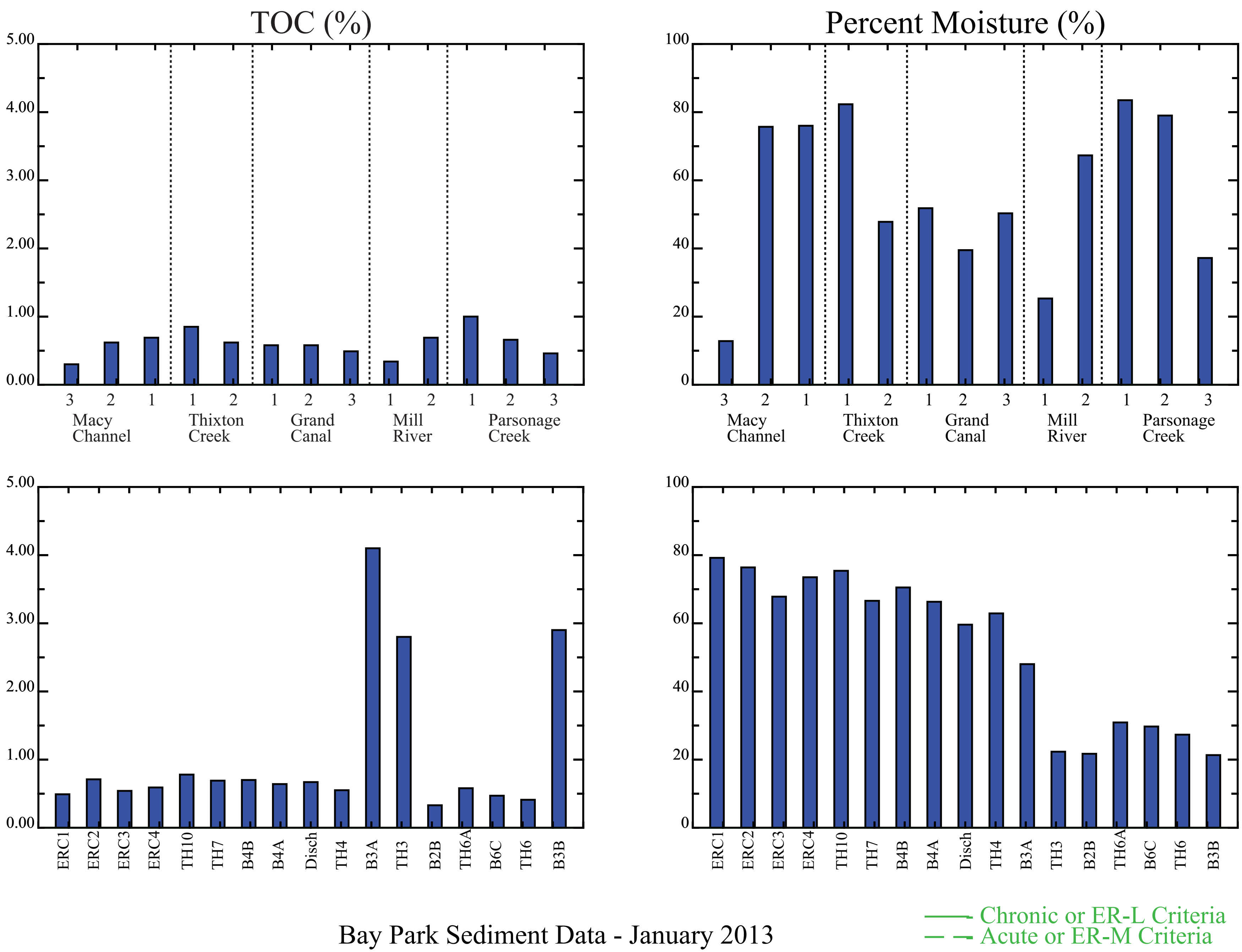


Figure 5-1. Sediment TOC and Percent Moisture Data

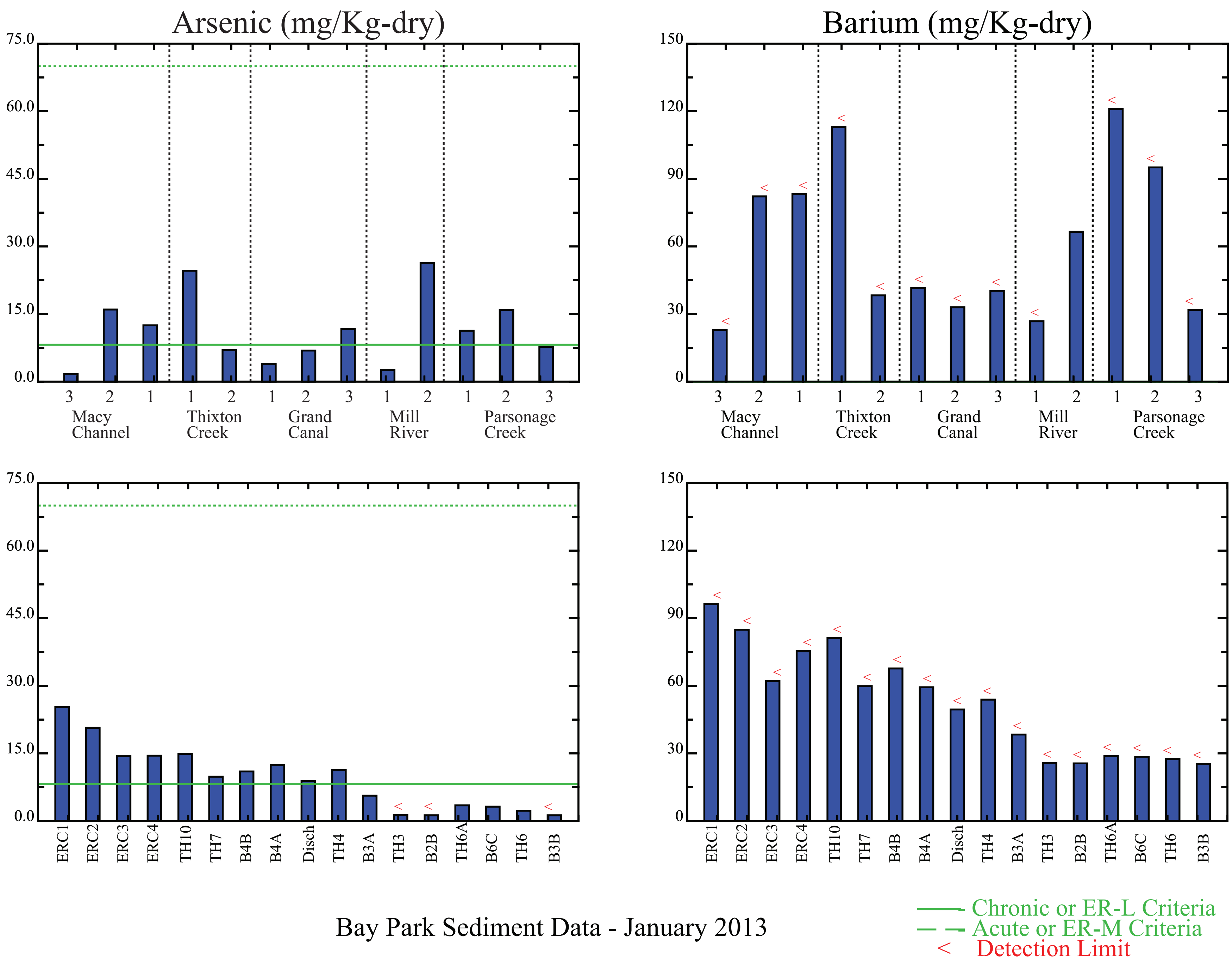


Figure 5-2. Sediment Arsenic and Barium Data

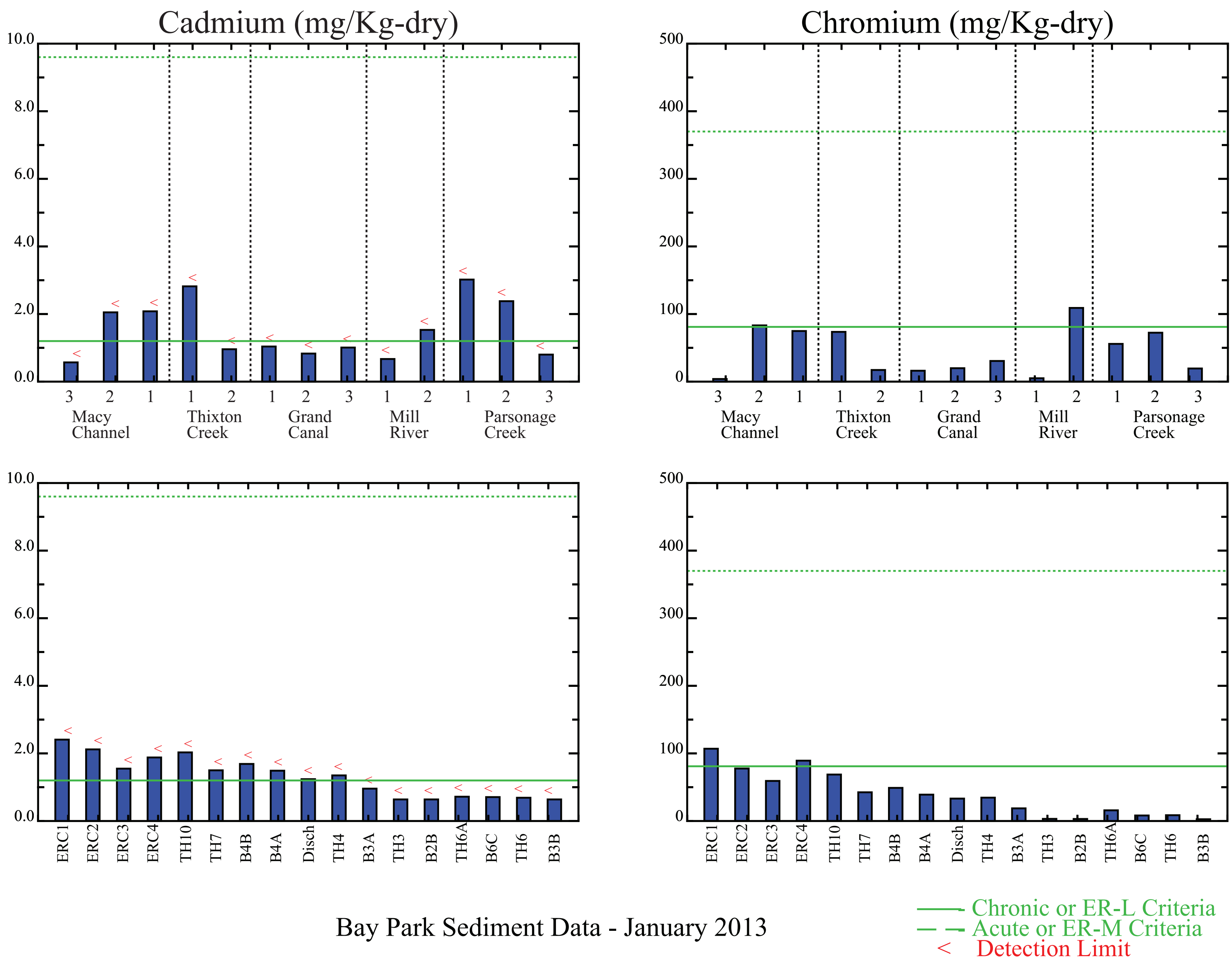
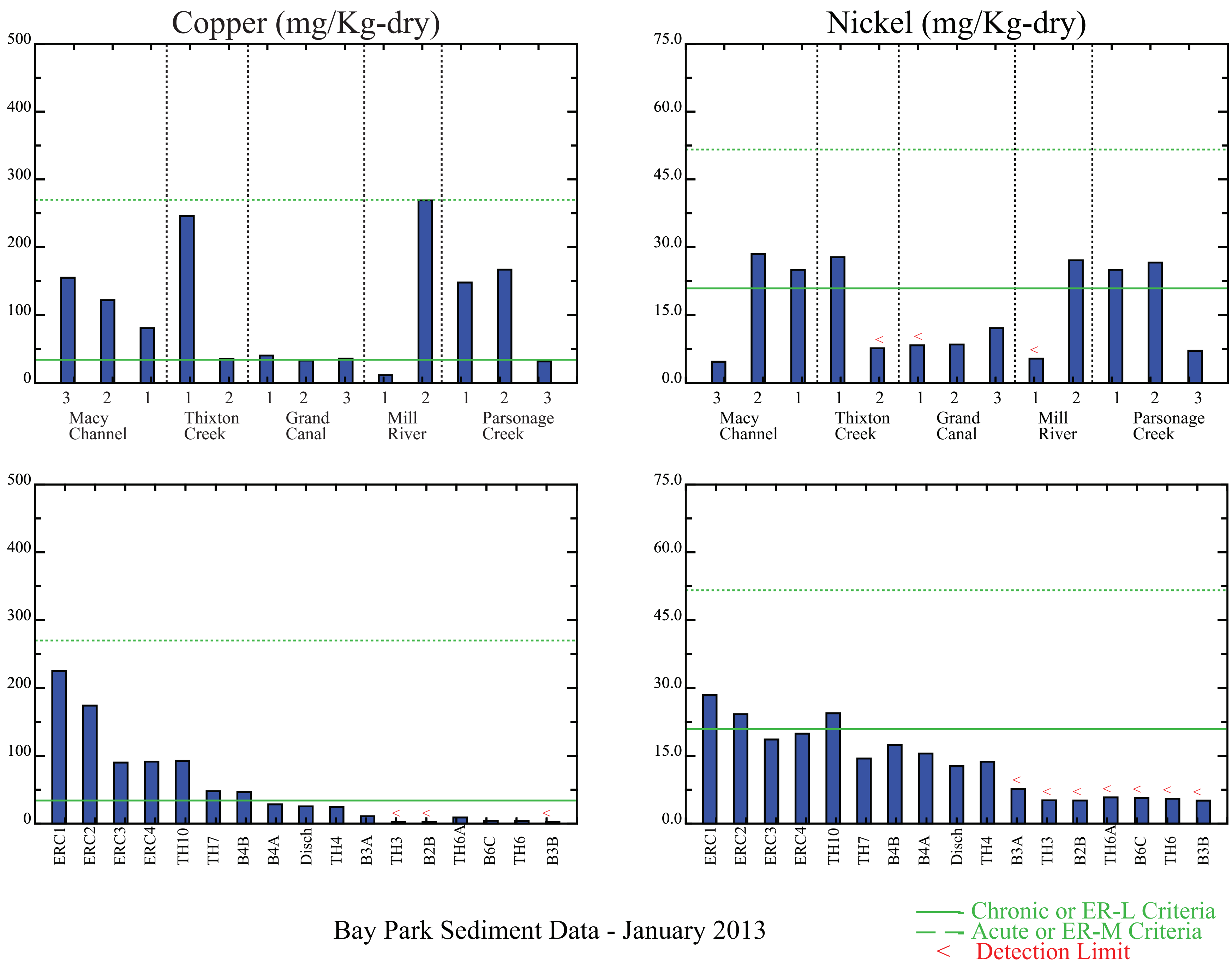


Figure 5-3. Sediment Cadmium and Chromium Data



Bay Park Sediment Data - January 2013

Figure 5-4. Sediment Copper and Nickel Data

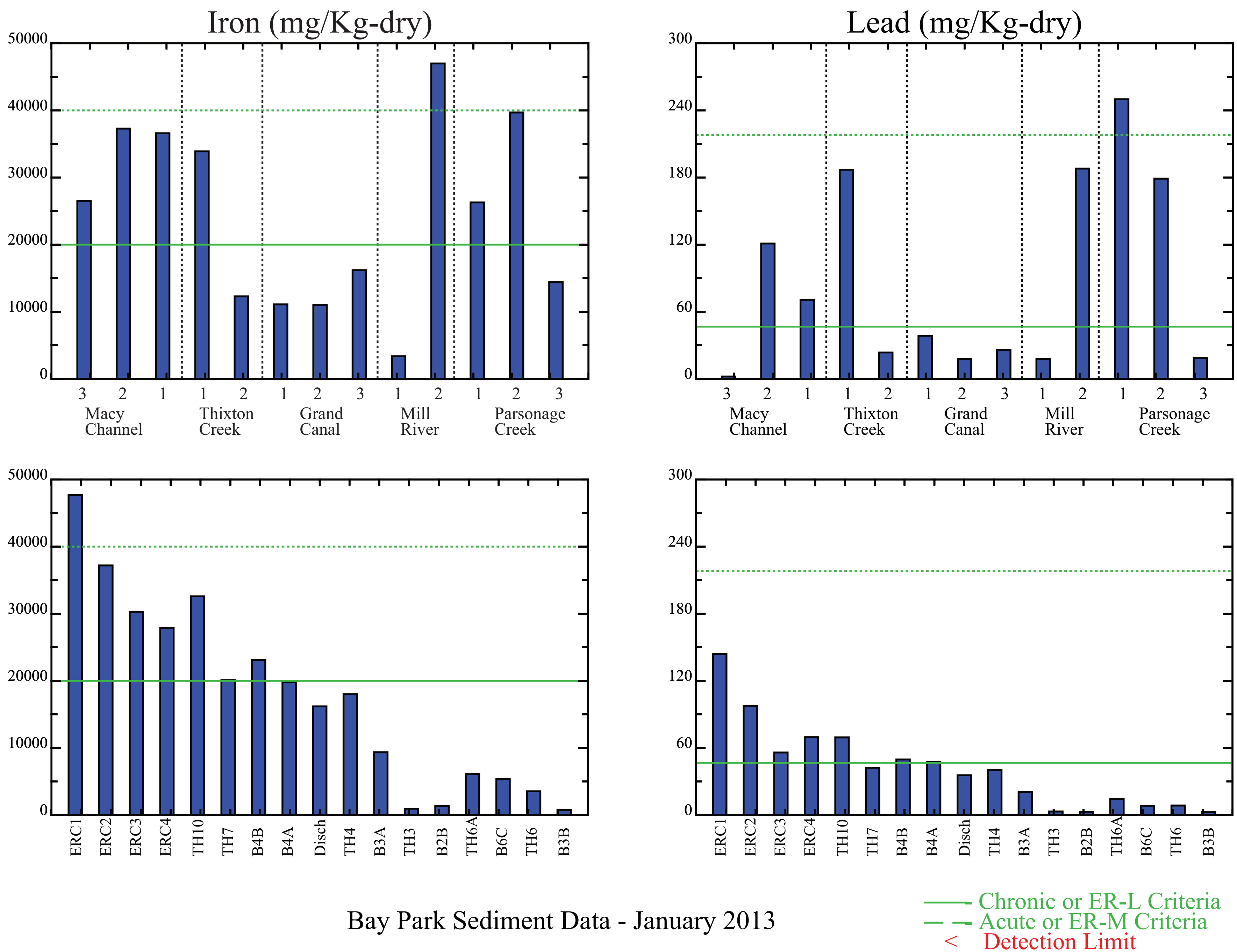


Figure 5-5. Sediment Iron and Lead Data

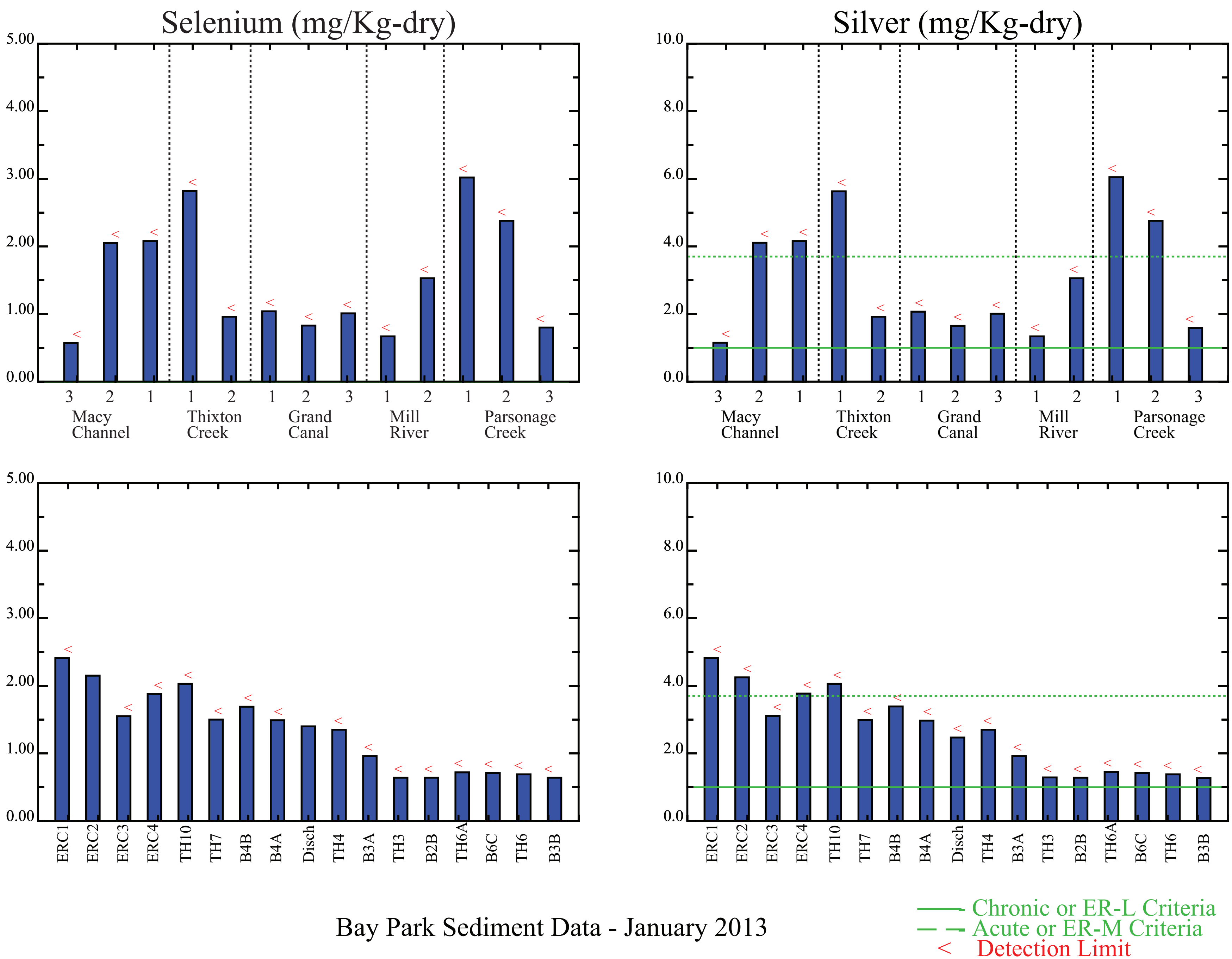


Figure 5-6. Sediment Selenium and Silver Data

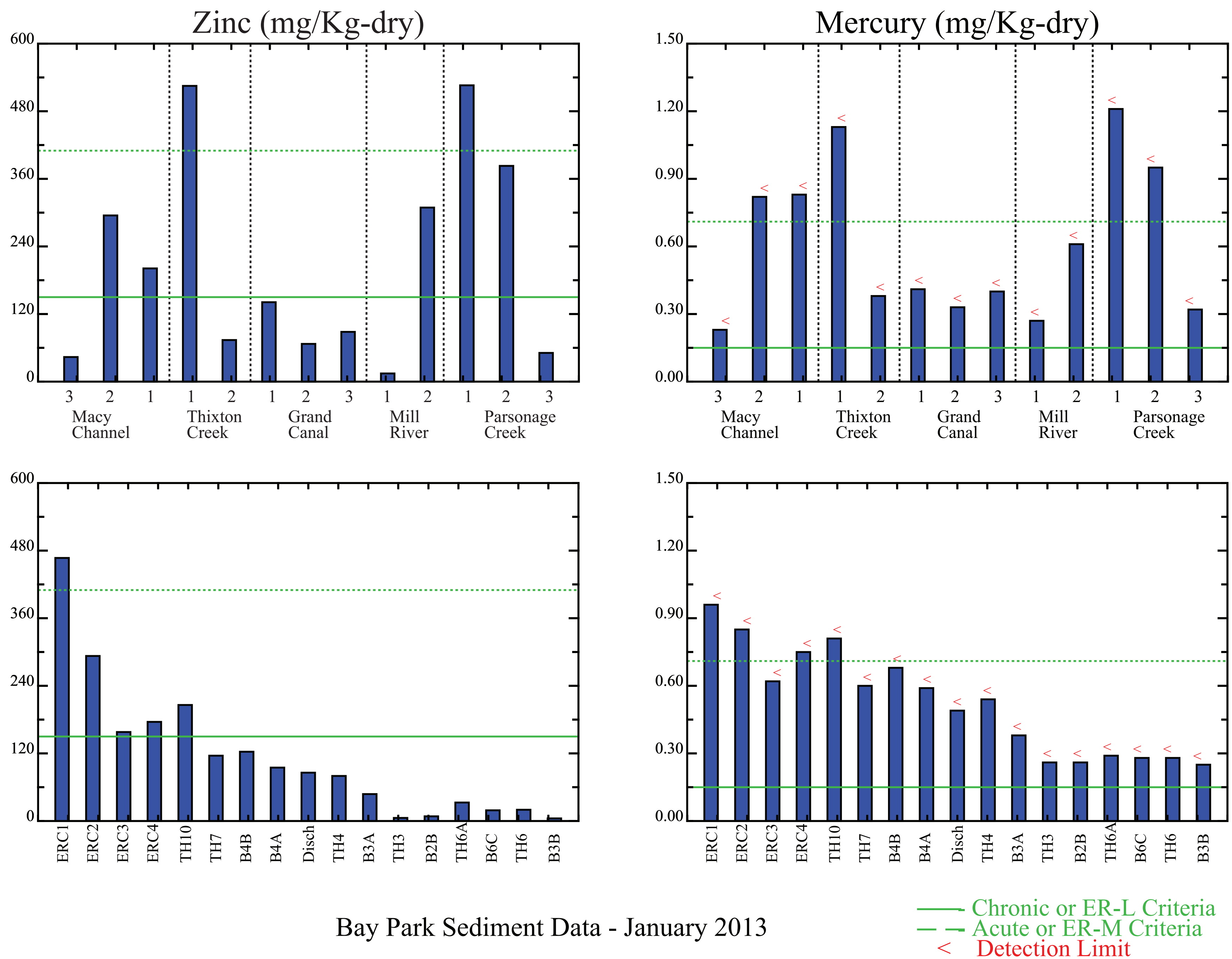


Figure 5-7. Sediment Zinc and Mercury Data

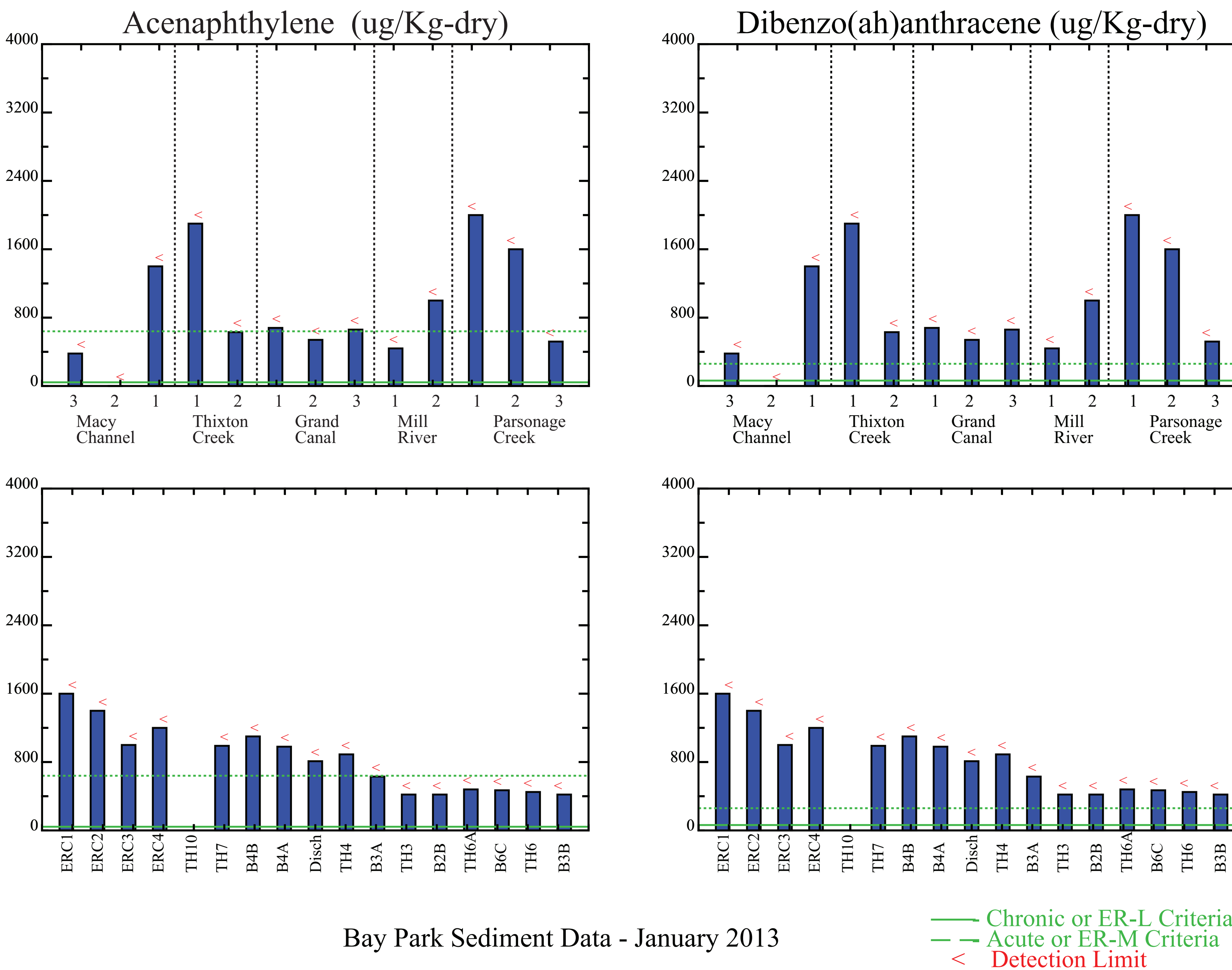


Figure 5-8. Sediment Acenaphthylene and Dibenzo(ah)anthracene Data

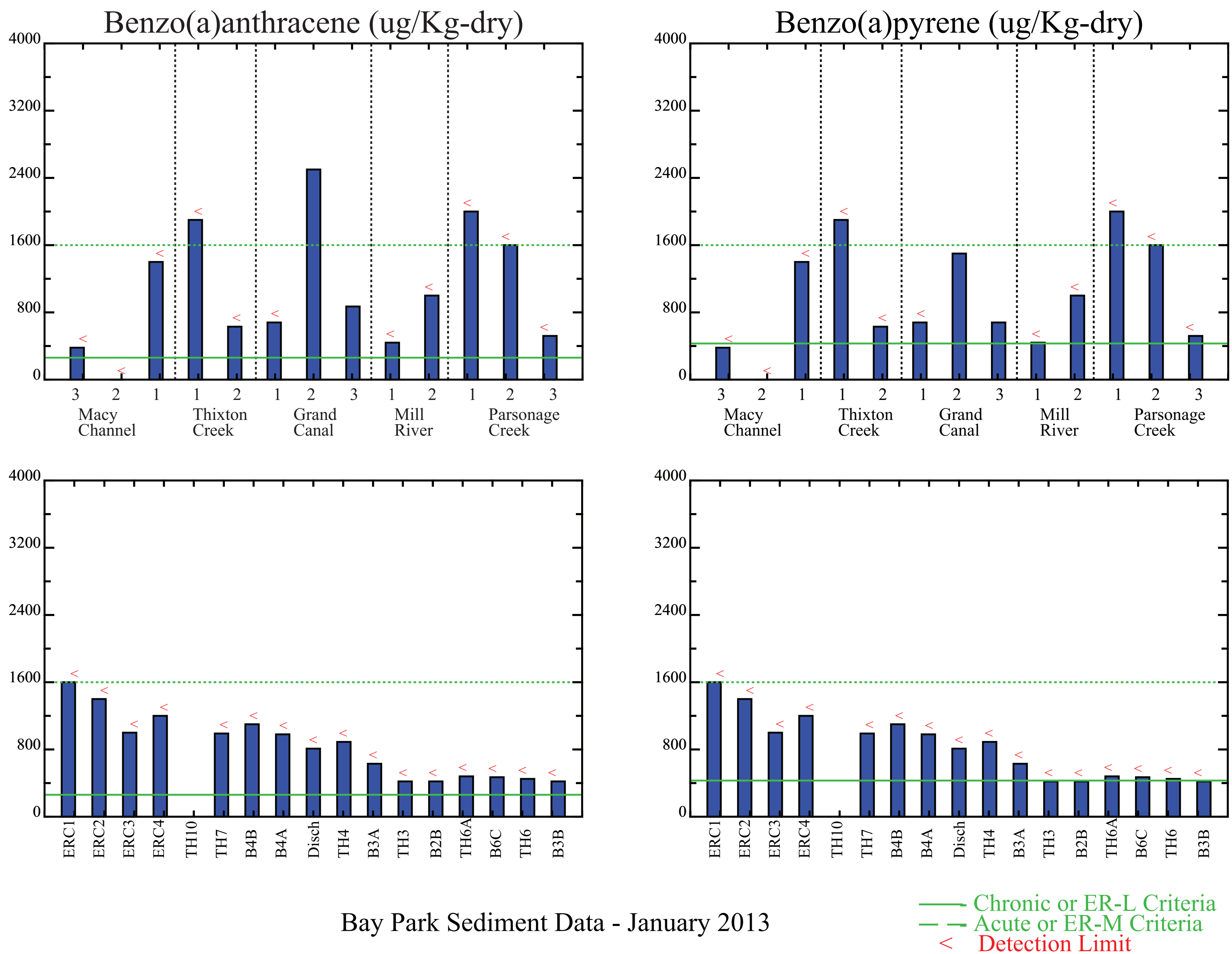


Figure 5-9. Sediment Benzo(a)anthracene and Benzo(a)pyrene Data

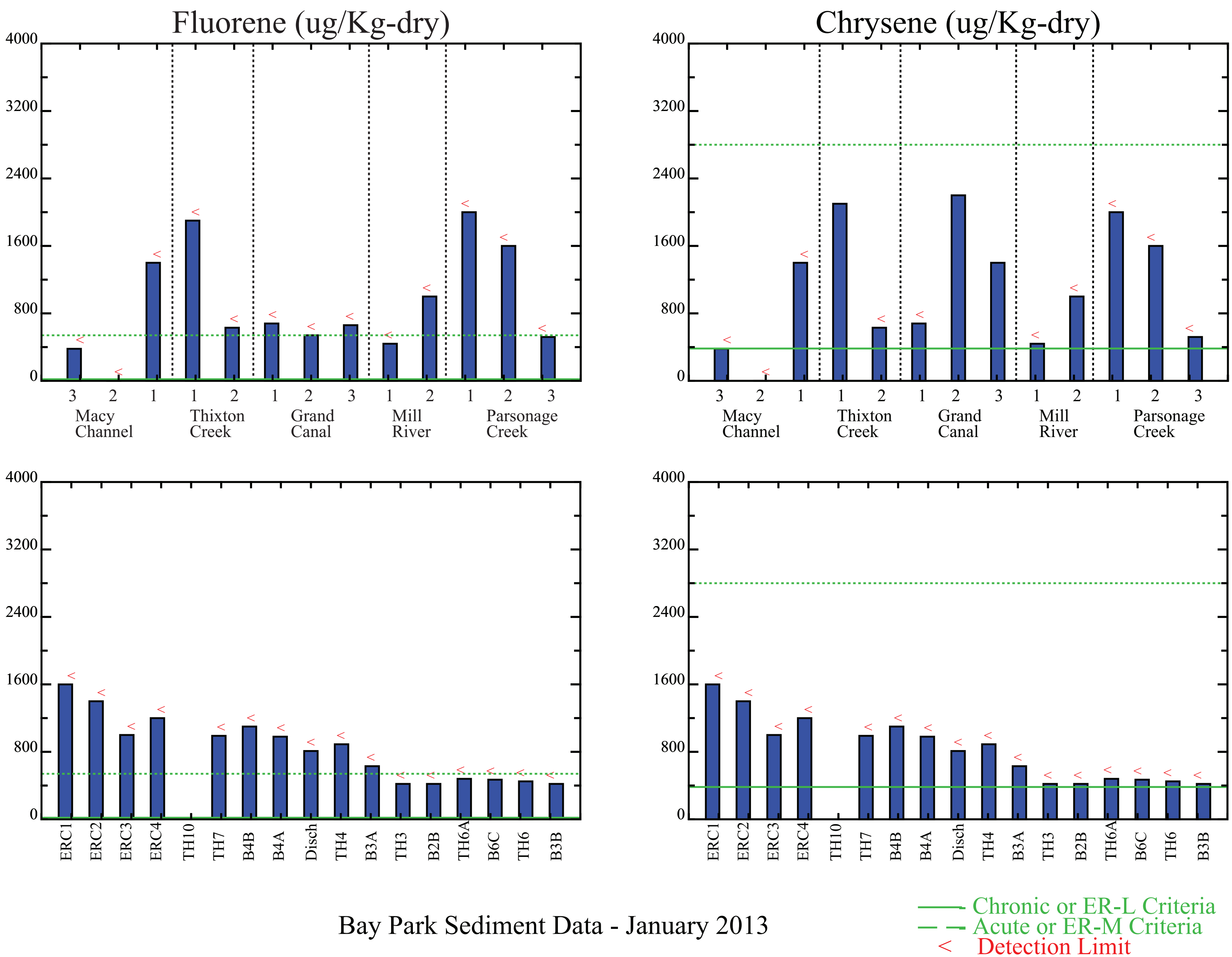


Figure 5-10. Sediment Fluorene and Chrysene Data

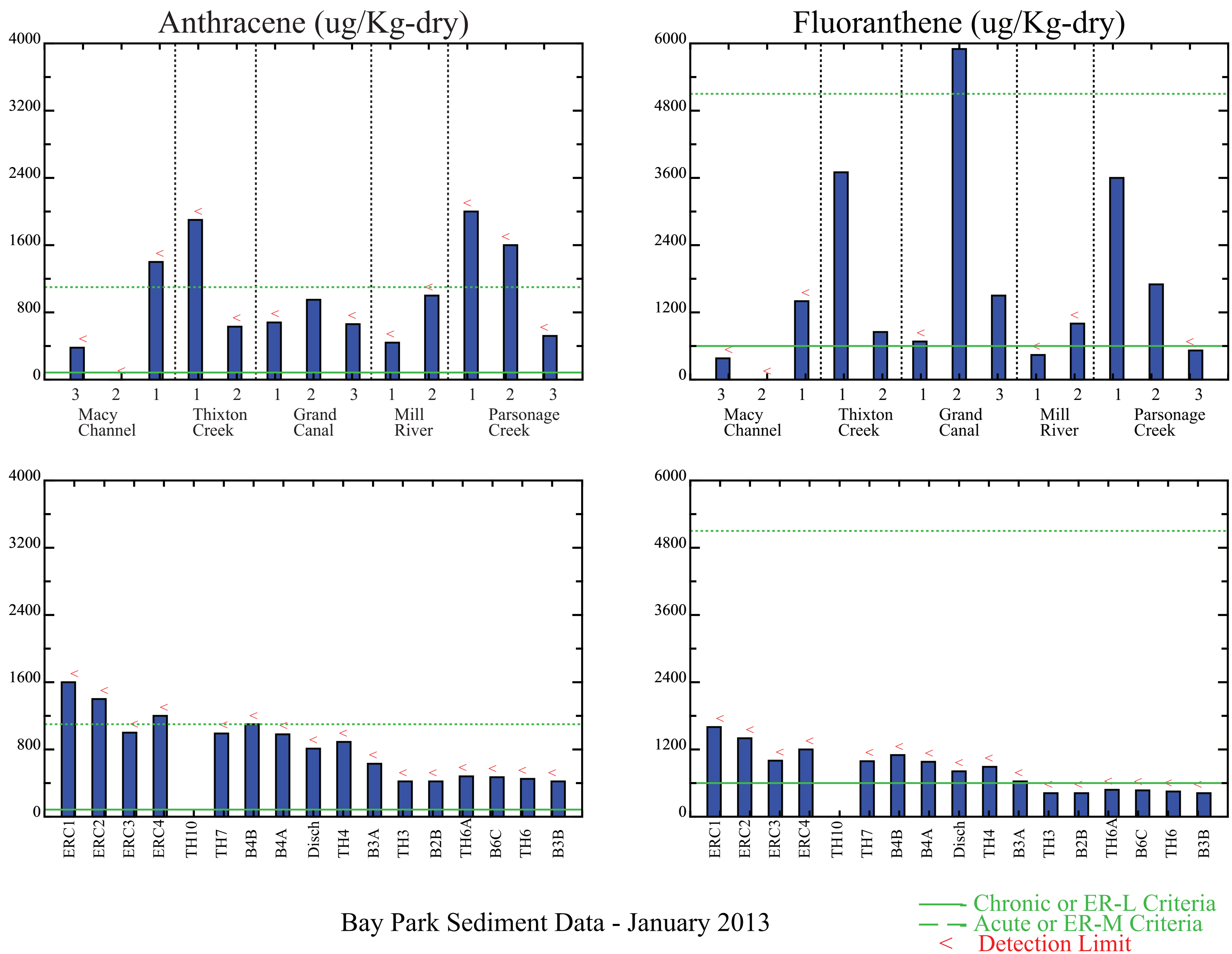


Figure 5-11. Sediment Anthracene and Fluoranthene Data

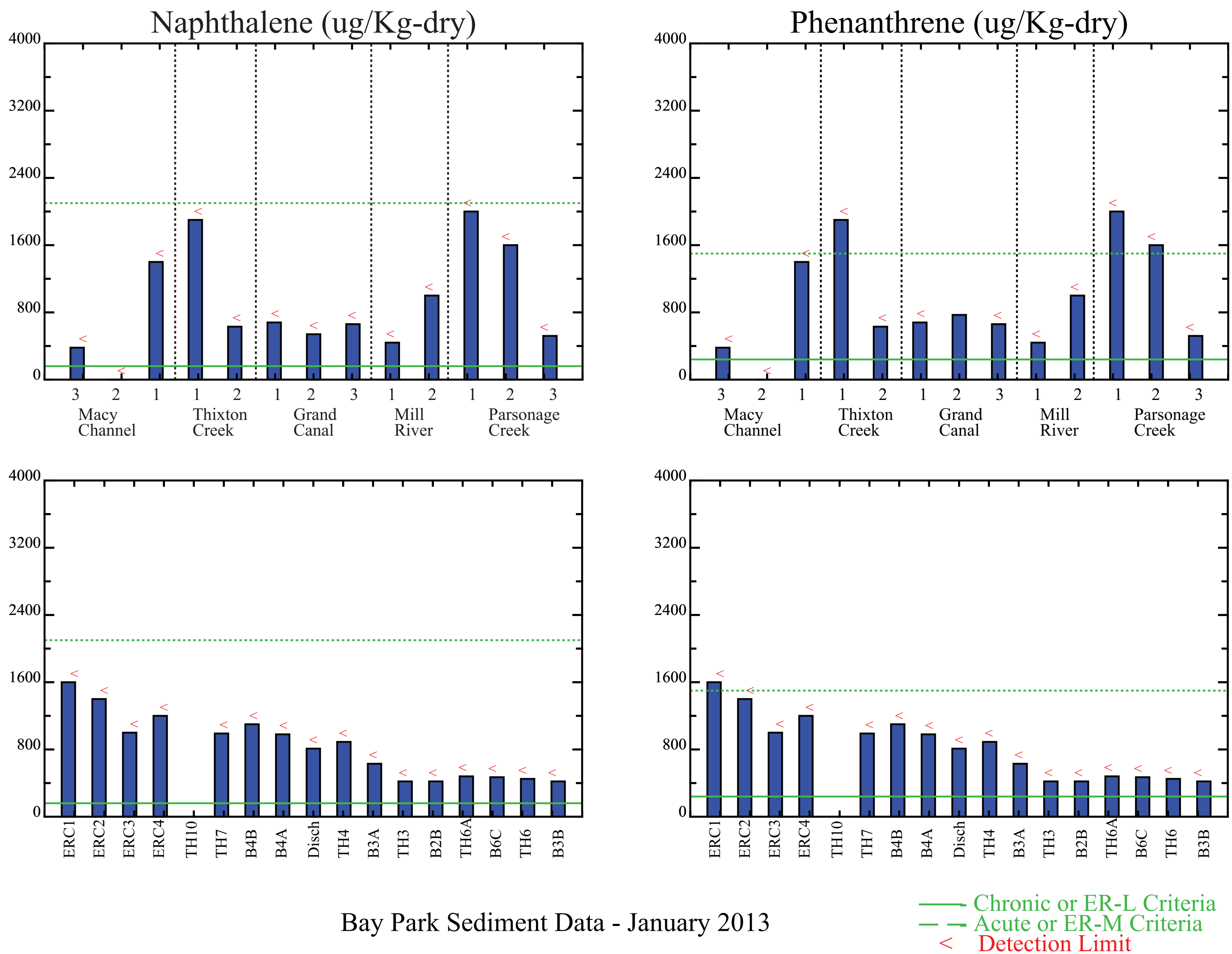


Figure 5-12. Sediment Naphthalene and Phenanthrene Data

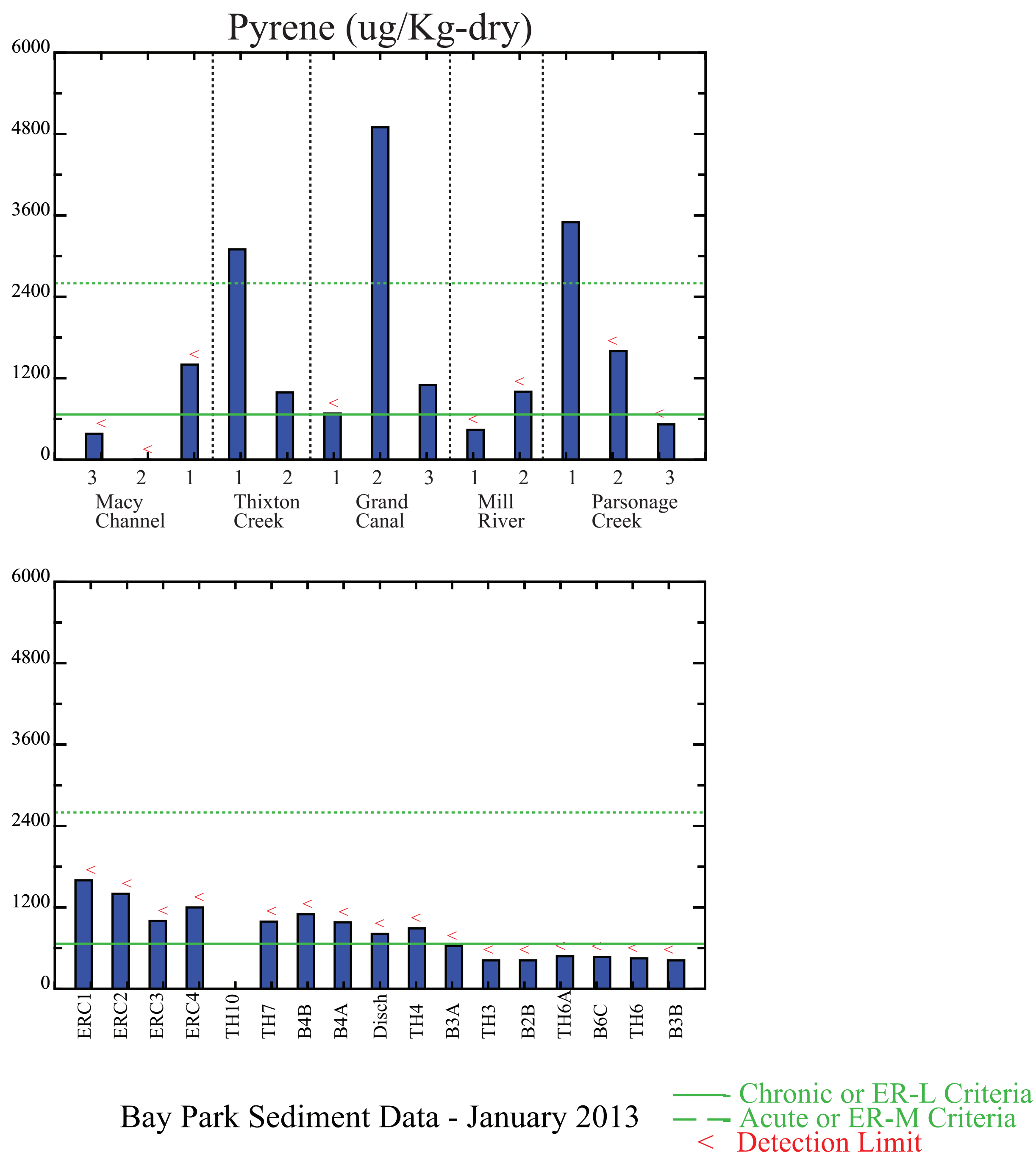


Figure 5-13. Sediment Pyrene Data

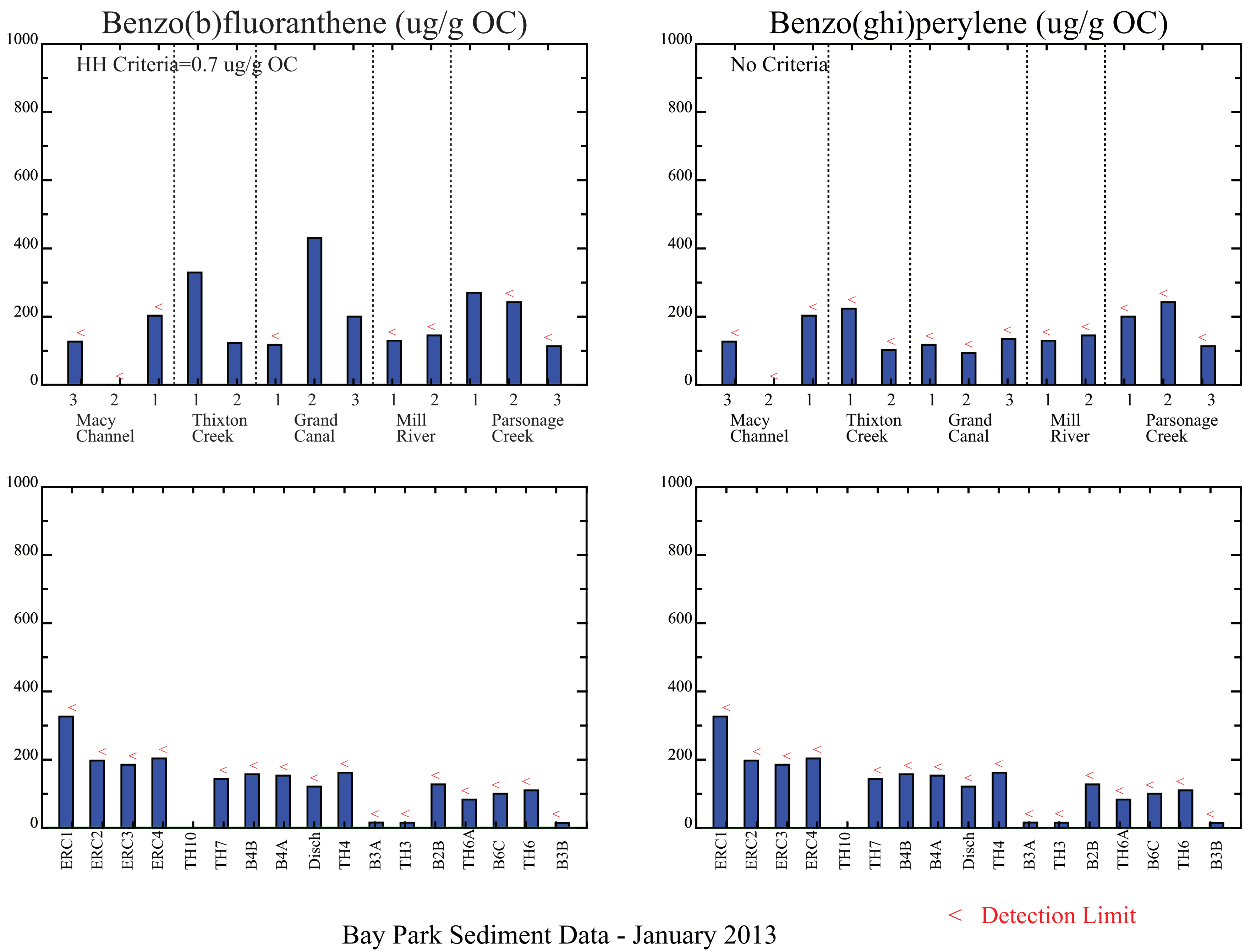


Figure 5-14. Sediment Benzo(b)fluoranthene and Benzo(ghi)perylene Data

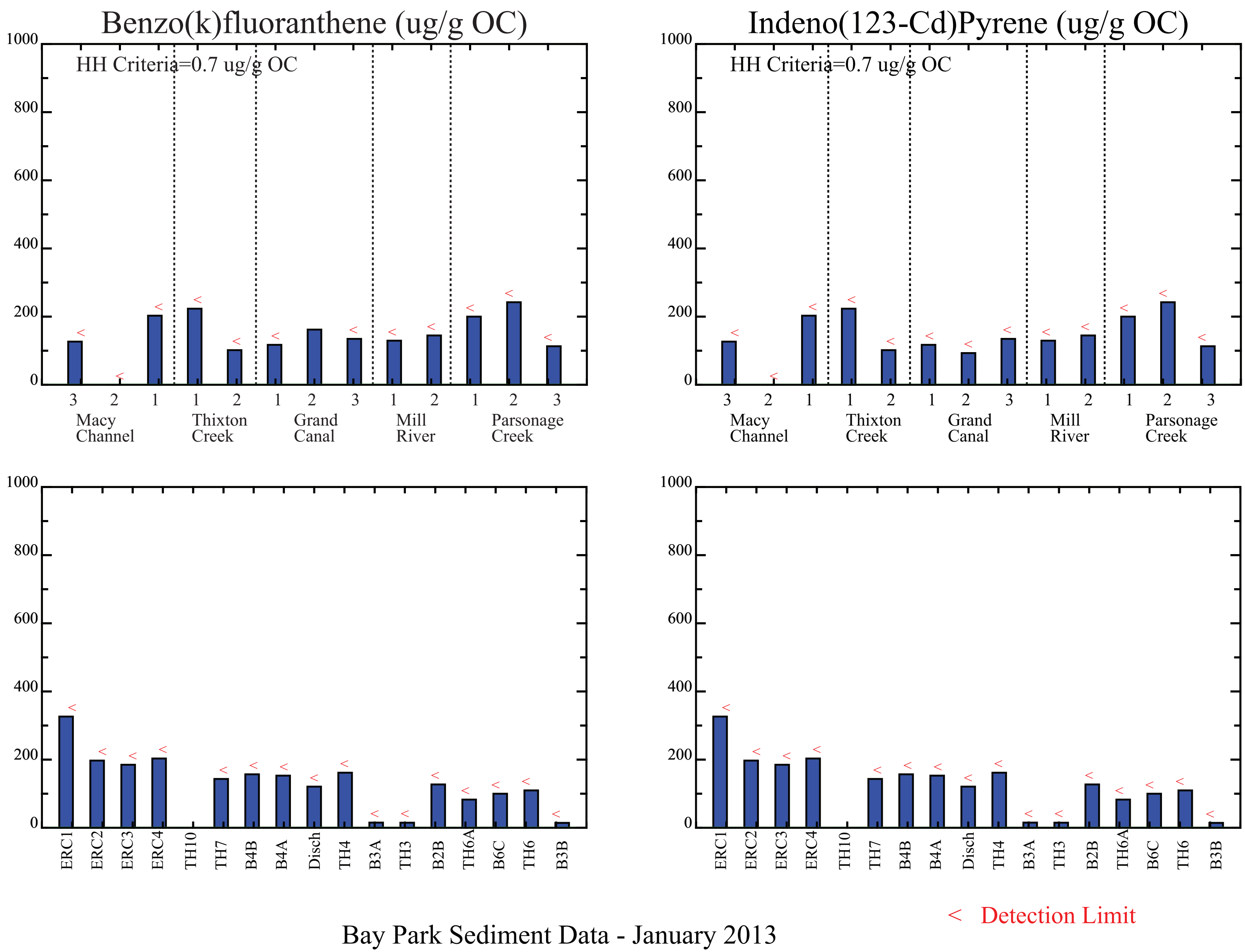


Figure 5-15. Sediment Benzo(k)fluoranthene and Indeo(123-cd)pyrene Data

SECTION 6

COMPUTER MODELING

In addition, to direct sampling of water quality within the creeks and bay, mathematical computer modeling is a valuable tool in assessing the impacts of pollutant sources on water quality. Although a fully calibrated mathematical water quality model does not exist for the waters impacted by the Bay Park STP discharge, the SUNY School of Marine and Atmospheric Sciences (SoMAS) has a finite-volume hydrodynamic model of the Great South Bay coastal lagoonal system of Long Island. The model (FVCOM – Finite Volume Coast Ocean Model) is a three-dimensional primitive equation ocean model that conserves momentum, energy, heat, salinity and density, includes advanced turbulent closure schemes, and matches a quadratic bottom drag with the interior through a logarithmic bottom boundary layer. The model is particularly suited to applications where the advection and mixing of salt, heat, nutrients, and biological constituents are important issues. Figures 6-1 through 6-3 present representations of the model domain and shows the model segmentation.

This existing hydrodynamic simulation was used as part of this impact assessment to provide insight to the potential impacts of the discharge of partially treated Bay Park STP sewage through the assessment of flushing times. In this application, primarily due to time constraints, the model was applied in its existing form without modeling the specific conditions of Hurricane Sandy or regridding to refine the model in the tributaries of interest. Therefore these model runs should be considered screening simulations to provide additional information beyond what the sampling program provided.

In portions of the bay, particles were released into the model at locations of known discharges, and tracked to assess flushing time. To simulate the discharge of raw sewage into the tidal creeks, particles were released for 36 hours and then tracked to determine how long it takes for the particles to leave the tributary. This modeling was conducted in Macy Channel, East Rockaway Channel (Mill River), and Parsonage Creek. Particles were also released from the existing Reynolds Channel outfall and the auxiliary outfall. Since the pumps required to send all of the effluent to the Reynolds Channel Outfall were not operational immediately after the storm, the simulations release particles to the Reynolds Channel outfall only during the six hours of low tide. The particles were released to the auxiliary outfall during the six hours of high tide.

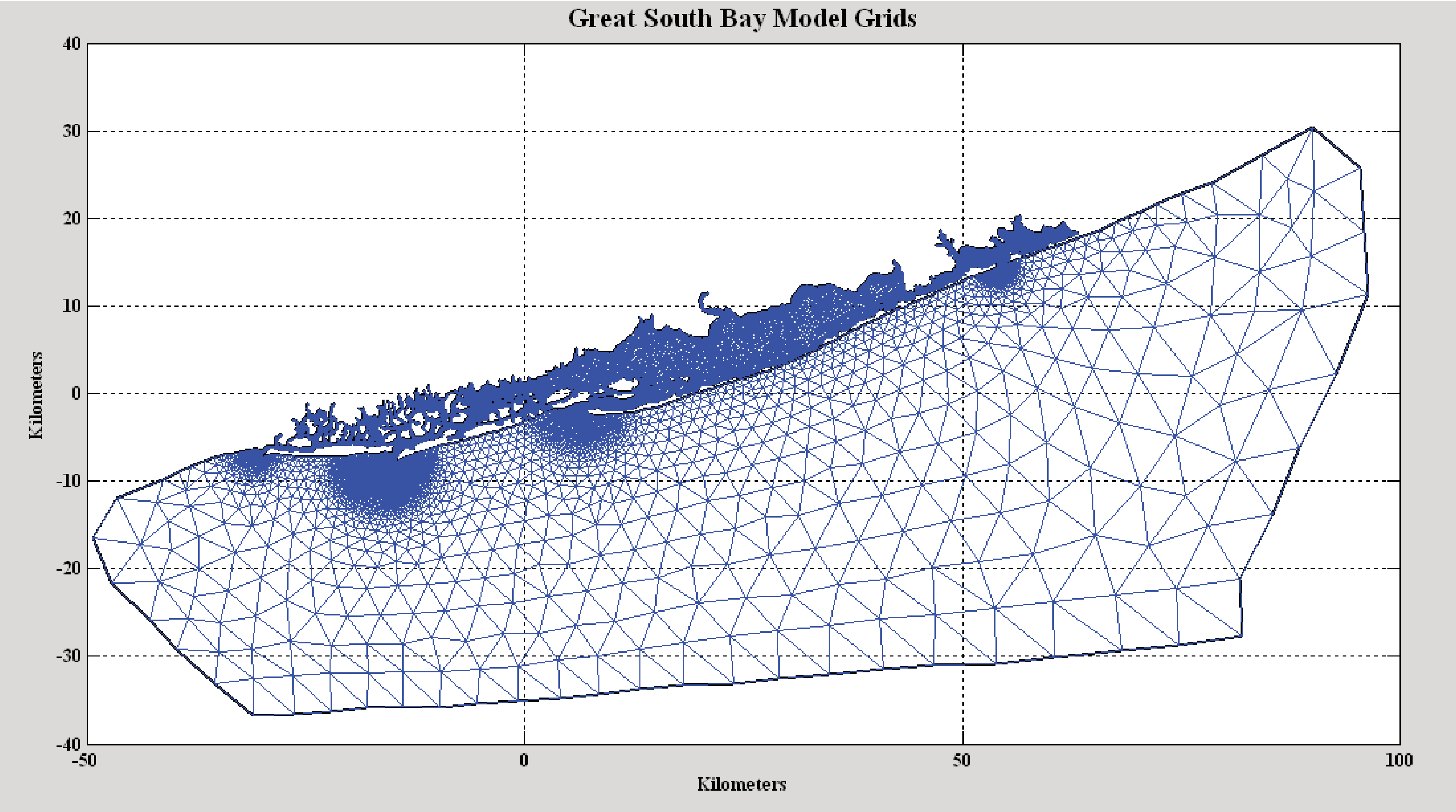


Figure 6-1. SUNY FVCOM Model Domain for the Great South Bay Model

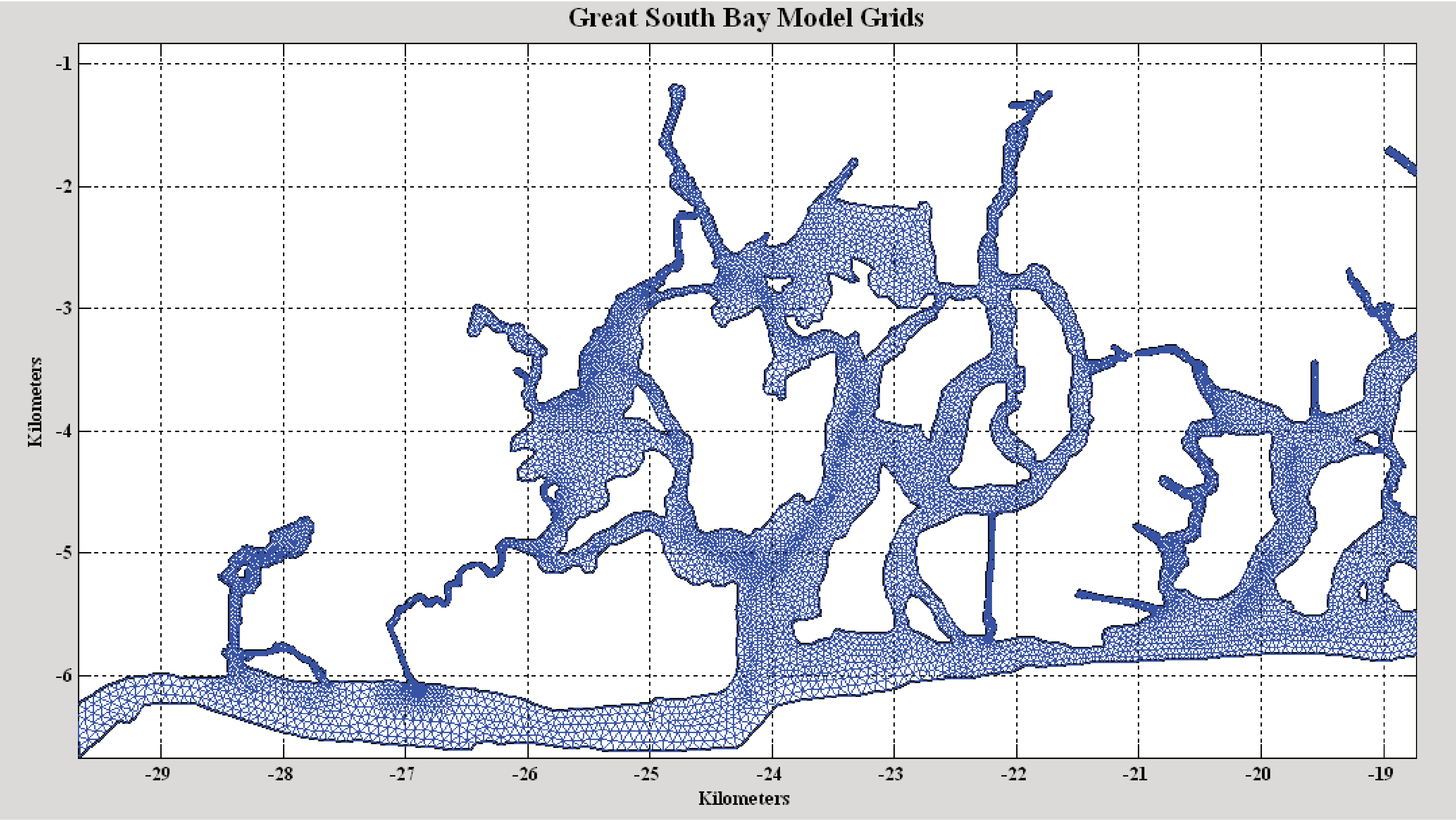


Figure 6-2. SUNY FVCOM Model Segmentation in West Hempstead Bay

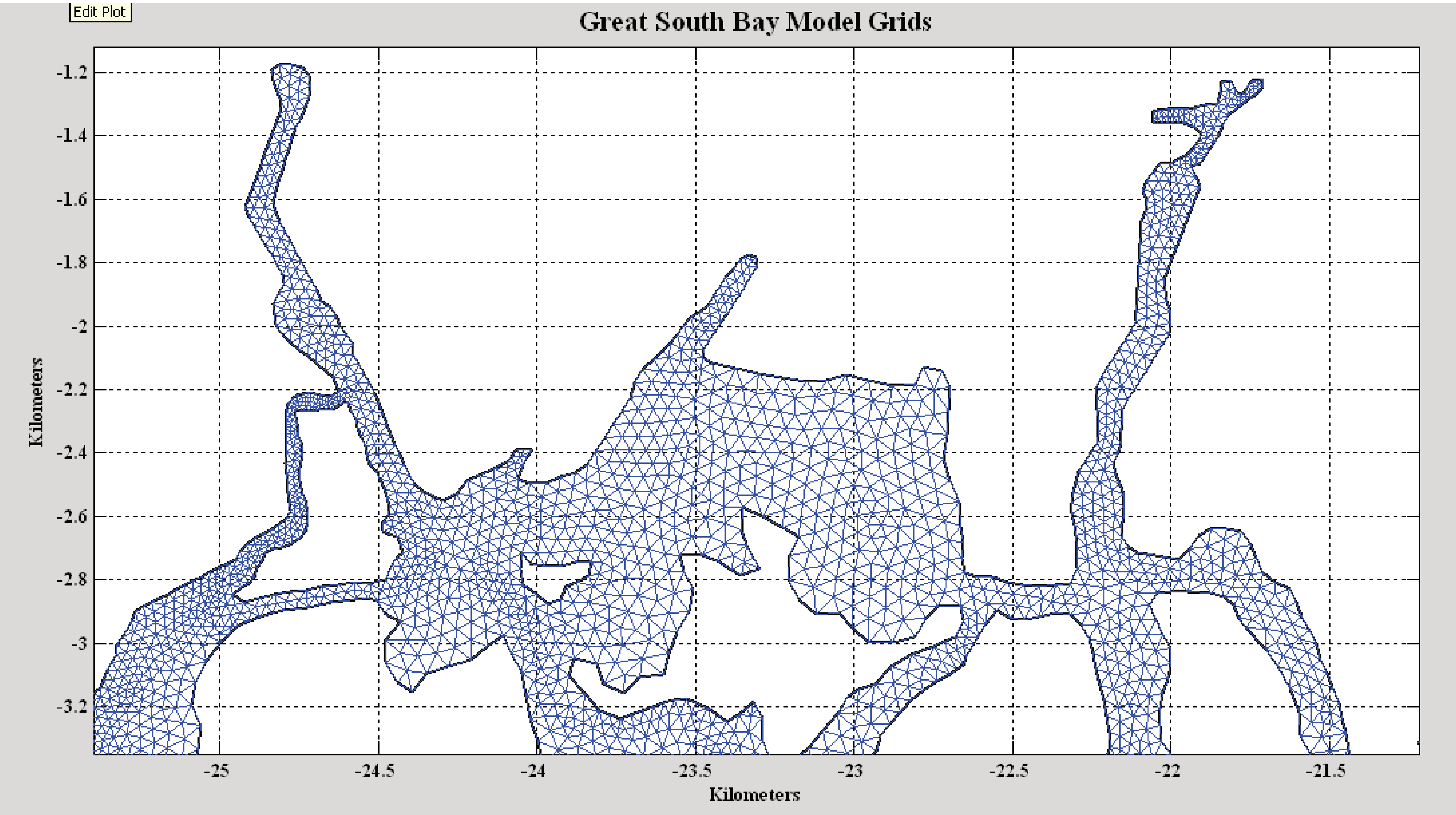


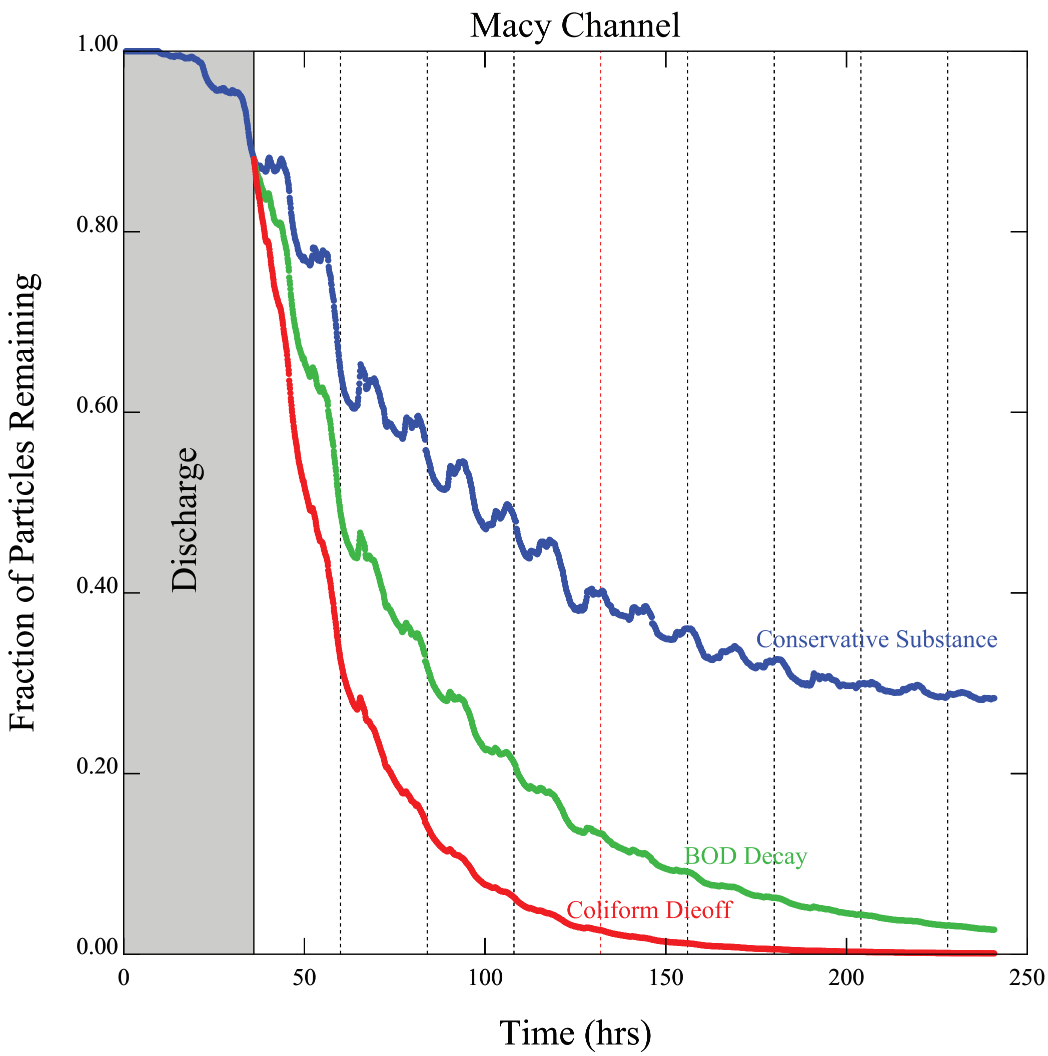
Figure 6-3. SUNY FVCOM Model Segmentation in northern West Hempstead Bay Including Macy Channel and East Rockaway Channel

Tributary Detention Time

Macy Channel is well represented in the model segmentation. It received a raw sewage discharge near its head end for approximately two days. This discharge was simulated in the FVCOM model by releasing particles over a 36 hour period. The model tracked the particle movement in the model and analysis was completed to calculate how many of the particles released remained in the channel over time. The results are presented in Figure 6-4 as the blue line. The particles in the model are treated as a conservative substance, meaning there is no loss associated with decay or settling. Since raw sewage is not a conservative substance, additional calculations were completed for BOD and coliform to estimate the additional loss rate due to decay or die-off. Settling was not considered. Assuming a decay rate of BOD for untreated sewage as 0.35/d, a temperature of 10 °C and a temperature correction factor of 1.047, a rounded decay rate of 0.275/d was calculated and added to the loss associated with flushing. The BOD calculation is shown as the green line. Similarly, coliform was assigned a base loss rate of 0.8/d plus a salinity loss rate assuming 90 percent seawater resulting in an addition loss of 0.54/d for a total rate of 1.34/d. Using the temperature correction factor of 1.07 a die-off rate of 0.68/d was calculated, and added to the flushing loss rate. The estimated loss rate for coliform bacteria is represented by the red line in Figure 6-4. A calculation for enterococci resulted in a loss rate of 0.62/d plus the loss due to flushing (not shown).

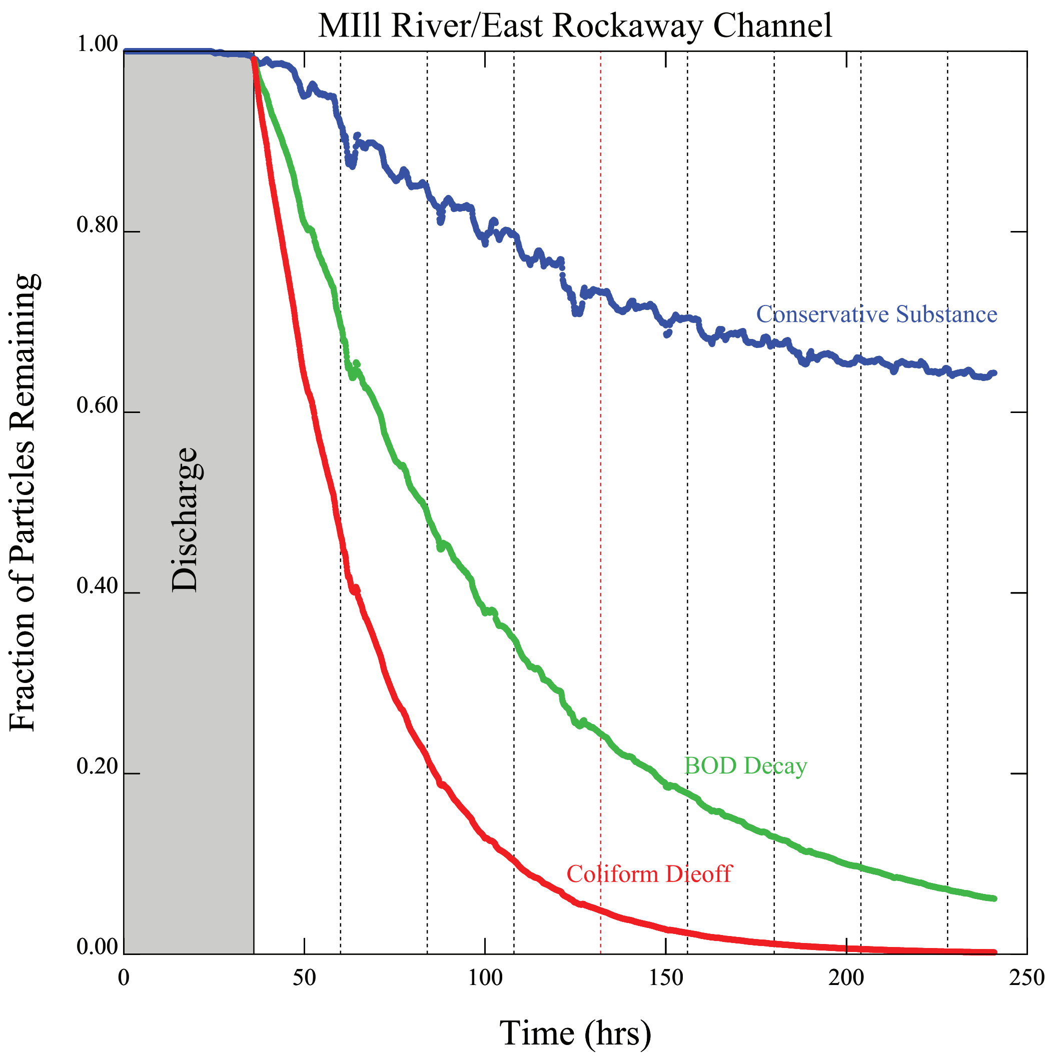
Table 6-1 presents the fraction of particles (or mass) remaining after the cessation of raw discharge. These estimates are all approximate since the tributary is not perfectly represented by the model, the tidal and weather conditions are not the same as the post-storm tides, and the temperature changes over time, which affects the decay and die-off rates. It is possible that more flushing occurred after Hurricane Sandy due to the extreme water levels during the storm. For Macy Channel, the calculations suggest that within a week of the cessation of the raw sewage, the vast majority of the BOD and bacteria had been flushed out or decayed away. Thus, any impact from the discharge was short-lived.

The FVCOM model does not include the upstream portion of the Mill River where the raw sewage was discharged, so particles were released at the point in the model that was the most upstream. The model results should be viewed as approximate. Figure 6-5 presents the flushing analysis for the Mill River/East Rockaway Channel. This tributary behaves differently than Macy Channel and flushes at a much slower rate. The model does include a freshwater flow at the head end, but it does not include flow from the auxiliary outfall, which was in operation after the raw sewage discharge was terminated. The model indicates that approximately two-thirds of a conservative substance that was in the tributary at the end of the 36-hour discharge period would remain in the tributary after a week. Since BOD associated with raw sewage and bacteria have high decay and die-off rates, less than 10 percent of these substances would be expected to remain in the tributary after seven days.



SUNY Modeling Analysis

Figure 6-4. Flushing Analysis using Particle Tracking in Macy Channel



SUNY Modeling Analysis

Figure 6-5. Flushing Analysis using Particle Tracking in East Rockaway Channel

The model results for Parsonage Creek are presented in Figure 6-6. Parsonage Creek is probably the least well represented tributary of the three that were examined. In the model it is represented more as an embayment than a tributary although there is a freshwater source assigned in the model. At this location, the particles exit the tributary quite rapidly. At the end of the 36-hour discharge period, the majority of the particles have been flushed out. Over the next 24-hour period, nearly three-quarters of the particles that had remained were flushed out. After three days the particles dissipate very slowly. The modeling suggests that once the discharge raw sewage reached the mouth of Parsonage Creek, it was flushed away rapidly.

Table 6-1. Percent of Mass Remaining after 1, 3 and 7 days.

		Percent remaining after 1, 3, 7 Days								
		Macy Channel			**East Rockaway Channel**			**Parsonage Creek**		
Substance	Rate (/d)	1	3	7	1	3	7	1	3	7
Conservative		73	55	34	93	80	66	27	11	8.2
BOD	0.275	55	24	5	70	35	9.7	20	4.7	1.2
Coliform	0.68	37	7.1	0.3	47	10	0.6	14	1.4	0.07
Enterococci	0.62	39	8.5	0.4	50	12	0.9	14	1.7	0.1

The results of these model simulations show that within a few days of the cessation of a discharge into the local creeks, pathogen concentrations would be reduced significantly through the process of flushing by tide water and the natural decay of these organisms in the salt water environment. Depending on the waterway, pathogen concentrations would be expected to reduced by a factor of more than 100:1 seven days after the end of the discharge of sewage into the creek.

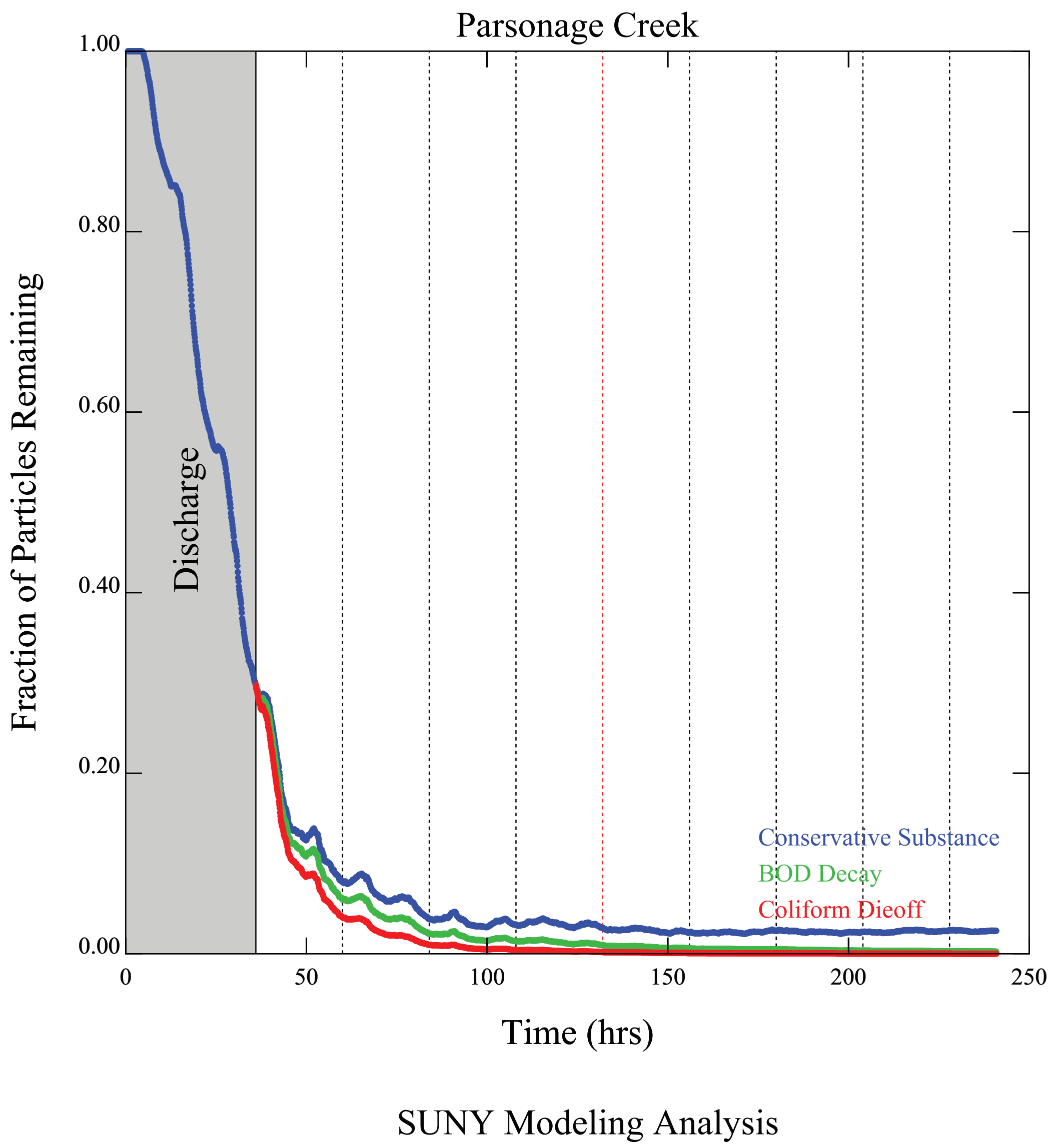


Figure 6-6. Flushing Analysis using Particle Tracking in Parsonage Creek

SECTION 7

DISCUSSION/CONCLUSIONS

Water Quality

The water quality data collected after Hurricane Sandy showed that water quality was somewhat adversely affected by the storm. The discharge of untreated and partially treated wastewater from the Bay Park STP could have contributed to the impact, but allocation of the contribution of impact to Bay Park cannot be made at this time. The data also shows that the impact was short-lived and that West Hempstead Bay and its tributaries returned to normal conditions by mid- to late-December. DO levels were below the 4.8 mg/L chronic NYS water quality standard on occasion in some of the tributaries during November including the reference tributary Thixton Creek. DO levels in the Creeks never went below the 3.0 mg/L acute NYS water quality standard. Coliform and enterococci concentrations exceeded standards during November, but were significantly lower during December.

In the bay, DO concentrations were above the DO standard for the entire sampling period at all of the locations that were visited. Coliform and enterococci concentrations exceeded standards during November, but were significantly lower during December. Enterococci geometric means continued to be above 35 no./100 mL during December. Bay Park STP effluent data indicate that chlorination was effective during December, which suggests elevated bacteria levels were from a source other than the STP.

As the NYSDEC dissolved oxygen standards are set to be protective of biota in all life stages and measured dissolved oxygen concentrations, although possibly somewhat depressed for a period, were at levels that would not be expected to have any short or long term impacts on biota. Pathogen standards are typically set for two reasons: protection of humans against contact with infectious organisms and protection of humans from consuming shellfish contaminated from the uptake of pathogenic organisms. For the periods of time, pathogen concentrations were observed to be elevated above allowable NYSDEC standards, it would not be expected that local residents would have been exposed to them from swimming or secondary contact recreation because of (a) the fact the storm occurred well outside of the summer recreational period and (b) the other impacts of the hurricane (lack of power to homes, damage to homes, damage to recreation vessels, etc.) generally kept residents out of the impacted waters. With respect to the issue of consumption of contaminated shellfish, residents were not observed by the field sampling crews to be out in the creeks and/or bay shellfishing for the same reasons that residents were not using the waters for recreation.

Chlorine Impacts to Estuarine Biota

TRC was not measured in the bay or creek as part of the sampling program. Only after reviewing the STP effluent data did it become apparent that TRC could have potentially impacted water quality and aquatic biota post-Sandy.

Wastewater treatment plants typically require a relatively high concentration (>8 mg/L) of sodium hypochlorite (NaOCl) in order to disinfect bacteria and other pathogens present in effluent prior to discharge into receiving waters. Dechlorination of the treated effluent, prior to discharge, is accomplished by the addition of $NaHSO_3$ at the Bay Park STP, but this process was inoperable in the weeks following Hurricane Sandy. Once discharged into receiving waters, NaOCl is readily converted to NaCl in sunlight and quickly diluted. The decomposition rate of NaOCl is also pH dependent with a peak rate at pH 7, slightly below that of most estuarine receiving waters.

In natural waters (fresh and saline) free chlorine is represented as hypochlorous acid and hypochlorite ion. If ammonia is present, monochloramine and dichloromine will be present. All four of these forms are toxic to aquatic/marine organisms. Additionally, in marine waters, the presence of bromine leads to the formation of oxidants such as hypobromous acid, hypobromous ion and bromamines, which are also toxic. Marine invertebrates are more sensitive to chlorine oxidants derived from chloromine than sodium hypochlorite; the opposite is true for fishes (USEPA 1985). To protect organisms from TRC toxicity, NYSDEC has promulgated TRC criteria for New York State based on Ambient Water Quality Criteria for Chlorine (USEPA 1985). A chronic standard of 7.5 μg/L and an acute standard of 13 μg/L have been chosen by the NYSDEC using guidance from EPA research.

As noted above, NYS has established a water quality standard for residual chlorine in the bay. To obtain additional insight to the potential harm that could be caused by chlorine levels elevated above this standard, a literature review was performed. As discussed in Section 2.3, the Bay Park STP effluent did exhibit residual chlorine concentrations, for a period of time, at concentrations above the allowable permit limit of 0.5 mg/L. This allowable limit was set by the NYSDEC to allow for dilution and decay both within the effluent outfall pipe and the mixing zone to result in ambient residual chlorine concentrations in Reynolds Channel that would comply with the required standards of 7.5 and 13 μg/L.

The Bay Park STP effluent chlorine residual concentration that was measured to be between 2-10 mg/L during November, with occasional measurements above this range, represents a concentration that was more than a factor of 10 greater than the permit limits for the facility. Assuming a 10:1 dilution through the outfall or within East Rockaway Channel, it is estimated that the concentration of residual chlorine as it entered the receiving waters of Hempstead Bay or ERC during the critical monitoring period was in the range of 0.2 – 1 mg/L, or 200 to 1,000 μg/L. Additional, more rigorous analysis of the decay and dilution of TRC is presented in Appendix A, and is based on a NYSDEC memo (Mirza 2003) and previous work conducted by HydroQual. Although the field sampling crews did not observe any obvious impacts of these elevated residual chlorine concentration on biota during the time they were in the field, impacts could be expected. In order to assess the potential impacts, a detailed review of available literature was performed and summarized in the following paragraphs.

A number of bioassay studies have documented the potential for population level impacts in estuarine and marine fish and invertebrates, many of which are of recreational and commercial importance. McLean (1973) documented significant impacts in studies of several common estuarine crustaceans, including copepods, barnacle larvae, amphipods and grass shrimp (*Palaemonetes pugio*). For example, a 5-minute exposure to total chlorine at 2.5 mg/L immediately resulted in 80% mortality in barnacle larvae and 90% mortality in copepods. Grass shrimp and amphipods exhibited little to no mortality under the same exposure regime. However, an increase in exposure time to 3 hours increased amphipod mortality to 35%. Amphipod mortality reached nearly 100% at 96 hours following the initial 3-hr exposure. The use of grass shrimp as a test organism resulted in no mortality immediately following a 3-hr exposure; however, 70% mortality occurred 48 hours after exposure and nearly 100% mortality occurred 9 hours post-exposure. The author concluded that because small crustaceans, including copepods, amphipods and grass shrimp represent an important food source for estuarine consumers, high mortality of these prey species in response to chlorinated WWTP effluent discharges represents a potentially significant impact to estuarine and coastal food chains.

Bellanca and Bailey (1977) performed extensive chlorine toxicity studies using several estuarine fish and shellfish species in response to growing concerns over the effects of sewage treatment plant effluent on fisheries resources, including commercially harvested oyster reefs, in the James River sub-estuary of Chesapeake Bay. Using a common estuarine fish (Spot, *Leiostomus xanthurus*) they documented survival times as low as 10 minutes in live box studies with a total chlorine residual concentration of 1.0 mg/L. Subsequent laboratory bioassays documented a 24 hr TL_m (median tolerance limit; equivalent to median lethal dose or LD_{50}) of 0.14 mg/L and a 96-hr TL_m of 0.09 mg/L. The authors noted, via comparison to previous studies, that mortality rates observed in saltwater were similar to levels previously documented for chlorine impacts to freshwater fish species.

Bioassays using copepods, oyster larvae, and clam larvae indicated that these common estuarine plankters were highly sensitive to chlorine, with 48 hr TL_m values of 0.005 mg/L or less. Bioassays using two common estuarine forage species (silversides, *Menidia spp*. and grass shrimp) yielded a 96- hr TL_m of 0.037 mg/L and 0.22 mg/L, respectively. The results of these studies validated the presumption put forth by marine resource managers that very low chlorine levels were potentially impacting oyster populations in the Chesapeake Bay region, as oyster larvae were shown to be sensitive to chlorine residual concentrations too low to be accurately measured (Bellanca and Bailey 1977).

Common estuarine fish and invertebrate species likely to be present within the Hempstead Bay-South Oyster Bay complex are listed in Table 7-1, along with their documented acute chlorine toxicity levels, as determined by literature review. Nearly all of the species listed are subject to population-level impacts at chlorine levels below those estimated to be present in the near field during November 2012.

However, the timing of the storm and subsequent Bay Park STP failure was, to some degree, fortuitous with regard to impacts to estuarine organisms. Most fish and shellfish in temperate estuaries spawn approximately between April and July. Thus, the likelihood of very sensitive early life stages (larvae and post-larvae) of most fish and shellfish present in the area of the elevated chlorinated effluent discharge was remote. Furthermore, adult finfish have the ability to move away from areas of poor water quality; larvae and early juveniles lack the motility of adults. However, sessile invertebrates (e.g., mussels, oysters, clams, scallops) are only able to avoid potentially toxic water quality conditions by cessation of feeding (filtration) activity. Fortunately, the buoyant freshwater effluent plume tends to stay in the surface waters away from the bottom feeding organisms. In addition, estuarine/marine organisms are more sensitive to chorine produced oxidants when subjected to elevated temperatures (thermal stress). Had the Bay Park STP failure occurred during mid-summer, the potential for increased toxicity to early life stages as well as adult fish and invertebrates in Hempstead Bay would have been much greater.

Table 7-1. Chlorine toxicity thresholds for estuarine fish and invertebrates commonly found in the Hempstead Bays - South Oyster Bay ecosystem. Source: USEPA (1985).

Species	Acute toxicity level (mg/L)
American oyster (*Crassostrea virginica*)	0.005 - 0.026
Copepod (*Acartia tonsa*)	0.029
Silversides (*Menidia* sp.)	0.037- 0.054
Striped bass (*Morone saxatilis*) larvae	0.04-0.07
Naked Goby (*Gobiosoma bosci*)	0.08
Spot (*Leiostomus xanthurus*)	0.09
Hermit crab (*Pagurus* spp.) larvae	0.147
Threespine stickleback (*Gasterosteus aculeatus*)	0.167
Grass shrimp (*Palaemonetes pugio*)	0.22
Northern pipefish (*Syngnathus fuscus*)	0.27
Blue crab (*Callinectes sapidus*)	0.70 -0.86
Shore crab (*Hemigrapsus* sp.)	1.4

Sediment

The sediment data collected during the one sampling event during January showed that some areas of the bay and its tributaries have elevated metals levels above guidance ERL and ERM levels. The distribution of the metals did not indicate that the Bay Park STP was the sole or major source of the metals. Areas with the highest metals concentrations included the reference creek and locations away from outfalls or raw sewage discharge locations. The sediment sampling did not find high PAH levels in the bay, but PAHs were present in some of the creeks including the reference creek, Thixton Creek.

Remediation

Based on the data collected, it does not appear that there is any need for Nassau County to undertake any remedial actions to improve water quality as a result of impacts from Hurricane Sandy. Impacts to water quality after Hurricane Sandy were short-lived and caused by a number of factors. These factors include: the discharge of untreated and partially treated sewage, stormwater runoff, the resuspension of bay and creek sediments, and runoff associated with the storm's tidal surge. Based on the December water quality data, water quality has returned to normal conditions.

Sediment sampling indicates that some areas have metals and PAH levels higher than New York State sediment guidance levels. The sources of contaminants or how long the contaminants have been in the sediments cannot be determined without additional study. According to the sediment guidance document "These criteria do not necessarily represent the final concentrations that must be achieved through sediment remediation. Comprehensive sediment testing and risk management are necessary to establish when remediation is appropriate and what final contaminant concentrations the sediment remediation efforts should achieve." At this point no remedial actions appear to be required because additional sampling would need to be conducted and it is not clear who might be the responsible party, or parties.

SECTION 8

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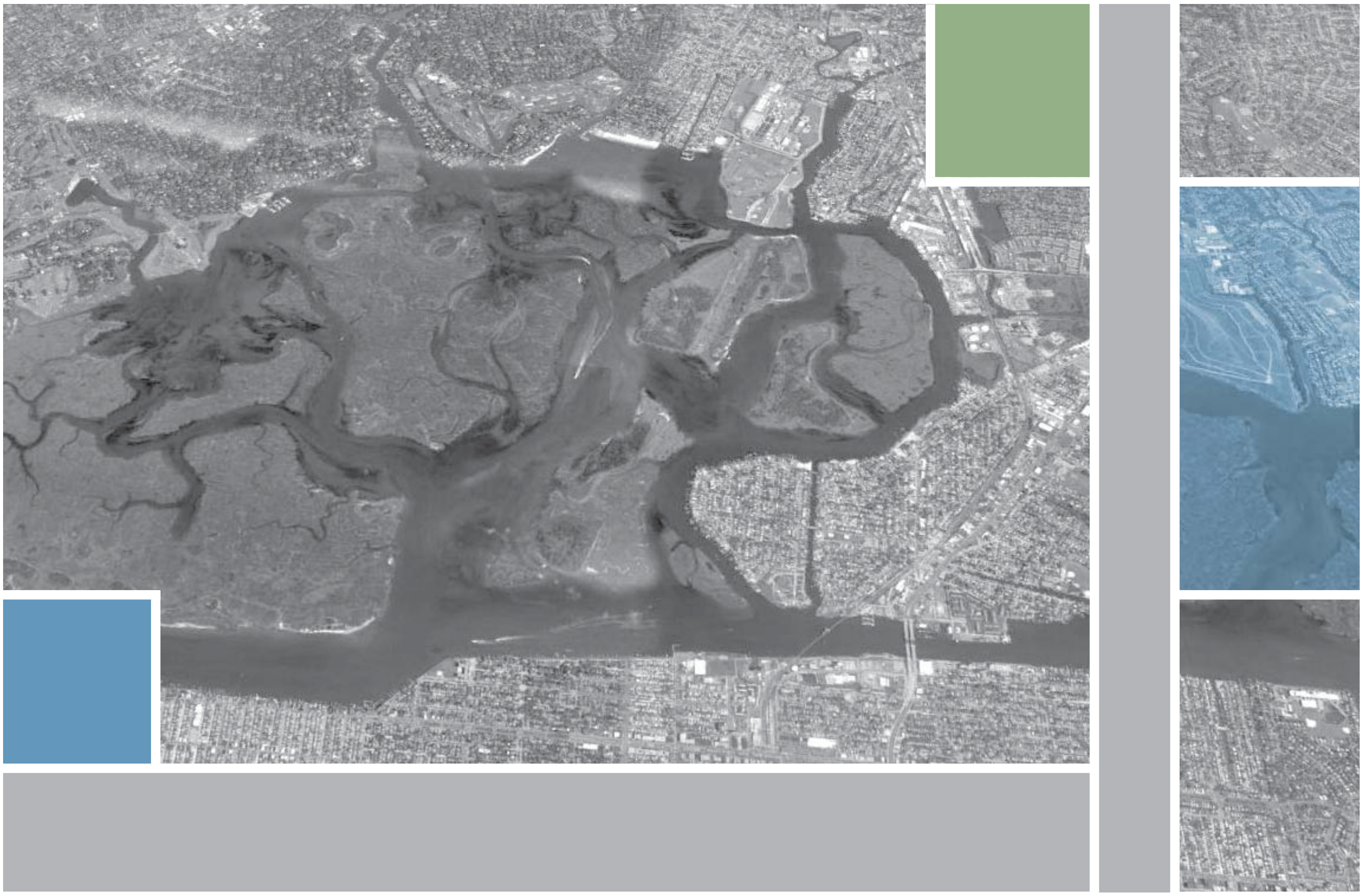

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