Water Quality Report
For
The Silvermine River and Lower Norwalk River Storm Drains
May Through August 2014

SM4 in Zone B of the Silvermine River

Submitted By:
Richard Harris, Principle Investigator, Staff Scientist/Director of the Harbor Watch Program at Earthplace, Westport, CT Phone: 203-227-7253

Peter Fraboni, Associate Director & QA/QC Officer for the Harbor Watch Program at Earthplace, Westport, CT

Nicole Cantatore, Laboratory Director of Harbor Watch Auxiliary Laboratory in Norwalk, CT

Joshua Cooper, Coastal Studies Technician and Quality Assurance Officer of Harbor Watch, A Program of Earthplace Westport, CT

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Acknowledgements

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Harbor Watch also wishes to thank the following departments and agencies for their help in the investigation of storm drain systems and rivers for pollution sources. Areas studied during the summer of 2014 included the Silvermine River, the lower end of the Norwalk River, and the Norwalk River Estuary thanks to funding provided by The Norwalk Shellfish Commission and the Norwalk Health Department under the direction of the Mayor's Water Quality Committee. Special thanks go to Jan Schaefer, Chair Person of the Mayor's Water Quality Committee who arranged a grant from Newman's Own Foundation to assist HW in completing the large monitoring project on the Norwalk River Watershed. HW was also provided the use of two Norwalk summer interns, Brittany Weinsoff and Allison Villa. They conducted the monitoring of the Lower Silvermine River, the Lower Norwalk River and the major Norwalk River Storm drains discharging to the lower Norwalk River and the Norwalk River Estuary.

The Norwalk Public Works, Conservation and Health Departments helped by providing drawings of the storm sewers and technical background and lab support. Mike Yeosock, Senior Civil Engineer, was particularly helpful in providing maps on drainage systems and was quick to follow up on leads provided by HW on possible sources of sewage infiltration. Special thanks goes to Nick Berkun, Junior Engineer, with WPCA who with his crew has been very helpful with a truck mounted Cues pipeline camera in identifying

illegal hook-ups to several major storm drain systems. Nick has used his extensive computer skills in tracking down pipelines and correcting existing drawings for the City.

HW also wishes to thank the Norwalk Health Department for taking the time to survey areas where HW believed that pollution problems existed after extensive testing turned up elevated bacteria counts. Tom Closter, Director of Environmental Services, was always available to walk the suspected sites and help HW gain access to monitoring sites located on private property. The Norwalk Public Health laboratory has also been a great support in helping HW do interlab work in cross checking samples to meet EPA and CT DEEP quality assurance requirements.

It is also fitting to recognize Chris Malik of CT DEEP who has helped obtain EPA funding (319 and 604B) on a total of eight storm drain systems to date which will allow HW to undertake a detailed analysis of these systems and find sources of sewage infiltration and/or illegal cross connections. Chris has also provided extensive background information on Keeler Brook and Tim Bridges of the EPA's technical group in Chelmsford Mass (EPA Region I) has helped with complimentary tests for pollution from pharmaceuticals and other man-made products to further support the work of HW. All the support mentioned above helped complete the work in a team effort. This research would not be successful or completed without the people and resources mentioned above.

Richard Harris
Director Harbor Watch, a Program of Earthplace.

Abstract:
Harbor Watch (HW), the volunteer water quality program of Earthplace, the Nature Discovery Center, has the overall mission of maintaining and improving the biological integrity of rivers and estuaries within Fairfield County. HW works with the Norwalk Mayor's water Quality Committee each summer to monitor the Silvermine and Norwalk rivers, the Norwalk River Estuary in an effort to 1) locate sources of indicator bacteria impairment from numerous storm drain discharges to both rivers; 2) protect the rivers from ill-advised residential management practices along the river banks; and 3) assess the bacteria concentrations entering the Norwalk and Silvermine Rivers from pollution sources upstream.

Dissolved oxygen (DO) levels, conductivity, temperatures, and water samples are taken weekly. Membrane filtration is performed for fecal coliform and *E. coli* bacteria at the Earthplace laboratory. *E. coli* input profiles affected by various weather patterns and stream flow are extrapolated from the data to help find sources in the waterways of elevated bacteria counts. The result of this survey shows the lower Silvermine and Norwalk rivers and numerous storm drain discharges to be moderately polluted with *E. coli* bacteria. Some of the storm drains discharging to the Norwalk River Estuary are heavily polluted and will be further investigated by HW under a CT DEEP contract and a Connecticut Department of Agriculture Grant and an EPA Urban Waters Grant during 2014.

Introduction:
Brittany Weinsoff and Allison Villa, of The University of Bridgeport and The University of Connecticut respectively, were hired by the Norwalk Health Department and Norwalk Shellfish Commission. Both were assigned to HW and began monitoring water quality in mid-May and completed their work in August of 2014. These interns worked primarily as a team though occasionally also with trained volunteers under the direction and oversight of the HW staff to investigate the health of the lower watershed of the Silvermine and Norwalk rivers as well as monitoring nine continuously running storm drain discharges to the Norwalk River and the Norwalk River Estuary. The objective of the water monitoring research was to discover sources of bacterial (*E. coli*) pollution from point and non-point sources.

Research Zones

During the summer of 2014, the Silvermine workload focused on three zones indicated as A, B, and storm drain discharges to the lower Norwalk River and the Norwalk River Estuary (Figure 1, Figure 2, Figure 3, Figure 4). The first of these zones, running from Borglum Road to the former Silvermine Tavern at Perry Avenue, is referred to as Zone A. This section of the Silvermine River and Belden Hill Brook has been studied over 8 years to monitor the effect of a large hobby farm on water quality. The farm property is poorly located for housing farm animals on a property that is situated between the two water bodies. The Silvermine River and Belden Hill Brook form a confluence at the southern end of the farm property (Figure 5). Over the years, water quality has slowly improved as farm animals (including two llamas) were relocated and in 2011 the original farm owners moved away, along with the rest of the farm animals. The new owners show little interest in boarding farm animals on the property. This change of ownership has proved to be very beneficial to water quality of Belden Hill Brook. Additionally the closing of the Silvermine Tavern Restaurant has resulted in improvement of the water quality in the vicinity of SM6.

Zone B, is located in the Silvermine River starting at the Silvermine elementary school property, which borders the river and flows south to James Street (Figure 2). Zone B was first explored in detail by the 2008 Norwalk Mayor's Water Quality Committee interns because of elevated *E. coli* bacteria counts found at site SM3 (Figure 2). In addition, new sites were established in the slower moving ponds that characterize the Silvermine River in that section south of the Merritt Parkway Bridge downstream (south) to James Street (Figure 2). As in 2005 to 2013, the lower Silvermine River was found to be lightly to moderately polluted with *E. coli* bacteria.

Nine large, continuously running storm drains are discharging fresh water to the lower Norwalk River (Figure 3) and the Norwalk River Estuary (Figure 4). They are monitored every two weeks under a variety of weather conditions to assess the extent of *E. coli* bacteria input and to rank the discharges in order of priority for eventual repairs. Over the past few years elevated bacteria counts were recorded from the discharge of these drains to the lower Norwalk River (Figure 3) which re-focused the research the HW effort to include several marine drains discharging to the harbor waters (Figure 4). Continued monitoring, research, and repairs to the infrastructure are essential to promote the health of the lower Norwalk River and the estuary.

Figure 1 Map of Zone A for the Silvermine River from Borglum Road South to the Perry Avenue Bridge, showing six monitoring sites on the Silvermine River and three sites on Belden Hill Brook

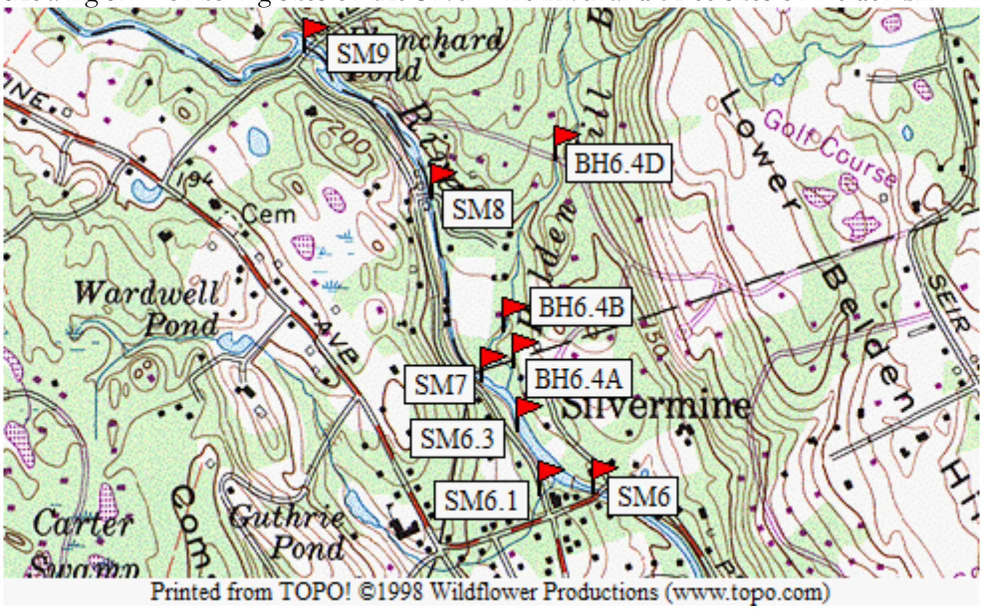


Figure 2 Map of Zone B for the Silvermine River from the Silvermine Elementary School to James Street showing ten monitoring sites on the Silvermine River

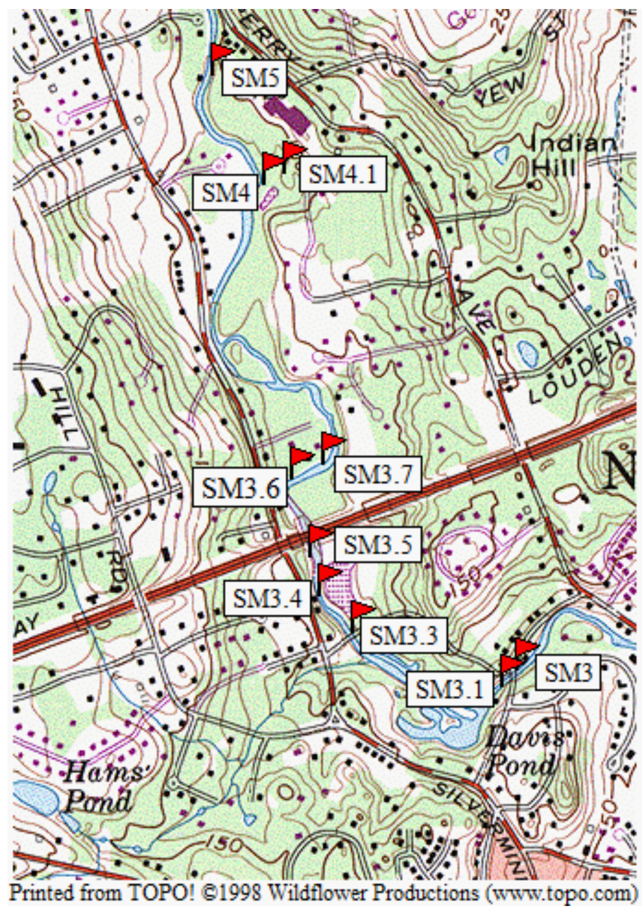


Figure 3 Map of five storm drains discharging to the lower Norwalk River and one site at the Wall Street Bridge where the Norwalk River enters the Norwalk River Estuary

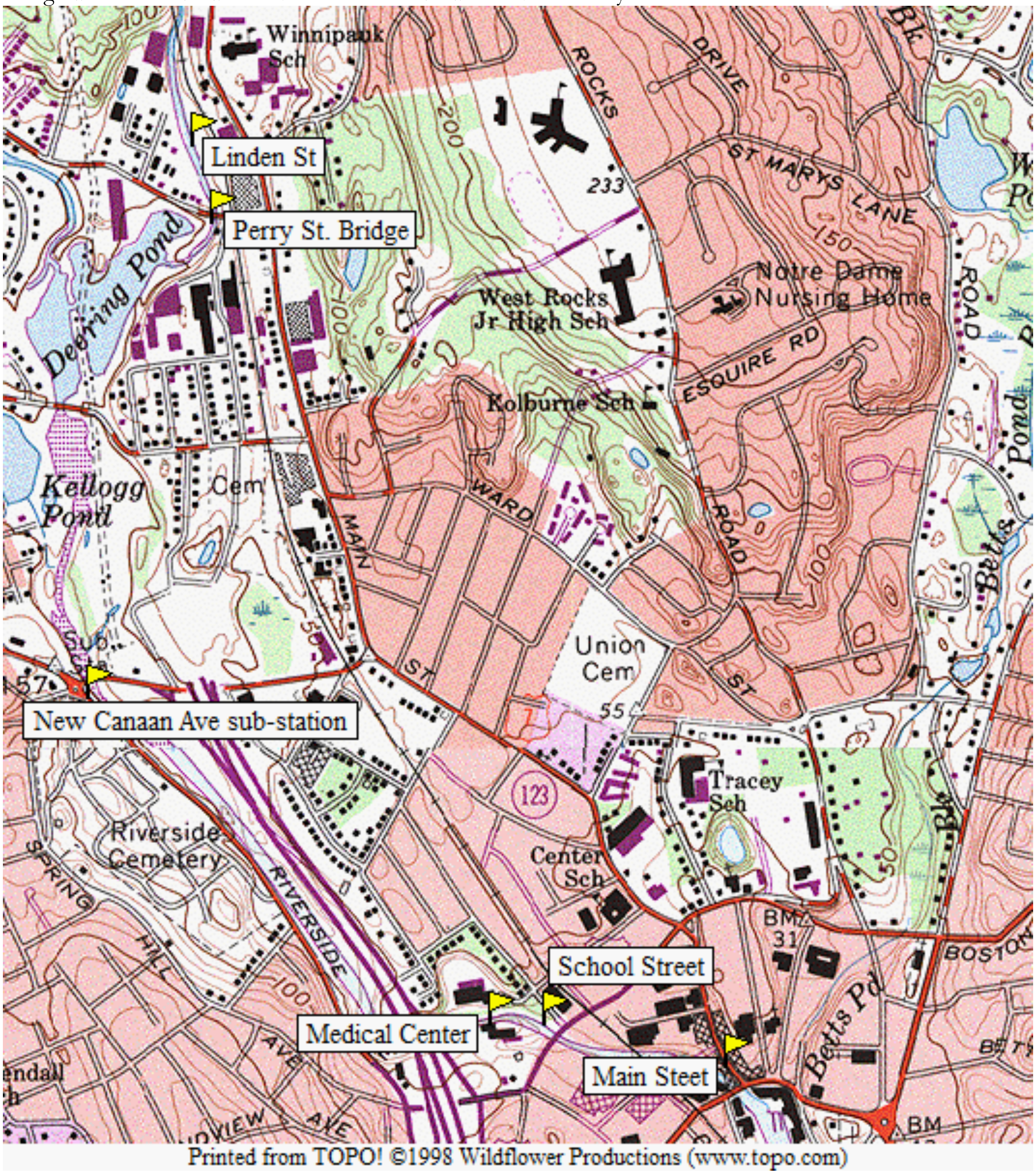


Figure 4 Map of four storm drains discharging to the Norwalk River Estuary

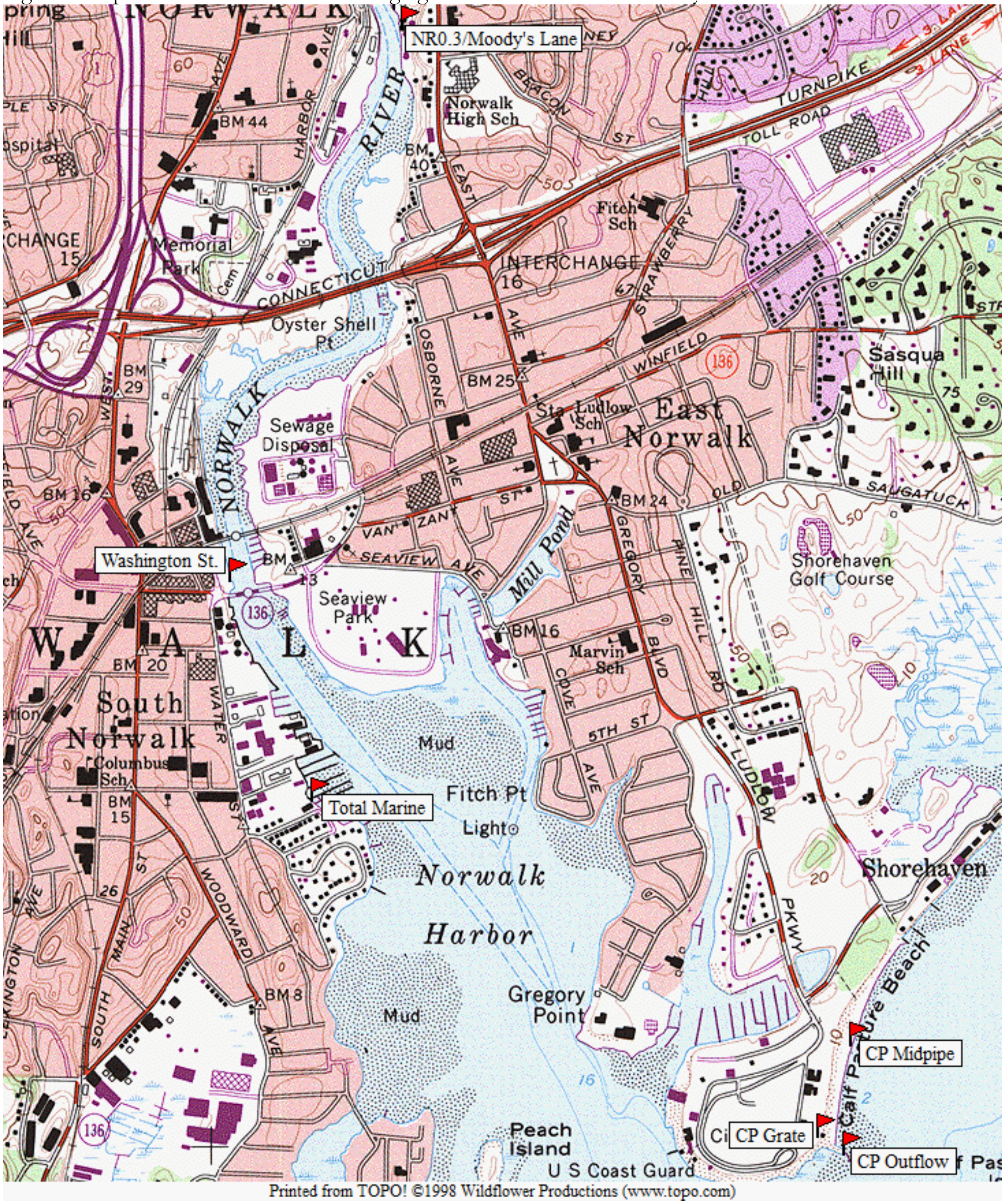
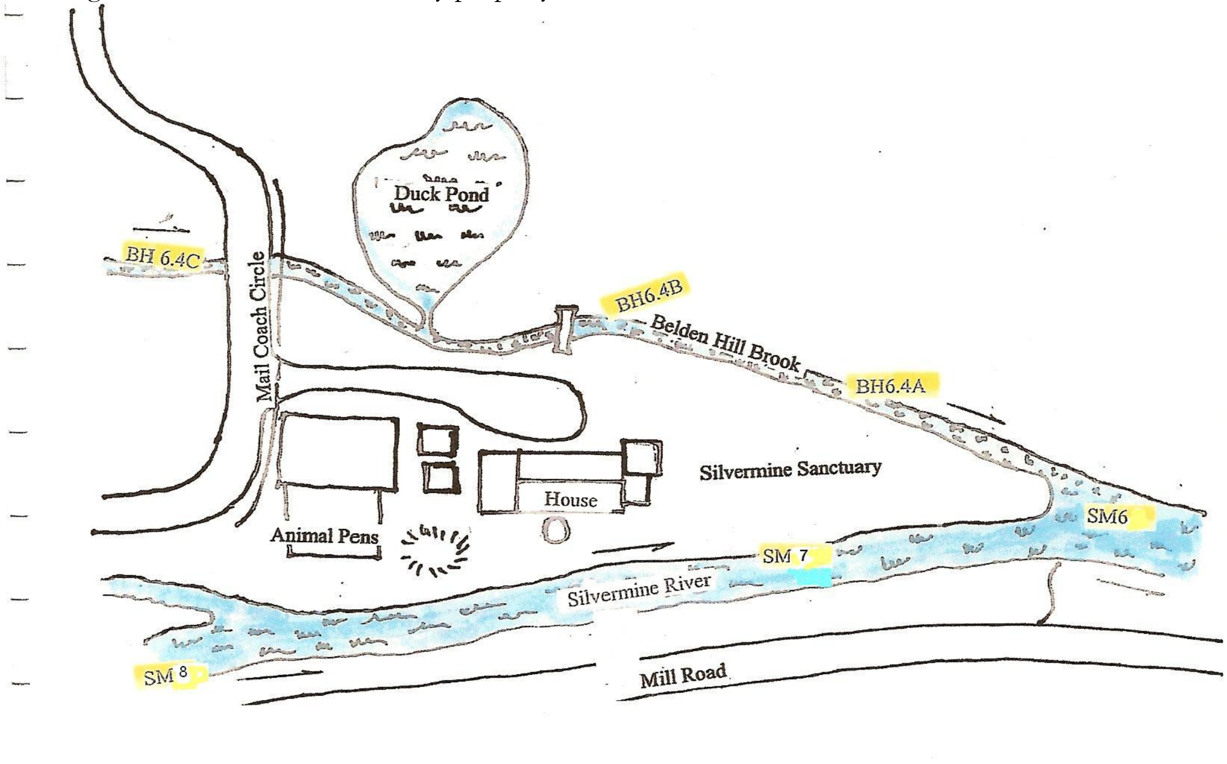


Figure 5 Map of three monitoring sites on the Silvermine River and two sites on Belden Hill Brook around the margin of the Silvermine Sanctuary property



Note: Monitoring site BH6.4D lies to the north on Musket Ridge Road.

Methods and Procedures:
Protocol established in the HW EPA approved Quality Assurance Project Plan (QAPP #10160, approved 9/16/2010) for the Norwalk River explains the methods used for water quality monitoring. Testing is carried out once a month for Zone A, and every two weeks for Zone B and the storm drains on the lower Norwalk River. The interns leave Earthplace, located in Westport, CT, before 10 AM and generally return in the early afternoon after testing the Silvermine River or storm drain discharges. The testing of the Silvermine River centers on monitoring levels of *E. coli* bacteria because of swimming and fishing safety issues (Table 1).

Conductivity (QAPP Appendix A3.8) and Dissolved Oxygen (QAPP Appendix A3.3) are run *in situ* with meters. General observations, time, water temperature, and air temperature are recorded at each site, with the information entered on a HW Data Sheet (QAPP Appendix A5.1). Water samples are also taken at each site by inserting a sterilized bottle upside down and turning it underwater to prevent obtaining surface films or disturbing the river bottom (QAPP Appendix A1.1).

Membrane filtration tests for fecal coliform and *E. coli* bacteria are performed after the research team returns to the HW state certified lab located at Earthplace (QAPP Appendix A3.13). These tests are analyzed following Standard Methods, 21st edition (9222D, 9222G) and recorded in the HW Bacteria Log (QAPP Appendix A5.1).

The Silvermine water quality is evaluated against the "all other recreational uses" bacteria geometric mean of <126 CFUs/100mL, and a single sample maximum (SSM) of 576 CFUs/100mL.

Table 1 CT DEEP criterion for *E. coli* bacteria levels as applied to recreational use effective 2/25/11

Designated Use Recreation	Class	Indicator	Criteria
Designated Swimming	AA, A, B	*Escherichia coli*	Geometric Mean less than 126/100 CFU;*Single Sample Maximum 235/100
Non-designated Swimming	AA, A, B	*Escherichia coli*	Geometric Mean less than 126/100 CFU; Single Sample Maximum 410/100
All Other Recreational Uses	AA, A, B	*Escherichia coli*	Geometric Mean less than 126/100 CFU; Single Sample Maximum 576/100

*Colony Forming Units, a single E. coli cell which grows to visible size under the proper food source and incubation temperature as provided in the laboratory where it can be counted

Section I

Introduction, Zone A:
Zone A extends from Borglum Road to the Perry Avenue Bridge (Figure 1). The area is fully developed along the river with mostly older homes on large properties of one or more acres. All properties depend on septic systems for the disposal of human wastes. A new development of very large houses is on the west bank of the river just north of the Silvermine Tavern (Perry Avenue Bridge). While the river banks around the Borglum Road, site SM9 (Figure 1), show adequate riparian buffer, some evidence of poor property management at a few locations downstream exists along the river with yards mowed to the water's edge. All of this has helped take a toll on water quality due to river bank erosion. Some of the homeowners also have been overly aggressive with tree and riparian vegetation removal resulting in partially degraded river banks. A major impact on the waterway in years past has been a small farm built between the Silvermine River and Belden Hill Brook complete with a compliment of farm animals (Figure 5). By using the data from HW, the Town of Wilton's Inland Wetlands Commission ultimately convinced the owner to relocate her animals. Finally, the owner moved away. The new property owners do not seem interested in boarding animals near the two waterways.

Recent tests of Belden Hill Brook now show a slight increase in *E. coli* bacteria input to the brook upstream (to the Northeast) of the Silvermine Sanctuary property at site BH6.4D (Table 2). Another area of original concern was the elevated bacteria counts observed at site SM6, the base of the dam at the Silvermine Tavern. The closing of the Tavern's restaurant is a possible cause of partial improvement to water quality at this location (Table 2). A much smaller restaurant with an improved septic system is due to reopen during 2015.

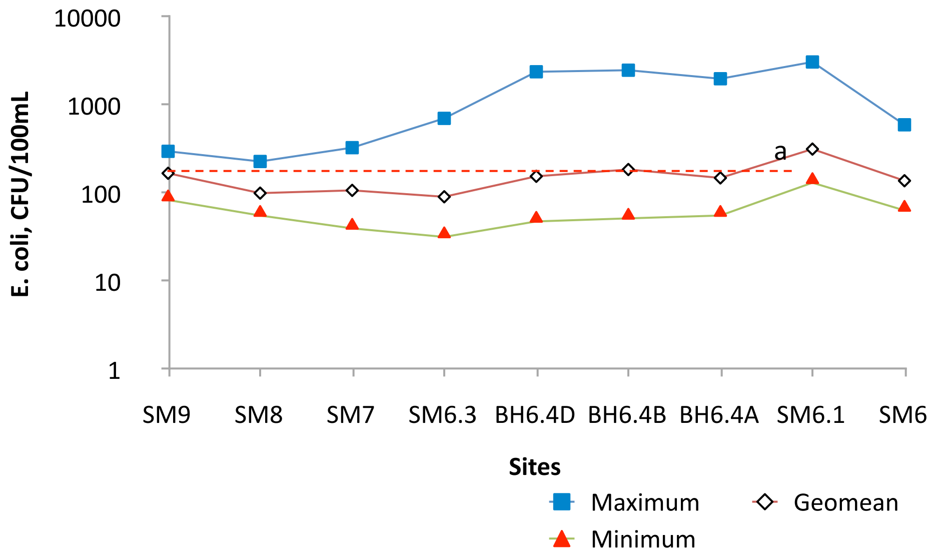
Results, Zone A:
Three sites, SM8, SM7, SM6.3 passed the CT DEEP geometric mean criterion of <126CFU/100mL. All other sites in Zone A failed this criterion (Figure 6, Table 2). All but three sites in Zone A, SM9, SM8, and SM7 failed the CT DEEP Single Sample Maximum (SSM) criterion, <10% samples taken at each site being <576CFU/100mL (Table 2).

Observed dissolved oxygen (DO) mean values and all single readings taken at all sites in Zone A met the CT DEEP criterion of ≥5mg/L for dissolved oxygen (Figure 7).

Observed conductivity means in Zone A ranged from a maximum of 315µS at site SM6.1 to a minimum of 250µS at SM6.3. The widest conductivity range was observed at BH6.4B with a range 90µS (Figure 8, Table 3). The narrowest was observed at SM9 with a range 19µS. The average range for sites in Zone A was 45µS (Table 3).

Rainfall during the monitoring period averaged 3.67 inches per month. July had the highest rainfall total at 4.98 inches of rain and August had the lowest rainfall total of 2.57 inches with 1.90 inches having fallen when testing was completed on 8/13.

Figure 6 Observed maximum, geometric means, and minimum values for *E. coli* bacteria concentrations at six monitoring sites in Zone A of the Silvermine River and three sites on Belden Hill Brook from May to August 2014



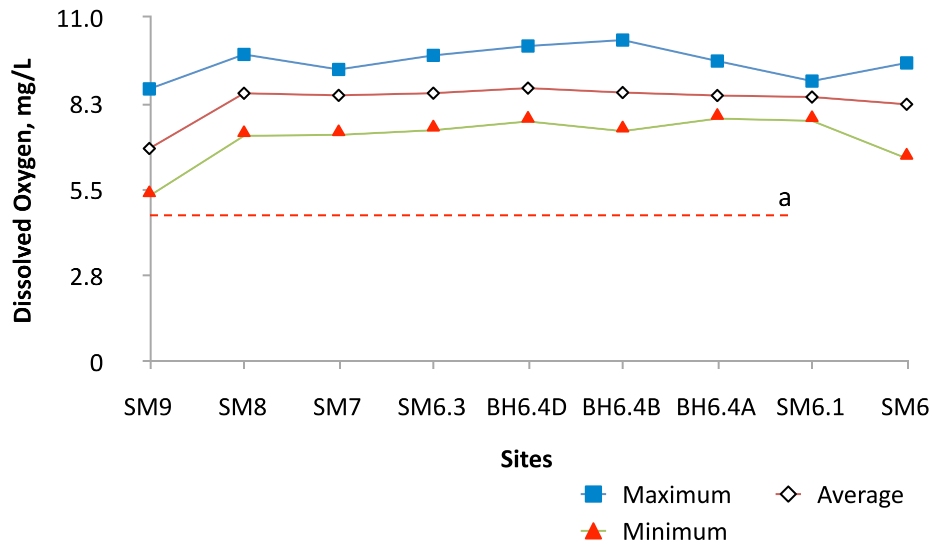
a CT DEEP geometric mean limit for a Class B River

Table 2 Observed *E. coli* bacteria concentrations, geometric means, and % frequency exceeding 576 CFU/100mL at six monitoring sites in Zone A on the Silvermine River, and three sites on Belden Hill Brook from May to August 2014

	5/29/2014	6/11/2014	7/9/2014	8/13/2014	**Geomean**	**% frequency over 576CFU/100mLs**
SM9	84	136	240	300	**169**	0.00%
SM8	56	124	64	230	**101**	0.00%
SM7	40	76	136	330	**108**	0.00%
SM6.3	48	64	32	710	**91**	25.00%
SM6.1	152	132	164	3100	**318**	25.00%
BH6.4D	48	56	92	2400	**156**	25.00%
BH6.4B	52	80	116	2500	**186**	25.00%
BH6.4A	56	56	80	2000	**150**	25.00%
SM6	64	88	112	600	**139**	25.00%
Rainfall, inches	0.67	0.90	0.12	1.42		
Days Prior*	1	2	1	0		

*Rainfall measured over 7 days, and not limited to the day listed on the above table.

Figure 7 Observed maximum, mean, and minimum values for dissolved oxygen at six monitoring sites in Zone A of the Silvermine River and three sites on Belden Hill Brook from May to August 2014



a CT DEEP average minimum limit for a Class B River

Figure 8 Observed maximum, mean, and minimum values for conductivity at six monitoring sites in Zone A of the Silvermine River and three sites on Belden Hill Brook from May to August 2014

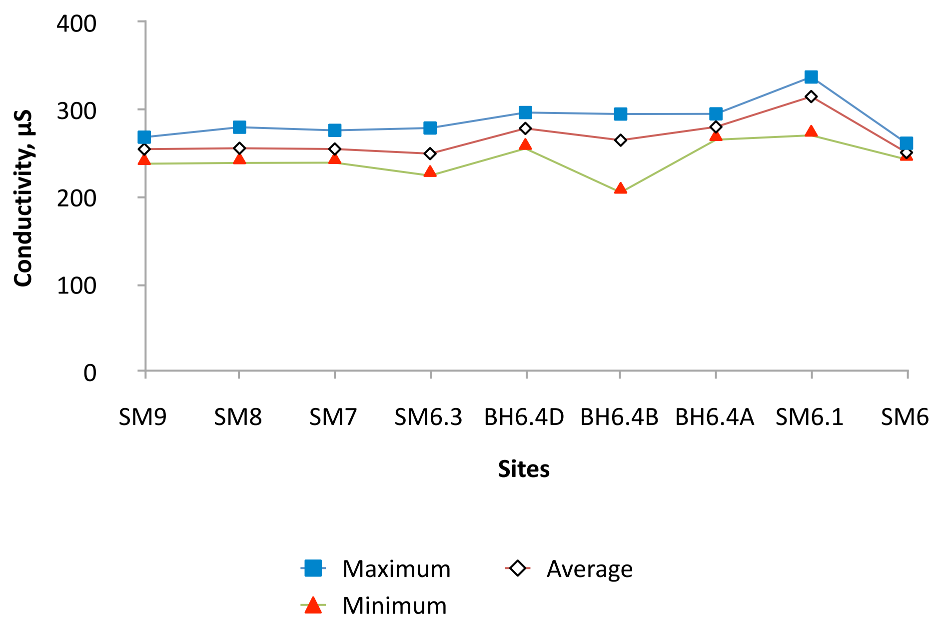
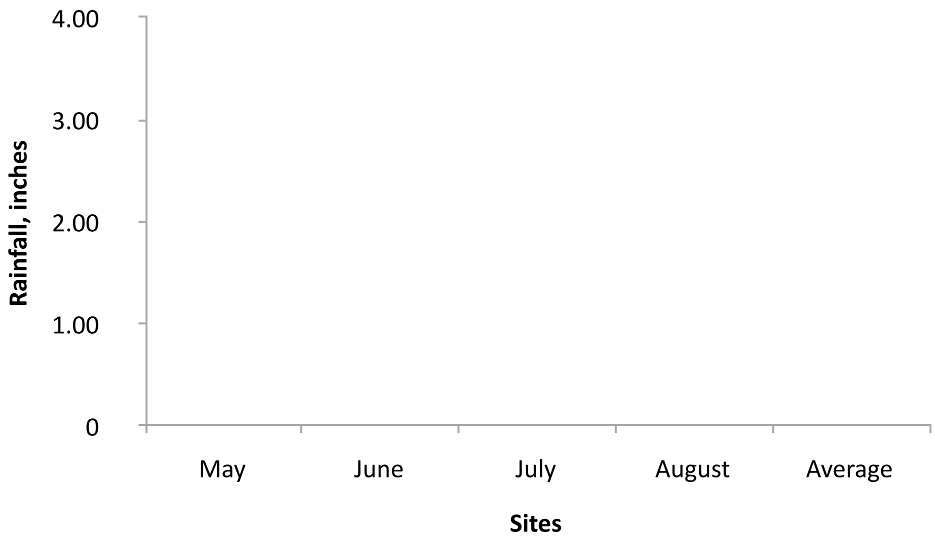


Table 3 Observed maximum, mean, minimum values for conductivity at six monitoring sites in Zone A of the Silvermine River and three sites on Belden Hill Brook from May through August 2014

	SM9	SM8	SM7	SM6.3	SM6.1	BH6.4D	BH6.4B	BH6.4A	SM6
Maximum	269	280	276	279	337	297	295	295	262
Minimum	238	239	239	225	271	256	205	266	243
Range	30	41	37	55	67	41	90	30	19
Average	255	256	255	250	315	279	265	280	251

Figure 9 Recorded rainfall for monitoring period from May to August 2014



Discussion, Zone A:
The likely reason for site failure in terms of *E. coli* in Zone A of the Silvermine River was the occurrence of 1.42 inches of rainfall on 8/13/2014 that significantly elevated the bacteria levels in Zone A and Belden Hill Brook specifically. The rainfall would have increased the effects of runoff into the river. The Silvermine River has a large proportion of homes directly along the river with most of the area employing septic systems. Any malfunctions or issues with these septic systems, such as a breakout, or infiltration of sewage into the river may result in large bacteria concentrations entering the river.

Dissolved oxygen levels were excellent during the monitoring period. No individual reading or average concentration failed to meet the CT DEEP criterion for dissolved oxygen. While water levels were lower due to the lack of rain, the tree cover along the river helps to limit the effects of the increasing water temperatures.

While the proximity of homes and more importantly septic systems to the water represents a likely vector for sewage infiltration into the Silvermine River, some positive impact may be achieved by the presence of riparian buffer along the river banks between properties which will help to buffer the river from the effects of runoff. Conductivity ranges for the sites in Zone A were limited when compared to other rivers in the area. The dryness of the summer outside of July had a direct effect on the flow rate in the river. This decreased river volume possibly helped concentrate the accumulation of bacteria in the waterway. Conversely, the lack of storm water runoff may have reduced bacteria impact at susceptible areas.

Table C1; Site numbers, descriptions and GPS coordinates for six monitoring sites on Silvermine River and three sites on Belden Hill Brook

Site No.	Site Description	GPS Coordinates
SM9	Borglum Road Bridge	Latitude: N 41° 09’ 34.7” Longitude: W 73° 27’ 09.5”

SM8	Silvermine Ave next to Red Barn	Latitude: N 41° 09' 24.2" Longitude: W 073° 26' 59.0"
SM7	Silvermine Ave	Latitude: N 41° 09' 14.2" Longitude: W 073° 26' 55.2"
BH6.4D	Musket Ridge Road	Latitude: N 41° 09' 28.0" Longitude: W 073° 26' 55.2"
BH6.4B	11 Mail Coach Drive downstream from the former Silvermine Sanctuary, upstream of BH6.4A	Latitude: N 41° 09' 12.7" Longitude: W 073° 26' 51.4"
BH6.4A	11 Mail Coach Drive downstream from Silvermine Sanctuary, near confluence with Silvermine River	Latitude: N 41° 09' 11.9" Longitude: W 073° 26' 52.1"
SM6.3	Confluence of Belden Hill Brook and the Silvermine River	Latitude: N 41° 09' 10.8" Longitude: W073° 26' 51.6"
SM6.1	Side stream next to Silvermine Tavern	Latitude: N 41° 09' 03.9" Longitude: W073° 26' 49.1"
SM6	Perry Avenue Bridge	Latitude: N 41° 09' 05.0" Longitude: W 073° 26' 44.4"

Section II

Introduction, Zone B:
The lower end of Silvermine River widens into a series of ponds and backwaters as the waterway approaches its confluence with the Norwalk River at Deering Pond (Figure 2). Stream flow is reduced as the river enters the ponds and the water deepens. This condition allows the deposition of fine silt from land erosion upstream and the disposal of leaves and yard waste into the river to result in the loss of hard river bottom in many places.

The lower Silvermine River, from site SM5 at the Silvermine School to site SM3 at James Street (Figure 2) appears to be continually affected by poor property management, including the mowing of lawns to the edge of the river, which results in erosion of the riverbank. A historical example of such an occurrence can be seen behind the Silvermine Elementary School, where the Norwalk River Watershed Initiative tried to stabilize the banks with "J hooks", or large stone emplacements, to deflect the water away from the west bank (Appendix B). A very large storm on April 15, 2007 accomplished just the opposite. The J hooks were overridden, the west bank was severely eroded with the loss of trees, and the river bed shifted twenty feet to the west (Appendix B). No effort, with the exception of the removal of fallen trees by the city of Norwalk, was made to repair the damage. Another good example of stream bank erosion is found at HW monitoring site SM4 (Figure 2, Appendix B). Trees continue to fall here as the river undercuts the banks.

Three storm drain systems in Zone B that discharge into the Silvermine River were again monitored to determine the volume of indicator bacteria *(E. coli)* in the discharge. Two sites, SM3.5 and SM4.1, showed light pollution levels (Table 1, Table 4, Figure 10, and Appendix B). Site SM3.1 Pipe (a newly rebuilt bypass pipeline to relieve the pressure of flood conditions at a dam upstream) was randomly tested in an effort to assure that bacteria levels were substantially reduced after the failed septic system at #7 James Street was replaced during the fall months of 2010. Exploration of the lower end of Zone B of the Silvermine River stopped at James Street, site SM3 (Figure 2).

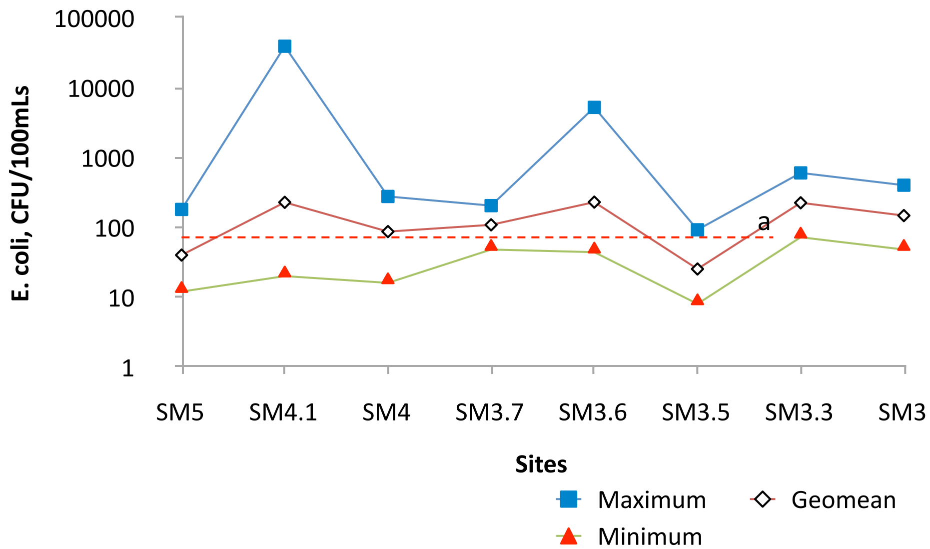
Results, Zone B:
Four sites: SM4.1, SM3.6, SM3.3, and SM3 failed the CT DEEP geometric mean criterion of <126 CFU/100mL in Zone B (Figure 10, Table 3). Sites SM4.1, SM3.6, and SM3.3 failed the CT DEEP Single Sample Maximum (SSM), <10% of all samples taken at a single site being <576CFU/100mL (Table 3).

Observed dissolved oxygen (DO) mean values at all sites in Zone B met the CT DEEP criterion of ≥5mg/L for dissolved oxygen (Figure 11). Sites SM4.1 and SM3.3 had individual DO readings that were below the criterion on 8/5/14.

Observed conductivity means in Zone B ranged from a maximum of 624µS at site SM3.5 to a minimum of 266µS at SM5. The widest conductivity range was observed at site SM3.5 at 129µS, and the narrowest range was observed at SM5 with a range of 42µS (Figure 12, Table 4). The average range for sites in Zone B was 78µS (Table 5).

Rainfall during the monitoring period averaged 3.67 inches per month. July had the highest rainfall total at 4.98 inches of rain and August had the lowest rainfall total of 2.57 inches with 1.90 inches having fallen when testing was completed on 8/13.

Figure 10 Observed maximum, geometric mean, and minimum values for *E. coli* at eight monitoring sites in Zone B of the Silvermine River from May to August 2014



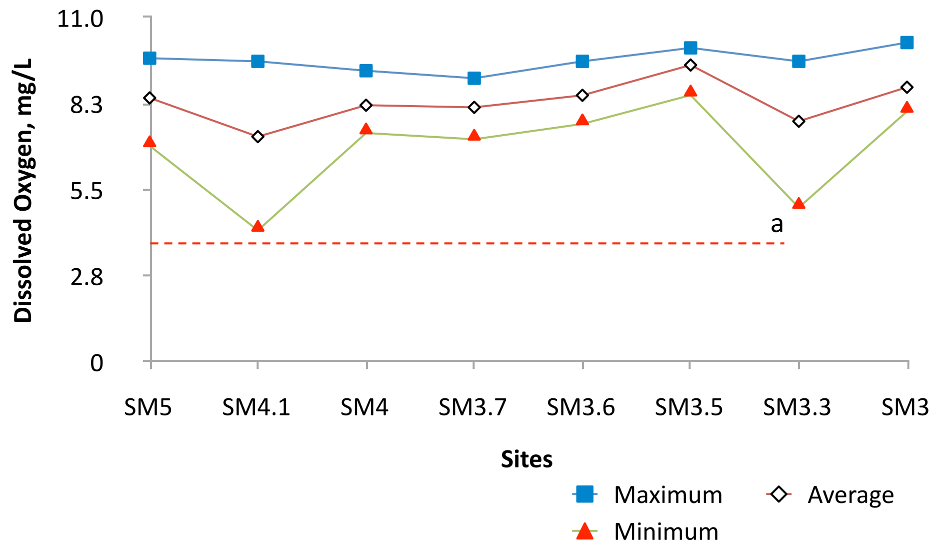
a CT DEEP geometric mean criterion for a class B river

Table 4 Observed *E. coli* bacteria concentrations, geometric means, and % frequency exceeding 576 CFU/100mLs at eight monitoring sites in Zone B on the Silvermine River, from May to August 2014

	5/20/14	5/28/14	6/10/14	6/25/14	7/8/14	8/5/14	8/19/14	8/28/14	**Geomean**	**% frequency over 576CFU/100mLs**
SM5	48	68	180	24	56	18	12		**40**	**0.00%**
SM4.1	32	36	1400	52	1440	20	76	39000	**227**	**37.50%**
SM4	112	88	276	16	196	120	36		**87**	**0.00%**
SM3.7	48	120	172	68	128	100	204		**108**	**0.00%**
SM3.6	44	96	220	5200	168	120	340		**229**	**14.29%**
SM3.5	28	12	88	8	92		12		**25**	**0.00%**
SM3.3	72	168	600	176	280	180	440		**224**	**14.29%**
SM3	108	196	400	112	260	124	48		**147**	**0.00%**
Rainfall, inches	0.64	0.67	2.19	0.43	2.01	0.48	1.42	0.36		
Days Prior*	3	0	0	6	0	2	6	1		

*Rainfall measured over 7 days, and not limited to the day listed on the above table.

Figure 11 Observed maximum, mean, and minimum values for dissolved oxygen at eight monitoring sites in Zone B of the Silvermine River from May to August 2014



a CT DEEP average minimum for a class B river

Figure 12 Observed maximum, mean, and minimum values for conductivity at eight monitoring sites in Zone B of the Silvermine River from May to August 2014

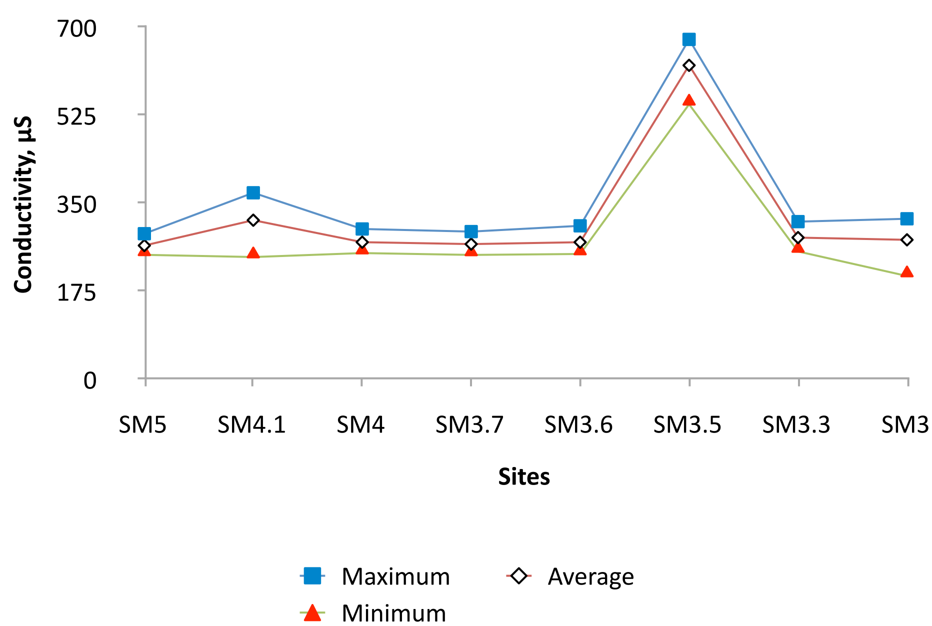


Table 5 Observed maximum, minimum, range and average values for conductivity at eight sites in Zone B of the Silvermine River from May to August 2014

	SM5	SM4.1	SM4	SM3.7	SM3.6	SM3.5	SM3.3	SM3
Maximum	290	371	299	294	305	676	314	319
Minimum	248	243	251	247	249	547	254	206
Range	42	128	48	46	56	129	59	114
Average	266	316	273	269	273	624	282	277

Discussion, Zone B:

The higher failure rate of sites in the lower half of Zone B indicates that either bacteria entering the river in the upper areas of the zone are surviving to the lower portion and then amplifying the effects of any additional bacterial infiltration, or there are one or more points of bacterial infiltration in the lower portion of Zone B that are causing elevated bacterial levels. Site SM4.1 was the exception in the upper part of Zone B. Site SM4.1 which had the second highest geomean of sites in Zone B is the outfall of a storm drain pipe that empties into a small pond which joins the main river above site SM4. SM4.1 which connects to a storm drain system serving Singing Woods Road also had the highest percentage of SSM failures and this suggests that some bacteria source is infiltrating the pipe system at some point. The relatively stagnant nature of the water movement in the pond may limit the movement of some of the bacteria into the river but further research is needed to understand the nature of this system.

Tree cover along the river providing shade for the water and the observed flow rate of the water was probably responsible for the passing dissolved oxygen levels observed during the monitoring period, the low oxygen levels seen at two sites on 8/5/14 were most likely due to short-term temperature increases and diminished water flow conditions.

Conductivity in Zone B was quite stable along the length of the zone, though conductivity ranges were slightly higher on average than in Zone A. Sites SM4.1 and SM3.5 were exceptions to this trend. Both are storm drain discharges into the main body of the river. SM3.5 was considerably higher in all aspects of conductivity as compared to all other sites in Zone B. The area around SM3.5 has a number of homes and this may be contributing to the higher conductivity levels observed there, but at this time the cause of these levels is unknown.

Table C2 Site numbers, descriptions and GPS coordinates for seven monitoring sites in Zone B of the Silvermine River

Site No.	Site Description	GPS coordinates
SM3	James Street	Latitude: N 41° 08’ 09.8” Longitude: W 073° 26’ 6.1”
SM3.3	DMR Bridge	Latitude: N 41° 08’ 15.0” Longitude: W 073° 26’ 21.4”
SM3.6	Private drive north of Merritt Parkway	Latitude: N 41° 08’ 18.4” Longitude: W 073° 26’ 23.8”
SM3.7	Private drive north of Merritt Parkway	Latitude: N 41° 08’ 21.4” Longitude: W 073° 26’ 27.2”
SM4	Singing Woods Drive	Latitude: N 41° 08’ 43.5” Longitude: W 073° 26’ 31.6”
SM4.1	Singing Woods Drive Drainage Pipe	Latitude: N 41° 08’ 50.7” Longitude: W 073° 26’ 35.2”
SM5	Silvermine Elementary School	Latitude: N 41° 08’ 50.7” Longitude: W 073° 26’ 35.2”

Section III

Introduction, Lower Norwalk River Storm Drains:
The storm drain section of the lower Norwalk River under investigation extends from the Linden Street storm drain discharge south to the mouth of Norwalk Harbor at Calf Pasture Beach (Figure 3, Figure 4). The lower end of the Norwalk River is characterized by the input from over one hundred storm drains. Several of these are quite large (up to 6 feet in diameter) with continually running discharges, the result of piping away small streams so that the overlying land could be utilized for structures. The subject of this section covers the continued monitoring of nine storm drain discharges which have been problematical over the past ten years in terms of elevated *E. coli* bacteria counts.

The banks in the lower section of the Norwalk River are characterized by an almost total loss of wetlands and most riparian buffers. An exception to this characterization is the remaining tree line between New Canaan Ave and Route 1 (Figure 3). Going downstream, the river banks are lined by light industry, a large medical building, asphalt plants and marinas (Figure 3, Figure 4). The river has been dramatically reshaped to mitigate flooding. Open space has been converted to parking lots all along the banks of the area. The storm drains in the lower Norwalk River are a prime example of where protection of the river's ecology was given little thought during all the development that has occurred over the last 200 years. The unintentional, cumulative effect of all this is the creation of a man-made waterway which has lost most of its natural amenities and has poor tidal flushing. The cost of remedial efforts at this point is not contemplated. Nevertheless, repair of the extensive infrastructure (the largest polluter) is possible and should be undertaken and maintained as funds become available[1].

Storm drains discharging to the estuary (Figure 4) are partially flooded by marine water at high tide. This necessitates taking bacteria samples at low tide to ensure mostly fresh water for the testing cycle.

Results, Lower Norwalk River Storm Drains:
All four saltwater storm drains exceeded the CT DEEP geometric mean criterion for a Class B river for *E. coli* of <126CFU/100mL (Figure 13, Table 6). The four saltwater storm drains also exceeded the CT DEEP single sample maximum criterion of <10% of all samples taken at a single site being <576CFU/100mL (Table 6). Four of the five freshwater storm drains: Linden, New Canaan, Medical, School exceeded the CT DEEP geometric mean criterion and all but the Perry Ave storm drain site exceeded the CT DEEP single sample maximum criterion (SSM) (Figure 14, Table 7).

Among the saltwater storm drains conductivity means ranged from a minimum of 11,654µS at Moody's Lane to a maximum of 36,696µS at Calf Pasture Outflow. Washington St. had the smallest conductivity range at 8,990µS, and Moody's Lane had the largest conductivity range of 24,794µS (Figure 15, Table 8). Among the freshwater sites New Canaan had the lowest mean conductivity at 448µS and Medical Center had the highest mean conductivity at 1,172µS. New Canaan had the smallest range at 35µS and Medical Center had the widest range at 1369µS (Figure 16, Table 9).

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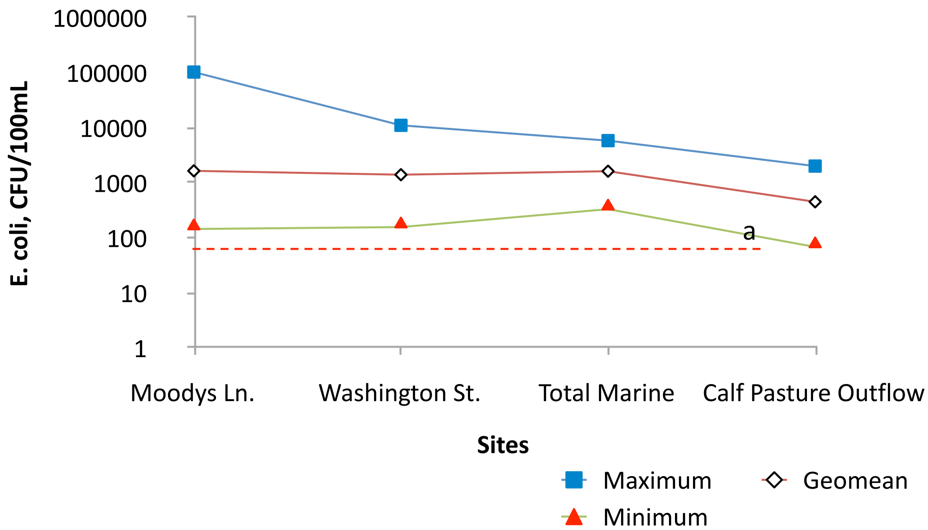
[1] The large storm drain network at Moody's Lane was in the process of being replaced by Norwalk's WPCA when a deteriorated sewer pipe was found between Lockwood St and Buckingham Place. HW had previously found the nearby storm drain to be contaminated with raw sewage and reported its findings to the Public Works Dept. (2009). The 70 year old sewer pipe was found to be infiltrating sewage to the storm drain. Over 700 feet of old clay sewer pipe has been replaced by Norwalk's DPW.

Figure 13 Observed maximum, geometric mean, and minimum values for *E. coli* at four saltwater storm drains in Norwalk Harbor from May to August 2014



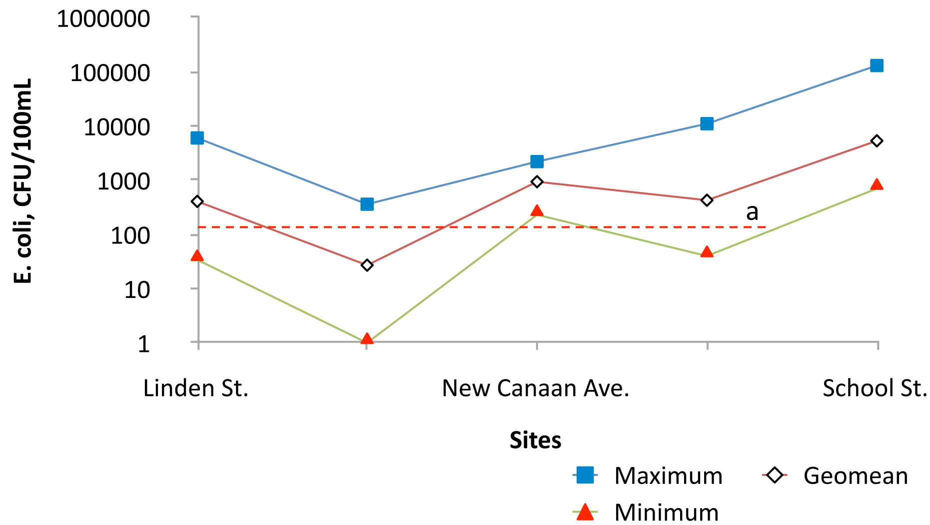
a CT DEEP geometric mean maximum for a class B river

Table 6 Observed *E. coli* bacteria concentrations, geometric means, and % frequency exceeding 576 CFU/100mLs at four saltwater storm drain sites in Norwalk Harbor from May to August 2014

	5/21/2014	6/3/2014	6/18/2014	7/2/2014	7/30/2014	8/6/2014	8/20/2014	**Geomean**	**% frequency over 576CFU/100mLs**
Moodys Ln.	102000		144	No Sample	620	1000	1300	**1639**	**80.00%**
Washington St.	7100	500	11000	890	156	900	2100	**1394**	**71.43%**
Total Marine	4700	3000	5800	1000	660	1600	330	**1614**	**85.71%**
Calf Pasture Outflow				2000	68	2000	150	**449**	**50.00%**
Rainfall, inches	0.62	0.39	0.99	0.73	0.28	0.48	1.42		
Days Prior*	5	0	5	0	2	3	7		

* Rainfall measured over 7 days, and not limited to the day listed on the above table.

Figure 14 Maximum, geometric mean, and minimum values for *E. coli* at five freshwater storm drains along the Norwalk River for May to August 2014



a CT DEEP geometric mean maximum for a class B river

Table 7 Observed *E. coli* bacteria concentrations, geometric means, and % frequency exceeding 576 CFU/ 100mLs at five freshwater storm drain sites on the Norwalk River from May to August 2014

	5/21/2014	6/3/2014	6/18/2014	7/2/2014	7/30/2014	8/6/2014	8/20/2014	**Geomean**	**% frequency over 576CFU/100mLs**
Linden St.	240	135	300	34	6000	3800	240	**406**	**28.57%**
Perry Ave.	96	200	360	24	16	1	4	**27**	**0.00%**
New Canaan Ave.		800	1900	230	2200			**936**	**75.00%**
Medical Center	TNTC	300	11000	40	760	1200	50	**427**	**42.86%**
School St.	4100	2300	130000	2600	20000	700	2700	**5319**	**100.00%**
Rainfall, inches	0.62	0.39	0.99	0.73	0.28	0.48	1.42		
Days Prior*	5	0	5	0	2	3	7		

* Rainfall measured over 7 days, and not limited to the day listed on the above table.

Figure 15 Maximum, mean, and minimum values for conductivity at four saltwater storm drains in Norwalk Harbor from May to August 2014

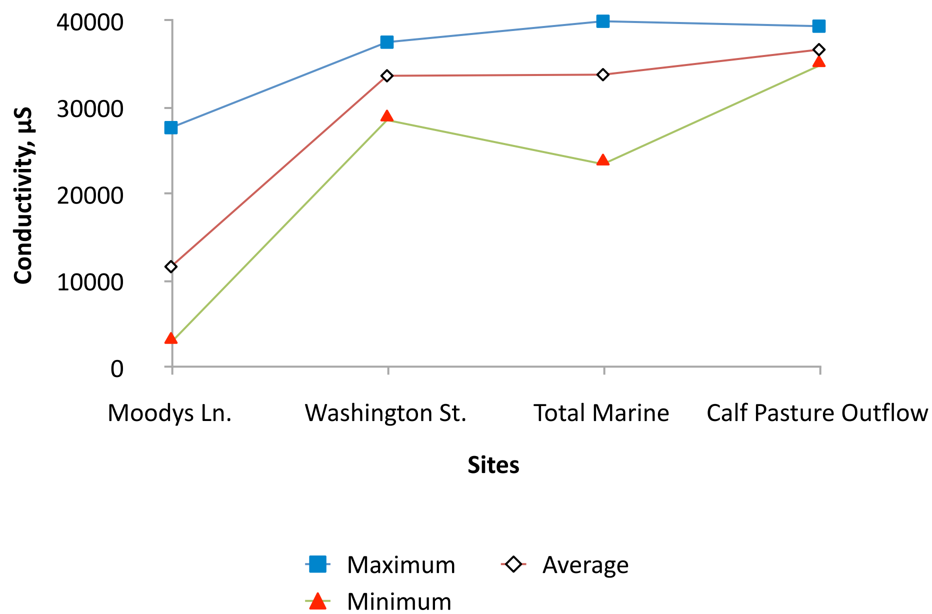


Table 8 Observed maximum, minimum, range and mean values for conductivity at four storm drains on Norwalk Harbor from May to August 2014

	Moodys Ln.	Washington St.	Total Marine	Calf Pasture Outflow
Maximum	27694	37558	39969	39403
Minimum	2900	28568	23485	34837
Range	24794	8990	16484	4566
Average	11654	33679	33808	36696

Figure 16 Observed maximum, mean, and minimum values for conductivity at five freshwater storm drains on the Norwalk River from May to August 2014

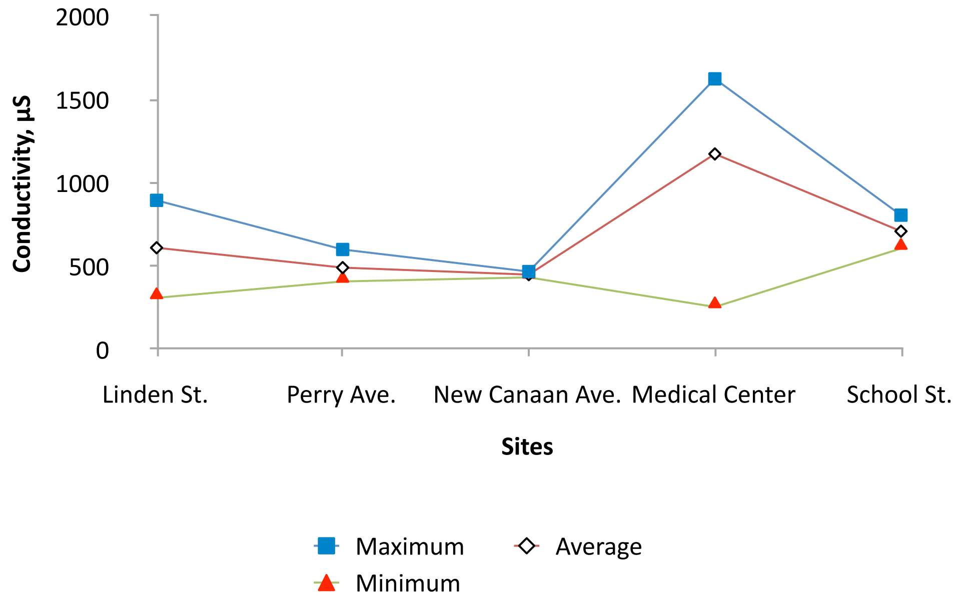


Table 9 Observed maximum, minimum, range and mean values for conductivity at five freshwater storm drains on the Norwalk River from May to August 2014

	Linden St.	Perry Ave.	New Canaan Ave	Medical Center	School St.
Maximum	894	599	467	1623	805
Minimum	309	407	432	254	605
Range	585	192	35	1369	200
Average	609	490	448	1172	709

Discussion, Storm Drain Systems Discharging to Norwalk Harbor

The pollution problems associated with most of the storm drains that continually discharge to the marine environment is based on age of the system and lack of maintenance. Most of these pipelines are in the older sections of Norwalk and may have been altered many times to meet surface development. As a result records are not always accurate. Sewage may be infiltrating the storm drain networks because of aging infrastructure, existing cross connections, and/or illegal hookups. Many of these problems stem from the fact that adjoining sanitary lines (some are over 70 years old) are made with clay pipe which deteriorates over time allowing sewerage to migrate through the soil and infiltrate adjoining storm drains. Many of these storm drains are made of reinforced concrete or galvanized metal pipe and have developed small leaks at the joints over many years which allow waste water products to enter the system (Table 6).

A problem which hinders the quality of bacteria testing in storm drains discharging to the marine environment is the fact that tidal excursions are entering these pipes for longer periods as climate change is advancing which serves to mitigate test results. All testing has to be planned around tidal cycles to assure accurate results. Rainfall also clearly has an effect on these storm drain networks by accelerating the flow of bacteria into marine waters, however, testing done during the relative dryness of the summer months indicates that the bacteria inputs into these systems is occurring regardless of rainfall (Table 6).

The tidal excursions were responsible for the elevated conductivity levels observed at the storm drain outfalls in Norwalk Harbor. While the Total Marine drain is partly submerged, even at low tide the other three storm drains discharge above low tide. Nevertheless water pouring out of the pipe routinely has high conductivity levels due to the extent of salt water incursion. The Moodys Lane outfall is an exception due to its position further up in the estuary, at the low point on a steep slope with its discharge to the Norwalk Harbor.

Storm Drain Systems Discharging to the Lower Norwalk River

The freshwater drainage pipelines are in a little better shape (Figure 14, Table 7). All of these storm drain outfalls are in commercial or residential areas and are also most likely being impacted by some illegal connections to the drainage networks or are subject to deteriorating infrastructure to a lesser degree. Harbor Watch has been working in partnership with city agencies such as WPCA's Ralph Kolb and Nick Berkun to improve the water quality of Norwalk Harbor with some real success stories, but even these repaired storm drain systems may need long term care and in some cases additional remediation to fully catch up with surface development. Further exploratory research is needed to determine where some of these pipes actually go and to locate possible pollution sources within these systems (Table 7).

In terms of conductivity, the Medical Center outfall had a very wide conductivity range as compared to the other storm drains in the freshwater section. It is believed that this storm drain services a more developed residential area near Norwalk Hospital and the conductivity levels at this site are primarily due to the higher degree of impervious surfaces, though there may be other factors contributing to it as well.

Table C3 Site name, descriptions, and GPS coordinates for four storm drains discharging into Norwalk Harbor

Site Name	Site Description	GPS coordinates
Calf Pasture Outflow	Pipe to the right side of path to the pier at Calf Pasture Beach	Latitude: N 41º 05' 01.3" Longitude: W 073º 23' 34.6"
Total Marine	End of Water Street at Total Marine Inc. boat launch.	Latitude: N 41º 05' 36.7" Longitude: W 073º 24' 45.8"
Washington Street	The Maritime Aquarium Imax theatre parking lot	Latitude: N 41º 05' 56.9" Longitude: W 073º 24' 56.1"
Moody's Lane	Norwalk Rowing Association Parking Lot, upstream of rowing docks	Latitude: N 41º 06' 55.1" Longitude: W 073º 24' 33.0"

Table C4 Site name, descriptions, and GPS coordinates for five storm drains discharging into the Norwalk River

Site Name	Site Description	GPS coordinates
School St.	Parking lot of The Old Mill Saloon and Smokehouse	Latitude: N 41º 07' 11.2" Longitude: W 073º 25' 4.1"
Medical Center	Rear of parking of Medical Center at 40 Cross St.	Latitude: N 41º 07' 09.7" Longitude: W 073º 25' 10.7"
New Canaan Ave.	On west bank downstream of New Canaan Ave. bridge	Latitude: N 41º 07' 33.9" Longitude: W 073º 25' 44.7"
Perry Ave.	Discharge on east side of Perry Ave. bridge abatement	Latitude: N 41º 08' 8.1" Longitude: W 073º 25' 32.3"
Linden St.	Dirt road parallel to railroad tracks off Perry Ave.	Latitude: N 41º 08' 12.3" Longitude: W 073º 25' 34.3"

Final Conclusions for the Silvermine River and Norwalk Storm Drains:
Although the major discharge points for *E. coli* bacteria into Norwalk Harbor are now known, finding the root cause of the inputs requires a detailed investigation of each storm drain network. The investigation must be done manhole by manhole to isolate illegal hookups and other possible sources of pollution. HW is currently surveying four storm drain systems discharging to Norwalk Harbor to help isolate other sources of pollution. Based on HW experiences, the process can take months and many tests for each system. We again thank the Public Works, WPCA Conservation, and Health Departments of Norwalk for their support in this effort.

Appendix A

References:

Harris, R. B. and P. J. Fraboni: Quality Assurance/Quality Control Plan for the Norwalk River Watershed Monitoring Project (QA No. CT00162) (re-approved US Environmental Protection Agency. 1986. Ambient Water Quality Criteria for Bacteria, US EPA 440/5-84-002, Washington, DC.

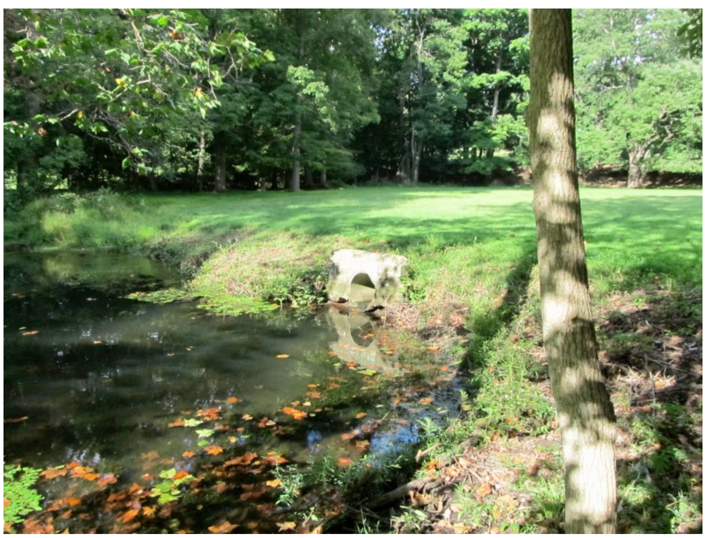
Harris, R. B and P.J. Fraboni: Water Quality Data Report for the Silvermine River and Lower Norwalk River June 2010 through August 2010.

Harris, R. B and P.J. Fraboni: Water Quality Data Report for The Silvermine River and Lower Norwalk River May 2011 through August 2011.

Eaton, A.D., Clesceri, L.S., Rice, E.W., and A.E. Greenberg. 2005. Standard Methods for the Examination of Water and Wastewater, 21st Ed. American Public Health Association, American Water Works Association, Water Environment Federation

Appendix B

Stream bank erosion at site SM3



SM4.1 located off Singing Woods Rd.

Example of severe bank erosion and fallen trees at site SM4

Alternate view of site SM4 showing the number of fallen trees

Remaining pieces of J-hooks that were installed in early 2000s at site SM5. Stream bank erosion can be seen in the background.

SM5, behind the Silvermine School, showing the erosion caused by J-hooks installed in the early 2000s