Sparkill Creek – Citizen Science Pathogen Indicator Project

Sparkill Creek Watershed Alliance January 24, 2015

Final Report

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Summary

A study of the Sparkill Creek in Rockland County NY and Bergen County NJ was conducted by Sparkill Creek Watershed Alliance (SCWA) during three summer months in 2014 to determine levels of pathogen indicator bacteria and other physical characteristics. We received guidance from the Environmental Protection Agency under a citizen science grant program along with administrative and technical support from the New England Interstate Water Pollution Control Commission and the NY-NJ Harbor & Estuary Program. The goals of our project were to gain skills and receive training so our group would be able to produce credible data and information used to better our understanding of local problems, specifically the presence of pathogen indicator species in local waterways.

Our study expanded prior testing on the Sparkill for enterococcus bacteria as reported by Riverkeeper Inc. on their collaborative work with the SCWA. The project results confirmed these previous findings: that enterococcus bacteria are widespread in the main stem of the Sparkill Creek, at levels significantly above EPA criteria for recreational contact. Further, we found that these bacteria are present at relatively high levels throughout the watershed. During or just after periods of rain, bacterial levels are increased by several orders of magnitude. These high counts during rain, likely mostly from surface water runoff, provide little useful data and make determination of other sources more difficult. However, as in the previous study, no point sources are clearly evident. This may be due to several factors including: widespread contamination from human sources such as multiple leaks from sewer mains or smaller leaders, leaks from multiple septic systems, release of bacteria stored in sediment, and/or "natural" sources such as animals, birds and plants. While contamination from human sources may be significant, this is impossible to confirm from the current test results. Bacterial contamination from other sources seems just as likely and may serve to mask the origin of sewage related point sources if they are present. Data from this study will be publicly available on the EPA STORET database. The project was also evaluated for its value to our group both for the data produced and in learning how to interact with regulatory authorities and funding organizations.

Contents

New York - New Jersey Harbor & Estuary Program
www.harborestuary.org

United States Environmental Protection Agency

NEIWPCC
New England Interstate Water Pollution Control Commission

Introduction

The Sparkill Creek watershed occupies the southeastern portion of Rockland County, NY plus a smaller section in Bergen County, NJ totaling almost 12 square miles (Figure 1). In many respects it is a typical suburban stream, with several apparently pristine parkland areas, residential areas and more heavily developed light industrial and commercial strips. There are no significant agricultural areas in the watershed.

The creek is listed on the New York State Department of Environmental Conservation Priority Water Body List of stressed streams[1]. The creek received sanitary effluent at numerous points before two wastewater treatment plants (Orangetown and Rockland County) were built on the banks of the stream about fifty years ago. These two sanitary systems are separate from the storm water sewer system. The treated effluent from both plants is piped to a single outfall in the Hudson River near the end of the Piermont Pier. Nearby, the creek enters the Hudson River at the northern edge of the Piermont Marsh, an important part of the Hudson River National Estuarine Research Reserve.

Figure 1: The Sparkill Creek Watershed.
Note the NY/NJ border crossing the watershed, the Tappan Zee Bridge to the north, and the confluence of the creek with the Hudson River at Piermont

Project Goals and Objectives

The Citizen Science Project has these goals:

- Produce valid data pertaining to the creek through training and work with partners;
- Confirm earlier enterococcus test results;
- Expand our testing to better understand our previous results and identify sources of bacterial contamination.

To reach these goals we had the following Objectives: 1) expand test points to new locations, including sites away from sewer lines and testing in the Sparkill Brook (Bergen County, NJ) that joins the main stem of the Sparkill Creek at the New York border; 2) increase testing frequency to provide a more systematic assessment of bacterial presence in varied conditions; 3) strengthen monitoring abilities through training and experience; and subsequently 4) share our lessons, experiences and conclusions with our community and other watershed monitoring groups; and 5) communicate appropriate findings to local officials.

Background

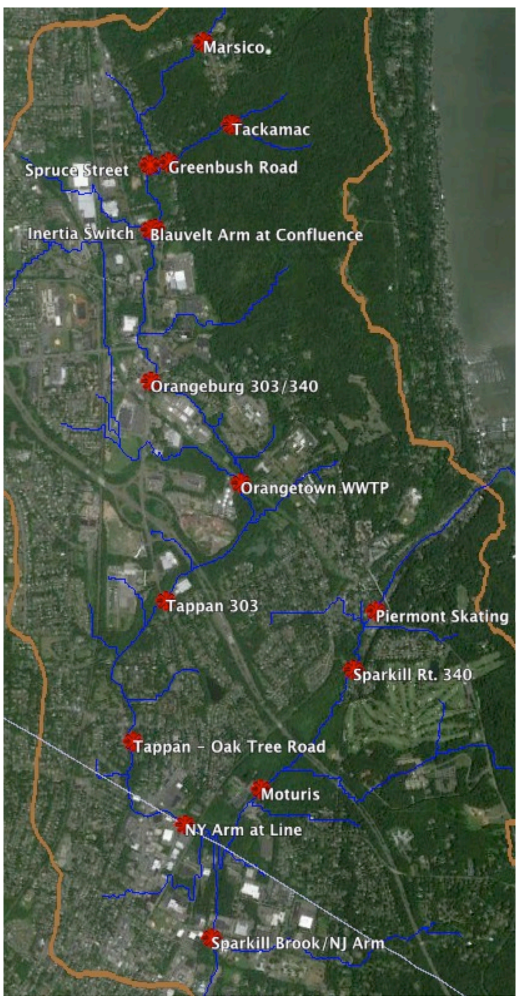
The Sparkill Creek Watershed Alliance (SCWA) has collected samples at 16 sites (Figure 2) under Riverkeeper's direction each summer since 2011 after their early results showed higher than expected enterococcus counts at several Sparkill sites. Riverkeeper published initial results confirming these high

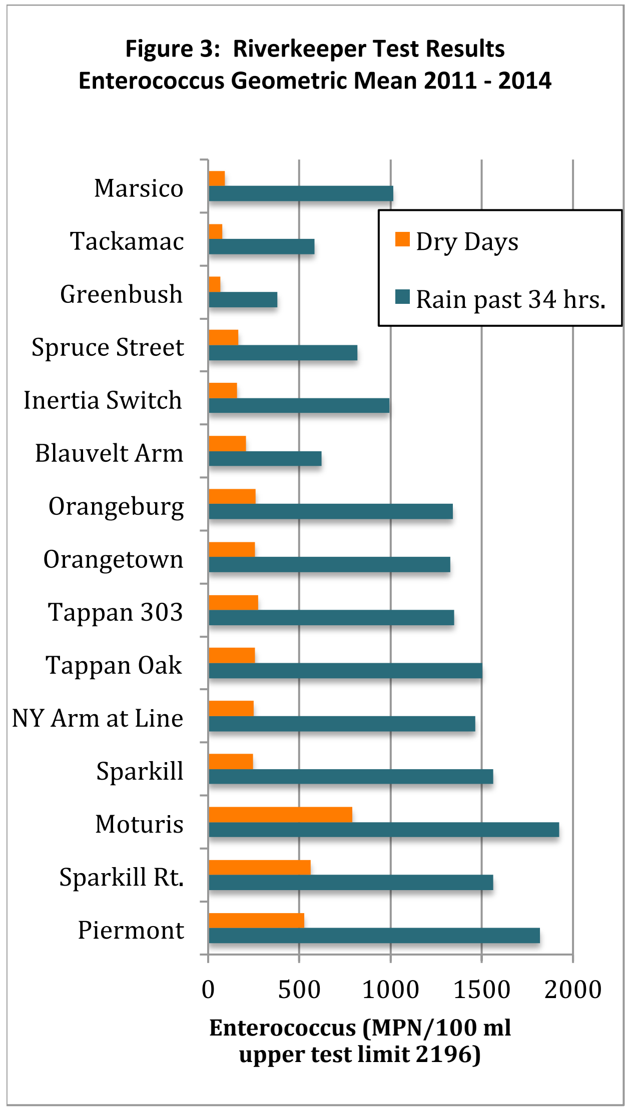
[1] *New York State Section 303(d) List of Impaired/TMDL Waters 2013* http://www.dec.ny.gov/docs/water_pdf/303dlistfinal12.pdf

levels in 2011 and 2014 where the Sparkill was ranked as the most chronically contaminated of the tributaries tested that enter the Hudson River Estuary.[2,3]

These results (Figure 3) show widespread and persistent enterococcus levels throughout the length of the stream. After rain events even the sites furthest from developed areas are likely to show unexpectedly high enterococcus levels. Though count levels are generally higher at downstream sites, there is no clear point source or even several sources evident, especially when considering results from individual test days, as these varied widely. Although highly elevated counts are apparent at each of the test locations especially during wet periods, the more developed downstream sites continue to show higher counts on drier test days too. All sites are found to be above the EPA Recreational Water Quality Criteria maximum of 35 cfu/100 ml for direct recreational contact.[4]

Figure 2: Sites Sampled 2011 – 2014 by the SCWA for Riverkeeper enterococcus testing program. Blue lines are modeled stream.





[2] T. Brown, *How is the Water? Sewage Contamination in the Hudson River Estuary 2006-2010*; Riverkeeper, 2011 http://www.riverkeeper.org/wp-content/uploads/2011/08/RvK_How-Is-the-Water_2006-10.pdf
[3] http://www.riverkeeper.org/water-quality/citizen-data/sparkill-creek-watershed/ - chart
[4] US EPA 2012 Recreational Water Quality Criteria – Criteria Document

Project Design and Site Selection

Test parameters, test frequency and duration, and test protocol were defined by the terms of the grant. Our design role was mostly about site selection. Results reported above in the years prior to this project were the starting point for selecting new sites designed to gain additional information on the extent of bacterial loading in the Sparkill watershed. The previous test sites were mostly on the main stem of the creek. Frequently the creek and these sites are literally on top of sanitary sewer lines (Figure 4). It has been suggested that significant levels of enterococcus might be present in the ground water adjacent to and under the main stem; this is reportedly the case in preliminary testing at one sampling well site.[5] Sites were selected to find out if the results at main stem sites were typical of other areas.

Sixteen sites were selected using the following general criteria:

- Confirm previously tested sites
- Add more headwater sites
- Add sites away from the main stem basin
- Add surface and storm water sources
- Add areas served solely by septic systems
- Include sites in the Sparkill Brook sub-watershed in Bergen County, NJ.

The sites for this project, designated with the project number codes are shown in Figure 5. Location and other site information is in Appendix 1 plus site selection and other project information in Appendix 2.

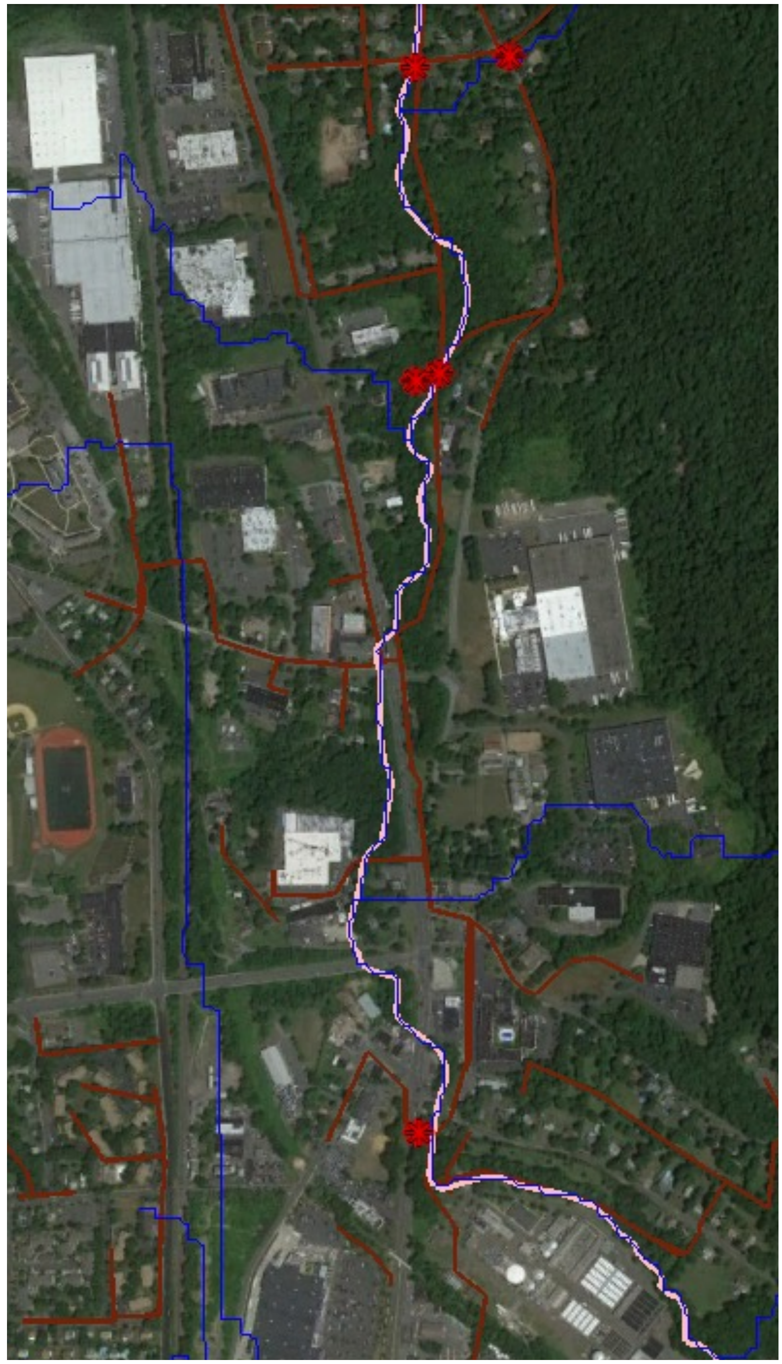


Figure 4: Part of the Sparkill, showing Riverkeeper sites 2011 - 2014.

Sparkill Creek Main Stem — Modeled Tributaries — Sewer Mains

[5] John Lipscomb, Riverkeeper; personal communication.

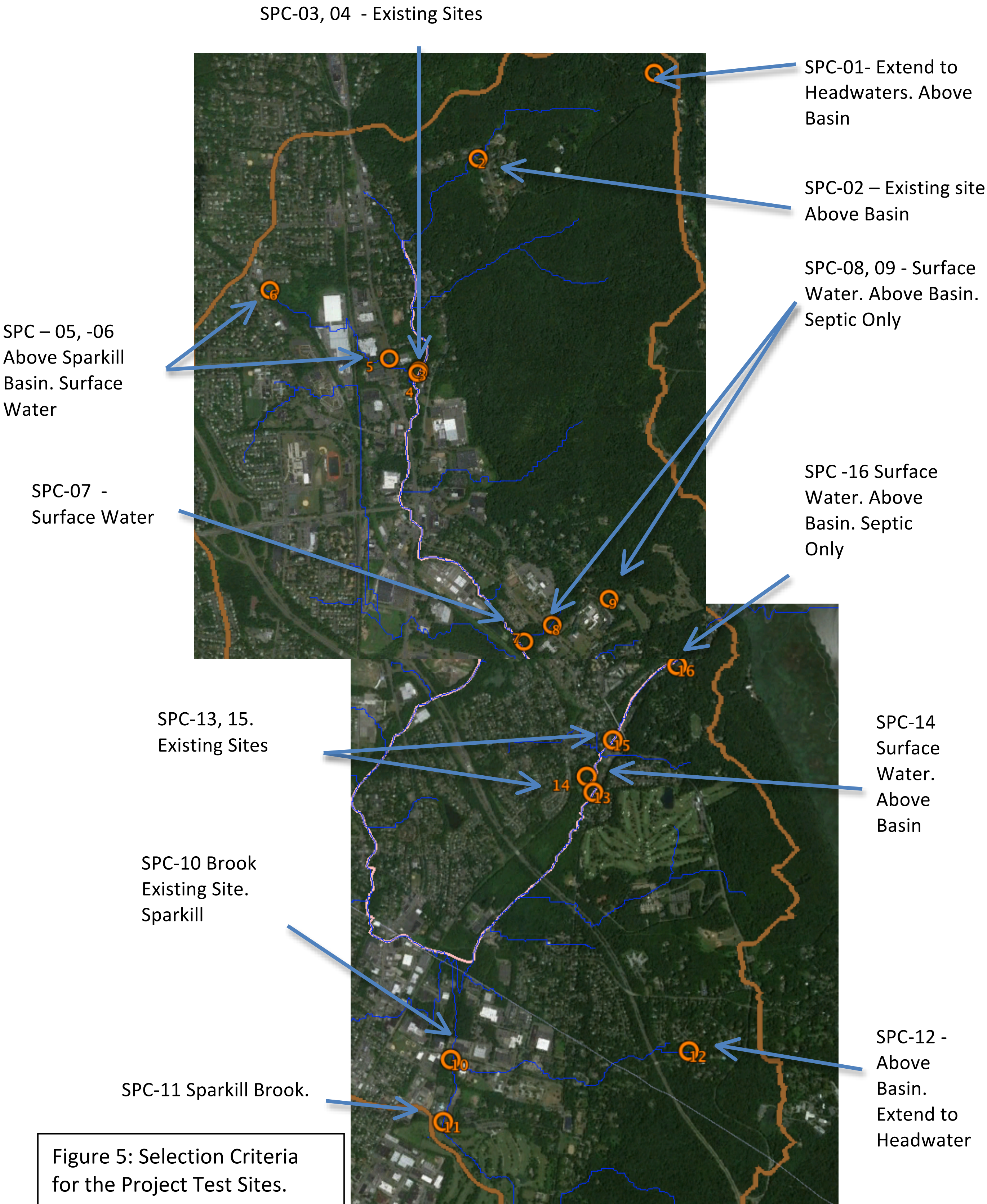


Figure 5: Selection Criteria for the Project Test Sites.

Training and Testing Activity

The project was conducted by Sparkill Creek Watershed Alliance members plus two students and a faculty advisor from Rutgers University (See Personnel and Acknowledgements section). Team members participated in a May 2014 training session at the EPA Region 2 Edison laboratory on sampling, instrumentation, laboratory technique, and data management. Further training in data management and assessment and presentation was conducted in October and November.

Tests were conducted each Monday in June, July and August plus an additional day each month. The selection of 16 test sites was ambitious considering the time constraints for testing and the travel time to the EPA lab in Edison, NJ. Therefore the field work was divided between two sampling teams. A YSI Professional Plus handheld meter was purchased to complement the YSI 556 meter supplied by EPA. The two teams met in the morning to calibrate the instruments, and then each sampled at 7 to 9 sites before reconvening at mid-day. Each team had a minimum of two members to make the collection and recording more efficient and for safety compliance. Typically, the students brought the samples to the Edison lab, conducted the lab work, and entered the bulk of the data into a working spreadsheet. SCWA members were involved in each day of training and sampling plus several opportunities to conduct lab work and data entry. The EPA lab staff provided invaluable assistance both to supervise our early work and then to read the lab results on the day following the sampling.

In addition to visual observations at each site and collecting weather information, the following properties were determined:

- Conductivity
- Specific Conductance
- Temperature
- pH
- Dissolved Oxygen
- Enterococcus Counts

Data Quality and Quality Assurance

Test procedures were guided by training and the Citizen Science Pathogen Monitoring – QAPP – CSPathogen (Appendix 3 and at the referenced link[6]).

In accordance with the Enterococcus testing procedure in the QAPP, both a blank control and positive control samples were analyzed with each batch of samples. No failure of blanks or positive control samples was found. Replicate samples were also taken for Enterococcus determination on 13 test days (details in Appendix 4 - Replicate Testing of Site Samples). The duplicate enterococcus results often varied widely (up to 61% variance from the mean). Several reasons seem possible: 1) sample contamination, 2) variation of the sample source, 3) inherent variability of the test. Though contamination is always possible, there are no indications that contamination was a factor and seems unlikely; blank samples never showed positive results. Some variation of sample source seems possible though not known to be a significant factor. Duplicate samples were not taken from exactly the same larger sample. Rather, samples were taken from the same site location within a short period of time. The effect of this factor is not known but there is no reason to suspect that it results in large differences. Variability in the results seems most likely to be inherent in the test itself. This is demonstrated by the results of the positive control tests. This seems reasonable considering that an acceptable result for the 1000 MPN/ml control is -50% to + 100%. Though

[6] http://www.harborestuary.org/citizenscience-2014project.htm

our replicate testing confirms the somewhat qualitative nature of this determination, there is nothing to indicate any failure of testing technique or procedure.

The YSI multimeter instruments were calibrated at the beginning of each test day. (The barometric pressure was determined from the YSI ProPlus and entered in the YSI 556). Required calibration checks were also made each day at the conclusion of testing. Some drift was sometimes noted at this time but in no case was an instrument found to be outside of the specified calibration limits. Replicate determinations of physical properties were made at two different locations (details in Appendix 4 - Replicate Testing of Site Samples). Temperature, and specific conductance and conductivity were stable. Determination of pH varied slightly but not significantly considering the variability associated with values close to pH 7. Dissolved oxygen (DO) varied by about 8% from the mean in one case. It is likely that this is due to the duration of the sampling time for these multiple samples rather than on instrument error. The DO determination is dependent on flow past the probe membrane to prevent depletion of oxygen adjacent to the probe. In this case it is likely that DO was depleted as the two additional sample readings were recorded. Though this would not be the case for typical DO samples, it demonstrates the importance of maintaining sample flow past the probe. This is especially true for the YSI ProPlus instrument, which uses a more responsive probe than the YSI 556. A team training was held early in the project sampling phase to improve calibration skills and to assess the sensitivity of the two DO probes used here.

The YSI 556 and YSI ProPlus instruments were compared at the end of 13 sampling days. Readings were usually taken side by side in flowing portion of the stream near site SPC-07 (See Appendix 5 – Comparison of Multimeter Instruments). Variation from the mean readings was typically less than 5% but several exceptions are noted. There was good agreement between the instruments for temperature and pH readings. Dissolved oxygen showed > 5% variation on August 4 (where other differences in readings suggest the sample may have been different) and August 14. In both cases the YSI ProPlus had the lower reading, suggesting that the response time played a role. Conductivity and specific conductance were generally in good agreement with three exceptions. The August 4 readings varied by about 10% in both tests. No calibration issues are noted; it is likely that the sample was slightly different. The July 31 reading varied between 5 and 10% of the mean. In this case the YSI ProPlus post calibration check was somewhat off but still well within the specified limit. Both of the tests for August 25 varied from the mean by > 20%. The post calibration check of the YSI 556 showed it to be almost at the 500 µS/cm limit.

Finally, the data (both the original data sheets and the excel sheet compilation) were checked for transcription errors and otherwise unreasonable entries. Reasonableness was determined by comparison to other sites under similar conditions and comparison to the same site on different days. Most unreasonable entries were changed based on re-interpretation of handwriting or on reasonable assumptions of transposition errors. Classification and entry of data into the final form for STORET upload was conducted with the assistance of the EPA Region 2 office and the STORET Helpdesk.

Results

Enterococcus testing is summarized in Table 1 and Figures 6 and 7. The geometric mean of all test values was greater than the EPA recreational water quality criteria of 35 cfu/100ml[7] for each of the 16 sites. This was true even for the mean of the values recorded on days without significant rain although some single test values were below this ßlimit at some sites. “Dry” test days are defined as not having rainfall greater than 0.05 inches from the time of sampling through the prior day.

[7] CFU = Colony Forming Units

As expected, the influence of rain is dramatic. Enterococcus counts for some sites were recorded at negligible levels during dry weather only to increase over a thousand-fold after significant rain. The highest values are from samples collected during periods of rain at very small tributaries (Tweed, Closter Rd, Ferdon). Note that two of these sites were frequently dry so results are not the mean but rather single values.

Results from samples collected on dry days are generally more consistent. One outlier is SPC-06 Upper Blauvelt Arm with a mean of 498 MPN/100ml (see Discussion below). Besides this site, counts of the main stem and Sparkill Brook sites generally had mean values around 200 MPN/100ml. Other sites often had lower values in dry weather.

Results correlated to our site selection process:

- Correlation to prior test results

The project results are not at odds with prior results though correlation was difficult for this year's testing. Even though test days were often just a few days apart, more often than not the weather conditions were different for the two tests days, which likely influenced the results considerably. Dry weather results are more reliably compared. In four of the six sites, mean results vary by 5 to 40%. For the Rt. 340 Sparkill (SPC-13) and the Skating Pond (SPC-15) sites the project mean results were less than 50% of the prior testing mean values. Even considering this variation, the conclusion that both sites have significantly elevated counts remains the same.

- Headwater sites

Generally the small upland sites had similar results to the upland sites tested previously. That is: counts were very elevated in wet weather even at sites remote from human development (SPC-01, Tweed). For upland sites closer to development the results are mixed; the Marsico (SPC-02) and Trib 9a Kings Hwy (SPC-09) sites were low compared to Closter Rd (SPC-12) where counts were amongst the highest in the study. In all cases these sites are upstream of any sewer main crossings.

- Surface and storm water sources

Surface and storm water supplies much of the flow at the headwater sites discussed above. Sites with the most input of storm water in developed areas are the Blauvelt Arm (SPC-04), Graney Gardens (SPC14) and Ferdon Outfall (SPC-16). During rain events the counts were amongst the highest recorded in the study. During dry weather they were often amongst the lowest. Results from the Upper Blauvelt Arm during dry weather stand out from all other results (see discussion below).

- Areas served solely by septic systems

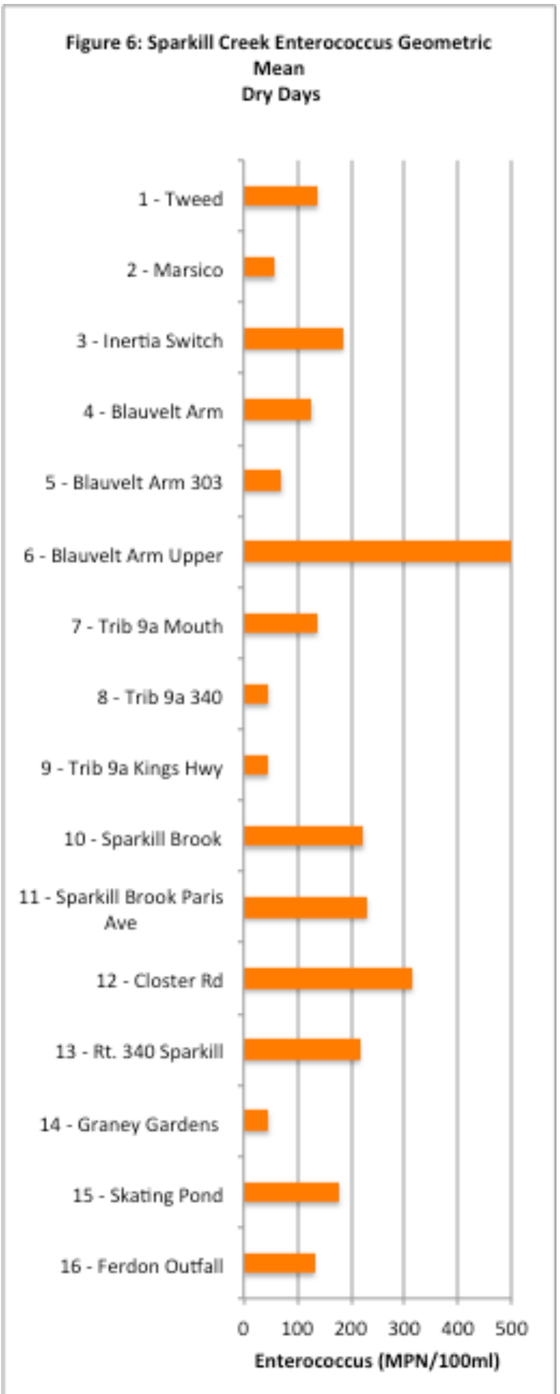
Areas with only septic systems feed two sites, Trib 9a at Kings Hwy (SPC-09) and Ferdon Outfall (SPC-16). As noted above for these sites, enterococcus counts can be high here in wet weather. During dry periods, counts are among the lowest of the study.

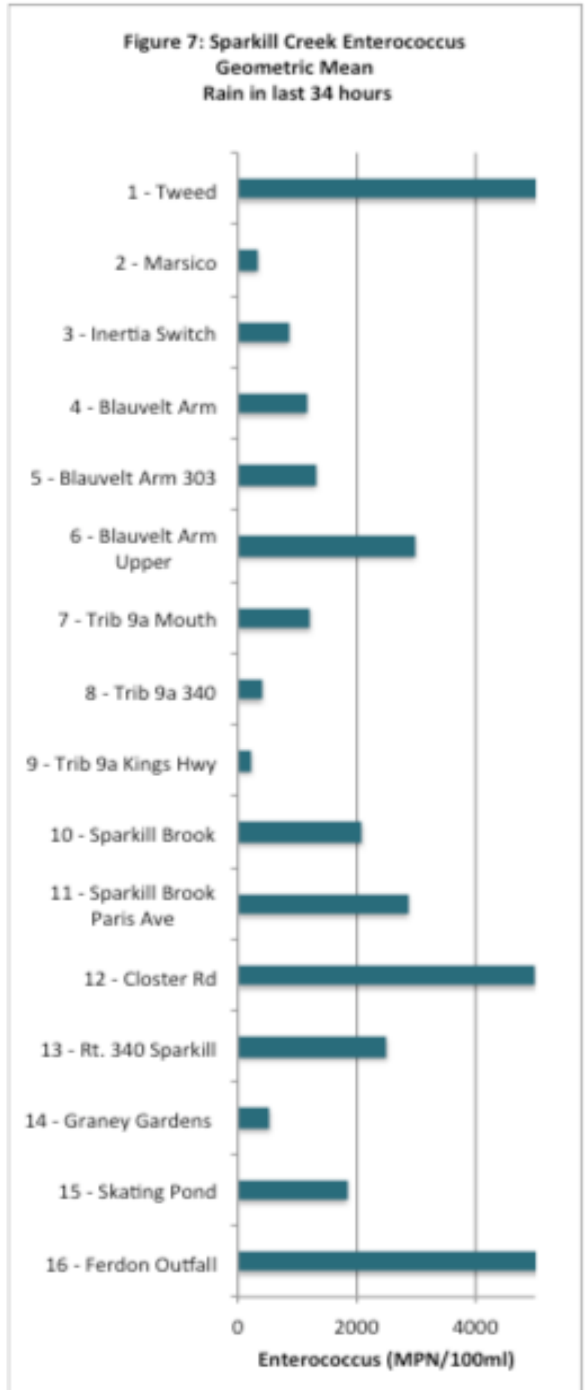
- Sites on the Sparkill Brook Bergen County, NJ.

These two sites have results similar to the other lower main stem sites along the Sparkill Creek. Notably, the Sparkill Brook Paris Ave (SPC-11) site, which drains substantially from the Rockleigh Golf Course, has results very similar to the Sparkill Brook site (SPC-10) and the next site downstream on the main stem, Rt. 340 Sparkill (SPC-13).

- Sites out of the main stem basin

Sites in the basin are defined as the main stem including the two Sparkill Brook sites plus tributary samples collected at the confluence with the main stem (SPC-03, 04, 07, 10, 11, 13, and 15). The geometric mean of the dry weather enterococcus counts for these sites is 181 MPN/100ml compared to the mean of 97 MPN/100ml for the remaining upland sites. While the basin sites are almost twice the value of the upland sites, both are significantly above the EPA criteria of 35 cfu/100ml.





Note: Sites 1 and 16 were small so were frequently dry; total samples were between 3 and 5. There was only one sample at each of these sites during rainy periods.
MPN = Most Probable Number

Table 1: Enterococcus Counts (MPN/100ml)

Site ID	SPC-01	SPC-02	SPC-03	SPC-04	SPC-05	SPC-06	SPC-07	SPC-08	SPC-09	SPC-10	SPC-11	SPC-12	SPC-13	SPC-14	SPC-15	SPC-16	Rain Note:
Site=>	Tweed	Marsico	Inertia Switch	Blauvelt Arm	Blauvelt Arm 303	Blauvelt Arm Upper	Trib 9a Mouth	Trib 9a 340	Trib 9a Kings Hwy	Sparkill Brook	Sparkill Brook Paris Ave	Closter Rd	Rt. 340 Sparkill	Graney Gardens	Skating Pond	Ferdon Outfall	“Rain” if prior 34 hrs. >0.05"
2-Jun-14	10	185	120	31	30	336	153	75	52	109	85	272	226	*<10*	223	160	Dry
9-Jun-14	14136	4884	7270	4352	4352	14136	15531	10462	7270	11199	*>24196*	15531	19863	19863	12997	*>24196*	Rain
16-Jun-14	1565	30	663	118	160	537	72	52	52	201	253	243	292	74	243	109	Dry
23-Jun-14		41	404	109	156	1169	158	41	63	228	201	480	373	31	288		Dry
30-Jun-14		30	109	41	52	563	61	41	51	150	175	246	181	30	96		Dry
7-Jul-14	309	98	379	109	66	3076	134	75	98	171	259	185	318	98	420		Dry
14-Jul-14		216	1274	15531	24196	5794	888	233	41	3255	3076	2400	2359	74	1789		Rain
21-Jul-14		20	144	203	63	1106	145	53	*5*	86	197	279	187	52	171		Dry
28-Jul-14		63	275	362	379	2987	481	85	52	473	545	3654	644	211	292		Rain
31-Jul-14		63	443	201	201	281	228	20	218	228	241	617	203	62	252		Dry
4-Aug-14	75	31	213	197	146	933	110	63	41	697	1050	350	663	262	350		Dry
11-Aug-14		179	53	723	41	292	318		52	259	120	295	110	31	63		Dry
14-Aug-14		187	213	73	75	323	331	134	171	1112	1664	4611	1314	272	1670		Rain
18-Aug-14		173	98	218	30	238	259	31	41	677	288	733	245	52	135		Dry
25-Aug-14		30	97	63	41	63	74		20	226	294	160	52	52	73		Dry
Geomean	348	92	279	229	155	802	245	91	70	406	452	658	417	90	332	750	

Notes: The geometric mean has less significance for sites with few samples (SPC-01 and -16).
MPN = Most Probable Number; Rain data from Weather Underground station KNYTAPPA3
Readings at SPC-05 and SPC-06 on July 14 were influenced by a dead deer in the tributary just upstream from the SPC-05 sample point though rain was also an influence.

Besides enterococcus counts, physical data were collected at each site (Temperature, Dissolved Oxygen, pH, Conductivity and Specific Conductance are detailed in Table 2). These measurements were not a prime objective of this study though they may prove useful for this and other work in the future. For instance, direct support of the enterococcus count data can be found in the temperature data confirming the general rise in counts with the rise in temperature during the late spring and summer. All results are detailed in Table 2. Bacterial source determination may benefit from these data. For instance, surface water typically has more dissolved salts – especially during rain – than other sources, so samples showing high specific conductance are likely to originate from the surface. Some groundwater mineral sources may contain carbonates so higher pH may indicate a groundwater source. These aspects are not fully evaluated here.

For general stream health, Dissolved Oxygen (DO) is most significant. DO ranges from very low readings (1 mg/l) to readings above 10 mg/l. The lowest readings were from small tributaries, often with little flow and in the presence of organic material. Low DO readings in these cases, especially accompanied by high temperatures, are not surprising. Several DO readings in the range of 3 to 5 mg/l on the Sparkill Brook and Rt. 340 sites do suggest the need for further monitoring.

All of the data collected in this study, along with visual observations for each sampling day and site, will be available on the EPA STORET database.[8]

[8] http://www.epa.gov/storet/

Table 2: Sparkill Creek Collected Data

Site:	SPC-01 Tweed	SPC-02 Marsico	SPC-03 Inertia Switch	SPC-04 Blauvelt Arm	SPC-05 Blauvelt Arm 303	SPC-06 Blauvelt Arm Upper	SPC-07 Trib 9a Mouth	SPC-08 Trib 9a 340	SPC-09 Trib 9a Kings Hwy	SPC-10 Sparkill Brook	SPC-11 Sparkill Brook Paris Ave	SPC-12 Closter Rd	SPC-13 Rt. 340 Sparkill	SPC-14 Graney Gardens	SPC-15 Skating Pond	SPC-16 Ferdon Outfall
Temperature, water (deg C)																
2014-06-02	15.2	16.0	13.9	17.1	17.8	13.7	15.9	13.6	14.0	13.0	14.7	14.8	14.6	13.1	14.8	14.3
2014-06-09	16.6	18.4	16.6	19.4	19.7	17.1	17.0	16.9	16.0	17.9	17.4	16.8	17.8	14.1	17.9	17.2
2014-06-16	18.1	21.4	17.8	20.7	20.1	16.3	19.6	18.3	16.8	18.0	17.4	15.5	17.5	14.2	17.6	17.4
2014-06-23		18.7	15.1	18.7	20.9	15.4	18.9	17.0	16.3	17.9	17.2	14.7	17.2	14.2	17.4	
2014-06-30		20.1	16.1	19.5	21.6	16.4	19.6	19.6	18.4	20.0	14.3	16.1	18.9	14.6	19.0	
2014-07-07	19.9	20.6	17.8	20.4	21.7	17.3	21.3	20.2	18.4	20.3	20.1	18.6	19.8	15.9	19.8	
2014-07-14		21.8	18.7	22.2	22.7	19.9	21.0	21.5	19.0	22.0	21.1	20.0	21.6	16.0	21.6	
2014-07-21		19.2	15.9	19.3	21.2	16.9	18.5	18.9	17.1	19.1	18.5	18.0	18.3	15.6	18.4	
2014-07-28		21.7	16.9	21.2	22.5	18.6	20.8	21.8	18.8	21.8	21.4	19.4	20.7	16.0	20.5	
2014-07-31		18.0	15.1	18.2	19.9	16.5	17.6		17.0	18.4	18.3	17.4	17.6	15.6	17.8	
2014-08-04	19.4	20.2	17.0	20.1	21.9	17.6	19.4	19.6	17.1	19.3	19.1	19.8	19.0	16.3	19.0	
2014-08-11		19.7	15.8	19.8	22.3	17.3	18.9		18.1	19.6	19.4	18.9	18.2	15.9	19.0	
2014-08-14		18.0	15.6	18.4	19.9	17.3	18.1	16.9	17.4	19.0	18.6	17.7	18.7	16.2	18.9	
2014-08-18		17.2	15.3	17.7	19.9	16.3	16.6	16.8	16.4	17.7	17.7	17.1	16.9	15.8	17.6	
2014-08-25		18.4	15.7	18.4	20.7	16.8	17.9		17.7	18.5	18.5	17.7	16.0	15.9	18.0	
Dissolved oxygen (DO) (mg/l)																
2014-06-02	5.2	10.4	8.7	8.9	10.0	7.8	8.3	5.8	9.5	9.2	8.7	8.5	6.4	9.9	7.1	4.6
2014-06-09	6.8	8.3	8.5	8.5	7.0	6.8	7.4	6.4	8.8	9.0	7.9	9.0	7.1	9.0	7.3	7.4
2014-06-16	3.3	8.5	7.6	7.9	9.1	7.1	7.2	1.4	9.3	8.4	8.5	9.2	6.5	9.8	6.9	3.8
2014-06-23		9.1	7.7	8.2	9.8	7.0	7.1	1.4	9.0	7.4	8.0	9.0	5.8	10.0	6.0	
2014-06-30		8.7	6.9	7.7	9.7	6.2	7.0	5.3	7.9	7.2	8.2	8.9	5.3	9.9	5.9	
2014-07-07	3.2	8.0	6.9	6.6	7.9	6.0	7.4	3.0	7.9	7.0	7.3	8.2	5.5	8.9	5.5	
2014-07-14		8.2	7.2	7.2	7.5	4.8	6.7	2.4	9.1	7.3	7.4	9.1	5.7	10.0	6.1	
2014-07-21		9.4	8.2	8.2	9.7	6.5	8.1	1.0	10.3	8.1	7.7	9.5	6.5	10.9	6.6	
2014-07-28		7.9	7.0	6.7	7.5	4.1	5.6	0.8	8.7	6.4	5.0	9.5	5.7	10.0	5.5	
2014-07-31		8.8	7.5	8.1	8.4	5.7	6.4	9.6	6.5	5.3	8.3	5.4	10.0	6.4		
2014-08-04	4.6	9.5	8.0	7.7	9.3	6.7	7.2	3.9	7.8	6.6	6.9	7.9	6.0	8.7	5.8	
2014-08-11		8.5	7.3	8.0	8.5	5.7	4.4	7.7	6.3	7.4	2.9	4.4	9.1	5.8		
2014-08-14		8.7	7.8	7.4	8.5	6.1	6.3	3.6	8.0	6.8	6.4	8.0	5.6	8.3	6.1	
2014-08-18		9.0	7.8	7.8	8.5	5.8	5.5	1.8	7.7	6.2	5.7	7.8	4.5	9.1	5.7	
2014-08-25		9.0	10.0	8.1	8.9	3.7	5.6	8.6	5.8	5.2	3.4	5.0	9.1	6.2		

Table 2: Sparkill Creek Collected Data (Continued)

Site:	SPC-01	SPC-02	SPC-03	SPC-04	SPC-05	SPC-06	SPC-07	SPC-08	SPC-09	SPC-10	SPC-11	SPC-12	SPC-13	SPC-14	SPC-15	SPC-16
	Tweed	Marsico	Inertia Switch	Blauvelt Arm	Blauvelt Arm 303	Blauvelt Arm Upper	Trib 9a Mouth	Trib 9a 340	Trib 9a Kings Hwy	Sparkill Brook	Sparkill Brook Paris Ave	Closter Rd	Rt. 340 Sparkill	Graney Gardens	Skating Pond	Ferdon Outfall
pH																
2014-06-02	6.4	7.5	7.1	7.5	8.0	7.1	7.3	6.8	7.5	7.1	7.9	7.4	7.3	7.7	7.5	7.1
2014-06-09	6.4	7.5	7.2	7.5	7.6	7.0	7.1	6.9	7.4	7.3	7.2	7.3	7.4	7.3	7.4	7.4
2014-06-16	6.1	7.5	7.2	7.5	8.0	7.0	7.3	6.9	7.6	7.5	7.6	7.4	7.4	7.6	7.4	7.0
2014-06-23		7.7	7.3	7.5	8.2	7.0	7.4	6.8	7.8	7.4	7.2	7.3	7.4	7.7	7.5	
2014-06-30		7.8	7.3	7.5	8.2	6.9	6.9	7.3	7.9	7.6	7.5	7.6	7.5	7.7	7.6	
2014-07-07	6.0	7.4	7.2	7.3	7.9	6.8	7.3	6.8	7.7	7.4	7.2	7.3	7.4	7.6	7.5	
2014-07-14		7.7	7.3	7.5	7.6	6.7	7.5	7.0	7.7	7.4	7.4	7.5	7.5	7.5	7.6	
2014-07-21		7.8	7.3	7.4	8.0	6.7	7.7	7.1	7.8	7.5	7.1	7.7	7.5	7.7	7.5	
2014-07-28		7.8	7.4	7.4	7.6	6.8	7.4	7.1	7.8	7.4	7.0	7.5	7.4	7.6	7.5	
2014-07-31		7.7	7.4	7.5	7.7	6.9	7.1		7.6	7.3	7.1	7.2	7.2	7.4	7.3	
2014-08-04	6.7	7.5	7.5	7.5	7.9	6.9	7.5	7.2	7.8	7.3	7.4	7.6	7.3	7.6	7.4	
2014-08-11		7.8	7.4	7.5	7.9	6.9	7.4		7.9	7.4	7.3	6.7	7.4	7.8	7.6	
2014-08-14		7.5	7.3	7.3	7.5	6.3	7.4	7.3	8.0	7.5	7.6	7.6	7.4	7.7	7.8	
2014-08-18		7.9	7.6	7.5	8.0	7.5	7.4	7.4	8.1	7.5	7.6	7.5	7.4	7.8	7.6	
2014-08-25		7.7	7.5	7.5	7.7	6.2	7.4		7.8	7.4	6.9	6.9	7.3	7.8	7.7	
Specific conductance (uS/cm)																
2014-06-02	328	342	473	867	965	1228	324	340	110	298	384	448	622	722	633	396
2014-06-09	395	395	434	413	642	766	227	327	114	351	385	242	507	88	465	127
2014-06-16	390	330	498	853	865	1810	350	333	124	514	471	458	654	780	661	444
2014-06-23		488	650	830	797	1192	677	590	148	526	447	485	789	830	794	
2014-06-30		512	741	866	848	1176	669	785	160	523	432	516	813	725	820	
2014-07-07	589	457	607	906	890	1102	544	532	131	533	492	503	678	825	690	
2014-07-14		486	621	657	618	784	475	808	169	403	389	520	650	817	641	
2014-07-21		401	666	775	709	1078	883	557	159	541	410	514	798	800	806	
2014-07-28		475	745	757	713	965	794	663	172	509	424	610	846	73	846	
2014-07-31		429	649	677	464	932	729		171	540	435	995	821	843	832	
2014-08-04	600	550	790	840	760	1005	780	720	167	502	457	495	642	797	647	
2014-08-11		520	796	748	676	1061	816		182	519	436	581	821	7.83	841	
2014-08-14		449	750	701	590	1084	650	580	184	548	352	577	470	842	477	
2014-08-18		478	786	761	649	1058	833	635	189	512	438	534	804	880	812	
2014-08-25		720	1158	1064	937	1446	1252		197	517	428	575	812	857	838	

Table 2: Sparkill Creek Collected Data (Continued)

Site:	SPC-01	SPC-02	SPC-03	SPC-04	SPC-05	SPC-06	SPC-07	SPC-08	SPC-09	SPC-10	SPC-11	SPC-12	SPC-13	SPC-14	SPC-15	SPC-16
	Tweed	Marsico	Inertia Switch	Blauvelt Arm	Blauvelt Arm 303	Blauvelt Arm Upper	Trib 9a Mouth	Trib 9a 340	Trib 9a Kings Hwy	Sparkill Brook	Sparkill Brook Paris Ave	Closter Rd	Rt. 340 Sparkill	Graney Gardens	Skating Pond	Ferdon Outfall
Enterococcus (MPN/100ml)																
2014-06-02	10	185	120	31	30	336	153	75	52	109	85	272	226	<10	223	160
2014-06-09	14136	4884	7270	4352	4352	14136	15531	10462	7270	11199	>24196	15531	19863	19863	12997	>24196
2014-06-16	1565	30	663	118	160	537	72	52	52	201	253	243	292	74	243	109
2014-06-23		41	404	109	156	1169	158	41	63	228	201	480	373	31	288	
2014-06-30		30	109	41	52	563	61	41	95	150	175	246	181	30	96	
2014-07-07	309	98	379	109	62	3076	134	75	98	171	259	185	318	98	420	
2014-07-14		216	1274	15531	24196	5794	888	233	41	3255	3076	2400	2359	74	1789	
2014-07-21		20	144	203	63	1106	145	53		86	197	279	187	52	171	
2014-07-28		63	275	362	379	2987	481	85	52	473	545	3654	644	211	292	
2014-07-31		63	443	201	201	281	228	20	218	228	241	617	203	62	252	
2014-08-04	75	31	213	197	146	933	110	63	41	697	1050	350	663	262	350	
2014-08-11		179	53	723	41	292	318		52	259	120	295	110	31	63	
2014-08-14		187	213	73	75	323	331	134	171	1112	1664	4611	1314	272	1670	
2014-08-18		173	98	218	30	238	259	31	41	677	288	733	245	52	135	
2014-08-25		30	97	63	41	63	74		20	226	294	160	52	52	73	

Discussion

The enterococcus count results of this study contribute to our overall understanding of the watershed. But the results continue to be confounding in most cases. Answers to basic questions are still not always clear:

- Are there clear point sources of potential sewage contamination?

No. Though significantly higher counts are recorded along the main stem and tend to increase at sites further downstream. Contamination may indeed be a significant factor but if so it is likely to be from multiple and widespread sources. Alternatively, point sources may be present but they are masked by the general presence of enterococcus throughout the watershed.

- Is there evidence that higher counts during rainy periods are due to leaking sewer mains?

Not much. Sewer mains could be a direct source in some cases but very high counts are observed in areas far from sewer mains, at sites fed mostly by storm water, from developed areas served only by septic systems and from areas remote from any development.
But where sewer mains are present, especially along the main stem, mean counts are higher and they increase at sites further downstream. This increase with more contribution from the watershed as a whole may be related to sewer mains, septic systems, or other unknown sources.

- Do the results allow alternative explanations?

Yes. The Sparkill basin is interlaced with sewer mains but most if not all test sites along the main stem also have significant sediment levels. The depth of mud in and along the streambed increases at sites further downstream. This does not rule out sewage as an ultimate source, as sediment may simply serve to store bacteria from any source (including animals and plants). Increased counts during rainy periods may be due to release of bacteria from sediment storage rather than due to a rain-related increase in sewer main leakage.

It appears though that this and any explanation of enterococcus test results related to potential sources is bound to be complex. Some correlation with sediment levels can be seen by casual observation of both Riverkeeper's results and the results of this study: a relatively large increase in counts is observed as the creek approaches the two sewage treatment plants but also correlates with sediment levels; counts increase along trib 9a (SPC-09, 08, and 07) where no sewer lines are present – the upland counts on trib 9a are generally low, midstream is slightly higher (very muddy site) and the mouth is much higher (but located at the end of a long muddy wetland area).

- How useful is the enterococcus test for our goal of determining pathogen sources?

Apparently limited. The test offers some utility in gross identification of potential contamination. The results may ultimately lead to identification of pathogen sources but its utility in defining these sources comprehensively seems doubtful. Data collected during rain do not appear to be useful for our goal. The lingering effect of rain is not known so even defining acceptable dry test days is problematic. (The best correlation of rain to enterococcus counts was found to be the sum of rainfall on the test day and the day prior but other studies have used different periods; even in a small watershed like the Sparkill, rain occurs at some sites and not at others.) Beyond the question of rain and the large contribution from surface runoff, many questions remain on the certainty that these bacteria originate from human sources. A test developed to protect beaches from excursions at a nearby sewage outfall may not be suitable for our more complex freshwater environment.

Next Steps

Immediate Actions

1 Mean enterococcus counts at the Upper Blauvelt Arm (SPC-04) are substantially higher than any other site during dry weather. This site has two unusual factors: 1- it is fed from a small storm water detention basin from the Blauvelt area, 2- a sewage transfer pump is located very nearby. Sewage overflow at this pumping station or at adjacent pipes was noted within the last several years.[9] Another site with somewhat elevated counts is Closter Rd (SPC-12) this may also require follow up though no obvious source is evident. These results will be presented to the Orangetown Sewer District authorities for further investigation.

2 Though not part of this project, it should be noted that the Riverkeeper study cited above shows the Moturis site to have significantly higher mean enterococcus levels than other nearby sites. This site has many of the characteristics that correlate to high counts (downstream main stem, immediate runoff from paved areas, very high sediment level). However, there has been recent work by Rockland County to replace the Oak Tree Road bridge just upstream of this site. This work required the relocation of one or more sewer lines crossing the creek at this location. As in other areas, sediment may play a significant role. Sediment disturbance was extensive here and in the year prior at a location on the Sparkill Brook just upstream of the bridge. As above, our results will be forward to the local authorities for further investigation.

3 The Rockland County Department of Health, at the request of the New York State Department of Environmental Conservation, has conducted dye tracer tests on sanitary systems along the Sparkill in Piermont in the very recent past. The results of our study should be of value in their investigation. We hope to consult with these departments in the near future.

- Longer-term actions

1 Consult with local and state authorities on the significance of our findings and gain knowledge about pathogen source identification.

2 Continue a collaborative project with Dominican College using DNA techniques to identify enterococcus species in Sparkill samples.

3 Explore the use of alternative tests that may complement our studies with the continued goal of identifying pathogen sources.

4 Continue to share our experiences with local watershed or environmental groups, local and state authorities, local college professors, the Sparkill community and interested public.

The Citizen Science Project Experience

We value the data collected here, which we hope will form the foundation for a greater understanding of our watershed. But information produced in this project was not the only benefit. As an informal volunteer group we brought enthusiasm and commitment to this project. Just as important was learning the many other essential elements necessary for success. These elements are often taken for granted in our professional lives but only necessary for volunteer organizations when starting a structured project. Without a formal organization board, incorporation, insurance, or a bank account, we quickly realized that we were unprepared to be a contractor for this grant. Perhaps this was not the intent of this Citizen Science grant, but it spurred us to establish these important requirements.

[9] John Hayes, local resident. Personal communication.

We found that the agencies involved with this project have a high regard for citizen groups and the success of citizen science. Still, like us, they probably found themselves dealing with unexpected challenges particularly with a group like ours who had never contracted for any services or interacted with any of the several agencies involved.

Generally we found that the project was originally designed on an achievable schedule. A Federal shutdown in late 2013 delayed the initial planning at a critical time. The schedule was ultimately delayed to the limit but certainly not the fault of the planners. This initial period was the one of uncertainty and difficulty as we struggled to organize our capabilities, considerably revise our proposals, understand the processes of our funding agencies and project requirements, and meet a strained schedule. After the program started, there were some day to day problems but in general we were well trained and understood the program and how to make it work.

This citizen science project elevated our standing in the community particularly; invitations to participate in an advisory capacity on two recent local watershed issues were certainly influenced by our participation in the project. Further, the status afforded us by acceptance into this program allowed us to attract the university and student support that was essential to the project success.

In short, not only have we met our immediate goals for this project, it has benefited us in ways we had not anticipated.

Personnel and Acknowledgements

Our Team

Rutgers University

Dr. Brent Turrin – Faculty Advisor and Consultant

Anna Gravina and Rodrigo Jordy – Lead Samplers, Laboratory and Data Entry Specialists

Sparkill Creek Watershed Alliance

Robert Tompkins – Safety Officer, Sample Coordination, Budget Management

Rob Sturgeon – Sample and Laboratory Team

Jim Elling – Sample and Field Team

Laurie Peek – Sample and Field Team

Margaret Grace – Sample and Field Team

Larry Vail – Project Leader

Riverkeeper Inc.

Fiscal Agent and Consultant

Appreciation

We thank the Environmental Protection Agency for support of Citizen Science and especially the dedicated staff of Region 2 for their help and encouragement. This project was made possible through the administrative support of the New England Interstate Water Pollution Control Commission which we appreciate. Essential to our success has been the unflagging work of Gabriela Munoz of the Harbor and Estuary Program in guiding us through every step of this project.

Project Period: Jan. 1, 2014 – Jan. 15, 2015

Grant Award for this Project through NEIWPCC and the Hudson Estuary Program: $25,000

This project was funded by an agreement (I98297411) awarded by the Environmental Protection Agency to the New England Interstate Water Pollution Control Commission. Although the information in this document has been funded wholly or in part by the United States Environmental Protection Agency under agreement I98297411 to NEIWPCC, it has not undergone the Agency's publications review process and therefore, may not necessarily reflect the views of the Agency and no official endorsement should be inferred. The viewpoints expressed here do not necessarily represent those of NEIWPCC or U.S. EPA nor does mention of trade names, commercial products, or causes constitute endorsement or recommendation for use.

NEIWPCC Project Code 2014-006

SCWA Contact: Larry Vail 845 642 5044 Lawrencedvail@gmail.com

Appendix1 - Sparkill Creek Citizen Science Sample Locations

Site	Site Description	Latitude	Longitude
SPC-01	Tweed	41.070922°	-073.928047°
SPC-02	Marsico	41.0663667°	-073.9407333°
SPC-03	Inertia Switch (main stem)	41.054469°	-073.945072
SPC-04	Blauvelt Arm	41.0543333°	-073.9451500°
SPC-05	Blauvelt Arm at 303	*41.05515*	-073.94725
SPC-06	Blauvelt Arm at upstream detention	41.0590167°	-073.9560667°
SPC-07	Trib 9a at confluence	41.0390333°	-073.9372667°
SPC-08	Trib 9a at 340	41.03998	-073.93517
SPC-09	Trib 9a at Kings Hwy	41.0415	-073.93101
SPC-10	Sparkill Brook	41.00763	-073.93997
SPC-11	Sparkill Brook at Paris Ave	41.00341	-073.94065
SPC-12	Closter Rd	41.00822	-073.91865
SPC-13	Rt. 340 Sparkill	41.02576	-073.92716
SPC-14	Graney Gardens Outfall	41.02683	-073.92776
SPC-15	Skating Pond	41.02931	-073.92541
SPC-16	Ferdon Outfall	41.03429	-073.91965

Location ID	SPC-01
Location Description	Tweed

Latitude	41.070922°
Longitude	-073.928047°

Directions NE on Clausland Mtn Rd. Left (N) at stop sign (Tweed). Park immediately on Right.

Safety Traffic is light here but motorists are not expecting pedestrians. Cyclists appear from north noiselessly.

Site Site is on right side of road and a hundred feet down Tweed from parking.

Notes The site is on State Park land. This tributary originates to the east of the road in a wet area at the edge of the watershed. If there is no flow during dry conditions, seek water further east. Note that though this site is fairly remote, drainage from at least some part of one ressidential property across Clausland Mountain Rd. does enter the wet area that feeds this site.

Location ID: SPC-02

Location Description: Marsico

Latitude	41.0663667°
Longitude	-073.9407333°

Directions From 303 N, right (E) on Spruce and continue (or from Greenbush N) onto Clausland Mtn Rd. Left Valenza, Left Marsico Court. Park imme-diately on street. Site is on right

Safety Marsico is a dead end street. Traffic minimal.

Site Access via driveway to left of stream. Sample near culvert (upstream of road, north side). Include confluence of both the small stream and input from black culvert entering at this site.

Notes Also sampled for Riverkeeper program. This site is downstream of SPC-01 Tweed but the area in between has several small ponds/reservoirs. Some undoubtedly flow to this site but note inflow further up Marsico into this former wetland area. Note sewage pump station just up Marsico on right. Immediate neighbors interested in this project and are friendly.

Location ID: SPC-03

Location Description: Inertia Switch (main stem)

Latitude	41.054469°
Longitude	-073.945072

Directions
South on Greenbush Rd. to Inertia Switch. Right into parking lot. Sample at both SPC-03 and SPC-04 at this location.

Safety
Parking lot is an active work site. Be aware of trucks. Sampling site may be flooded during heavy rains. Wear at least knee high boots for wading to adjacent sample site (SPC-04)

Site
Walk north across lawn with stream on your left. Site is upstream 100' into wooded area on eastern bank. Sample above confluence of Blauvelt arm. Site SPC-04 is on this arm at left of photo.

Notes
Brian DiGeralamo at Inertia Switch is a long time friend of the Sparkill Creek and the SCWA. We have his permission to enter property. Park to far left of lot if possible or across Greenbush if lot is full. Don't harm his chickens.
brian@intertiaswitch.com
845) 359-8300
(845) 642-8344

Location ID: SPC-04

Location Description: Blauvelt Arm

Latitude	41.0543333°
Longitude	-073.9451500°

Directions As in SPC-03.
From SPC-03, wade across shallow section of creek to access this incoming tributary.

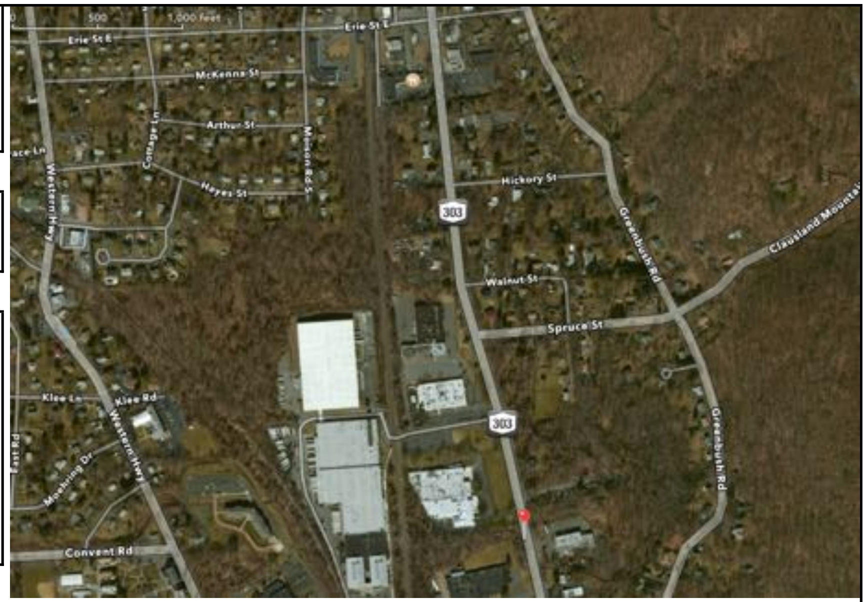
Safety As for SPC-03. Main stem of Sparkill is shallow above SPC-03 sample point even with moderate rain effect. Some deeper portions (3-4 ft.) at confluence. Blauvelt Arm also shallow. Knee high boots will ordinarily be sufficient.

Site Sample best at SW corner of this confluence. Photos are looking upstream.

Notes Under flood conditions this site may be better accessed from parking lot of building on Rt. 303 (Approximately 523 Rt 30, Orangeburg NY) - see path in photo here to back of building.

Location ID: SPC-05

Location Description: Blauvelt Arm at 303



Latitude	41.05515
Longitude	-073.94725

Directions South on Rt 303 past Glenshaw, park just past Instrumentation Laboratory entrance. Sample point is just off 303 on right down bank.

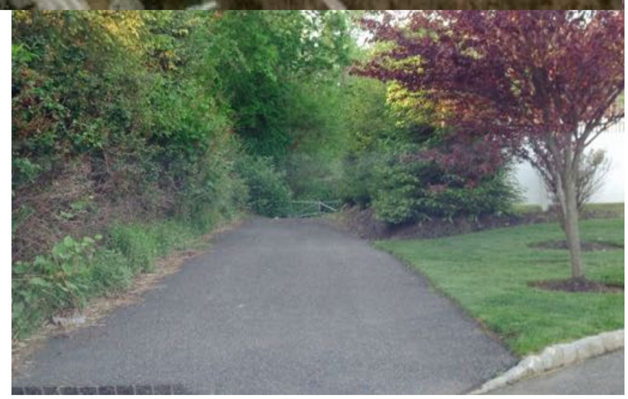
Safety Take care on busy Rt. 303. Park on 303 Right of Way - not parking lot.

Site Site is small tributary just west of Rt. 303 down bank just downstream the bend

Notes The original intent was to sample upstream of this location near the RR tracks however, access is Instrumentation Laboratory who declined (Jeanette DeGennaro EHS Compliance Manager, 845-365-8044). As a result the sample point is just downstream of the main Rockland County sewer line to the treatment plant. Elevated access covers visible on across stream from sample point.

Location ID:	SPC-06
Location Description:	Blauvelt Arm Upstream
Latitude	41.0590167°
Longitude	-073.9560667°

Directions From Western Hwy N, right on N Troop Rd then right on Murphy Ct to 2/3 around circle to access road in photo. Park on Murphy. Walk down road past gate.



Safety Many children play on this dead end street. Some concern by neighbors of transients at adjacent empty stores.

Site The access road joins the former railroad right of way now the Clarke Rail Trail. Site at outflow to the left of the trail past the detention pond in back of the house (photo at right taken from the trail).

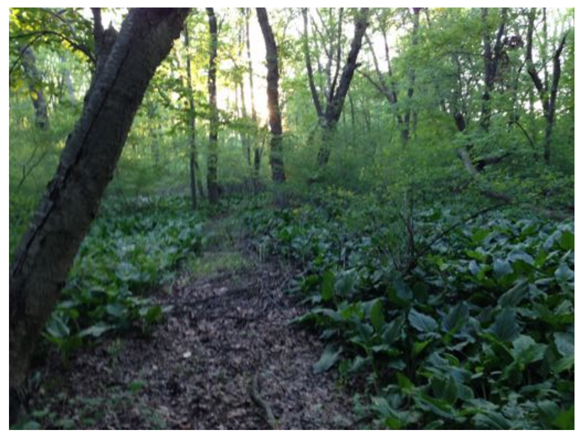
Notes Kali Ct shown on the map above <u>does not exist.</u> Note sewer pump station at Murphy Ct circle. John Hayes (cell 917 676 4817) at 14 Murphy Ct is aware of our work; use him as a reference if issues arise. This is on the Clarke Rail Trail, public property. Alternative access is from the left of Wally's Ice Cream on Western Hwy at end of parking lot at Trail sign. Modeled flow shows this site feeding SPC 05 but exact flow uncertain

Location ID:	SPC-07
Location Description:	Trib 9a at confluence

Latitude	41.0390333°
Longitude	-073.9372667°

Directions	NW on Rt. 340; turn rt to access road across from LIU building. (Park here for SPC-08 too). Walk across 340 past end of traffic circle and along NW side of building.

Safety	Route 340 is a relatively busy road. Take care. This site is accessed by a trail which is often muddy or even submerged. Rubber boots mandatory. **Poison ivy** is prevalent.



Site	Walk next to the LIU building to the end of the grass and into the woods. Follow an old trail 100 yards until the tributary is visible. Sample site is ~20 yard from the confluence with the Sparkill.

Notes	Alternative access from the rail trail at the Orangeburg WWTP. This requires wading the Sparkill. The LIU building is rented from the Venture Center. Mark Lukens at Camp Venture has granted us access with the cooperation of the site manager Diana Delollio (845 365 1316). Calling her a day before testing will help. We may get parking on the driveway circle.

Location ID:	SPC-08
Location Description:	Trib 9a at 340

Latitude	41.03998
Longitude	-073.93517

Directions	Route 340 to Dominican Convent entrance across from LIU . Park along the parallel access road for this site and SPC-07

Safety	**Poidon Ivy** is prevalent though low at beginning of season. This site is muddy. Recent storms have brought many downed trees; flow is restricted. Sampling may be easier to the left along the shore. Use of a pole will help avoid problems with the muddy bank.

Site	Site is across access road into the woods on the left (west) side.

Notes	This site is on border of the college and the convent. Messages to buildings manager are yet to be returned. This stream is directly downstream of SPC-09. Note clogged culvert in photo. When assessed in winter 2014 this site was more free flowing. Subsequently, blockage to the pond outfall has restricted the flow considerably.

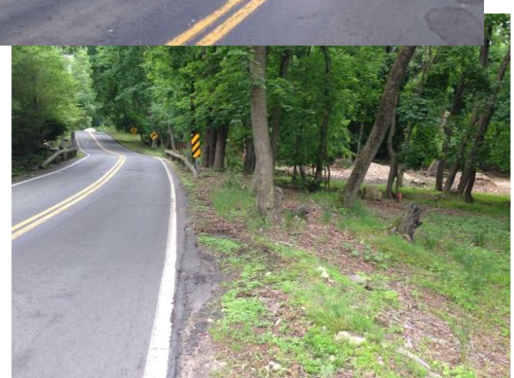
Location ID:	SPC-09
Location Description:	Trib 9a at Kings Hwy

Latitude	41.04150
Longitude	-073.93101

Directions	Kings Hwy from either Rt 303 or Rt. 340 to Dowling Gardens driveway (turn south) across road from 171 King's Hwy then immediate left to small lot right.

Safety	This road has minimal traffic but the curve and rise present limited visibility. This is a senior citizen facility.

Site	Site is back up the stream between the driveway and Kings Hwy. Approach from the left side (west).



Notes	This site is fed by a small pond in back (north) of 171 Kings Hwy. In the dry parts of the season when flow is low this pond may be substantially if not totally fed by a drinking water well overflow. Septic input higher up the watershed seems unlikely though some houses are situated there.

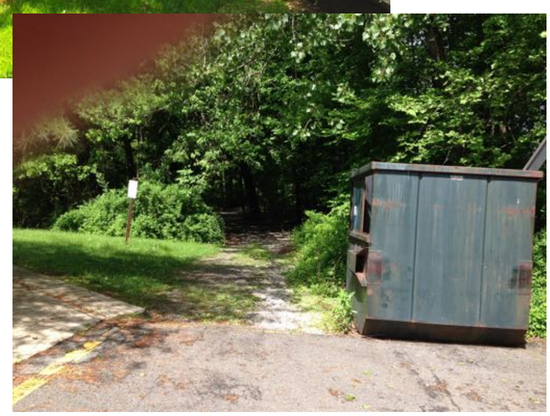
Location ID: SPC-10

Location Description: Sparkill Brook

Latitude	41.00763
Longitude	-073.93997

Directions North on Piermont Rd (340 in NY) past Willow. Take left (west) just before Link Dr. at one way road to Bergen Medical Center. Proceed straight to end and park.

Safety Observe one way street signs. Parking lot may hae multiple uses. Banks at the site are very muddy though trail and bridge are sound. Take care when driving out of this area past the fire house - pedestrians and slow moving cars.



Site Walk down trail past dumpster to Sparkill Brook. Site is on the near bank to the left of the bridge. Sampling done here for Riverkeeper project (blue circle). Plan on taking sample more conveniently from upstream side of bridge with pole (red circle).

Notes This area likely one of the older developments in this office park. Remains of old sewage treatment facility seen from the trail. When leaving, follow one way street out of parking lot to the right. This road exits to Piermont Road at intersection with Willow (see SPC-12)

Location ID: SPC-11

Location Description: Sparkill Brook at Paris Ave

Latitude	41.00341
Longitude	-073.94065

Directions Take Paris Ave. East from Livingston for about half mile. Take driveway right before Sparkill Brook bridge to park.

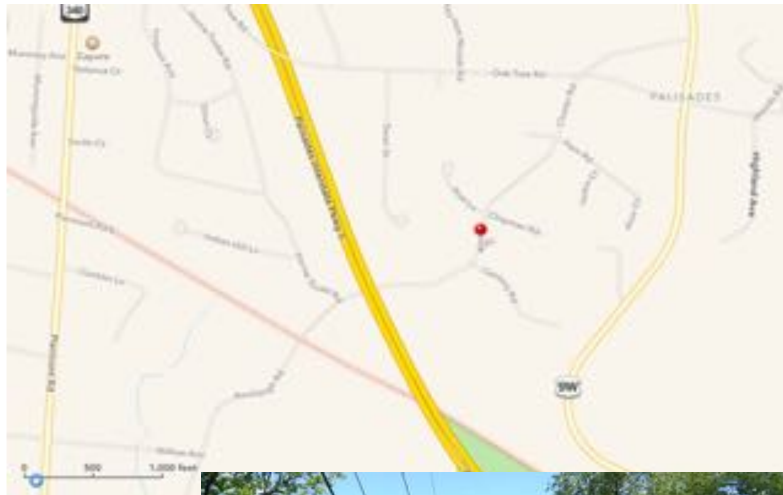
Safety Slope is somewhat steep but access next to bridge where purchase is possible.

Site Site is directly down the bank next to bridge.

Notes The stream flows from the Rockleigh Golf Course.

Location ID: SPC-12

Location Description: Closter Road

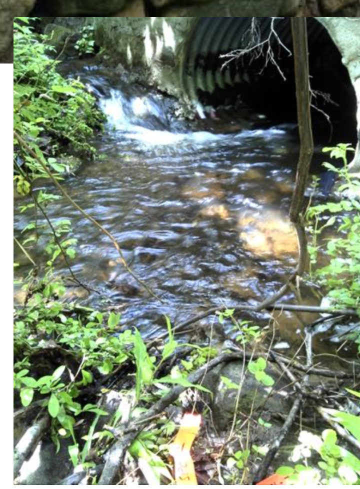


Latitude	41.00822
Longitude	-073.91865

Directions From Oak Tree Rd take Closter Rd south or from Piermont Rd north take Willow; turn left Closter to vicinity of Century Road for best parking. See Note

Safety Virtually no walkway on this narrow road between cars and the stone wall. Park on Willow. Care must be taken with the walls but they are low and ground relatively even.

Site Site is over rock wall on east side of road at catch basin. Best access is from adjacent driveway to the north where the stone wall is easy to get over. Note whether the sample represents both small streams or only one. Alternatively could be taken from road with pole.



Notes Will attempt communication with neighbors with driveway. This area has sewers in the street but little upstream of the site. Watershed ends approximately at Rt. 9W to the east.
Note that Willow Ave is one way (eastbound) during the morning hours so this site is best sampled after the NJ sites.

Location ID: SPC-13

Location Description: Rt. 340 Sparkill

Latitude	41.02576
Longitude	-073.92716

Directions Rt 340 south past firehouse and group of houses. Turn right (west) into bare parking area. Site is accessed at north end of the lot through trees (photo).

Safety **Poison Ivy** abounds in the short distance from parking lot to stream. Stream bank is very muddy.

Site Site is directly adjacent to the parking area with eroded muddy banks. This site may be easier sampled with a pole especially during wet periods.

Notes Parcel owned by Town of Orangetown. Slightly upstream of SPC-14 outfall. This site is sampled for the Riverkeeper project.

Location ID: SPC-14

Location Description: Graney Gardens

Latitude	41.02683
Longitude	-073.92776

Directions From Washington St (Main St, Sparkill) turn onto Williams St. Before road turns to left follow road straight to dead end. Park, follow dirt path straight on.

Safety This site is inundated with **poison ivy**. Some parts of the path may be muddy. Overgrowth contains thorns (cat briar and similar sharp plants)

Site Follow path to a bowl, frequently filled with water. Going around it to right to avoid much poison ivy. Exit bowl area two thirds of the way around (about 10 o'clock) via swale leading to stream. Site is a catch basin to left of swale 20 yards along. Listen for constant water falling. Sample this catch basin using pole.

Notes This catch basin (photo near right) feeds a second large pipe that empties into the stream (photo far right) where sampling would be difficult. Plus, in flood, the stream is above the pipe. Note after sampling season: the approach to this site has been cleared for development. This approach will be a street.

Location ID: SPC-15

Location Description: Skating Pond

Latitude	41.02931
Longitude	-073.92541

Directions North on Rt. 340 to stop sign in Sparkill. Bear ldft on 340, pass Ferdon Ave. Immediately pass over bridge and turn right to park.

Safety Relatively high traffic area at this intersection. Frequent cyclists. Water may be high after rain. Careful of sharp rocks.

Site Site is just down stream of bridge on North bank.

Notes This is likely the most sampled and tested site on the Sparkill, having been part of most studies in the last decade. Adminsistered by Village of Piermont, the pond is property of United Water; possibly same for this site.

Location ID:	SPC-16
Location Description:	Ferdon Outfall

Latitude	41.03429
Longitude	-073.91965

Directions	NEast on Ferdon from Rt 340 toward Piermont. Site is on right just prior to Rockland rd and bridge and before Outside Inn Gallery. Park on right before site.

Safety	Busy local road.

Site	The streamlet feeds the catch basin at right side of road from the right (south). Sample slightly upstream at the small footbridge.

Notes	This streamlet source is surface water from the homes along Rockland Rd. and Tallman park. It is small and may not be running in late summer - check upstream for more flow.

Appendix 2: Sparkill Creek Citizen Science Pathogen Indicator Test Plan–QAPP Addendum

See harborestuary.org/pdf/CitizenScience/SCWA_CS_QAPP_Addendum_Rev2.pdf

Appendix 3: Citizen Science Pathogen Monitoring–QAPP

See http://harborestuary.org/pdf/CitizenScienceFinal_CSPathogenMonitoringQAPPRev1_Signed.pdf

Appendix 4 - Replicate Testing of Site Results

Physical Data Replicates

Site: Date: Instrument:	Units	SPC-02 2014-06-23 YSI 556		SPC-15 2014-08-14 YSI ProPlus			Maximum Difference	Maximum Difference from Mean, %
Temperature	deg C	18.71	18.78	18.9	18.9	18.9	0.07	<1
Dissolved Oxygen	mg/l	9.12	8.82	6.05	5.68	5.14	0.91	8
pH		7.72	7.66	7.75	7.57	7.49	0.51	3
Specific conductance	μS/cm	490	488	477	477	477	1	<1
Conductivity	mS/cm	0.429	0.432	0.421	0.421	0.422	0.003	<1

Enterococcus Replicates

Test Date	Site	Enterococcus MPN/100ml		Mean	Difference	Difference from Mean, %
9-Jun-14	SPC-06	14136	9804	11970	4332	18
16-Jun-14	SPC-11	253	132	192.5	121	31
23-Jun-14	SPC-02	41	41	41	0	0
30-Jun-14	SPC-09	95	51	73	44	30
7-Jul-14	SPC-03	379	211	295	168	28
14-Jul-14	SPC-03	1274	1169	1222	105	4
28-Jul-14	SPC-07	481	457	469	24	3
31-Jul-14	SPC-06	281	246	263.5	35	7
4-Aug-14	SPC-15	350	336	343	14	2
11-Aug-14	SPC-02	179	142	160.5	37	12
14-Aug-14	SPC-15	1670	1374	1522	296	10
18-Aug-14	SPC-09	41	10	25.5	31	61
25-Aug-14	SPC-15	73	52	62.5	21	17

Appendix 5 - Comparison of Multimeter Instruments

Date	Determination	Units	YSI 556	YSI ProPlus	Difference from Mean, %	Note
30-Jun-14	Temperature, water	deg C	18.62	18.7	0.2	
30-Jun-14	pH		7.62	7.65	0.2	
30-Jun-14	Dissolved oxygen (DO)	mg/l	7.52	7.46	0.4	
30-Jun-14	Conductivity	mS/cm	0.818	0.774	2.8	
30-Jun-14	Specific conductance	uS/cm	932	880	2.9	
7-Jul-14	Temperature, water	deg C	19.3	19.4	0.3	
7-Jul-14	pH		7.5	7.59	0.6	
7-Jul-14	Dissolved oxygen (DO)	mg/l	7.2	7.35	1.0	
7-Jul-14	Conductivity	mS/cm	0.722	0.656	4.8	
7-Jul-14	Specific conductance	uS/cm	800	731	4.5	
14-Jul-14	Temperature, water	deg C	20.75	20.90	0.4	
14-Jul-14	pH		7.42	7.48	0.4	
14-Jul-14	Dissolved oxygen (DO)	mg/l	7.674	7.30	2.5	
14-Jul-14	Conductivity	mS/cm	0.695	0.558	**10.9**	
14-Jul-14	Specific conductance	uS/cm	639	606	2.7	
21-Jul-14	Temperature, water	deg C	18.32	18.5	0.5	
21-Jul-14	pH		7.61	7.66	0.3	
21-Jul-14	Dissolved oxygen (DO)	mg/l	7.41	8.14	4.7	
21-Jul-14	Conductivity	mS/cm	0.770	0.773	0.2	
21-Jul-14	Specific conductance	uS/cm	882	883	0.1	
28-Jul-14	Temperature, water	deg C	19.95	20.10	0.4	
28-Jul-14	pH		7.47	7.45	0.1	
28-Jul-14	Dissolved oxygen (DO)	mg/l	5.83	6.25	3.5	
28-Jul-14	Conductivity	mS/cm	0.803	0.803	0.0	
28-Jul-14	Specific conductance	uS/cm	891	886	0.3	
31-Jul-14	Temperature, water	deg C	17.48	17.6	0.3	
31-Jul-14	pH		7.56	7.33	1.5	
31-Jul-14	Dissolved oxygen (DO)	mg/l	7.87	7.9	0.2	
31-Jul-14	Conductivity	mS/cm	0.960	0.787	**9.9**	
31-Jul-14	Specific conductance	uS/cm	825	916	**5.2**	YSI ProPlus Post Calibration check somewhat high
4-Aug-14	Temperature, water	deg C	19.39	19.5	0.3	
4-Aug-14	pH		7.46	7.33	0.9	
4-Aug-14	Dissolved oxygen (DO)	mg/l	**7.42**	**5.86**	**11.7**	
4-Aug-14	Conductivity	mS/cm	**0.700**	**0.572**	**10.1**	
4-Aug-14	Specific conductance	uS/cm	780	639	**9.9**	Post calibration check normal
11-Aug-14	Temperature, water	deg C	20.5	20.3	0.5	Same beaker sample
11-Aug-14	pH		7.61	7.69	0.5	
11-Aug-14	Dissolved oxygen (DO)	mg/l	7.49	7.20	2.0	
11-Aug-14	Conductivity	mS/cm	0.859	0.843	0.9	
11-Aug-14	Specific conductance	uS/cm	938	927	0.6	
14-Aug-14	Temperature, water	deg C	18.1	18.3	0.5	
14-Aug-14	pH		7.4	7.6	1.3	
14-Aug-14	Dissolved oxygen (DO)	mg/l	7.29	6.4	**6.5**	
14-Aug-14	Conductivity	mS/cm	0.684	0.637	3.6	
14-Aug-14	Specific conductance	uS/cm	784	731	3.5	
18-Aug-14	Temperature, water	deg C	17.0	17.3	0.9	
18-Aug-14	pH		7.46	7.66	1.3	
18-Aug-14	Dissolved oxygen (DO)	mg/l	7.89	7.14	5.0	
18-Aug-14	Conductivity	mS/cm	0.810	0.777	2.1	
18-Aug-14	Specific conductance	uS/cm	946	912	1.8	
25-Aug-14	Temperature, water	deg C	17.8	17.9	0.3	
25-Aug-14	pH		7.48	7.69	1.4	
25-Aug-14	Dissolved oxygen (DO)	mg/l	8.0	7.35	4.2	
25-Aug-14	Conductivity	mS/cm	**1.218**	**0.797**	**20.9**	
25-Aug-14	Specific conductance	uS/cm	1406	920	**20.9**	YSI 556 Calibration post check barely within limit