Swamp River

Baseline Water Quality Assessment

Dutchess County, New York

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Executive Summary

In 2009, a group of scientists, river advocates and government officials gathered to discuss alarming trends in the health of Dutchess County's Swamp River. Recent monitoring along the River indicated a decline in water quality as compared to previous years, and polluted runoff from agricultural and developed landscapes was thought to be the primary cause. While the Swamp River was not yet seriously degraded, these water quality observations combined with new development in the watershed warned of more severe impacts were possible in the future without intervention.

The 2009 gathering (called the Swamp River Scientific Advisory Council) evaluated existing water quality information for the Swamp River and identified the need for a base-line assesment of water chemistry, as well as concentrations of bacterial colonies associated with pollution. The assessment was conducted in 2010, and is described in this report. This information will allow for better understanding of water quality trends and the impacts of land-use changes in the watershed

This initial assessment found water quality impacts commonly associated with urban stormwater runoff at the headwaters, where there is denser development associated with the Village of Pawling. The relationship between development and water quality degradation is well understood and well documented. Without the incorporation of stormwater management systems that mimic natural hydrology, additional polluted runoff from new development in the watershed will further degrade water quality in the Swamp River.

Two downstream sites showed elevated nutrients and associated eutrophication, as well as elevated coliform bacteria levels. Further study is required to determine the source of these contaminants, although livestock, faulty septic systems or some combination of the two are likely possibilities.

Given that water quality has already begun to deteriorate in response to current land use, and further impacts associated with development in the watershed are likely, we recommend the following next steps:

- Reconvene the Swamp River Scientific Advisory Committee and other partners working in the watershed to share data and coordinate future activities;
- Share the results of this study with watershed municipalities and work towards the adoption of LID and other practices for limiting polluted runoff from development;
- Identify priority stream reaches for restoration;
    - Map existing riparian vegetation and identify areas of degraded buffer.
    - Identify zones of high pollutant loading based on water quality data, physical assessments, and land-use analysis.
    - Undertake a "build-out" analysis of watershed to understand potential extent/distribution of land use change under current municipal regulations.
- Conduct further monitoring at the five sites evaluated during this study to deepen understanding of water quality trends and sources of impairment.

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- Dr. Stuart Findlay, Aquatic Ecologist, Cary Institute of Ecosystem Studies
- Vijay Gandhi, NYSDEC, Region 3, Division of Water
- Sibylle Gilbert, Vice President, Oblong Land Conservancy
- Vicky Kelly, Manager, Environmental Monitoring Program, Cary Institute of Ecosystem Studies
- Dr. Michael Klemens, Research Conservationist, Cary Institute of Ecosystem Studies
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Introduction

In 2007 and 2008, NYSDEC performed an inventory and assessment of waters within the New York portion of the Housatonic River watershed, including lands within the Tenmile, Green and Williams drainages[1]. This assessment found that the New York portion of the Housatonic watershed as a whole was healthy; only 34 of 379 stream miles (less than 10%) of the Housatonic-bound streams in New York were impacted enough to be included on the Priority Waterbodies List[2].

Water quality issues identified in the watershed were in large part localized to the Swamp River, a sub-basin of the Tenmile River. All 34 listed stream-miles were found within the Swamp River drainage. These reaches were listed as "stressed", indicating that they were still supporting their designated uses, but there was noticeable evidence of water quality impacts and potentially worsening conditions. The report notes that bioindicator macroinvertebrates were collected from the Swamp River in1992 and again in 2002, with the 2002 results indicating a noticeable decline in conditions. While the report is not definitive in identifying the cause of these water quality impacts, it lists non-point source nutrient pollution as a suspected factor[3].

In response to NYSDEC's findings and the potential for further deterioration of water quality in the Swamp River, stakeholder groups from the region formed the Swamp River Scientific Advisory Council (SAC). The SAC convened its first meeting in 2009. Participants included the Cary Institute of Ecosystem Studies, Friends of the Great Swamp (FrOGS), Housatonic Valley Association (HVA), Oblong Land Conservancy, Marist College, NYSDEC, Pawling Conservation Advisory Council, and the Pawling Corporation. The SAC determined that this base-line water quality study of the Swamp River was necessary in order to evaluate the environmental impacts of any proposed development. SAC partners initiated the study in spring 2010.

Swamp River Overview:

The Swamp River's headwaters flow from southeastern New York's largest freshwater wetland complex, the Great Swamp. The Great Swamp has been recognized as ecologically significant by a variety of government agencies and organizations[4]. It supports a diverse biota, including several rare and declining

[1] Under the Clean Water Act, the New York State Department of Environmental Conservation (NYSDEC) must provide regular assessments of water quality and the ability of particular waters to support the uses for which they have been designated (water supply, public bathing, aquatic life, secondary recreation, etc.). NYSDEC conducts inventory and assessment of water resources on a rotating basis within all of New York's major watersheds, and returns to each watershed every two or three years. In addition to documenting waters that are healthy, the information gathered during these watershed-based studies is used to identify waters that are currently supporting their designated uses but are at risk, and to identify waters that are not currently supporting designated uses. These waters are included on New York State's Priority Waterbodies List (PWL).

[2] New York State Department of Environmental Conservation (NYSDEC). 1998. *Housatonic River Basin Waterbody Inventory and Priority Waterbodies List.* (http://www.dec.ny.gov/docs/water_pdf/pwlhous08.pdf)

[3] ibid

[4] Dutchess County. 1992. Critical Environmental Area Designation. (http://www.dec.ny.gov/permits/25141.html)
Putnam County. 1998. Critical Environmental Area Designation. (http://www.dec.ny.gov/permits/25113.html)

species[5]. Waters within the nine-square-mile wetland divide into a northward flow and a southward flow. The northward flow, which is carried by the Swamp River and its tributaries, is the focus of this study.

The Swamp River is one of three major sub-basins of the Tenmile River, which is tributary to the Housatonic River (Figure 1). While The Tenmile basin is located almost entirely within New York, it flows into Connecticut and joins the Housatonic on the Kent-New Milford border, just below Bull's Bridge. The Tenmile basin covers nearly 210 square miles, extending from the town of Northeast south, through the towns of Amenia and Dover, and into Pawling (Figure 2).

The Swamp River originates in Pawling, New York, and runs northward for 13 miles before reaching its confluence with the Tenmile River at Dover Plains, New York. The Swamp/Tenmile confluence is located slightly northeast of the intersection of Old Post Road and Lime Kiln Road. Three main tributaries flow into the Swamp River downstream of the headwater branches: the Mill River drainage, which includes Stony Brook, Beaver Brook, Doctors Brook, and Coopertown Brook, drains the northwestern portion of the watershed; Burton Brook drains the west central portion of the watershed; and Hiller Brook drains the southwestern portion of the watershed (Figure 3).

Land use/land cover in the watershed is predominantly rural in character, with small population centers surrounded by large tracts of native forest and agricultural lands. According to the 2006 National Land Cover Dataset, only about 4% of the watershed was developed as of 2006, but that development was notably concentrated near the streams within the basin (Figure 4). Historic development adjacent to the river has included floodplain encroachment and channel modifications, particularly near the developed areas of Pawling and Dover.

Audubon Society. 2002. Important Bird Area Designation-Open Space Conservation Plan. (http://netapp.audubon.org/iba/site/756)

The Nature Conservancy. 1999. *The Great Swamp: A Watershed Conservation Strategy*. (http://www.nature.org/ourinitiatives/regions/northamerica/unitedstates/newyork/placesweprotect/easternnewyork/wherewework/eastern-great-swamp.xml)

[5] ibid

Stevens, Gretchen. 2010. "Cool Ravines and other Biodiversity Hotspots in the Town of Dover" *News from Hudsonia* 24:1 (Summer)

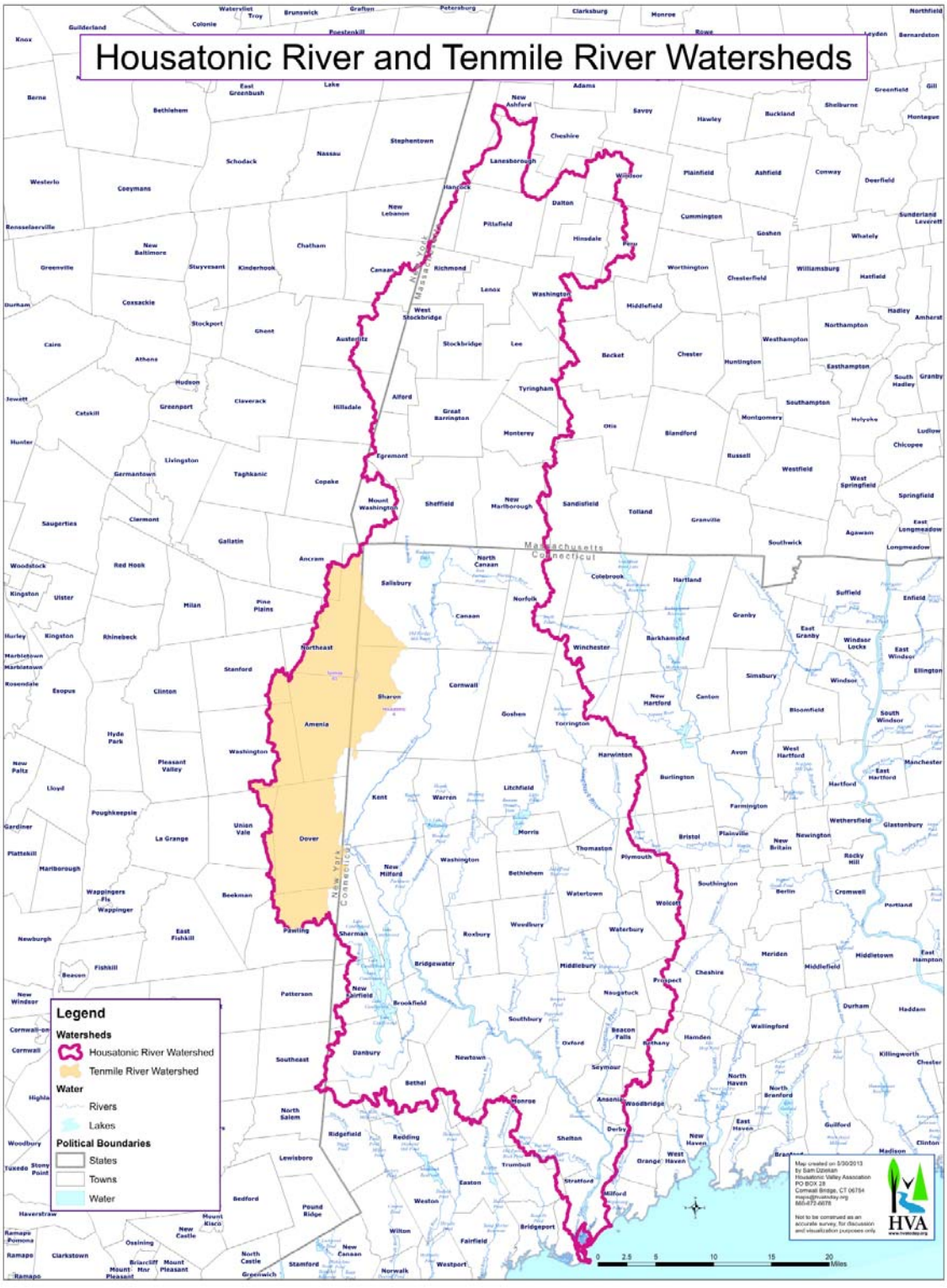


Figure 1. The Housatonic River Basin, including the Tenmile River Watershed highlighted in orange.

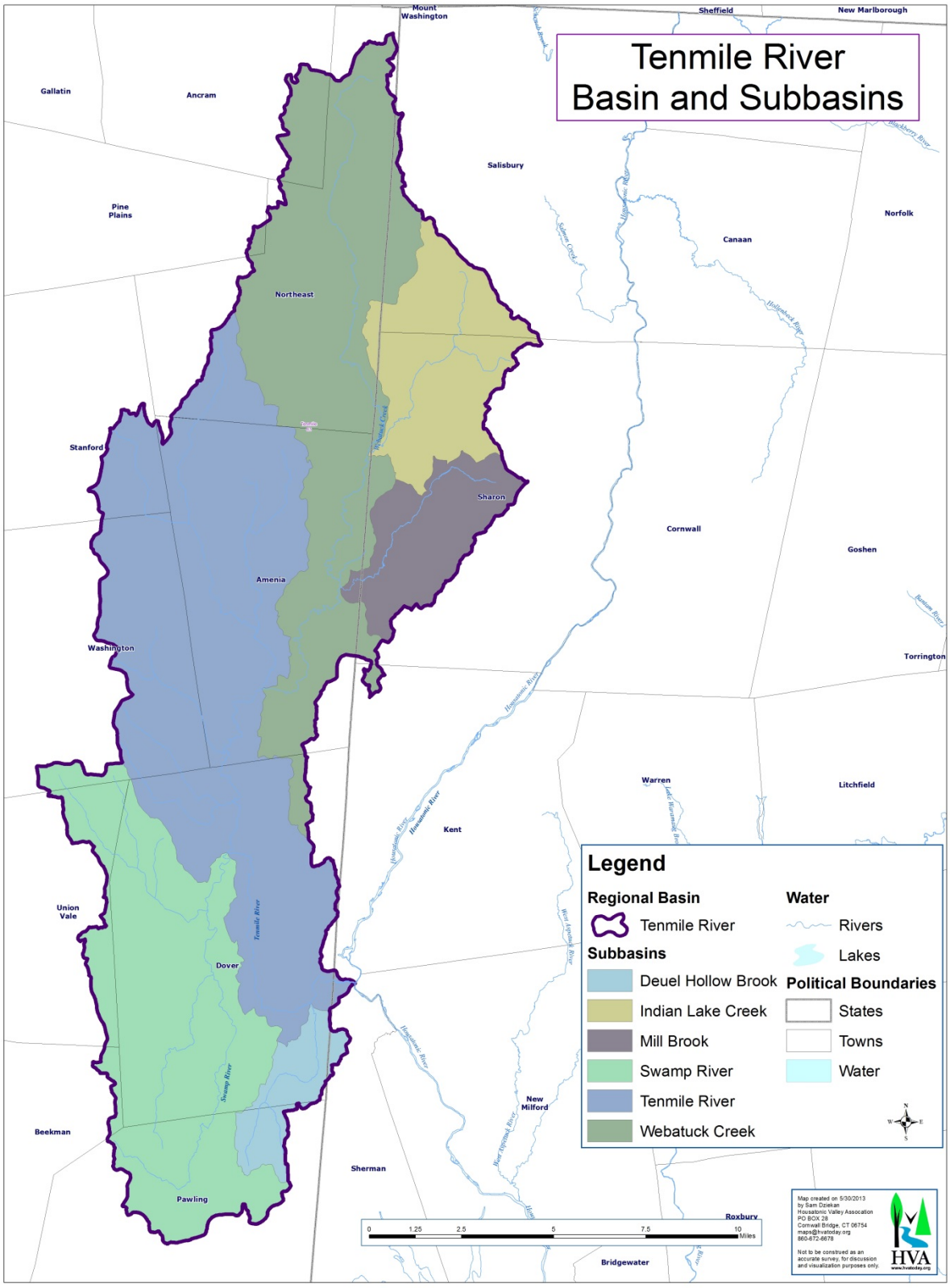


Figure 2. The Tenmile River Watershed, with the Swamp River sub-basin in the south.

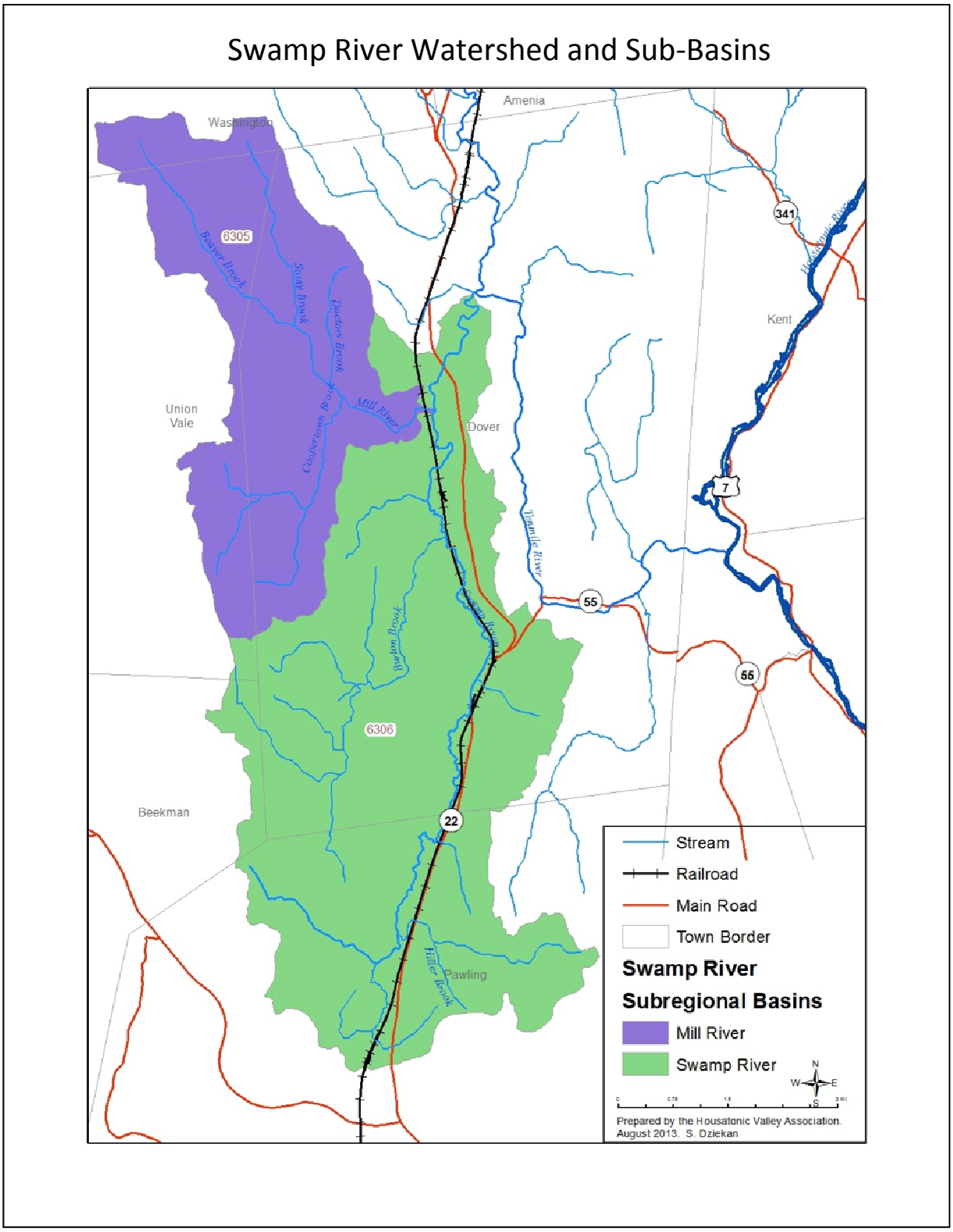


Figure 3. Swamp River Watershed and Sub-Basins

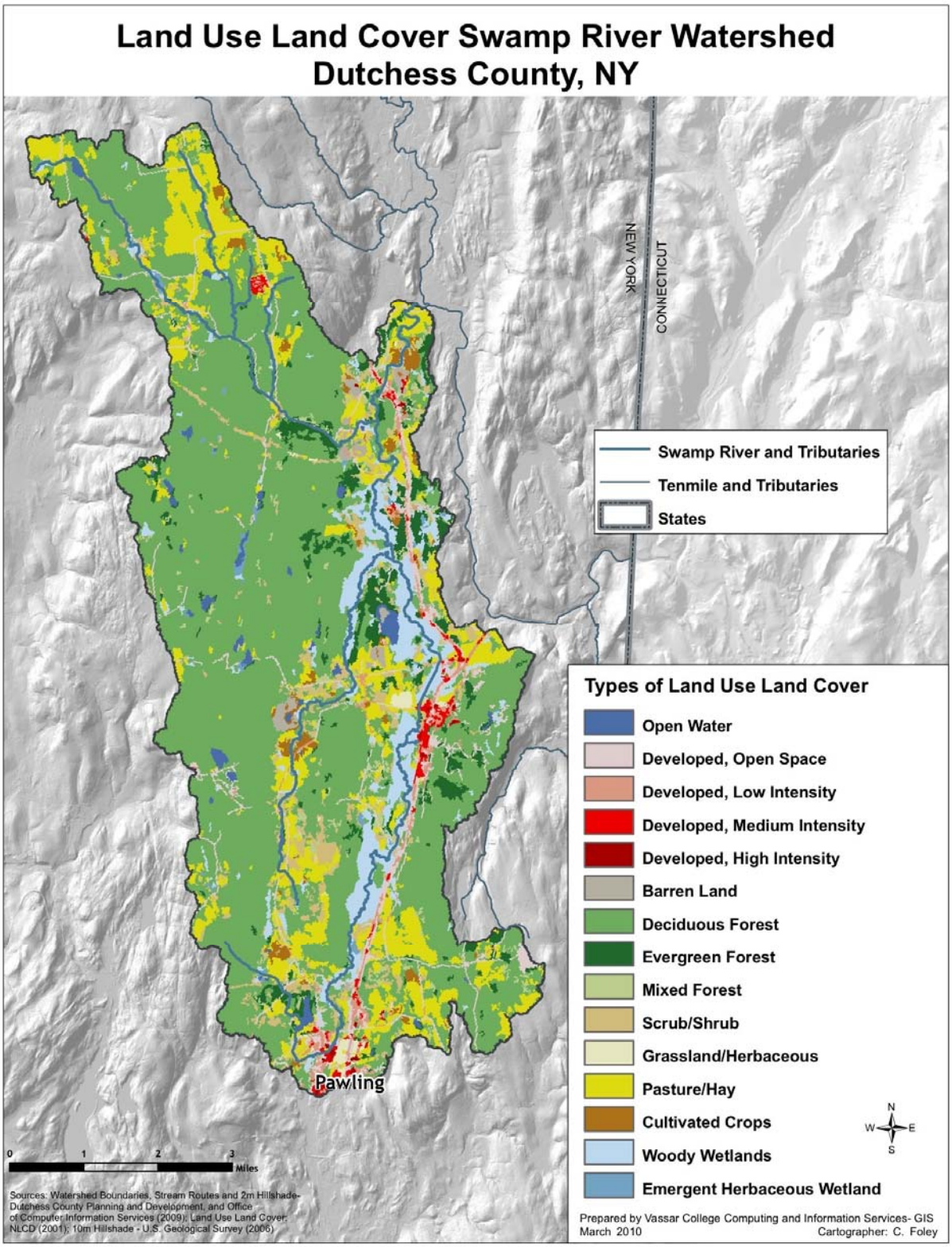


Figure 4. Swamp River Land Use (Source: NLCD 2006)

Study Objectives

The 2010 Swamp River baseline water quality assessment was intended to be 'Phase I' of a longer-term, more comprehensive effort to identify water quality impairments and threats, to enable the development of a Swamp River Sub-basin management plan. This preliminary assessment sought to:

1. Work with the Swamp River Scientific Advisory Council to identify five (5) sites located along the Swamp River main stem, which would provide a meaningful and reliable overview of existing water quality conditions in the sub-basin.

2. Collect and test water quality samples at the selected sites from early spring through fall for a single calendar year. Water quality parameters to be tested included those possessing a known response to watershed land use changes, in particular those that would be expected to change as development in the sub-basin increases - e.g. nutrients (phosphorous and nitrogen), pathogens (coliform bacteria), and other chemicals associated with management of the human landscape - either direct (magnesium, calcium, sodium) or indirect (dissolved oxygen, total dissolved solids).

3. Based on these baseline results, identify areas of concern within the study area that may warrant further monitoring.

4. Report findings with sub-basin stakeholder groups and other interested parties.

Study Site Selection

The main stem of the Swamp River is approximately 13 miles in length. It was determined that five sites would be sufficient to capture the spatial variability of water quality conditions along the length of the river. Study sites were selected to ensure safe access and presence of necessary sampling conditions (i.e. water deep enough to sample). Sites were also strategically distributed along the river to try to capture priority areas of concern – either those areas currently believed to be contributing to a decline in water quality, or those locations proposed for future development.

Five sites were ultimately selected (Figure 5): adjacent to the Pawling Corporation facility (Town of Pawling), at Murrow Park (Town of Pawling), upstream of the Appalachian Trail footbridge crossing (Town of Pawling), near the Wheeler Road DEC fishing access (Town of Dover), and upstream of the Old Post Road bridge (Town of Dover).

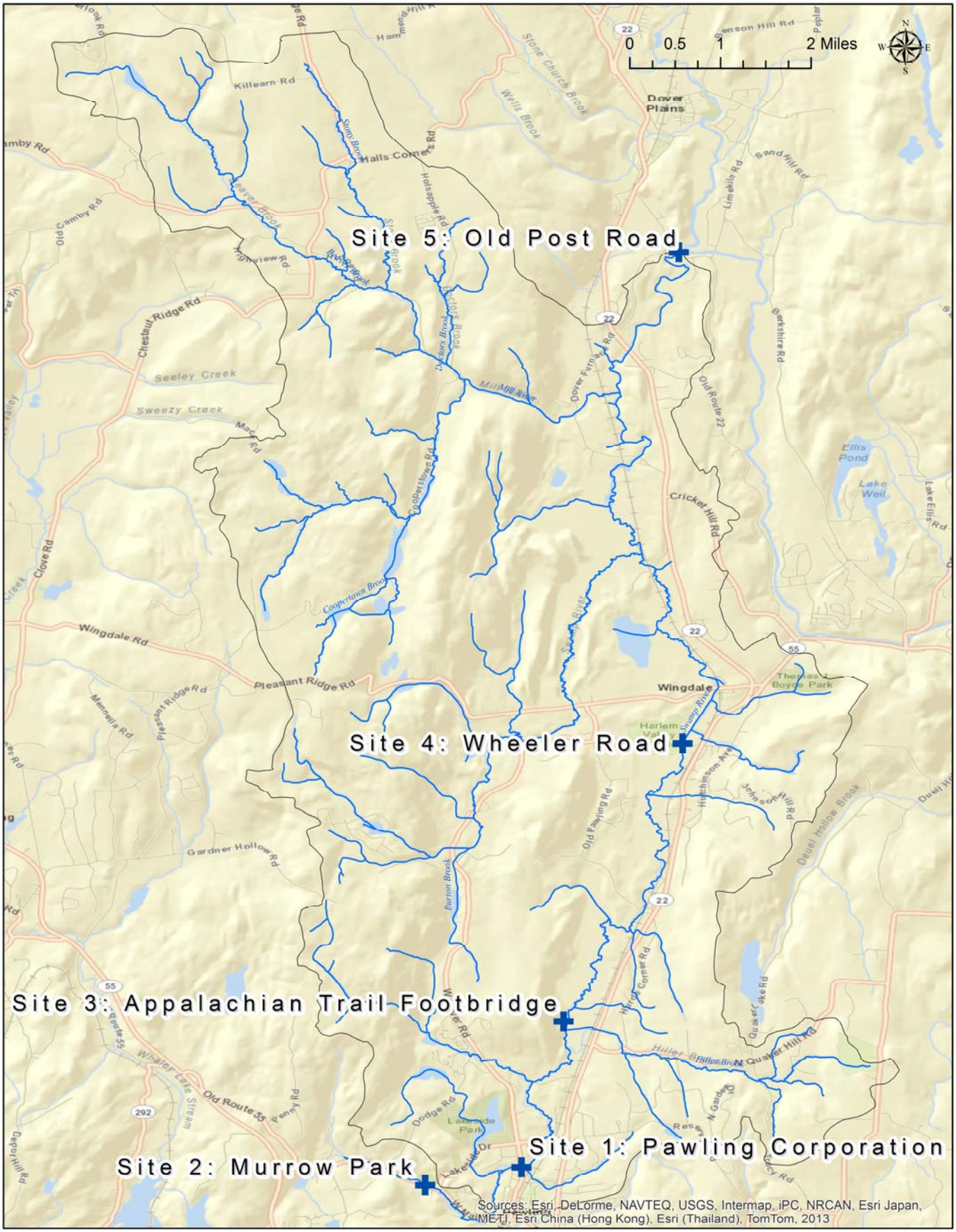


Figure 5: Sites selected for water quality testing.

Table 1. Locations and rationale for choosing each of the sites used in baseline surveys of Swamp River watershed water quality. Listed from upstream to downstream (south to north)					
Site	**Name & Description**	**Location**	**Rationale**	**Latitude**	**Longitude**
1	Pawling Corp. (parking lot, right rear, upstream culvert)	Coleman Rd. Pawling,N.Y.	North of river divide; downstream Pawling STP outflow	41.571889	-73.597240
2	Murrow Park (adjacent gazebo)	Lakeside Drive Pawling,N.Y.	Head of northern basin	41.567816	-73.615386
3	Appalachian Trail Footbridge (upstream)	Route 22 Pawling,N.Y.	Downstream of Hiller Brook Confluence	41.594018	-73.592895
4	Wheeler Road (adjacent DEC fishing access)	Wheeler Road Dover,N.Y.	Location of former Harlem Valley Psychiatric Facility and proposed mixed-use development	41.638148	-73.574069
5	Old Post Road (upstream)	Old Post Road Dover,N.Y.	Upstream of confluence with Tenmile River	41.715436	-73.575579

Methods

Each site was sampled for a suite of chemical parameters (Table 2). As a quality control check, samples were split and analyzed by two independent laboratories (Smith Laboratory in Hyde Park, N.Y.and the Cary Institute of Ecosystem Studies in Millbrook, N.Y.). The laboratories tested the samples for a common suite of parameters including phosphate, ammonia, nitrate-nitrogen, calcium, potassium, magnesium, sodium and sulfate. (Each laboratory also analyzed samples for several unique parameters as noted in Table 2). Samples were also collected from each site and preserved with sodium thiosulfate to be analyzed by Smith Laboratory for total coliform bacteria and *Escherichia coli* (E. coli) bacteria.

Sites were sampled by HVA staff and volunteers on April 20, June 23, August 18, and October 13, 2010. Sampling dates were selected randomly in advance. On each date sites were sampled in numerical order beginning with Site 1. Sampling began at approximately 9:30 AM and concluded before noon.

Bottles containing preservatives were stored in a cooler on ice both before and after the sampling event. Samples were delivered to the laboratory for analysis during the same day as the sampling event (within 6.5 hours of the first sample collection).

Table 2. Water quality variables measured during baseline surveys of Swamp River watershed			
Parameter	**Abbreviation**	**Smith Lab.**	**Cary Institute**
Total Dissolved Phosphorus	TDP		X
Phosphate as P	PO4-P	X	X
Total Dissolved Nitrogen	TDN		X
Total Kjeldahl Nitrogen	TKN	X	
Ammonia, as Nitrogen	NH3-N	X	X
Nitrate-Nitrogen	NO3-N	X	X
Nitrite-Nitrogen	NO2-N	X	
Calcium	Ca++	X	X
Potassium	K	X	X
Magnesium	Mg	X	X
Sodium	Na+	X	X
Chloride	Cl-		X
Sulfate	SO4	X	X
Solids, Total Dissolved	TDS	X	
Dissolved Oxygen	DO	X	
pH	pH		X
Conductivity	Conductivity		X

Results

Table 3. Dissolved Oxygen (DO), conductivity, and pH at Swamp River watershed sites during baseline surveys. For each parameter, the reference value is shown[6]. Results falling outside of the reference value are highlighted in red.

	April 20			June 23 (Heavy rainfall within 24 hours)			Aug 18 (Heavy rainfall with 72 hours)			October 13		
	DO	Conductivity (Cary)	pH (Cary)	DO	Conductivity (Cary)	pH (Cary)	DO	Conductivity (Cary)	pH (Cary)	DO	Conductivity (Cary)	pH (Cary)
Units	mg/L	µmhos/cm	pH Units	mg/L	µmhos/cm	pH Units	mg/L	µmhos/cm	pH Units	mg/L	µmhos/cm	pH Units
Reference	>6.0	150-500	6.5-8.5	>6.0	150-500	6.5-8.5	>6.0	150-500	6.5-8.5	>6.0	150-500	6.5-8.5
1: Pawling Corp.	10.9 @ 16 C	**708**	8.4	8.3 @ 18 C	**720**	8.3	8.0 @ 16 C	**1080**	8.4	9.3 @ 14 C	**946**	8.2
2: Murrow Park	11.6 @ 12 C	340	8.2	9.3 @ 18 C	419	8.1	9.2 @ 17 C	557	8.4	10.8 @ 13 C	394	8.1
3: AT Trail	9.6 @ 13 C	445	8.0	5.0 @ 22 C	**670**	8.2	**2.8 @ 18 C**	**705**	8.2	**4.1 @ 13 C**	518	8.0
4: Wheeler Rd.	8.3 @ 16 C	416	8.1	6.7 @ 20 C	588	8.0	6.3 @ 20 C	**626**	8	**4.3 @ 13 C**	451	8.0
5: Old Post Rd.	11.9 @ 14 C	316	8.2	9.5 @ 20 C	359	8.0	9.9 @ 17 C	518	8.3	10.6 @ 14 C	324	8.0

[6] Federal standards: pH for Class AA, A, B, and C water shall not be less than 6.5 nor more than 8.5; for Class AA(T), A(T), B(T), and C(T) trout waters, the minimum daily average DO levels shall not be less than 6.0 mg/L and at no time shall the concentration be less than 5.0 mg/L. Findlay et al (2010) report that studies of inland fresh water indicated that stream supporting good mixed fisheries had a conductivity range of 150 to 500 µmhos/cm.

Table 4. Total Dissolved Phosphorous & Phosphate Results												
	April 20			June 23 (Heavy rainfall within 24 hours)			Aug 18			Oct 13		
	TDP	PO4-P (Smith)	PO4-P (Cary)	TDP	PO4-P (Smith)	PO4-P (Cary)	TDP	PO4-P (Smith)	PO4-P (Cary)	TDP	PO4-P (Smith)	PO4-P (Cary)
Units	mg/L			mg/L			mg/L			mg/L		
Reference		<0.1 mg/L*			<0.1 mg/L*			<0.1 mg/L*			<0.1 mg/L*	
1: Pawling Corp	0.011	<0.05	0.003	0.016	0.05	0.01	0.024	<0.05	0.019	0.011	<0.05	0.008
2: Murrow Park	0.01	<0.05	0.002	0.017	<0.05	0.013	0.01	0.05	0.009	0.006	0.08	0.003
3: AT Trail	0.046	0.08	0.042	0.035	0.06	0.029	0.093	**0.15**	0.081	0.102	**0.15**	**0.105**
4: Wheeler Rd.	0.027	**0.12**	0.019	0.028	**0.16**	0.017	0.043	**0.20**	0.028	0.035	<0.05	0.029
5: Old Post Rd.	0.013	<0.05	0.006	0.023	0.05	0.017	0.021	0.06	0.013	0.018	<0.05	0.014

*To control eutrophication, USEPA recommends limiting phosphate concentrations to .05 mg/L in waters that drain to lakes, ponds, reservoirs, and 0.1 mg/L in free flowing rivers and streams[7]

[7] USEPA 1996. "Technical Guidance Manual for Developing Total Maximum Loads." *Book II: Streams and Rivers. Part 1: Biochemical Oxygen Demand/Dissolved Oxygen and Nutrients/Eutrophication*. N.p., n.d. Web. <http://water.epa.gov/scitech/datait/models/upload/2006_12_05_standards_tmdl_guidance.pdf>.

Table 5. Total Dissolved Nitrogen (TDN), Total Kjeldahl Nitrogen (TKN), Ammonia (NH3-N), Nitrate (NO3-N), and Nitrite(NO3-N) Results

	April 20							June 23 (Heavy rainfall within 24 hours)							August 18							October 13						
	TDN	TKN	NH3-N (Smith)	NH3-N (Cary)	NO3-N (Smith)	NO3-N (Cary)	NO2-N	TDN	TKN	NH3-N (Smith)	NH3-N (Cary)	NO3-N (Smith)	NO3-N (Cary)	NO2-N	TDN	TKN	NH3-N (Smith)	NH3-N (Cary)	NO3-N (Smith)	NO3-N (Cary)	NO2-N	TDN	TKN	NH3-N (Smith)	NH3-N (Cary)	NO3-N (Smith)	NO3-N (Cary)	NO2-N
Units	mg/L	mg/L	mg/L		mg/L		mg/L	mg/L	mg/L	mg/L		mg/L		mg/L	mg/L	mg/L	mg/L		mg/L		mg/L	mg/L	mg/L	mg/L		mg/L	mg/L	mg/L
Reference			<0.035 mg/L							<0.035 mg/L							<0.035 mg/L							0.035 mg/L			
1: Pawling Corp.	1.05	< 1.0	< 1.0	<0.02	0.99	0.99	< 0.01	0.87	< 1.0	< 1.0	0.03	0.78	0.75	< 0.01	1.1	< 1.0	< 1.0	<0.02	1.02	0.99	< 0.01	1.29	< 1.0	< 1.0	<0.02	0.09	1.18	< 0.01
2: Murrow Park	0.35	< 1.0	< 1.0	<0.02	0.32	0.32	< 0.01	0.55	< 1.0	< 1.0	0.02	0.46	0.48	< 0.01	0.45	< 1.0	< 1.0	<0.02	0.43	0.37	< 0.01	0.52	< 1.0	< 1.0	<0.02	0.18	0.4	< 0.01
3: AT Trail	0.64	< 1.0	< 1.0	**0.04**	0.52	0.55	< 0.01	0.51	< 1.0	< 1.0	0.03	0.24	0.24	< 0.01	0.57	< 1.0	< 1.0	**0.12**	0.08	0.04	< 0.01	1.18	< 1.0	< 1.0	**0.12**	0.84	0.86	0.02
4: Wheeler Rd.	0.11	< 1.0	< 1.0	<0.02	<0.01	<0.02	< 0.01	0.4	< 1.0	< 1.0	0.03	<0.01	<0.02	< 0.01	0.55	< 1.0	< 1.0	<0.02	0.06	<0.02	< 0.01	0.63	< 1.0	< 1.0	**0.04**	0.38	0.17	< 0.01
5: Old Post Rd.	0.09	< 1.0	< 1.0	<0.02	0.03	0.03	< 0.01	0.47	< 1.0	< 1.0	<0.02	0.30	0.31	< 0.01	0.36	< 1.0	< 1.0	<0.02	0.17	0.13	< 0.01	0.34	< 1.0	< 1.0	<0.02	1.17	0.12	< 0.01

Comments – AT Trail – slightly elevated ammonia levels (Based upon NYSDEC standard of <35 ug/L given pH 8.0-9.0 and temperature 15-30C for un-ionized ammonia)[8].

[8]NYSDEC 1999. Env. Conservation Regulations Chapter X, Part 703: Surface Water and Groundwater Quality Standards and Groundwater Effluent Limitations. (http://www.dec.ny.gov/regs/4590.html)

Table 6. Potassium (K+), Magnesium (Mg++), and Sulfate (SO4--) Results

	April 20						June 23 (Heavy rainfall within 24 hours)						Aug 18						October 13					
	K+ (Smith)	K+ (Cary)	Mg++ (Smith)	Mg++ (Cary)	SO4—(Smith)	SO4 – (Cary)	K+ (Smith)	K+ (Cary)	Mg++ (Smith)	Mg++ (Cary)	SO4—(Smith)	SO4 – (Cary)	K+ (Smith)	K+ (Cary)	Mg++ (Smith)	Mg++ (Cary)	SO4—(Smith)	SO4 – (Cary)	K+ (Smith)	K+ (Cary)	Mg++ (Smith)	Mg++ (Cary)	SO4—(Smith)	SO4 – (Cary)
Units	mg/L		mg/L		mg/L	mg/L	mg/L		mg/L		mg/L	mg/L	mg/L		mg/L		mg/L	mg/L	mg/L		mg/L		mg/L	mg/L
Reference			<35 mg/L						<35 mg/L						<35 mg/L						<35 mg/L			
1: Pawling Corp.	3.79	41.5	26.2	26.1	17	16.6	4.47	4.35	24.2	23.6	14	13.5	5.7	5.69	34.1	33.1	19	18.4	5.19	5.58	33.5	31.5	21	20.4
2: Murrow Park	2.88	21.4	10.4	10	13	13.3	3.95	4.06	12.1	11.5	12	11.4	4.93	5.03	17.5	16.5	17	16	3.62	3.9	11.5	10.4	18	17.9
3: AT Trail	3.4	22.9	15.8	15.6	12	11.6	5.89	5.88	21.1	20.9	11	10.7	6.89	6.74	22.2	20.1	20	18.3	5.12	5.28	17.2	15.3	20	19.7
4: Wheeler Rd.	2.72	20.5	15.1	15.1	10	8.78	3.03	2.91	20.2	19.2	3	3.07	5.71	4.96	20.5	18.4	19	17.7	4.51	4.97	16.0	14.7	16	16.1
5: Old Post Rd.	2.16	15.4	11.1	11.2	10	9.73	2.18	2.19	11.2	10.9	12	11.2	4.23	4.21	18.3	16.8	36	35	2.66	3.01	10.4	9.86	**	19.1

Federal standard for magnesium in Class A and AA waters is <35 mg/L[9]

[9]NYSDEC 1999. Env. Conservation Regulations Chapter X, Part 703: Surface Water and Groundwater Quality Standards and Groundwater Effluent Limitations. (http://www.dec.ny.gov/regs/4590.html)

Table 7. Sodium (Na+), Calcium (Ca++), Chloride (Cl-), and Total Dissolved Solids (TDS) Results

	April 20						June 23 (Heavy rainfall within 24 hours)						Aug 18						October 13					
	Na+ (Smith)	Na+ (Cary)	Ca++ (Smith)	Ca++ (Cary)	Cl- (Cary)	TDS (Smith)	Na+ (Smith)	Na+ (Cary)	Ca++ (Smith)	Ca++ (Cary)	Cl- (Cary)	TDS (Smith)	Na+ (Smith)	Na+ (Cary)	Ca++ (Smith)	Ca++ (Cary)	Cl- (Cary)	TDS (Smith)	Na+ (Smith)	Na+ (Cary)	Ca++ (Smith)	Ca++ (Cary)	Cl- (Cary)	TDS (Smith)
Units	mg/L		mg/L		mg/L	mg/L	mg/L		mg/L		mg/L	mg/L	mg/L		mg/L		mg/L	mg/L	mg/L		mg/L		mg/L	mg/L
Reference	20 mg/L*				35*	<500	20 mg/L*				35*	<500	20 mg/L*				35*	<500	20 mg/L*				35*	<500
1: Pawling Corp.	**43.3**	**41.5**	66.7	67.2	94.3	470	**42.3**	**41.3**	59.4	59.4	89.6	365	**65.3**	**69.2**	86.7	88.1	162	272	**59.2**	**56.8**	84.8	83.5	133	180
2: Murrow Park	**23.6**	**21.4**	31.0	30.5	44.9	258	**23.3**	**23.9**	35.5	35	46.2	205	**26.0**	**27.1**	50.5	50.6	65.6	380	**25.9**	**25**	33.5	31.7	49.4	265
3: AT Trail	**23.5**	**22.9**	43.1	44.5	50.5	292	**38.6**	**38.1**	56.1	56.3	83.2	310	**44.2**	**45**	57.4	55.6	94.3	402	**31.1**	**29.7**	45.3	43	61.1	278
4: Wheeler Rd.	**20.3**	**20.5**	42.5	43	41.8	225	**30.4**	**31.3**	52.0	51.5	63.9	292	**34.5**	**35.2**	55.2	52.6	78.4	290	**23.1**	**22.7**	41.8	41.2	46	210
5: Old Post Rd.	**14.9**	**15.4**	32.6	33.1	29.3	208	17.3	17.5	33.4	32.9	31.1	168	19.9	**21**	50.9	50.6	41.5	**570**	15.2	15.6	31.3	30.8	27.7	**530**

*Federal standard for Class A groundwater = <20 mg/L[10]

[10] NYSDEC 1999. Env. Conservation Regulations Chapter X, Part 703: Surface Water and Groundwater Quality Standards and Groundwater Effluent Limitations. (http://www.dec.ny.gov/regs/4590.html)

Dissolved Oxygen

A concentration of between 7 to 11 mg/L is ideal for survival of most stream fish[11]. The DO levels at Wheeler Road and AT sites fell below the recommended levels for all dates measured, with the exception of the April 20th date. The other three sites all fell within this recommended range (Table 8).

Table 8: *Dissolved Oxygen concentrations (mg/L) were lowest at AT and Wheeler Road sites*

	Pawling Corp	Murrow Park	AT	Wheeler Road	Old Post Road
20-Apr	10.9@16 C	11.6 @ 12 C	9.6 @ 13 C	8.3 @ 16 C	11.9 @ 14 C
23-Jun	8.3 @ 18 C	9.3 @ 18 C	**5.0 @ 22 C**	**6.7 @ 20 C**	9.5 @ 20 C
18-Aug	8.0 @ 16 C	9.2 @ 17 C	**2.8 @ 18 C**	**6.3 @ 20 C**	9.9 @ 17 C
13-Oct	9.3 @ 14 C	10.8 @ 13 C	**4.1@ 13 C**	**4.3 @ 13 C**	10.6 @ 14 C

Concentrations reflect seasonality

Seasonal variation in the concentration of NA^{+}, C^{++}, Cl^{-}, and TDS seemed to be related to flow. The highest concentrations of less reactive constituents (e.g., Mg+ and Cl-) were typically found in August, when water levels were lowest (Table 9). Concentrations of constituents that respond to biological demand (e.g., NH_3, NO_3 and PO_4) showed seasonal variations unrelated to flow (Tables 4 and 5). In October at Old Post Road there was an outlier amount of SO_4^{2-} of 7300 mg/L. Federal standard for TDS 'Shall be kept as low as practicable to maintain the best usage of waters, but in no case shall exceed 500 mg/L'[12].

Table 9: Sampling for baseline NA^{+}, Ca^{++}, Cl^{-}, TDS at Swamp River watershed sites

Seasonality Trend (Smith lab results)				
	Na+	Ca++	Cl-	TDS
Pawling				
20-Apr	43.3	66.7	94.3	**470**

[11] Behar, Sharon. 1997. *Testing the Waters: Chemical and Physical Vital Signs of a River*. River Watch Network, Montpelier, Vermont.

[12] U.S. Environmental Protection Agency. *Dissolved Solids: Water Quality Standards Criteria Summaries*. [S.l.]: BiblioGov, 2013. Print.

23-Jun	42.3	59.4	89.6	365
18-Aug	**65.3**	**86.7**	**162.0**	272
13-Oct	59.2	84.8	133.0	180
Murrow Park				
20-Apr	23.6	31.0	44.9	258
23-Jun	23.3	35.5	46.2	205
18-Aug	**26.0**	**50.5**	**65.6**	**380**
13-Oct	25.9	33.5	49.4	265
AT				
20-Apr	20.3	43.1	50.5	292
23-Jun	38.6	56.1	83.2	310
18-Aug	**44.2**	**57.4**	**94.3**	**402**
13-Oct	31.1	45.3	61.1	278
Wheeler Road				
20-Apr	14.9	42.5	41.8	225
23-Jun	30.4	52.0	63.9	**292**
18-Aug	**34.5**	**55.2**	**78.4**	290
13-Oct	23.1	41.8	46.0	210
Old Post Road				
20-Apr	14.9	32.6	29.3	208

23-Jun	17.3	33.4	31.1	168
18-Aug	**19.9**	**50.9**	**41.5**	**570**
13-Oct	15.2	31.3	27.7	**530**

Salts

The highest concentrations of Cl- occur at the upstream Pawling site, with a trend toward downstream dilution (Table 9). Chloride concentrations of approximately 140 mg/L should be suitable for survival of freshwater organisms for short-term exposure; while concentrations less than 35 mg/L are likely suitable during long-term exposure[13]. The highest Cl- concentration was 162 in August 18th at the Pawling site. The Na+/Cl- ratio of 0.71 indicates some retention of Na+, relative to Cl-, during transport in the river.

Conductivity

The Pawling site conductivity measurements fell consistently outside of the range of other sites, measuring a low of 708µmhos/cm and a high of 1080 µmhos/cm. Inland fresh water streams with a conductivity range of 150 to 500 µmhos/cm support good mixed fisheries and higher levels of conductivity may indicate point sources of sewage or stormwater runoff additions[14]. Conductivity is primarily reflective of an area's underlying geology. For example, granite bedrock is relatively inert compared to clay soils whose materials ionize easily when washed into water. Since streams tend to have fairly constant rates of conductivity, once a baseline is determined, variations to the baseline provide insight into possible discharge issues[15].

Table 10: Baseline conductivity (µmhos/cm) meaurements at Swamp River watershed sites

	Pawling Corp	Murrow Park	AT	Wheeler Road	Old Post Road
20-Apr	708	340	445	416	316
23-Jun	720	419	670	588	359
18-Aug	1080	557	705	626	518
13-Oct	946	394	518	451	324

[13] Findlay et al. 2010
[14] Findlay et al, 2010
[15] USEPA, 1997

Dissolved Nitrogen

Typically, nearly all of the total dissolved nitrogen was found as nitrate. Low concentrations of NH_4 are indicative of low contamination of the waters. Nitrate concentrations tend to decline downstream, possibly due to biological uptake[16].

Phosphates

To control eutrophication, USEPA recommends limiting phosphate concentrations to 0.05 mg/L in waters that drain to lakes, ponds, reservoirs, and 0.1 mg/L in free flowing rivers and streams[17]. Wheeler Road and the AT sites both exceeded these levels (Table 11).

Table 11: Dissolved Phosphate measurements (mg/L) at Swamp River watershed sites

Total Dissolved Phosphates								
	20-Apr		23-Jun		18-Aug		13-Oct	
	Smith	Cary	Smith	Cary	Smith	Cary	Smith	Cary
Pawling Corp	<0.05	0.00	0.05	0.01	<0.05	0.02	<0.05	0.01
Murrow Park	<0.05	0.00	<0.05	0.01	0.05	0.01	0.08	0.00
AT	0.08	0.04	0.06	0.03	**0.15**	0.08	**0.15**	**0.11**
Wheeler Road	**0.12**	0.02	**0.16**	0.02	**0.20**	0.03	<0.05	0.03
Old Post Road	<0.05	0.01	0.05	0.02	0.06	0.01	<0.05	0.01

E Coli and Coliform

The geometric means for the samples for *E coli* were as follows: April 20, 26.5; June 23, 801.5; August 18, 101.2; October 13, 78.6. The EPA criteria for bathing is <126 CFU per mL. All samples were below this benchmark with the exception of June 23. However, the June 23rd sample was taken within 24 hours after a heavy rainfall, which are known to temporarily elevate bacterial levels.

[16] Powers S., Johnson R., Stanley E. 2012. Nutrient Retention and the Problem of Hydrologic Disconnection in Streams and Wetlands. *Ecosystems* 15(3):435-449. Available from: Academic Search Complete, Ipswich, Mass.
[17] USEPA 1996

Table 12 E Coli and Coliform (CFU/100 mL)

E Coli and Coliform					
Project Sample ID	**Collection Date**	**Total Coliform**		**E. Coli**	
Lime Kiln Rd. Site #5	04/20/10	1,732.9	CFU/100mL	20.3	CFU/100mL
Wheeler Rd. DEC Fishing Access Site #4	04/20/10	547.5	CFU/100mL	35.4	CFU/100mL
App. Trail Site #3	04/20/10	> 2,419.6	CFU/100mL	28.5	CFU/100mL
Murrow Park Site #2	04/20/10	686.7	CFU/100mL	29.5	CFU/100mL
Pawling Corp. Site #1	04/20/10	829.7	CFU/100mL	21.8	CFU/100mL
Lime Kiln Rd. Site #5	06/23/10	> 2,419.6	CFU/100mL	2,419.6	CFU/100mL
Site #4 Wheeler Rd.	06/23/10	2,419.6	CFU/100mL	28.8	CFU/100mL
Site #3 A.P. Trail	06/23/10	> 2,419.6	CFU/100mL	1,986.3	CFU/100mL
Site #2 Murrow Park	06/23/10	> 2,419.6	CFU/100mL	1,203.3	CFU/100mL
Site #1 Pawling Corp.	06/23/10	> 2,419.6	CFU/100mL	1,986.3	CFU/100mL
Site #5 Lime Kiln Rd DEC Fishing Site	08/18/10	> 2,419.6	CFU/100mL	214.3	CFU/100mL
Site #4 Wheeler Rd Dec Fishing Site	08/18/10	> 2,419.6	CFU/100mL	42	CFU/100mL
Site #3 Appalachian Trail	08/18/10	> 2,419.6	CFU/100mL	58.8	CFU/100mL
Murrow Park Site 2	08/18/10	> 2,419.6	CFU/100mL	67.0	CFU/100mL
Pawling Corp-Site #1	08/18/10	> 2,419.6	CFU/100mL	298.7	CFU/100mL
Site 5 Lime Kiln DEC Site	10/13/10	> 2,419.6	CFU/100mL	344.8	CFU/100mL
Site 4 Wheeler Rd	10/13/10	> 2,419.6	CFU/100mL	58.3	CFU/100mL

Site 3 App. Trail	10/13/10	> 2,419.6	CFU/100mL	159.7	CFU/100mL
Site 2 Murrow Park	10/13/10	1,119.9	CFU/100mL	25.3	CFU/100mL
Site 1 Pawling Corp	10/13/10	> 2,419.6	CFU/100mL	36.9	CFU/100mL

Ammonia

Ammonia levels (NH_3) were generally low; levels ranged between a high of 0.12 and a low of <0.02 mg/L. One exception was the – AT Trail, April 20th and Wheeler Oct 13 0.04 measurement – slightly elevated ammonia level 0. 04 mg/L versus USEPA standard of no >.03 mg/L or the NYSDEC standard of <.035 mg/L given pH 8.0-9.0 and temperature 15-30C for un-ionized ammonia.

pH

Federal standards (DEP 703.3): pH for Class AA, A, B, and C water shall not be less than 6.5 nor more than 8.5; for Class AA(T), A(T), B(T), and C(T) trout waters. Although generally at the upper end, all sites were within this range.

Magnesium

Federal standard for magnesium in Class A and AA waters is <35 mg/L. None of the sites were outside of this range.

Split Sample Results Show Similar Outcomes

Overall lab results were similar between the two sets of samples tested by Cary Institute of Ecosystem Studies and Smith Labs and confirmed accuracy of results. Some variances between labs did exist as noted below.

- Nitrate data showed high degree of similarity across lab results for all dates except October 13th
- Total Dissolved Nitrogen (TDN), Total Kjeldahl Nitrogen (TJN) and Ammonia, direct comparison was impossible due to a difference in granularity between labs, (<1.0 mg/L Smith, <0.02 mg/L Cary). However, all data adhered to the <1.0 mg/L and can therefore be described as having a high degree of similarity.
- Results for Mg++, Sulfate, Na+ and CA++, high similarity between the labs; exception K+ April 20th results were dissimilar between the labs
- PO_4- results from the two labs were dissimilar
- Split sample results were not available for DO (Smith Lab only), Conductivity (Cary Lab only), pH (Cary Lab only), Cl- (Cary only) Total Dissolved Salts (TDS, Smith lab only), Total Dissolved Phosphorous (TDP, Smith Lab only), and NO2-N (Smith Lab only).

Discussion

The following trends were evident from review of the sampling data: (1) the highest concentrations of sampled constituents (nitrogen, magnesium, ammonia, sodium chloride and calcium) were nearest the upstream urban areas and the AT site; (2) the AT site tended to have the lowest DO concentration; (3) concentrations of all sampled constituents varied seasonally; (4) Na+ and Cl- concentrations were near or above maximum recommended levels for freshwater organisms during several sampling events; (5) a significant number of conductivity measurements exceeded the upper values recommended for fisheries.

In general, Na^{+} and Cl^{-} concentrations are higher than expected, possibly reflecting residual concentrations derived from road salt applied during the winter.

The high concentrations of Ca^{++} are generally indicative of "hard" waters and related to the underlying limestone geology of the region[18].

The Pawling site conductivity measurements fell consistently outside of the range of other sites, measuring a low of 708µmhos/cm and a high of 1080 µmhos/cm. Additional sampling is recommended to determine whether this data represents the baseline conductivity or whether some transitory event is impacting the measurements.

In general, water quality appeared to decrease with proximity to impervious ground cover and urbanization, which is consistent with trends noted in Findlay19. The highest concentrations of sampled constituents were found at the Pawling site. This site is also the most urbanized.

Existing transportation infrastructure in the Swamp River Watershed is likely to encourage additional conversion of vegetated and agricultural landscapes to developed landscapes, with a corresponding increase in impervious surface and associated water quality impacts. NYS Route 22 and the Metropolitan Transportation Authority's MetroNorth passenger rail line run along the Swamp River mainstem, making the river corridor attractive to development. A major new natural gas electricity generating plant is also being planned for Dover.

This initial assessment found that water quality decreased as adjacent impervious land cover increased. This relationship is well understood and well documented, and we can expect potential water quality impacts to the Swamp River to become more significant as more of the watershed is developed. Given that further land-use change in the watershed is likely and threats to water quality are imminent, we recommend the following next steps:

- Reconvene watershed stakeholders and other partners working in the watershed to share data and coordinate future activities.

[18] United States Geological Survey. 2013. *Quality of Ground Water*. N.p., n.d. Web. <http://pubs.usgs.gov/gip/gw/quality.html>.
[19] Findlay, Stuart et al. 2010. *Natural Resource Inventory of Dutchess County, N.Y.* Chapter 5, pp 1-26 (2010).

- Engage municipalities to share results of this study:
    - Identify areas where water quality protection and other community priorities overlap, such as flood damage prevention, river-based recreation, etc.
    - Work with communities to understand and adopt best development practices for water quality protection and other goals;
- Identify priority stream reaches for restoration;
    - Map existing riparian vegetation and identify areas of degraded buffer.
    - Identify zones of high pollutant loading based on water quality data and physical assessments as well as slope, soils, adjacent land-use, etc.
    - Undertake a "build-out" analysis of watershed to understand potential extent/distribution of land use change under current municipal regulations.
- Conduct further monitoring at the five sites evaluated during this study to deepen understanding of water quality trends and sources of impairment.
- Add additional sites as deemed necessary by the SAC.
- Continue to work with Cricket Valley to re-open the stream gage on the Swamp River, pending approval of their development plan.

Appendix A: Site Maps & Photographs

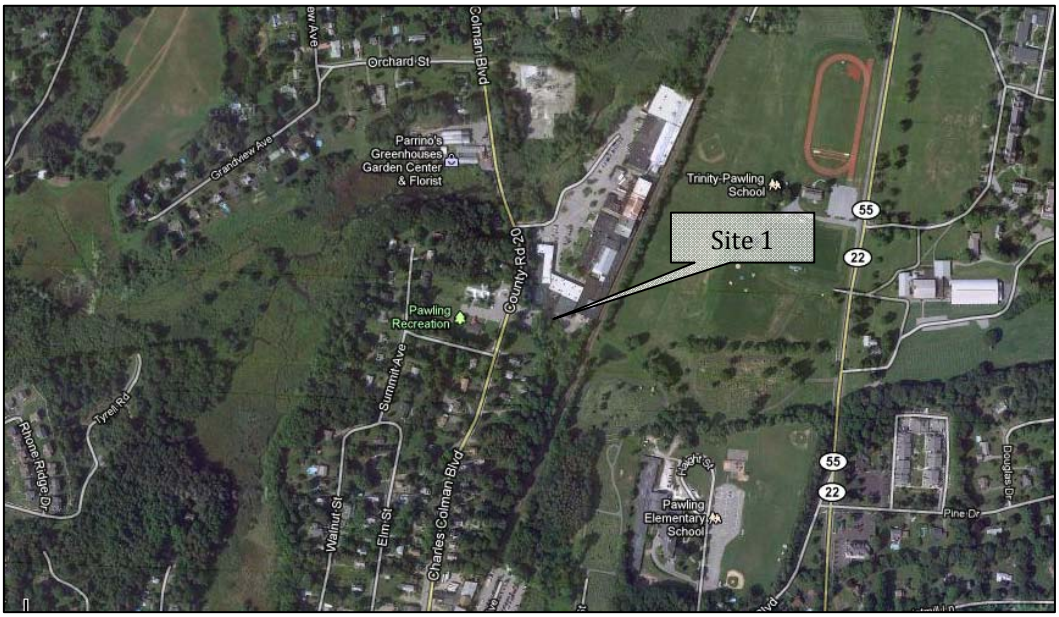
Site 1: Pawling Corporation Parking Lot (Pawling, N.Y.)

Coordinates: 41.571889, -73.597240

Description: Sampling site is located in the rear of the Pawling Corporation parking lot (off Coleman Road) to the right. Samples were collected upstream from the culvert which passes under the parking lot.

Rationale: Site is located north of headwater divide. Site is influenced by Village of Pawling; just downstream from the sewage treatment outflow.

Site Location Map:



Site Photos:

June 23, 2010

Site 2: Murrow Park (Pawling, N.Y.)

Coordinates: 41.567816, -73.615386

Description: Sampling site is located adjacent to the park gazebo.

Rationale: Site is representative of the head of the northern basin.

Site Location Map:

Site Photos:

June 23, 2010

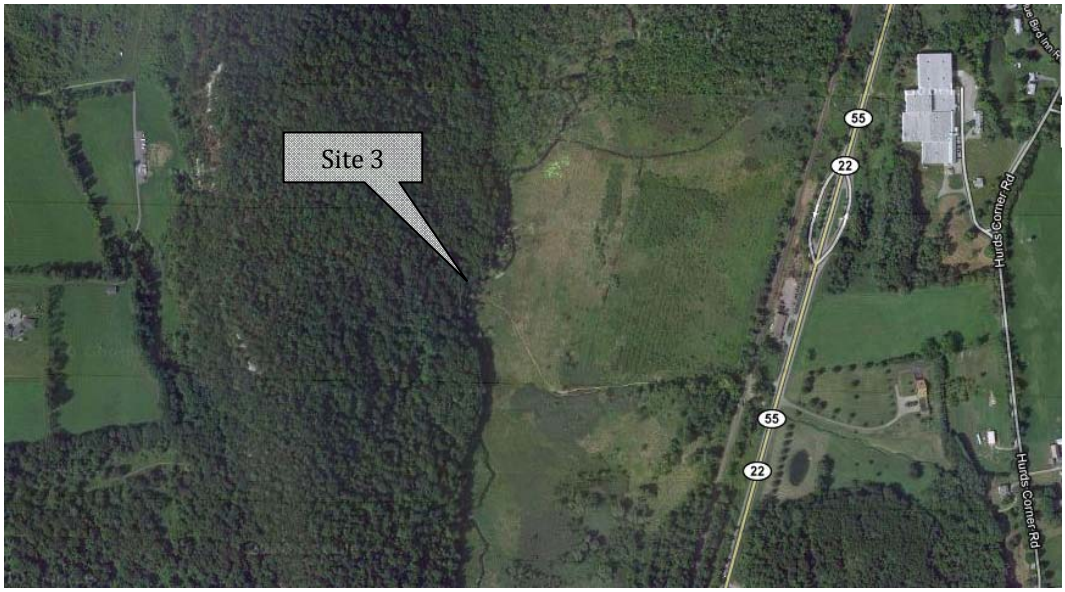
Site 3: Appalachian Trail (AT) Footbridge (Pawling, N.Y.)

Coordinates: 41.594018, -73.592895

Description: Sampling site is located directly upstream of AT footbridge. (Site is accessed by following path located adjacent to train platform off of Route 22.)

Rationale: Site is located slightly downstream of confluence with Hiller Brook.

Site Map:



Site Photos:

June 23, 2010

Site 4: Wheeler Road (Dover, N.Y.)

Coordinates: 41.638148, -73.574069

Description: Site is located adjacent to the DEC fishing access parking area; just downstream of the Wheeler Road crossing.

Rationale: Segment of Swamp River classified as Class A(T). Location of former Harlem Valley Psychiatric Facility and proposed Dover Knolls Development.

Site Map:

Site Photos:

June 23, 2010

Site 5: Old Post Road Bridge (Dover, N.Y.)

Coordinates: 41.715436, -73.575579

Description: Site is located just upstream of the Old Post Road stream crossing.

Rationale: Site is located approximately 200 meters upstream of confluence with Tenmile River.

Site Map:

Site Photos:

June 23, 2010

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