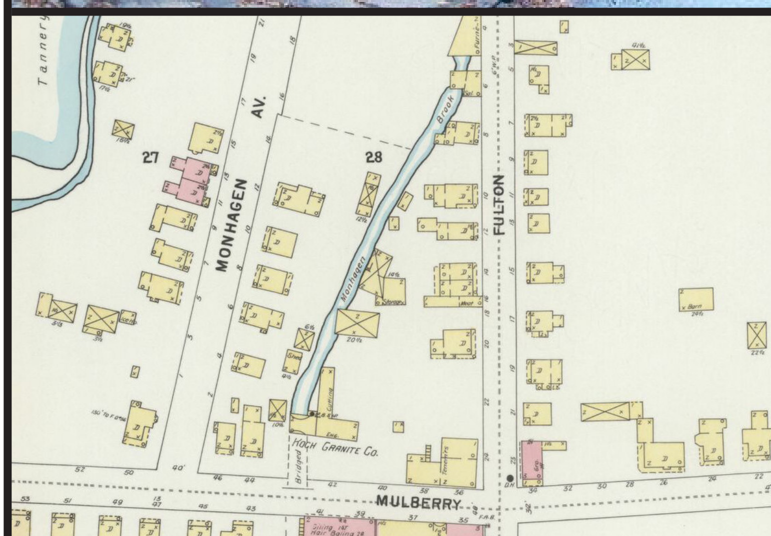
Monhagen Brook Watershed

Conservation and Management Plan



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OCWA

Orange County Soil and Water Conservation District

Acknowledgements

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Project partners are grateful to those who assisted with volunteer events such as stream walks, Trees for Tribs planting, and the Riverkeeper Sweeps in 2017 and 2018. Much gratitude is also given to the municipal staff that provided information and feedback, and enabled installation of stream signage for the Monhagen Brook. Additionally, partners would like to recognize and thank those who participated in the project's Advisory Committee, which met periodically to discuss recent progress and decide on next steps for the project.

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The project team, which includes the primary authors of this Plan, were Kevin Sumner (SWCD), Travis Ferry (SWCD), Sarah Archbald (OCWA contractor), and Kelly Morris (OCWA).

To get involved or learn more about the Monhagen Brook, visit the project's webpage http://waterauthority.orangecountygov.com/monhagen.html or contact the **project team:**

Orange County Water Authority 845-615-3868
Orange County Soil and Water Conservation District 845-343-1873

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Tables

[1] The majority of the map data displayed within this Plan was acquired through the NYS GIS Clearinghouse https://gis.ny.gov/. Other data was provided by the sources below.

The **Orange County Water Authority** provided the following datasets: Subbasins, Underground Segments of the Brook, Groundwater Features, Impervious Cover (based on Shippensburg University's land cover data), and Biomonitoring Locations. Demographic information is based on **US Census Bureau** data. Parkland was based on information from **Orange County's Real Property Division**. **Orange County Soil and Water Conservation District** provided the following datasets: Active Farmland, Phosphorus Monitoring Sites, and Stream Walk Segments. The **NYSDEC's Hudson River Estuary Program** provided data for dam and culverts. **Shippensburg University** provided data for land cover. The **Orange County Department of Health** provided the dataset for the City of Middletown's Drinking Water Supply and Associated Watersheds. **FEMA** provided data for floorplains.

Figures

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List of Acronyms and Abbreviations

ACoE = Army Corps of Engineers

BAP = Biological Assessment Profile

BAV = Beach Action Value

BMPs = Best Management Practices

CCE = Cornell Cooperative Extension of Orange County

DPW = Department of Public Works

ELAP = Environmental Laboratory Approval Program

EPA = United States Environmental Protection Agency

FEMA = Federal Emergency Management Agency

FJW = Federal Jurisdiction Wetlands

GIS = Geographic Information System

HABS = Harmful Algal Blooms

HREP = Hudson River Estuary Program

ISD = Impact Source Determination

MS4 = Municipal Separate Storm Sewer System

NWI = National Wetlands Inventory

NYRCR = New York Rising Community Reconstruction Program

NYS = New York State

NYSDEC = New York State Department of Environmental Conservation

NYSFWW = New York State Freshwater Wetlands

OCPD = Orange County Department of Planning

OCWA = Orange County Water Authority

PPM = parts per million

PWL = Priority Waterbodies List

SGCN = Species of Greatest Conservation Need

SPDES = State Pollutant Discharge Elimination System (Permit)

SSO = Sanitary sewer overflow

STV = Statistical Threshold Value

SUNY = State University of New York

SWCD = Orange County Soil and Water Conservation District

The City = The City of Middletown

The County = Orange County, NY

The Watershed = The Monhagen Brook Watershed

USDA = Unites States Department of Agriculture

USGS = United States Geological Survey

WRWP = Wallkill River Watershed Conservation and Management Plan

Preface

The purpose of a watershed management plan is to identify water resource issues, to compile information that can help characterize reasons why the issues exist, and to develop a plan of action for remediation the issue of concern. Plans can be focused on the drainage area of any waterbody, be it a river, stream, lake, or wetland. The purpose and direction of each management plan depends upon the element of concern involving that waterbody. The direction can be protection, remediation, or – as is the case in this Plan – both.

This Watershed Plan is a non-regulatory guidance document *and is intended to be a source of information that can inform a variety of audiences and assist municipalities, agencies, and others in acquiring grants and other funds. This Plan also provides information that can assist in steering the work of scientific researchers and other stakeholders.*

A primary intent of this Plan is to heighten awareness of the Monhagen Brook and the factors that influence its water quality.

There have been many watershed plans developed for waterbodies in Orange County. As shown in Table 1, the first watershed-based plan within Orange County was released in 2005 and focused on the Wallkill River (Map 1). The Wallkill River's watershed includes two states, five counties, and over forty local municipalities. Subsequent watershed planning efforts in Orange County began to down-size thereafter, beginning with the Moodna Creek, then the Quassaick Creek, and now the Monhagen Brook Watershed. Two plans have also been completed for reservoir watersheds in the County, and they address the unique issues of concern within each of those drinking water supplies.

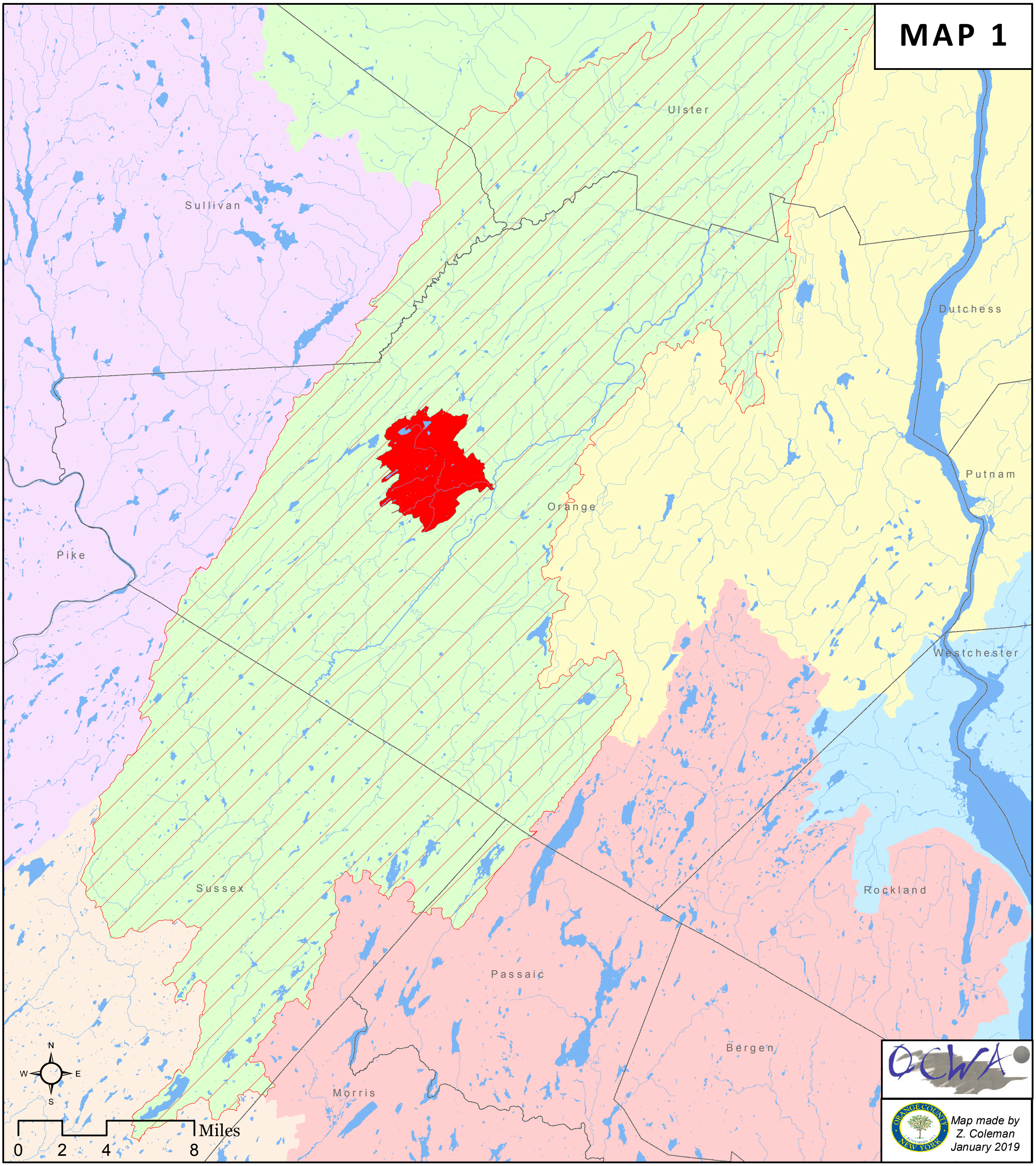
The OCWA and SWCD have been involved in the development of the majority of these plans. Learning from the experience of contributing to or managing these plans, both agencies agree that a smaller scale allows for a more usable plan because it allows for more site-specific investigation and analysis, thus resulting in a document that can be immediately used by municipalities, agencies, residents, volunteers, and other stakeholders to take actions that will assist in improving the state of the Watershed.

It is the hope of the writers of this document that this Plan does not sit on a dusty shelf, but that it is recognized as an enlightening and valuable review of this diverse urban watershed and that it will enable its readers to move directly into implementation of its recommended actions.

Plan name	Year	Size of watershed (square miles)	Core issues addressed in plan
Streams and Rivers			
Wallkill River Conservation and Management Plan	2005	800	erosion in the Black Dirt Region, flood mitigation, water quality
Moodna Creek Conservation and Management Plan	2010	180	flood mitigation, water quality, conservation of scenic and natural resources
Quassaick Creek Watershed Management Plan	2014	56	water quality, preservation of Creek's riparian corridor, water supply protection
Monhagen Brook Watershed Plan	2018	12	water quality
Reservoirs			
Tuxedo Park Lakes Management Plan	2009	2.8	control of Eurasian milfoil, cyanobacteria, overall reservoir watershed management
Glenmere Lake Watershed Management Plan	2012	2.4	submerged aquatic vegetation, habitat for the northern cricket frog

Table 1. Existing watershed plans for waterbodies in Orange County

Monhagen Brook Watershed: Regional Watersheds



Regional Watersheds

- Hackensack-Passaic
- Hudson-Wappinger
- Lower Hudson
- Middle Delaware-Mongaup-Brodhead
- Middle Delaware-Musconetcong
- Wallkill-Rondout
- Monhagen Brook Watershed
- Wallkill River Watershed
- Lakes, Ponds, and Major Rivers
- Rivers and Streams
- County Boundaries

Chapter 1
Introduction & Project Background

Development and Purpose of this Plan

The Monhagen Brook Watershed Conservation and Management Plan (Plan) was a collaborative effort between many parties, including the primary authors from the Orange County Water Authority (OCWA[1]) and the Orange County Soil and Water Conservation District (SWCD[2]), secondary authors (NYSDEC staff[3]), and the various parties noted in the *Acknowledgements* who gave information and feedback throughout the planning process. This Chapter presents the goals of and justification for this Watershed Plan, the outreach methods used to engage stakeholders, and a description of the Monhagen Brook's history.

Goals of this Plan

The primary mission of this Watershed Plan is to compile information about water *resources* and identify ways to protect and enhance them. While this Plan will give ample attention to water *quality* concerns, water *resource* management provides a more holistic framework from which to work, as this framework encompasses not just quality concerns but also such issues as hydrologic changes (e.g. reduced stream base flows, reduced groundwater recharge, flooding, etc.), which in more urbanized watersheds with high imperviousness can rival pollution/water quality concerns.

Through outreach to the various stakeholders and the project team's research, the following goals were set for this planning project:

1. establish a current and science-based understanding of phosphorus loading in the Watershed, and identify measures for reducing loading.
2. compile information about the natural resources in the Watershed, focused largely on biological and water resources, and identify ways to protect and enhance them.
3. inventory issues and opportunities along the entire length of the Monhagen Brook, and develop a site-specific inventory of potential future projects for stream protection and stormwater management.
4. expose a wide audience to the values of and challenges for the Monhagen Brook.

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[1] OCWA project manager and OCWA's contractor

[2] SWCD Executive Director and Technician

[3] Hudson River Estuary Program and Division of Water staff

5. educate a variety of stakeholders throughout the Watershed about the principles and purposes for watershed management, in general, and in this Watershed, in particular.
6. enhance local land use regulations to better protect and restore the Watershed's natural resources.

Each recommendation in this Plan aligns with at least one of the above goals, and the *Recommendations* table (Table 11) is organized by which goal it would meet, if implemented.

Outreach

To create this Plan, the project team:

- formed an Advisory Committee made up of a broad array of stakeholders, which met regularly throughout the two-year planning process to discuss progress and next steps.
- presented to the elected officials of each of the Watershed's three municipalities (City of Middletown, Town of Wallkill, Town of Wawayanda) to explain the project, provide background information on the Monhagen Brook's conditions, and solicit input.
- worked directly with the Watershed's three municipalities to acquire information to help this Plan be more relevant to those communities.
- held public meetings – announced via press release, emails, and posters – to present the project and its goals, seek public comment, and recruit volunteers.
- enlisted volunteers to assist with stream walks, phosphorus monitoring, tree planting, and garbage cleanup.
- communicated with business-owners and property owners adjacent to the Brook to discuss issues related to dumpster management.

The interest and assistance gained by these efforts informed the planning process and improved the prospects for implementation of Plan recommendations. Volunteers and the municipalities will likely continue to participate in efforts to improve the health of the Brook due to the strength of the partnerships created. For example, the project team's intent for retaining volunteerism is to have cleanup events on a regular basis, to continue tree-plantings and stream walks, and to develop even more roles for volunteers. The team fully expects to work with the three municipalities on implementation projects such as stormwater retrofits, riparian buffer improvements/protection, best management practices (BMPs) on municipal properties, enhancements to municipal codes, and other actions listed in the *Recommendations* table. The process outlined above facilitated the creation of this Plan. The following sections detail previous efforts and provide background information and context for this Plan.

Implementation of Wallkill River Watershed Conservation and Management Plan

As noted in the *Preface*, this Watershed Plan follows in the footsteps of several other watershed plans that were completed for waterbodies that are fully or partially within Orange County. The Monhagen Brook is a tributary of the Wallkill River, and therefore this Plan includes recommendations complementary to those in *The Wallkill River Watershed Conservation and Management Plan* (WRWP, 2007). Development of the WRWP was a collaborative effort, with contributions from many agencies and individuals. Below is a description of the highlights of the WRWP, as well as some discussion of how this Plan is an implementation project of the WRWP.

Public Input

Effective implementation of any plan cannot happen without broad support, and such support is not likely to emerge for a plan written in isolation from stakeholders. The WRWP boasted a broad-based steering committee and formally began with a public meeting to assess concerns and priorities.

The WRWP public meetings identified stream buffers, overdevelopment of land, litter and debris, and loss of family farms as priority issues. Based on observations in the Monhagen and beyond, little has changed in ten years. And while picking up litter may not be as complex a notion as restoring a degraded stream corridor, litter and debris are most definitely a highly visible and serious issue plaguing the more urbanized reaches of the Monhagen. This Plan attempts to address all of the above issues, recognizing that more resources, increased enforcement, and significant adjustments in public attitude are necessary for substantive improvement.

Education

The WRWP gives considerable attention to the importance of education alongside implementation of on-the-ground projects. Not unlike securing funding for watershed plans, finding funding and support for conservation education is a continual challenge. One successful example is the OCWA's Conservation Education program, which

Figure 1. Students participate in the OCWA's engaging *Conservation Education* program

has offered outreach to schools and communities since 1994. Over the years, OCWA's two Conservation Educators have reached over 125,000 students in dozens of schools in nearly every district in the County.

These engaging, hands-on programs bring critical conservation perspectives and environmental science curriculum to classrooms, as well as public events, field trips, festivals, and community groups. Originally focusing on water quality and quantity issues, the Conservation Education program has broadened its scope to include important, interrelated topics in sustainability, climate change, energy use, and solid waste management. Educating students from a young age about environmental issues, the impacts of their actions, and the key role they play in making change is an essential aspect of protecting resources at the local level and beyond. It is also worth noting that this programming helps many communities throughout the County comply with their MS4 (Municipal Separate Storm Sewer System) permit requirements for education and outreach.

Wetlands

The WRWP emphasizes the importance of recognizing wetland quality issues even as regulatory programs attempt to address wetland losses. The manageable size of the Monhagen watershed allows for a more focused look at mapped and unmapped wetlands, along with some degree of quality assessment – particularly with regard to non-native and invasive vegetation. Mapping work done by the New York State Department of Environmental Conservation (NYSDEC) in the 1970s established designated NYSDEC wetlands in support of the State's Freshwater Wetlands regulations. NYSDEC revised these maps in the 2010s, which allows for valuable comparison and analysis.

Stormwater Concerns and Retrofits

The WRWP identifies challenges associated with retrofitting stormwater treatment measures into urban areas that were developed before the advent of modern stormwater management understanding and regulatory requirements. It also calls for the development of a Stormwater Retrofit Opportunity Project List. The Monhagen Plan elaborates on these challenges and presents a field-reviewed list as recommended by the WRWP. In addition, ambitious green infrastructure redevelopment for downtown Middletown is discussed.

The WRWP also presents a discussion of the typical pollutant removal performance of common stormwater treatment practices. It notes that these practices are typically only able to remove 40% of Total Phosphorus (P). This raises questions about our ability to effectively mitigate the impacts of new *and* old development on water resources. It is of particular concern in the Monhagen where the Brook has been determined by NYSDEC to be P-impaired. While avoiding any negative impacts whatsoever may be an impractical expectation, this is one example that supports the notion of "treatment trains" – routing stormwater through more than one treatment practice – even where one practice may satisfy regulatory requirements, and other more thoughtful approaches to providing more effective treatment of stormwater runoff.

Wastewater

The WRWP presents a good summary of regional wastewater issues, including aging infrastructure, inflow and infiltration, and "on-site" verses central sewer systems. With the extent of development in the Monhagen, these issues certainly deserve renewed and more detailed discussion. The contribution of wastewater (from point sources, permitted discharges, and the myriad individually-owned and operated septic systems) to P loading and other water quality concerns such as bacteria is a looming and unanswered question at this time. A P monitoring effort was performed in conjunction with this Plan, but was meant primarily as a precursor to assist in the design of a more sophisticated future study that will better quantify and identify sources of P loading (see Table 11 in the *Recommendations Chapter*).

Riparian Buffer Analysis

The WRWP included results of a remote sensing (GIS) exercise that examined all major stream corridors in the Watershed, identifying reaches that appeared to lack significant buffer protection and recommended actions that could be taken at those locations. The Monhagen Plan takes this type of analysis to the next level by presenting a field-reviewed list of potential stream corridor restoration opportunities (See Appendix 11).

Implementation of the Hudson River Estuary Program's Action Agenda

The NYSDEC's Hudson River Estuary Program has supported watershed planning in the Hudson River estuary watershed for over 15 years, funding the Wallkill River Watershed Conservation and Management Plan (2007) as well as this plan for the Monhagen Brook. The Estuary Program is guided by an Action Agenda, updated every five years, that serves as the programmatic directive for allocation of its funds and staff time. Of the many Benefits and actions listed in Hudson River Estuary Action Agenda 2015-2020, this Watershed Plan implements the following:

Benefit 1: Clean Water

- Implement tributary watershed strategies to address stormwater impacts to streams, rivers, and the estuary.
- Work with watershed groups, regional partners and municipalities to implement resource strategies that protect the biological integrity of streams and rivers in the watershed and their influence on the estuary.
- Encourage communities to adopt and implement long-range capital improvement or asset management plans and resiliency strategies for their sewer systems and treatment plants, which will benefit economic competitiveness and also reduce sewage overflows and pathogen and

nutrient loads.

Benefit 2: Resilient Communities

- Identify, prioritize, design and implement projects on tributaries of the Hudson to right-size stream/road crossings; conserve floodplains and stream buffers where ecological benefit and managing flood risk can be achieved.
- Develop and publicize natural and nature-based solutions and best management practices (BMPs) for streamside buffers and riparian conservation.
- Map priority areas and restore native vegetation on the banks and floodplains of streams and rivers.

The partners involved in the development of this Plan will be working with the Estuary Program and other stakeholders in the future to collaborate on the implementation of this Plan's recommendations.

Water Quality Concerns

Sources of pollution are typically compartmentalized as being "point" or "nonpoint." In the most basic definition, point source pollutants come from the end of a pipe or a discrete discharge point, while nonpoint pollution comes from more diffuse sources in the landscape. Point sources, such as outfalls from sewage treatment plants, are required to apply for a State Pollution Discharge Elimination System (SPDES) permit from NYSDEC and follow the stipulations associated with the permit; non-point sources, on the other hand, are much more challenging to identify, monitor, and regulate. The Clean Water Act regulations resulted in improvements in the performance of sewage treatment plants (point sources) in the 1970's, causing lingering pollution in waterways to call attention to the significant contribution of nonpoint sources to water quality.

This Plan gives more attention to the category of nonpoint source pollution because point sources in the Watershed are limited (there are no permitted SPDES discharges in the Watershed, for example), thereby offering fewer opportunities for specific recommendations. Nonpoint sources can include at least the following:

- urban/suburban development, especially construction activity
- streambank erosion
- on-site septic systems
- agricultural land

Some of the more significant pollutants contributed by nonpoint sources include:

- silt/sediment
- nutrients (phosphorus, nitrogen)
- pesticides
- bacteria

- organic matter (which, when in excess, consumes oxygen and impacts aquatic life)
- chlorides
- plastics
- petroleum products

The New York State Department of Environmental Conservation (NYSDEC) lists the Monhagen Brook as impaired due to pollution from both point and nonpoint sources. This status is proclaimed on the NYSDEC's Priority Waterbodies List (PWL), which is an inventory of surface waters throughout the State that identifies and describes water quality concerns where they are known. The PWL designates four categories of impacts, which are listed in increasing severity as (from least to most impaired): 1) threatened, 2) stressed, 3) impaired, and 4) precluded. The Monhagen Brook is listed as impaired, with **the primary pollutant being listed as phosphorus**. The role and importance of phosphorus to water quality is discussed more fully in several sections of this Plan.

Brief History of the Monhagen Brook Watershed[4]

The Monhagen Brook was vital to the development of the region around what is today the city of Middletown, in Orange County, New York. Throughout history, humans have utilized its waters and ecological services in a variety of ways. Like many waterways, it supported urban and industrial growth and thus its history is inextricably linked with human impacts and includes a legacy of pollution and flooding that continues to this day.

Before colonization, the Monhagen Brook Watershed was inhabited by the Waoraneck Munsee people, part of the larger Lenni Lenape tribe of the Eastern Algonquian language group. Their history extends for many thousands of years prior to the relatively brief period of more recent local history that is summarized here. The Waoraneck Munsee used the Brook for fishing and drinking water; the watershed provided hunting grounds and rich agricultural lands. The name “Monhagen” is thought to have roots in the Algonquin language, as well as possibly being fused with a common Irish surname of settlers in the area, “Monaghan.” By 1800, the Brook acquired its modern name, and any name it was previously known by has not been recorded.

Today, many street names in Middletown refer to the prominence of the Brook throughout history. Monhagen Avenue was named for the Brook, along with Canal Street. Fulton Street, under which the buried Brook now flows, was originally called “Water Street.”

Europeans began settling the region in the 1700s, acquiring large tracts of “wilderness” as colonial patents and pushing the indigenous population from their lands. The first settlers arrived to the local area in the 1740s, though growth was slow in the early decades, tending to rise in clusters around newly established churches, followed by a variety of small businesses to support local families.

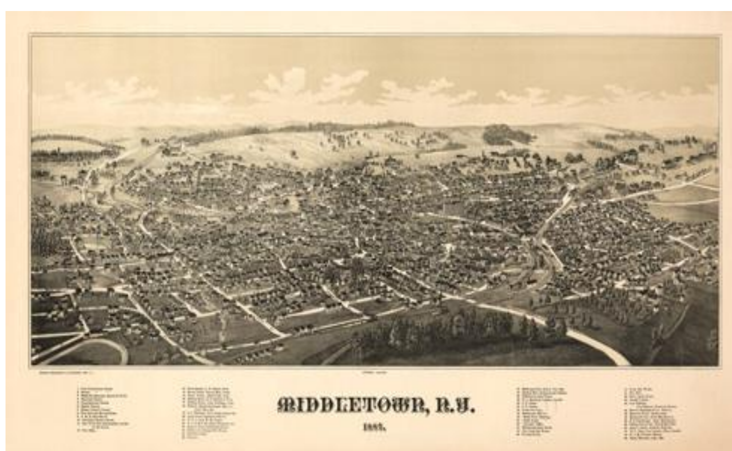

Figure 2. L.R. Burleigh map of Middletown, NY, 1887

Middletown grew through the 19th century. Its location near the “Middle” of Orange County between Newburgh and Port Jervis, and with the Monhagen Brook running through its center, was

[4] This section draws on information from discussions with Alyssa Masotto, Local History Librarian at Middletown Thrall Library; Evan Pritchard, Founder & Director, Center for Algonquin Culture; Peter Laskaris, Historical Society of Middletown & Wallkill Precinct; and Gerry Kleiner, City of Middletown Alderman.

well placed for industrial growth and commerce. The village was established in 1848, soon after the New York & Erie Railroad (later renamed the Erie Railroad) began daily service with Middletown as the end of the line. Later, other railroads, including the New York, Ontario & Western railroad (O&W) continued to spur growth by connecting residents, businesses, and farms with greater Orange County, the New York City metropolitan area, and western New York state.

Figure 3. First steam power plant in Middletown, NY along West Main Street, approximately 1905

The late 1800s were boom years for Middletown, especially after the Civil War period, and it was incorporated as a city in 1888. Major industries, many of which were located along the banks of the Monhagen Brook and its tributaries, included a gristmill, a tannery, hat factories, a knitting mill, and an auxiliary plant. Although these industries relied on groundwater wells, water from the Brook was also used, while at the same time it was utilized for sewage and waste disposal and dumping. To keep up with industry's growing demand for water, the first municipal waterworks was established in 1866 and the Monhagen Reservoir was constructed in 1867.

Figure 4. Building Monhagen Lake Reservoir in 1867

As a result of industrial and population growth, human impacts on the Monhagen Brook intensified. Outside of the city center, the Brook flowed through farmland. Dairy farming was another important industry in Orange County and water quality was of particular concern to landowners and livestock farmers downstream. The development of Middletown as a railroad hub meant that local butter and milk could be transported efficiently to markets in New York City.

Figure 5. Flooding along Fulton Street, July 1937

Efforts by landowners in the watershed to gain monetary compensation for damages cause by poor water quality are recorded as far back as the 1870's. These disputes continued for decades, though the city secured its legal rights to use the brook as its sewer in 1881 at a cost of $23,000. Still, the "virtually open sewer" with "foul odors" causing a "health menace" to the local population was the subject of ongoing contention ("Sewage in Monhagen Brook," 1948).[5] Pollution issues due to sewage and industrial waste discharges are documented throughout Middletown's history and well into the 20th century.

Flooding became a problem as Middletown grew. Naturally, the Brook has always flooded, but as the number of residents, buildings, and roads grew, so too did the adverse impacts of flooding. Major floods with extensive damage occurred in 1862, 1870, and 1903, with numerous more minor incidents occurring regularly with significant storm events.

Alongside the growth of the City came infrastructure projects to manage the flow of the Monhagen Brook. Much of Middletown's stormwater infrastructure was developed during its industrial growth period from the mid 1800s through the early 1900s. The course of the Brook was changed, while box culverts and piped sections were added to accommodate development and mitigate flooding. Most of the Brook remained above ground through the 1920's, though its main tributary in the center of the city, the Draper Brook, was already extensively buried at this point. More major public works projects began in the 1930's during the onset of the U.S. government's Works Progress Administration when extensive sections of the Brook were enclosed in box culverts and buried underground. A local newspaper article from this period boasts of this "extensive program to cover brooks with attractive concrete culverts," revealing the ethos of the time ("Draper Brook Project," 1938).[6] This approach to controlling the Brook continued through early 1960s Urban Renewal when a long section of the Brook was enclosed in concrete box culverts to run underneath Fulton Street and along sections parallel to Monhagen Avenue.

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[5] "Sewage in Monhagen Brook," *Middletown Times Herald*, Nov. 23, 1948.

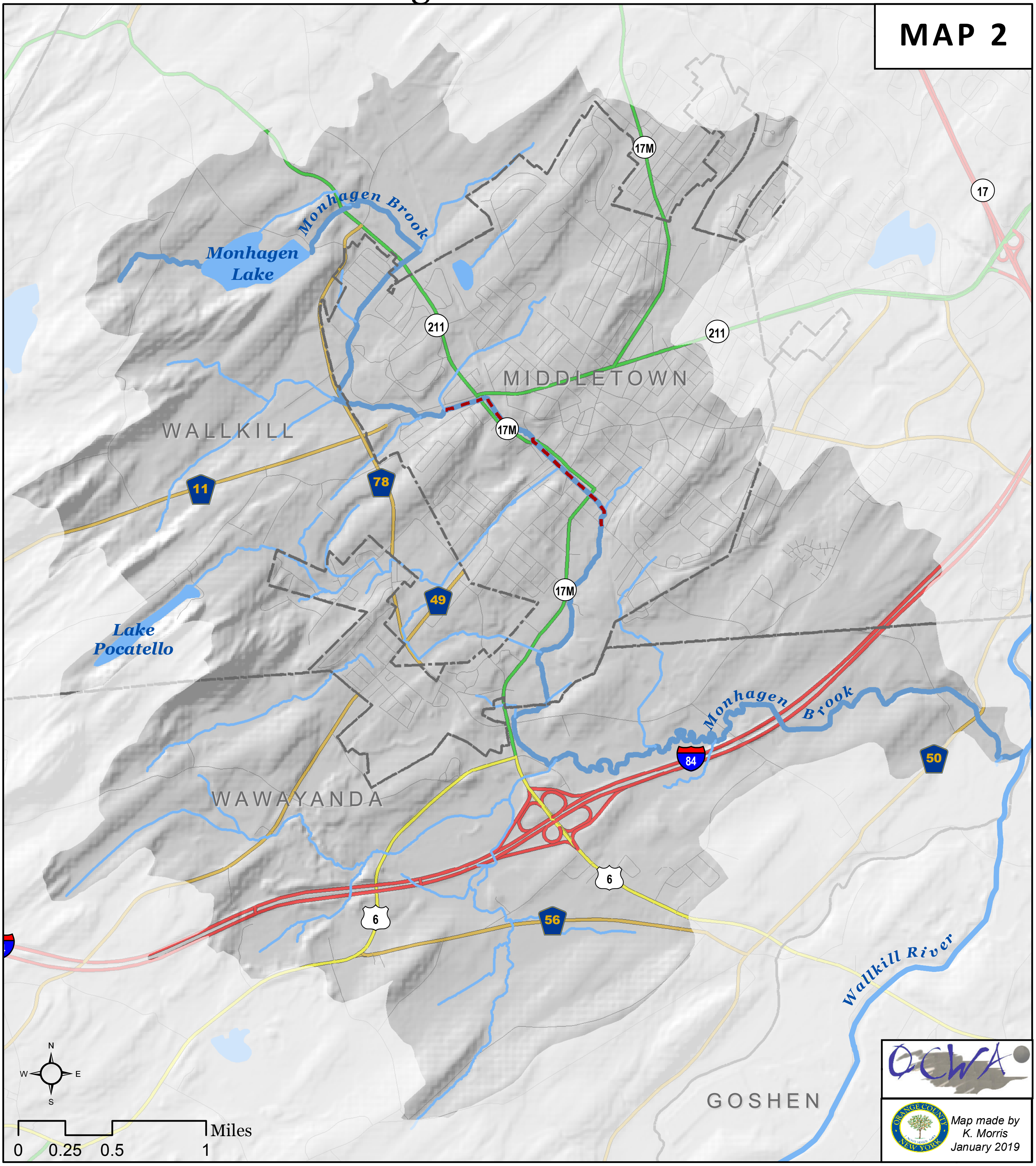
[6] "Draper Brook Project," *Middletown Times Herald*, p. 34, June 8, 1938.

Historical efforts to manage the Brook and accommodate continuous growth generally did not take into account the natural hydrology of the watershed. The City now experiences the consequences of aging and undersized stormwater infrastructure. It is estimated that 250 structures are built on the 151 acres of the City that lie within the Brook's 100-year floodplain (an additional 21 acres of the City are within 500-year floodplain). Most of this is clustered along the course of the Monhagen Brook and the Draper Brook, its main tributary.

In recent history, the Monhagen Brook continued to experience issues with flooding and water quality. These impacts will be discussed more thoroughly throughout this Plan.

Figure 6. The Draper Brook flows through the City of Middletown, shown on historical Sanborn Map.

Monhagen Brook Watershed



Municipal Boundaries
Underground segments of Brook
Water Bodies
Streams
Monhagen Brook
Interstate
Federal Highway
State Route
County Road
Local Road

The Orange County Department of Planning and the County of Orange make no warranty whatsoever as to the accuracy or completeness of any information depicted on this map. Data depicted here may have been developed in cooperation with other County departments, as well as other Federal, State and Local government agencies. The County of Orange hereby disclaims liability for any loss or damage resulting from the use of the information and/or representations contained herein.

Chapter 2
Watershed Characterization & Issues

Overview of the Watershed

The Monhagen Brook originates from groundwater seeps adjacent to the City of Middletown's Water Treatment Plant, down-gradient from Monhagen Lake. Historically, the Brook flowed freely from its headwaters to the Wallkill River, but it was dammed in the 1860s to form Monhagen Lake, separating the Brook from its historic origins. From its new headwaters, it winds through the City of Middletown, at times underground in box culverts, before daylighting at Genung Street and flowing almost parallel to Dolson Avenue/NYS Rte. 17M. The Brook then joins with a major tributary (unnamed) and heads east, morphing into a series of oxbows in the flat hayfields that can be seen from Interstate 84. On its last stretch before reaching its destination of the Wallkill River, the Brook finds its way under I-84 and through some more natural areas near Golf Links Road. In total, the Brook runs 6.7 miles.

The Monhagen Brook's Watershed (the Watershed) spans 17.2 square miles, or 11,000 acres (Map 2). It is one of 69 major tributaries to the Wallkill River, which is a major tributary to the Hudson River. The Watershed includes portions of three municipalities: the City of Middletown, the Town of Wallkill, and the Town of Wawayanda. It is fully within Orange County, New York.

Hydrology

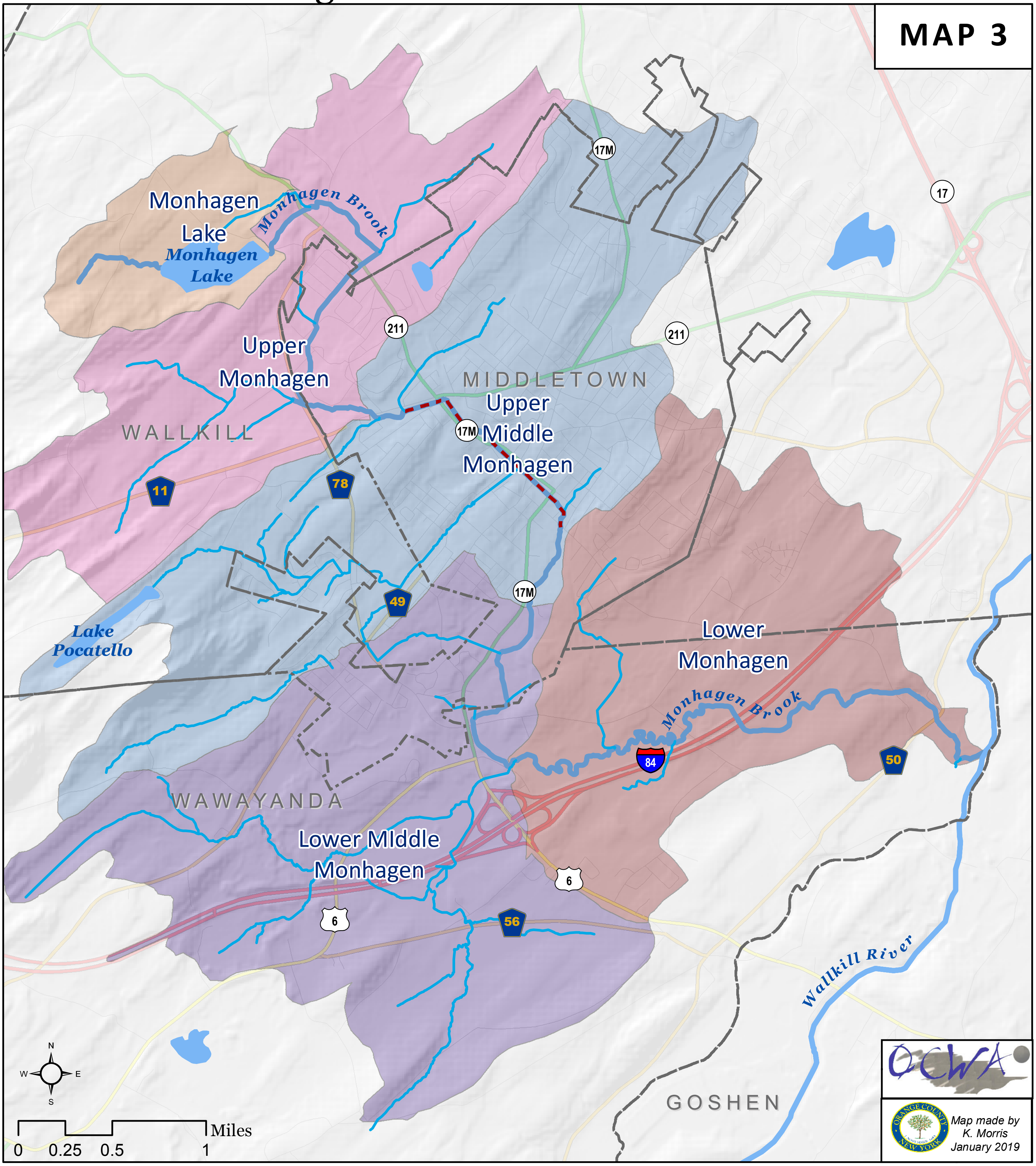
Subbasins and Streams

Even with a watershed as small as the Monhagen's, it is useful to subdivide it into smaller parts for analysis and comparison. In this case, the Watershed was divided into five subbasins that essentially compartmentalize the major water features within the Watershed into drainage areas that are roughly the same size.

These five subbasins, which will be referenced throughout this Plan and are shown in Map 3 and detailed in Figure 9, are:

Figure 7. Volunteers record observations while conducting a stream walk on the Monhagen Brook in spring 2017.

Monhagen Brook Watershed: Subbasins



Lower MIddle Monhagen	Municipal Boundaries	Interstate
Lower Monhagen	Underground segments of Brook	Federal Highway
Monhagen Lake	Water Bodies	State Route
Upper Middle Monhagen	Streams	County Road
Upper Monhagen	Monhagen Brook	Local Road

Monhagen Lake

This subbasin includes the area that drains into the City of Middletown's drinking water supply, Monhagen Lake. The area is largely protected due to land acquisition by the City but does have some agricultural and residential land uses.

Upper Monhagen

This subbasin begins below the Lake, where the stream now originates, and then flows through a large wetland complex, a housing development, the Maple Hill Elementary and Monhagen Middle School campus, and the grounds of the Middletown Campus, which was historically a psychiatric hospital. This subbasin ends approximately where the Brook crosses W. Main Street. Two unnamed tributaries can be found in this subbasin; one flows through the wetland complex and the other by the Middle School.

Upper Middle Monhagen

At W. Main Street, the Brook enters the Upper Middle Monhagen subbasin, which encompasses a large portion of the City of Middletown, as well as a tributary that flows through the SUNY Orange campus. The section through campus is mostly buried, as is the main stem of the Brook in a number of places. The buried sections start along W. Main Street and continue past the Middletown Department of Public Works (DPW) garage, daylighting briefly a few times. Once the stream hits Fulton Street it is buried until it emerges again at Genung Street. The Monhagen has only one named tributary, Draper Brook, which can be found in this subbasin. The Draper Brook joins the Monhagen just upstream of Genung Street, although it would be difficult to find their confluence, as the entire tributary has been buried in underground culverts.

Lower Middle Monhagen

Below Genung Street, the Brook continues into the Lower Middle subbasin. This basin drains the southern portion of Middletown, as well as the more rural area to the west. This includes the tributary flowing past the newly developed CPV power plant. This tributary drains a large portion of the western part of the Watershed, collecting water from both north and south of I-84. The main stem then flows roughly parallel to the corridor of shopping complexes found along Dolsontown Avenue. The subbasin ends approximately where the tributary flowing past the CPV plant joins the Brook.

Lower Monhagen

At the confluence of the CPV tributary and the main stem, the Lower Monhagen subbasin begins. This subbasin drains the remainder of the Watershed. This area is primarily rural, though one tributary drains a few housing complexes in the northern portion of the basin. The main stem in this stretch is characterized by the slow, meandering path it takes along I-84, before it turns south and meets with the

Wallkill River.

Floodplains

As the Brook begins its journey downstream of Monhagen Lake, it makes its way through suburban and rural neighborhoods and maintains access to some of its floodplain on one or both sides. This area also hosts a large wetland complex that gives the Brook room for flood storage. There is also floodplain area along County Rd. 78 where a tributary and the Brook's main stem flow. While the stream channel itself appears unnaturally straight, the floodplain area appears to be intact and not encroached upon by development. This area can also be recognized as floodplain because of soil mapped as "alluvial," which is deposited by moving water. For more in-depth discussion, see the *Soils* section of this Plan.

As the Brook makes its way into the City and underneath W. Main Street, impacts to the floodplain start to be seen. The segment along W. Main has recently been channelized with concrete block retaining walls before entering the first underground stretch. Further downstream, there are a few daylighted segments, but little floodplain exists in these locations. Once the stream daylights at Genung Street, it again has access to some forested floodplain on its west bank. In this area, a small sliver along the stream corridor is mapped as alluvial soils. Moving downstream, as the Brook swings closer to Dolson Avenue, and subsequently closer to development, it again loses much of its floodplain. High, steep banks characterize this stretch and leave little room for floodwaters to spread out.

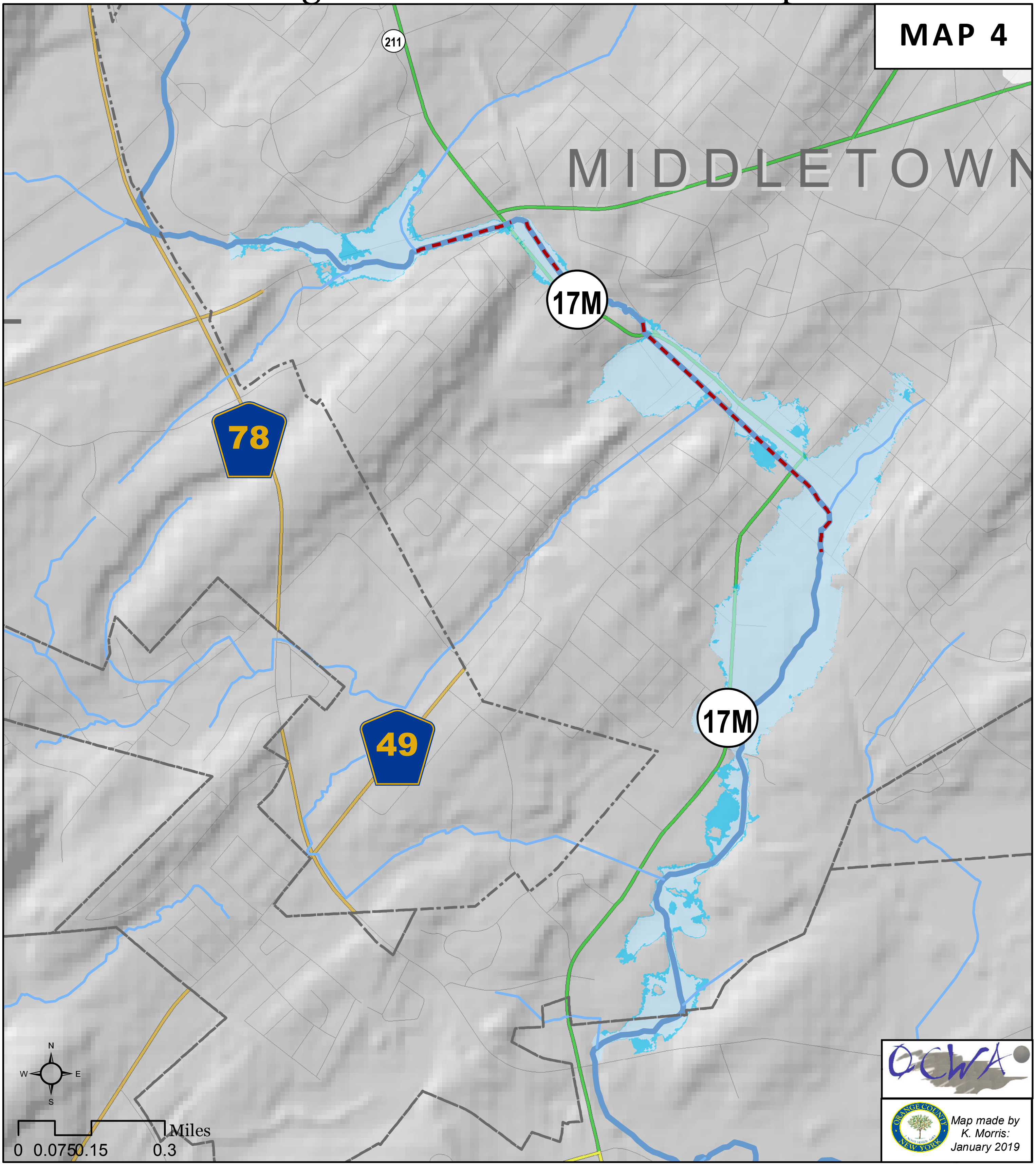
Moving further downstream, the Brook passes by the City of Middletown wastewater treatment plant and regains some of its floodplain. Further on, along I-84, is a low gradient, meandering stretch with intact floodplain characterized by large, flat fields. This area is also mapped as alluvial soils. As the Brook approaches the Wallkill River, it loses its low gradient meandering nature and with it, some of its floodplain. One exception is the natural canyon-like segment up and downstream of McManus Road.

Another noteworthy feature related to floodplains, large portions of the area from Genung Street to Dolsontown Road were mapped as "fill" or "dump soils" (Map 5). This may seem obvious given the expanse of development, but as this stretch of stream corridor shows alluvial soils, it is possible that this is evidence of floodplain that was filled in to allow for further development.

Many of the Brook's tributaries mimic the main stem itself: more urbanized stretches are likely to be buried or channelized, meaning little to no floodplain, while those flowing through rural areas still have natural floodplains, allowing floodwaters the space to spread out and dissipate energy.

The Federal Emergency Management Agency (FEMA) regularly maps floodplains for insurance and planning purposes (Map 4). The most commonly-used features of these maps are the 100-year and 500-year floodplains. In this Watershed, FEMA floodplains only extend from upstream of W. Main Street in the City to Dolsontown Road. The majority of the mapped floodplain is 100-year floodplain, with some

Monhagen Brook Watershed: Floodplains

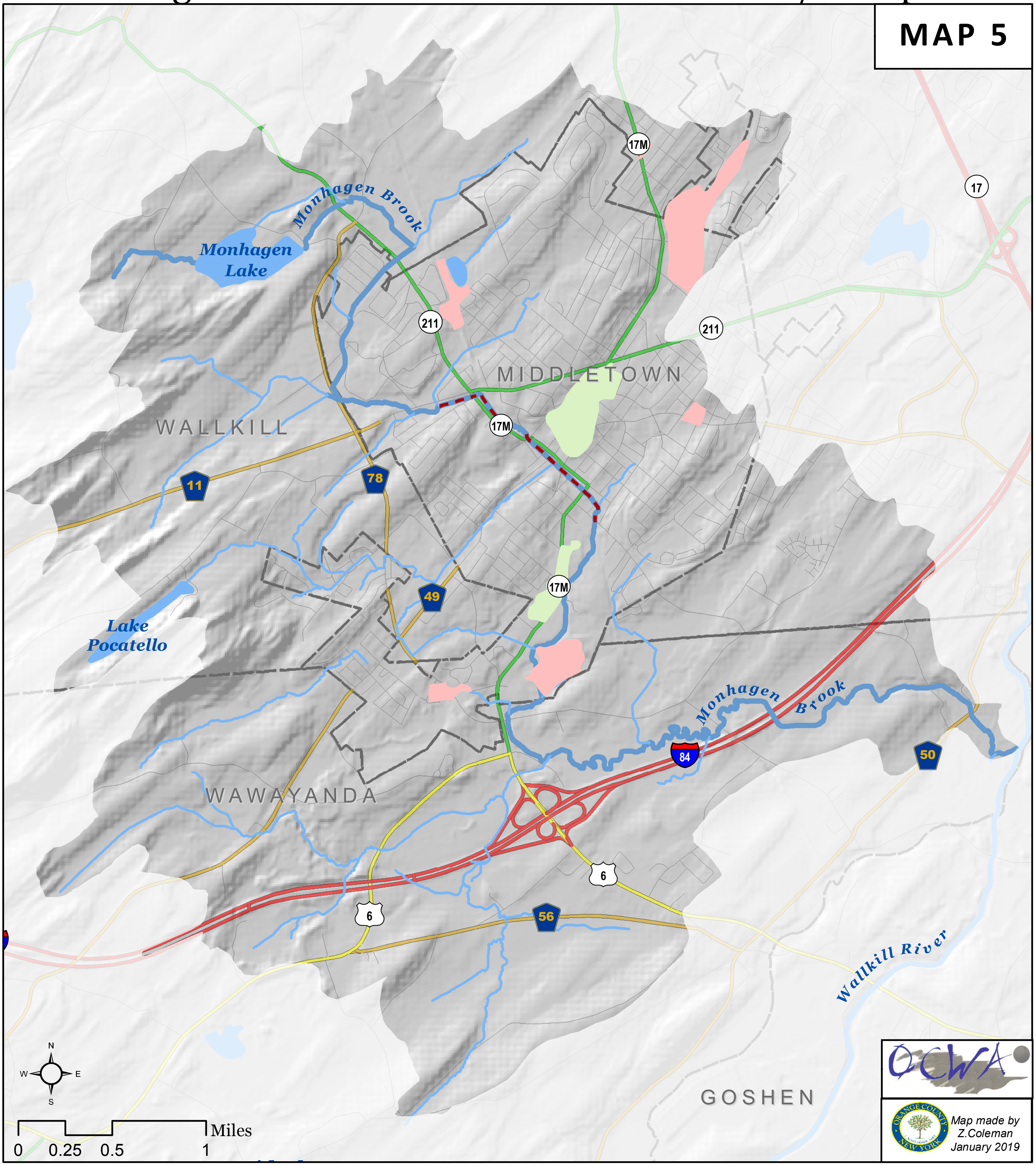


FEMA Flood Zones

Flood Zones

- 500 Year Flood Zone
- 100 Year Flood Zone
- Municipal Boundaries
- Underground segments of Brook
- Water Bodies
- Streams
- Monhagen Brook
- Interstate
- Federal Highway
- State Route
- County Road
- Local Road

Monhagen Brook Watershed: Urban and Fill/Dump Soils



Fill/Dump Soils
Urban Soils
Municipal Boundaries
Underground segments of Brook
Water Bodies
Streams
Monhagen Brook
Interstate
Federal Highway
State Route
County Road
Local Road

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pockets farther from the stream mapped as 500-year.

Lakes & Ponds

There are two named lakes in the Watershed: Lake Pocatello (23 acres; Class C), and Monhagen Lake (63 acres; Class AA), and one large pond in Fancher-Davidge Park (10 acres; Class C). Lake Pocatello is in the Town of Wallkill. It is a recreational lake lined with residences for 40% of its shoreline. Most of the houses around the Lake have a vegetated buffer between their yards and the Lake, so the lake shore is almost entirely lined with trees – a positive characteristic for stormwater filtration, water quality, and habitat.

Monhagen Lake is also entirely within the Town of Wallkill but has a totally different purpose: serving as one of the reservoirs supplying water to the City of Middletown. It has an average depth of 11 feet and a maximum depth of 22 feet. Its watershed is approximately 290 acres and is predominantly forested, thanks to land acquisition by the City of Middletown, which purchased the land out of interest for protecting its vital water source.

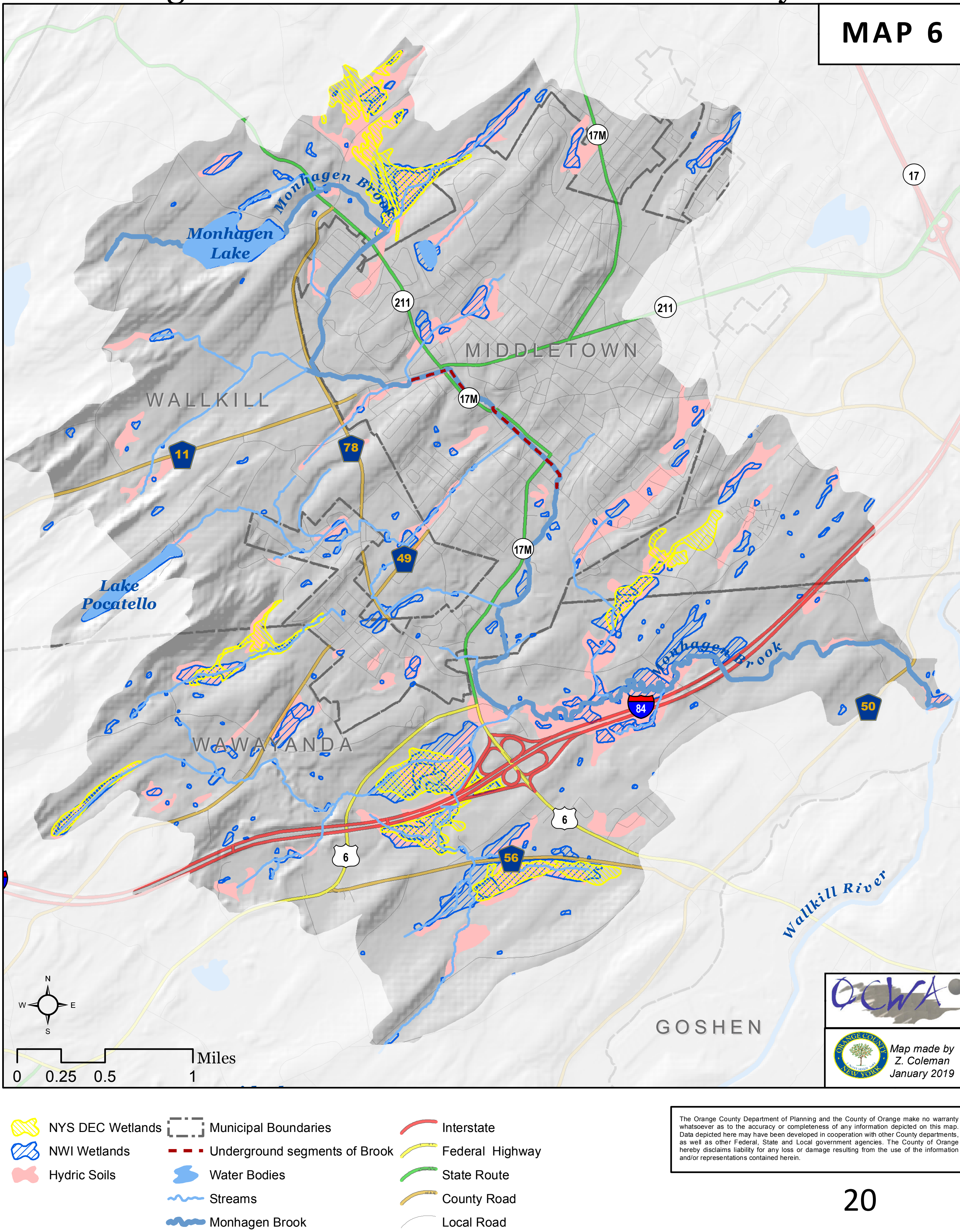
Wetlands[1]

There are several large wetland complexes in the Watershed, as shown in Map 6. The New York State Department of Environmental Conservation (NYSDEC) regulates wetlands of 12.4 acres or more as per the State Freshwater Wetlands Act; smaller wetlands with special local significance may also be protected. There are six state-regulated wetlands within the Watershed, encompassing a total of 330 acres (known as New York State Freshwater Wetlands – "NYSFWW"). For a detailed description of these NYSFWWs, see Appendix 12. There are about 780 acres of *potential* wetlands in the Watershed that were mapped through the U.S. Fish and Wildlife's National Wetlands Inventory (NWI) but these maps are not considered to be regulatory documents. These 780 acres include some but not all of the 330 acres of mapped NYSFWW. General understanding is that NWI maps were prepared primarily from interpretation of aerial imagery with limited "ground-truthing."

A resource that may be more useful than the NWI maps for predicting the location of wetlands not included on NYSFWW mapping is the Orange County Soil Survey published by the United States Department of Agriculture (USDA). Review of Map 6 in combination with the following text begins to reveal the complexity of wetland mapping and regulation. The map overlays the NYSFWW, NWI wetlands, and *hydric* soils as identified by the Soil Survey. There are about 980 acres of hydric soils in the Watershed. Hydric soils are a key concern for determining the location of federally regulated

[1] Brian Drumm, Wetlands Biologist, NYSDEC, assisted in accessing important mapping information about wetlands in the Watershed.

Monhagen Brook Watershed: Wetlands and Hydric Soils



wetlands. Since they are primarily regulated by the US Army Corps of Engineers (ACoE), these wetlands are often referred to informally as Army Corps wetlands.

A full discussion of federal wetlands is beyond the scope of this Plan, but a general understanding is important to this wetlands section. A common misconception is that there are "federal wetland maps" similar to the NYSFWW maps. Additionally, the NWI maps are sometimes mistakenly referred to as "the federal wetland maps" but, as noted, the NWI maps are not regulatory documents. When it comes to avoiding impacts to federal wetlands, it is incumbent upon the person or entity proposing an action on the land to determine if there are any federally protected wetlands near the proposed project area. This is done by means of a federal jurisdictional wetlands (FJW) determination by a qualified consultant (usually a biologist or a soil scientist), which must be reviewed and accepted by the ACoE. To be a FJW, the area *must* exhibit hydric soils, but must exhibit other wetland indicators as well. Therefore, not all hydric soils will necessarily be determined to be FJW's, though a strong correlation can be expected. Map 6 demonstrates that there is not a strong correlation between hydric soils and NWI wetlands. Since NYSFWW's generally must be greater than 12.4 acres, and since NYS's mapping procedures focused more on vegetation than soils, a strong correlation between them and hydric soil areas would not necessarily be expected.

Recent work to update the NYSFWW maps (originally mapped 30 or more years ago) is expected to yield a somewhat closer correlation with hydric soils than is depicted here since, among other reasons, wetland areas previously farmed and excluded from earlier mapping have in many cases reverted to wetland vegetation. However, hydric soil areas smaller than 12.4 acres will still be expected to cause total hydric soil acreage in the Watershed to be considerably higher than NYSFWW acreage. It is noted that federal wetland regulations do not recognize a lower size limit but, as described above, normally require an on-site delineation to determine their occurrence. If a Watershed-wide mapping of FJW's were to be undertaken, one would expect the total acreage to be strongly correlated with hydric soil acreage. Quantitative analysis of recently prepared maps showing additions and deletions of wetland areas on the NYSFWW map base was not possible at time of publication of this Plan due to unavailability of digital data.

Additional wetland discussion can be found in the *Implementation of Wallkill River Watershed Plan and Biological Resources* sections of this Plan, as well as Appendix 12.

Groundwater

Groundwater resources in Orange County have been studied extensively, notably by Frimpter of the US Geological Society (1970) and in a comprehensive groundwater study commissioned by the Orange County Water Authority (1994). A brief summary relevant to the Monhagen Watershed will be presented here; interested readers should refer to those two resources for more detailed, technical information.

Groundwater resources are generally recognized in two categorizes – unconsolidated aquifers (usually sand and gravel deposits) and bedrock aquifers. The highest yielding aquifers are those that occur in sand and gravel deposits that are hydraulically connected to streams or rivers. Some sand and gravel deposits are below the water table, but are overlaid by tighter-textured clays and silts that separate the aquifer from the surface water source (confining layers) so generally do not offer yields comparable to unconfined sand and gravel aquifers. Most residential wells draw their water from bedrock aquifers because drill rigs need only penetrate the bedrock and intersect cracks, with the bedrock itself providing the structural casing for the well. The cracks hopefully yield potable and nearly sediment-free water in quantities sufficient for a household (solid steel casing is needed for the portion of the well that passes through the overlying unconsolidated material). This simplifies the well development process as compared to developing a well in a sand and gravel aquifer where a casing must be designed to allow inflow of the groundwater while excluding the unconsolidated material that holds the groundwater.

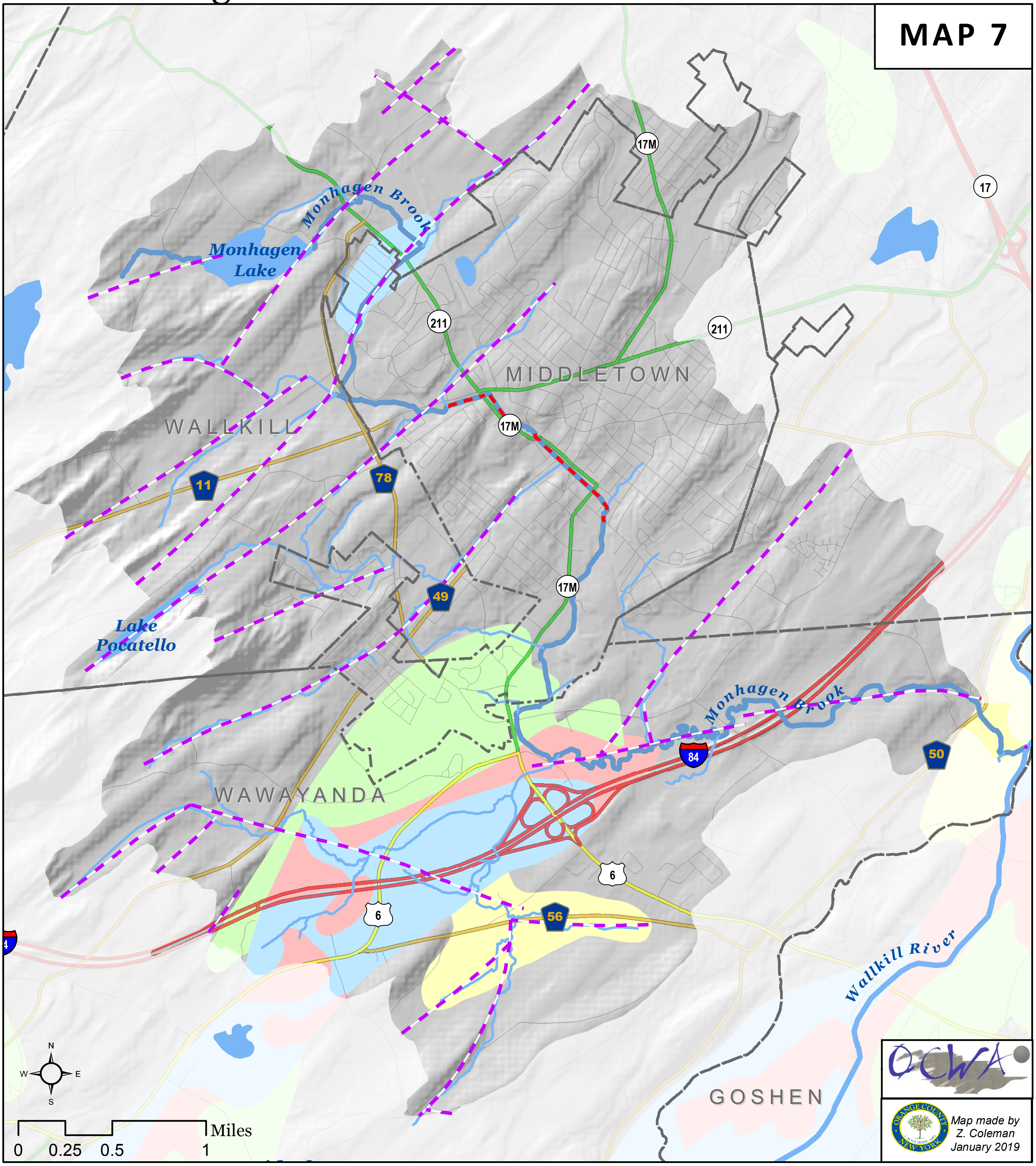
Community wells are most often developed in higher-yielding sand and gravel aquifers. However, where bedrock is highly fractured and multiple fractures can be penetrated by the well, yields sufficient for community supplies can sometimes be obtained. Other landscape features can enhance the likelihood of a well in a “fracture trace” (mapped bedrock areas thought to exhibit extensive fracturing) yielding quantities of groundwater sufficient for a community well. Wetlands are one of the landscape features that can enhance yields when they are located over areas of highly fractured bedrock.

Map 7 shows the occurrence of sand and gravel aquifers and fracture traces in the Monhagen Watershed. The most significant of these is aptly named the “Monhagen Brook Valley Aquifer.” Information on the number of wells currently drawing from this or other unconsolidated aquifers in the Watershed was not available. The importance of protecting water quality in the Monhagen Brook surface water system, and thus present and future drinking water supplies, is amplified by the aforementioned direct connection between unconfined sand and gravel aquifers and their associated surface water recharge source. Bedrock aquifers are thought to be less susceptible to pollution due to the longer distance and travel time surface water must flow to reach them, but the common occurrence of bacteria, nitrates, and other pollutants in bedrock wells argues for vigilant land management practices throughout the Watershed.

It is noted that the largest population center and central water system in the Watershed, that of the City of Middletown, is supplied by a system of surface water reservoirs, not groundwater wells. However, there are many residential and community wells in the Watershed, and future population growth can be expected to increase demand on groundwater resources.

An important summation of the hydrology section of this Plan is that surface water, groundwater,

Monhagen Brook Watershed: Groundwater Features



Stratified sand/gravel at land surface and below the water table
Stratified sand/gravel below clay or silt and the water table
Stratified clay/silt w/no or thin layers of sand/gravel at land surface and below the water table
Stratified sand/gravel at land surface and above the water table
Bedrock Fracture Traces
Municipal Boundaries
Underground segments of Brook
Water Bodies
Streams
Monhagen Brook
Interstate
Federal Highway
State Route
County Road
Local Road

wetlands, and floodplains are intricately connected in ways that are not always readily apparent but that argue for the utmost caution in matters of land management and land use planning to preserve both water quality and quantity, as well as to minimize flooding impacts.

Land Use & Land Cover

Analyzing a watershed's landscape is an essential part of understanding the overall dynamics within that watershed and can help identify areas to target for remediation, conservation, and monitoring. The analysis completed for this Plan was informed by many types of information, one of the more important of which is land cover. Land cover is the type of vegetation or man-made constructions on the land. Impervious land cover is an especially useful indicator of watershed dynamics because the amount of impervious surfaces – most commonly being pavement and buildings - affects water quality, stream morphology, and watershed hydrology. A watershed with a high percentage of impervious surfaces has different characteristics than a watershed with a higher degree of natural vegetation. Increases in impervious surfaces result in increases in the following conditions:

- streambank instability and erosion
- water quality impacts, such as increased surface water temperature and pollutant loads
- flash flooding
- reduced groundwater recharge and subsequent low base flows in streams during times of low precipitation

A common theme in watershed planning is to maintain an impervious cover amount of roughly 10%. In an urbanized area, that ratio can be a difficult goal to achieve. While the project partners know the "lay of the land" well in this Watershed from first-hand experience, data provided by University of Vermont's Spatial Analysis Lab[2] (Map 8) proved useful in determining areas where management activities should be focused.

[2] University of Vermont's Spatial Analysis Lab used aerial imagery from 2013 to automatically generate land cover classes that are represented by 1-meter pixels.

This highly detailed data classified land cover into one of twelve classes below:

1. Water
2. Wetlands
3. Tree Canopy
4. Tree Canopy Over Structures
5. Tree Canopy Over Roads
6. Tree Canopy Over Other Impervious Surfaces
7. Structures
8. Other Impervious Surfaces
9. Roads
10. Scrub-Shrub
11. Low Vegetation
12. Barren

Classes 4 – 8 all include impervious surfaces and were thus grouped together and treated as one class, called "Impervious," during the land cover analysis. Calculations were run for each of the Watershed's five subbasins to determine the percentage of land cover classes for each. The results are shown in Figure 9.

Based on that data, the Monhagen Brook Watershed is estimated to be almost 20% impervious (Figure 8). Broken down by subbasin, as shown in Map 9 and Figure 9, the Monhagen Lake subbasin has the lowest percentage of impervious (3%) while the Upper Middle Monhagen has the highest, at 33%.

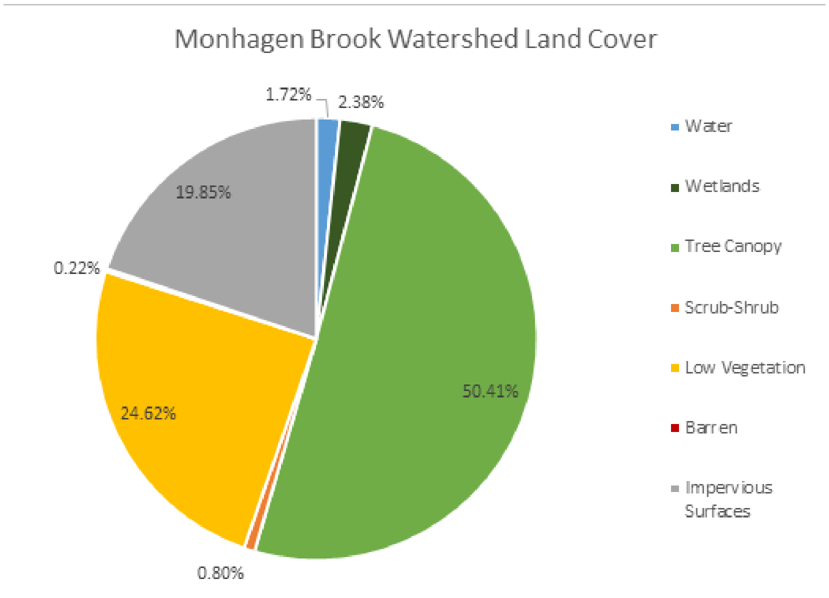
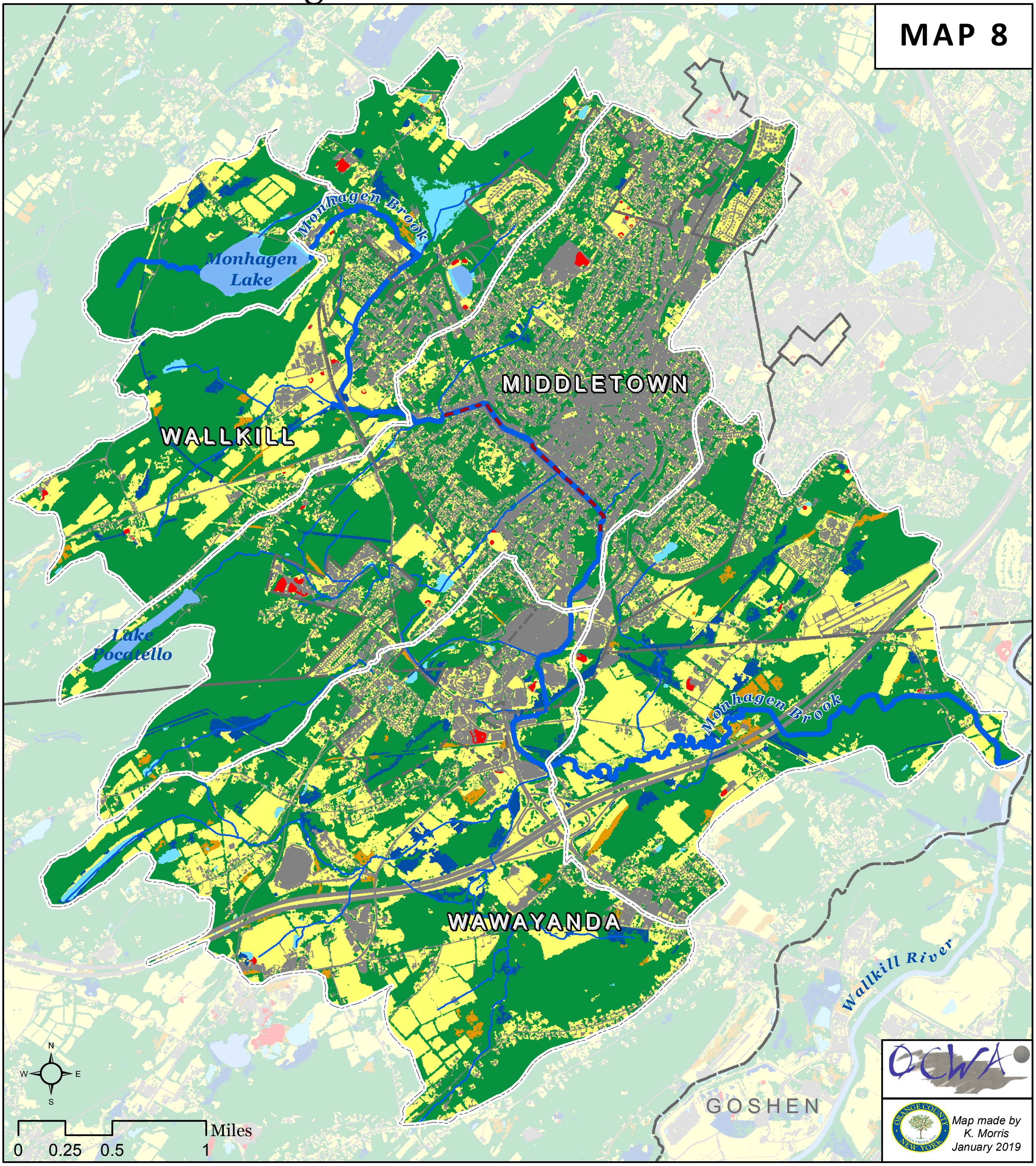


Figure 8. Percentages of land cover types within the Monhagen Brook Watershed.

In addition to impervious cover, land cover analysis in general is important for understanding watershed dynamics, and therefore a land cover analysis was performed for the Watershed.

Monhagen Brook Watershed: Land Cover



- Barren
- Impervious Surfaces
- Low Vegetation
- Scrub-Shrub
- Tree Canopy
- Water
- Wetlands (emergent)
- Subbasins
- Municipal Boundaries
- Underground segments of Brook
- Water Bodies
- Streams
- Monhagen Brook

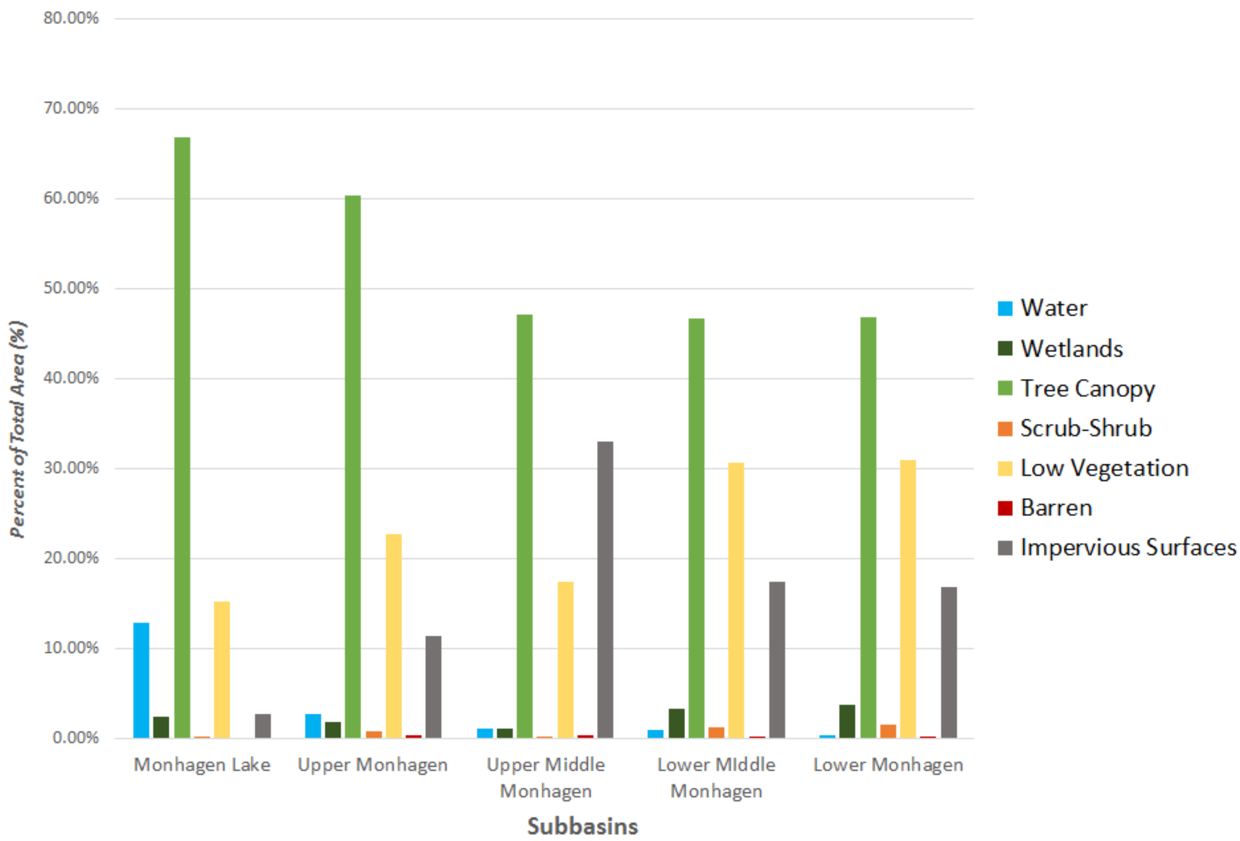
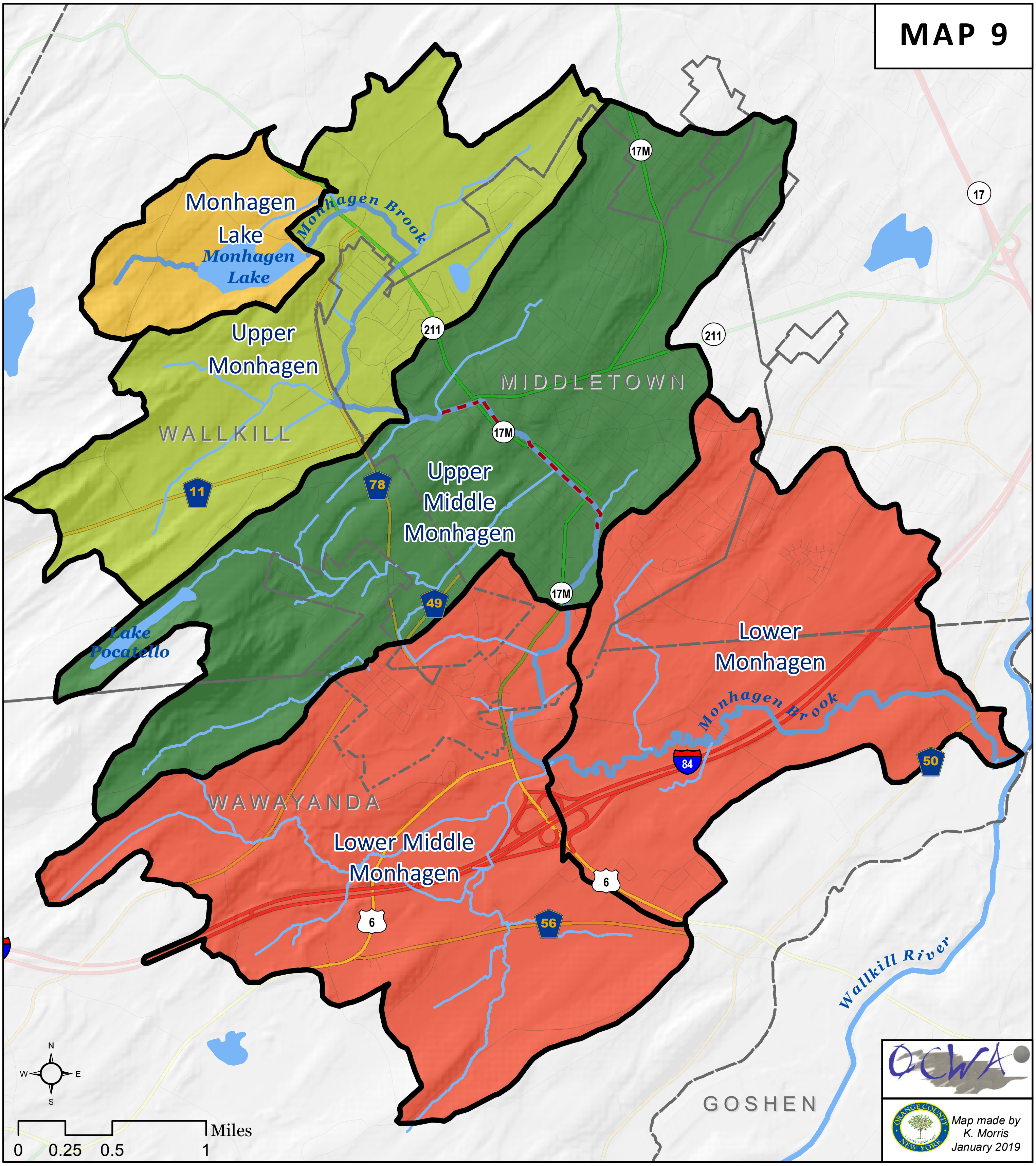


Figure 9. Percentages of land cover types within the five subbasins of the Monhagen Brook Watershed.

This analysis showed that all of the five subwatersheds have a relatively high degree of tree canopy, with Monhagen Lake being the highest, followed by the Upper Monhagen, and then the three remaining subwatersheds being roughly the same. The Lower Middle and Lower Monhagen subwatersheds had the highest percentage of low vegetation, likely due to the prevalence of agricultural fields such as hay fields. Classes such as Barren and Scrub Shrub do not comprise substantial areas within any portion of the Monhagen Brook Watershed. Impervious cover was highest in the Upper Middle Monhagen, which is not surprising considering it constitutes the most urban section of the Watershed, and the Monhagen Lake had the lowest impervious covers.

Watershed planners typically identify areas with a high degree of natural cover, such as the Monhagen Lake, as priorities for conservation; fortunately, the City of Middletown has not only been acquiring land within that subwatershed for years, but has also acquired State funding in 2018 through the State's Water Quality Improvement Project Program to protect more land within its drinking water supply watersheds. For subwatersheds with more impervious surfaces, such as the Upper Middle Monhagen, approaches tend to be more focused on restoration, such as stormwater retrofits, daylighting, and other

Monhagen Brook Watershed: Impervious Cover per Subbasin



% Impervious

- 3
- 11
- 17
- 33

- Municipal Boundaries
- Underground segments of Brook
- Water Bodies
- Streams
- Monhagen Brook
- Interstate
- Federal Highway
- State Route
- County Road
- Local Road

strategies that are included in the *Recommendations* of this Plan.

This land cover analysis is useful for identifying and prioritizing focal areas for further examination or specific practices, noting that there is no substitute for field visits as well as aerial imagery. This analysis can also lead to more refined examinations of smaller drainage areas within the subwatersheds that could assist with further identification of priority areas.

Recent Development Trends

Recent large-scale development within the Watershed has been predominantly commercial and industrial in nature. Based on an analysis of the approved GML §239 referrals[3] reviewed by the Orange County Department of Planning, of the roughly 33 referrals within the Watershed that were ultimately approved by the municipalities between August 2008 and August 2018, 23 were either commercial or industrial projects. Some of the most notable projects are located on US Rte. 6 in Wawayanda, including the approved and constructed 223,000 ft^2 CPV natural gas power plant between US Rte. 6 and I-84, an approved 240,000 ft^2 warehouse on a reclaimed mining site near the CPV plant off of US Rte. 6, and an approved and constructed 52,000 ft^2 hotel near the intersection of US Rte. 6 and NYS Rte. 17M. The approved projects represent a potential increase of approximately 600,000 ft^2 of commercial or industrial space.

This may only represent a fraction of future build-out. Current zoning in the areas of Dolsontown Road (Wawayanda), James P. Kelly Way (aka County Rd. 78, Middletown), US Rte. 6/NYS Rte. 17M (Middletown/Wawayanda) encourages commercial and industrial development. Dolsontown Road in particular has large parcels with wide-ranging large-scale development potential. It should also be noted, and as referenced in the footnote, that only projects within a 500' distance to a State or County Highway, State or County-owned park, County-owned facility, or Agricultural District must be referred to the County for review. New commercial and industrial development outside of these areas would therefore not be reflected in the analysis above.

With the growth of commercial and industrial developments within the Watershed, residential development can be expected to increase to accommodate workers and residents drawn to the commercial amenities. Several notable large-scale residential apartment projects are underway or have been completed in the past several years within the Watershed near the areas experiencing commercial and industrial growth. Sterling Parc Arpartments and a recently expanded Sutton Hill Apartments are located off of James P. Kelly Way in close proximity to the NYS Rte. 17M commercial corridor. Southgate Middletown is a luxury apartment development located west of Sterling Parc and north of the CPV plant.

[3] Local boards are required to refer certain land use-related actions to the County Planning Department as per NYS General Municipal Law section 239 (l, m, and n) for comment. While not all local land use actions are sent to the County, the majority of actions are subject to referral.

The Highrose Ridge Apartments complex is located to the north of these developments, just east of Lake Pocatello. Apartment and condominium complexes will likely continue to be developed within the Watershed in the future to accommodate growing demand.

As alluded to in the *Land Use Regulations* section, local officials have significant power over the fate of the waterbodies within their jurisdiction through their land use regulation authority. And therefore it is critical to the health of the Brook, the Wallkill River, the Hudson River, and ultimately the Atlantic Ocean and beyond that local policies and actions be mindful of the fact that what happens on the land greatly affects the nearby waterways, and use their judgment accordingly. The project team who developed this Plan will continue to work with local officials on watershed-friendly policies and enforcement, as noted in the Table 11: *Listing of Additional Recommendations*.

Demographics

Consideration of demographics can assist in understanding the stakeholders within a watershed, and thus affect the actions that are taken to protect, restore, and manage the watershed. Analysis of information from the US Census Bureau indicates that the Monhagen Brook Watershed conforms generally to the demographics of Orange County as a whole. The City of Middletown is younger and less affluent than the County average, balanced by the Towns of Wawayanda and Wallkill, which are older and wealthier than the County average. The Watershed has more renters than the County average, and the average renter household size is higher than that of the County as a whole.

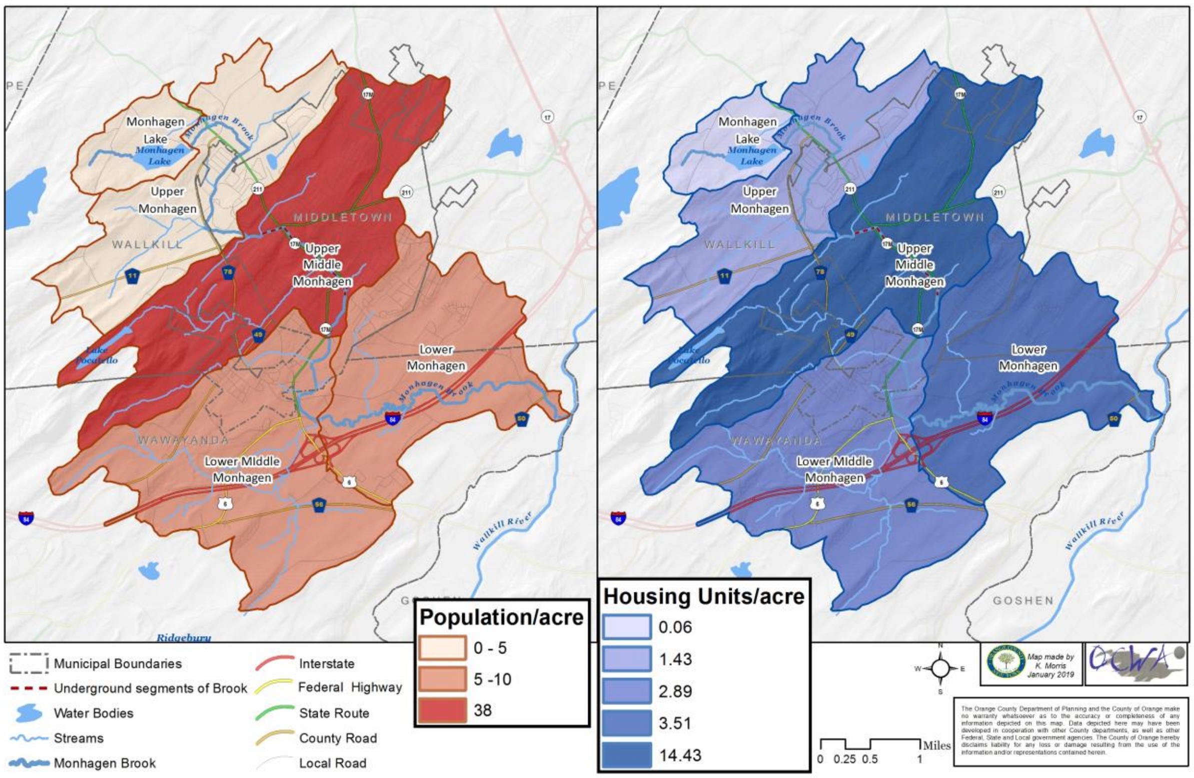
	Housing		Population	
	Units	**Units/Acre**	**Population**	**Density/Acre**
Total	**12,167**		**31,214**	
SUBBASIN				
Monhagen Lake	30	0.06	77	0.14
Upper Monhagen	782	1.43	2,170	3.98
Upper Middle Monhagen	7,865	14.43	20,781	38.13
Lower Middle Monhagen	1,577	2.89	3,496	6.41
Lower Monhagen	1,913	3.51	4,690	8.61

Table 2. Demographic statistics by subbasin

The population increase within the Watershed from 2000 to 2010 is consistent with the County's growth rate of 9.2% during that timeframe, and the 2016 Census estimate shows that the Watershed population has grown very slightly since

2010, which is also consistent with the County's slow growth since the economic downturn that began in 2008.

As displayed in Table 2 and Map 10, the Watershed varies in land use intensity, which is reflected by population and housing numbers from the 2010 Census. Not surprisingly, the subwatershed with the highest population and housing density includes the urban core of Middletown, while the Monhagen Lake subwatershed, which is largely protected, has the fewest residents and houses.



Map 10. Demographic statistics by subbasin.

Soils

Not surprisingly, the soils of the Monhagen Brook Watershed closely reflect the makeup of the County at large. The Soil Survey of Orange County[4] indicates, "Orange County was moderately affected by glaciation." Consequently, 86% of the County's land surface is covered by glacial till. Also known as "rock flour," glacial till is composed primarily of fine-textured particles, predominately silt, pushed

[4] Natural Resource Conservation Service, 1981

ahead of advancing glaciers and dropped behind as they retreated. These particles tend to restrict drainage/infiltration resulting in moderately to somewhat poorly drained soils. Orange County farmers have been known to speak of soils that are typically suitable for cultivation for only a couple of days in the late spring/early summer before becoming too wet, akin to trying to work concrete. This characterization clearly evolved from experience in farming glacial till soils.

Owing largely to their slow permeability, till soils commonly exhibit a “perched” water table that may sit near the surface at wetter times of the year. Distinguished from a “true” water table that is hydrologically connected with a stream or other waterbody, perched water tables result from the buildup of shallow groundwater over restrictive soil layers. On sloping areas, these perched water tables often intersect the surface, resulting in wet spots or springs. Understanding these characteristics of till soils is important for a range of land use considerations from farming to building construction and on-site septic systems.

Till soils are usually loaded with rocks of all sizes and shapes that were bulldozed from bedrock by the glacier before being dragged and mixed into the ground moraine. The myriad rock walls in the County are testimony to this glacial history and to the centuries of rock picking undertaken by determined farmers. Some areas were so dominated by this rocky glacial debris that even intrepid farmers shied away from attempting to clear the area for cultivation. These areas typically became low-management pasturelands and often ended up being mapped as “extremely stony” phases of the parent soil type (see the Alden-AC and Erie-ESB mapping units, for example).

The remaining 14% of land in the County is mapped as a variety of different soil types: sand and gravel deposited by glacial meltwater (glacial outwash); fine-textured, rock-free soils that formed in ponded areas following the retreat of the glacier (lacustrine deposits); alluvial soils (formed by deposition of stream sediments); organic deposits (black dirt); open water; and urban land (disturbed/made).

Though vegetables and other more fickle crops can be coaxed from Orange County soils, particularly from the better drained outwash soils, the soils of the County are generally better suited to support the “hay/pasture/field crop” scenario associated with dairy farming that is currently in decline but historically was the mainstay of agriculture in the County.

As for the Monhagen Brook Watershed, 78.2% of the land area is till, 8.3% is glaciofluvial (outwash), 5.8% is lacustrine, 2.3% is alluvial, and 5.2% is characterized as miscellaneous. As previously noted, this aligns with the overall glacially influenced landscape of Orange County soils.

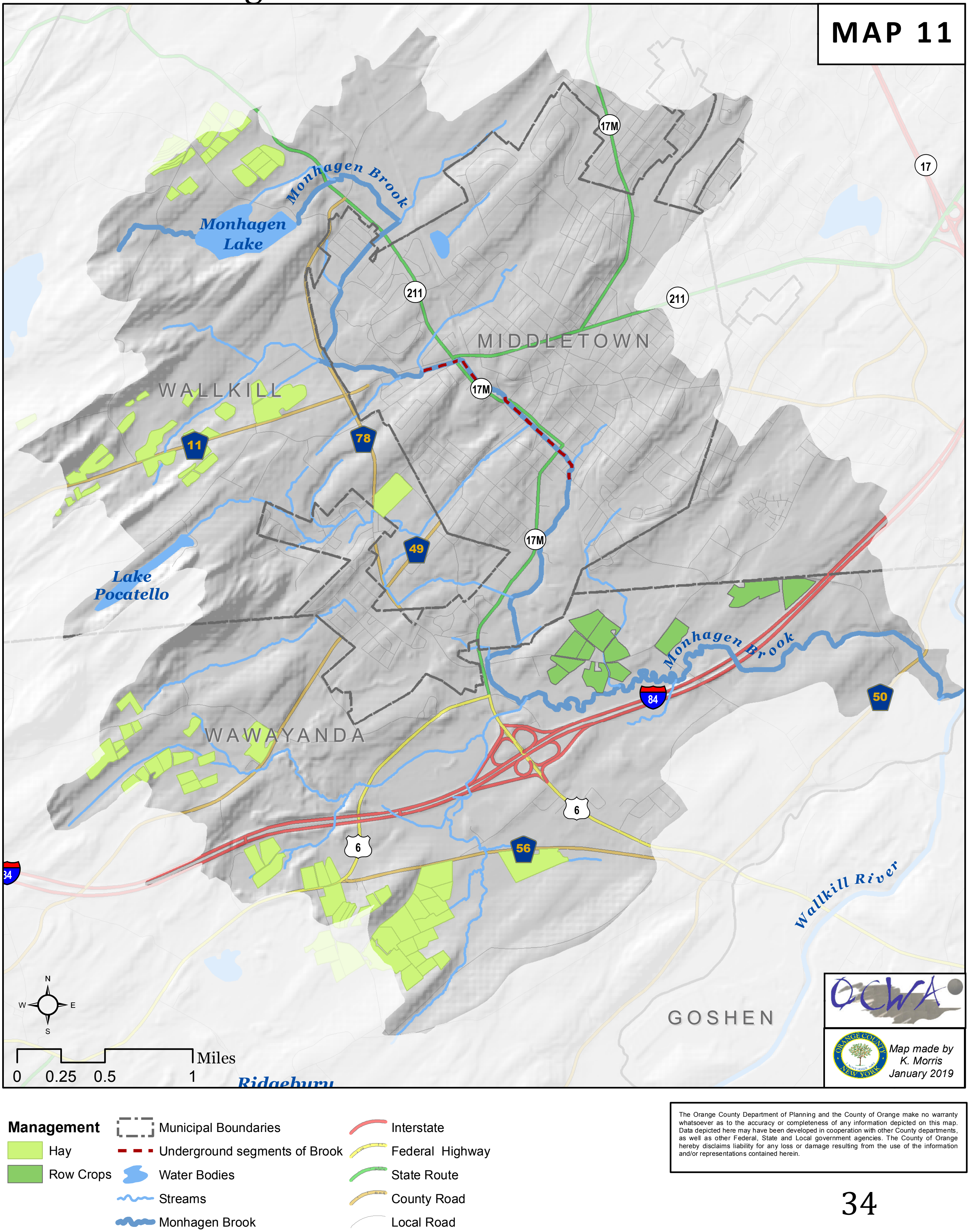
TILL	acres	OUTWASH	acres	LACUSTRINE	acres	ALLUVIAL	acres	OTHER	acres
AC	156	Fd	63	UnB	32	Cf	60	My	68
ANC	64	AdB	13	Ca	116	Du	152	Wd	164
AND	72	CgB	8	HH	44	Pa	22		
Ab	255	CnB	16	Ma	169	UH	168		
BnB	173	CnC	5	Ra	80	Ur	90		
BnC	75	HoA	60	RbA	60	W	131		
ESB	442	HoB	302	Sb	15				
ErA	524	HoC	167	UF	22				
ErB	1,337	HoD	99	ScA	31				
MNE	46	OVE	28	ScB	34				
MdB	3,334	Pg	5						
MdC	1,217	RhB	52						
MdD	291	RhC	34						
NaD	55								
RSB	91								
RSD	150								
RSF	51								
SXC	302								
SXD	4								
total acres	**8,639**		**851**		**602**		**623**		**232**
percent of watershed	**78.9%**		**7.8%**		**5.5%**		**5.7%**		**2.1%**

Notes
1. See Plan text for explanation of the categories till, outwash, lacustrine, alluvial and other.
2. Soil Symbols (AC, MY, etc.) are from the Soil Survey of Orange County, NY.

Table 3. Soils of the Monhagen Brook Watershed

The importance of soils in natural resource management cannot be overemphasized. Having a thorough understanding of their geologic history, characteristics, capabilities, and limitations is critical in the context of developing a watershed and conservation management plan. Appendix 1 includes additional information about soils in the Watershed.

Monhagen Brook Watershed: Active Farmland



Agriculture

The *Soils* section of this Plan notes the limited suitability of much of Orange County's land for high-value crops, which tend to demand soils of uniform texture and drainage. The soils of the County were, however, well suited to the dairy farming that historically dominated the agricultural landscape and to the hay/pasture/corn crops that provided the main feed source for cows. The number of dairies in the County is said to have been over 500 in the 1950's, and by inventory of the Orange County Soil and Water Conservation District (SWCD) in the 1980's, they numbered 250. At the time of the writing of the Wallkill Watershed Conservation and Management Plan (2007), the number was in the 90's. In 2018, the number is around 40 within the County. The decline of dairy farms in the County over the last 30 years affected the landscape of the Monhagen Watershed, as well as the County as a whole. Map 11 shows the areas that are used for agricultural purposes, being either row crops (primarily corn) or for hay. In total, approximately 660 acres of the Watershed are considered agricultural (this calculation is based on aerial imagery and local knowledge).

At the writing of the Wallkill River Watershed Conservation and Management Plan (2007), there were three farms in the Monhagen Watershed shipping milk. One of them was the largest dairy farm in the County with, at times, over 1,000 milk cows. No farms in the Monhagen Watershed are currently shipping milk in 2018. There are several small operations raising dairy replacement animals, but impacts to the Watershed from dairy farming – positive *or* negative – are generally of small significance and not anticipated to increase anytime in the near future. Although not precisely quantified, knowledge of the few local agencies that deal with agricultural producers indicates that there are a comparably small number of operations with non-bovine farm animals such as goats, chickens, pigs, etc. Therefore, the agricultural activity in the Watershed is not considered to be of major significance in terms of natural resource management.

A cursory survey of recent aerial photography around the Watershed shows substantial evidence of *past* agricultural land use. Almost all of these areas are now either low-management hayland that are unlikely to receive commercial fertilizer and may not even be harvested every year, or have been mostly abandoned from agricultural production and are in the early stages of succession to herbaceous and woody vegetation that follows the discontinuance of a regular mowing regimen. These circumstances point to the difficulty in precisely defining the extent of agricultural land use.

Row crops or other annual crops are more likely to receive amendments such as herbicides and fertilizer, and are more prone to erosion, therefore making a more significant contribution to water quality issues such as excess phosphorus. Total acreage of annual row crops within the Watershed is estimated to be 140 acres in recent years, though production can change significantly from year-to-year depending on weather, short-term farm economics, and other factors. This is almost entirely field corn, but in any given year could include a smaller acreage of soybeans. Over 100 acres of these row crops are lands rented by various owners to a cash crop farmer. The remaining row crop acreage is composed of small cornfields associated with cow farming operations whose headquarters are outside the Watershed, or are fields planted as wildlife/hunting plots. The cash crop lands are generally mildly sloping and are almost entirely “corn-for-grain,” with stalks/crop residue left behind to protect the soil; therefore erosion/sedimentation concerns are limited.

The extent of nutrient and/or pesticide application in the Watershed has not been quantified. However, the negative water quality impacts of agriculture is likely less significant than non-agricultural land uses in the Watershed due to the low percentage of overall acreage, the management factors detailed above, and the land uses and infrastructure challenges detailed throughout this Plan. In the future, if non-agricultural concerns are adequately addressed, renewed attention to remaining issues from agricultural lands might be warranted. This is not to say that agricultural conservation projects will not be aggressively pursued if opportunities present themselves.

Water Quality

NYSDEC’s Water Quality Standards and Classifications designate the “best uses” that waterbodies should support and are the basis for programs to protect New York State waters. The Monhagen Brook is classified as a “Class C” waterway. Waterways within this class are expected to support fisheries and be suitable for non-contact activities. As noted previously, the Brook is on the NYSDEC’s Priority Waterbodies List (PWL) because phosphorus pollution may be impairing the stream from meeting its “best uses.” Below is a summation of the work that has been done to better understand the water quality within the Monhagen Brook.

Phosphorus

Phosphorus (P) originates from many sources. One of the main sources is soil, which typically contains significant quantities of attached phosphorus. Therefore, waterbodies in watersheds with high rates of erosion are likely to show phosphorus-related impacts. Given that the primary pollutant of the Wallkill River, to which the Monhagen is a tributary, is silt/sediment, understanding the sources of both of these pollutants is of critical importance.

Phosphorus is one of the three macronutrients found in commercial fertilizer and, in the right place and in the right quantity, benefits plant growth with minimal impact to water resources. In many freshwater systems, potentially including the Monhagen Brook Watershed, phosphorus is considered to be the limiting nutrient, meaning that its concentration in the water is almost solely responsible for dictating the pace of aquatic weed and algae growth. Minute quantities can stimulate rates of aquatic plant growth that impact human uses of waterbodies and also affect other aquatic organisms.

Elevated levels of phosphorus entering Monhagen Brook, as with any waterbody, can have a significant impact on water quality. In addition to causing excessive weed and algal growth, which is aesthetically unpleasing, some algal blooms caused by cyanobacteria can produce toxins harmful to human and animal health. These harmful algal blooms (HABs) were documented in 2015 and 2016 at various locations on the Wallkill River, which Monhagen Brook drains into, as well as in Monhagen Lake in 2017. The Monhagen Brook is likely contributing to the phosphorus in the Wallkill River given its status on the Priority Waterbodies List (PWL) and the data gathered for this Watershed Plan. The field data provides a good baseline in support of a more rigorous chemical sampling program within the Monhagen Brook Watershed that could better define the sources and concentrations of phosphorus.

There is no national water quality standard for phosphorus. The United States Environmental Protection Agency (EPA) has non-regulatory criteria based on a general classification of a waterbody and encourages states to develop their own criteria based on local conditions and information. EPA criteria are less than 0.1 ppm for streams/rivers, 0.05 ppm for streams entering lakes, and 0.025 ppm for lakes/reservoirs. The NYSDEC is currently in the process of creating numeric phosphorus concentration standards that will be supported by the EPA, but has yet to propose or publish these standards, or define how they will be used. Currently, nutrients such as phosphorus are regulated as a narrative water quality standard by NYSDEC. The narrative standard for phosphorus is: "none in amounts that result in the growths of algae, weeds, and slimes that will impair the waters for their best usage."

As mentioned before, the NYSDEC PWL classifies the Monhagen Brook as "phosphorus impaired." This characterization is based on biomonitoring results and what the NYSDEC calls "Impact Source Determination" (ISD).[5] Benthic macroinvertebrates have been widely studied and shown to be an accurate method of determining if a waterbody is impaired. NYSDEC's ISD takes biomonitoring a step further and uses the results to determine *sources* of impairment. This is done by developing "model communities" for each of the six impact source classes, which are: 1) nonpoint nutrient additions, 2) siltation, 3) toxic, 4) organic (sewage effluent or animal wastes), 5) complex (municipal and/or industrial), and 6) impoundment. The seventh class is known as natural, meaning there is no impact to the benthic macroinvertebrate community. These model communities are then compared to biomonitoring results from a location and matched. Often, the sample does not match any one category perfectly and multiple sources are then listed for impairment. See the *Stream Biomonitoring* section for more information and data on the Brook.

Phosphorus Monitoring

Apart from sporadic "grab sampling," a chemical sampling program designed to provide more specifics on sources and other aspects of phosphorus presence in the Monhagen Brook had not been undertaken

[5] Riva-Murray, K., Bode, R. W., Phillips, P. J., & Wall, G. L. (2002). Impact source determination with biomonitoring data in New York State: concordance with environmental data. Northeastern Naturalist, 127-162.

in the past. This led Orange County Soil and Water (SWCD) to spearhead an initiative to collect phosphorus samples along the main stem and some tributaries of the Brook as part of this project. Due to funding limitations, this sampling effort was not a comprehensive, rigorous phosphorus study. Rather, it was meant to characterize impacts and gather a better idea of potential sources throughout the Watershed. Due to the limited nature of the study, any interpretations of the data should be similarly limited in scope.

Volunteers were utilized to help collect samples. This reduced sampling costs, allowing the entire grant-funded sampling budget to be dedicated to analysis. In addition, using volunteers increased local resident involvement in the planning process. All samples were analyzed for total phosphorus at Upstate Freshwater Institute in Syracuse, NY. For complete sampling protocol, see Appendix 2.

Sample sites were selected at various locations along the main stem and tributaries of the Brook to gather a snapshot of different land uses within the Watershed. See Map 12 for phosphorus sampling locations. Sampling events occurred on 4/10/2017, 5/22/2017, 10/10/2017, 1/23/2018, and 6/20/2018. See Table 4 for complete results. The large gap between May 2017 and October 2017 sampling events was due to sampling equipment failure resulting in a lack of data for this time period.

Figure 10. Gathering a phosphorus sample

Testing Site	Location	Main Stem (MS) or Tributary (Trib)	Date				
			4/10/17	5/22/17	10/10/17	1/23/18**	6/21/18
			(µg/L)				
1	Monhagen Reservoir	MS	25.7	45.6	37.7	68	54.7
2	Gold Minds	Trib	21.8	40.2	46.5	56.3	48.8
3	Fulton St.	MS	26.0	149.9	61.4	308.4	61.7
4	Rowley Center	Trib	33.7	-	56.7	276.5	78.5
5	Genung St.	MS	28.9	135.4	58.1	338.6	236.8
6	W. Main	MS	31.1	39.2	69.5	191.1	62
7	Dolsontown (Shell Station.)	MS	30.8	61.6	56.0	157.5	105.6
8	Rt. 49/Allen Dr.	Trib	36.9	75.8	54.0	171	36.7
9	Healey Bros.	Trib	52.6	70.9	171.7	169.3	195.8
10	Factory Ruins	MS	66.8	87.7	56.0	162.6	130.8

* Bottle broke during transport, no value reportable for that location
** Wet weather sampling

Table 4. Results of phosphorus sampling in 2017-2018. Sampling work designed and organized by SWCD

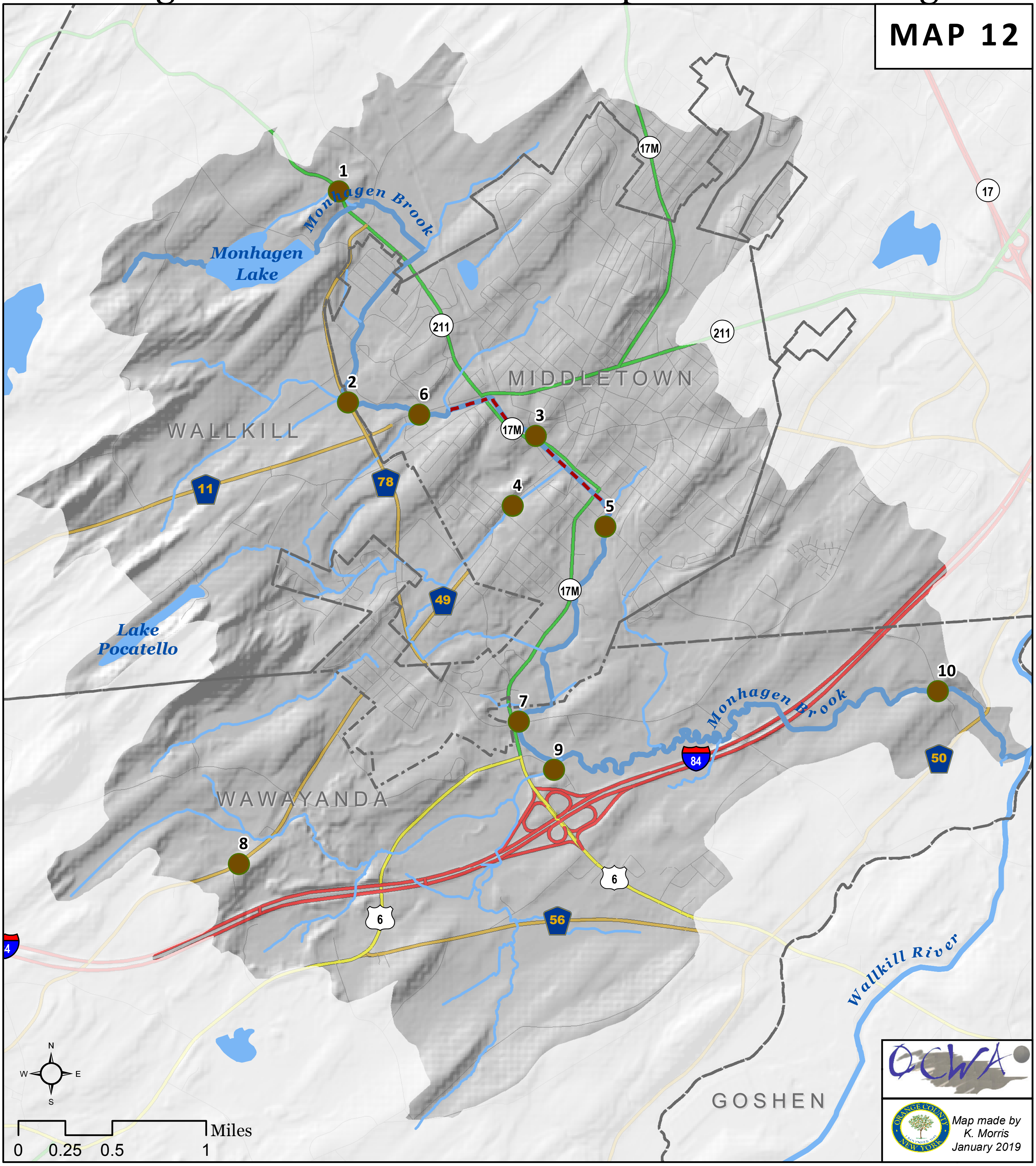
Results of the study show phosphorus coming from all areas of the Watershed. Some of these areas are predominantly agricultural (ex. Sample site 8) but some of the highest phosphorus concentrations were taken from the more urban/suburban areas of the Watershed (Fulton and Genung Streets). Generally, phosphorus concentrations increased or stayed roughly the same as water flowed down the main stem of Monhagen Brook. Further investigation using flow data will yield a better understanding of stream dynamics and lead to a more accurate identification of phosphorus loading. The results do suggest that urban/suburban influences are a contributing factor, possibly the primary factor, to phosphorus concentrations in Monhagen Brook as the Fulton and Genung Street sampling locations are both highly urbanized.

While the sampling dates are somewhat sporadic, they were selected in order to catch both low-flow and high-flow events. To augment these results, a better-funded, rigorously designed study would more precisely identify sources and quantities of phosphorus loading. Such a study would help hone and reinforce recommendations for phosphorus reduction practices made in the current Plan, as well as develop new strategies for phosphorus reduction.

NYSDEC Sampling of Stream Chemistry & Macroinvertebrates

In 2017, the NYSDEC's water quality monitoring programs developed an approach to better understand water quality impacts in the Wallkill River and initiate planning activities for water quality improvement. In 2008 the NYSDEC's water quality monitoring program had conducted routine monitoring that resulted in a report suggesting water quality had declined in certain areas of the Wallkill River when compared

Monhagen Brook Watershed: Phosphorus Monitoring Sites



Phosphorus Sampling Locations
Municipal Boundaries
Underground segments of Brook
Water Bodies
Streams
Monhagen Brook
Interstate
Federal Highway
State Route
County Road
Local Road

with previous sampling in the 1990's (http://www.dec.ny.gov/docs/water_pdf/wallkill08.pdf). More recent follow-up water quality monitoring in 2012 suggested further impacts to aquatic life. Additionally, the Wallkill River experienced documented Harmful Algal Blooms (HABs) in 2015 and 2016, which significantly impacted recreation on the river (http://www.dec.ny.gov/chemical/83332.html).

Methods

NYSDEC's water quality monitoring programs and Hudson River Estuary Program worked together to collect water quality samples in the Wallkill River watershed. Between July and October 2017, NYSDEC staff collected biological and water chemical data at 13 sites in the Wallkill River and several tributaries, including the mouth of the Monhagen Brook at Golf Links Road, Middletown. Sampling included three dry weather samples and two wet weather samples. In 2018, NYSDEC expanded the study to 30 sites, and included two sites on the Monhagen Brook. Results from 2018 are forthcoming.

Equipment selection, equipment cleaning, sampling collection, and sample processing methods followed procedures as specified in the Quality Assurance Project Plan for Rotating Integrated Basin Studies (NYS DEC 2017) and the Standard Operating Procedure: Collection of Water Column Samples from Rotating Integrated Basin Studies (NYS DEC SOP #210-17). This includes collection of water samples using width integrated methods and isokinetic depth-integrating samplers. Samples were composited into a churn splitter for division into bottles for delivery to the laboratory. In low velocities where isokinetic samplers were not appropriate for use, integrated samples were collected using open bottle verticals. Samples were analyzed at ALS Environmental, a NYSDEC contract laboratory with ELAP (Environmental Laboratory Approval Program) certification for these parameters.

Water chemistry samples were collected and analyzed for field parameters, nutrients, turbidity, minerals, total dissolved solids, unfiltered trace elements, and chlorophyll-a. Multiparameter meters used to measure field parameters were calibrated for dissolved oxygen, pH, and specific conductance.

Results

In 2017, the sampling site on the Monhagen Brook was as close to the mouth as possible, to characterize the overall contribution of the Watershed to the Wallkill River. This was at Golf Links Road, Middletown, 0.4 miles from the Wallkill River (ID: 13-MOHN-0.4). Sampling dates were 7/19/17 (14:50, dry weather), 8/1/17 (12:46, dry weather), 9/6/17 (12:25, wet weather), 9/19/17 (11:50, dry weather), and 10/11/17 (12:34, wet weather). In 2018, sampling continued at this site, in addition to a new site at Campbell Plaza on Dolson Avenue, 200 meters upstream of the Middletown sewage treatment plant (ID: 13-MONH-4.1).

Field Parameters

Site	Parameter	Average value
13-MONH-0.4	Water temperature	21.47 °C
13-MONH-0.4	Specific conductivity	927.4 Umhos/cm
13-MONH-0.4	pH	8.17
13-MONH-0.4	Dissolved oxygen	9.76 mg/L

Nutrients

Site	Parameter	Average value
13-MONH-0.4	Nitrate + Nitrite as Nitrogen	229.8 μg/L
13-MONH-0.4	Nitrogen, ammonia (as N)	18.4 μg/L
13-MONH-0.4	Nitrogen, nitrate (as N)	229.8 μg/L
13-MONH-0.4	Phosphorus, total (as P)	78.6 μg/L

Metals

Site	Parameter	Average value
13-MONH-0.4	Aluminum	137.1 μg/L
13-MONH-0.4	Arsenic	0.895 μg/L L
13-MONH-0.4	Copper	3.2 μg/L
13-MONH-0.4	Iron	352 μg/L
13-MONH-0.4	Lead	1.504 μg/L

13-MONH-0.4	Nickle	2.9 µg/L
13-MONH-0.4	Zinc	5.5 µg/L

<u>Other</u>

Site	Parameter	Average value
13-MONH-0.4	Alkalinity, total (as CaCO3)	146,000 µg/L
13-MONH-0.4	Chloride (as Cl)	203,200 µg/L
13-MONH-0.4	Chlorophyll A	4.228 µg/L
13-MONH-0.4	Conductivity at 25 degrees Celsius	999 Umhos/cm
13-MONH-0.4	Hardness (as CaCO3)	228,000 µg/L
13-MONH-0.4	Magnesium	9930 µg/L
13-MONH-0.4	pH	8.08
13-MONH-0.4	Total Dissolved Solids (residue, filterable)	521,000 µg/L
13-MONH-0.4	Turbidity	4.49 NTU

Table 5. Results of NYSDEC's sampling of the Monhagen Brook in 2017.

Of the 13 sites in the Wallkill River and tributaries, specific conductivity was highest in the Rio Grande and the Monhagen Brook, and higher during dry weather than wet weather. Total dissolved solids was also highest in the Rio Grande and Monhagen Brook; this parameter often tracks specific conductance.

Enterococcus[6]

In 2016, Riverkeeper and community partners, including members of the Wallkill River Watershed Alliance, tested the Monhagen Brook for the bacterial indicators of fecal contamination *Enterococcus* (Entero) and *Escherichia coli*. This sampling was part of a two-year Riverkeeper study designed to identify sources of fecal contamination to the Wallkill River, where results of Entero monitoring by Riverkeeper and community partners since 2012 have documented chronic, severe, and widespread fecal contamination[7]. The source tracking project was funded by a grant from the Hudson River Estuary Program of the NYSDEC.

Background

Entero and *E. coli* are bacteria that live in the digestive systems of humans and other animals. Although some strains of Entero and *E. coli* can make people sick, the types present in the environment usually do not cause illness. However, they indicate the likely presence of untreated waste, and therefore an increased chance that pathogens may be present. Entero and *E. coli* are recommended by the Environmental Protection Agency (EPA) to evaluate water quality for recreational use; NYS has not set a water quality standard for these bacteria.

Riverkeeper assesses water quality using the EPA's science-based 2012 Recreational Water Quality Criteria[8], which recommends thresholds of Entero and *E. coli* per 100 ml of water, consistent with use of the waterbody for "primary contact recreation." This includes swimming, bathing, child water play, and other activities where ingestion of water or full immersion of the body is likely. NYSDEC currently uses total and fecal coliform standards to regulate recreational water quality.

EPA recommends three different ways of using Entero and *E. coli* to assess recreational water quality. These are summarized in Table 6.

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[6] This section contains excerpts from a report by Riverkeeper entitled "Community Science Program: Monhagen Brook Fecal Contamination Monitoring Results," which is included as Appendix 7 to the Plan.

[7] www.riverkeeper.org/water-quality/citizen-data/wallkill-river

[8] https://www.epa.gov/wqc/2012-recreational-water-quality-criteria

Criterion	Threshold	
	Enterococcus	*E. coli*
Beach Action Value (BAV) If a single sample tests above this level, the EPA recommends public notification, and recommends against swimming.	60 Entero/100 mL	190 E. coli/100 mL
Geometric Mean (GM) A geometric mean (a type of weighted average) above this value indicates that chronic contamination is present and that the water is unsuitable for swimming.	30 Entero / 100 mL	100 E. coli / 100 mL
Statistical Threshold Value (STV) If more than 10% of samples exceed this value, it indicates that occasional contamination spikes are occurring and that the water is unsuitable for swimming.	110 Entero / 100 mL	320 E. coli / 100 mL

Table 6. Overview of criteria for two bacteria of concern within waterbodies.

Methods

Samples were collected weekly during August 2016 at McVeigh Road in the Town of Wawayanda. This site was selected because the objective of the sampling was to characterize inputs from various tributary watersheds to the Wallkill River's main stem, and this is an accessible location close to the Monhagen Brook's confluence with the Wallkill River. Samples were also collected from 12 other Wallkill River tributaries on the same dates.

Samples were collected and processed by volunteer community scientists who were trained by Riverkeeper staff. Bacterial counts were determined using the IDEXX Enterolert and Colilert systems, which are EPA-approved methods for enumerating these bacteria in surface water samples.

Fecal contamination varies from place to place and over time, so the sampling results from this location are not indicative of conditions elsewhere in the Monhagen Brook Watershed, or to predict future conditions at any time and place. Entero and *E. coli* are indicative of water quality for recreation. These results should not be used to determine water quality with respect to fish and other aquatic life, or the presence of other types of pollution (e.g., nutrients, sediment, toxic chemicals).

Results

A total of 5 samples were analyzed. Results are shown in Table 7. Of the 5 samples, 4 exceeded the Beach Action Value (BAV) for both Entero and *E. coli*, and one did not exceed the BAV for either indicator. All samples that exceeded the BAV also exceeded the Statistical Threshold Value, for both indicators. The geometric means of all samples taken were 533.4 cells/100 mL for Entero and 695.4 cells/100 mL for *E. coli*. These results indicate that fecal contamination is present at this site, and that it is frequent and severe.

Sampling Date	Entero Count (cells/100 mL)	*E. coli* Count (cells/100 mL)	Cumulative Rainfall 4 days prior to sampling (inches)
August 1	>2420*	>2420*	3.05
August 8	120	350	0.00
August 15	355	426	0.95
August 22	10462	8664	0.83
August 29	40	52	0.00

*2,420 cells/100 mL is the limit of detection for undiluted samples. After August 1, all samples were diluted tenfold. *Enterococcus* and *E. coli* counts shown here have been adjusted for dilution.

Table 7. Results of Riverkeeper's sampling at McVeigh Road in the Town of Wawayanda in 2017.

Comparison with other Wallkill River Tributaries

In addition to the Monhagen Brook, 12 other Wallkill River tributaries were sampled in August 2016. Results are shown in Figure 11. All watersheds sampled exceeded the geomean criterion for one or both fecal-indicator bacteria. Of the 13 tributaries studied, the Monhagen Brook had the sixth-worst Entero geometric mean and the fifth-worst *E. coli* geometric mean, showing that the Monhagen Brook is an important contributor to fecal contamination in the Wallkill River, and a high priority area for eliminating fecal pollution in the Watershed.

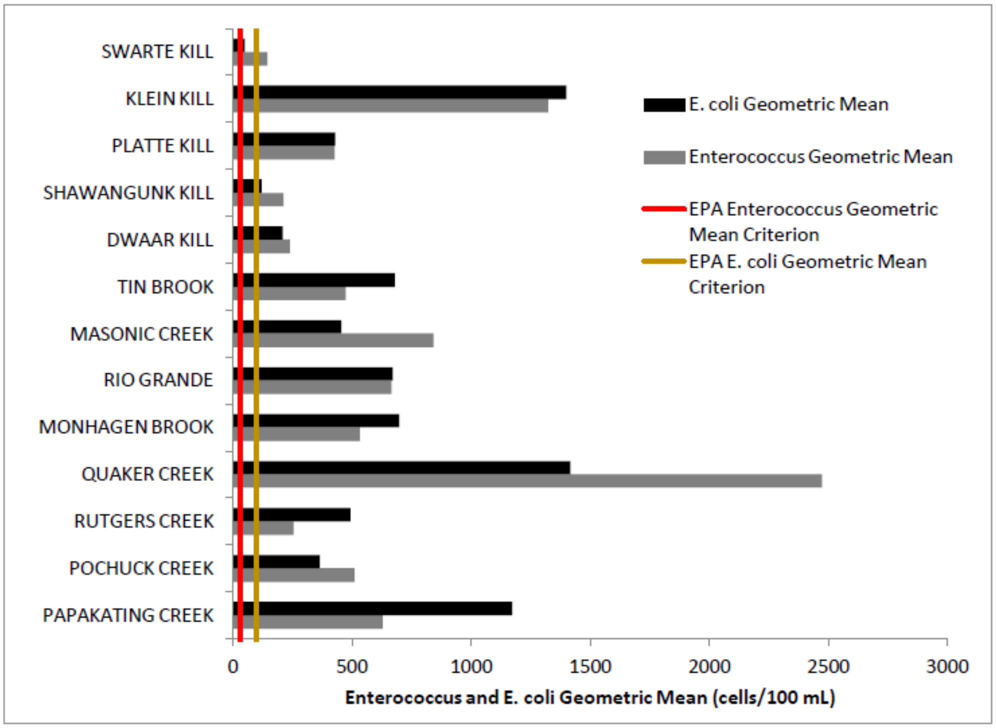


Figure 11. Comparison of Riverkeeper's results throughout the Hudson River Watershed in 2017.

Stream Biomonitoring

While phosphorus and enterococcus sampling methods involve a grab sample of water that may show a very different result if taken the following day or week due to changing environmental conditions, stream biomonitoring is an indicator of overall, integrated water quality over a long period of time. In New York, the NYSDEC developed a biomonitoring methodology that is similar to methods used in other states and around the world. The technique is based on the idea that the living inhabitants of a stream are like "canaries in a coal mine." These organisms are affected by the quality of the water in which they live, and this provides the basis for developing correlations with overall water quality. This method does not focus primarily on analyzing water for specific chemical constituents (although some basic chemistry data is collected during the process). Instead, the process is based on counting the numbers and diversity of different aquatic invertebrate species to assess the biological community structure. Because some organisms are more sensitive to pollution and others are more tolerant, the presence or absence and relative numbers of different species provide a reliable indicator of water quality. This method has been developed and refined into a reliable, controlled scientific protocol that has been approved by the EPA to meet Federal requirements for New York State's water quality monitoring programs. As a measure of its reliability and acceptance in the scientific community, it is also sometimes used for regulatory compliance purposes, including legal proceedings. See Appendix 3 for a detailed overview of the rationale for this approach and methodology.

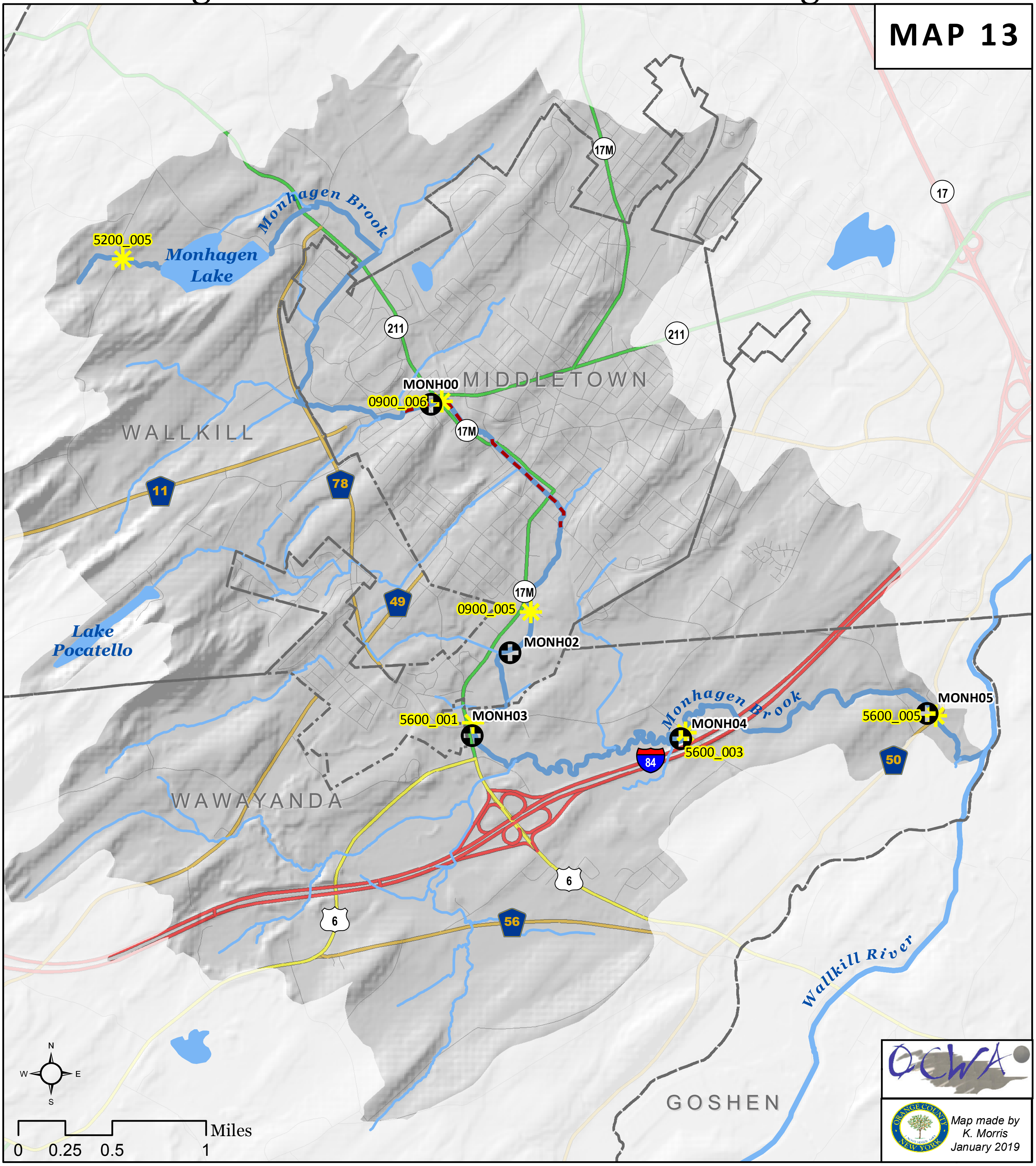
The NYSDEC methodology uses four different analyses, or metrics, for assessing water quality. These four metrics are then combined to produce one overall water quality score called the Biological Assessment Profile (BAP). The BAP is expressed in two ways in NYSDEC's reports: a numerical value from 0-10, where 10 equals the best possible water quality; and a narrative description. The narrative descriptors are non-impacted, slightly impacted, moderately impacted, and severely impacted, each of which corresponds to a range of numerical BAP values (a BAP score of 0-2.50 is termed severely impacted; 2.51-5.00, moderately impacted; 5.01-7.50 is slightly impacted; and 7.51-10.00 is non-impacted). As described in the *Phosphorus* section, the NYSDEC methodology also includes a separate metric, Impact Source Determination, or ISD. The ISDs for each of the sites in the Monhagen Brook can be found for the Orange County Water Authority (OCWA) data in the stream biomonitoring reports located on the OCWA's website.

	Biological Assessment Profile (BAP) Score																		
	Station ID	**1986**	**1992**	**1993**	**1998**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**
DEC DATA	MONH00	3.02		5.37															
	MONH02	1.62	4.24																
	MONH03	1.22	4.46	5.3															
	MONH04	0.28	4.71	4.5	4.57														
	MONH05	0.67	5.01	4.81															5.78
OC DATA	0900_005						4.6	4.07		5.37	5.76								
	0900_006						5.5	6.68											
	5600_001						4.5												
	5600_003					3	4	5.58											
	5600_005						4.55	5.56				4.91		5.62					
Average BAP Score, per year:		**1.362**	**4.605**	**4.995**	**4.57**	**3**	**4.63**	**5.473**		**5.37**	**5.76**	**4.91**		**5.62**					**5.78**

Table 8. Results of stream biomonitoring data for the Monhagen Brook for 1986 – 2017

For the Monhagen Brook, biomonitoring data exists as far back as 1986 and has been reported as recently as 2017 (Table 8). Both the NYSDEC and the OCWA have collected data, often at similar or identical locations (Map 13) and only on the main stem of Monhagen Brook, not its tributaries. While linear trends are not apparent (Figure 12), it is promising to see that the very poor water quality, represented by the BAP score, in 1986 improved dramatically beginning in the 1990s. This could be due to many factors, including sewer and storm sewer upgrades, changes in land use, actions brought about through enhanced environmental regulations at the local, state, or federal level, or other factors. Actions recommended in this Plan, when implemented, will further help the Brook's overall ecosystem

Monhagen Brook Watershed: Biomonitoring Locations



NYSDEC Stream monitoring stations
OCWA Stream biomonitoring stations
Municipal Boundaries
Underground segments of Brook
Water Bodies
Streams
Monhagen Brook
Interstate
Federal Highway
State Route
County Road
Local Road

The Orange County Department of Planning and the County of Orange make no warranty whatsoever as to the accuracy or completeness of any information depicted on this map. Data depicted here may have been developed in cooperation with other County departments, as well as other Federal, State and Local government agencies. The County of Orange hereby disclaims liability for any loss or damage resulting from the use of the information and/or representations contained herein.

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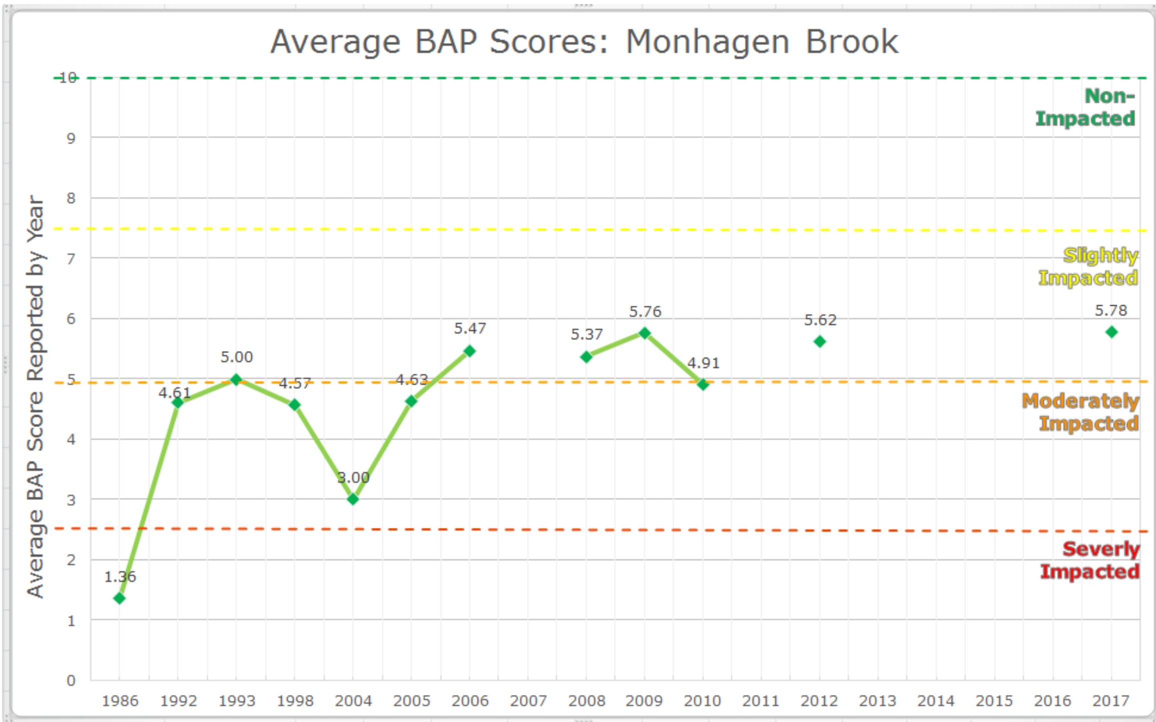


Figure 12. Graph depicting biomonitoring results from 1986 - 2017

In contrast to the characterization above, Dr. Joseph Zurovchak, a SUNY Orange Biology professor, reported a decline in "sensitive" species and trend toward more "tolerant" species based on his twelve-year study of macroinvertebrates in the Brook. This suggests a trend toward a less healthy stream with lower biodiversity. However, these findings were reported anecdotally, so further analysis is needed. This points to the complexity of identifying water quality trends in streams when using macroinvertebrates as the parameter for assessment.

Wastewater

Wastewater, or sewage, is treated in two ways in the Watershed; either by individual septic systems or by a centralized sewage collection system that feeds into a wastewater treatment plant. The more rural areas of the Watershed, such as the areas within Wawayanda and Wallkill, are generally served by individual on-site septic systems, while the areas of more concentrated development are connected to a centralized wastewater collection and treatment system. Both types of treatment can leak wastewater into the environment if not properly maintained, inspected, and repaired when necessary.

There are several areas in the Watershed that are served with central sewer, but none of those systems are more extensive than the City of Middletown's. Like many older sewage collection systems in the region, the City of Middletown's system experiences inflow and infiltration during times of intense precipitation due to deficiencies in the aging network of pipes. This can lead to sanitary sewer overflows (SSOs), or discharges, of untreated sewage into the environment.

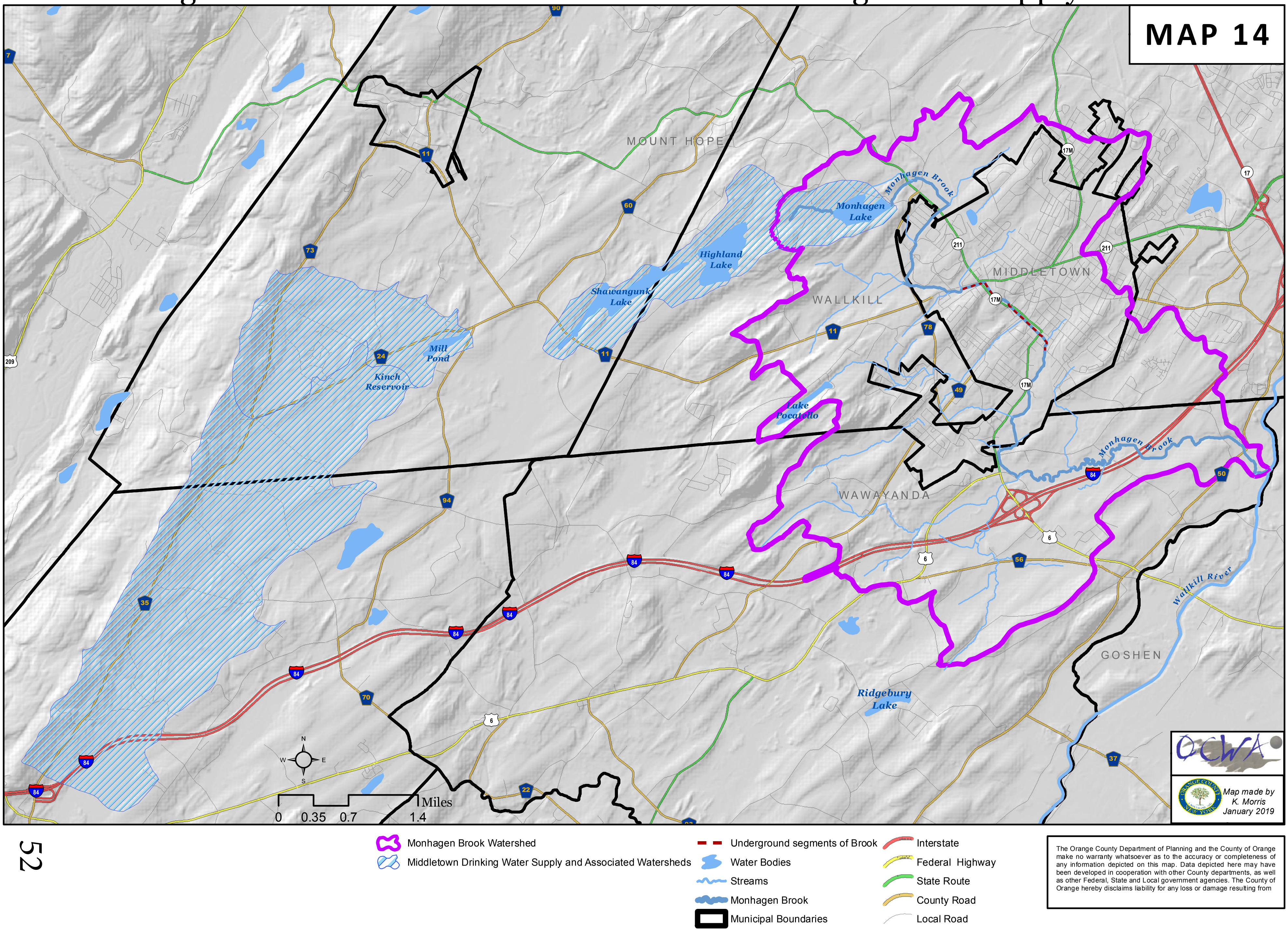
In 2013, New York State passed the Sewage Pollution Right to Know Act, which requires owners and operators of publicly owned treatment works and sewage collection systems to report all discharges of untreated or partially treated wastewater to the NYSDEC within 2 hours after the discovery, and to the public within 4 hours after discovery. These reports are automatically posted online via the NY-Alert system. The City of Middletown has been reporting SSOs since this law was passed. As an example, in October 2018, the City reported three instances of SSOs, all on October 11th. The overflows ranged from approximately 2.5 to 6.5 hours in duration and released approximately 10 – 100 gallons per minute of untreated wastewater into the Watershed. The reported duration and flow numbers for these events are estimates, and the actual volume is not known. Such overflows of untreated wastewater impact water quality in the Watershed.

It is important to note that Middletown is in no way unique with its SSO problem; many of the post-industrialized urban areas in the region have aging and at times neglected infrastructure and suffer from inflow and infiltration. The cost of replacing and/or repairing sewer mains, regulators, and associated infrastructure is extremely high, and thus controlling SSOs is an ongoing challenge. In addition to responding to emergency sewer infrastructure issues, many municipalities, including Middletown, are taking steps to proactively replace and repair their collection systems. Such work not only reduces environmental contamination but also decreases the volume of stormwater and groundwater that is flowing into - and often overwhelming - wastewater treatment plants. Continued future investment for upgrading centralized sewer systems and regular maintenance of individual septic systems will be needed to reduce nutrient loading in the Monhagen Brook Watershed.

Drinking Water

Water supplies for drinking water within the Watershed are a combination of private wells and centralized water from Middletown's water distribution system. The City's source water is supplied by a network of five reservoirs: Monhagen Lake, Highland Lake, Shawangunk Lake, Mill Pond, and Kinch Reservoir (Map 14). Pipes and pump stations connect these waterbodies, allowing water to be pumped from one reservoir to another, or directly to the water treatment plant (Figure 13). Monhagen Lake is the only one of the five reservoirs that is located within the Monhagen Brook Watershed, and therefore the remaining four will not be addressed within this Plan. As previously noted, Monhagen Lake is not hydrologically connected to the Monhagen Brook through surface water; after the Brook was dammed to create a drinking water supply reservoir for the City of Middletown in 1867, its headwaters became a

Monhagen Brook Watershed: Middletown's Drinking Water Supply Watershed



groundwater seep that is located immediately down gradient from the dam.

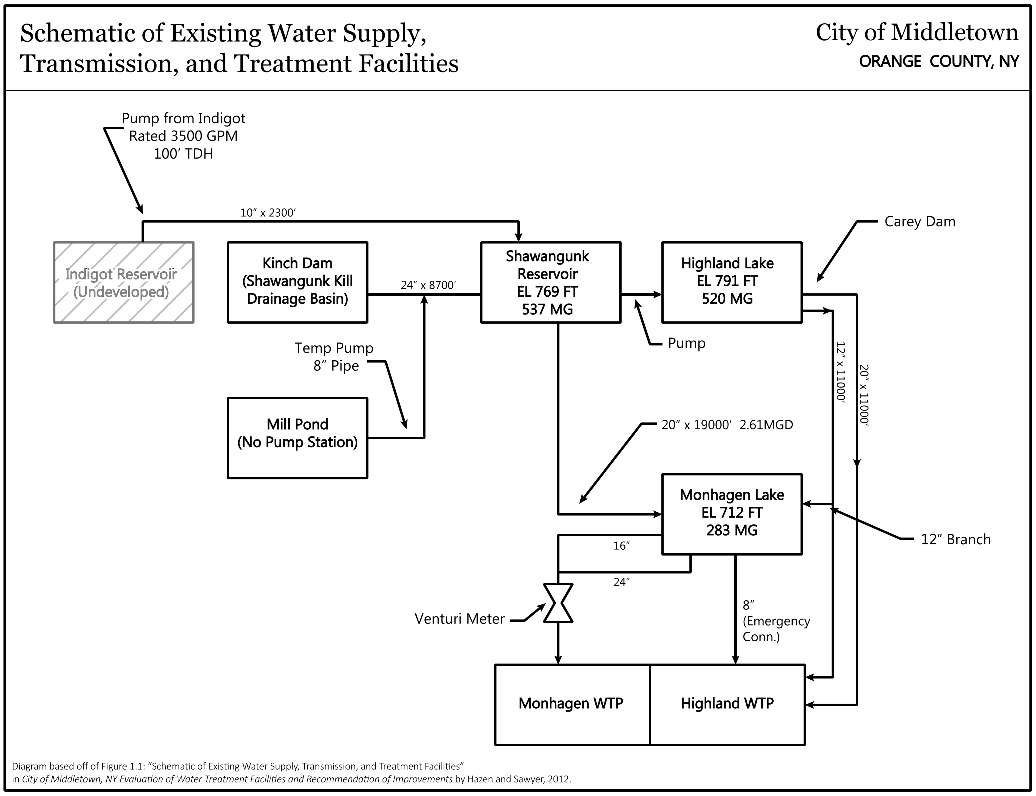


Figure 13. Diagram describing how the City's drinking water reservoirs are interconnected.

It should also be noted that Monhagen Lake suffered a documented harmful algal bloom in 2017, which prevented the City from using it as a water source for a short period of time. Because of this concern, Monhagen Lake was identified as one of twelve waterbodies to receive funding from the State to develop an Action Plan to address the algal bloom issue. Finalized in 2018, the Action Plan (the executive summary of which is Appendix 3 to this Plan) identified the following priority actions for remediating harmful algae blooms in the Lake:

- Update land classification for the reservoir system watershed areas
- Complete a feasibility study and cost estimate to upgrade Hudson Valley Estates wastewater treatment plant
- Research sources of algal blooms and cyanotoxins, conduct thermal and dissolved oxygen profiles to evaluate stratification, and complete a feasibility study to install aeration facilities

- Purchase land and conservation easements and enhance riparian buffers, and
- Pursue engineering studies to evaluate the efficacy of additional treatment at public water facilities

Additionally, the City received funding from NYS for further land acquisition within the City's reservoir watersheds. Although the Monhagen Lake's watershed is largely preserved due to land acquisition by the City of Middletown, the remaining four reservoir watersheds have large areas of unconserved and privately-owned land that will be reviewed and assessed for its conservation value.

The Towns of Wawayanda and Wallkill are predominantly served by private or, in some cases, community wells. No known concerns were expressed by these municipalities regarding water supply at the time of the writing of this Plan.

Biological Resources[9]

Healthy streams and watersheds with a high percentage of forest provide a wide range of benefits to people and wildlife: cleaner air and water, reduced stormwater runoff and attenuated flood impacts, climate moderation, enhanced outdoor recreation opportunities, scenic beauty, and sense of place. Historical patterns of development in and around Middletown have jeopardized these ecological functions and increased the community's vulnerability to flooding and water quality degradation. Much of downtown Middletown is within the historical floodplain of the Monhagen Brook and its tributaries, or was originally wetland. Management of upland areas directly impacts watershed dynamics and downstream water quality, and is thus of vital importance to consider. This Plan seeks to improve water quality in the Brook while restoring degraded habitat throughout the Watershed to protect and enhance biological resources in the region.

This section will highlight important habitats and their biodiversity (defined as the variability among living organisms in an environment) and discuss key ecological challenges faced in the Watershed. It draws upon information from the NYSDEC, the New York Natural Heritage Program, and existing local and regional watershed plans. For additional description of valuable habitat to protect within the Monhagen Brook Watershed, see also the *Land Conservation Analysis* section in Chapter 3 of this Plan.

Though common species occur throughout the Watershed, the emphasis here is on documented species listed as state- or federally-endangered, threatened, special concern, and Species of Greatest Conservation Need (SGCN). Refer to Appendix 5 for a complete list of documented species of

[9] This section was completed with editorial and substantive contributions from Ingrid Haeckel, Conservation and Land Use Specialist, and Laura Heady, Conservation and Land Use Program Coordinator, Hudson River Estuary Program/Cornell University.

conservation concern and listing status that are referenced in this section. SGCN are species identified in the State Wildlife Action Plan that are experiencing some level of population decline, have identified threats that may put them in jeopardy, and need conservation actions to maintain stable population levels or sustain recovery (NYSDEC 2015). In addition, Audubon New York identified the Hudson River Valley priority birds by assessing continental, national, and regional bird planning initiatives in addition to state and federal priority designations. Residents and naturalists familiar with the Monhagen Brook Watershed may have additional knowledge about high-quality ecosystems and rare species occurrences that can enhance this summary.

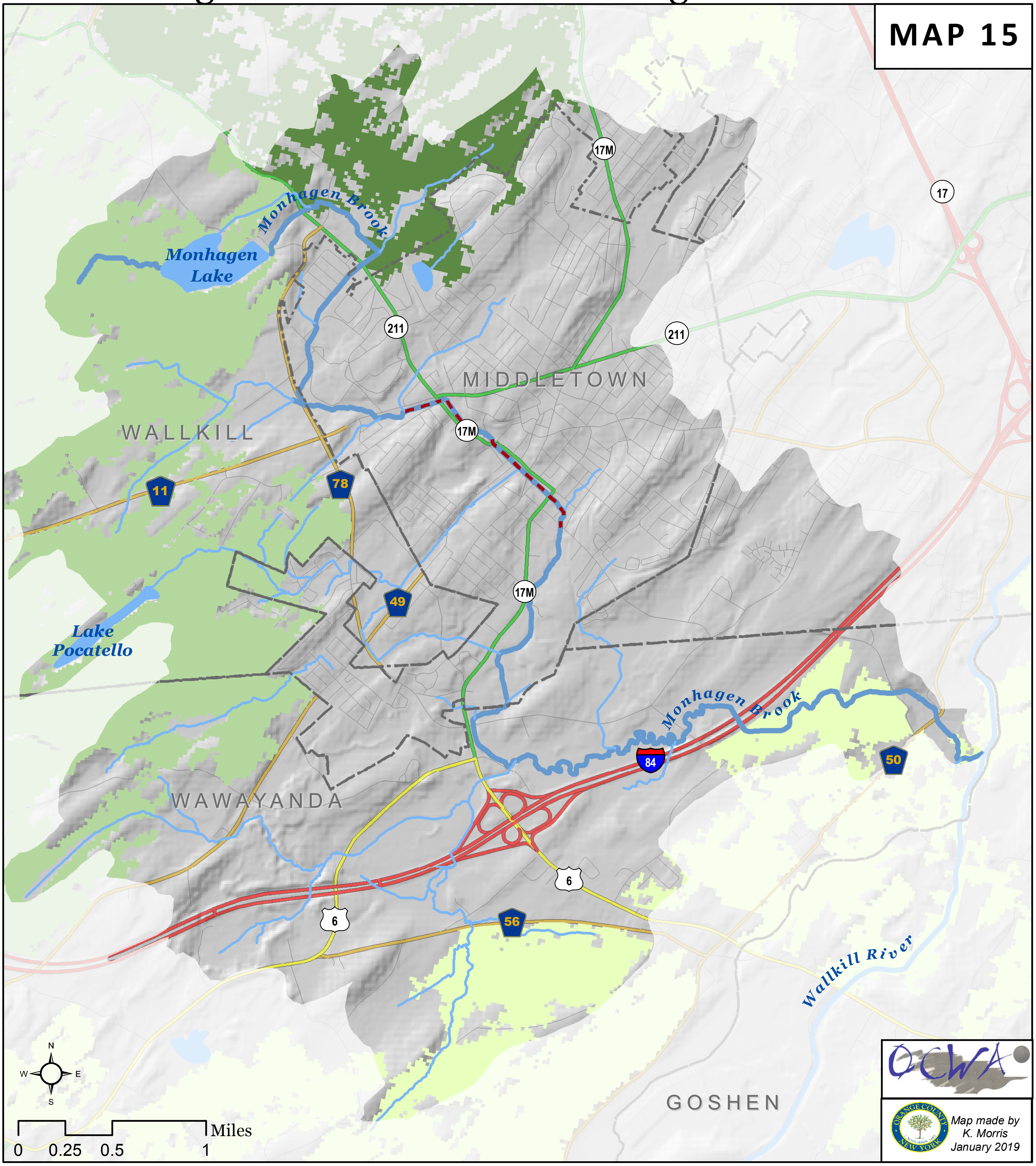
Forests

Forests provide numerous benefits, including wildlife habitat, water filtration, climate moderation, soil stabilization, and forest products. In general, larger forests provide higher quality habitat, are more resilient to impacts such as climate change, and provide important corridors and connectivity with the wider ecosystem. Much of the forested land in the Monhagen Brook Watershed is comprised of relatively small, fragmented patches and immature forest regrowth from previously cleared land. Some of these forest areas are of lower ecological value than larger, contiguous, and more mature forests, but nonetheless, represent important habitat within the Watershed and provide essential ecological services.

The City has made efforts to protect forestland and open space around its source water reservoirs in the northwestern portion of the Watershed where the Monhagen Brook originates. This area, along with forest on the western and northern boundaries of the Watershed in the area of Fancher-Davidge Park include forest identified by the NYSDEC Hudson River Estuary Program as “locally and regionally significant,” with the potential wide ranging benefits of providing wildlife habitat (particularly for more sensitive species), protecting clean water, moderating climate, and supplying forest products. In the southernmost and eastern portions of the Watershed where the Monhagen approaches its confluence with the Wallkill River, are “stepping stone” forest patches of over 200 acres. Below is a description of the characteristics and values of each of these forest sizes:

> Regionally important: (14,999 down to 6,000 acres) Patches > 6,000 acres provide habitat to more area-sensitive species and can accommodate large-scale disturbances that maintain forest health over time. Smaller patches are often less able to maintain the entire range of needed habitats and successional stages after large-scale disturbances.
>
> Locally important: (5,999 down to 2,000 acres) These smaller but locally important forest ecosystems often represent the lower limit of intact, viable forest size for forest-dependent birds. Such bird species often require 2,500 to 7,500 acres of intact interior habitat. These forests, like the larger regionally important forests, also provide corridors and

Monhagen Brook Watershed: Contiguous Forest Areas



Forest patches (acres)
- Stepping Stone
- Locally Significant
- Regionally Significant

- Municipal Boundaries
- Underground segments of Brook
- Water Bodies
- Streams
- Monhagen Brook

- Interstate
- Federal Highway
- State Route
- County Road
- Local Road

connectivity among forest ecosystems within Orange County.

Stepping stone forests: (1,999 down to 200 acres) These smaller forest ecosystems provide valuable corridors (relatively broad, not just a narrow strip) and links to larger patches of habitat such as the local, regional, and global forests found in Orange County, enabling a large array of wide-ranging and area-sensitive species to move from one habitat to another across an otherwise hostile and fragmented landscape. They also provide important habitat at key times during many animals' life cycles and should be considered the absolute minimum size for intact forest ecosystems. Forests as small as 200 acres will support some forest interior bird species, but several may be missing, and species that prefer "edge" habitats will dominate.

Map 15 shows contiguous forest areas and was developed by Cornell University and NYSDEC using 2010 forest cover data from the Coastal Change Analysis Program. Size classes are based on ecological importance and follow the Orange County Open Space Plan (2004).

Riparian and floodplain forests are of particular importance to water quality and quantity in a stream. Along with providing critical wildlife habitat, they stabilize stream banks, reduce erosion, and minimize flood impacts by slowing and storing floodwaters. These "buffer" functions are important to consider in the urbanized setting of Middletown, which is vulnerable to flooding and pollution impacts from runoff into the Brook carrying nonpoint source pollutants.

Riparian ecosystems cycle nutrients between the land and water. Vegetation along stream banks creates habitat and feeds the food web of aquatic species with plant debris; nutrients are returned to the forest during natural times of flooding. In addition to supporting stream species of fish, amphibians, reptiles, insects, and other macroinvertebrates, many bird and mammal species find food and water in streams and may nest or forage exclusively near water. Forested areas along stream banks shade and cool the water, maintaining suitable temperature for more sensitive species that cannot survive in water warmed by runoff from hot pavement or from unshaded stream banks devoid of vegetative cover. Many riparian areas along the Monhagen have been impacted by development, where impervious surfaces extend to the edges of the stream bank, lawns are mowed of all vegetation, forest has been cleared, and floodplains altered.

Wildlife records indicate the availability of large, high-quality forests in the Watershed. The 2000-2005 NYS Breeding Bird Atlas documented 13 forest-interior breeding bird species of conservation concern in the area, including scarlet tanager, wood thrush, and sharp-shinned hawk. Watershed forests also provide important summer habitat for the Indiana Bat, which hibernates nearby. Indiana bat, a federally endangered species, will forage for insects throughout wooded areas and along streams; female bats roost in snags and dying trees. Several forest-associated reptiles are also in the Watershed and potentially threatened: the Eastern box turtle, found primarily in well-drained and open deciduous forests and also along field edges, shrublands, wetlands, and streams; the northern copperhead snake, in rocky, forested hillsides and various wetlands; and the wood turtle, along low gradient perennial streams and adjacent forests and open habitats.

Though often overlooked, young forests also provide important habitat for numerous wildlife species. They occur on abandoned farmland and in recently cleared areas characterized by few or no mature trees, with a diverse mix of shrubs and/or tree saplings, along with openings where grasses and wildflowers grow. Young forest wildlife species have declined throughout the region as former agricultural areas have been developed or grown into mature forests, and natural forest disturbances that trigger young forest growth, such as fires, have been suppressed. Records from the *NYS Breeding Bird Atlas* support the presence of twelve species of conservation concern in the Monhagen Brook Watershed that prefer young forest and shrubland habitat, including American woodcock, blue-winged warbler, brown thrasher, and ruffed grouse.

Regardless of size or habitat values, all forests, including within urban areas, help to manage stormwater, moderate temperature, improve air and water quality, and provide other ecosystem benefits within the Watershed. Forest protection can be accomplished through measures such as purchasing forestland, using conservation easements, ecologically-minded subdivision design, and encouraging sustainable forest management practices.

Grasslands

Grassland or meadow habitat can support a variety of life, including rare plants, butterflies, reptiles, and birds, in addition to offering scenic value. The quantity and quality of grasslands for wildlife have plummeted in the Northeast during the last century due to increased human population, sprawl development, changes in agricultural technology, and loss of family farms. This continuing trend threatens populations of grassland birds that have adapted to the agricultural landscape. The *2000-2005 NYS Breeding Bird Atlas* documented breeding by four grassland bird species of conservation concern in the Middletown area, including eastern meadowlark, bobolink, and American kestrel.

Wetlands

There are many types of wetlands in the Monhagen Brook Watershed, including wet meadows, emergent marsh, forested and shrub swamps, vernal pools, and open water. Diverse wetland habitats are integral to watershed health and are essential to the relationship between stream and upland habitats for birds, reptiles, amphibians, and rare plant communities. Wetlands also play a crucial role in protecting water quality and supply, recharging groundwater and regulating stream flow, and mitigating flooding in vulnerable areas throughout the City of Middletown. The upland area surrounding a wetland is essential to its survival and function; both may diminish when a wetland is surrounded by pavement, buildings, and pollution-generating or other incompatible land uses.

Although wetlands are now recognized for their critical ecological, economic, and watershed functions, in the past they were viewed as wastelands and thus commonly drained, filled, and developed. Limited information is available about wildlife occurring in wetlands throughout the Monhagen Brook Watershed. Snapping turtle occurs in marshes and other slow-moving aquatic habitats of the Watershed, and other reptiles such as box turtle and northern copperhead will occasionally use wetlands. Wetlands are also discussed in the *Introduction* of this Plan and the *Hydrology* section, with a detailed description of significant wetland habitats in the Watershed included as Appendix 12.

Streams and Waterbodies

Healthy stream corridors which offer high quality habitat are characterized by natural vegetated banks and buffers, unaltered hydrology, and undeveloped riparian areas. These characteristics also contribute to higher water quality and other conditions that support more sensitive species of fish, amphibians, reptiles, insects, and other macroinvertebrates. Healthy stream habitats are themselves diverse; riffles, pools, woody debris, and variations in water depth, flow, substrate, and cover provide a variety of habitats for aquatic organisms. The simplification that occurs when streams are highly impacted, like urbanized sections of the Monhagen Brook, is reflected in a loss of aquatic biodiversity and other species that rely on it.

The most biologically intact stretches of the Brook are found upstream, as it flows out of the Monhagen Reservoir and then downstream of the City as it flows toward the Wallkill River. In between, where the Brook flows through the City of Middletown, significant stretches flow under the ground in box culverts and the Brook is impacted by contiguous development and the resulting degradation of its banks, riparian areas, and floodplains.

Wildlife observations made during the spring of 2017 “stream walks” corroborate the characterization of the stream above: the upper and lower stretches of the Brook are the most biologically intact and the middle section flowing through the City is the most ecologically altered. Many fish, including bass and sunfish, and crayfish were observed in the upper section of the Watershed and downstream of the City. In the City, deer, snapping turtle, and Canada geese were observed. While these common species are not particularly noteworthy, they supply evidence of wildlife using the stream corridor, even in more urban sections where habitat may be highly impacted.

As part of NYSDEC stream biomonitoring work, wildlife observations were also made in the summer of 2017 at a site off Golf Links Road near the confluence of the Wallkill River. Snapping turtle, crayfish, great blue heron, bald eagle, and raccoon footprints were observed, again highlighting some of the more common species that rely on the Brook and its watershed for habitat.

A NYSDEC survey of the Brook from 1936 collected no fish and documented warm and polluted water. Findings from 1966 and 1977 are listed below, though no context was provided as to where these species were found or what collection methods were used:

1. 1966 NYSDEC Survey – brown bullhead, golden shiner, largemouth bass, pumpkinseed
2. 1977 NYSDEC Survey – bluegill, common carp, golden shiner, longnose dace, white sucker
3. 1977 NYSDEC Survey – black crappie, bluegill, brown bullhead, golden shiner, pumpkinseed, redfin pickerel, yellow perch

The most recent NYSDEC survey took place in 2016 as a region-wide effort to document brook trout in small streams. The sampling occurred near Pilgrim Place where NYS Rte. 211 crosses the Brook. The Monhagen Brook's water quality and temperature do not support native brook trout, which require clear, cool, well-oxygenated streams and lakes and depend on clean gravel areas for spawning. However the electrofishing survey picked up samples of bluegill, yellow bullhead, white sucker, yellow perch, and spotfin shiner. This was merely a presence/absence survey and was not meant to provide information on any population or size estimates.

As describes in the *Hydrology* section, in addition to the Monhagen Brook, the Watershed has three other significant bodies of surface water: Monhagen Lake, Lake Pocatello, and Fancher-Davidge Pond. These were surveyed by the Adirondack Lakes Survey Corporation in 1987. In Monhagen Lake, the survey identified bluegill, brown bullhead, chain pickerel, golden shiner, largemouth bass, pumpkinseed, smallmouth bass, and yellow perch. In Lake Pocatello, black crappie, brown bullhead, chain pickerel, golden shiner, largemouth bass, pumpkinseed, yellow perch were identified. In Fancher-Davidge Pond, black crappie, bluegill, brown bullhead, chain pickerel, common carp, golden shiner, pumpkinseed, and white perch were found.

Ecological Challenges

Fragmentation

Species require certain habitat conditions for survival, which can easily be impacted by human activities. Habitat fragmentation – the fragmentation or division of large, contiguous habitats into smaller, isolated remnants – is a common result of development. Fragmentation impacts habitat size, quality, connectivity, complexity, and other conditions within the habitat, and can accelerate the spread of invasive and non-native species. Together, these forces can lead to decreased habitat availability and suitability for sensitive species, and increased competition for resources, predation, micro-climatic differences, and other adverse "edge" effects. Populations of sensitive species may decline or be lost from the location entirely. Evidence of this impact is noticeable and widespread throughout the

Monhagen Brook Watershed.

Invasive Species

While the distribution and impacts of invasive species have not been studied in depth within the Watershed, presence of invasive species has been recurrently documented by the project team and others. Several invasive terrestrial plant species are commonly found along the stream corridor, including Japanese knotweed, phragmites (aka common reed), purple loosestrife, burning bush, and multi-flora rose. These species were introduced for a variety of reasons, such as ornamental purposes (i.e. Japanese knotweed and burning bush) and erosion control (i.e. multiflora rose). Some introductions were accidental (i.e. phragmites). To learn more about invasive species in New York State, visit the *New York Invasive Species Information* website (www.nyis.info).

Some invasive species are known to accelerate erosion and sedimentation, particularly Japanese knotweed, to the further detriment of an already phosphorus-impaired watershed. SWCD is documenting locations of particularly intense invasive establishment along the stream corridor, particularly Japanese knotweed and phragmites, in order to develop a list of locations for potential treatment. Treatment of these areas would provide many benefits, including but not limited to: erosion and sediment reduction, streambank stabilization, and riparian habitat enhancement.

Some of the most prominent invasive plants in the Watershed are:

Japanese Knotweed

Introduced to the U.S. from Eastern Asia as an ornamental plant in the 1800s, it thrives in disturbed areas, spreads rapidly, and its bamboo-like stems can grow 15 feet tall. Tolerating a wide range of growing conditions such as deep shade, high temperature, high salinity, and drought, it is commonly found growing on stream banks, where it chokes out native vegetation, leaving bare soil susceptible to erosion. Established populations can be very hard to eradicate. Hand pulling or digging of smaller plants is one method of control, although this can be time consuming and resprouting may occur if roots are left in the soil. Chemical control with herbicides may also be used, either on foliage or freshly cut stems. Japanese knotweed is listed as a prohibited plant on the New York State Prohibited and Regulated Invasive Species List. This means the species cannot be knowingly possessed with the intent to sell, import, purchase, transport, propagate, or introduce.


Figure 14: Picture of Japanese knotweed in bloom (left) and typical growth along a streambank (right)

Common Reed (Phragmites)

There are three subspecies of common reed, *Phragmites australis*, one of which is native to New York. The nonnative strain was introduced from Europe in ship ballast in the late 18th or early 19th century and is now the most common form found in the state. The plant, which is a member of the grass family, can reach over 15 feet tall, often forming dense stands. It grows in many locations such as roadside ditches, swales, wetlands, marshes, disturbed areas, and river, lake, and pond edges. Methods of treatment include prevention through maintenance of competing native vegetation, repeated mowing, herbicide, and fire. Common reed is listed as a prohibited plant on the New York State Prohibited and Regulated Invasive Species List.

Figure 15. Picture of typical stand of Phragmites found in the Watershed.

Climate Change

According to New York's ClimAID report (2011, 2014), impacts of climate change are already being observed in New York State. Since 1970, the average annual temperature (statewide) has risen about 2.4 degrees Fahrenheit, with winters warming even more. Precipitation has increased overall, but summers have gotten drier with intermittent heavy precipitation and periods of drought. Markers of springtime have shifted a week earlier, affecting pollinator species. Population ranges of breeding birds have shifted northward. Climate projections predict increased warming, intensifying heavy precipitation events, and more severe summer droughts. These changes will continue to impact the biological resources of the region, favoring more tolerant non-native and invasive species and lowering biodiversity. Insuring habitat connectivity and wildlife corridors becomes increasingly important as habitat ranges shift and habitats become more fragmented. Drought imposes stress on plant and animal species and severe storms and flooding can damage already impacted stream corridors, making wetlands, riparian buffers, and an overall healthily functioning ecosystem critical to resiliency in the environment and the community. For more on climate change impacts in the Watershed, see the *Flooding* section of this Plan.

Stream Channel Modification

A major challenge for the health of the Monhagen Brook is posed by the historical engineering of its stream channel. Stretches flowing underground in box culverts cannot support normal aquatic life and disrupt the continuity of the corridor, which in a naturally flowing stream is a long, linear ecosystem that acts as a roadway for organisms and materials to travel. Culverts at road and rail crossings very often act as barriers as well; little consideration was given in their design to natural hydrology, sediment transport, fish and wildlife passage, or the movement of woody debris. Healthier sections of the Brook are thus fragmented and isolated as many species cannot pass through culverts where the channel is paved in concrete and there is no aquatic plant life or natural light; sometimes passages are completely occluded by impassable barriers. Culverts and other barriers to aquatic migration are shown on Map 16. For further discussion of barriers and aquatic connectivity, see *Culvert Barrier Assessment* section.

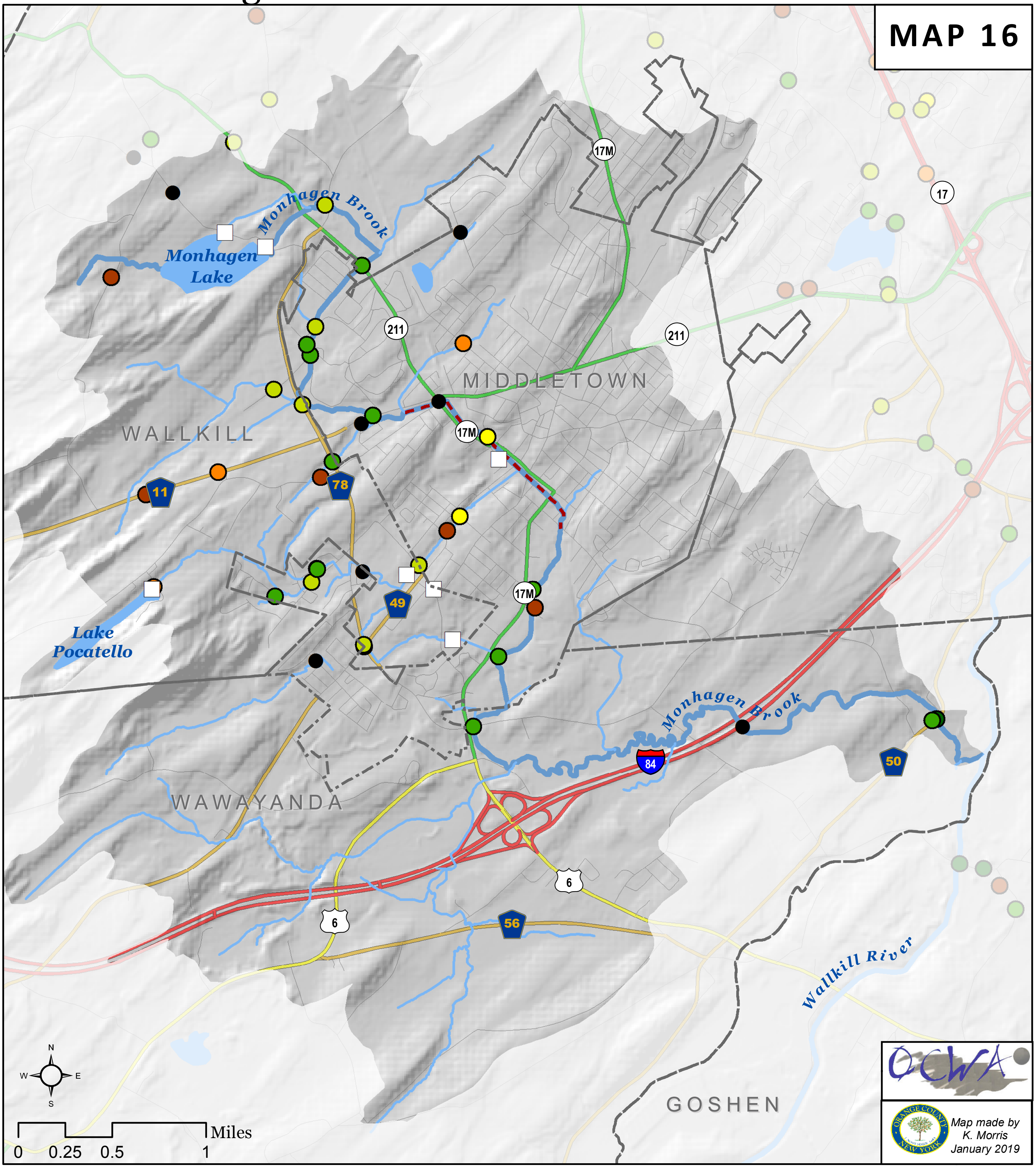
The Value of woody debris as habitat

Scott Cuppett, NYSDEC

Woody debris, such as branches, logs, and stumps, are a natural component of healthy streams. Woody material provides the basis of the food chain, as well as important aquatic habitat in the Monhagen Brook Watershed. There is often a temptation to remove in-stream woody debris because it is assumed to contribute to flood risk, but this is not always the case. In fact, woody debris can help slow and dissipate floodwater over the natural floodplain, reducing downstream impacts. There are exceptions to this notion that woody debris should be left in the stream, however, namely when it directly threatens infrastructure (e.g., buildings, roads, etc.) or accumulates at culverts and bridges. See the NYSDEC factsheet for guidance on woody debris removal: https://www.dec.ny.gov/lands/92418.html

A lack of interconnected, high quality habitat is of concern not only because of the resultant decline in biodiversity, but also because of the loss of ecosystem services these habitats provide and the associated impacts on human health and well-being, the economy, and the community as a whole. However, opportunities for meaningful work towards more sustainable land use exist where highly impacted biological resources have been identified. And despite the challenges outlined above, the Monhagen Brook Watershed remains rich in biodiversity. Further study is needed along with efforts to

Monhagen Brook Watershed: Dams and Culverts



Dams

Culvert Evaluation

- no score - missing data
- No barrier
- Insignificant barrier
- Minor barrier
- Moderate barrier
- Significant barrier
- Severe barrier

Municipal Boundaries
Underground segments of Brook
Streams
Monhagen Brook
Water Bodies
Interstate
Federal Highway
State Route
County Road
Local Road

protect open spaces throughout the City, improve water quality in the Brook, remediate degraded sites, restore damaged riparian areas, and revitalize natural areas into parks and other spaces of community value. This will create new habitat out of degraded or underutilized land, enhance the quality of existing fragmented habitat, and improve connectivity between habitat patches, all while at the same time realizing economic and social benefits. Many projects detailed in this Plan hope to accomplish these holistic goals.

Dams

According to a dataset from NYSDEC, there are seven dams in the Monhagen Watershed (Map 16). Two of these are associated with the City of Middletown's Monhagen Lake reservoir. Three of the dams in the dataset are separate but in close proximity on the grounds of Saint Albert's Seminary in Middletown; they create three ponds visible from Wawayanda Avenue. Lake Pocatello dam is in the southwestern corner of the Watershed, as is a privately owned dam near Playtogs Plaza. There are additional dams within the Watershed that are smaller and/or do not meet thresholds of the NYSDEC listing. None of them are located within the channel of Monhagen Brook main stem or any of the major tributaries as shown on maps in the Plan.

A discussion of dams in the context of engineering and regulatory concerns is beyond the scope of this Plan. A brief discussion of their ecological significance will be presented. See, also, the *Culvert Barrier Assessment* section of the Plan.

Figure 16. Runoff enters the Saint Alberts ponds from the southwest and exists to the northeast. The two small white dots in the first pond are thought to be aerators. The SUNY campus, through and under which this tributary flows, is visible in the northeast corner.

Three of the dams listed above are in headwater reaches of the Watershed. Monhagen Lake, the City reservoir on the main stem of the Brook, has a drainage area of only about 200 acres and Lake Pocatello has a drainage area of about 100 acres. While dams are generally recognized to be a disruption to the natural ecology of the stream system, the position of these three dams in headwater areas at least limits their disruption of aquatic fauna migration and related stream functions to the uppermost reaches of the stream. It has been demonstrated that aquatic communities downstream from impoundments differ from communities found in the absence of these features, so impacts do exist beyond the migration barriers the dams create.

As noted, three of the dams on the listing are close together, with the first impoundment flowing directly into the second, then the third. They are located on a tributary originating at Lake Pocatello and draining just under 800 acres (around 7% of the entire Monhagen Watershed). These features impede the movement of aquatic organisms. At least one of the ponds has a structural spillway with several feet of vertical separation from crest to normal water level in the next pond. The impoundments may also be affecting the delivery of phosphorus downstream, though the specifics of this impact are not understood. It may be that they impact the timing/seasonal distribution of delivery of this phosphorus fraction more than the total quantity. However, the ponds are known to host Canadian geese, sometimes in numbers that may contribute to increased loading downstream.

Some 800 feet downstream from the third dam, the stream enters a buried conduit as it passes under the SUNY Orange parking garage facility. The stream emerges after traveling underground for 300 feet, and sees daylight for about 600 feet before once again entering an underground conduit where it stays for 1500 feet before joining the main stem of the Brook under Fulton Street. Given these circumstances, the dams at Saint Alberts may not be the lead issue in the health of this tributary of the Brook. It also should be noted that the ponds provide some recreational and aesthetic value to Watershed residents and visitors. A potentially productive idea for this locale might be to work with the Seminary managers to manage phosphorus inputs to and outputs from the ponds for the benefit of the receiving waters as well as the ponds themselves. Aerators have been observed in the ponds, which help to manage the symptoms of phosphorus enrichment, but not the causes.

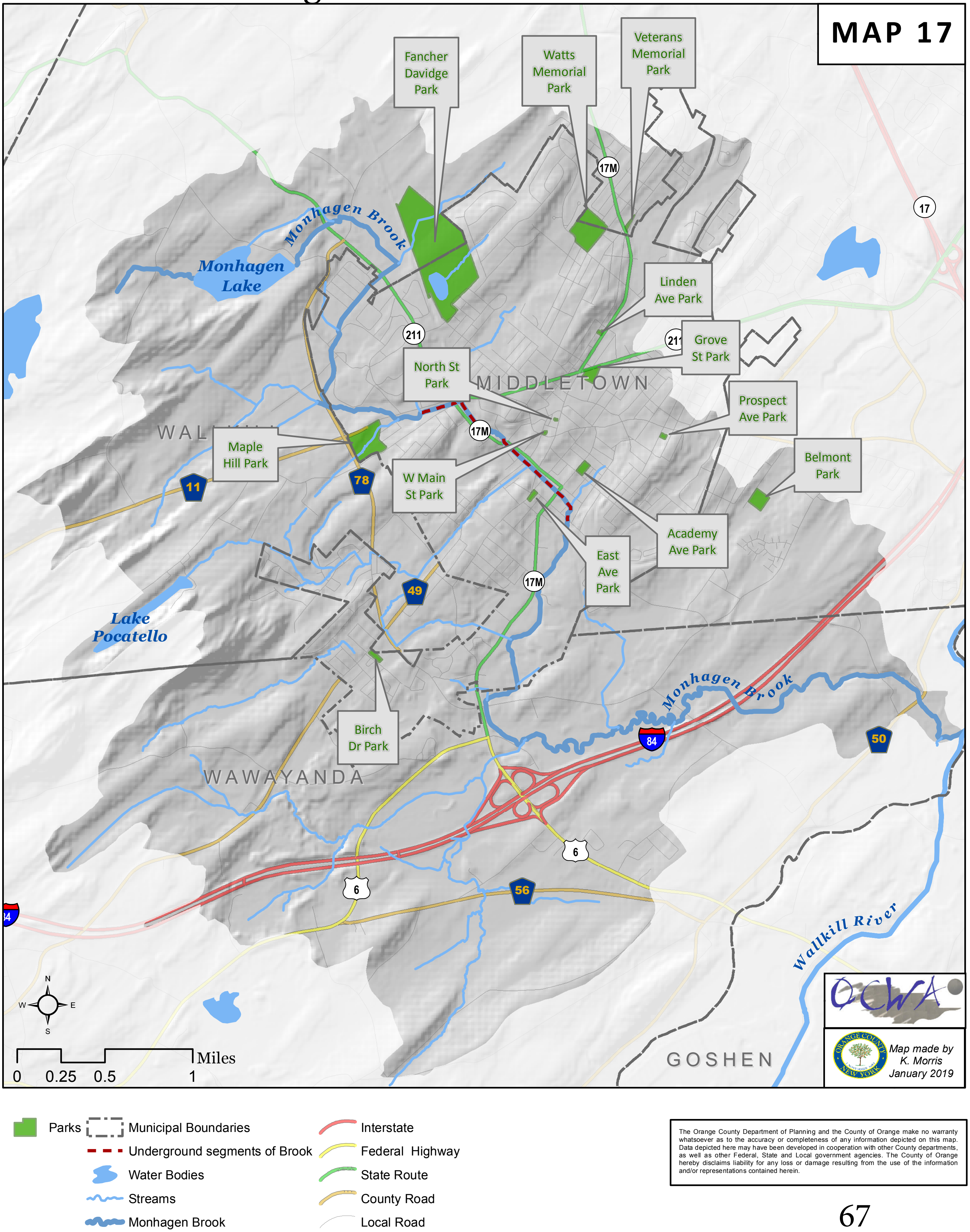
The last, privately owned dam on the listing is on an unnamed and small drainageway that enters the buried stormwater drainage network under the Platogs Plaza just downstream from the impoundment. As with the Saint Alberts ponds, it can be safely stated that the alterations to this drainage from the point of the impoundment to the point it daylights at the main stem of the Brook behind ShopRite are of more concern in terms of natural functions and ecology than the dam itself.

Although this was not the case historically, dams on the main stem, or for that matter the major tributaries, of the Monhagen are of fairly limited consequence especially when compared to other alterations such as culverts, buried sections, channel modifications, urban runoff, and riparian area disruptions, all of which are discussed in other sections of this Plan.

Recreation

There are nineteen parks in the Monhagen Brook Watershed, seventeen of which are in the City of Middletown. Their total of 245 acres represents approximately 7.5% of land in the City; in the

Monhagen Brook Watershed: Parkland



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Watershed, approximately 2% of the land is parkland. Many of these parks are small. Sixteen are about 4 acres or less in size. The remaining larger parks include Watts Memorial Park, Maple Hill Park, and Fancher-Davidge Park.

Fancher-Davidge Park, the City's largest, sprawls over 190 acres. It has a 40-acre pond, popular for fishing and surrounded by walking paths, forest, and wetland areas. These natural resources are described in more detail in the *Hydrology and Biological Resources* sections. The developed portion of the park offers basketball courts, softball and turf play fields, shelters, a picnic area, and cooking grills. There is outdoor ice skating in the winter and a swimming pool in the summer, and also a playground and horse rings. Fancher-Davidge Park hosts many festive community events throughout the year, including summer concerts and popular holiday celebrations. Check the City's Parks and Recreation website for details: https://www.middletown-ny.com/en/departments/recreation-parks.html

The 18.75-acre Maple Hill Park offers many of the same amenities for park goers and additionally has tennis courts, an adjacent dog park, and a disk golf course under construction. The park has a pond (.9 acre) open to fishing and a small tributary of the Monhagen Brook flowing through it. A City of Middletown project is underway to improve the pond's berm to increase floodwater retention and address flooding issues downstream. This project is discussed further in the *Flooding* section.

See Table 9 for a listing of each park and its amenities and Map 17 for the locations of parks throughout the Watershed.

Another natural and recreational asset under development in the Watershed is the Heritage Trail, a joint project being carried out by the County Departments of Planning and Parks, Recreation and Conservation along with the City of Middletown. An extension to the existing Heritage Trail will pass through the Watershed and run through the center of the City of Middletown, past the Thrall Library. Timing and extent are uncertain at the writing of this Plan but it is hoped at the Trail could be in place in just a few years.

It is worth noting that there are no parks along the length of the Monhagen Brook that provide public access to the stream as a recreational feature. Maple Hill and Fancher-Davidge Parks each have a tributary flowing through, but it is a recommendation of this Plan to improve public access to natural and recreational resources in the Watershed, acknowledging that increased awareness and enjoyment of these assets will support efforts to protect and enhance them (see Table 11: Listing of Additional Recommendations).

Park Name	Acreage	Amenities	Water Resources	Opportunities	
				Riparian Planting	Signage
City of Middletown					
Academy Avenue Park	1.9	Outdoor concert area, playground			
Beattie Hill Park	0.6	Playground			
Ben & Paula Amchir Park	1.5	Basketball, cooking grills, picnic area, playground, shelters	Stream frontage (unnamed tributary of Monhagen Brook)		◆
Bennett Hill Park	1.1	Basketball, playground			
Erie Way Park	2	skate park			
Fancher-Davidge Park	192.3	Basketball, cooking grills, fishing, horse rings, outdoor ice skating, picnic areas, playground, rest rooms, shelters, softball, swimming pool, turf playfields	40-acre pond and wetlands	◆	◆
Festival Square	0.25	Outdoor concert area			
Jerome W. Neill Jr. Park	0.4	Basketball, cooking grills, picnic areas, playground, shelters			
Jerry's Park	0.15				
Katherine Chappell Memorial Park	3.9	Basketball, cooking grills, picnic area			
Maple Hill Park	18.75	Basketball, cooking grills, fishing, outdoor ice skating, picnic area, playground, rest rooms, shelters, softball, swimming pool, tennis courts, turf playfield	.9-acre pond; stream (unnamed tributary of Monhagen Brook)	◆	◆
116 North Street Park	0.1	Bench			
Run 4 Downtown Park	0.1	Outdoor concert area			
Sproat Street Park	0.9	Playground, Swimming Pool			
Thrall Park	3.61	Playground			
Wallace Park	0.13	Statue			
Watts Memorial Park	17.6	Baseball, basketball, football, restrooms, shelters, soccer, softball, turf playfields			
Private Developement					
David Moore Heights Playground	1.8	Basketball, playground			
Town of Wawayanda					
Ryerson Road Park		not yet constructed			
Town of Wallkill					
Belmont Avenue Park	4.2	Picnic area, playground, softball	0.7 acres surface water, wetland, stream	◆	◆
Veterans Memorial Park		September 11 Memorial			

Table 9. Parks located within the Monhagen Brook Watershed

Stormwater Management

Erosion and Sediment Pollution

While the term "stormwater" often refers to runoff from highly urbanized areas, runoff from suburban or rural parts of the landscape can also impact water resources significantly. One of the more well-recognized sources of nonpoint source stormwater pollution is agricultural land, especially poorly managed farmland that is under an annual tillage system. As note in the *Agriculture* section of this Plan, farmland managed in such a manner is quite limited – possibly even nonexistent - in the Monhagen Watershed, and therefore highly unlikely to be a significant contributor to sediment or phosphorus.

Construction Sites

A more important stormwater-related contributor to phosphorus in the Watershed is erosion from construction sites with insufficient control measures. Current NYSDEC stormwater regulations require any construction site disturbing more than one acre to gain coverage under a stormwater construction general permit, and to prepare and implement an erosion and sediment control plan. However, as demonstrated in Figure 17, large amounts of sediment can still leave a construction site during a rain event and quickly end up in a stream or other waterbody when approved control measures are not installed, monitored, and/or maintained correctly. These poorly managed construction sites could result in erosion rates of up to 100 tons of soil per acre per year. While these rates of erosion would likely be vastly reduced once the construction phase is completed and the site is vegetated, built, or otherwise stabilized, significant water quality impacts result from these short term, high rates of erosion.

Figure 17. A nearby construction site causes a silt plume in a tributary of the Monhagen Brook in 2018. The site had erosion and sediment control measures in place, but they were not installed properly.

Unfortunately, the combination of fine soil particles that characterize the Watershed's glacial till landscape, the imperfect science of erosion and sediment control, negligent compliance on permitted construction sites, and other factors cause construction site erosion to continue to be a significant contributor to water quality problems in the Watershed.

Streambanks and Ditches

Other potentially significant sources of erosion and attached phosphorus include streambank erosion and road ditches. Streambanks naturally undergo erosion, but human influence on streams and their watersheds often accelerate these processes. Streams with urbanized watersheds tend to be “flashy,” meaning that their flows rise quickly and then fall quickly after a significant rain event. This is a result of the rapidity with which runoff reaches the stream from impervious surfaces and storm drainage systems. This rapidly-flowing stormwater contributes to flooding and exacerbates erosion issues (see *Stormwater Retrofit* section of this Plan for more on this topic).

Straightening and deepening of streams also accelerate streambank erosion. Such activities may be done with good intentions but often result in unwanted consequences, including accelerated erosion as the stream attempts to re-establish equilibrium. The *Stormwater Retrofit* section of this Plan discusses a site where impervious area runoff sheds directly onto the stream bank, adding to the above-described streambank erosion mechanisms.

Road ditches are a necessary and accepted road construction feature to collect and drain runoff, but because they connect directly with streams and other waterbodies, they are essentially part of the surface water system. Their capacity and function is maintained by excavating out soil, plants, and collected debris, and therefore any erosion that occurs in the ditch has a high likelihood of contributing sediment directly into a natural waterbody due to the exposed nature of the soil. Given this typical lack of uniform vegetative cover in addition to the practice of regular ditch maintenance using excavating equipment, there is little opportunity for any pollutant mitigation in the road ditch network. Conversely in fact, these ditches are more likely to generate pollutants in the form of eroded soil (including any additional pollutants of concern, such as phosphorus, that tend to be attached to soil particles). These open ditch systems are extensive in the Watershed.

While silt/sediment is in itself a large concern, the impaired status of the Monhagen demands a particular focus on the sources of phosphorus in the Watershed. As noted, phosphorus is closely associated with erosion and sedimentation along with numerous other point and nonpoint sources, including centralized sewage treatment systems and on-site septic systems. Although not as readily recognized as a phosphorus source, generalized urban stormwater runoff has been demonstrated to contain concentrations of phosphorus that can contribute to accelerated eutrophication and related water quality problems.

Grey Infrastructure

Stormwater management in the Monhagen can be fairly safely described as traditional "grey infrastructure." This is a term that has emerged largely in conjunction with the term "green infrastructure," which is described in more detail in the *Stormwater Retrofits* section of this Plan. In contrast to green infrastructure, which attempts to utilize plants and other natural systems in the management of stormwater, grey infrastructure is characterized by pumps, ditches, pipes, catch basins, and detention ponds. Grey infrastructure is generally very effective at accomplishing what it has historically been intended to do: rapidly remove stormwater runoff from streets, parking lots, and other urbanized areas. Ironically, its efficiency and effectiveness at accomplishing this goal tends to be in direct conflict with the goals of green infrastructure and water quality-focused stormwater management. While there may be some areas of the country that have made more significant advances incorporating green infrastructure into their stormwater management paradigms, the long legacy of grey infrastructure and its ubiquitous integration into the urban landscape, even in progressive areas, will dictate at best a gradual transition. Some areas that have made significant advances in this regard have made them in response to regulatory pressures resulting from drinking water protection concerns or other identified water quality impairments, however this is not always the case.

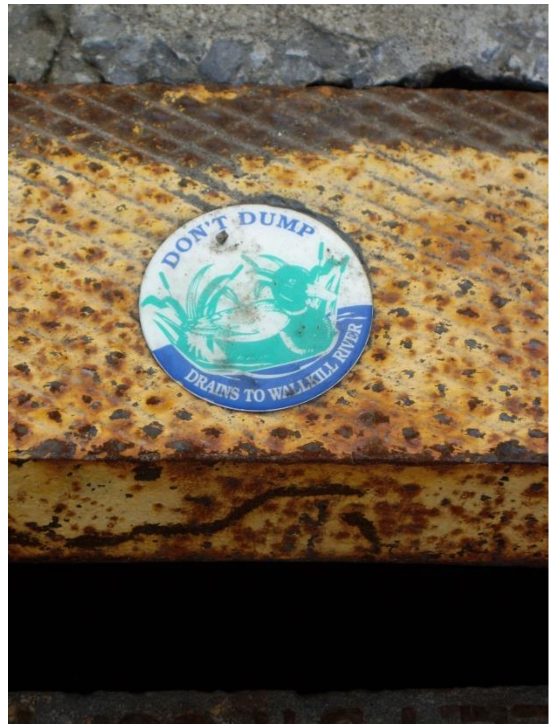


Figure 18. Storm drain markers in the City of Middletown remind residents where the water goes. Middletown's markers are due to be updated. Future markers could highlight the Wallkill tributary that drains most of the City - the Monhagen Brook.

Traditional grey infrastructure found in more highly urbanized areas is perhaps best typified by paved streets, concrete curbs funneling stormwater runoff to catch basins, and buried networks of collection pipes often outletting directly into streams. While the general public tends to be aware of these systems at least to the point where stormwater enters catch basins, they often do not know where the water goes from there. The public may even think the catch basin leads to a treatment plant (this might, in fact, be partially true in a community with "combined sewer overflows," but there are no such communities in the Monhagen Watershed). Detention ponds could be considered an intermediary practice in the evolution of modern stormwater management. These early generation stormwater management practices are common features on 1970's-1980's era developments in the Monhagen and elsewhere. They were developed in response to concerns about downstream impacts – primarily peak flow increases – resulting from the rapid and efficient removal of stormwater by grey infrastructure. Typically, they were little more than large impoundments with outlet structures that limited downstream flows to pre-development levels, and were typically unsightly. While they do provide a flood mitigation function, they are not generally considered to be a green infrastructure measure. See the *Stormwater Retrofits* section of this Plan for additional discussion of the stormwater detention practice.

Grey infrastructure and the impervious surfaces associated with it are commonly implicated as the cause of unstable, eroding stream channels (see *Stormwater Retrofit* section). In some cases, the grey infrastructure may extend beyond the street/catch basin/pipe collection system to the receiving stream, showing up in the form of channelization, hardened banks, or completely buried, concrete encased, or piped conveyances. Whether done to address instability resulting from urban runoff or not, such alterations to the natural stream channel tend to amplify the negative impacts of human activities on the health of the Watershed. The highly modified character of the Monhagen Brook and some of its tributaries as they pass through the Middletown urbanized area, although an understandable consequence of long-term historical priorities, typifies the extension of grey infrastructure to receiving waters that often happens in areas where streams traverse urban areas.

Figure 19. This section of the Brook east of Monhagen Avenue in Middletown "daylights" for a short run before returning underground. The pre-cast concrete block walls typify the extension of grey infrastructure techniques beyond the streets, catch basins, and collection systems to the stream itself.

Stormwater Management Challenges

Figure 20. Parking lot runoff is collected and treated by this Bioretention Basin retrofit in the City of Middletown. Before the retrofit, the runoff drained directly into the Monhagen Brook, seen in the right of the photo. Measures such as this can be expected to remove about 40% of the phosphorus from the runoff stream. Similar removal rates can be expected for other dissolved pollutants.

Beyond the obvious water resource impacts, other issues related to stormwater include funding for planning, design, construction, and maintenance, as well as the pragmatic challenges of determining which sources should be prioritized, assessing the efficacy of available treatment technologies, and fitting control measures into already crowded urban settings. It is hoped that the modeling, sampling, and careful analysis undertaken as part of this Plan will provide good guidance on how and where mitigation efforts should be prioritized. The Wallkill River Watershed Conservation and Management Plan, some of the key findings of which are summarized in the *Introduction* to this Plan, discusses the efficacy of "accepted" treatment practices. The modest pollutant removal performance of these practices is a troubling concern, and one that should legitimize seeking stormwater management plans that go beyond minimum requirements (which can often be met by routing runoff through one treatment practice). The green infrastructure/runoff reduction requirements that were recently added to NYS's Stormwater Construction permit attempt to establish a more holistic stormwater management paradigm that gets away from "single practice treatment." More time will likely be needed before an objective assessment can be made of how genuinely developers and their consultants have embraced these concepts. The pessimist would argue that, often, the bare minimum will still be delivered without vigorous oversight by review authorities. The primary review responsibility in MS4 areas lies with the local municipality. In the case of the Monhagen, all three local municipalities comprising the Watershed are MS4 communities: the City of Middletown, the Town of Waywayanda, and the Town of Wallkill.

In the highly developed Monhagen Watershed, stormwater management challenges can be viewed as two-fold. One challenge is to genuinely apply the holistic principles of green infrastructure to new development. The second, and arguable greater challenge, is to "retrofit" green infrastructure principles into the significant portions of the developed Watershed that were built before the advent and understanding of these principles.

Flooding [10]

Middletown has a long history of flooding. The most extreme in recent years came in late summer 2011 when Hurricane Irene and Tropical Storm Lee hit the City. On August 28, 2011, Hurricane Irene dropped over 8.5 inches of rain in a twelve-hour period. Less than two weeks later, while the City was reeling in the aftermath of the destruction caused by Irene, Tropical Storm Lee brought another 5 inches of rain and caused more flooding and damage. This section draws upon information from Middletown's *New York Rising Community Reconstruction Plan (2014)* and the *Town of Wallkill/ City of Middletown Natural Hazards Mitigation Plan (2014),* which can be referenced for further information about ongoing flooding issues, storm damages, community characterization, and proposed plans.

Figure 21. Floodwaters at the intersection of Fulton and Academy Streets during Hurricane Irene in 2011.

During Irene, floodwaters inundated the City, wreaking havoc on private property and public infrastructure. Many of the main roadways within and out of the City were blocked, essentially cutting off access in all directions, dangerously preventing evacuation, and isolating vulnerable residents from rescuers.

Where the Monhagen is buried and flows under Fulton Street, the force of the floodwaters ruptured the box culverts and the roadway above. After floodwaters subsided, the road collapsed into huge craters created by the damaged culverts. Businesses in the center of Middletown were without power for nearly a week. After the storms, Middletown developed a list of damages to its public infrastructure, including roadways, culverts, and City facilities that totaled $7,134,800. Private property damages were substantial.

[10] Mapped floodplains are shown earlier in this Chapter in Map 4.

Middletown's vulnerability is in large part due to its situation within the Monhagen Brook Watershed. Its natural hydrology funnels water from a wide upland area through the City center where development, with a high percentage of impervious surfaces, surrounds the stream and its tributaries. Much of the City was built atop wetland and floodplain and many such ecological buffers no longer exist. Undersized, aging, and damaged stormwater infrastructure exacerbate the issue as storm events often overwhelm drainageways and cause flooding in many areas along the course of the Brook. Highly vulnerable areas include: downtown Middletown; Pilgrim Estates neighborhood; Co. Rd. 78 near Monhagen Middle & Maple Hill Schools; West Main Street; City properties including Water Department, salt storage, and DPW garage; Fulton Street downstream to Genung Street; Sterling Street neighborhood.

Based on data from the *National Flood Insurance Program*, it is estimated that within the City of Middletown are 250 structures valued at $33 million sitting within the 100-year floodplain of the Monhagen Brook and its tributaries. These include residential, commercial, and industrial structures along with utilities and city- and state-run properties. This accounts for 8.2% of total parcels in the City, with approximately 5% of the land area (151 acres) located within 100-year floodplain. An additional 1% (21 acres) falls within the 500-year floodplain. Additional discussion of floodplains can be found in the *Hydrology* section of this Plan and are presented on Map 4.

In the aftermath of Hurricane Irene, Tropical Storm Lee, and a year later, Hurricane Sandy, state government developed the *New York Rising Community Reconstruction Program* (NYRCR) to support recovery in hard-hit communities throughout the state. Middletown was allotted up to 3 million in state funding to implement key projects developed in its NYRCR Plan (completed December 2014). The Planning Committee developed four "Proposed Projects" and four "Featured Projects" to address vulnerabilities in the Watershed and increase community resiliency in the face of future extreme weather events. Proposed Projects would draw from allotted funds through the NYRCR, whereas Featured Projects do not seek to be funded in this way. Additionally, the committee made several "Resiliency Recommendations," which include all other projects and actions recommended by the plan.

Simultaneously, the *Town of Wallkill/ City of Middletown Natural Hazards Mitigation Plan* was developed. This is a FEMA requirement for local municipalities to qualify for Federal disaster relief aid. Although this plan more broadly examined threats from many types of natural disasters, it identified flooding as the most serious hazard the City and Town face, and therefore the primary focus of the plan and the majority of the dozens of proposed mitigations relate to flooding. Several projects, most of which address repairs to damaged stormwater infrastructure, are included in both plans.

It is important to note that while these plans share the common goal of better stormwater management to reduce the risk of serious flooding, the vision for the Monhagen Brook Watershed Plan is more comprehensive in scope, taking into consideration ecological and hydrological principles and the long-term revitalization of the Watershed as a whole.

What follows is a brief summary of NYRCR Plan Proposed and Featured Projects. The "Monhagen Brook Culvert and Dredging Project" proposes to dredge culverts and remove piers along the Monhagen and Draper Brooks and re-channelize a section of the Monhagen Brook downstream from Genung Street. Another proposes culvert improvements at West Main Street and Monhagen Avenue, which would involve upgrading existing culverts to increase stream flow, and also streambank mitigation of the day-lighted section of Monhagen Brook between Monhagen Avenue and the entrance of the culvert. "West Main Street Streambank Mitigation" includes the restoration of streambanks and riparian areas to "improve flow conditions, reduce erosion, and provide additional flood attenuation, if possible." A final, more ambitious proposed project that would be completed in phases is the "Dorthea Dix Drive Flood Retention/Wetland Construction/Restoration Project." The first phase would involve "engineering, construction, and re-channelization of the Monhagen Brook," along with development of wetland mitigation areas and an interpretive trail system. The second phase proposes the renovation of a vacant building into a community recreation center that could function as an Emergency Operation Center and shelter, along with further development of wetland mitigation areas and an expanded trail system (implementation of phase 2 is not included in the first round of funding).

The NYRCR Plan details four other Featured Projects, which propose improvements to Maple Hill Park, upgrades to the Middletown New Jersey Railroad bridge, acquisition of additional emergency response equipment, and the development of a buy-out or elevation program for properties experiencing repeated severe flooding in the Sterling Street, Genung Street, and West Main Street neighborhoods.

- Aging, undersized, and damaged stormwater infrastructure;
- Deterioration and prevalence of lingering damage to roadways from increasingly intense storm events;
- Lack of appropriate emergency response access to the southern side of the City during intense storm events;
- Uncoordinated development in the upstream Monhagen and Draper Brook watersheds;
- Lack of strategically located open space and green/ infiltration areas in the densely developed City;
- Lack of interconnected green infrastructure and open space;
- Socially vulnerable populations located in FHAs;
- Local business interruptions and economic loss due to flooding damages, power loss, and flooded access routes during storm events;
- Extreme flood events that adversely affect performance of the City wastewater treatment plant and its available capacity due to inflow/infiltration;
- Underutilization of vacant properties and lack of strategic investment; and
- Disinvestment of commercial and retail within the Central Business District due to the high density shopping and retail center in the Town of Wallkill.
- The City no longer has direct transit rail access.

Figure 22. "Critical Issues" for the City of Middletown, as identified by the NYRCR Plan (2014)

At the writing of this Plan, a few of these projects are underway, including work at Maple Hill Park and along the banks of the Brook just downstream from West Main Street.

There is a great deal of overlap between analysis of critical issues and key challenges made in the NYRCR Plan (Figure 22), the Town of Wallkill/ City of Middletown Natural Hazards Mitigation Plan, and the Monhagen Brook Watershed Plan. It is agreed that the level of urbanization along the Brook (much of which is private property) restricts intervention, while the history of the stream's engineering and adjacent development limits possibilities for restoration to a more natural system. The Plans identify many of the same "problem areas" as potential stream corridor restoration sites. However, this Plan seeks to emphasize a modern stream restoration approach, employing natural channel design techniques wherever possible. This approach takes into account the hydrology of the Watershed as a whole and recognizes that heavy engineering solutions can have negative impacts on ecosystem health and water quality, and at times, even exacerbate the problems they are attempting to address.

Effective engineering solutions should attempt to mimic and support natural systems. Flood attenuation measures such as floodplain benches, constructed wetlands, revegetated stream banks, and restored riparian areas slow and store floodwater while filtering contaminants that impact the health of the Brook. For a more thorough analysis of these stream corridor restoration principles and practices, see for example: http://www.catskillstreams.org/pdfs/chemungstreamguide.pdf

Wherever possible, practices to avoid include: dredging outside of buried culverts, removal of vegetation along streambanks, straightening or re-channelizing the Brook's natural course, and further development of hardened (concrete) streambanks and buried culverts. See the *Recommendations* section for detailed descriptions of proposed projects that will address flooding issues in the Watershed.

As described in the *Ecological Challenges* portion of the *Biological Resources* section of this Plan, widespread impacts of climate change are already being observed regionally. In the Hudson Valley, annual average temperatures are on the rise, annual precipitation has been increasing, and instances of extreme weather, such as heavy precipitation events, are increasing in frequency. Climate projections predict increased warming, intensified storm events, and more severe summer droughts. These changes have widespread implications, and therefore planning that takes climate change impacts into account is essential for any area that has repeatedly identified flooding as one of its most critical issues. Detailed information and recommendations found throughout this Plan directly address these future challenges and focus on the core topics of: the health of stream corridors; the need for stormwater retrofit; the importance of wetlands, floodplains, and riparian areas; and new, innovative approaches to stormwater management. See the NYSDEC's "Impacts of Climate Change in New York" page for more information: https://www.dec.ny.gov/energy/94702.html.

The Monhagen Brook and its tributaries continue to be a source of flooding with the potential to damage homes and public infrastructure, isolate socially vulnerable populations, and create dangerous situations during extreme weather events (the likelihood of which is increasing due to climate change). A great deal of research, planning, and resources have been directed at solutions to this critical issue and some progress has already been made. One recommendation of this Plan is to assemble a committee, including representatives from the City of Middletown, the Town of Wallkill, and local water resource managers, to analyze all three Plans and reconcile the important goal of flood mitigation with comprehensive, watershed-based strategies that address these issues in a holistic way (See *Recommendations* table 5.1).

Culvert Barrier Assessment

The NYSDEC Hudson River Estuary Program began assessing road-stream crossings (i.e., culverts and bridges) in the Monhagen Watershed in 2017 to characterize and better understand the aquatic barriers and localized flooding hazards. Undersized and poorly designed culverts and bridges can restrict the movement of aquatic life (such as fish or crayfish) and terrestrial animals using the stream corridor (turtles and salamanders). After assessing these barriers, municipalities are encouraged to replace and mitigate the most significant barriers to create a more resilient watershed, reduce flooding, and improve aquatic connections. The Hudson River Estuary Program has assessed 180 bridges and culverts in an area that includes part of the Monhagen Brook Watershed. The assessment resulted in 41 bridges or culverts being considered severe, significant, or moderate barriers to aquatic life and/or obstructions to the movement of flow. See Map 16 and Appendix 6 for additional information on the status and importance of barrier assessments.

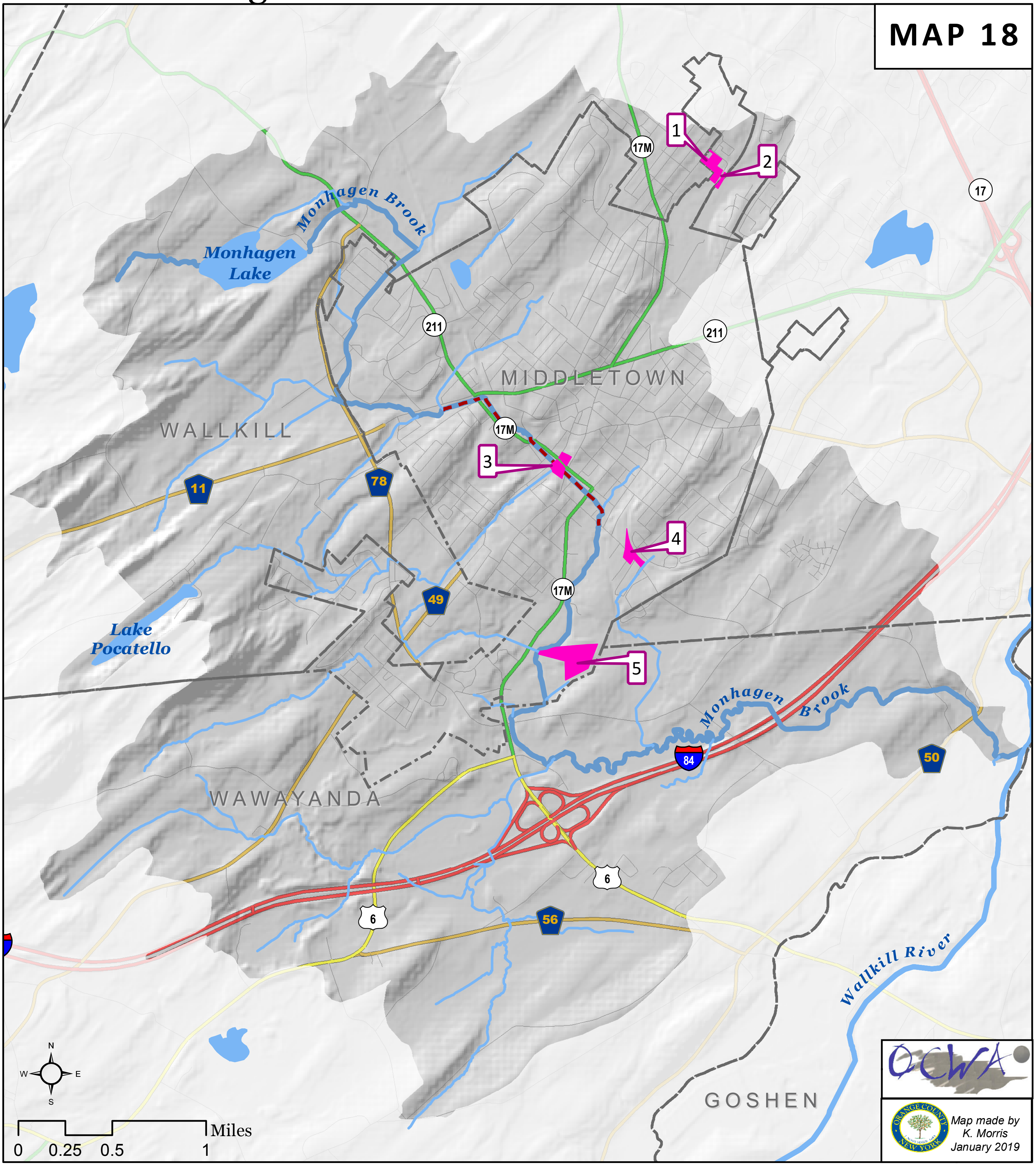
Risk Sites[11]

There are five State Superfund sites within the Monhagen Brook Watershed. Superfund sites are locations contaminated by hazardous wastes that pose a risk to human health and/or the environment and require a long-term cleanup response. The Inactive Hazardous Waste Disposal Site Program is the NYSDEC's program for identifying, investigating, cleaning up, and monitoring these sites (carried out by the Division of Environmental Remediation). Below is a brief description of the five sites in the Watershed and their known impacts, if any, on the Monhagen Brook (Map 18). For more information, see DECinfo Locator Environmental Quality Map: https://dec.ny.gov/pubs/109457.html.

The "General Switch Site" is located off of Highland Avenue, north of its intersection with NYS Rte. 17M. It sits at the northern boundary of the Watershed and is bordered by residential properties in a semi-industrial area. Dating back to 1958, the site was home to a manufacturer of electrical supplies and is contaminated by two spilled volatile organic compounds, tetrachloroethylene (PCE) and trichloroethylene (TCE); chemicals used in the production of electrical switches, circuit breakers, and panel boards. NYSDEC investigations identified several "hot spots" of soil contamination throughout the 5-acre site that could present a significant environmental threat. As part of their cleanup, soil removal was completed in 1999. However, chlorinated solvents, PCE, and TCE also impact the groundwater and remediation efforts are ongoing.

[11] Information about the risk sites detailed in this section is publically available through the NYSDEC Division of Environmental Remediation online database. https://www.dec.ny.gov/chemical/8437.html

Monhagen Brook Watershed: Remediation Sites



NYSDEC Remediation sites
1 - General Switch
2 - Lubricant Packing Co.
3 - O&R Fulton St Gas Plant
4 - O&R Genung St Gas Plant
5 - Middletown Dump

Municipal Boundaries
Underground segments of Brook
Water Bodies
Streams
Monhagen Brook

Interstate
Federal Highway
State Route
County Road
Local Road

Surrounding homes are on the public drinking water supply. Therefore, human exposure to contaminated groundwater is not expected and contact with contaminated soils is not likely to occur unless subsurface soils are excavated or disturbed. This site is classified under code “2” meaning the presence of hazardous waste has been confirmed and it represents a significant threat to public health and/or the environment and further action is required.

Adjacent to the General Switch Site across Industrial Place sits another State Superfund site, the one-acre “Lubricant Packing Co. Site.” A commercial tenant currently occupies a building on the site. In operation from 1962 – 1991, Lubricant Packaging and Supply Company (formerly F&W Bearing Service) operations included the degreasing and re-lubrication of metal ball bearings, the packaging of various lubricants, and the use of the toxic solvent 1,1,1-trichloroethane (1,1,1-TCA). Drummed chemical products were commonly kept outdoors; contamination is attributed to spills and improper storage.

Based on NYSDEC investigations, the primary contaminant of concern is a volatile organic compound, 1, 1, 1-TCA, and its breakdown products including 1, 1-dichloroethane, and chloroethane. Previous investigations indicate several soil contamination “hot spots” throughout the site. Groundwater has also been impacted. Leachate from the adjacent General Switch site also appears to be polluting groundwater at the Lubricant Packaging site.

At the time of NYSDEC’s Remedial Investigation, no impacts to fish and wildlife resources were identified. As for potential surface water contamination, there is a seasonal wetland area located to the west on the General Switch Property, and an intermittent wetland to the east, the direction in which the groundwater flows. It is noteworthy that surface water from the site and surrounding area within the Industrial Park drains into an unnamed tributary (locally known as Draper Run) of the Monhagen Brook. There is at least the potential for toxins to move into the stream by way of groundwater flow or with sediments in runoff, but this has not been studied.

The site is completely fenced, restricting public access. Contaminated groundwater is not used for drinking or other purposes; the site is served by public water supply. Volatile organic compounds in the soil or groundwater may move into the soil vapor (air spaces within the soil), which in turn may move into overlying buildings and affect the indoor air quality. A sub-slab depressurization system has been installed within the occupied portion of the on-site building to prevent vapors beneath the slab from entering the building but the potential still exists for people to inhale contaminants due to soil vapor intrusion in any future on-site building. Sampling indicates soil vapor intrusion is a potential concern for off-site buildings as well. The Lubricant Packing Co. Site is also classified under code “2,” meaning it presents a significant threat to humans and/or the environment due to the ongoing release of chlorinated organic compounds from the source area to groundwater and soil vapor.

The third Superfund site in the Watershed is the “O & R Fulton Street Manufactured Gas Plant,” located in a commercial area of Middletown south of the city center. The former gas plant currently houses an auto body shop and a transmission shop and also includes the parking lot of the Middletown branch of the US Post Office, where a naphtha gas tank used during production was located. The entire site encompasses approximately 1.8 acres.

The plant, which produced a combustible gas from coal, was in operation from 1887-1952. The contaminant of concern is coal tar, which is a condensate from the gas manufacturing process. In 1985 during excavation for a construction project, workers encountered a gasholder containing coal tar from the historic manufactured gas plant. Shallow coal tar remains a significant source of contamination under the site.

The site sits atop the historic course of the Monhagan Brook, which now flows underneath Fulton Street in a box culvert. The buried coal tar continues to release toxins into the groundwater, which has been shown to contain levels above State Standards. The groundwater is not used as a source of drinking water, and according to publically available NYSDEC reports, the chemical leachate passes below the Monhagen's box culvert but does not impact the stream within. This site's classification code is "A," meaning active because remediation is underway and not yet completed.

The "O & R Genung Street Manufactured Gas Plant" site, which was developed as a replacement to the Fulton Street Plant described above, is located on Genung Street on the southeastern outskirts of the City. The Monhagen flows by, approximately 800 feet to the west. The 2.6-acre site is currently vacant, except for a natural gas regulating station on the southwest parcel. There are residential properties nearby to the south.

The plant was in use from 1918 – 1957, also producing combustible gas from coal. After, the site was used for fuel oil and jet fuel storage. An initial investigation of the site was performed in 1998 and identified contaminated soil and groundwater.

Like the Fulton Street Superfund site, the primary source of contamination is coal tar. Coal tar contains BTEX compounds (benzene, toluene, ethylbenzene, and xylene) and PAHs (polycyclic aromatic hydrocarbons). NYSDEC investigations identified coal tar deposits and soil and groundwater contaminated by the above named compounds at the site, particularly the northwest parcel. The site presents a significant environmental threat due to the ongoing presence of coal tar within 4 feet of the surface and releases of contamination from the coal tar into the groundwater. Groundwater flow is from northeast to southwest, in the direction of the Monhagen Brook. This site is also classified "A," meaning active; remediation work is underway and not yet complete.

The 22-acre "Middletown Dump Site" sits adjacent to the Middletown Wastewater Treatment Plant off of Dolson Avenue (NYS Rte. 17M) and is currently owned by the City. The Monhagen Brook flows along the edge of the Superfund site for about 600 feet. This site was an active landfill and incinerator from

1952 -1969. Approximately 450 tons of hazardous materials were disposed of there, including benzene, toluene, ethanol, methanol, waste oil, and still bottom residues, much of which was incinerated and the resulting ash was buried in the landfill. The remaining waste was buried directly into the landfill. The site still receives construction and demolition debris from town activities such as road cleaning, tree pruning, and catch basin cleaning.

This history of hazardous waste deposition potentially threatens groundwater, soil, and surface water with toxins that can leach from the landfill. A NYSDEC Phase I Investigation was completed in 1988 and a Preliminary Site Assessment was completed in 1993. Sampling conducted at that time included surface water, sediment, domestic well water, soil borings, and groundwater. Sediment samples indicated low concentrations of methylene chloride and acetone, and one surface water sample indicated the presence of methylene chloride. The subsurface samples found trichloroethane (at 5ppb). In groundwater, two organic compounds were found exceeding NYS Class GA Groundwater Standards: 1-2 dichloroethene (at 36 ppb) and trichloroethene (at 34 ppb).

However, these levels of groundwater contamination are considered low and are not thought to represent a significant threat to the environment (only 1 of 4 wells was determined to exceed state groundwater standards). NYSDEC's limited sampling did not indicate significant contamination. Nearby residential drinking water supply wells were later tested in 2000 and indicated no impacts from the nearby landfill. This site is under classification "3," meaning "contamination does not presently and is not reasonably foreseeable to constitute a significant threat to public health or the environment," and therefore further action may be deferred. A recycling and ethanol production facility is proposed for construction on the site. Prior to construction, additional subsurface investigation is planned.

Another noteworthy site in the Watershed is the Competitive Power Ventures (CPV) Valley Energy Center. This facility is the most significant development within the Watershed in recent years, sitting between the fork of two unnamed tributaries of the Monhagen Brook, which flow by directly to its north and south. A natural gas pipeline also crosses beneath one of the streams to supply the plant. See *Recent Development Trends* within the *Land Use & Land Cover* section for more details.

In addition to the sites detailed above, there are several other remediation, bulk storage, and special permit sites throughout the Watershed, as shown in Table 10, below.

REMEDIATION SITES	REMEDIATION PROGRAM	LOCATION	SIZE	OWNER	DETAILS
302 1/2 & 324 1/2 East Main Street *Class N	Environmental Restoration Program	*same as site name*	49 Acres	City of Middletown	*none provided*
Erie Way Post Office Site *Class N	Voluntary Cleanup Program	Erie Way, Henry St, Union St. & West Main St.	3.6 acres	City of Middletown	Site used as rail yard from mid-1800's - 1983. Contamination concern from spilled deisel and a leaking underground storage tank (removed by City in 1987). DEC investigation in 2000 found contaminated soil and groundwater.
Middletown Landfill *Class N	Voluntary Cleanup Program	159 Dolson Avenue, Middletown	18.45 acres	City of Middletown	Detailed information provided in discussion of Middletown Dump State Superfund site in *Risk Sites* section of this Plan.

*** Class N Sites: "DEC offers this information with the caution that the amount of information provided for Class N sites is highly variable, not necessarily based on any DEC investigation, sometimes of unknown origin, and sometimes is many years old. Due to the preliminary nature of this information, significant conclusions or decisions should not be based solely upon this summary."**

CHEMICAL BULK STORAGE SITES	USE	LOCATION	TANK INFORMATION
Genpak Corp.	Manufacture of foamed polystyrene food trays and containers	26 Republic Plaza, Middletown	One aboveground tank (3,300 gallons) in contact with the soil
Shared Textile Services (Unitex Textiles)	Industrial laundry & linen service	192 Monhagen Avenue, Middletown	information withheld
City of Middletown Water Treatment Plant	Drinking water treatment from City reservoir system	88 Pilgrims Corners Road, Middletown	information withheld
City of Middletown Wastewater Tretment Plant	Wastewater treatement from City sewage system	159 Dolson Avenue, Middletown	One aboveground tank (10,000 gallons) in subterranean vault with access for inspections

OTHER SITES IN WATERSHED	TYPE OF SITE	LOCATION	ADDITIONAL DETAILS
City of Middletown Sewage Treatment Plant	Wastewater Treatment Facility; SPDES Permit	159 Dolson Avenue, Middletown	Although the Plant sits within the Watershed, its effluent is released into the Wallkill River, not the Monhagen Brook. There is listed, however, an alternate/backup outfall into the Monhagen Brook.
Mine ID #30508	Reclaimed Mine	135 North Street, Middletown	Sand and gravel; 4 acres reclaimed; last inspected in 2005
Pine Lane Mine #30545	Active Mine/Reclaimed Mine	NYS Rte. 6 near I-84 overpass & Co. Rte. 56 intersection	Sand and gravel; 25 acres permited and in use; 55 acres reclaimed; last inspected 2018; permitted until 2023
Genpak Corp.	Title V Air Facilty	26 Republic Plaza, Middletown	Manufacture of foamed polystyrene food trays and containers
Alliance Energy - Shoemaker Gas Turbine Facility	Title V Air Facilty	71 Dolson Avenue, Middletown	55MW kerosene and natural gas-burning power plant in operation since 1971
There are 4 additional industrial stormwater permits within the Watershed	SPEDS permits		

Table 10. Listing of risk sites within the Watershed

Discrete or cumulative impacts on water resources from these locations and activities are not known. As described above, the Monhagen Brook and its tributaries flow by several highly contaminated sites. Pollutants travel with normal hydrologic processes, such as runoff, groundwater seepage, and baseflow. However, routine water quality monitoring does not test for these toxins and a study of ecological impacts from past or present industrial activities would be challenging to undertake. Industrial pollution of ground and surface waters is a pervasive issue, but within the Monhagen Brook Watershed, these risk sites at least do not pose a direct threat to the City's source water, as none are located within the reservoir system's watershed.

Stream Walk Assessments

Gaining an understanding of the "on the ground" conditions is an important task for any watershed management plan. Walking and making observations along the entire 6.7-mile length of the Monhagen Brook from Monhagen Lake to its confluence with the Wallkill River is a very time-consuming task. To make this task more manageable, the project team recruited volunteers to walk segments of the stream, recording their detailed observations along the way. The Brook was divided into eight segments ranging in length from 0.7 miles to 1.5 miles (Map 19). Each segment was then assigned to a group of two or more volunteers. Walks were conducted from mid-April to mid-June of 2017, with the majority completed in May. Streamside landowners were notified and given the opportunity to opt out of having their section walked; only one landowner out of dozens chose to not allow volunteers to access their property.

Figure 23. Garbage collected behind a log jam on the Monhagen Brook. Woody material is generally good for the health of the stream, whereas the garbage is obviously not.

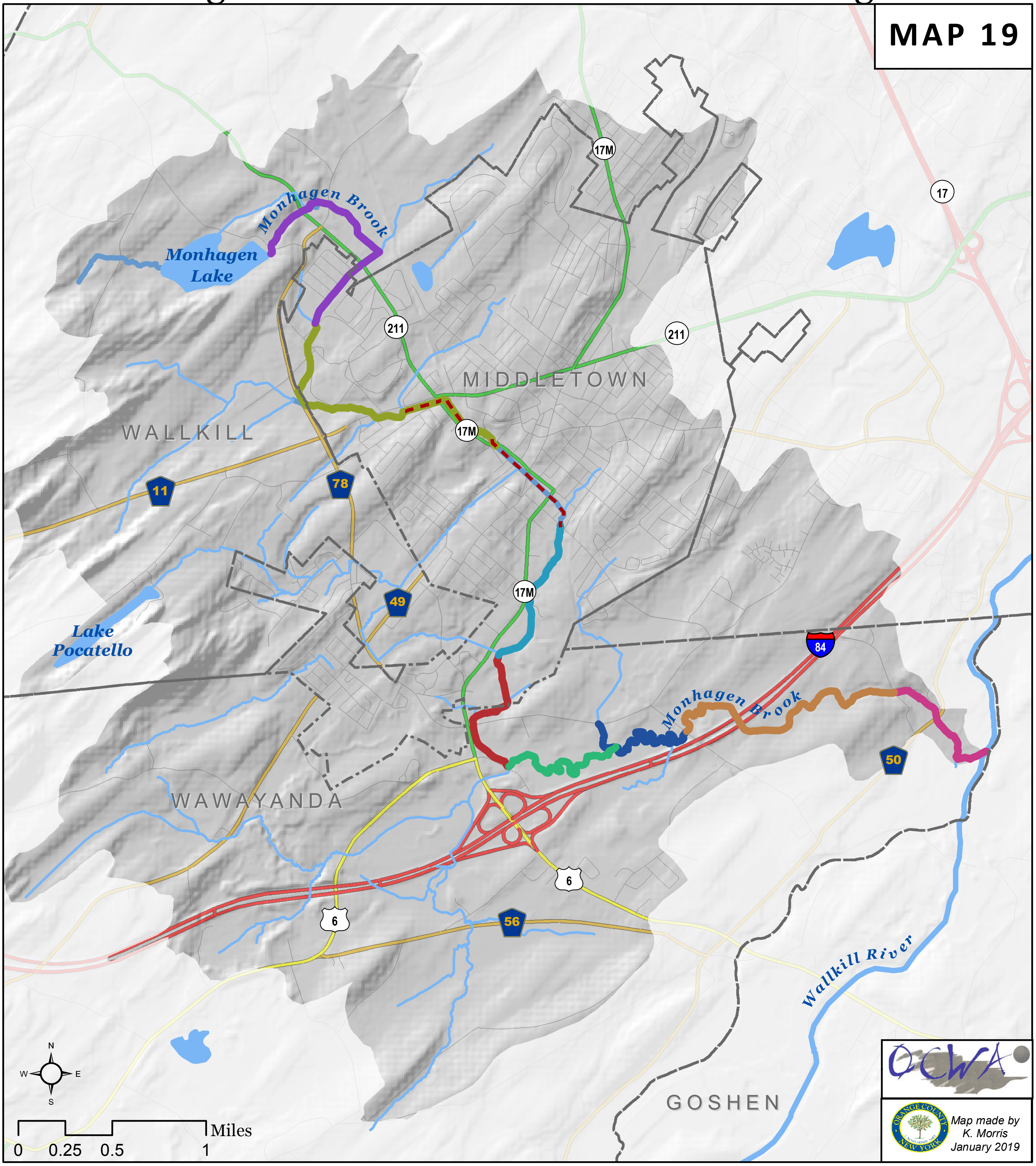
Volunteers were trained on what features to look for on their walks prior to starting them. Safety was a priority; therefore no one walked a segment alone. Volunteers noted current and previous weather conditions, the number of vehicle crossings, land use, project opportunities, and other important features[12]. Volunteers were encouraged to document their walk with photographs. Aerial maps were invaluable in determining the locations of key features and the photographs taken by stream walkers.

Notable and sometimes common features identified by volunteers included:

- **GARBAGE** along the stream corridor in the more urbanized areas of the Watershed. Accumulations of garbage were found in the lower reaches of the Watershed, often behind woody debris jams. These accumulations are likely the result of upstream garbage washing downstream and collecting behind the jams rather than being dumped there. This information will help to determine the location of future cleanup efforts along the Brook.
- **INVASIVE SPECIES**, primarily Japanese knotweed.

[12] See Appendix 8 for the form used by volunteers and staff during the stream walks.

Monhagen Brook Watershed: Stream Walk Segments



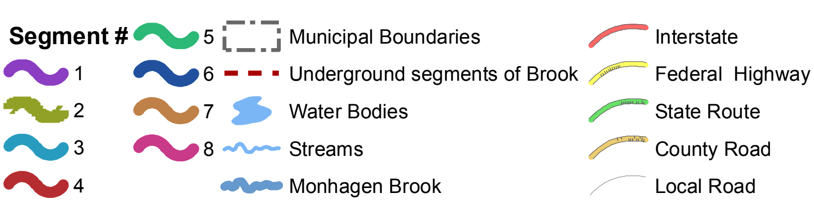


Figure 24. Severe streambank erosion near Shell gas station on the corner of Dolson Avenue and Dolsontown Road.

Typical photo of streambank erosion in the Watershed, often found on the outside bend of the stream. Photo taken in the oxbows of the Brook, between Dolsontown Rd and I-84.

- **PIPES DISCHARGING INTO THE STREAM**; the size, condition, and flow status were recorded for each pipe.
- **STREAMBANK EROSION** of varying extent. One notable section of severe erosion is just upstream of Dolsontown Road, behind a Shell gas station where the streambank is very high and is eroding up to the parking lot at the top of the bank.
- **BURIED STRETCHES OF THE BROOK** within the City of Middletown. These stretches were mapped and are shown throughout the maps within this Plan.
- **CONCRETE-LINED STREAMBANKS**, notably at the Middletown Campus near County Rd. 78. Modern bank stabilization techniques could be used to restore these areas to a more natural state and improve habitat and water quality. Although concrete lined banks can prevent erosion, they speed the flow of water, unintentionally increasing erosion in downstream areas.
- **NATURAL AREAS** that could be conservation priorities. These areas provide many benefits to the Watershed, from wildlife habitat to water quality improvement to public recreation.

Information gathered by the stream walks has been a great asset in developing other sections of the Plan. See Appendix 8 for the Stream Survey Worksheet that was used during this field work. Orange County Soil and Water (SWCD) compiled all of the stream walk information and used it to generate a list of potential restoration projects that could be implemented if funding and landowner cooperation were secured. Potential projects range from invasive species removal to stream restoration and green infrastructure retrofits. See Appendix 10 for a detailed list of potential projects.

Littering & Refuse Pollution

Figure 25. Volunteers clean up the banks of the Monhagen Brook off Dolson Avenue. Unfortunately, it didn't take long for the garbage to reappear.

As noted in the *Introduction* of this Plan, litter was identified as a priority issue at a public meeting held as part of the Wallkill River Watershed Conservation and Management Plan (2007), and it is no less an issue today in the Monhagen Book watershed. This is not a surprising finding in an urbanized watershed. The City of Middletown, like most local municipalities, has a litter control ordinance and it is likely that even with vigorous enforcement, litter would still be a problem in busy, densely developed areas. Observations along the Dolson Avenue commercial corridor reveal an alarming litter problem. Addressing this situation will require action at numerous levels, including improved dumpster management. The proximity of commercial dumpsters to the Brook along Dolson Avenue allows large volumes of solid waste to enter the stream corridor. Trails of litter from dumpsters to the Brook have been observed while conducting stream walks, stream cleanups, and fieldwork. Further downstream where the Brook enters flatter terrain, solid waste collects in "debris dams," which eventually clear themselves and then litter continues downstream to the Wallkill River and beyond.

Some improvements to dumpster management are simple. Keeping lids closed whenever possible vastly reduces windblown materials reaching the stream. Overfilled dumpsters are another related problem that indicate the need for more frequently scheduled pickups. Another improvement opportunity is to surround dumpsters by fenced enclosures. This is not only a good idea from a litter control standpoint, it is required by City ordinance. It is worth noting that some dumpsters are located literally right at the top of the streambank, thus relocation is an option that should be seriously considered.

Another related issue of importance is pollution caused by leachate from dumpsters and other solid waste handling devices. A full discussion of this issue is beyond the scope of this Plan and potentially involves several regulatory programs. Some communities have been more proactive in addressing this issue. See, for example, the PowerPoint presentation from a 2014 stormwater conference in the State of Washington (https://www.co.pierce.wa.us/ArchiveCenter/ViewFile/Item/3425). A worthwhile future initiative might be to undertake a thorough inventory and review of such facilities in the Watershed with the goal of developing an improvement/management plan. In the meantime, promotion of common sense management measures could result in significant water quality benefits. Such measures include inspection and maintenance of dumpster integrity, relocation away from water resources and storm drain inlets where feasible, placement of impervious surfaces under dumpsters, and careful emptying practices.

Littering by individuals is undoubtedly a significant contributor to the overall problem of solid waste pollution in the Watershed. Like dumpster management, littering is regulated by ordinance. However, it is also difficult to effectively enforce. More aggressive enforcement can be recommended, but should be accompanied by increased public education. This could include signage around the Watershed, and perhaps more strategic and expanded placement of proper waste receptacles. Another important form of education is direct outreach to local businesses so owners and their employees can begin to implement better management practices.

Figure 26. Litter fills the forest floor from the edge of a commercial parking lot to the Monhagen Brook in the background.

An action item for this Plan is to develop and distribute educational materials aimed at both business owners and employees regarding improved dumpster management for the benefit of the Brook as well as the aesthetics and health of the Watershed in general (see *Recommendations* table 3.3)**.** Principles to be encouraged include:

- Close the Lid
- Don't overfill; compress or schedule more frequent pick-up if necessary
- Package/secure loose, light materials
- Consider relocation away from water resource/storm drain inlet
- Provide enclosure as required by City of Middletown's Litter Ordinance
- Add impervious surface if lacking, with attention to drainage

A broader educational effort aimed at Watershed residents and shoppers should be pursued as part of the overall outreach and education efforts that following the completion of this Plan. This can include additional signage throughout busy areas of the Watershed, more strategically placed trash receptacles, public service announcements, and other measures.

From the City of Middletown's Litter Ordinance:

> All permanent on-site dumpsters shall be obscured from view by fencing or other suitable enclosures. The enclosures shall be substantially opaque when viewed from the exterior and shall prevent the dumpster from being viewed. The enclosures shall be at least six feet high but no more than nine feet high. The enclosures shall be equipped with a locking gate at all business and commercial premises. Temporary dumpsters are excluded from this provision.
> [Added 7-8-1996]

Chapter 3
Opportunities & Recommendations

Building upon the information described in the previous Chapters, this Chapter presents general and site-specific actions that can preserve and improve the condition of the Monhagen Brook and its Watershed. It is followed by the *Recommendations* table, which summarizes and builds upon these actions. This Chapter is informed by stakeholder input, information gathered during the planning process, and the project team's institutional knowledge.

Stormwater Retrofits

The *Stormwater Issue*s section of this Plan discusses the impact of older urban areas, with their extensive "grey infrastructure," on water resources and some of the challenges associated with efforts to mitigate these impacts. Even on new developments, implementing effective stormwater management is challenging when regulations often can be met by routing runoff through a single treatment that may remove less than half of stormwater pollutants. In existing urban areas, like those found throughout the Monhagen Brook Watershed, fitting even a single treatment practice into the runoff stream can be very challenging, much less providing multiple levels of treatment as would be ideal. This section will further explore opportunities for comprehensive and ambitious watershed management aimed at both existing urban areas and new development that will results in water quality improvements.

Evolution of Modern Stormwater Management

"Stormwater retrofits" refers to retrofitting, or adding, water quality and/or quantity management measures to settings where they were do not currently exist. This is in contrast to new developments where, commonly, such measures are required by law. The more general term, "stormwater management," could include the simple collection and removal of stormwater from a development site (think catch basins and pipes), which has been common practice for hundreds of years.

The advent of "modern" stormwater management occurred over a period of time. In the 1970's in Orange County, impacts of urban runoff, such as increased downstream flooding and destabilized streambanks, became better recognized. Measures to address these concerns were starting to be required for new development (most often through the authority of local municipal Planning Boards via the Site Plan Review process). Initially, this stormwater management primarily took the form of what are called dry detention basins. As the name implies, these structures typically are empty and dry between storm events, but collect and detain stormwater during runoff events, releasing it at a rate that does not exceed the “pre-development” peak discharge. Engineers would speak of “shaving the peak” off of the higher runoff rates that resulted from increased impervious surfaces due to development. While generally effective at addressing downstream flooding issues caused by urbanization, dry detention provides little if any mitigation of the urban pollutants that collect on impervious surfaces and are rapidly transported to receiving waters by the traditional stormwater conveyance systems that were the norm.

Other impacts of impervious surfaces, such as reduction of groundwater recharge and robbing of stream base flows, were also not being addressed by dry detention practices. As these and other impacts of urban runoff became better recognized, and as federal Clean Water Act requirements began to filter down to the State and local level, stormwater management on new developments became more rigorous and sophisticated. However, the water quality impacts from stormwater runoff in established urban areas remained, as evidenced in a watershed like the Monhagen.

While many retrofit technologies are available, space and funding equally challenge comprehensive and effective solutions to stormwater runoff. In some contexts where there are heightened concerns for drinking water protection or receiving waters are listed as “impaired,” urban retrofits may be part of a mandated management plan. This is not the case in the Monhagen Brook Watershed. *There is no mandate for a stormwater management plan for this Watershed; this Plan is a non-regulatory guidance document meant to serve as a reference for future management actions and addresses topics in addition to stormwater.*

Green Infrastructure

As regulation of stormwater runoff has progressed, so has the science and art. Stormwater regulations in NY and elsewhere now emphasize the use of holistic approaches such as green infrastructure and runoff reduction designed to integrate treatment of stormwater into site designs as opposed to “end of pipe” or single practice approaches. Green infrastructure encompasses many practices and techniques employing both manufactured products and biological systems, with the overall goal of mimicking natural

Figure 27. Parking lot islands, like this one in the James Street parking lot, will be depressed below rather than elevated above the adjacent pavement when the lot is retrofitted. Runoff from the pavement will then flow into the island and be cleansed and filtered by soil and vegetation. The dumpsters in the background have already been relocated from the parking lot.

hydrologic processes.

Above-ground stormwater/green infrastructure measures – often employing plants and biological processes to enhance pollutant treatment – are significantly cheaper to install than underground systems or those that involve removing and replacing conventional impervious surfaces (for example, replacing a parking lot with pervious pavement). This confounds efforts to effectively address stormwater runoff from the existing surface landscape in older urban areas like Middletown where undeveloped green space is often in short supply.

This Plan describes a short list of sites in the Watershed under consideration for stormwater retrofits and green infrastructure. Although many more sites would benefit from intervention, these particular sites were chosen as “low-hanging fruit” opportunities after consideration of the challenges and opportunities described below. Ongoing efforts to implement an ambitious green infrastructure plan in downtown Middletown will also be described. Finally in this section, a proposed Residential Rain Garden Cost-Sharing program will be discussed. Additional sites will be considered for this ambitious retrofit program as progress is made to secure funding and gain cooperation with necessary decision-makers.

Extensive existing “traditional” stormwater infrastructure, limited space, limited funding, and the general lack of priority that stormwater management holds in the host of issues facing urban managers will undoubtedly make urban stormwater retrofits a long term challenge for water quality managers.

Commercial Developments

Campbell Plaza Retail Mall

Known locally as the ShopRite Plaza, this 15-acre site on Dolson Avenue in Middletown is essentially 100% impervious cover composed of roofs, asphalt, and concrete surfaces. It is a particularly interesting candidate for a case study since it borders the Monhagen Brook for approximately 1700 feet. While it should be remembered that sites distant from the Brook can have comparable water quality impacts to those more proximal given the storm drainage networks that convey runoff directly to the Brook, there are several reasons for giving Campbell Plaza heightened attention in this Plan. The proximity of the Brook along with the high number of patrons visiting this site daily creates unique opportunities for public outreach and education. This site offers opportunities not only for impervious area runoff management, but also for other potential improvements to the riparian corridor such as streambank stabilization, stream buffer enhancement, and better solid waste management.

Figure 28. Construction of the Campbell Plaza Bioretention Basin

In cooperation with Campbell Plaza management, SWCD designed and installed several small-scale stormwater management/green infrastructure measures at this site, including a bioretention basin (Figure 27) and several hundred feet of streambank stabilization along stretches that are experiencing significant erosion. Commonly it is the in-channel flow of a stream that wears away at the banks. In this case, much of the erosion is due to concentrated flows of runoff from the Plaza parking lot spilling over the steep banks of the Brook. When impervious surfaces extend to the edge of the streambank, there is little room for buffers or stormwater treatment measures, but the bioretention basin that was installed in 2016 took advantage of a narrow but adequate idle area between the parking lot edge and the top of the streambank. An elongated basin design collects runoff directly from the adjacent asphalt surface, while additional modifications that included reshaping the driveway edge, installation of curbing, and grassed swales, direct additional driveway runoff to the basin. This project exemplifies how creative and adaptable design strategies can offer significant improvements to a sites that at first seemed to offer little opportunity for retrofits that would be affordable and acceptable to site owners and managers.

The area where the bioretention basin was built was previously being used for dumpsters. Fortunately, there was enough room on the driveway edge to relocate the dumpsters, leaving the area available for the bioretention basin construction. Since property managers were already concerned about the proximity of the steep streambank to the heavily used driveway, the addition of a curb to the bioretention basin design helped to secure their support for the project since the curb presents a more tangible definition to the edge of the driveway while also enhancing the pollutant collection and treatment functions of the bioretention basin. A chain fence along the edge of the driveway provides further definition while providing some additional protection for the runoff management measures.

While noteworthy for their creative approach to a challenging site, these measures treat only a small portion of the total stormwater runoff from Campbell Plaza. Even by installing additional measures along the 1700 feet of streambank, only a small percentage of the total runoff would be collected and treated due to the configuration of the parking lot drainage system that routes stormwater to internal catch basins throughout the Plaza. A project to provide more comprehensive treatment would be expensive and would involve major construction. The cost and disruption to normal use of the site hinders buy-in for such retrofits. There are, however, additional benefits beyond water quality improvement that should be recognized, include improved parking lot aesthetics, safety, more parking spaces, improved air quality, and cooler temperatures. An additional consideration is whether the parking lot is reaching the end of its life and needs to be redone anyway, in which case a retrofit could be a win-win. A total redesign of the Campbell Plaza parking lot was given some consideration at the time of the bioretention basin demonstration project in 2016, but did not move beyond the general discussion phase.

Playtogs Plaza

Playtogs Plaza sits directly across from Campbell Plaza on Dolson Avenue in Middletown, and like Campbell Plaza, this 28-acre site is essentially 100% impervious with a conventional catch basin/storm sewer drainage system. Though not directly bordering Monhagen Brook, it is just 1,000 feet away and its drainage reaches the Brook quickly via conventional stormwater pipes.

These two sites comprise over 40 acres of impervious surfaces, with stormwater draining unmitigated to the Monhagen Brook. This area provides a sense of the scope of work that would be required to implement substantive retrofit improvements in the Watershed. There are many obstacles to establishing a stormwater management system that adequately treats runoff before it enters the Brook, including owner approval and high construction costs. Retrofitting this area would likely be in the millions of dollars, and it is just 40 acres of impervious surface in a 7,680 acre highly-urbanized watershed. The cost of improving stormwater quality through infrastructure is thus daunting, but every retrofit project helps incrementally reduce the amount of phosphorus and other pollutants entering the Brook and other waterways.

Downtown Middletown

In 2015, SWCD sought to expand its green infrastructure work beyond small-scale demonstration projects, to projects that treated more expansive areas of urban runoff and held greater potential to deliver meaningful water quality improvements. In partnership with the City of Middletown and Lehman & Getz Engineering of Warwick (L&G), a conceptual green infrastructure design was developed for the James Street parking lot – a major municipal parking lot in the heart of downtown Middletown. Grant funding was sought in 2015 and 2016 to progress from conceptual design to final design and construction, but was not secured.

To their credit, in 2017 the City chose to move forward with this and other downtown green infrastructure projects using funding the City had already secured (Figure 28). These projects dovetailed nicely with other downtown revitalization projects planned and underway, including extension of the Heritage Trail through the City and a park/farmers market. As planning for the initial green infrastructure sites, including James Street, progressed, more opportunities for retrofits presented themselves and City officials authorized L&G to prepare designs for these sites. In all, there at least ten sites that have been evaluated and are in various stages of planning and design. These sites are listed in the *Stormwater Retrofit Inventory List* included in Appendix 10.

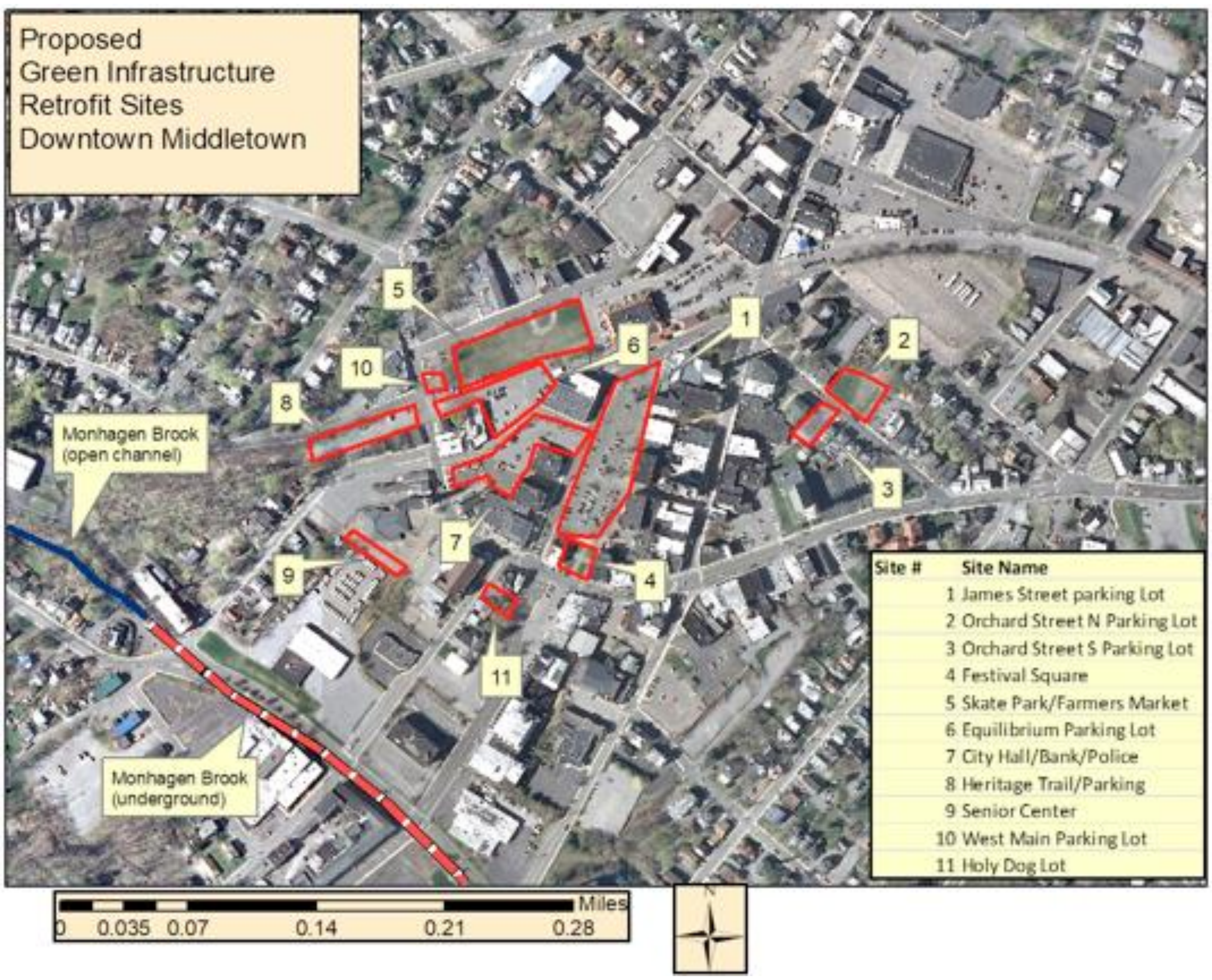


Figure 29. Proposed GI sites, downtown Middletown

With these ambitious plans, Middletown is poised to become a leader in proactive adoption of green infrastructure design that will make substantial improvements to water quality and flood protection in the Monhagen Brook Watershed.

General Urbanized Area Runoff

Along with the commercial scenarios described above are the streets, driveways, sidewalks, rooftops, and associated impervious surfaces spread throughout the urbanized areas of the Watershed. Combined, these smaller and often disconnected impervious areas likely exceed the total area of imperviousness associated with large commercial developments and highly urbanized areas. Interestingly, a cursory examination of aerial imagery of the Watershed reveals substantial "green" and mostly pervious areas intermixed with the impervious surfaces. These range from larger green spaces like Watts Park, the Middletown Community Campus (formerly a State-owned psychiatric center), and Hillside Cemetery, to hundreds of residential yards and other small, vegetated areas. If the concept of green infrastructure were to be fully implemented utilizing all the existing green areas, impacts to the Brook from urban runoff would be vastly reduced. In reality, such an effort would have many practical obstacles. As described above, there are many "low-hanging fruit" sites where, with manageable expense and effort, green infrastructure principles could be employed to provide treatment for some portion of urbanized areas. Perhaps the most straightforward type of retrofit site is one where an existing green area such as a turf grass lawn occurs slightly downslope from an impervious area such as a parking lot.

The accompanying photo of the US Post Office on Fulton Street in Middletown provides an example (Figure 29). Note the catch basin in the corner of the parking lot, which undoubtedly drains via a storm water pipe to the nearby Monhagen Brook buried under Fulton Street. Next to, and downslope from the parking lot is a lawn area that fronts out on Fulton Street. By making fairly simple adjustments to the drainage in the corner of the parking lot, for example elevating the catch basin inlet slightly and notching or boring through the existing concrete curb to release low flows from the parking lot surface to the lawn area, the "first flush" of stormwater

Figure 30. This site demonstrates some of the characteristics that make for a feasible potential storm water retrofit project.

from the parking lot could potentially be collected, treated, and infiltrated. While there are various green infrastructure practices that might be suitable for this location, the bioretention basin concept will be used for this example. The mild slope of the lawn area lends itself to the creation of a broad pooling basin via a balanced cut/fill operation. Its position slightly downslope from the lowest corner of the parking lot allows for gravity filling of the basin, with bypass of excess runoff back to the existing catch basin. With skillful design, the bioretention basin will look like an intentional landscape feature of the Post Office facility.

The potential retrofit sites described in this Plan are meant to exemplify recommended actions rather than provide an exhaustive list of potential sites. Those familiar with urbanized areas of the Watershed who have an understanding of the characteristics that make for a good retrofit site are encouraged to submit ideas for further consideration.

Residential Rain Garden Cost-Share Program

The green infrastructure practice known as bioretention, which is mentioned several times in this Plan, has become a common practice in the region. It is common for the terms “bioretention” and “rain garden” to be used interchangeably, and although they have technical differences, they function similarly. Rain gardens are typically smaller in scale, and in residential settings where the primary stormwater source is roof runoff, rain garden practices are more commonly employed. Increasingly, rain gardens are part of new residential development site plans as part of the designer’s attempt to comply with green infrastructure/runoff reduction requirements. Some communities promote retrofitting of rain gardens into existing residential areas which, as discussed, can be significant contributors to water resource problems in highly developed watersheds such as the Monhagen. While the programs take many different forms, often a cost-sharing arrangement is included to incentivize homeowner participation. Another appealing aspect of this practice for homeowners, especially those with a penchant for gardening, is the wide variety of appropriate plant species and the flexibility and creativity of the design process. When skillfully designed, a rain garden is a beautiful landscape enhancement that provides pragmatic stormwater management functions.

One of the recommended *Priority Actions* of this Plan is to study the feasibility of a Rain Garden Cost-Sharing Program for the Monhagen Brook Watershed (*Recommendation* 3.8). Such a program holds the potential to not only directly address water resource concerns by removing pollutants and attenuating stormwater flow that can cause flooding, it will also contribute to the education and outreach goals of the Plan.

Stream Corridor Restoration

As noted in the *Stormwater Retrofit* section, sites distant from receiving waters can have comparable water quality impacts to sites close to the water resource of concern. This includes urban sites reaching the receiving water via a stormwater drainage conveyance or other sites reaching the water resource of concern via tributary streams or other less conspicuous concentrated flows such as drainage ditches. Nevertheless, stream corridors deserve special attention and protection for the special watershed services they provide – not the least of which is as wildlife corridors. Properly designed and managed urban stream corridors provide many other benefits, including filtering of stormwater runoff, shading to keep water cooler, reducing stream bank erosion, and passive recreation. Achieving all these benefits can be very difficult when historic development has encroached on the stream corridor, which is often the case in urbanized areas that likely grew where they did because of the services the stream offered.

Figure 31. Stream corridor restoration opportunity behind Campbell Plaza in the City of Middletown.

Figure 32. Stream corridor restoration opportunity at Monhagen Ave in the City of Middletown.

Like stormwater retrofits, it is useful to view urban stream corridor improvement in terms of feasibility. By no means should more challenging and expensive efforts, such as stream daylighting, be discounted. But it may make sense to focus initial efforts on more affordable and simpler projects. The *Stormwater Retrofits* section discusses some opportunities for corridor improvement on a commercial site in conjunction with impervious area treatment measures.

The Campbell Plaza site was described earlier in this Chapter and the stream corridor is shown in Figure 30.

This corridor could be enhanced to provide better habitat as well as stormwater treatment. Another urban stream corridor restoration opportunity exists further upstream at a smaller commercial site currently used as the headquarters for a landscaping business. This site is along a reach of the Brook that daylights from a buried section after crossing underneath Monhagen Avenue, and is just upstream from the City's Department of Public Works (DPW) garage where the Brook is once again mostly buried (Figure 31). Downstream from Monhagen Avenue, the channel is open for 200 feet before entering a buried section. The north side of the channel is a very steep slope bordering a gas station, which offers little opportunity for corridor enhancement. The south side, however, adjacent to the landscape business, is a much lower bank and could be more feasibly restored if the business/landowner were able to sacrifice some land along the edge of the Brook.

Figure 33. Volunteers plant trees and install protective tubes on the Gold Minds site next to tributary of Monhagen Brook, 2016.

These urban stream corridor restoration opportunities offer large potential benefits but also present many of the same challenges as urban stormwater retrofit sites, including space limitations, the presence of utilities, and higher costs.

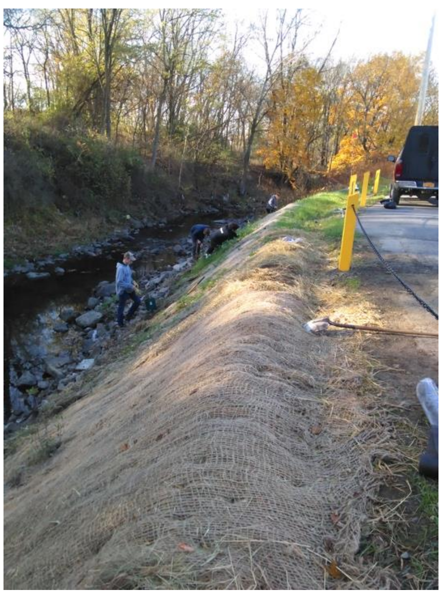


Figure 34. The stream corridor at Campbell Plaza presents more constraints than the Gold Minds site, but significant improvements are still possible. Here, Scouts plant shrubs on a re-constructed streambank.

There are also restoration opportunities in less developed portions of the Watershed. For example, in many locations where streams pass through or near residential yards, homeowners mow grass lawns to the edge of the streambank, essentially eliminating any vegetated buffer. While homeowners may enjoy seeing more of the stream, in some cases when educated about the benefits of vegetated buffers to stream health, they may agree to adjust their mowing habits. This is a simple practice that will provide benefits to stream health and water quality.

Adding woody vegetation can provide even more benefit both in residential areas and on larger tracts of undeveloped or agricultural lands near the Brook. The site pictured in Figure 32 was part of a land tract used for hunting had historically been mowed infrequently. The owners agreed to the establishment of a tree buffer for 100 feet on both sides of the Brook that traversed this field. This and other riparian enhancement projects in the Monhagen Watershed have been completed under the planning guidance of SWCD and the NYSDEC's Trees for Tribs program, with assistance from numerous other groups and individuals (Figure 33).

A helpful resource for assessing and prioritizing riparian areas for protection and restoration can be found through the NYSDEC's NY Natural Heritage Program: http://www.nynhp.org/treesfortribsny

Land Conservation Analysis

The Orange County Land Trust conducted a GIS analysis of the Watershed to determine priority areas for the protection of the Monhagen Brook. The goals of the analysis were to identify areas with natural cover and landscape features that benefit the Brook's water quality, and to find areas that, if developed, would have a negative impact on the Brook. The following landscape features were mapped and used in the analysis:

- steep slopes
- wetlands and wetland buffers
- floodplains
- streams and stream buffers
- areas adjacent to existing protected land
- land use (natural cover)

Parameters that were considered to be more important for water quality in the Monhagen Brook Watershed were given more influence in the analysis using a weighted overlay in GIS. See below for the data sources used, all of which are publically accessible data layers. The final analysis was done on a 5m by 5m raster grid for the entire watershed of the Monhagen Brook.

A high resolution (1 meter) land cover data based on LiDAR was recently developed for all of Orange County by the University of Vermont Spatial Analysis Lab using aerial photos from 2013. This data was used to identify areas with natural cover and areas covered with impervious surfaces. It is important to note that the goal of this analysis was to identify land types and areas that are most important to the water quality of the Brook, and not necessarily to identify specific properties for protection.

Results

A few general areas were identified:

-- the area in the vicinity of Monhagen Lake and surrounding protected land
-- the wetland complex and buffer area north of Fancher-Davidge Park
-- the undeveloped forested lands surrounding Lake Pocatello, especially southeast of the lake

-- the undeveloped forest and wetlands between US Rte. 6 and Greeves Road
-- smaller areas of wetlands and forested land along streams, especially within the floodplain of the Brook

While this should not be considered a comprehensive analysis, it is a useful first step in determining important areas to protect in order to maintain and improve the quality of the Monhagen Brook.

Data Sources: Steep slopes: derived from USGS 1m DEM; Wetlands and wetland buffers: NYSDEC Wetlands, USFWS National Wetland Inventory; Floodplains: FEMA Flood Hazard Layer; Streams and stream buffers: NYSDEC Streams, National Hydrography Dataset, Orange County Department of Planning; Areas adjacent to existing protected land: New York Protected Areas Database, Orange County Department of Planning; Land use (natural cover): High-Resolution Land Cover Delaware River Basin 2016 - University of Vermont Spatial Analysis Laboratory

Land Use Regulations

The Watershed includes portions of three municipalities: the City of Middletown, and the Towns of Wawayanda and Wallkill. Each have distinct comprehensive plans and land use regulations, which makes management complex because management approaches often depend upon local land use goals and laws, as well as municipal leadership; therefore there are three avenues of management of this Watershed. To assess the regulatory differences, the Planning Department completed an analysis of municipal land use regulations, using the Center for Watershed Protection's Updated Code and Ordinance Worksheet[1] (COW, Appendix 9). The Worksheet was created to help local stakeholders evaluate their municipality's development regulations in order to identify areas of municipal codes that could be improved by either permitting or requiring site developers to minimize impervious cover, conserve important natural areas and use runoff reduction practices to better manage stormwater. Regulations that were evaluated pertained to:

[1] https://www.cwp.org/updated-code-ordinance-worksheet-improving-local-development-regulations/

- street width and length requirements
- right of way length
- cul-de-sacs
- swales and curbs
- parking lot requirements and design
- open space or cluster subdivisions
- setbacks
- sidewalk requirements and design
- driveway requirements and design
- rooftop runoff
- stream buffers
- clearing and grading
- tree conservation
- stormwater outfalls

This review of municipal regulations revealed some common trends, notably that minimizing impervious surface is not a common consideration during the permitting process of site plans and subdivisions. As well, regulations either do not mention topics that relate to best practices for stormwater runoff, land conservation, and water resource protection, or the regulations go against the criteria used in the COW. Overall, the review of land use regulations revealed that there is ample room for improvement in order to better manage water resources.

A key next step for updating regulations to be more in line with best watershed management practices is to work with planning and zoning board members to review their respective completed COW and discuss what updates the boards would be interested in making. Amendments to zoning that could be considered include protective zoning for the City's reservoir watersheds, increased setbacks from waterbodies (including wetlands), incentives for conservation subdivisions, and other measures to reduce impervious surfaces.

Further Recommendations

Following is a listing (Table 11) of both specific and general recommendations for actions that can be taken to protect and restore the Monhagen Brook Watershed. Some of these actions overlap or are in line with the previous text in this Chapter, while others are additional to those just covered in this Chapter. The recommendations with a star (★) in the Priority Action column are the highest priority recommendations based on consensus of the Advisory Committee and the project team.

Table 11: Additional Recommendations

Number	Recommendation	Strategy	Target Subbasin	Primary Partners	Timing*	Potential Cost**	Priority Action	Additional Goals Addressed
Goal 1: Establish a current and science-based understanding of phosphorus loading in the Watershed, and identify measures for reducing loading.								
1.1	Develop a comprehensive water quality monitoring program in Monhagen Brook.	Design & implement a monitoring program for the Watershed, primarily focusing on phosphorus, but with the potential to add other parameters as needed.	All	SWCD, NYSDEC		$	★	Goal 2
1.2	Continue to research causes of HABs in Monhagen Lake.	Establish comprehensive monitoring program, including collection of phosphorus and chlorophyll-A data.	Monhagen Lake	City of Middletown, NYSDEC		$$		Goal 2
1.3	Develop 9 Element Watershed Management Plan (9E) for the Monhagen Brook.	Building off the Monhagen Brook Watershed Plan, meet remaining 9E criteria by further identifying and quantifying water quality issues, stating goals for improvements, and developing viable strategies and BMPs to address issues and meet goals.	All	OCWA, SWCD, NYSDEC		$	★	Goal 2; Goal 3
1.4	Reduce inflow and infiltration in sewage collection systems, notably the City of Middletown's system.	Continue to identify locations within sewage treatment systems in need of repair and allocate or seek remediation funds.	All	Municipalities	ongoing	$$$	★	Goal 3
Goal 2: Develop a compilation of information about biological and water resources in the Watershed, and identify ways to protect and enhance those resources.								
2.1	Conduct further field study of wetlands in the Watershed.	Field verify wetlands in the Watershed; inventory and describe critical habitats and smaller wetlands (<12.4 acres).	All	Residents; high school and college students, working with faculty	1+	$		Goal 3
2.2	Conduct further field study of biological resources in the Watershed.	Conduct preliminary biodiversity study within the Watershed, possibly using the methodology developed by Hudsonia, Ltd; inventory and describe critical habitats to prioritize for conservation.	All	Residents; high school and college students, working with faculty	1+	$		Goal 4

Table 11: Additional Recommendations

Number	Recommendation	Strategy	Target Subbasin	Primary Partners	Timing*	Potential Cost**	Priority Action	Additional Goals Addressed
2.3	Enhance wildlife habitat in the Watershed.	Pursue selected riparian corridor revegetation projects to improve ecological conditions and connectivity along the Brook.	All	SWCD	1+	$		Goal 3
2.4	Minimize invasive species.	Develop invasive species control and eradication program, focusing on streambanks and corridors. To the extent possible, pursue alternative methods to minimize herbicide use.	All	SWCD	ongoing	$$		Goal 3
Goal 3: Identify potential future projects for stream protection and stormwater management.								
3.1	Pursue stream corridor restoration opportunities.	Develop detailed plans and seek funding for projects on the list of field-vetted high priority restoration sites. Continue identifyng additional high potential sites, based on existing field examination.	All	SWCD, Municipalities	ongoing	$$		Goal 2
3.2	Improve compliance with stormwater construction permit/erosion and sediment control on construction sites.	Mitigate cumulative water quality impacts of siltation and associated pollutants by, 1) ensuring initial plans meet appropriate standards, 2) conducting regular inspections by qualified professionals, 3) ensuring the improvements recommended by inspectors are implemented quickly by site managers.	All	NYSDEC; City of Middletown; Town of Wallkill; Town of Wawayanda	ongoing	$		Goal 5
3.3	Promote improved dumpster and litter management practices and ordinances throughout Watershed, focusing on Dolson Ave. corridor.	Develop public education campaign about pollution impacts of solid waste, along with updating BMPs for businesses and supporting more rigorous enforcement of littering and dumpster laws.	All	SWCD, City of Middletown	1+	$	★	Goal 4

Table 11: Additional Recommendations

Number	Recommendation	Strategy	Target Subbasin	Primary Partners	Timing*	Potential Cost**	Priority Action	Additional Goals Addressed
3.4	Implement Stormwater Retrofits in existing urbanized areas within the Watershed.	Continue aggressive efforts to plan, design, fund, and install retrofit projects on selected sites, prioritizing the Downtown Middletown Green Infrastructure Retofit Plan. A specific goal is to prepare and submit an application to NYS's CFA in the summer of 2019.	Upper Middle and Lower Middle	SWCD, Municipalities	1+	$$$		Goal 5
3.5	Daylight portions of the Monhagen Brook.	Daylight key sections of the Brook and tributaries that flow underground to restore stream corridor. Continue to explore other "naturalization" opportunities for highly altered segments of Brook.	Upper Middle	City of Middletown	6+	$$$		Goal 2; Goal 5
3.6.1	Address flooding of the Monhagen Brook in Middletown.	Develop program to incentivize disconnection of downspouts with Middletown's centralized stormwater system.	Upper Middle	City of Middletown, SWCD	1+	$		Goal 5
3.6.2	Address flooding of the Monhagen Brook in Middletown.	Continue to address inflow and infiltration problems throughout Middletown's sanitary sewer system.	Upper Middle, Lower Middle	City of Middletown	ongoing	$$$		Goal 2; Goal 5
3.7	Develop residential rain garden program.	Develop cost-sharing program to incentivize residents to design, plan, and install rain gardens, directly reducing urban runoff impacts and furthering water resource education and outreach goals throughout the Watershed.	All	SWCD, Municipalities, CCE's Master Gardeners	2-5	$	★	Goal 4; Goal 5
Goal 4: Expose a wide audience to the values of and challenges for the Monhagen Brook.								
4.1.1	Deepen public awareness of natural resources in the Watershed to promote need for conservation.	Include Watershed-specific information into OCWA's Conservation Education curriculum; expand Conservation Education Programming to reach more students.	All	OCWA	1+	$		Goal 5

Table 11: Additional Recommendations

Number	Recommendation	Strategy	Target Subbasin	Primary Partners	Timing*	Potential Cost**	Priority Action	Additional Goals Addressed
4.1.2	Deepen public awareness of natural resources in the Watershed to promote need for conservation.	Continue installation of watershed signage; design and install informational kiosk in public space.	Upper Middle	OCPD, OCLT, Municipalities	1+	$		Goal 2; Goal 5
4.2	Improve public access to natural resources in the Watershed.	Support outside initiatives to improve parks & create interpretive wetland trail.	All	Municipalities	2 - 5	$		Goal 2
4.3	Maintain a web presence where information about the Watershed can be accessed.	Develop interactive map with photos and other data. Continue to hold public events related to the Brook.	All	OCWA	ongoing	$		Goal 5
Goal 5: Educate a variety of stakeholders throughout the Watershed about the principles and purposes for watershed management of the Monhagen Brook.								
5.1	Form committee that will work to implement this Plan, the NYRCR Plan, and the Natural Hazard Mitigation Plan.	Review recommendations and current progress from each plan; collaborate where possible and reconcile important shared goals with comprehensive, watershed-based strategies and ecological design priciples. Seek consensus around priority actions and approach for implementation. Identify and engage additional stakeholders.	All	SWCD, OCPD, Municipalities, planning & engineering consultants	1+	$	★	Goal 1; Goal 3; Goal 4
5.2	Educate land use decision-makers on the importance of water resources.	Host educational sessions and share information via email to board members.	All	OCPD, OCMPF	ongoing	$		Goal 4, Goal 6
Goal 6: Enhance local land use regulations to better protect and restore the Watershed's natural resources.								
6.1.1	Amend municipal codes, where needed, to make them more watershed-friendly.	Work with municipal boards to review the Code and Ordinance Worksheet results and identify priority actions that could be taken.	All	OCPD, Municipalites	ongoing	$		Goal 3; Goal 5
6.1.2	Amend municipal codes, where needed, to make them more watershed-friendly.	Provide model language to municipalities to make the amendment process more stream-lined.	All	OCPD, Municipalites	ongoing	$		Goal 5

Table 11: Additional Recommendations

Number	Recommendation	Strategy	Target Subbasin	Primary Partners	Timing*	Potential Cost**	Priority Action	Additional Goals Addressed
6.2	Enhance local regulations and enforcement in order to improve watershed management.	Work cooperatively with municipal planning and zoning board members to identify areas for improvement in local codes, using the results of the Code and Ordinance Worksheet as a starting point.	All	Municipalities, OCPD	ongoing	$		Goal 3; Goal 4; Goal 5

***Timing:** **1+** = strategy should be implemented in the first year; **2-5** = strategy should be implemented in year 2 to year 5; **6+** = strategy should be implemented in year 6 or afterwards. Years reference the year that this Plan was finalized (2019).

****Potential Cost: $** = under $50K; **$$** = between $50K and $250K; **$$$** = greater than $250K

Acronyms: CCE = Cornell Cooperative Extension; OCLT = Orange County Land Trust; OCMPF = Orange County Municipal Planning Federationl; OCPD = Orange County Planning Department;

Appendices

1. Additional Observations about Soils in the Watershed
2. Phosphorus Reconnaissance in the Monhagen Brook Watershed
3. The Rationale of Biological Monitoring
4. Harmful Algal Bloom Action Plan: Monhagen-Middletown Reservoir System
5. Known Species of Conservation Concern in the Monhagen Brook Watershed, NY
6. Aquatic Connectivity: Identifying Barriers to Organisms & Hazards to Communities
7. Riverkeeper Community Science Program: Monhagen Brook Fecal Contamination Monitoring Results
8. Stream Survey Worksheet
9. Code & Ordinance Worksheet
10. Potential Stormwater Retrofit Project Sites
11. Potential Stream Corridor Restoration Sites
12. Significant Wetlands of the Monhagen Brook Watershed

Appendix 1

Additional Observations about Soils in the Watershed

Additional Observations about Soils in the Watershed

Kevin Sumner, SWCD

The City of Middletown was established and built largely on Mardin soils – the most common soil type in the County. It is a till soil, so it exhibits the marginal drainage and rockiness already noted; however Mardin is on the better end of the spectrum within the range of till soil characteristics. This goes for the Middletown Community Campus (formerly the Middletown Psychiatric Center) as well. Areas of somewhat poorer drainage in the City are typically the Erie or Alden till soil types. As would be expected, mapping units that reflect significant human disturbance of the ground surface are also common in the City and its environs. These include Du-Dumps, Ur-Urban land, and UH-Udorthents, smoothed.

An interesting soils feature in the heart of the City is a 40 acre pocket of organic, or "black dirt," soils showing the Cf mapping unit (Carlisle Muck, ponded). This is the same soil type that is predominant in the County's Pine Island black dirt region. The "ponded" qualifier generally indicates the area was not drained for agricultural production at the time of the fieldwork for the Soil Survey (late 1970's), although historical aerial photography and anecdotal reports suggest that the area was farmed in the past and may have been a "victory garden" at the time of the second World War. The area is now dominated by the non-native, invasive plant phragmites. Much of this area will be visible from the Heritage Trail – a biking/walking path largely on old rail beds that will soon be extended through the City. An intriguing idea would be to renovate this black dirt for community gardens or into a more natural wetland plant community.

Much of the "shallow to bedrock" soils in the Watershed, including the ANC, AND, NaD, RSB, RSD, and RSF mapping units, occur in the western portion, associated with Middletown's hilly reservoir lands as well as the higher elevations around Lake Pocatello and Sayers Hill (south of Lake Pocatello). These higher areas were scraped more aggressively by the glacier and have developed at best a thin mantle of till over the bedrock.

As noted, alluvial soils form in association with stream systems. There are two alluvial soil types found in the Monhagen watershed – Wayland-Wd and Middlebury-My. While there is a fairly extensive network of streams in the watershed, including the main stem of the Monhagen Brook and no less than eight tributaries, the appearance of alluvial soils in these stream corridors is fairly limited. Of the 164 acres of Wd soils, 143 of these occur along the main stem of the Brook in the low-gradient, meandering reach visible from I- 84 just east of NYS Route 6/17M (exit 3). The remaining 90 or so acres of alluvial deposits occur in numerous smaller stream reaches distributed around the Watershed.

For those itching to observe examples of some of these titillating soil features, a good and quite visible cross-section exists around the Middletown schools complex on County Route 78, west of Middletown.

Much of the school complex was extensively disturbed during construction so in an updated soil survey might better fit the Udorthents-UH (man-made cut/fill areas) mapping unit. However, previous to disturbance, the site exhibited a mixture of till, outwash, alluvial, and lake-laid (lacustrine) soils as the areas surrounding the school complex still do. The western end of the site is mapped as the somewhat poorly drained till soil Erie gravelly silt loam-ErA. These areas likely would have met the farmers' categorization of soils that might only be suitable for tillage two days out of the year. The northern end, conversely, is mapped as AdB-Allard silt loam, one of the best agricultural soils in the County. It can be assumed that past dairy/field crop farmers would have reserved this area for their more drainage–sensitive crops, like alfalfa. Its fine-texture and slope combine to create the potential for erosion, so the inclusion of close-growing hay crops like grass and alfalfa would have helped to preserve the soil's natural productivity. Much of the school complex itself, including the Monhagen Middle School (the building closer to County Route 78), no doubt to the delight of the designers and building contractors, sits on the Hoosic mapping unit (HoA,HoB) – "somewhat excessively drained" sand and gravel outwash deposits. They would find no high water table to design around or contend with during construction, and might even find some "aggregate-grade" sand and gravel (gravel pits in Orange County are commonly found within the Hoosic mapping unit). Just south of the school complex extending on both sides of Egerton Road can be found the lake-laid Scio mapping unit (ScB). It is bisected by a tributary of Monhagen Brook originating at an old farm pond near the western limits of the Watershed. This soil type is characterized by silts and very fine sands. It is commonly farmed in the County, and can be quite productive but exhibits variable drainage. The writer has been up to his axles more than once in attempting to traverse this soil by pickup truck at the wrong time.

South of the Scio unit, and extending across the County road at the intersection of the aforementioned tributary and the main stem of the Brook, is an example of the Middlebury alluvial soil (My). While most geological processes occur so slowly that they easily elude our ready understanding, unaltered streams flood onto their floodplain quite frequently in geologic terms (on average twice in three years, according to natural channel design experts). Therefore, we can in some cases observe in the course of human lifetimes alluvial soils forming and see changes to the floodplain through which their nurturing streams flow. One might even come back after a large storm event and find the stream in a different location of the floodplain, accompanied by thick new alluvial deposits on the land surface. Further south from the Middlebury mapping unit, the ground rises noticeably as it transitions from an outwash/alluvial setting to the more common till landscape and the Erie mapping unit already mentioned and occurring on the other side of the tributary stream valley. However, this is the "extremely stony" phase of the mapping unit (ESB) – which may explain why the area is forested and not open/hayland like the area west of the school complex has been in recent years. Further yet south, and also west of the school complex are fairly expansive areas of the Mardin mapping unit (MdB, MdC), already discussed as the predominant soil type in the County and one with, for the most part, manageable limitations for agricultural and urban uses.

Appendix 2

Phosphorus Reconnaissance in the Monhagen Brook Watershed

Phosphorus Reconnaissance in the Monhagen Brook Watershed

Prepared By: Orange County Soil and Water Conservation District (KMS, NM), latest update:9/2017

The Monhagen Brook Watershed is a small (17 SM) watershed in central Orange County, NY. It encompasses almost the entire City of Middletown as well as portions of the Towns of Wallkill and Wawayanda, and exhibits a fairly high percentage of impervious cover (12%), according to the Wallkill River Watershed and Conservation Plan (2007). Some agriculture occurs in the Watershed, but its contribution to water quality issues is unknown.

The NYSDEC PWL classifies the Monhagen Brook as 'phosphorus impaired'. This characterization is based on 'impact source determination' inferences derived primarily from biological investigations. Apart from sporadic 'grab sampling', a planned chemical sampling program designed to reinforce or dispute the 'impaired' categorization and provide more specifics on sources and other aspects of phosphorus presence in the stream has not been undertaken.

In 2016, a watershed planning initiative was begun for the Monhagen. Part of the work plan for this initiative includes an effort to move toward the verification goals described above. The topic is of interest not only for general understanding of water quality conditions of this urban stream and to better design a protection/improvement program, but also for economic and potential regulatory concerns. 'Impaired' classifications may result in the development of Total Maximum Daily Load (TMDL) requirements by NYSDEC, which can be very expensive to meet/implement. Therefore, it becomes even more important to develop/obtain robust water quality data so that resources applied to protection/improvement efforts are appropriately directed and effective.

While the Monhagen planning initiative work plan includes a sampling component, very limited funding is allocated to it, as many other important work tasks are by necessity part of a comprehensive watershed planning initiative and the overall funding for this Plan is quite modest.

This study design is intended to elaborate the Monhagen Brook phosphorus issue to the greatest extent possible within the budgetary and staffing constraints available. Some of the questions for which the study aims to provide direction follow.

1. What are the typical concentrations of phosphorus in both base flow and storm flows in the various tributaries of the Monhagen and moving downstream on the main stem?
2. How do these concentrations relate to flow and loading at the various sampling points?
3. Do actual phosphorus levels support previously conducted impact source determinations and do they warrant/support the Monhagen's 'phosphorus-impaired' status?
4. Do sampling results inform watershed planners about which watershed management measures should be emphasized to more effectively address phosphorus impacts on the Brook?
5. Is phosphorus entering the Brook from any portions of the watershed disproportionately, and how should these findings influence watershed management efforts?

While it is understood that a study employing limited resources will be unlikely to fully answer all these questions, the goal will be to answer them as fully as possible and to facilitate and inform future, more ambitious sampling/monitoring efforts.

Sampling Program Details

Since P concentrations in the context of surface water quality are relevant at levels below the detection limits of most kits or equipment likely to be available to non-professionals, this study intends to contract with the Upstate Freshwater

Institute in Syracuse, NY to provide sample analysis services. After careful research, UFI was determined to have the most ideal sample detection limits for testing Total P. The lab can detect levels well below the threshold for meaningful results. The number of samples to be tested is driven by the Project budget which allocates $1,000 to lab services. At the negotiated fee of $16.50/sample, 50-60 individual tests will be able to be run through the course of the study. The exact details of the lab work may be modified as the study progresses. The costs associated with Project planning, sample collection, delivery to the lab, etc., will be covered by other sources.

This number of individual sample runs will allow for 5 temporally separated collections at 10 strategically chosen sites around the Watershed. Two of the 5 samples will be collected at low/base flow conditions, with the remaining three timed to coincide with elevated stream stage associated with precipitation events. Volunteers will be enlisted to cover each of the ten sampling sites, and will be instructed with regard to proper sample collection and handling procedures. They will be notified when to sample, within a window of 1-2 hours, by the sampling Program Coordinator (PC). Volunteers will be supplied with properly prepared sample bottles in advance by the PC. The samples will then be delivered by the volunteers to the PC, or picked up from the volunteers, and delivered to the lab within the required time frame as instructed by the lab. Attachment A is a map of the Watershed with major tributaries and designated sampling points identified.

Flow Measurements

Concentration data will be made more useful when combined with flow data in order to allow for a snapshot of loading at the time of sample collection. This component of the sampling program will be more useful for rough calculation of loading per time unit for base flow conditions than for storm events since logistics and budget will not allow for sample collections throughout the varying rates of discharge associated with storm events. The PC in cooperation with the sampling volunteers will collect field data at each site including measurement of the physical cross-sectional area of the stream channel and velocity measurements at various stream stages. The development of stage-discharge curves for each site may be attempted. A stage measurement device will be provided at each site to enable the volunteer to record a stage reading at the time of each sample collection. This component of the sampling project will be undertaken as time, expertise and resources allow.

Adjustments During the Study

Depending on the results collected and other findings as the Watershed planning process progresses, sample sites may be adjusted, or additional sample collections added if additional resources can be identified.

Other Water Quality Data

Depending on the expertise and time available from volunteers, as well as the availability of appropriate equipment and supplies, volunteers may collect additional measurements at their respective sampling locations or at additional locations. This may include parameters more reliably measured stream-side – such as dissolved oxygen, conductivity and pH. However, these data will be collected less formally for whatever insight into stream water quality they may provide, with the focus of the study remaining on P.

Use of Study Results

This study is intended primarily to steer and inform future investigations with less limiting budget concerns, and is not being prepared using the rigorous scientific procedures and protocols normally associated with professionally designed water quality sampling efforts. The results are expected to meet the goals as stated herein and to be a reasonable and defensible use of the modest Project funding. However, any distribution of the Project data or summaries/interpretations thereof will be made only with careful qualification.

Appendix 3

The Rationale of Biological Monitoring

THE RATIONALE OF BIOLOGICAL MONITORING

(From NYS DEC report by Bode et. al., Appendix VIII, p. 373.)

Biological monitoring as applied here refers to the use of resident benthic macroinvertebrate communities as indicators of water quality. Macroinvertebrates are larger-than-microscopic invertebrate animals that inhabit aquatic habitats; freshwater forms are primarily aquatic insects, worms, clams, snails, and crustaceans.

Concept

Nearly all streams are inhabited by a community of benthic macroinvertebrates. The species comprising the community each occupy a distinct niche defined and limited by a set of environmental requirements. The composition of the macroinvertebrate community is thus determined by many factors, including habitat, food source, flow 6
regime, temperature, and water quality. The community is presumed to be controlled primarily by water quality if the other factors are determined to be constant or optimal. Community components which can change with water quality include species richness, diversity, balance, abundance, and presence/absence of tolerant or intolerant species. Various indices or metrics are used to measure these community changes.

Assessments of water quality are based on metric values of the community, compared to expected metric values.

Advantages of using macroinvertebrates as water quality indicators:

1. they are sensitive to environmental impacts
2. they are less mobile than fish, and thus cannot avoid discharges
3. they can indicate effects of spills, intermittent discharges, and lapses in treatment
4. they are indicators of overall, integrated water quality, including synergistic effects and substances lower than detectable limits
5. they are abundant in most streams and are relatively easy and inexpensive to sample
6. they are able to detect non-chemical impacts to the habitat, such as siltation or thermal changes
7. they are vital components of the aquatic ecosystem and important as a food source for fish
8. they are more readily perceived by the public as tangible indicators of water quality
9. they can often provide an on-site estimate of water quality
10. they can often be used to identify specific stresses or sources of impairment
11. they can be preserved and archived for decades, allowing for direct comparison of specimens
12. they bioaccumulate many contaminants, so that analysis of their tissues is a good monitor of toxic substances in the aquatic food chain

Limitations

1. Biological monitoring is not intended to replace chemical sampling, toxicity testing, or fish surveys. Each of these measurements provides information not contained in the others.
2. Substances may be present in levels exceeding ambient water quality criteria, yet have no apparent adverse community impact.
3. Macroinvertebrate sampling cannot determine if water is safe for drinking.

Appendix 4

Harmful Algal Bloom Action Plan Monhagen-Middletown Reservoir System

NEW YORK STATE OF OPPORTUNITY | Department of Environmental Conservation | Department of Health | Agriculture and Markets

HARMFUL ALGAL BLOOM ACTION PLAN

MONHAGEN-MIDDLETOWN RESERVOIR SYSTEM

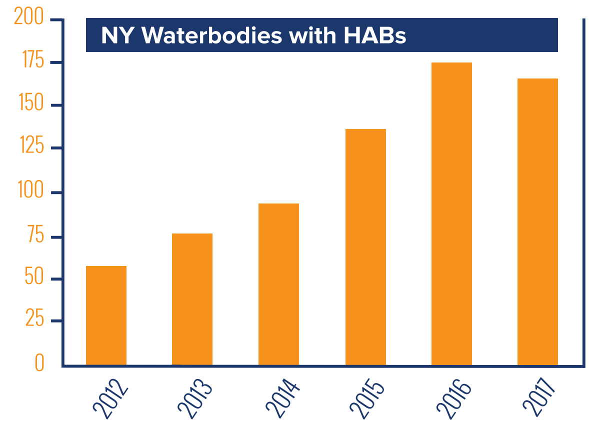
EXECUTIVE SUMMARY

SAFEGUARDING NEW YORK'S WATER

Protecting water quality is essential to healthy, vibrant communities, clean drinking water, and an array of recreational uses that benefit our local and regional economies.

Governor Cuomo recognizes that investments in water quality protection are critical to the future of our communities and the state. Under his direction, New York has launched an aggressive effort to protect state waters, including the landmark $2.5 billion Clean Water Infrastructure Act of 2017, and a first-of-its-kind, comprehensive initiative to reduce the frequency of harmful algal blooms (HABs).

New York recognizes the threat HABs pose to our drinking water, outdoor recreation, fish and animals, and human health. In 2017, more than 100 beaches were closed for at least part of the summer due to HABs, and some lakes that serve as the primary drinking water source for their communities were threatened by HABs for the first time.



GOVERNOR CUOMO'S FOUR-POINT HARMFUL ALGAL BLOOM INITIATIVE

In his 2018 State of the State address, Governor Cuomo announced a $65 million, four-point initiative to aggressively combat HABs in Upstate New York, with the goal to identify contributing factors fueling HABs, and implement innovative strategies to address their causes and protect water quality.

Under this initiative, the Governor's Water Quality Rapid Response Team focused strategic planning efforts on 12 priority lakes across New York that have experienced or are vulnerable to HABs. The team brought together national, state, and local experts to discuss the science of HABs, and held four regional summits that focused on conditions that were potentially affecting the waters and contributing to HABs formation, and immediate and long-range actions to reduce the frequency and /or treat HABs.

Although the 12 selected lakes are unique and represent a wide range of conditions, the goal was to identify factors that lead to HABs in specific water bodies, and apply the information learned to other lakes facing similar threats. The Rapid Response Team, national stakeholders, and local steering committees worked together collaboratively to develop science-driven Action Plans for each of the 12 lakes to reduce the sources of pollution that spark algal blooms. The state will provide nearly $60 million in grant funding to implement the Action Plans, including new monitoring and treatment technologies.

FOUR-POINT INITIATIVE

1 **PRIORITY LAKE IDENTIFICATION**
Identify 12 priority waterbodies that represent a wide range of conditions and vulnerabilities—the lessons learned will be applied to other impacted waterbodies in the future.

2 **REGIONAL SUMMITS**
Convene four Regional Summits to bring together nation-leading experts with Steering Committees of local stakeholders.

3 **ACTION PLAN DEVELOPMENT**
Continue to engage the nation-leading experts and local Steering Committees to complete Action Plans for each priority waterbody, identifying the unique factors fueling HABs—and recommending tailored strategies to reduce blooms.

4 **ACTION PLAN IMPLEMENTATION**
Provide nearly $60 million in grant funding to implement the Action Plans, including new monitoring and treatment technologies.

TO LEARN MORE ABOUT HABs, VISIT: on.ny.gov/hab www.health.ny.gov/HarmfulAlgae

MONHAGEN-MIDDLETOWN RESERVOIR SYSTEM

Orange County

Monhagen-Middletown Reservoir System includes five reservoirs covering 287 acres located in the Towns of Wallkill and Mount Hope, in Orange County. The Monhagen-Middletown Reservoir System is one of the 12 priority waterbodies impacted by HABs. The City of Middletown currently does not permit public access for recreational purposes, but at least one of the reservoirs, Mill Pond, has private landowners adjacent to the reservoir who have recreation access.

The significant sources of phosphorus loading in the reservoir system are:

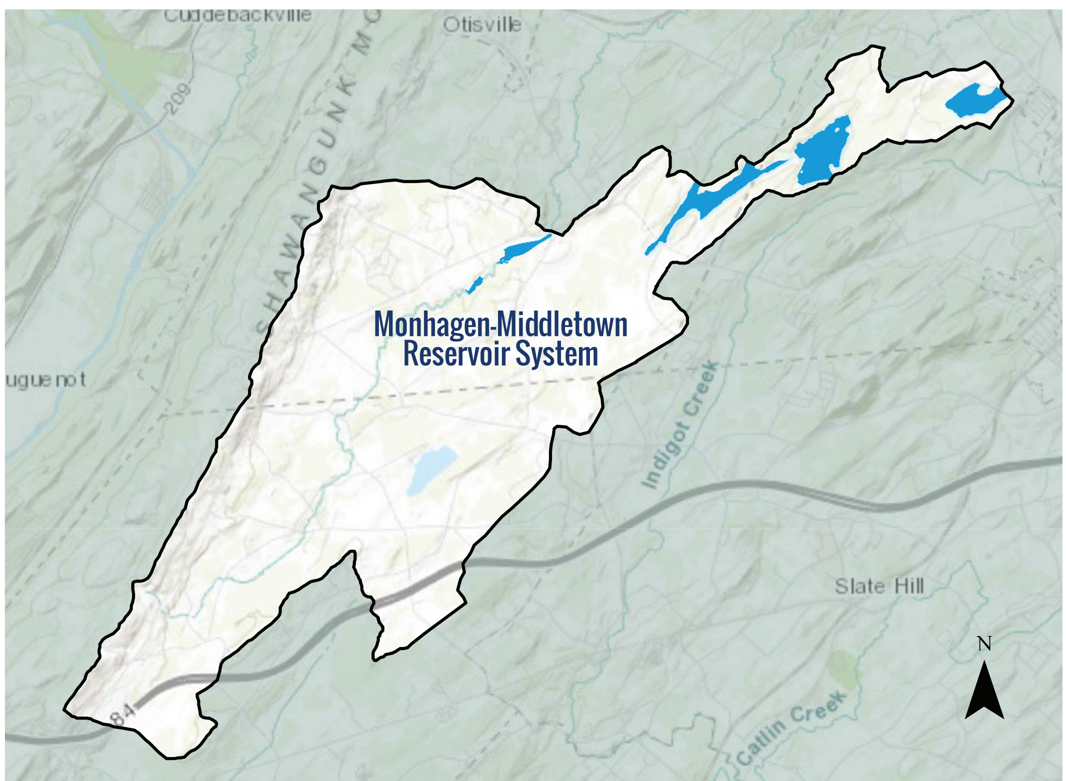
- Phosphorus inputs associated with wastewater treatment plant discharges; and
- Nonpoint sources and nutrient impacts from forested and agricultural runoff.

Monhagen-Middletown Reservoir System reportedly experiences periodic HABs, though HABs-specific data are not available for any of the waterbodies in the Monhagen-Middletown Reservoir System.

Although the causes of HABs vary from lake to lake, phosphorus pollution—from sources such as wastewater treatment plants, septic systems, and fertilizer runoff—is a major contributor. Other factors likely contributing to the uptick in HABs include higher temperatures, increased precipitation, and invasive species.

With input from national and local experts, the Water Quality Rapid Response Team identified a suite of priority actions (see Section 13 of the Action Plan for the complete list) to address HABs in the Monhagen-Middletown Reservoir System, including the following:

- Update land classification for the reservoir system watershed areas;
- Complete a feasibility study and cost estimate to upgrade Hidden Valley Estates wastewater treatment plant (WWTP);
- Research sources of algal blooms and cyanotoxins, conduct thermal and dissolved oxygen profiles to evaluate stratification, and complete a feasibility study to install aeration facilities;
- Purchase land and conservation easements, and enhance riparian buffers; and
- Pursue engineering studies to evaluate the efficacy of additional treatment at public water systems.



The black outline shows the lake's watershed area: all the land area where rain, snowmelt, streams or runoff flow into the lake. Land uses and activities on the land in this area have the potential to impact the lake.

MONHAGEN-MIDDLETOWN RESERVOIR SYSTEM CONTINUED

NEW YORK'S COMMITMENT TO PROTECTING OUR WATERS FROM HABS

New York is committed to addressing threats related to HABs, and will continue to monitor conditions in Monhagen-Middletown Reservoir System while working with researchers, scientists, and others who recognize the urgency of action to protect water quality.

Governor Cuomo is committed to providing nearly $60 million in grants to implement the priority actions included in these Action Plans, including new monitoring and treatment technologies. The New York State Water Quality Rapid Response Team has established a one-stop shop funding portal and stands ready to assist all partners in securing funding and expeditiously implementing priority projects. A description of the various funding streams available and links for applications can be found here: https://on.ny.gov/HABsAction.

This Action Plan is intended to be a 'living document' for Monhagen-Middletown Reservoir System and interested members of the public are encouraged to submit comments and ideas to DOWInformation@dec.ny.gov to assist with HABs prevention and treatment moving forward.

NEW YORK STATE RESOURCES

Drinking Water Monitoring and Technical Assistance:

The state provides ongoing technical assistance for public water suppliers to optimize drinking water treatment when HABs and toxins might affect treated water. The U.S. EPA recommends a 10-day health advisory level of 0.3 micrograms per liter for HAB toxins, called microcystins, in drinking water for young children.

Public Outreach and Education:

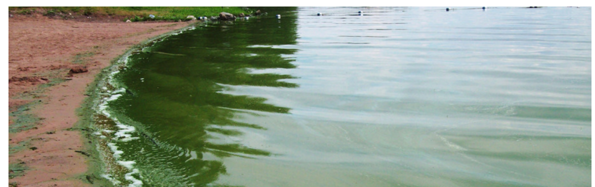
The **Know It, Avoid It, Report It** campaign helps educate New Yorkers about recognizing HABs, taking steps to reduce exposure, and reporting HABs to state and local agencies. The state also requires regulated beaches to close swimming areas when HABs are observed and to test water before reopening.

Research, Surveillance, and Monitoring:

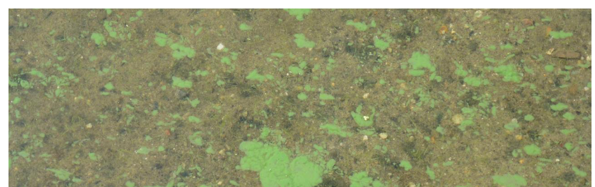
Various state agencies, local authorities and organizations, and academic partners are working together to develop strategies to prevent and mitigate HABs. The state tracks HAB occurrences and illnesses related to exposure.

Water Quality and Pollution Control:

State laws and programs help control pollution and reduce nutrients from entering surface waters. State funding is available for municipalities, soil and water conservation districts, and non-profit organizations to implement projects that reduce nutrient runoff.



Pea soup appearance



Floating dots or clumps

Spilled paint appearance

Streaks on the water's surface

CONTACT WITH HABs CAN CAUSE HEALTH EFFECTS

Exposure to HABs can cause diarrhea, nausea, or vomiting; skin, eye or throat irritation; and allergic reactions or breathing difficulties.

Appendix 5

Known Species of Conservation Concern in the Monhagen Brook Watershed, NY

Known Species of Conservation Concern in the Monhagen Brook Watershed, NY

The following table lists species of conservation concern that have been observed in the Monhagen Brook Watershed. The information comes from the New York Natural Heritage Program (NYNHP) biodiversity databases, the 2000-2005 New York State Breeding Bird Atlas (NYBBA), the 1990-1999 New York Amphibian and Reptile Atlas (NYARA). The table only includes species listed in New York as endangered or threatened (at the state (NY) and/or federal (US) level), special concern, rare, Species of Greatest Conservation Need (SGCN), or a Hudson River Valley Priority Bird species recognized by Audubon New York. Primary habitat types are provided for each species, but for conservation and planning purposes, it's important to recognize that many species utilize more than one kind of habitat. More information on rare animals, plants, and ecological communities can be found at http://guides.nynhp.org. **Note:** Additional rare species and significant habitats may occur in the Monhagen Brook Watershed.

			NY Conservation Status					
Common Name	**Scientific Name**	**General Habitat**	Endangered	Threatened	NY Special Concern	NY Species of Greatest Conservation Need xx = high priority	Hudson River Valley Priority Bird	**Data Source**
Mammals								
Indiana Bat	*Myotis sodalis*	forest, caves	US, NY			xx		NYNHP

Birds								
American Goldfinch	*Spinus tristis*	young forest, shrubland					x	NYBBA
American Kestrel[1]	*Falco sparverius*	grassland				x	x	NYBBA
American Redstart	*Setophaga ruticilla*	forest					x	NYBBA
American Woodcock	*Scolopax minor*	young forest, shrubland				x	x	NYBBA
Baltimore Oriole	*Icterus galbula*	forest					x	NYBBA
Belted Kingfisher	*Megaceryle alcyon*	open water					x	NYBBA
Black-and-white Warbler[1]	*Mniotilta varia*	forest					x	NYBBA
Black-billed Cuckoo[1]	*Coccyzus erythropthalmus*	young forest, shrubland				x	x	NYBBA
Blue-Winged Warbler[1]	*Vermivora pinus*	young forest, shrubland				x	x	NYBBA
Bobolink[1]	*Dolichonyx oryzivorus*	grassland				xx	x	NYBBA
Broad-winged Hawk	*Buteo platypterus*	forest					x	NYBBA

			NY Conservation Status					
Common Name	**Scientific Name**	**General Habitat**	Endangered	Threatened	NY Special Concern	NY Species of Greatest Conservation Need xx = high priority	Hudson River Valley Priority Bird	**Data Source**
Brown Thrasher	*Toxostoma rufum*	young forest, shrubland				xx	x	NYBBA
Chestnut-sided Warbler	*Setophaga pensylvanica*	young forest, shrubland					x	NYBBA
Chimney Swift	*Chaetura pelagica*	urban					x	NYBBA
Cooper's Hawk	*Accipiter cooperii*	forest			x		x	NYBBA
Downy Woodpecker	*Picoides pubescens*	forest					x	NYBBA
Eastern Kingbird	*Tyrannus tyrannus*	young forest, shrubland					x	NYBBA
Eastern Meadowlark	*Sturnella magna*	grassland				xx	x	NYBBA
Eastern Towhee	*Pipilo erythrophthalmus*	young forest, shrubland					x	NYBBA
Eastern Wood-Pewee	*Contopus virens*	forest					x	NYBBA
Field Sparrow	*Spizella pusilla*	young forest, shrubland					x	NYBBA
Northern Flicker	*Colaptes auratus*	forest					x	NYBBA
Rose-breasted Grosbeak	*Pheucticus ludovicianus*	forest					x	NYBBA
Ruffed Grouse[1]	*Bonasa umbellus*	young forest, shrubland				x	x	NYBBA
Savannah Sparrow[1]	*Passerculus sandwichensis*	grassland					x	NYBBA
Scarlet Tanager	*Piranga olivacea*	forest				x	x	NYBBA
Sharp-shinned Hawk[1]	*Accipter striatus*	forest			x	x	x	NYBBA
Veery	*Catharus fuscescens*	forest					x	NYBBA
Willow Flycatcher	*Empidonax trailli*	young forest, shrubland					x	NYBBA
Wood Thrush	*Hylocichla mustelina*	forest				x	x	NYBBA

Known Species of Conservation Concern in the Monhagen Brook Watershed, NY

Common Name	Scientific Name	General Habitat	NY Conservation Status: Endangered	Threatened	NY Special Concern	NY Species of Greatest Conservation Need xx = high priority	Hudson River Valley Priority Bird	Data Source
Yellow-billed Cuckoo[1]	*Coccyzus americanus*	young forest, shrubland					x	NYBBA
Yellow-throated Vireo	*Vireo flavifrons*	forest					x	NYBBA
[1] Records from NYBBA Block 5458C, 34% located within the Monhagen Brook Watershed. Remaining records are from block 5458A, 97% located within the watershed.								

Reptiles								
Common Snapping Turtle	*Chelydra s. serpentina*	wetlands				x		NYARA
Eastern Box Turtle	*Terrapene c. carolina*	forest			x	xx		NYARA
Northern Copperhead	*Agkistrodon contortrix mokasen*	forest, rocky areas, wetlands				x		NYARA
Wood Turtle	*Glyptemys insculpta*	stream			x	xx		NYARA

This document was created by the New York State Department of Environmental Conservation's Hudson River Estuary Program and Cornell University's Department of Natural Resources with funding from the NYS Environmental Protection Fund.

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Appendix 6

Aquatic Connectivity:

Identifying Barriers to Organisms and Hazards to Communities

AQUATIC CONNECTIVITY

Identifying Barriers to Organisms and Hazards to Communities

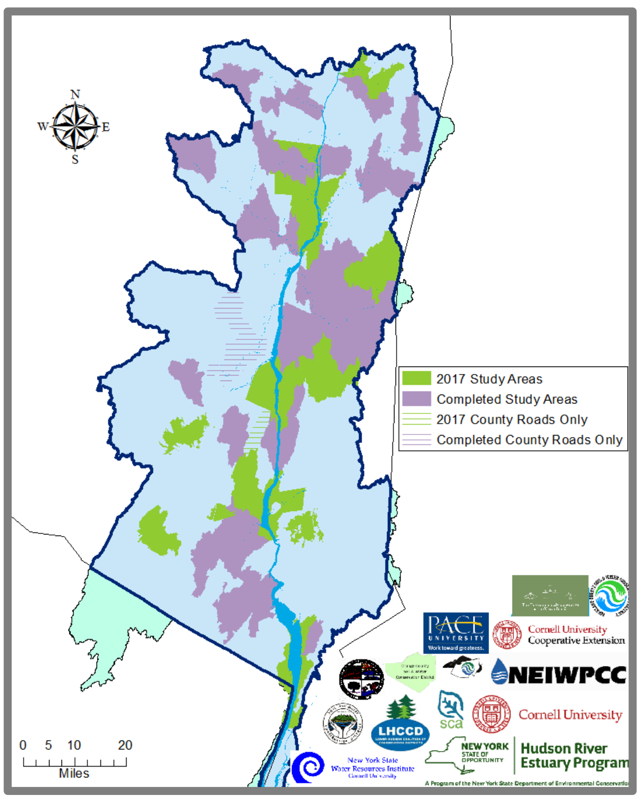
Problem Road Culverts

Poorly designed and undersized culverts are barriers to aquatic organisms and hazards to communities during storms. Streams are linear habitats for aquatic and semi-aquatic species such as American eel, herring, stream salamanders, turtles and crayfish. Road crossings can fragment streams into small pieces, preventing organisms from accessing critical habitats.

Culverts also may be infrastructure liabilities and flooding hazards for communities. During storms, undersized or improperly installed culverts can become clogged with debris or overwhelmed, leading to road flooding, stream bank erosion, or even washout of the whole road.

Culverts such as this one constrict the natural flow of the stream, have a perched outlet that only strong swimmers can jump and contain no natural streambed. Many culverts and dams fragment stream habitats.

Municipalities can receive help prioritizing culverts that could be upgraded, benefitting aquatic organisms and communities' bottom lines.



Culvert assessments have been conducted in thirty-one subwatersheds, with twenty more underway.

Studies have found that about two-thirds of crossings are not fully passable to aquatic organisms. The NYSDEC Hudson River Estuary Program, other NYSDEC branches, Soil and Water Conservation Districts, and interested county and local partners are working to reconnect tributaries within the Estuary watershed by surveying and prioritizing impassable and undersized culverts. Road crossings with unnatural stream bottoms, a perched outlet where a culvert adds an unnatural step to the stream, or other conditions are often barriers to organisms that need to go up and down streams.

Cornell University hydrologists model each crossing for the maximum storm interval (return period) the crossing could pass without spilling over the road. Undersized culverts are more likely to flood the road and washout during large storms. Emergency replacement of failed culverts costs more money and disrupts essential services such as hospital access during flood events. **This project connects interested communities with funding sources to replace impassable, undersized culverts with fully passable, properly sized culverts.**

Empowering Communities

After the assessment work, communities have data on each crossing's passability and capacity scoring information. This data is also available on the Cornell WRI Aquatic Connectivity Map and the North Atlantic Aquatic Connectivity Collaborative database. Estuary Program staff are available for technical assistance and presentations to help communities use the information.

To help communities reconnect their streams and proactively remove flooding hazards, Estuary Program grants can fund these planning and mitigation steps.

Scenic Hudson Land Trust received a grant to improve the aquatic organism passability and reduce the flooding hazard of this vital piece of infrastructure.

1.) **Assess Culverts and Bridges** for aquatic organism passability and storm capacity by partner organizations or Estuary Program staff.
2.) **Prioritize Problem Culverts** within a management plan. After the crossings have been assessed and modeled, municipalities can rank crossings by passability, capacity and local needs. This document can be added to a Natural Resource Inventory or Hazard Mitigation Plan.
3.) **Design Replacements** through conceptual or shovel-ready engineering plans. This process also addresses relevant permits required for a construction mitigation project.
4.) **Fix Problem Culverts** by upgrading infrastructure to be fully passable to organisms and reduce flooding hazards.

Removing harmful and unnecessary stream barriers will benefit our resident and migratory fish, as well as all the other organisms that use our streams. New York has seen a dramatic increase in the amount of rain falling during large storms, and climate change projections suggest that will continue. Planning for fully passable crossings for organisms also means planning for structures capable of handling more frequent and intense storm events. This project gives communities a clear understanding of where problem stream barriers are, and provides funding to fix them.

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KEY POINTS

Partners have assessed over 6,600 crossings

- 20% of these are substantial barriers to aquatic organisms
- 71% of crossings are undersized
- Problems are more pronounced for locally owned roads

Appendix 7

Riverkeeper Community Science Program: Monhagen Brook Fecal Contamination Monitoring Results

RIVERKEEPER COMMUNITY SCIENCE PROGRAM: MONHAGEN BROOK FECAL CONTAMINATION MONITORING RESULTS

INTRODUCTION

In 2016, Riverkeeper and community partners, including members of the Wallkill River Watershed Alliance, tested the Monhagen Brook for the bacterial indicators of fecal contamination *Enterococcus* (Entero) and *Escherichia coli*. This sampling was part of a two-year Riverkeeper study designed to identify sources of fecal contamination to the Wallkill River, where results of Entero monitoring by Riverkeeper and community partners since 2012 have documented chronic, severe, and widespread fecal contamination.[1] The source tracking project was funded by a grant from the Hudson River Estuary Program of the New York State Department of Environmental Conservation (NYS DEC).

BACKGROUND

Entero and *E. coli* are bacteria that live in the digestive systems of humans and other animals. Although some strains of Entero and *E. coli* can make people sick, the types present in the environment usually do not cause illness. However, they indicate the likely presence of untreated waste, and therefore an increased chance that pathogens may be present. Entero and *E. coli* are recommended by the Environmental Protection Agency (EPA) to evaluate water quality for recreational use.

Riverkeeper assesses water quality using the EPA's science-based 2012 Recreational Water Quality Criteria[2], which recommends thresholds of Entero and *E. coli* per 100 ml of water, consistent with use of the waterbody for "primary contact recreation." This includes swimming, bathing, child water play, and other activities where ingestion of water or full immersion of the body is likely. NYS DEC currently uses total and fecal coliform standards to regulate recreational water quality, but is in the process of updating its standards to reflect the EPA's 2012 guidance.

EPA recommends three different ways of using these Entero and *E. coli* to assess recreational water quality. These are summarized in Table 1.

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[1] www.riverkeeper.org/water-quality/citizen-data/wallkill-river

[2] https://www.epa.gov/wqc/2012-recreational-water-quality-criteria

TABLE 1: EPA RECREATIONAL WATER QUALITY CRITERIA FOR *ENTEROCOCCUS* AND *E. COLI*

Criterion	Threshold	
	Enterococcus	***E. coli***
Beach Action Value (BAV) If a single sample tests above this level, the EPA recommends public notification, and recommends against swimming.	60 Entero/100 mL	190 E. coli/100 mL
Geometric Mean (GM) A geometric mean (a type of weighted average) above this value indicates that chronic contamination is present and that the water is unsuitable for swimming.	30 Entero / 100 mL	100 E. coli / 100 mL
Statistical Threshold Value (STV) If more than 10% of samples exceed this value, it indicates that occasional contamination spikes are occurring and that the water is unsuitable for swimming.	110 Entero / 100 mL	320 E. coli / 100 mL

Sources of fecal contamination may include sewage infrastructure failures, sewer overflows, inadequate sewage treatment, septic system failures, agricultural runoff, urban runoff, and wildlife. The fecal-indicator bacteria reported here do not differentiate among sources, but other methods can do so.

METHODS

Samples were collected weekly during August 2016 at McVeigh Road in the Town of Wawayanda. This site was selected because the objective of the sampling was to characterize inputs from various tributary watersheds to the Wallkill River's main stem, and this is an accessible location close to the Monhagen Brook's confluence with the Wallkill River. Samples were also collected from 12 other Wallkill River tributaries on the same dates.

Samples were collected and processed by volunteer community scientists who were trained by Riverkeeper staff. Bacterial counts were determined using the IDEXX Enterolert and Colilert systems, which are EPA-approved methods for enumerating these bacteria in surface water samples.[3]

Fecal contamination varies from place to place and over time, so the sampling results from this location are not indicative of conditions elsewhere in the Monhagen Brook watershed, or to predict future conditions at any time and place. Entero and *E. coli* are indicative of water quality for recreation. These results should not be used to determine water quality with respect to fish and other aquatic life, or the presence of other types of pollution (e.g., nutrients, sediment, toxic chemicals).

[3] https://www.idexx.com/corporate/products-and-services/products-and-services.html

RESULTS

A total of 5 samples were analyzed. Results are shown in Table 2. Of the 5 samples, 4 exceeded the BAV for both Entero and *E. coli*, and one did not exceed the BAV for either indicator. All samples that exceeded the BAV also exceeded the STV, for both indicators. The geometric means of all samples taken were 533.4 cells/100 mL for Entero and 695.4 cells/100 mL for *E. coli*. These results indicate that fecal contamination is present at this site, and that it is frequent and severe.

TABLE 2: ENTEROCOCCUS AND E. COLI RESULTS OF ALL MONHAGEN BROOK SAMPLES, AUGUST 2016

Sampling Date	Entero Count (cells/100 mL)	*E. coli* Count (cells/100 mL)	Cumulative Rainfall 4 days prior to sampling (inches)
August 1	>2420*	>2420*	3.05
August 8	120	350	0.00
August 15	355	426	0.95
August 22	10462	8664	0.83
August 29	40	52	0.00

*2,420 cells/100 mL is the limit of detection for undiluted samples. After August 1, all samples were diluted tenfold. *Enterococcus* and *E. coli* counts shown here have been adjusted for dilution.

WET WEATHER AND WATER QUALITY

In combined sewer systems, heavy rains trigger releases of untreated sewage directly into waterways. Even in systems where stormwater and wastewater are separated by design, leaks and cross-connections allow stormwater infiltration into the wastewater system. The increased flows may cause infrastructure failures during storms. Stormwater runoff from streets, feedlots and farms, and areas with failed septic systems can also deliver fecal contamination to streams.

Riverkeeper defines wet weather as 0.25 or more inches of cumulative precipitation on the day of sampling and three days prior. Three of our 2016 Monhagen Brook samples were collected during wet weather (August 1, August 15, August 22), and 2 were collected during dry weather (August 8, August 29).

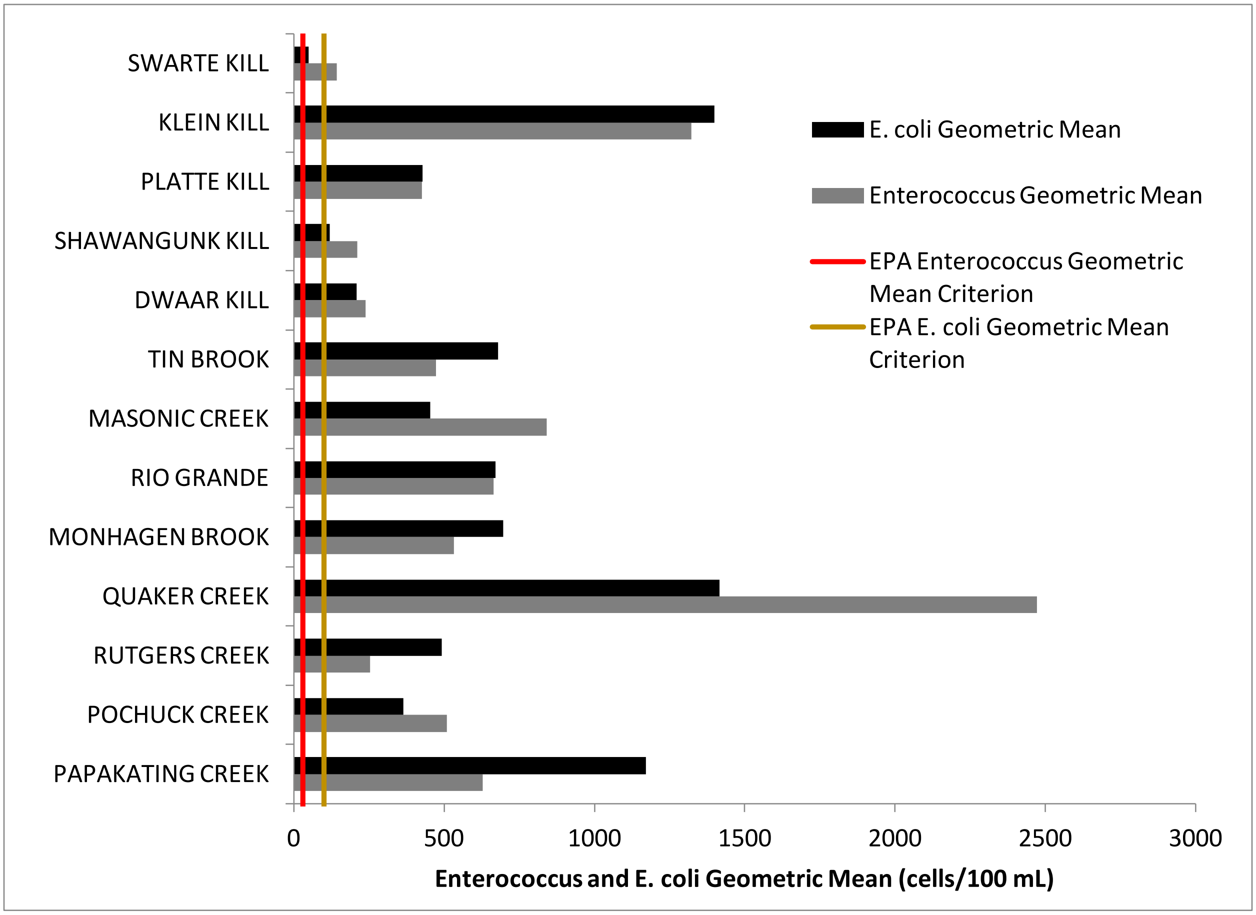
All 3 wet-weather samples exceeded the BAV and STV for both fecal-indicator bacteria. The highest Entero and *E. coli* counts observed during the project were in wet weather samples. One dry-weather sample exceeded the BAV and STV for both fecal-indicator bacteria, and the other dry-weather sample fell below the BAV and STV for both fecal-indicator bacteria. Geometric means were not calculated for wet and dry samples separately because of the small number of samples.

These results show that wet weather increases fecal contamination at this location and that dry-weather contamination occurs sometimes. Additional sampling would help determine how frequently dry-weather contamination exists.

COMPARISON WITH OTHER WALLKILL RIVER TRIBUTARIES

In addition to the Monhagen Brook, 12 other Wallkill River tributaries were sampled in August 2016. Results are shown in Figure 1. All watersheds sampled exceeded the geomean criterion for one or both fecal-indicator bacteria. Of the 13 tributaries studied, the Monhagen Brook had the sixth-worst Entero geometric mean and the fifth-worst *E. coli* geometric mean, showing that the Monhagen Brook is an important contributor to fecal contamination in the Wallkill River, and a high priority area for eliminating fecal pollution in the watershed.

FIGURE 1: ENTEROCOCCUS AND E. COLI GEOMETRIC MEANS OF ALL SAMPLES FROM 13 WALLKILL RIVER TRIBUTARIES, AUGUST 2016



CONCLUSIONS AND NEXT STEPS

The results summarized above provide information about the conditions at McVeigh Rd and the Monhagen Brook's impact on the Wallkill River. A site survey or stream walk, and additional sampling, are needed to determine the source(s) of contamination at McVeigh Rd. The NYS Department of Environmental Conservation is developing a draft pathogen source tracking protocol that, when published, could be put to use here. Additional sampling, at other sites and over a longer time period, would be needed to determine the range of conditions present throughout the Monhagen Brook watershed, the conditions people are likely to encounter when they enter the water elsewhere, and how weather affects water quality in this stream. Given separate sewer overflow events documented by the Sewage Pollution Right to Know Law, and the presence of nearly 200 stormwater outfalls in the City of Middletown, illicit discharge detection and elimination, and projects to reduce and eliminate inflow and infiltration are likely to be high priorities. The new draft MS4 General Permit includes provisions for annual outfall monitoring in priority waterways, and both Monhegan Brook and Wallkill River should be designated as priority waterways, based in part on data presented here and available at Riverkeeper.org.

EPA's recreational water quality criteria include three different measures to assess the severity, frequency and duration of contamination. The 2016 sampling results exceeded all three EPA thresholds. In 4 of 5 samples, the water quality at McVeigh Rd was unsuitable for swimming, water play, and other primary contact activities at the time of sampling, according to both bacterial indicators measured. The geometric means of bacterial counts exceeded EPA thresholds by factors of approximately 7 (E. coli) and 18 (Entero). And 80% of samples exceeded the STV, compared to the threshold value of 10%.

Based on these results and the conditions that we have observed throughout the Wallkill watershed, Riverkeeper recommends that further fecal indicator testing be done in the Monhagen Brook watershed, and that source tracking to follow up on results be prioritized. The data can be used to help determine whether portions of the creek are safe for primary contact, and to define specific projects that would improve water quality.

In 2017 Riverkeeper will complete the second year of this source tracking study, with a focus on DNA-based testing for indicators of human, cattle, horse and Canada goose fecal contamination. No sampling is planned in the Monhagen Brook in 2017. However, results of both sampling years will be included in an update to the Wallkill River Watershed Management Plan focused on fecal contamination, and study conclusions may be broadly applicable to the Monhagen Brook.

Appendix 8

Stream Survey Worksheet

Edward A. Diana
County Executive

STREAM SURVEY WORKSHEET

Completely read the Stream Survey Guidelines prior to starting your stream walk. Begin your walk at the outlet of the stream segment and walk upstream. Collect information from the stream segment, as well as its perennial tributaries. Answer the questions based on your observations at the time of the survey. Any relevant information from previous knowledge should be recorded in section IV.3 Other comments/concerns.

Stream Name: ____________________ Segment: from ____________________ to ____________________

Name: ____________________ Phone: ____________________

Date: ____________________ Time: ____________________

Weather Conditions: ____________________ Temperature Air: ________ °F Water: ________ °F

Weather Conditions, past 48 hours: ____________________

General Characteristics

I.1 Describe the location and context of the stream. Indicate start, finish, landmarks, significant features and/or roadways that would help locate your segment:

____

____

____

____

____

____

I.2 Measure the depth and the width of the stream, at a minimum of four locations.

Stream Location	Stream Depth (in feet)	Stream Width (in feet)
Location 1	____________________	____________________
Location 2	____________________	____________________
Location 3	____________________	____________________
Location 4	____________________	____________________
	Total: ________ /4 = ________ Average	Total: ________ /4 = ________ Average

I.3 Tally Vehicle Crossings and Type over the course of the survey:

____

____

I.4 Describe the existing land uses and/or cover types surrounding your segment, rate as a percentage:

________________ High Density Residential ________________ Industrial

________________ Medium Density Residential ________________ Commercial

________________ Low Density Residential ________________ Agriculture

________________ Schools ________________ Forest

________________ Recreational ________________ Roadways

If commercial and/or industrial, describe type: ____

____

____

I.5 Are there visible human activities taking place along the segment; as evidenced by litter, bike & hiking trails, roads, camping areas, etc.:

If yes, briefly describe activities: ____

____

If yes, is the area public or privately owned: ____

____

Detailed Characteristics and Scoring

Walk the entire stream corridor and make notes on the following characteristics. Utilize the descriptions and charts under section II Detailed Characteristics and Scoring outlined in the Stream Survey Guidelines. Each characteristic can be rated with a value of one (1) through ten (10). Rate only those elements appropriate to the stream segment you are assessing i.e. riffle, embeddedness, and canopy cover may not apply to all segments. Additionally, a characteristic may not be easily determined; in this case the characteristic should not be ranked but notations of the characteristic should be made and a rank of N/A applied. If you are unsure or if the stream condition is between two rating scores for a given parameter, please assign the lowest score that applies.

II.1 Channel Condition: __________________ Notes: ____

____

____

II.2 Riparian Zone: ____________________ % canopy cover over stream:______________ Notes: ____________________

____

____

II.3 Stormwater retrofit need and potential:______ Notes, including potential solutions to the issue:___________________

____

____

II.4 Bank Stability: ______________________ Notes: ____

____

____

II.5 Water Appearance: ___________________ Notes:
____

____

____

II.6 Channel Embeddednes:________________ Notes:____

____

____

II.7 Riffles and Pools:___________________ Notes:____

____

____

II.8 Invasive species ____

____

____

II.9 Barriers to Fish Movement: (List any & photograph):

____

____

____

Stream Project Opportunities

- ☐ Stormwater retrofit
- ☐ Habitat conservation
- ☐ Riparian protection
- ☐ Stormwater Enhancement
- ☐ Habitat enhancement
- ☐ Riparian corridor enhancement
- ☐ Bank stabilization
- ☐ Trees for Tributaries
- ☐ Riparian corridor restoration
- ☐ Passive recreation
- ☐ Active recreation
- ☐ Other: ________________________

Describe how the above may improve the stream Segment:____

____

____

Additional Information

IV.1 Did you walk this whole section of the stream? ☐ Yes ☐ No

If no, briefly explain why: ____

____

____

IV.2 Other comments/concerns/remediation suggestions:____

____

____

____

____

____

Outfall Pipe 1: (Photo #__ and mark on map) GPS Coordinates____________________N
Diameter:___________in ____________________W
Headwall? YES NO Double culvert? YES NO Streambank at outfall eroded? YES NO
Pipe Material: concrete steel PVC Clay Other
Location of Pipe: in stream, at top of bank, in bank, out of/ under bridge, other__________________
Channel downstream eroded? YES NO
Pipe gathers water from (road, yard, farm, etc.):____
Flow appearance: clear turbid oily foamy colored other________ Flow is: none, intermittent, steady

Outfall Pipe 2: (Photo # __and mark on map) GPS Coordinates____________________N
Diameter:___________in ____________________W
Headwall? YES NO Double culvert? YES NO Streambank at outfall eroded? YES NO
Pipe Material: concrete steel PVC Clay Other
Location of Pipe: in stream, at top of bank, in bank, out of/ under bridge, other__________________
Channel downstream eroded? YES NO
Pipe gathers water from (road, yard, farm, etc.):____
Flow appearance: clear turbid oily foamy colored other________ Flow is: none, intermittent, steady

Drainage Ditch: (Photograph #__ and mark on map) GPS Coordinates _________________N
Width of ditch________ft _________________W
Begins at: ________________________ Ditch lining: stone, vegetation, concrete, mud, other________
Ditch is: Stable, Eroding Ditch Flow is: none, intermittent, steady
Stream channel downstream is: stable, eroded, silted Flow is: clear, cloudy, oily, foamy, colored
Ditch comes from:

Drainage Ditch: (Photograph #__ and mark on map) GPS Coordinates __________________N
Width of ditch________ft __________________W
Begins at: __________________ Ditch lining: stone, vegetation, concrete, mud, other____________
Ditch is: Stable, Eroding Ditch Flow is: none, intermittent, steady

Stream channel downstream is: stable, eroded, silted Flow is: clear, cloudy, oily, foamy, colored
Ditch comes from:

Describe stream's connectivity to floodprone areas:____

____

____

____

____

____

____

____

Appendix 9

Code & Ordinance Worksheet

Code and Ordinance Worksheet

As referenced in Chapter 3, the Orange County Planning Department performed an audit of municipal regulations based on the Center for Watershed Protection's Code and Ordinance Worksheet (2016) during this planning project. The full COW and a scoring spreadsheet can be found at: https://www.cwp.org/updated-code-ordinance-worksheet-improving-local-development-regulations/

Below are the questions along with the points associated with each answer. The maximum number of points is 100; the higher the score, the more watershed-friendly the municipality's regulations.

Questions
Street Width
Is the minimum pavement width allowed for streets in low density residential developments that have less than 500 daily trips (ADT) between 18-22 feet? *Yes = 4 points*
Street Length
Do street standards promote the most efficient street layouts that reduce overall street length? *Yes = 1 point*
Right-of-Way Width
Is the minimum right of way (ROW) width for a residential street less than 45 feet? *Yes = 3 points*
Does the code allow utilities to be placed under the paved section of the ROW? *Yes = 1 point*
Cul-de-Sacs
What is the minimum radius allowed for cul-de-sacs? *If answer < 35 feet = 3 points / If answer is more than 36 feet = 1 pt*
Can a landscaped island be created within the cul-de-sac? *Yes = 1 point*
Are alternative turnarounds such as "hammerheads" allowed on short streets in low density residential developments? *Yes = 1 point*
Vegetated Open Channels
Are curb and gutters required for most residential street sections? *No = 2 points*
Are there established design criteria for swales that can provide stormwater quality treatment (i.e., dry swales, biofilters, or grass swales)? *Yes = 2 pts*
Parking Ratios
Is the minimum parking ratio for a professional office building (per 1000 ft2 of gross floor area) < 3 spaces? *Yes = 1 point*
Is the minimum required prking ratio for shopping centers (per 1000 ft2 gross floor area) ≤ 4.5 spaces? *Yes = 1 point*
Is the minimum required parking ratio for single family homes (per home) ≤ 2 spaces? *Yes = 1 point*

Are your parking requirements set as maximum or median (rather than minimum) requirements? *Yes = 2 points*
Parking Codes
Is the use of shared parking arrangements promoted? *Yes = 1 point*
Are model shared parking agreements provided? *Yes = 1 point*
Are parking ratios reduced if shared parking arrangements are in place? *Yes = 1 point*
If mass transit is provided nearby, is the parking ratio reduced? *Yes = 1 point*
Parking Lots
Is the minimum stall width for a standard parking space 9 ft or less? *Yes = 1 point*
Is the minimum stall length for a standard parking space 18 feet for less? *Yes = 1 pt*
Are at least 30% of the spaces at larger commercial parking lots required to have smaller dimensions for compact cars? *Yes = 1 point*
Can pervious materials be used for spillover parking areas? *Yes = 2 points*
Structured Parking
Are there any incentives for developers to provide parking within garages rather than surface parking lots? *Yes = 1 point*
Parking Lot Runoff
Is a minimum percentage of a parking lot required to be landscaped? *Yes = 2 points*
Is the use of bioretention islands and other stormwater practices within landscaped areas or setbacks allowed? *Yes = 2 points*
Open Space Design
Are open space or cluster development designs allowed in the community? *Yes = 3 points / No = skip to next section*
Is land conservation or impervious cover reduction a major goal or objective of the open space design ordinance? *Yes = 1 pt*
Are submittal or review requirements for open space design greater than those for conventional development? *No = 1 point*
Is open space or cluster design a by-right form of development? *Yes = 1 point*
Are flexible site design criteria available for developers that utilize open space or cluster design options (e.g., setbacks, road widths, lot sizes)? *Yes = 2 points*
Setbacks and Frontages
Are irregular lot shapes (e.g. pie-shaped, flag lots) allowed in the community? *Yes = 1 point*
What is the minimum requirement for front setbacks for a one half (1/2) acre residential lot? *If answer ≤ 20 ft = 1 point*
What is the minimum requirement for rear setbacks for a one half (1/2) acre residential lot? *If answer ≤ 25 ft = 1 point*
What is the minimum requirement for side setbacks for a one half (1/2) acre residential lot? *If answer ≤ 8 ft = 1 point*

What is the minimum frontage distance for a one half (1/2) acre residential lot? *If answer < 80 ft = 2 points*
Sidewalks
Is the minimum sidewalk width allowed in the community ≤ 4 ft? *Yes = 2 points*
Can alternate pedestrian networks be substituted for sidewalks (e.g. trails through common areas)? *Yes = 1 point*
Are sidewalks always required on both sides of residential streets? *No = 2 points*
Are sidewalks generally sloped so they drain to the front yard rather than the street? *Yes = 1 point*
Driveways
Are minimum driveway widths 9 feet or less (one lane) or 18 feet or less (two lanes)? *Yes = 2 points*
Can pervious materials be used for single family home driveways (e.g. grass, grave, porous pavers, etc.)? *Yes = 2 points*
Can a "two track" design be used at single family driveways? *Yes = 1 point*
Are shared driveways permitted in residential developments? *Yes = 1 point*
Open Space Management (Skip to next section if open space, cluster, or conservation developments are not allowed in your community)
Are open space areas required to be consolidated into larger units? *Yes = 1 point*
Can open space be managed by a third party using land trusts or conservation easements? *Yes = 1 point*
Does the community have enforceable requirements to establish associations that can effectively manage open space? *Yes = 2 pts*
Does a minimum percentage of open space have to managed in a natural condition? *Yes = 1 point*
Are allowable and unallowable uses for open space in residential developments defined? *Yes = 1 point*
Rooftop Runoff
Can rooftop runoff be discharged to yard areas? *Yes = 2 points*
Do current grading or drainage requirements allow for temporary ponding of stormwater on front yards or rooftops? *Yes = 2 points*
Buffer Systems
Is there a stream buffer ordinance in the community? *Yes = 2 points*
If so, is the minimum buffer width 75 ft or more? *Yes = 1 point*
Is expansion of the buffer to include freshwater wetlands, steep slopes or the 100-year floodplain required? *Yes = 1 point*
Buffer Maintenance (If you do not have stream buffer requirements in your community, skip to next section)
Does the stream buffer ordinance specify that at least part of the stream buffer be maintained with native vegitation? *Yes = 2 points*

Does the stream buffer ordinance outline allowable uses? *Yes = 1 point*
Does the ordinance specify enforcement and education mechanisms? *Yes = 1 point*
Clearing and Grading
Is there any ordinance that requires or encourages the preservation of natural vegetation at residential development sites? *Yes = 2 points*
Do reserve septic field areas need to be cleared of trees at the time of development? *No = 1 point*
Tree Conservation
If forests or specimen trees are present at residential development sites, does some of the stand have to be preserved? *Yes = 2 points*
Are the limits of disturbance shown on construction plans adequate for preventing clearing of natural vegetative cover during construction? *Yes = 1 point*
Conservation incentives
Are there any incentives to developers or landowners to conserve non-regulated land (open space design, density bonuses, stormwater credits or lower property tax rates)? *Yes = 2 points*
Is flexibility to meet land conservation restrictions (e.g. density compensation, buffer averaging, transferable development rights, off-site mitigation) offered to developers? *Yes = 2 points*
Stormwater Outfalls
Is stormwater required to be treated for quality before it is discharged? *Yes = 2 points*
Does a floodplain ordinance that restricts or prohibits development within the 100-year floodplain exist? *Yes = 2 points*
Are there effective design criteria for stormwater best management practices (BMPs)? *Yes = 1 point*
Can stormwater be directly discharged into a jurisdictional wetland without pretreatment? *No = 1 point*

Appendix 10

Potential Stormwater Retrofit Project Sites

Potential Storm Water Retrofit Project Sites
Monhagen Brook Watershed
2018

Site #	Site Name	Location/Address	Municipality	S-B-L	Latitude	Longitude	Ownership	Feasibility (1 = High, 5 = Low)	Has there been any outreach to owner/ operator?	Riparian/ Streambank Restoration Opportunity?	Comments
1	Campbell Plaza	125 Dolson Avenue, Middletown, NY 10940	Middletown	48-2-7.2, 48-2-1.1	41.42962	-74.423429	private	3	No	Potentially	A small bioretention basin was installed behind the Plaza next to Monhagen Brook in 2016. Approximately 100 feet of eroding stream bank was also repaired. More options exist for small retrofits that would not require major re-configuration of the parking lot, for example where parking lot drainage concentrates to one point before shedding directly to the Brook. A large scale re-design of the parking lot would provide more significant benefits. This site is decribed more fully in the narrative of the Monhagen Watershed Plan.
2	Playtogs Plaza	128 Dolson Avenue, Middletown, NY 10940	Middletown	48-1-1.2, additional adjacent parcels	41.43033	-74.426204	private	5	No	No	This large 28 acre shopping complex off Dolson Ave includes numerous businesses. Limited areas exist for retrofits that would not require loss of existing parking stalls or drive areas. A large scale modern GI re-design could be considered with owner interest. This site is decribed more fully in the narrative of the Monhagen Watershed Plan.
3	Middletown Post Office Employee Lot	40 Fulton Street, Middletown, NY 10940	Middletown	40-10-1	41.44222	-74.422196	federal government	2	No	No	Employee parking lot drains to catch basin in the corner of the lot, then to Monhagen Brook. Drainage could be re-routed to a lawn area downslope from the parking lot for stormwater treatment. This site is discussed in the Monhagen Brook Watershed Plan as an example of a site with features that would facilitate a retrofit.
4	Middletown Post Office Customer Lot	40 Fulton Street, Middletown, NY 10940	Middletown	40-10-1	41.44271	-74.422971	federal government	3	No	No	There is a lawn area downslope of the parking lot, but the parking lot is sloped to internal catch basins so the site is not ideally suited to a retrofit.
5	Dollar General Parking Lot	65 Dolson Avenue	Middletown	45-4-10	41.43385	-74.421328	private	1	No	No	Entire parking lot drains towards Monhagen Brook. A wooded area between the parking lot and the Brook buffers the Brook, but more formal treatment measures would improve performance.
7	Genung St. Used Car Lot	50 1/2-64 Genung Street	Middletown	41-1-12	41.43757	-74.418362	private	3	No	yes	An existing asphalt parking lot extends to top of stream bank along the border of much of this site. An effective retrofit would likely require giving up a strip of asphalt. It might be feasible to install a curb or other measure to divert parking lot runoff along top of bank to a point where it can be dispersed/filtered, which would limit loss of usable area.
9	Downtown Middletown Parking Lots	James St., Orchard St.	Middletown	31-9-1 and adjacent parcels, 31-6-29 and adjacent parcels	41.44642	-74.42075	City	1	Yes	No	Conceptual plans for a re-design of James Street and a new GI parking lot design for Orchard Street were prepared by Lehman and Getz Engineering in cooperation with OCSWCD and the City in 2016. Two CFA funding proposals were unsuccessful. The City has expressed willingness to pursue these projects as part of the $10M economic development award they received in 2016. As of 1/2019, final designs were nearing completion.

Potential Storm Water Retrofit Project Sites
Monhagen Brook Watershed
2018

Site #	Site Name	Location/Address	Municipality	S-B-L	Latitude	Longitude	Ownership	Feasibility (1 = High, 5 = Low)	Has there been any outreach to owner/ operator?	Riparian/ Streambank Restoration Opportunity?	Comments
10	SUNY Orange Campus	South Street, Wawayanda Avenue	Middletown	39-1-1.2 and adjacent parcels	41.26347	-74.2561	County	2	Yes	Potentially	A small bioretention basin was installed here in 2011 near the library and Morrison Hall. Rain Gardens were provided for roof runoff treatment when the new kindercollege was constructed. Other potential sites have been ID'd by OCSWCD in consultation with SUNY Sustainability Committee. Students from Spring/2018 Environmental Conservation class inventoried the campus for an updated list of potential project sites.
11	County Office Building	18-38 Seward Avenue	Middletown	21-2-13.2	41.45437	-74.43793	County	2	Yes	No	Three stormwater retrofits have been installed here since 2010 - 2 bioretention basins and 1 stormwater planter. More could be added. An additional filtering practice site was studied off the north end of the building. Utilities and disturbed soils should be expected. Given the County ownership of the property, the location of the Orange County Cornell Cooperative Extension offices here and their sponsorship of an annual series of stormwater management workshops, this could be considered an ideal stormwater management demonstration area.
12	Downtown Middletown Park	along Union Street between West Main and James.	Middletown	31-12-12.122	41.26819	-74.25307	City	2	yes	No	This area is planned to become a park/greenspace that will include a farmers market. The Heritage Trail biking/walking path will pass along the edge of the park. Several GI measures could be incorporated into the greenspace of the park, including 1) collection and treatment of the runoff from planned small parking lot at the west end of the parcel, and 2) treatment of runoff from existing impervious surface adjacent to the park parcel (where it can feasibly be routed). This an ideal site for GI practices that include interpretive/educational signage.
13	Downtown Middletown - Senior Center	southeast of Mill St., southwest of West Main	Middletown	35-1-3	41.2672	-74.25402	City	2	Yes	no	A large area of impervious surfaces, including the Senior Center lot, the adjacent funeral home and church, drains to an existing catch basin in the southwest corner of the lot (next to 35-1-8.2). The catch basin undoubtedly connects with the Monhagen Brook under Fulton Street some 500 feet away. A practice in this location would be expected to have a high cost-benefit ratio. The site would be much more feasible if a small portion of 35-1-8.2 could be utilized (through agreement, lot line change or other means), but a smaller practice may still be feasible without the adjacent privately-owned parcel.
14	Downtown Middletown - City Hall/police/bank	Henry Street	Middletown	31-11-7, 31-11-3, 31-11-2,31-11-1	41.26762	-74.25317	City and private	2	yes	No	Bank parking lot and City/police parking lot connect. Bank has agreed to be part of a retrofit.

Potential Storm Water Retrofit Project Sites
Monhagen Brook Watershed
2018

Site #	Site Name	Location/Address	Municipality	S-B-L	Latitude	Longitude	Ownership	Feasibility (1 = High, 5 = Low)	Has there been any outreach to owner/ operator?	Riparian/ Streambank Restoration Opportunity?	Comments
15	Downtown Middletown - municipal lot surrounding Equilibrium Brewery	Henry Street	Middletown	31-12-13.11	41.26798	-74.25312	City	2	yes	No	Some of this municipal parking lot drains to Site 12, so some treatment could be done on that site. Much of the lot drains to internal catch basins.
16	Downtown Middletown - Festival Square	West Main Street	Middletown	31-10-17.2	41.26716	-74.25742	City	2	yes	No	The City holds music and other events here. It is a small site, but ideal for GI practices that include interpretive/educational signage. There are internal storm drain inlets that may be able to be re-configured to include some measure of SW treatment. There are pavers that could be replaced with permeable pavers.
17	Downtown Middletown - Holy Dog and adjacent lot	between Mulberry and Canal, at north end near West Main	Middletown	35-2-1, 35-2-4	41.26699	-74.25319	City	2	yes	No	Not an expansive impervious area to be captured, but there is some room to work

Notes

1. Communication with and support from site owners and other involved stakeholders would be a necessary prerequisite to progressing any of these potential projects beyond this listing. Downtown Middletown Site #9 is currently in the design phase. Sites 13 through 17 have been endorsed by the City for further study. Other sites listed are for example only and no support or endorsement by site owners or managers is implied.
2. Cost estimates are not included due to the preliminary status of planning and investigation that has been performed for most of the sites.
3. This should not be considered a comprehensive list of storm water retrofit sites in the Watershed. It is presented in effort to describe a range of sites that hold potential for such measures, and to demonstrate that there are myriad opportunities to retrofit storm water management improvements into existing urbanized areas if resources are available to do so.
4. Feasibility rankings are qualitative, and are based on such factors as site size, complexity of anticipated construction and status of discussion and/or buy-in with site owners or managers.

Appendix 11

Potential Stream Corridor Restoration Sites

Potential Stream Corridor Restoration Sites
Monhagen Brook Watershed
2019

Site #	Site Name	Location/Address	S-B-L	Latitude	Longitude	Ownership	Suggested Practice	Feasibility (1 = High, 5 = Low)	Stormwater?	Invasive Species?	L-less complex, M-More complex	Comments
1	Riparian buffer downstream of Ingrassia Rd.	36 Ingrassia Road, Middletown, NY 10940	49-1-23.2 (Wallkill)	41.462724	-74.44199	private	Riparian buffer	1	Potentially		L	Plant a riparian buffer along both sides of the stream, stream is small but so is potential buffer area. Landowners may not want to give up much yard. There may be potential to treat stormwater from restaurant parking lot near north bank of stream.
2	Riparian buffer upstream of Ashley Ave.	Dorthea Dix and Ashley Ave.	21-2-31 (Middletown)	41.454386	-74.443615	private (Fei Tian College)	Riparian buffer	1			L	Plant a riparian area with native woody vegetation. Attempts in 2018 to contact landowner to discuss possible projects were unsuccessful.
3	Community Campus streambanks	Dorthea Dix and Ashley Ave.	21-2-7.2 (Middletown)	41.452694	-74.444086	NYS	Streambank restoration, riparian buffer	2			M	A portion of the banks are currently lined with concrete and area has little riparian buffer. Small stream in this section could make it a relatively easy project. A riparian planting project done here several years ago has had generally poor results, including being mowed by NYS maintenance staff, but some trees survived on the east side of the Brook.
4	Co. Rt. 78 Meadow	corner of Egerton and County Route 78	21-2-31 (Middletown)	41.448811	-74.445258	private (Fei Tian College)	Riparian buffer	1			L	Monhagen Brook flows through a large meadow East of County Rt. 78. Ample room exists here for a riparian buffer restoration/planting. Attempts in 2018 to contact landowner to discuss possible projects were unsuccessful. This site is identified in Middletown's NY Rising plan as a possible multi-function restoration site. A project here would augment and complement an exisitng riparian buffer planting project on a tributary of the Brook southwest of this site on the other side of County Route 78.
5	Riparian area at W. Main St. bridge	244-246 West Main St	28-6-1.2 (Middletown)	41.446582	-74.437793	private	Riparian buffer	2		Japanese Knotweed	L	In 2018, a small Japenese Knotweed control and riparian planting project was completed just north of the West Main Street bridge. Area downstream of W. Main St. bridge would benefit from a larger riparian buffer and Japanese Knotweed removal. A municipal project undertaken here, largely completed in 2018, hardened much of the banks - limiting the feasibility of pursuing natural corridor and bank treatment methods.
6	Streambanks behind W. Main residential area	51 California Ave.	28-7-29 and adjacent parcels (Middletown)	41.446439	-74.435393	Private, multiple	Streambank, floodplain restoration	3			M	Streambanks are concrete walls, stream is disconnected from floodplain. Room likely exists to improve area. Multiple landowners involved could be challenging. A municipal project undertaken here, largely completed in 2018, hardened much of the banks - limiting the feasibility of pursuing natural corridor and bank treatment methods.
7	Avery Rose Properties	88 Monhagen Ave.	30-1-2.22 (Middletown)	41.447773	-74.430602	private	Streambank restoration, riparian buffer	3	Potentially		M	A short 200ft section of Monhagen Brook is not buried here. If adjacent property owner/business on south side of the stream was willing to sacrifice some room a streambank/riparian restoration could be done here. A stormwater retrofit could potentially be incorporated.
8	Erosion downstream of Genung St.	48 Genung Street Rear	41-1-13 (Middletown)	41.436676	-74.41906	private (O&R)	Streambank restoration	2			M	Erosion exists downstream of Genung St. Access to area may be hard as the area is pretty well wooded.
9	Campbell Plaza	125 Dolson Avenue	48-2-7.2, 48-2-1.1 (Middletown)	41.42962	-74.423429	private	Streambank restoration, riparian buffer	3	yes	yes	M	The Plaza borders 1700 feet of Monhagen Brook. Opportunities for stormwater retrofits at this site are discussed in the Watershed Plan and on the Stormwater Retrofit Opportunities List. There is little room for a substantive buffer on the Plaza side, but improvements could be made by stabilizing steep and eroding banks, removing invasive vegetation and re-planting with appropriate native vegetation, and adding stormwater management and narrow buffers where feasible. Removal of some asphalt would almost certainly be necessary, so genuine interest from site owners/managers would be imperative. The opposite side of the Brook is owned by the City of Middletown. Ideally, work would be done on both sides of the Brook.
10	Riparian buffer and erosion behind Johnson's Subaru	Dolsontown Road	4-1-50.2 (Wawayanda)	41.423992	-74.42502	private	Streambank restoration, riparian buffer	2		Japanese Knotweed, Potentially Phragmites	M	Small area on both sides of the stream that could benefit from invasives removal and replanting with a riparian buffer.
11	Shell Station streambank erosion	249 Dolson Ave.	4-1-34.1 (Wawayanda)	41.42296	-74.427755	private	Streambank stabilization	4			M	High bank with no room between eroding bank and gas station parking lot. Parking lot fence has already been moved back once. This site is a significant contributor to sediment loading in the Brook.
12	Car Wash	1002 Dolsontown Road	4-1-50.3 (Wawayanda)	41.25342	-74.25655	private	Streambank stabilization, riparian buffer	3			L	Streamside vegetation was removed when site work was done for the car wash. The reason for its removal is unclear and may be related to visibility for business purposes, but removal to the degree that occurred appears to have been excessive. Re-planting with appropriate vegetation that is acceptable to the owner would help protect the Brook. Using public resources to replace the vegetation that was removed might not be appropriate.

Potential Stream Corridor Restoration Sites
Monhagen Brook Watershed
2019

Site #	Site Name	Location/Address	S-B-L	Latitude	Longitude	Ownership	Suggested Practice	Feasibility (1 = High, 5 = Low)	Stormwater?	Invasive Species?	L-less complex, M-More complex	Comments
13	Riparian area along Sunrise Park Rd.	Sunrise Park Road	4-1-36.21 (Wawayanda)	41.419992	-74.424942	private	Riparian buffer	2		Japanese Knotweed	L	Small area adjacent to Sunrise Park Rd. that could benefit from invasives removal (Japanese Knotweed) and replanting with a riparian buffer.
14	Erosion and riparian area between Sunrise Park Rd. to McVeigh Rd.	Dolsontown Road	6-1-3.32 (Wawayanda)	41.420298	-74.414617	private	Streambank stabilization, riparian buffer	3		Japanese Knotweed	M	Area where Monhagen turns away from Sunrise Park Rd. and flows through a series of meadows towards McVeigh Rd. Area is low gradient and stream meanders back and forth a lot. Banks are eroding in multiple areas, mostly where woody vegetation is not present. Some sections may be active hayland. Area also includes powerline right of way, bank stabilization may be a priority but plantings may need to be modified for those areas. A small tributary comes in from the North in this section that could also be addressed, at least upstream to Dolsontown Rd. The meander pattern and stream bank erosion in this area may be to some degree natural as a result of the geomorphology, but sediment loading to the Brook nevertheless results.
15	Riparian area downstream of McVeigh Rd.	208 McVeigh Road	1-1-51.22 (Wawayanda)	41.423072	-74.405455	private (O&R)	Riparian buffer	2			M	Meandering area downstream of McVeigh Rd. Segment of stream lacks a woody riparian buffer and could potentially benefit from the addition of one. Largest challenge is that most of the area is within powerline right of way for adjacent transformer station.
16	Erosion upstream of McManus Rd.	232 McManus Road	1-1-23 (Wawayanda)	41.425186	-74.385902	private	Streambank stabilization, riparian buffer	3			M	A 400 to 500 ft. reach upstream of McManus Rd. includes sections of erosion on both sides of the stream. Streamside homeowner may be interested if erosion is threatening home.
17	Golf Links Rd. erosion	County Route 50	1-1-67.1 (Wawayanda)	41.422906	-74.380018	Private	Streambank stabilization, riparian buffer	2			L	Erosion is occuring downstream of Golf Links Rd. Area is a farm field with plenty of room to work.
18	Riparian area downstream of Golf Links Rd.	County Route 50	1-1-67.1 (Wawayanda)	41.422019	-74.378654	private	Riparian buffer	1			L	Downstream of Golf Links rd. and the powerline Right-of-way is a section of stream that could benefit from an enhanced riparian buffer.

1. Communication with and support from site owners and other involved stakeholders would be a necessary prerequisite to progressing any of thes potential projects beyond this listing. Sites listed here are for example only and no support from or endorsement by site owners or managers is implied.
2. Cost estimates are not included due to the preliminary status of planning and investigation that has been undertaken. Costs for riparian plantings that do not involve grading or other work requiring heavy equipment are expected to be very modest, especially if Trees for Tribs assitance for planting materials can be accessed.
3. This should not be considered a comprehensive list of stream corridor restoration sites in the Watershed. It is presented in effort to describe and identify a range of sites that hold potential for such measures, and to demonstrate that there are myriad opportunities to make improvements to the stream corridors in the Watershed if resources and commitment are available to do so.
4. Feasibility and complexity ratings are qualitative and based on experience and judgment of technicians evaluating the sites.

Appendix 12

Significant Wetlands of the Monhagen Brook Watershed

Significant Wetlands of the Monhagen Brook Watershed

Kevin Sumner, District Manager, SWCD

Notes About This Section:

- Designations are from the New York State Freshwater Wetlands (NYSFWW) mapping, which will be referred to here as the "Official Map," or from the more recent wetland "Additions" mapping described in the *Wetlands* section in Chapter 2 of this Plan.
- "MD" refers to the *Middletown Quadrangle* – a mapping convention used by the US Geological Survey (USGS) and also on the NYSFWW maps.
- Wetland Classes are from the NYSFWW and are intended to rank wetlands by benefit and value, with 1 being the highest and 4 the lowest. See: http://www.dec.ny.gov/gis/erm/wetlands.html for more on wetland classes and NYSDEC's Freshwater Wetlands Program.
- In addition to providing a brief description of the individually designated wetlands, observations are made in regards to the relationship between NYSFWW, the National Wetland Inventory (NWI), and soil characteristics as described in the Orange County Published Soil Survey (Soil Survey).
- Only wetlands identified on the Official Map or the Additions Map are described here. This should not be interpreted to suggest that smaller wetlands lack importance.
- Due to difficulty in obtaining a version of the Additions mapping compatible with Geographic Information System (GIS) software, it is only presented on a Middletown Quadrangle map of NYSFWW mapping and is not reflected on the map showing NYSFWW, NWI, and hydric soils in the Monhagen Watershed.
- This section is not a technical document, but rather an attempt to informally characterize the larger mapped wetlands in the Monhagen Brook Watershed. This section and any accompanying maps should not be used for land use planning or for determining areas that may be regulated by federal, state, or local agencies. It is presented purely for informational purposes.

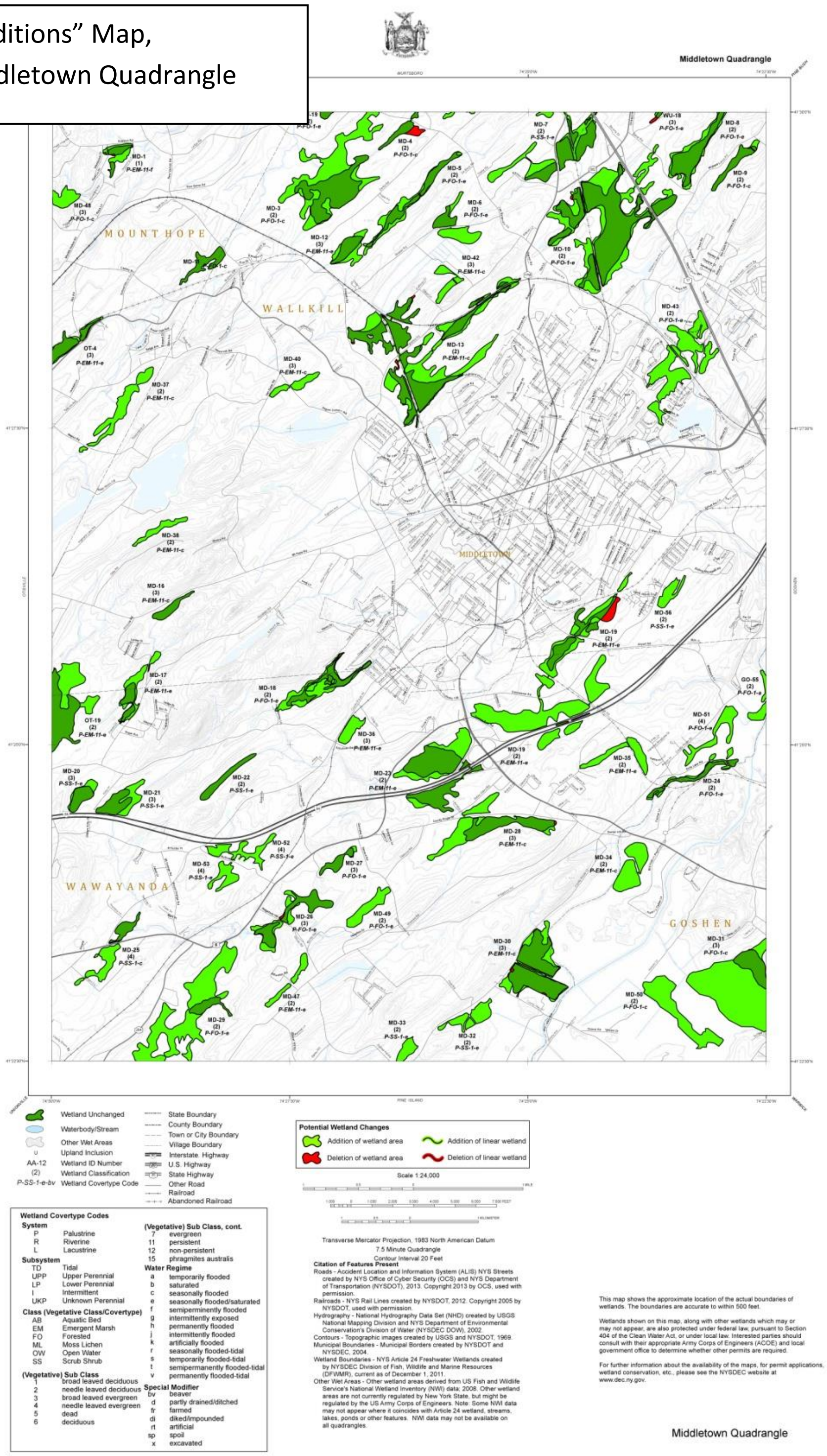
MD-36

This wetland at the corner of Wawayanda Avenue and Kirbytown Road encompasses about 17 acres – above the 12.4-acre size normally required for designation on NYSFWW mapping. This area does not show up on the Official Map; however it is included on the Additions Map, where it is designated as a Class 3 wetland.

MD-36 viewed from Wawayanda Avenue

There are two primary underlying soil types, Carlisle muck, ponded (Cf), and Scarboro mucky sandy loam (Sb). These are both hydric soils; therefore the Soil Survey predicts the occurrence of wetlands in this location. The NWI mapping also predicts their occurrence, though the NWI boundaries extend well into adjacent upland areas including well-to-excessively drained Hoosic soils (HoB, HoC), reinforcing the caution which should be applied in interpreting the accuracy of the NWI mapping.

“Additions” Map, Middletown Quadrangle



Carlisle is the same soil type found extensively in the Pine Island black dirt farming region of Orange County. Although difficult to imagine from current conditions, the area was probably farmed in the past. Aerial photography from as recently as 1994 appears to show a system of drainage ditches running from the southeastern edge of the wetland towards a stream/main ditch that flows in a southwesterly direction parallel to Wawayanda Avenue and a Railroad grade. This drainage passes under Kirbytown Road just east of Wawayanda Avenue, then travels in an easterly direction before entering a major tributary of the Monhagen Brook near the CPV facility off Rte. 6. This tributary joins the main stem of the Brook near the Rte. 17M/I-84 intersection southeast of the City of

Middletown.

There are several open water areas within this wetland complex. The dominant plant species appears to be Cattails (Typhus sp.), though other native plant species occur. Some small tree and woody shrubs occur as well. Overall, the wetland appears to reflect some modest diversity without an inordinate amount of invasive non-native plants.

MD-13

This wetland complex occurs in the northern limits of the Watershed and includes over 140 acres as shown on the Official Map. Interestingly, it encompasses some significant upland areas identified in the Soil Survey as Mardin – a generally well-drained soil type. MD-13 is a Class 2 wetland. On the Additions Map, the limits of this complex were expanded significantly, mostly to the northeast.

A nature trail originating within the City of Middletown's Fancher-Davidge Park affords an engaging view of the southern end of this wetland, including some expansive open water areas. This portion of the wetland is mapped in the Soil Survey as Histic Humaquepts (HH) – one of the few technical soil names in the Survey. The HH mapping unit is commonly called "freshwater marsh," and represents what is likely the more common public perception of what a wetland "should" look like. A lesson for those not familiar with the breadth of conditions that can result in an area being mapped as wetlands is that open water and Cattails are not a prerequisite. Areas without standing water, or even on a slope, can still meet wetland criteria. Outside the open water area at the southern end, most of this complex is wooded wetland. The complex is divided by several roads and the future Heritage Trail railroad grade.

The main stem of the Monhagen Brook touches the southern end of MD-13, about 4,000 feet downstream from Monhagen Lake, and just upstream of where the Brook passes under Rte. 211.

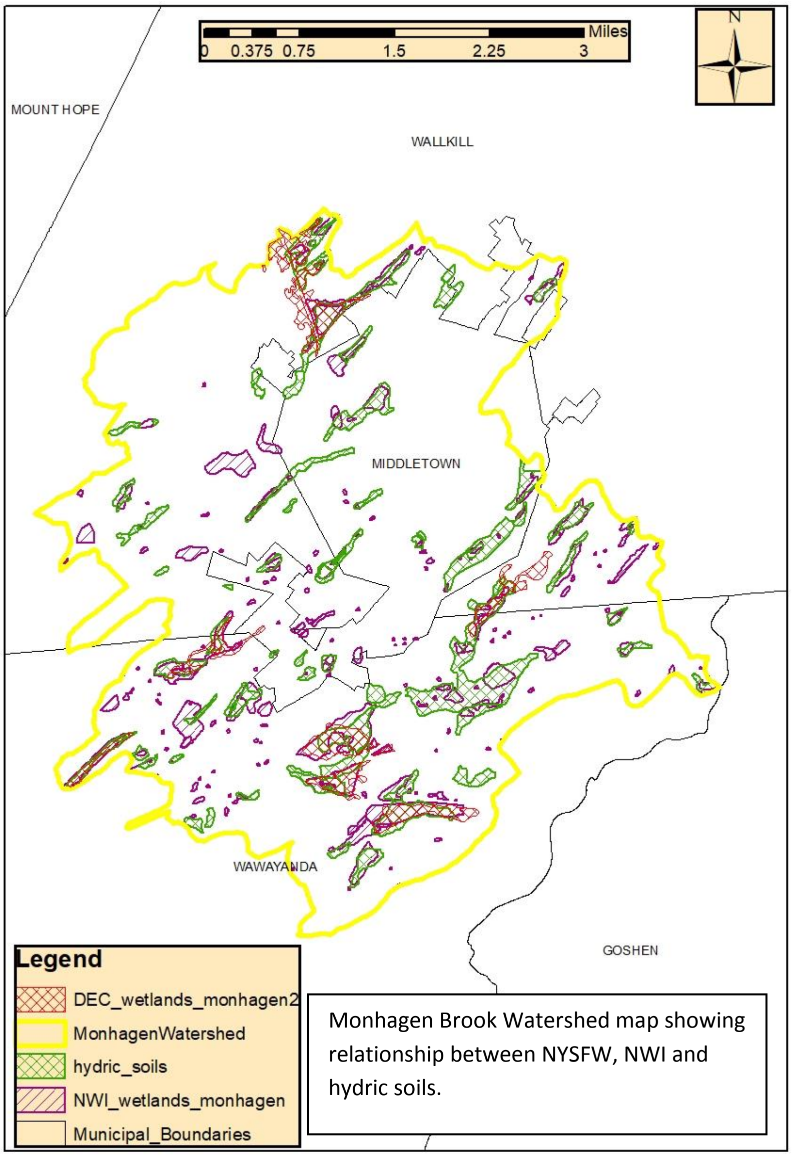
MD-40

This relatively small area does not show up on the Official Map but was added on the Additions Map as a Class 3 wetland. It occurs very close to the divide in the northeastern corner of the Watershed. It appears to correspond approximately with an area of Erie (potentially hydric) and Alden (hydric) soils. The wetland is part of a former dairy farm, portions of which are still harvested for hay at the time of this writing. The farmed condition of the land may have been the reason it was not included on the Official Map. Some portions of MD-40 on the west side of Pilgrim Corners Road are well on their successional way to woods, but most of the wetland is dominated by wet-tolerant herbaceous cover with just sporadic woody vegetation. There is a significant stand of purple loostrife (a common invasive species in the region) established amongst other herbaceous vegetation on the west side of Pilgrims Corners Road. This wetland likely provides cover and other habitat requirements that, in combination with the nearby annually mowed hayfields, elevates the value of the area for wildlife.

Monhagen Lake, Middletown's primary reservoir, is only about 1400 feet to the south. This area does not show up on the NWI maps.

MD-18

This Class 2 wetland occurs in a valley between two “mountains” – such that they are in the moderate topography of Orange County – in the southwestern portion of the Watershed. Like most of the wetlands on the Additions Map, it gained considerable areal extent as compared to the 30 acres depicted on the Official Map. As is also typical, the area displays a rough, somewhat confusing correlation between hydric soils, NWI wetlands, and NYSFWW mapping.



Monhagen Brook Watershed map showing relationship between NYSFW, NWI and hydric soils.

Most of this wetland is wooded. A stream that runs through the center of the valley and the wetland originates 1800 feet to the west at two small ponds just north of Kirbytown Road.

The upper, or western, portion is mapped as Palms muck, with 16 to 50 inches of organic deposits reflecting the watery environment in which this soil formed. The lower, or eastern, portion is primarily the Alden and Erie till soils. At the far eastern end, the wetland pinches down to a skinny corridor associated with the stream before ending as the stream enters the residential neighborhood of Middletown know as Amchir.

MD-23

One of the largest in the Watershed at 100 acres, this Class 2 wetland complex occurs on both sides of I-84, including inside the 3E exit ramps for Rte. 6/17M in the southern portion of the Watershed. The CPV Power Plant facility extends well into the portion of this wetland on the north side of I-84 (to be referred to as 23N) based on review of published digital data and aerial imagery. While an area some 3 acres in size identified as well drained Hoosic soils in the Soil Survey occurs within the limits of 23N, this is not the area encroached upon by the CPV complex. The soils encroached upon include the Ra and RbA mapping units (both hydric).

The eastern portion of 23N is mostly wooded, while the western portion is covered by CPV infrastructure or displays herbaceous ground cover. Up until the CPV facility was built, much of this area was in agricultural use. It had been partially drained by open ditches, and is dominated by cool season grasses that are typical in low management haylands in the northeastern US, especially reed canary grass (Phalaris arundinacea), which is considered to be invasive in NY and elsewhere. This species is found extensively in Orange County where good soil drainage is lacking. A large portion of these former agricultural fields were covered with temporary parking lots during the CPV active construction phase. The parking lots were removed as construction neared completion and the areas re-seeded. Assumedly, this was a condition of permitting of CPV's wetland disturbances.

A tributary of Monhagen Brook, mentioned above in the MD-36 description, runs through the northwest edge of 23N.

Most of the MD-23 wetland on the south side of I-84 (23S), while on soils that are considered hydric or potentially hydric, differs from the north side in that the soils are derived from glacial till deposits, rather than the lacustrine deposits that dominate the north side. A substantial block of woodlands (over 40 acres) exists to the west of 23S. The wetland area itself exhibits a mixture of lighter woody growth and herbaceous/shrub-scrub growth. One can surmise that the combination of woods and wetlands in this setting, along with active nearby farmland, makes this a locally important area for wildlife habitat.

The boundaries of MD-23 relative to the boundaries of wetlands shown in this locale on the NWI maps is as described for other wetlands in the Watershed.

MD-28

MD-28 is a 50-acre, Class 3 wetland that occurs entirely on the south side of county Rte. 56 on the Official Map, but extends onto the north side on the Additions Map. The Additions map also extends the wetland considerably to the west, across an unnamed tributary of the Monhagen Brook.

Cattails, willows, cool season grasses, and open water characterize about 23 acres of MD-28.

Much of this wetland is mapped as Madalin, a hydric soil high in lake-laid silts and clays.

Approximately 23 acres of MD-28 is mostly devoid of woody vegetation, owing partially to natural conditions that favor herbaceous growth, but perhaps also to recent agricultural activity. There is a defined drainageway through this portion of the wetland that is a Class B stream according to NYSDEC's Environmental Resource Mapper. Additional ditches point to past attempts to drain the area for agricultural use. Among other typical wetland vegetation, there is an abundance of willow growth in this portion of the wetland.

Surrounding the area characterized above as having been recently farmed is an area of successional woody growth also typical of previously farmed land, though these areas have been out of production for a longer period of time.

MD-19

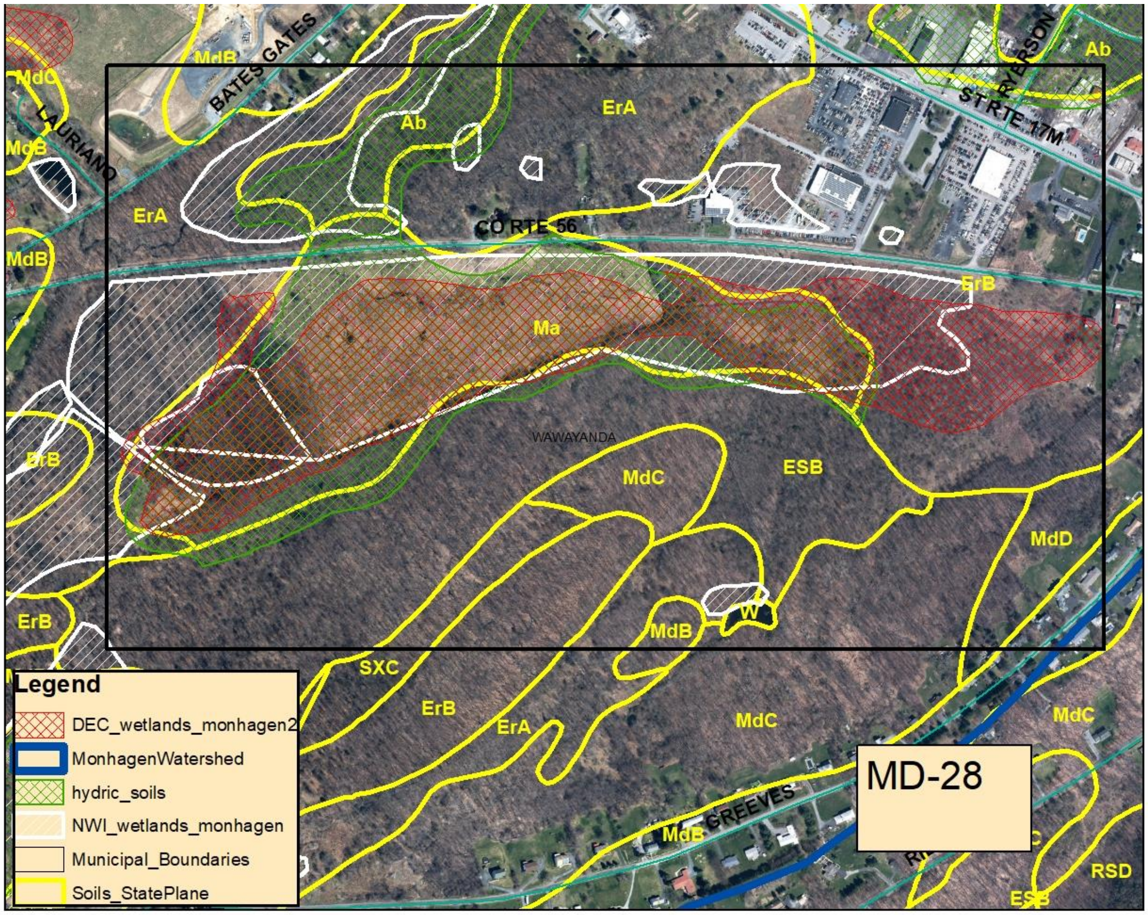
On the Official Map, MD-19 is entirely to the north of the abandoned railroad grade that will become the Heritage Trail. It extends north beyond Genung Street on the west side of Schutt Road. Three separate polygons total about 43 acres. It is a Class 2 wetland.

This complex changes dramatically on the Additions Maps, extending to the south side of the railroad grade, thence along a narrow stream corridor and across Dolsontown Road to the meandering main stem of the Monhagen Brook visible from I-84 east of Exit 3. The areas leading to and surrounding the Brook are mostly alluvial Wayland (Wd) soils, which are considered hydric. Much of this area continues to be in agricultural use, therefore the justification for considering it as additional wetlands is unclear since general understanding is that land is not considered "reverted to wetland" as long as it remains in active agriculture and does not display woody vegetation. The Additions Map shows the complex extending even further, to the south side of I-84 to areas of Canandaigua (hydric) and Wayland soils in two separate polygons.

MD-19 is the only wetland in the Watershed that shows a deletion of wetland. It is in the northern limits of the wetland, and appears to correspond to an area of Mardin soils (normally not hydric).

MD-56

The Additions Map shows a new Class 2 wetland near the eastern limits of the Watershed, just east of Schutt Road and north of Randall Airport. There are NWI wetlands and hydric or potentially hydric soils in the vicinity of MD-56, but the correlation between these three layers is even weaker than usual.



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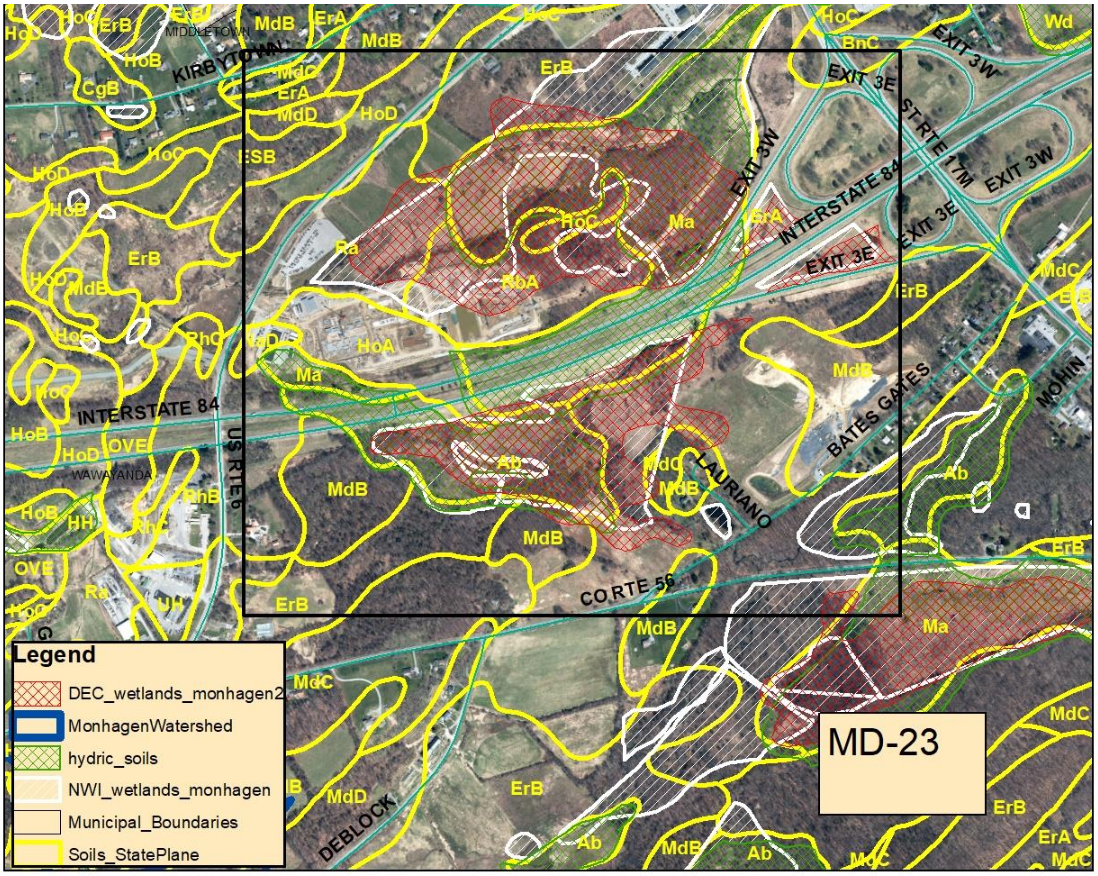
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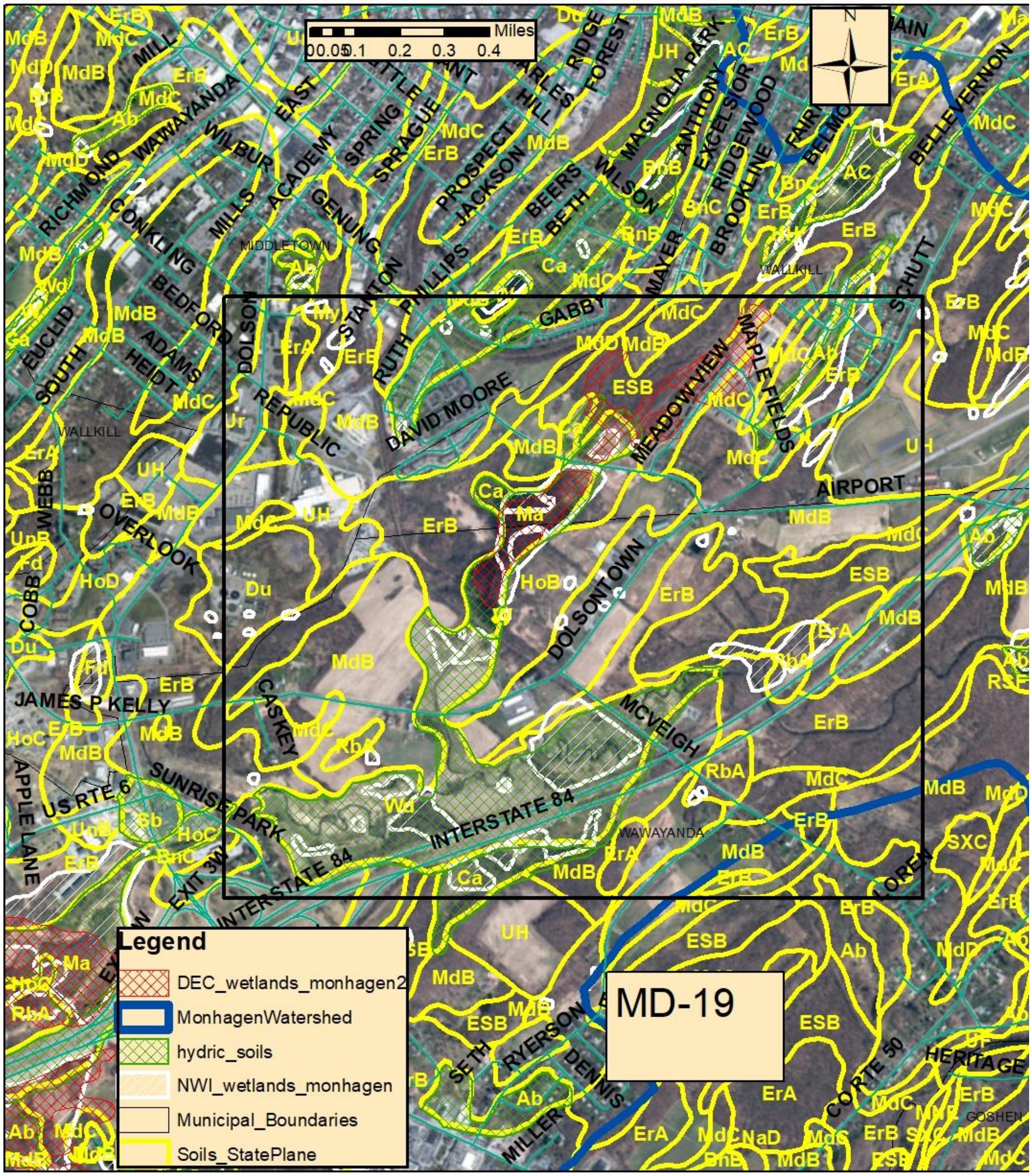
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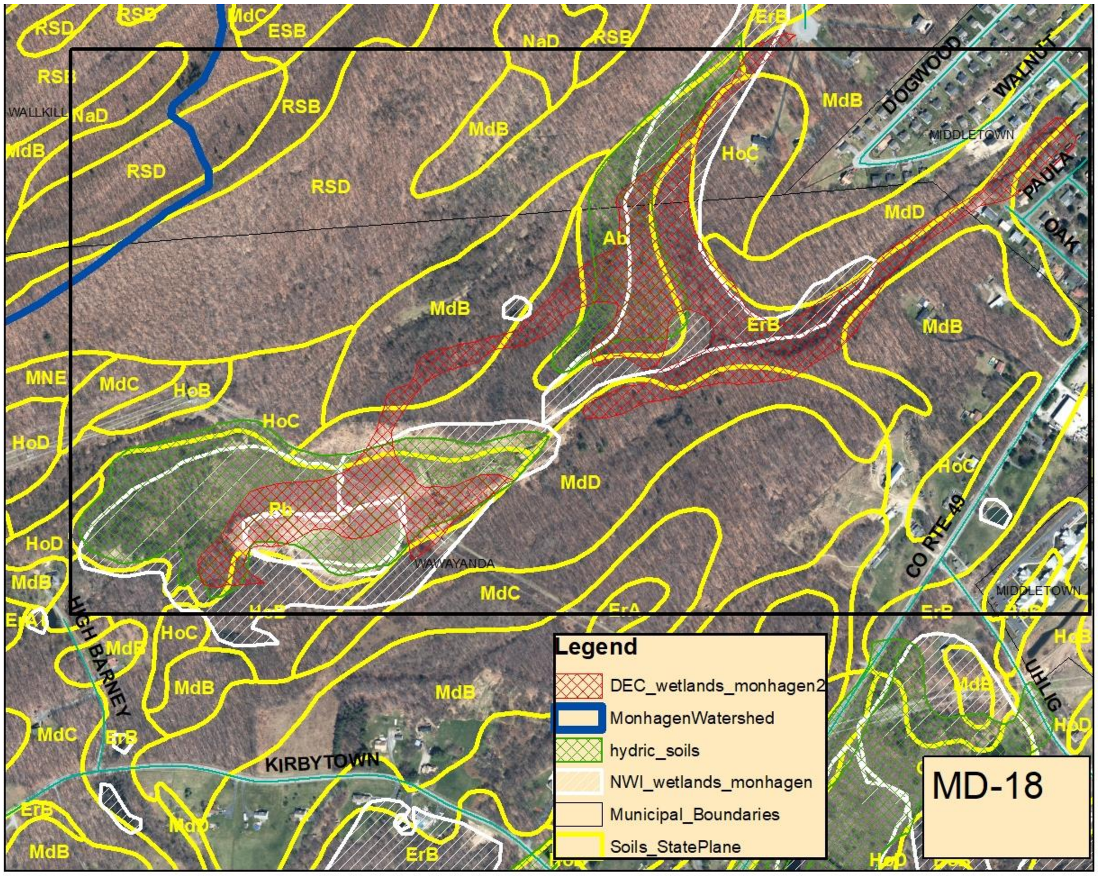
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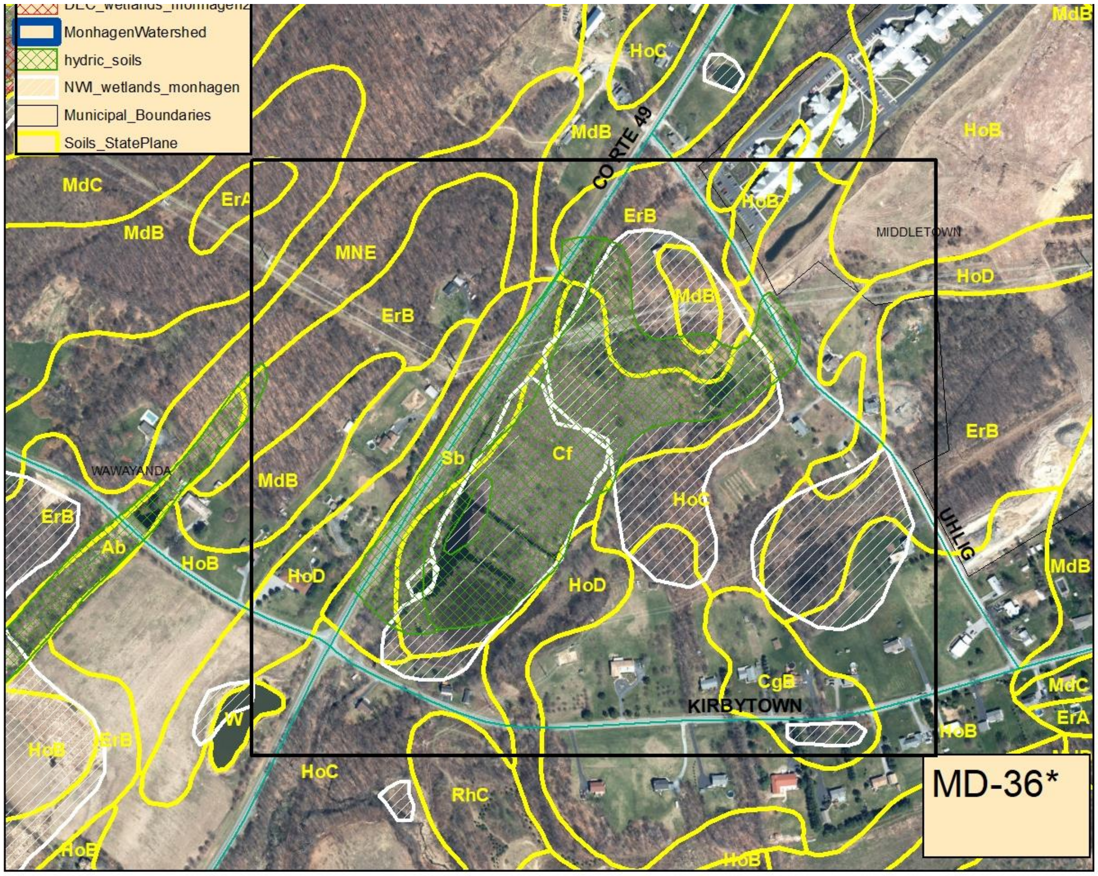
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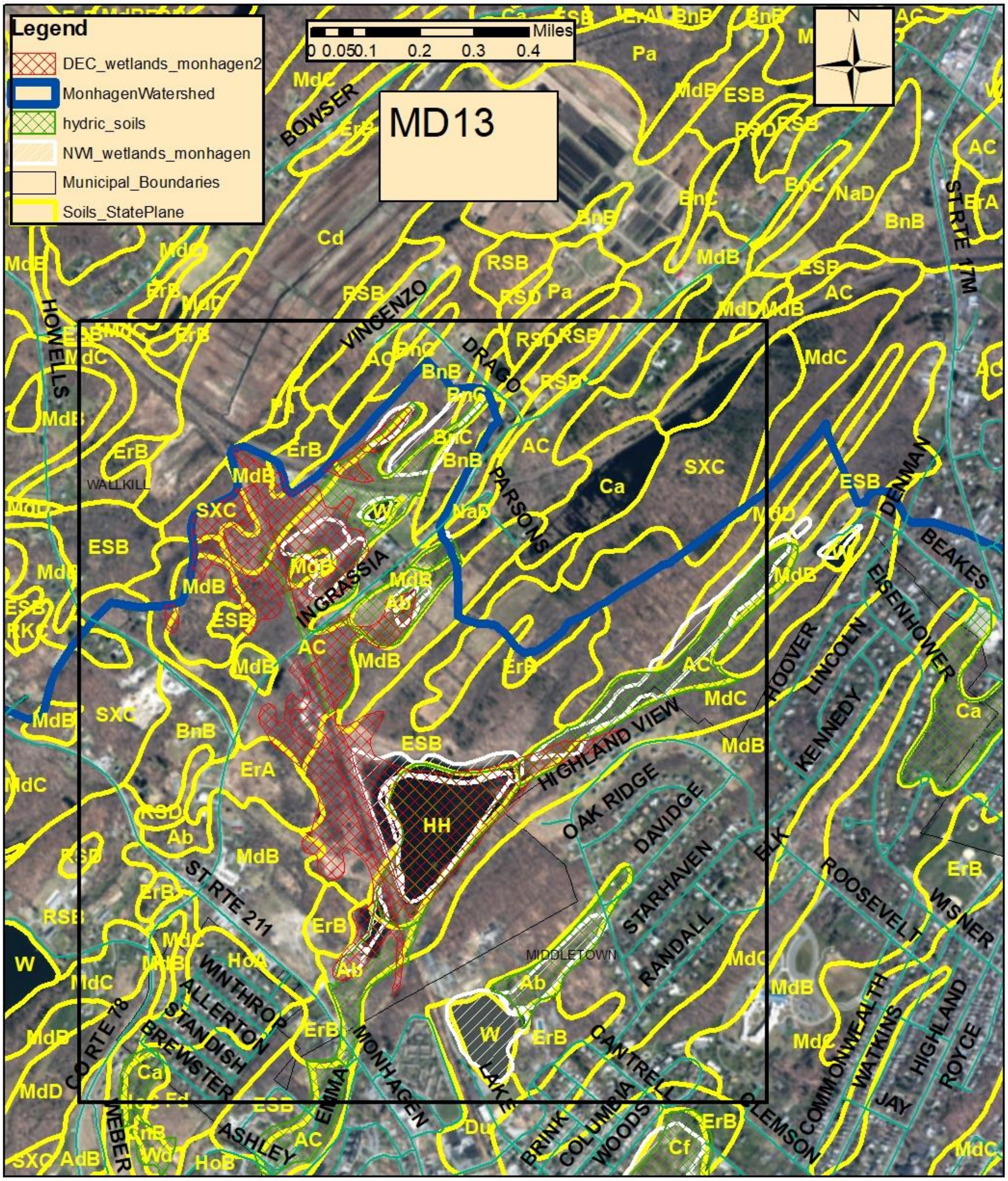
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STARHAVEN
RANDALL
ELK
HOOVER
LINCOLN
KENNEDY
EISENHOWER
DENMAN
BEAKES
ROOSEVELT
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CO RTE 78
WINTHROP
ALLERTON
STANDISH
BREWSTER
WEBER
ASHLEY
EMMA
MONHAGEN
LAKE
BRINK
COLUMBIA
WOODS
CANTRELL
CLEMSON
COMMONWEALTH
WATKINS
JAY
HIGHLAND
ROYCE

MD-13 – The open water roughly corresponds with the portion of the wetland mapped as *Histic Humaquepts* in the Orange County Published Soil Survey. The invasive plants multifloria rose and Japanese barberry were observed at this site, though not in abundance. The view is from the City of Middletown's Fancher-Davidge Park nature trail.

MD-19, looking west next to Genung Street. Cattails compete with a dense stand of what is thought to be reed canarygrass.