Moodna Creek Watershed Conservation and Management Plan



Prepared by the Orange County Water Authority

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- B Comparison of Fine and Coarse Scale Geospatial Assessments: Riparian Corridors of the Moodna Creek Watershed (John Mickelson)
- C General Concepts in Riparian Vegetation Ecology (Kevin Grieser of HREP)
- D Moodna Creek Dam Removal: New Windsor, NY (American Rivers)
- E Moodna Cultural Connections: Maringamus' Wigwam (Dr. Kate Ahmadi)
- F Watershed Modeling: Estimating Impacts of Future Land Use Change on Water Quantity and Quality (Molly Ramsey)
- G Biodiversity of the Moodna Creek Watershed: Important Resources and Conservation Recommendations (Laura Heady of HREP)
- H Potential Impacts of Climate Change on Sustainable Water Use in the Hudson River Valley (Allan Frei, Simon Gruber, Carina Molnar, Joseph Zurovchak, Shih Yan Lee)

I. Introduction

Background

The concept of developing a watershed plan for the Moodna Creek grew out of discussions between staff of the NYSDEC's Hudson River Estuary Program (HREP) and people living and working in the Moodna Creek Watershed who were interested in drawing attention to local These concerned citizens, including Simon Gruber, Dick Manley, Kate watershed issues. Ahmadi, Bill Schuster, Mary Gross-Ferraro and others, had already begun compiling information, observing water quality problems and noting opportunities for public access and These watershed issues and opportunities, coupled with ongoing other improvements. development pressures in the region, led these concerned citizens to form the Moodna Watershed Coalition, an ad-hoc citizens group that began meeting in early 2004 to explore ways to work together to protect and restore the Moodna Creek, its tributaries and the Watershed as a whole. Representatives of the Orange County Water Authority (OCWA), the Orange County Planning Department (OCPD), and the Orange County Soil and Water District participated in early meetings and provided technical support. The HREP staff encouraged the Coalition to seek state grants and other available resources. In 2004, Simon Gruber worked with OCWA staff to write a watershed planning grant proposal to the HREP. The grant was awarded and, together with matching funds from the OCWA, the funding has supported research and development of this Plan as well as related educational outreach to municipalities and other stakeholders in the Watershed.

The process for creating this Plan involved public meetings, discussions with residents and municipal officials, interviews with local professionals in relevant fields, and field investigations. The first public Moodna Watershed meeting was held on January 31, 2007 in the Blooming Grove Town Hall. This meeting was the kickoff to a series of public meetings that served as forums for education and discussion about issues related to the Moodna Creek and its watershed. Input from these meetings led directly to the prioritization of topics covered in this Watershed Plan. Flooding evolved as the major issue of concern in the Moodna Watershed; not only has the Moodna Creek itself caused significant property damage in several locations during past floods, but several of its tributaries are infamous for spilling over their banks and causing significant destruction. This top issue is discussed in the Flooding section, found in the "Issues" chapter. Other topics (many of which relate directly to flooding) that were brought to light during the public meetings included:

- stormwater management in new developments
- cumulative impacts of development on stream flow
- impacts of land clearing/clear cutting
- preservation of high priority surface water resources
- intermunicipal planning and coordination
- impacts of wastewater infrastructure on surface water quality
- wetland assessment and conservation
- protection of high priority habitats, including the mouth of the Moodna Creek
- public access to waterbodies/water-related recreational opportunities
- protection of stream-side vegetation
- management of dams

The above topics are explored further in both the "Issues" and "Recommendations" chapters.

Purpose and Goals of this Plan

The general goals of this Watershed Plan are to 1) **summarize existing conditions** in the Watershed, 2) **identify and describe issues** that are important to local communities and stakeholders, including assets, existing problems, risks, and opportunities, and 3) **develop** a prioritized list of **action items and recommendations** for addressing identified issues. An overarching goal during both the planning and implementation phases of this Plan is to increase public awareness of water resource issues, in general, and the Moodna Creek, in particular, so that Watershed stakeholders are better equipped to make decisions that will positively impact the Watershed and improve the local quality of life.

This Plan is designed to address local and intermunicipal goals, and also to fit within and support a broad regional context of watershed planning, conservation, and restoration. Because watersheds do not follow municipal boundaries, working in a watershed context requires communication and coordination between multiple municipalities; in the Moodna Creek Watershed, this means involving 22 municipalities. The planning process and the goals for this Plan itself include a strong emphasis on facilitating and developing an ongoing, coordinated intermunicipal program addressing watershed issues. The highest priority recommendation, in fact, is to develop an intermunicipal watershed group that will strive to cooperatively implement the remaining recommendations of this Plan and take on other important watershed issues as they arise.

A key starting point for understanding the existing regional context of the Plan can be found within the set of priorities identified in the Hudson River Estuary Program's Action Agenda. The Estuary is defined by NY State as the area from the Troy dam south to the Verrazano Narrows, and the surrounding watershed (see Map 2 of Regional Watersheds). This area includes the 153 mile-long main stem of the Hudson River, as well as upper New York Harbor, and the entire watershed area draining to this tidal portion of the river. This is a total of 5,200 square miles, out of the Hudson River's overall 13,400 square mile watershed. Of the twelve primary goals of the Estuary Program, one is focused on protecting tributaries of the Hudson River in the estuary region and is described this way:

HREP Action Agenda Goal 4 – Streams and Tributaries of the Hudson River Estuary Watershed: Protect and restore the streams, their corridors, and the watersheds that replenish the estuary and nourish its web of life —a system critical to the health and well-being of Hudson Valley residents and the estuary¹.

One of the key mechanisms to accomplish this goal is to encourage and support development of locally-driven watershed plans for tributaries of the estuary, with a focus on developing intermunicipal collaboration and involving a wide variety of stakeholders. While the regional goals outlined above are important as a starting point and overall context for this Plan, perhaps the Plan's most fundamental purpose is to articulate issues, challenges, risks and opportunities from a local point of view.

¹ HREP Action Agenda can be viewed at <u>www.dec.ny.gov/docs/remediation_hudson_pdf/hreagenda05.pdf</u>



Map 1: Regional Watersheds

Approach Used within this Plan

This Plan incorporates and encourages elements of the approach known as ecosystem-based management (EBM) for local and regional planning. EBM is a decision making and planning tactic that considers an entire ecological community, including humans, in the creation of a sound blueprint for the near- and long-term future. This differs from some traditional planning techniques in that it seeks to maintain and enhance the health of a vast natural system (i.e. an ecosystem, and in this case, a watershed) as a whole, rather than managing for one particular component of that system (e.g. a land use plan, or an economic development plan, or a farmland protection plan, etc). Although this Plan is centered on the management of one primary resource – water (both quality and quantity) – it does so by looking at the various factors that affect and depend on water resources and seeks to balance these factors through multi-disciplinary management tactics.

A few examples of EBM techniques included in this Plan are:

- **involvement of multiple types of stakeholders** in the planning process so as to get input on many components of the watershed
- addressing the complexity of natural processes and social systems by recommending **adaptive decision-making that recognizes changing circumstances** and updated scientific findings
- strongly endorsing the notion that future land use decisions be made in a way that **considers impacts to important ecosystem components** such as water, biological resources, and topography

This Plan divides the Moodna Creek Watershed into several subwatersheds; this is the approach commonly taken in watershed plans. The Center for Watershed Protection (CWP) states that watershed scale is a critical factor in preparing effective local watershed plans. The CWP recommends that watersheds of the size of Moodna Creek's should be "decomposed" into smaller, more manageable units to produce a meaningful watershed plan. This division into subbasins simplifies the management of the watershed because it breaks the watershed into smaller, more manageable and understandable geographic areas. These smaller subbasins are likely to be under the jurisdiction of fewer municipalities, simplifying the intermunicipal planning process, keeping the number of stakeholders in the process to a manageable number, and focusing responsibility for taking action on specific municipalities.

The subwatersheds of the Moodna Creek Watershed² include (see Map 1):

Beaver Dam Lake Subbasin	10.79 mi2	Newburgh, New Windsor, Blooming Grove, Cornwall
Black Meadow Creek Subbasin	14.04 mi2	Warwick, Chester, Goshen
Cromline Creek Subbasin	5.53 mi2	Blooming Grove, Hamptonburgh
Idlewild Creek Subbasin	6.94 mi2	Cornwall, Highlands, New Windsor
Mineral Springs Brook Subbasin	5.38 mi2	Woodbury, Cornwall, Highlands
Moodna Creek Central Subbasin	5.78 mi2	Blooming Grove, Cornwall, New Windsor
Moodna Creek East Subbasin	13.29 mi2	Blooming Grove, Cornwall, New Windsor

 $^{^2}$ The boundaries of the Moodna Watershed and its sub-watershed basins are derived from data created by the US Geological Survey and refined by OCWA. The USGS Hydrological Unit Code (HUC), created in the 1990's, divides the US into 2,264 Cataloging Units. The watershed of the Moodna Creek is part of the Hudson-Wappinger Watershed, HUC 02020008. A further subdivision of watersheds into 6th level hydrological units was completed by the USGS in 2002. OCWA revised the data using 1:24,000 scale 7.5 degree topographical maps to directly geocode elevation data. This yields the most precise local watershed boundaries currently available. This OCWA data forms the framework of the boundaries of the Moodna Creek Watershed, which includes all the 6th level HUC units tributary to fourth-order Moodna Creek. The 6th level HUC units contained within the Moodna Creek Watershed were grouped to create logical basins containing named third-order streams.

Moodna Creek Washingtonville Sub	5.42 mi2	Blooming Grove, Washingtonville, New Windsor
Moodna Creek West Subbasin	5.12 mi2	Blooming Grove, Washingtonville, New Windsor
Otter Kill North Subbasin	25.27 mi2	Hamptonburgh, New Windsor, Montgomery
Otter Kill South Subbasin	16.62 mi2	Hamptonburgh, Goshen
Perry Creek Subbasin	5.15 mi2	Blooming Grove
Satterly Creek Subbasin	12.17 mi2	Blooming Grove, S. Blooming Grove, Monroe
Seely Brook Subbasin	18.98 mi2	Monroe, Chester, Goshen, Hamptonburgh,
		Blooming Grove
Silver Stream Subbasin	7.09 mi2	New Windsor, Newburgh
Trout Brook Subbasin	6.37 mi2	Chester, Monroe, Warwick, Tuxedo
Woodbury Creek Subbasin	16.78 mi2	Woodbury, Cornell

Moodna Creek Watershed Atlas

The above subbasins are displayed on many of the maps in this Plan but can be more deeply explored in the Moodna Creek Watershed Atlas, which is a key outreach component of this Watershed Plan. The Atlas is available in two formats: PDF format on the OCWA's website and hardcopy (spiral-bound book) format from the OCWA office. This Atlas is a very useful tool for engineers, planners, developers, municipalities, researchers, and others who are interested in getting detailed information about the Watershed. Features displayed in the Atlas include protected open space, topography, groundwater resources, recreational trails, public parks, wastewater discharge points, wetlands, floodplains, and more. Ultimately, the Atlas will become the core feature of an interactive website where the public can query different sets of information, as well as research and produce maps.

Understanding a Watershed

Wherever you are on the Earth, you're in a watershed. In simplest terms, a watershed, also called a drainage basin or catchment, is an area of land that drains to a common point; for the Moodna Creek, this common point is the Moodna Bay, where the Creek flows into the Hudson River. There are numerous watersheds in Orange County and they range in size from a small area that flows into a pond to the 382 square mile area that drains into the Wallkill River. Eventually, all streams in the County end up in the Hudson, Delaware or Passaic Rivers. Recognizing that everyone lives in a watershed and that rain falling on land eventually drains into a stream, river, lake or ocean, it is not hard to understand why the actions we take on land could easily have an impact on the health and quality of our most important water resources.

The Moodna Creek Watershed: An Overview

The Moodna Creek Watershed covers 115,600 acres – or 180 square miles – of the eastern side of Orange County (see Map 2: Cultural and Hydrologic Features). The Watershed includes all or portions of 22 municipalities; it stretches from small sections of Warwick and Tuxedo to the south, all the way up to Newburgh and Montgomery to the north then spans an area from Goshen and Hamptonburgh to the west, to the towns of Cornwall and Highlands to the east. This Watershed is made up of hundreds of streams, each beginning as a small headwater stream and then merging with other streams before joining with the Moodna Creek, which then flows into the Hudson River just north of the Village of Cornwall-on-Hudson.



Map 2: Cultural and Hydrologic Features

Figure 1 is a relief map that shows the topography of the eastern portion of Orange County, with the Moodna Creek Watershed boundaries shown as a black line. The Moodna Creek is the wide blue swath in the center of the image, surrounded by its tributary streams and lakes. The Hudson River is the wide blue swath on the right side of the image. The mountains and ridges are represented by red coloring, while valleys are shown as gray or blue. Notice how the black watershed boundary follows ridgelines; this is especially notable on the bottom and right side of the image. Rain falling on one side of the watershed boundary line will flow into tributaries of the Moodna Creek and then ultimately into the Moodna Creek itself, while rain falling on the other side of the boundary line will flow into the Ramapo River, Wallkill River, or Quassaick Creek.



Figure 1: Topography of the Moodna Creek Watershed

Major tributaries of the Moodna Creek include:

• Otter Kill

- Satterly Creek Seely Brook
- Black Meadow Creek
- Woodbury Creek

Major lakes and reservoirs (in **bold**) in the Watershed include:

What is a Watershed Plan and What is its Purpose?

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- Tomahawk Lake
- Beaver Dam Lake
- Brown's Pond/Silver **Stream Reservoir**
- Crest View Lake
- Maybrook Reservoir
- Orange and Rockland Lakes
- Cromwell Lake
- Walton Lake

- Burnside Pond
- Upper Reservoir
- Tamarack Pond
- Sphagnum Pond
- Lake Frederick
- Arthurs Pond
- Hildegard Lake
- Earl Reservoir
- Sutherland Pond
- Lily Pond •

- Cromline Creek
- Idlewild Creek
- Merriewold Lake
- Korby Lake
- Goshen Reservoir 2
- Crestview Lake
- Shadow Lake
- Aleck Meadow Reservoir
- Hillside Lake
- A watershed plan is essentially an intermunicipal comprehensive plan that focuses on water resources. Watershed plans are intended to provide a management framework for restoring impaired waterbodies as well as for safeguarding healthy waterbodies. The rationale for watershed management is that if we properly manage activities on land, then we will be protecting water quality.

Watershed plans are a useful reference for many different audiences. Land use decision makers, including planning boards, conservation advisory councils, and municipal boards, can use watershed plans to determine possible downstream impacts of proposed developments, enlighten the SEQR process, assess the natural resource values within their communities, or to help inform large-scale decisions such as the delineation of zoning district boundaries. Water supply managers can better understand the factors that are influencing water quality in their waterbodies. Conservation-minded entities can pinpoint specific preservation targets. Watershed plans are educational to any audience because they encourage understanding of the principles and strategies that foster healthy streams, rivers, lakes and groundwater.

The Center for Watershed Protection, a Maryland-based organization that has emerged as a leading source of information and guidance on watershed planning, recommends that watersheds be managed through the utilization of eight watershed protection tools:

1. Land Use Planning addresses the degree and location of all future development expected in a watershed. It is the single most important factor in protecting and managing watersheds. Preparation of a watershed plan and adoption of watershed-based zoning allows municipal officials to consider the needs of the watershed paramount in making land use decisions

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- 2. *Land Conservation* is a critical tool for watershed management, used to protect critical habitat and sustain the integrity of the watershed and subbasin ecosystems.
- 3. *Aquatic Buffers* are placed along streams and shorelines and around natural wetlands in order to physically protect the stream, lake, or wetland from future disturbance or encroachment.
- 4. *Better Site Design*, also known as low impact development, encourages project design that reduces impervious surface cover onsite and increases the amount of conserved natural area.
- 5. Erosion and Sediment Control
- 6. Stormwater Treatment Practices
- 7. Non-Stormwater Discharges
- 8. Watershed Stewardship Programs

See <u>www.cwp.org</u> for more information, including case studies, model ordinances, educational resources, and more.

Key Principles and Terms for Watershed Planning

The following section gives insight into certain terms (highlighted in **bold**) used in this Plan that may be unfamiliar to many readers. Understanding these terms is important in order to comprehend how a watershed functions.

The streams within a drainage basin form a hierarchy, called **stream order**, within the watershed, with increasing volumes of water as the stream approaches the mouth. The higher numerical order that a stream possesses, the larger the contained flow and accumulation of output. A first-order stream within the watershed is located near the source and has no tributaries; a second-order stream is a channel fed by at least two first-order streams that proceeds toward the mouth of the larger channel; a third order stream is created by the joining of two or more second-order channels; and so forth. Streams in the lower orders are more vulnerable to pollution based on the low volume of water that they carry; they are typically less able to filter pollutants and remove sediments.

A frequently used term throughout the Moodna Watershed Plan is **brackish** water. This term describes water that is in a mixed state when it is not specifically saltwater or freshwater. As stated earlier, the tidal marsh at the mouth of the Moodna Creek is home to a confluence of freshwater and saline ocean water in the Hudson River; the recombination of these two into brackish zones largely defines the unique ecological community formed at the confluence of the Moodna Creek and the Hudson River.

Two terms used frequently in this Watershed Plan - **point source** and **non-point source pollution** - describe the nature by which pollutants enter the Moodna Creek Watershed. Point source pollution can be defined as a single location or source of pollutant output which, when controlled, does not yield further emission of that pollutant. An example of this could be a discharge pipe from a sewage plant or a leak from an industrial facility. Non-point pollution

sources are much more indirect and do not result from a single output point. These pollutants may enter the watershed through several non-discrete points, and can include a wide range of contaminants from fertilizers to pesticides. Most non-point source pollution in the Moodna Creek Watershed is discharged to streams via stormwater runoff.

Two related concepts which are also elaborated upon throughout this Watershed Plan are **imperviousness** and **groundwater recharge** (also called aquifer recharge). Impervious surfaces are land areas that do not allow water to absorb into the soil and include any land that is covered with concrete, asphalt, or rooftops. Groundwater recharge is the movement of water from the land downward through the soil and into the groundwater, thus replenishing groundwater levels, which can be depleted through the withdrawal of water from wells. A land area with a high percentage of impervious surfaces will generally have a low volume of groundwater recharge due to the fact that precipitation that falls on an impervious surface will not be able to soak into the ground and eventually reach the groundwater; it will instead become **stormwater runoff** (runoff). Runoff is water that flows over land (mostly impervious surfaces) until it reaches a water body. To summarize the relationship of the three terms described above: as imperviousness increases, runoff volumes increase and the rate of groundwater recharge decreases.

Too commonly, development creates a negative feedback loop with groundwater supplies. Land development increases not only impervious surface, as described above, but also the human demand on the existing water supply through the creation of new homes, industries, businesses and other facilities that require potable water. Groundwater resources may then be compromised or eliminated due to the decrease in groundwater recharge and the increase in water withdrawals from wells. The more land that is developed, the higher the demand for potable water is; yet the opportunities for groundwater recharge are fewer because of increased impervious surfaces. **Low Impact Development** (LID, also called Better Site Design) design principles were formulated in order to help alleviate this conundrum by reducing the amount of impervious surfaces. LID principles are discussed in more detail in the "Issues" section of this Plan.

II. Existing Conditions in the Moodna Watershed

The Moodna Creek is one of at least 65 streams and rivers that directly flow into the Hudson River Estuary. Hudson River tributaries vary in size from small streams that may dry-up during summer months, to larger rivers with watersheds that cover hundreds of square miles. In general, the Moodna is an average sized tributary compared to all the tributaries, draining approximately 180 square miles of land in Orange County. Tributaries such as the Moodna are interwoven components of the Hudson Estuary ecosystem. They can contribute freshwater, essential nutrients, possible contaminants, and typically form vital habitats at their confluence with the Hudson Estuary.

The Many Names of the Moodna Creek

The Moodna Creek has been referred to by many names during its relatively short human history. At the time of European contact, the Moodna Creek was called the Waoraneck, which is also the name of the Native American tribe that inhabited the area. Since at least the Orange County Charter of 1683, the lower part of the Moodna Creek towards the Hudson River was known as "Murderers' Creek." While the origin of the name "Murderers' Creek" is unknown, an 1875 atlas placed the name "Murdners" close to "Muringuius Wigwam," thereby inferring some relation of the Murderers' Creek to chief Maringamus of the Waoraneck tribe. There is, however, no evidence that Maringamus was a murderer; he was actually known as being friendly to settlers.

A legend, "Naoman," printed in the National Reader during the nineteenth century, may be more relevant in the historic naming of the Moodna Creek as "Murderers' Creek." This legend tells of the violent action taken by a local tribe that was angry at the incursions of settlers and thus murdered both a settler family who lived at the mouth of the Moodna Creek as well as an elderly Native friend who came to warn them. This legendary action could well have led to the infamous reference of "Murderers' Creek."

The name Moodna Creek was claimed by Nathaniel Parker Willis, a poet and writer who settled at Idlewild gorge in Cornwall in the mid-1800s. He wrote that Moodna was a local community name that was a deviation of the name of a late Indian chief, likely Maringamus.

The Lower Moodna Creek and Bay: Where the Moodna Meets the Hudson River Estuary ³

The Hudson River is unusual among other East Coast estuaries in that the tidal influence extends a relatively long distance, 150 miles, upstream to Troy (Dunwell, 1991). Brackish water normally moves as far upstream as 60 miles to Chelsea (between Newburgh and Poughkeepsie) and can reach even farther in drought years. The mixing of fresh and salt water is a critical factor that profoundly influences the river's ecology. Map 3 depicts this gradient along the Hudson River Estuary. The lower portion of the Moodna Creek also holds significant interaction with the Hudson River in terms of water flow and ecology. As noted above and detailed below,

³ Scott Cuppett, the manager of the Hudson River Estuary Program's watershed and tributary program, contributed this description of the Moodna Bay area.

the tidal wetlands at the mouth of the Creek is considered an important example of this kind of habitat, which is a key part of the overall Hudson River ecology.

Freshwater Flow

At the mouth of Hudson River tributaries, where they meet the tidal Hudson River, are tidal coves and bays, which are mixing zones for water draining from the Watershed and water of the Estuary. In the more southerly portions of the Estuary below Poughkeepsie, including the mouth of Moodna Creek, the water in the Hudson River mainstem can be brackish during certain times of year, while the water discharging from the tributary and its Watershed is entirely fresh. Freshwater inflows from tributary streams play an important role in maintaining salinity gradient in the Hudson River Estuary.



Essential Nutrients

Tributaries also contribute vital nutrients to the Hudson Estuary ecosystem. Carbon, for example, is one such nutrient that originates from vegetation, soils, and forests in the Watershed and makes its way to the Hudson Estuary where it is consumed by bacteria and animals, serving as an essential building block for the Hudson River Estuary food chain.

Pollutant Inputs

Water quality impacts to the Hudson River Estuary from the Moodna are most likely influenced at the tidal Moodna Bay where drainage waters are protected from dilution and dispersion by the overwhelming tidal waters of the Hudson River. Land uses in the Moodna Watershed, including agriculture, urban, commercial, and residential development, may have a negative impact not only on the small streams and rivers in the Moodna Watershed, but also in this tidal area of the Moodna where it meets the Hudson River. For example, excess sediment discharged from the tributary can settle in these coves, where the free flowing water meets the slower slack water in the Hudson River. This may lead to the cove becoming shallower, smothering the benthic habitat, creating opportunities for invasive vegetation to establish itself, and stressing native submerged aquatic vegetation. Elevated pathogen and nutrient levels from the Watershed may also contribute to water quality problems, threatening swimming fishing and recreational opportunities. The vulnerability of tributary mouths to Watershed impacts from far upstream as well as their ecological connection to the Hudson River Estuary ecosystem and the Atlantic Ocean, heightens the need for responsibility and caution from everyone living in the Hudson Valley.

Coastal Habitat

The tidal Moodna cove and corresponding 75 acre bay provide unique habitat where fresh and saltwater ecosystems converge. Moodna Bay is considered to be a high quality, irreplaceable significant coastal habitat in the Hudson River Estuary. Aquatic and terrestrial animal species use the bay for refuge, foraging, over-wintering, and reproduction. Many species of Hudson River fish and wildlife move between and among tributary mouths and coves, such as the



Moodna, to complete required parts of their life history. Moodna Creek, for example, is an important spawning area for anadromous fishes, such as alewife, blueback herring, smelt, white perch, tomcod, and striped bass. Figure 2 illustrates the movement of river herring along the Atlantic Coast. River herring, such as alewife and blueback herring use the mouth of the Moodna Creek for spawning in the spring. Leaving the Hudson River Estuary in early summer, these fish migrate northeast to the coast of Maine to spend the summer feeding and then migrate south to the coast of North and South Carolina. Fish, such as striped bass follow the herring along this migratory journey to prey on river herring.

Here are some examples of a few animals that use the Moodna as part of their life history:

- River herring (shown in Figure 2)
- Striped bass
- Blue crab
- Resident HR black bass
- Eels

- Migratory birds
- Ospreys
- Bald eagles
- Breeding bird species, including the least bittern

Tidal marshes and flats, such as those that exist at the mouth of the Moodna Creek, are among the most valuable fish and wildlife habitats in the Hudson Valley. Extensive flats at the Creek mouth provide spawning and nursery habitats for these species. A substantial warm water fish community also occupies the lower portion of the Moodna Creek throughout the year.

Where the Moodna Creek widens and thereafter is known as the Moodna Bay, there are extensive areas of emergent marsh, subtidal aquatic beds, and wooded islands. The underwater terrain (bathymetry) in the Bay provides important habitat niches that scientists are exploring to understand their role in the Hudson Estuary ecosystem. Many of the coves in the Moodna Bay contain tidal wetlands and beds of submerged aquatic vegetation (SAV) that are important habitats for Hudson River aquatic animals and contributors of dissolved oxygen to the Estuary. Increased photosynthesis in SAV beds has partially compensated for the decline in dissolved oxygen caused by the zebra mussel. Land uses in immediately adjacent upland areas, as well as other human intrusions including lighting, railroad tracks, and dams, can contribute to degraded habitat and water quality in the coves and bays. See the "Biodiversity" section for more information on the Moodna Bay.

Riparian Areas

Riparian vegetation (plants that grow on or near the banks of a natural watercourse) provide numerous benefits to water quality, aquatic and terrestrial plants and animals, and local landowners. Vegetated riparian zones facilitate stream stability and function by providing rooted structure to protect against bank erosion and flood damage. Riparian buffers, such as the one shown in Figure 3, offer protection against pollution and the adverse affects of human activities. Streamside forests reduce nutrient and sediment runoff, provide food and shelter, control fluctuations to stream temperature, and improve the aesthetic quality of the stream community.



Impacts of Disturbance on Riparian Vegetation

Natural Disturbance

Natural disturbances such as floods, ice or debris floes, high winds, pests and disease epidemics, droughts, and fires can greatly affect the health of riparian vegetation. The effect of flooding on healthy streamside vegetation is generally short term and the recovery/disturbance regime can be cyclical. Following a large flood, the channel and adjacent floodplains can be littered with everything from woody debris to downed live trees. In following years, much of the vegetation recovers, although if significant floods occur too frequently, large trees do not have the opportunity to reestablish.

Human Disturbance

The effects of natural disturbance on riparian vegetation are different from the effects of human disturbance in their temporal extents and significance. Human activities often significantly alter the natural conditions and therefore can have a longer-lasting impact on the survival and function of the existing riparian vegetation.

Outside Influences on Riparian Buffers

Agricultural Influence

Intensive grazing in riparian areas inhibits the growth, establishment, and regeneration of shrubs and trees, while the most intensive grazing can keep grasses at a height too low to effectively impede storm runoff and erosion. Therefore, continuous access to streams by livestock has the potential to significantly increase runoff and by association increase nutrient contamination and erosion. These effects can be mitigated by the United States Department of Agriculture's (USDA) Conservation Reserve Enhancement Program (CREP), which is a voluntary program that protects environmentally sensitive agriculture land with vegetative riparian buffers often associated with exclusionary livestock fencing.

Public Road and Utility Infrastructure Influence

Use and maintenance of state and local highways also impacts the vigor of riparian vegetation where narrow buffers exist between roads and streams. Because these areas receive runoff which typically contains sediment, pollutants, and road chemicals, they are more prone to stunted vegetative growth and increased stress or mortality in vegetation.

Residential Development Influence

Residential land use and development of new homes can have a significant impact on the Watershed and ecology of the riparian area. Houses require access roads and utility lines that often have to cross streams. Frequently, homeowners will remove all barrier plantings between a stream and the house, replacing those plantings with an unnatural mowed lawn. This subsequently causes or increases streambank erosion.

Designing and Managing a Healthy Riparian Buffer

Unhealthy Streamside Buffers

One of the most common characteristics of an unhealthy buffer is runoff. Runoff that moves over impervious surfaces, like roofs and paved driveways, flows at a greater speed which accelerates erosion and leaves no opportunity for pollutants and excess silt to filter out. A lawn, in addition to having essentially no habitat value, can actually accelerate runoff because water travels twice as fast over lawn as it does over a healthy forest floor; lawns also lack the deep roots required to stabilize streambanks and are therefore poor components for buffers. Hardened stream banks (those that have been paved or stabilized with rock wall, rip-rap, etc) can also cause downstream erosion, eliminate natural filtering, and degrade natural habitats.

Healthy Streamside Buffers

One of the main components to a healthy buffer is vegetation. Overhanging branches from trees and shrubs provide shade to keep streams from getting too warm for fish during the hot days of summer and also provide nesting places for birds and other wildlife. Leaves provide the base of the food chain in aquatic ecosystems, feeding insects on both the streambed and the floodplain that will in turn become prey for fish and small mammals. Native plants are the preferred choice for riparian plantings as they are adapted to the climate of the region and are typically more resistant to pests, diseases, and drought. Native plants also provide preferred habitat and food for native wildlife. When designing with native plants it is important to vary not only the species, but the type of vegetation. A broad composition should not only include trees and shrubs, but native grasses and wildflowers. One important note about the effectiveness of riparian areas is that their function is undermined by canals, ditches, swales, or any other feature that delivers water directly to the stream, thereby preventing the riparian vegetation from filtering the water before it enters the stream. Buffers function best when surface runoff is allowed to flow through the vegetation and soil before reaching the stream.

Local Perspective

Assessment of Riparian Corridors in Moodna Creek Watershed Submitted by John Mickelson

To support the OC Water Authority's Moodna project, the land cover contexts adjoining the Moodna's riparian corridors were evaluated, using a Geographic Information System (GIS). Funded by the Hudson River Estuary Program (HREP), under the auspices of the New England Interstate Water Pollution Control Commission (NEIWPCC), a ranking of the land cover types and habitats adjoining the riparian zones were constructed to provide an index of Stream Health and Stream Vulnerability.

Stream Health was estimated according to the land cover surrounding a particular riparian zone, where land classes are valued by their projected impact on local water quality. Within the model, stream corridors flowing through Forest, Wetland, and Shrub and other undisturbed land cover classes are ranked "5" or Excellent (on a scale of 1-5, with 5 being high) , while those surrounded by highly human impacted classes (Urban, Roads, Industrial, etc...) are ranked "1" or Poor. Intermediate classes are ranked along the gradient. The working assumption is that intact riparian corridors can better protect local water quality. Stream Vulnerability is approached similarly, and in addition to Land Cover includes Slope and Soil Permeability, to calculate an estimate of stream edge stability and the potential for erosion and run-off. The modeled Streamside Health and Stream Vulnerability values were summarized by the 17 sub-watersheds within the Moodna basin, to evaluate drainages with healthy and intact stream corridors as well as areas within the Moodna basin where water quality is likely to be affected by degraded riparian buffer zones.

The Cornell model, (http://strmhlth.cfe.cornell.edu/index.html) employs publicly available digital geospatial data and prepared software scripts to allow GIS users to assess stream-side patterns for their local stream networks. Since the best widely available land cover data for our entire region has a spatial resolution of 30m, the model was calibrated to utilize data and output results at this pixel size. A Hudson River Estuary Program team, considering riparian issues for some years, was interested in knowing how outputs from this approach might compare to one which utilized finer scale data. With their support, a finer grain assessment was commissioned for the Moodna basin, to better understand the relative cost\benefit issues of scale in the assessments as well as to support the OCWA project with high resolution riparian data.

The *Fine Scale* model calculates the same *Health* and *Vulnerability* layers, but employs higher resolution (10m) data. Fine scale Land cover data for both metrics were derived by hand-digitizing stream-side features from high-resolution (6" resolution) true-color, leaf-off digital air photos from 2004. A *Slope* layer was produced from a 10m digital elevation model (DEM) and *Soil Permeability* was rasterized to match this resolution from vector-based SSURGO soils data.

Comparisons of the two scale runs for the 17 sub-basins found that Stream Health models produced encouragingly similar patterns. The heavily forested basin containing Mineral Spring Brook (Woodbury, Cornwall) ranked at the top of both run's summary measures. Several of the more developed (Silver (Newburgh, New Windsor), Moodna Creek drainages Stream Washingtonville (New Windsor, Blooming Grove)), with high degrees of impervious surfaces, roads and residential areas were consistently modeled as containing Fair\Poor Stream Health. Stream Vulnerability metrics between the two methods did not compare as favorably due to a range of issues, including thematic resolution of input variables. Consequently it suggested that, while still valuable, interpretation of is Stream Vulnerability maps should be undertaken on a basin by basin basis, and will be most useful as an advanced planning tool. It is the hoped that the project and it's resulting data will help inform а better understanding of the spatial dynamics, indicators and trends within the stream corridors of the Moodna basin. While additional work is needed (field verification and calibration to water quality sampling), clearly the work can help define priority areas within the basin, including problematic hotspots as well as stream courses and basins where restoration of vegetated cover can improve the county's public water quality systems.

Water Quality of the Moodna Creek and its Tributaries

A reflection of its diverse landscapes and land uses, the Moodna Watershed includes a range of stream types; many of these are high quality streams that support healthy fisheries, while others have documented water quality problems and are in need of remediation. Orange County is unique in New York because of the wealth of surface water quality data that is available, thanks to extensive data collection by both the OCWA and the DEC. OCWA's research has determined that non-point source nutrient enrichment is the most common cause of water quality degradation in the Watershed and while such enrichment is typically caused by wastewater infrastructure (including sewage treatment plants and septic systems) and/or runoff that includes fertilizers, additional research must be completed in order to determine where specific contributors of excess nutrients are located.

The OCWA has sampled stream water quality throughout the Watershed on an annual basis since 2004 (Table 1). This data was collected using the sampling method utilized by the NYSDEC's Stream Biomonitoring Unit, a method that collects and analyzes macroinvertebrates as indicators of water quality. The results of this sampling are expressed via Biological Assessment Profile (BAP) scores, which are numbers ranging from 0 (worst water quality) to 10 (best water quality). This numerical scale is typically separated into four categories that serve as a non-regulatory classification system for streams and rivers: non-impacted (BAP 7.51 – 10.00), slightly impacted (5.01 - 7.50), moderately impacted (2.51 - 5.00), and severely impacted (0 - 2.50). This classification scheme is shown in Map 5, which displays the stream biomonitoring data from 2004 to 2008.

As seen in Table 1, water quality at 51 different sampling points throughout the Watershed varied widely. The best water quality was found downstream of Walton Lake in an unnamed

tributary (Station 4089_007; 8.80) in 2004 and in the Idlewild Creek at two sites just outside of the Village of Cornwall-on-Hudson (2489_007; 8.50) in 2004 and (2489_009; 8.30) in 2006. All three of these sites are downstream of reservoirs, which are generally safeguarded by the water supply manager in order to sustain their important role as a drinking water supply. Although no sites in the Moodna Watershed were deemed to be severely impacted, 18% of the sites had moderately impacted water quality. The poorest water quality in the Watershed was found in the Black Meadow Creek (2201_001; 3.12) in the Village of Chester in 2005, but improved slightly the follow year, and the Otter Kill (3489_001; 3.40) in 2005 in the southern portion of the Town of Hamptonburgh. In 2008, five sites were sampled, four of which were sampled in the past. Monitoring results for two sites on the Woodbury Creek indicate that the water quality from 2007 to 2008 had declined slightly, as had the quality at the Moodna Creek and Silver Stream sampling sites. Specific information, including pictures, detailed maps, macroinvertebrate species, and water quality parameters can be found in reports located on the OCWA website http://waterauthority.orangecountygov.com/, under Stream Water Quality Biomonitoring.

OCWA's Biomonitoring Project was not designed to generate conclusive determinations about the causes of impacts at any given site. The results do, however, provide a starting point for identifying sites with significant problems and for planning follow up studies to identify and correct these problems. To assist with such investigations, an Impact Source Determination (ISD) was determined for many of the sites sampled. This ISD is a ranking of the most likely cause of water quality impacts at each impacted site; it was ISD information that led to the conclusion that, at most sites in the Moodna Watershed, non point source nutrient enrichment is the most likely predominant cause of water quality degradation. Perhaps one of the most functional uses of the stream biomonitoring data is that it establishes baseline water quality information against which future water quality data can be compared to establish trends and changes over time.

Research performed by the DEC, who at times used OCWA's Stream Biomonitoring data to supplement their information, has revealed significant impairments in a select few surface waters. These streams, listed below, have been added to NYS's Priority Waterbodies List (PWL).

•	Moodna Creek, Up	Category: Minor Impacts			
	Aquatic Life				
	Causes:	Nutrients			
	Sources:	Agriculture, Urban/Storm Runoff			
•	Woodbury Creek a	nd Tribs	Category: Minor Impacts		
	Aquatic Life	Aquatic Life KNOWN to be STRESSED			
	Causes:	Nutrients, salts			
	Sources:	Deicing, Urban/Storm Runoff, Muni	nicipal		
•	Otter Kill/Black Me	eadow Creek and Tribs	Category: Threatened		
	Habitat/hydro				
	Causes:	Water level/flow, thermal changes			
	Sources:	Construction, Habitat Modification			
•	Woodbury Creek a	nd Tribs	Category: Minor Impacts		
	Aquatic Life	KNOWN to be STRESSED	_		
	Causes:	Nutrients, salts			

Sources: Deicing, Urban/Storm Runoff, Municipal

These streams and their tributaries are in need of enhanced protections to prevent further degradation and to restore their integrity. See <u>http://www.dec.ny.gov</u> for more information on the Priority Waterbodies List.

In general, the primary factors that influence water quality include the presence and structure of riparian vegetation, percent impervious surface of the watershed or subwatershed (areas with a high percentage of impervious surfaces are associated with low water quality), discharges of inadequately-treated wastewater, soil or groundwater contamination, and siltation. As shown in Map 4: Impervious Surfaces, there are substantial concentrations of impervious surfaces in the Watershed, which likely contribute to water quality declines unless surface runoff is adequately treated by stormwater facilities or by ample vegetated buffers on waterbodies. This Map symbolizes the sub-watersheds based on their percent impervious cover. While the OCWA

stream biomonitoring does data not conform necessarily to this guideline due the site-specific to nature of stream water quality as well as potential land cover data inaccuracies. research shows that water quality generally begins to degrade when the impervious cover in a watershed exceeds 10%. Degradation can obviously occur at lower impervious levels due to multiple different

circumstances. such as contributions by point sources of pollution. and likewise good water quality can be found in watersheds with impervious covers exceeding 15%; nevertheless, maintaining imperviousness below 15% is a goal of many watershed planners.



Map 4. Impervious Surfaces



Table 1:]	
Stream Biomonitor	Biological Assessment Profile (BAP) Score						
Stream Name	Station ID	2004	2005	2006	2007	2008	Municipality
Satterly Creek	2089_001	4.60					Blooming Grove
Satterly Creek	2089_002		6.40				Blooming Grove
Unnamed tributary	2089_003		5.30				Blooming Grove
Moodna Creek	2089_004	5.10	5.60				Washingtonville
Cromline Creek	2089_005	7.10					Blooming Grove
Perry Creek	2089_006		4.87	6.85			Blooming Grove
Perry Creek	2089_007		5.90	7.40	5.16		Blooming Grove
Cromline Creek	2089_008		4.70	4.16			Hamptonburgh
Satterly Creek	2089_009	5.50					Washingtonville
Black Meadow Creek	2201_001	3.30	3.12	4.60			Chester
Black Meadow Creek	2201_002					5.49	Chester
Seeley Brook	2289_002	5.60					Chester
Unnamed tributary	2289_003	6.90					Chester
Trout Brook	2289_005		6.50				Chester
Seeley Brook	2289_008		7.90	6.75			Chester
Seeley Brook	2289_009	5.60					Goshen
Idlewild Creek	2489_001			8.34			Cornwall
Moodna Creek	2489_002		7.60				Cornwall
Woodbury Creek	2489 003		7.30				Cornwall
Idlewild Creek	2489 004	5.30		7.09	2		Cornwall
Unnamed tributary	2489 006		8.20	8.20			Cornwall
Idlewild Creek	2489 007	8.50		7.72			Cornwall
Woodbury Creek	2489 008		8.20	7.30			Cornwall
Unnamed tributary	2489 009		8.30	7.15			Cornwall
Moodna Creek	2489 010		7.70	7.13		5.48	Cornwall
Mineral Spring	2489_011	8.10					Cornwall
Idlewild Creek	2489_012	6.60		5.80			New Windsor
Baby Brook	2489_013			7.60			New Windsor
Otter Kill	3089_003	6.10					Goshen
Otter Kill	3089_005		6.32		5.08		Goshen
Black Meadow Creek	3089_009		5.17	6.81	6.45		Goshen
Otter Kill	3489_001		3.40				Hamptonburgh
Otter Kill	3489_002		6.05				Hamptonburgh
Unnamed tributary	4089_003	7.80					Monroe
Unnamed tributary	4089_007	8.80					Chester
Moodna Creek	4800_003			6.02	5.68		New Windsor
Moodna Creek	4800_005			5.70			New Windsor
Unnamed tributary	4800_006		5.50				New Windsor
Unnamed tributary	4800_007	5.60	4.90	5.45			New Windsor
Unnamed tributary	4800_010				5.49		New Windsor
Silver Stream	4800_011		4.10	4.90		3.97	New Windsor
Moodna Creek	4800_012		6.00	5.28	4.66		New Windsor
Black Meadow Creek	5489_021	6.30					Chester
Mineral Spring	5889_001	6.80					Woodbury
Woodbury Creek	5889 002	5.20	5.70	5.80			Woodbury
Woodbury Creek	5889 007		6.40	6.70		6.47	Woodbury
Unnamed tributary	5889 009		7.49	6.70	8.25		Woodbury
Woodbury Creek	5889 010			4.16		3.75	Woodbury
Woodbury Creek	5889_011			5.60	7.30		Highland Mills
Unnamed tributary	5889_013			6.60	5.78		Highland Mills
Unnamed tributary	5889_014			4.98	3.74		Highland Mills

Lake Communities

Residents of lake communities have a unique interest in water quality since the condition of their lake affects neighborhood aesthetics, home values, recreational opportunities, and possibly human health. Yet a clustering of houses sited along or next to a lake increases the chances that contaminants will be deposited into the lake. The most common water quality concern in lakes that are influenced by residential uses is elevated nutrient levels. Typical sources of nutrient inputs include inadequately treated wastewater from failing septic systems or leaking sewer pipes, animal waste (especially dog and goose droppings), and lawn/garden fertilizers. Converting to a centralized wastewater system can solve problems associated with failing septic systems, but the cost is often prohibitive. In those cases, pinpointing and remediating failing units should occur. Many lake communities in Orange County have experienced water quality problems due to failing septic systems. One well-documented example is Greenwood Lake (in the Ramapo River Watershed), whose elevated phosphorous levels have landed it on NYS's 303(d) List of Imperiled Waterbodies.

Several lakes in the Watershed have been the focal point of residential development and thus have a unique set of issues and opportunities. Most prominent are:

- Beaver Dam Lake, which is almost entirely surrounded by an extensive network of approximately 750 homes. Beaver Dam Lake Association is a member of the NYS Federation of Lake Associations, Inc (NYSFOLA) and also participates in the Citizen Statewide Lake Assessment Program (CSLAP); a summary of the corresponding 2008 research is given below.
- Tomahawk Lake, which has a few dozen homes on the east side but is primarily encircled in forest. Tomahawk Lake Association is also a member of NYSFOLA. Other than recent concerns about widespread distribution of the invasive plant species, water chestnut, no additional data about this Lake was available during the creation of this Plan.
- Walton Lake, which has a dense residential neighborhood on one side and low-density homes on the other, is also used as a water supply for the Village of Chester. No water quality data was available during the creation of this Plan.
- Merriewold Lake, which is a small lake in Blooming Grove encircled by a few dozen homes. No water quality data was available during the creation of this Plan.

There are other lakes in the Watershed with a few to several houses along their borders but these are not as likely to be impacted by residential actions as those that are surrounded by homes. Brown's Pond, however, while not the center of a residential lake community, was nonetheless proven to be vulnerable to effects of nearby residential development when inadequate stormwater provisions during construction caused sedimentation of a portion of this reservoir.

Communities that are members of the NYSFOLA are able to participate in the Citizen Statewide Lake Assessment Program (CSLAP), which is a volunteer lake monitoring program run by the NYSDEC and NYSFOLA. This Program relies on citizen volunteers to collect biweekly water quality data and samples from June through October. Parameters include temperature, transparency, conductivity, pH, color, phosphorous, nitrogen, Chlorophyll a, and calcium. Water samples are sent to a state-certified lab for analyses and are ultimately included in a report generated by NYSFOLA & NYSDEC. Additionally, the data is stored electronically to allow for comparison of historical data and current conditions. Participation in the CSLAP gives lake

communities a solid base for making management decisions and also empowers residents to act as responsible stewards of their lake.

As referenced above, Beaver Dam Lake had been studied more than any other lake in the Watershed at the time of this Plan's creation. The Lake's 2008 CSLAP report identified some water quality issues including, but not limited to, consistently high phosphorus levels, low water clarity readings, high pH, intermediate ammonia readings, and high total nitrogen levels. Some of these findings are noted to be above NYS water quality standards for swimming, aquatic organisms and animals, and will likely cause nuisance algae blooms, reduce clarity and water quality and affect aquatic life. This is the first year Beaver Dam Lake was involved in this study and it is too early to determine what actions should be taken to address these issues, but some early predictions for management of water quality conditions may focus on reducing nutrient loading to the lake through maintaining septic systems, shoreline buffer zones, limited use of lawn fertilizers, minimizing land disturbances in the near-lake watershed, and localized stormwater management.

Biological Resources

The plants, animals, and habitats—the *biodiversity*—of the Moodna Watershed are a significant part of the region's character and natural infrastructure. They contribute directly to the quality and quantity of drinking water available to its residents. Land-use decisions made at the municipal and regional level will have lasting impacts on the function of natural systems, and their ability to support human communities. Loss of habitat can lead to a corresponding loss in basic watershed functions, such as water infiltration and purification by forests and grasslands, erosion control along stream banks, and flood attenuation in wetlands. Habitat loss and the fragmentation created by suburban sprawl also creates unsuitable conditions for many native plants and animals, and leads to ideal conditions for invasive species to take hold.

As detailed in this section, the Moodna Watershed supports abundant biodiversity, including many rare plant and animal species that are listed as endangered, threatened, or of special concern on both the federal and state species lists. The NY Natural Heritage Program worked with the Hudson River Estuary Program to map areas that are expected to be important to known populations of rare species and to significant ecosystems; these are called Important Areas and are shown in Map 6. As well, the NY Natural Heritage Program has deemed that substantial portions of the Watershed support Significant Natural Communities, which are ecological areas that are either rare in New York State or are an outstanding example of a more common natural community. Map 6 shows the geographic extent of these two biological resource classifications combined with a rare species inventory compiled by the OCPA in 2004.

The Moodna Watershed has an extremely rich diversity of amphibians and reptiles, many of which are rare. These species often require several different habitats for survival, so maintaining landscape connectivity is extremely important. (Mitchell et al. 2006) Within New York, the NYS-Endangered northern cricket frog frequently moves more than 300m (984 ft) from its summer wetland habitat. These movements utilize a variety of habitat types including wetlands, vernal pools, and forested uplands and may extend as far as 1.3km (0.8miles). Similarly, the spotted turtle needs to make overland movements to access different seasonal habitats.



Recognition of Significant Biodiversity in the Moodna Creek Watershed

Moodna Creek, together with its tributary the Otter Kill Creek, is identified in the Orange County Open Space Plan as a Priority Aquatic System (June 2004). The Open Space Plan and the Southern Wallkill Biodiversity Plan (Miller et al. 2005) also identifies several areas within the Moodna Watershed as Biological Diversity Hotspots, including Goose Pond, Bellvale, Snake, Brimstone, and Sugar Loaf and Schunnemunk Mountains and the Otter Kill, Seely Brook, and Black Meadow Creek corridors and Purgatory Swamp. In addition, the Biodiversity Plan identifies the Moodna/Otter Kill corridor as a Potential Wildlife Corridor. The Moodna Creek mouth and tidal wetlands were designated as "irreplaceable" Significant Coastal Fish and Wildlife Habitat by the NYS Coastal Zone Management Program, and highlighted as one of four Selected Priority Watersheds by the Orange County Open Space Plan (June 2004). The Nature Conservancy's report, Identifying Conservation Priorities in the Hudson River Estuary Watershed, identifies the Moodna Creek Watershed among a short list of priority watersheds within the Hudson River Estuary Watershed (Shirer and Tear 2005). The Highlands Coalition has designated the Schunnemunk Mountain/Moodna Creek/Woodcock Mountain area as one of its Critical Treasure Areas in the New York Highlands, in part due to its biodiversity values (Highlands Coalition 2005). A southern portion of the Moodna Watershed is included in the "Highlands" Significant Biodiversity Area (SBA) in the NYSDEC's Hudson River Estuary Wildlife and Habitat Conservation Framework (Penhollow et al. 2006).

Hudson River Shoreline: The Moodna Mouth

At the confluence of the Moodna Creek and Hudson River, the input of nutrients from the Moodna Watershed, the mixing of the Moodna's fresh water with brackish water from the Hudson, and the tidal influence of the estuary together create conditions and habitats that are uncommon in New York. The confluence of the Moodna and Hudson provides important habitat for bald eagle (NYS Threatened) and osprey (NYS Special Concern). It is one of the few areas in the Hudson where eagles are consistently observed in the summer. The area is considered important breeding habitat for bald eagle by the NY Natural Heritage Program and supports a wintering population of bald eagles from December through March. The tidal freshwater marsh at the mouth of the Moodna is the largest in Orange County. This 59 acre (24 ha), Class 1 NYS Regulatory Freshwater wetland includes areas of brackish tidal marsh and brackish intertidal mudflats. Statewide, there are few occurrences of these rare ecological communities, which host suites of species especially adapted to the changing conditions caused by tides. The wetland complex at the Moodna mouth is both breeding habitat and migratory area for birds; the creek is also thought to be a major crossing point for raptors migrating along the northern slope of the Hudson Highlands. These significant natural areas are shown in Map 7.

In the lower reach of the Moodna Creek, anadromous fish, including alewife and blueback herring, enter the creek in the spring for spawning, and the resulting larval fish develop in the flats at the creek mouth. The lower portion of the Moodna also supports a warmwater fish community throughout the year. As the salt front moves up the Hudson, bluefish, bay anchovy, weakfish, Atlantic silversides, hogchoker, and blue crab may enter the tributary to feed. Submerged aquatic vegetation (SAV) beds occur in the lower reach of the creek, in the embayment, and east of the train trestle along the Hudson shoreline. Unlike other tidal coves and bays in the Hudson where the invasive water chestnut often dominates and poses management challenges, the SAV beds at the Moodna mouth are comprised of water celery, a native plant.



Streams and Riparian Corridors

Streams and the vegetated corridors around them (called "riparian areas") support a high abundance and diversity of plants and animals, and are used as wildlife transportation routes if suitable habitat remains. Riparian areas often contain seasonally-flooded wetlands that provide habitat for the Hudson Valley's globally important amphibian and reptile diversity. For example, the wood turtle is found in stream corridors of the Black Meadow Creek, Otter Kill, Seely Brook and Woodbury Creek, and the northern red salamander and northern dusky salamander occur in headwater streams of the Watershed. The cerulean warbler and least flycatcher are stream corridor birds that have declined throughout their ranges in recent decades, but are still found in the Moodna Creek Watershed. The Watershed and its stream corridors are also home to important bird species such as harrier and short eared owls, as well as the Federally endangered Indiana bat (NYS Endangered), and possibly big brown bat, little brown bat, and the rare eastern small-footed bat (NYS Special Concern).

Little comprehensive monitoring of the Moodna Creek fish community has been conducted, resulting in sparse data regarding the abundance of fish within the Watershed. Other major tributaries of the Hudson River have experienced declines in fish diversity and shifts in abundance between the 1930s and the 1990s related to changing land uses and pollution. It is likely that parts of the Moodna Creek system have experienced these declines as well (Stainbrook et al. 2006, Daniels 1999).

Wetlands

The Moodna Creek Watershed contains a diversity of wetland habitats, including freshwater tidal marsh at the creek mouth, small woodland pools, hardwood swamps, springs and seeps, wet meadows, fens and beaver ponds. Wetland areas that are known to support rare species or otherwise significant biodiversity include Purgatory Swamp, the mouth of the Moodna Creek, small wetlands in the Highlands Mountains, and the Otter Kill, Seely Brook, the Black Meadow Creek basins.

Wetlands support a rich diversity of rare wetland wildlife, including southern leopard frog (NYS Special Concern), northern cricket frog (NYS Endangered), marbled salamander (NYS Special Concern – Watch List), bog turtle (NYS Endangered, Federally threatened), spotted turtle (NYS Special Concern – Watch List), great blue heron rookeries, nesting bald eagle (NYS Threatened), gray petaltail (NYS Special Concern), New England bluet, and many dragonflies and damselflies. Recently a significant population of the rare crustacean C. gynecia has been found in ephemeral pools and other small wetlands in the Black Meadow Creek Basin (New York Natural History Council, pers.comm). This important new discovery suggests that continued biological study can teach us more about the Watershed's biodiversity.`

Fens and woodland pools are two small but important wetland habitats that are often missed completely during the land use and conservation planning process and therefore warrant special conservation consideration, as they support species that rarely occur in other habitat types. Fens are an uncommon type of wet meadow, and provide habitat for rare plants, bog turtle, spotted turtle, ribbon snake, and several butterflies like the dion skipper. Woodland pools are excellent "nurseries" for developing amphibian eggs and larvae, and provide important breeding habitat for marbled salamander, Jefferson salamander, blue-spotted salamander, spotted salamander, wood frog, and fairy shrimp. In order to sustain populations of pool-breeding amphibians, substantial forested habitat in the surrounding area must be protected. The distribution of fens and woodland pools on private lands is relatively unknown or undocumented for the Watershed.

Grasslands, Shrublands, and Farmland

Historical agricultural practices, along with current farming activities, have maintained important early successional habitats like meadows and shrubby old fields in the Watershed. While larger grassland areas are best for supporting a diversity of grassland-breeding birds, some of the remaining small meadows in the Moodna Watershed are suitable for species that require less area for breeding, such as bobolink. Grassland species that were reported as 'confirmed breeders' in the Watershed during the 2000-2005 NYS Breeding Bird Atlas include bobolink, eastern meadowlark, and savannah sparrow; several additional grassland species were observed during the Atlas but breeding was not confirmed. The open, grassy areas at Stewart International Airport have historically supported grassland breeding birds, including upland sandpiper (NYS Threatened) in the 1980s. Given the recent expansion of the airport, it is uncertain whether grassland habitat remains available; however, small local airports and other facilities with large 'lawns' may provide suitable breeding or overwintering habitat if managed appropriately. Northern harrier (NYS Threatened) and short-eared owl (NYS Endangered) have been observed using grasslands near Purgatory Swamp as overwintering habitat. Old fields and shrublands are also valuable as part of the habitat complex of eastern box turtle (NYS Special Concern - Watch List), which was documented in nearly all subbasins in the southern half of the Watershed during the NYS Herp Atlas Project. While primarily a species of riparian corridors, wood turtle also uses field habitats, and other turtle species may seek nesting sites in open, exposed areas of meadows.

Cliffs and Caves

The mountains and ridges of the Moodna Watershed create an array of habitats and natural communities that are not found in other parts of the Watershed, including outcrops, ledges, acidic talus slopes, rocky summit grassland, and pitch pine-oak-heath rocky summit. Rare plants such as green rock-cress (NYS Threatened) and violet wood-sorrel (NYS Threatened) have been documented in ridge habitats in the Watershed, along with a number of rare dragonflies, butterflies, and moths like pine barrens underwing (NYS Special Concern). The ridges of the Moodna Watershed support populations of species like timber rattlesnake (NYS Threatened), northern copperhead, black rat snake, and eastern racer. While rocky habitats provide den and basking sites, these species use forests and some wetland habitats for other life needs, and require connected landscapes in order to move from one habitat to the next. Other species that may inhabit rocky ridges in the Watershed include five-lined skink, slimy salamander, peregrine falcon, porcupine, and bobcat, and many songbirds and raptors use the ridges of the Highlands as migratory corridors.

The Bull Mine in Satterly Creek basin provides important overwintering habitat for eastern small-footed myotis (NYS Special Concern) and Indiana bat (NYS Endangered). Human disturbance while bats are overwintering is a serious threat, particularly after tens of thousands of hibernating bats died throughout the winter of 2007-08 in the Northeast for unknown reasons. Bats play a very important role in the ecosystem, each consuming as many as 3,000 flying insects each night during the summer.

Cores, Connections, and Landscape Perspective

Analysis of biodiversity resources at the Watershed scale enables residents, planners, and conservation leaders to recognize patterns across the larger landscape, and to see the "big picture" that is often left out of the traditional site-plan review process, which is influenced by zoning requirements, Department of Health approvals, location of infrastructure, and similar concerns. The Moodna Creek Watershed Plan offers an opportunity for municipalities to identify their individual and shared resources, set priorities, and create new approaches for planning with a more comprehensive perspective.

The Orange County Open Space Plan (2004) identified a number of resources located in the Moodna Watershed as "Core Biological Diversity Areas". These include:

- Hudson Highlands (including Sterling Forest, Storm King, and Black Rock Forest)
- Schunnemunk Mountain
- Goosepond Mountain (including Goosepond Mountain State Park)
- Purgatory Swamp
- Stewart State Forest.

These large areas, many of which are protected, are known biodiversity hotspots with primarily undeveloped lands. Recent research suggests that habitat restoration efforts should focus on enlarging core areas, particularly by widening narrow sections of large fragments, to provide more interior habitat for core-dwelling species and to reduce invasive species, which flourish at the edge of habitat fragments (Ewers and Didham 2007). Studies at more local scales will help to determine what additional, smaller hotspots may be important components of this conservation network. For example, the Southern Wallkill Biodiversity Plan emphasized the biological importance of the Black Meadow Creek corridor and its relationship to Glenmere Lake, which is outside of the Moodna Watershed but supports a northern cricket frog (NYS Endangered) population that crosses the boundary (Miller et al. 2005). Spanning two distinct Watersheds, this area hosts significant populations of several rare, threatened and endangered species; some even consider this land to be the most biologically diverse in the County. Such diversity includes thirteen species of salamanders, New York State's largest concentration of the state-endangered northern cricket frog, birds such as pied-billed grebes, northern harriers, redshouldered hawks, red-headed woodpeckers, and bald eagles, and bog turtle habitat. An irregular, previously unrecorded color variant of the spring peeper has also been identified at this site. Such rich diversity is worthy of protection and appropriate management, and since Orange County owns a significant amount of land around Glenmere Lake and the Black Meadow Creek (Towns of Warwick and Chester), this Plan therefore recommends that a management plan be completed for this important natural resources.

Identifying and conserving links between biodiversity cores is necessary to allow wildlife to overcome fragmentation and still move between habitats. These wildlife 'corridors' are not the narrow, straight passageways we are familiar with in our built environment; rather, they need to be broad, natural areas without roads, housing developments, and other fragmenting features. Well-connected landscapes enable wildlife to move safely and maintain genetic exchange, and may also enable future migrations northward and to higher elevations, as species respond to climate change.

The following recommendations for landscape connections incorporate suggestions included in the Orange County Open Space Plan (2004):

- Goosepond Mountain to Sterling Forest
- Goosepond Mountain to Schunnemunk Mountain
- Schunnemunk Mountain to Stewart State Forest
- Schunnemunk Mountain to Storm King
- Black Meadow Reservoir to Purgatory Swamp
- Otter Kill/Moodna Creek corridor (linear along river)
- Stream corridors throughout the Watershed

Land cover and fragmenting features in these potential connections will need to be assessed to determine feasibility for establishing functional biodiversity corridors. In addition to maintaining existing connections, there may be opportunities to restore linkages severed by major roadways, dams, and other barriers. Subsequent steps may require intermunicipal partnerships, outreach to landowners, coordination with land trusts, and planning tools such as conservation overlay zones, critical environmental areas, and conservation subdivision guidelines.

Conclusions

Whatever the scale, the key steps to conserving biodiversity resources are to (1) identify resources, (2) prioritize resources, and (3) plan, protect, and manage resources. The Moodna Creek Watershed Plan is a tool that stakeholders can use to learn about their local resources, set priorities, identify gaps in information and set goals for future study; ultimately this will help to establish a framework for protecting the biodiversity of the Watershed for future generations.

Forest Resources

Over the course of history, the Moodna Watershed has been much more abundantly forested, and at times less forested, than it is today. Currently, forest cover predominates only in the southeastern quadrant of the Watershed (Map 8: Land Cover). In this area only about 10% of the land is developed and only a few percent is cultivated. The major forests within this quadrant are either private holdings, such as the large tract of Black Rock Forest, owned by a not-for-profit foundation, or public lands such as on Schunnemunk Mountain and the federal property on the West Point Military Reservation. In contrast, in the other three quadrants of the Watershed the land is predominantly either cultivated or developed, with only about 25% currently in forest cover. However, as a long inhabited area, (first by Native Americans and later by Euro-American settlers and their descendants) all forests within the Watershed have been impacted by human activity. All have been cut, many have been repeatedly cut, developed and/or cultivated, and many have been burned. As a result, most of the Watershed's forests are currently in relatively young developmental stages.
Forest Types and Successional Status

Forest types and composition vary throughout the Watershed in part due to many environmental factors, but also due to a range of historical and current human impacts such as introduced pests and pathogens, generations of repeated logging, suppression of fires, altered trophic dynamics (e.g. loss of predators), atmospheric deposition, and changing climate; these have all further altered the composition of the region's forests and ecological processes.

Eastern deciduous forests naturally cycle through successional sequences from young woodlands to middle-aged forest to old forest, with changes in species composition over time from short-lived trees requiring high light to slower growing, shade-tolerant trees with long life spans. But all forests are periodically reset to earlier stages by disturbance (fires, windthrow, etc.). Only a few trees around the Watershed have reached documented ages of 200 years or more (e.g. D'Arrigo et al. 2001). Human activities typically increase disturbance frequency and thus generally result in more young forest at the expense of old forest. The region's youngest forests are dominated by fast-growing, light requiring species such as gray birch, black birch, pin cherry, red cedar, and aspen. These are eventually replaced by longer lived, more shade-tolerant species such as red maple and most of the oaks. In the absence of disturbance, oaks and red maples would eventually be replaced by the longest-lived and most shade tolerant tree species such as sugar maple, hemlock and beech. But an intermediate disturbance regime has allowed oaks to dominate forests over much of the region for the last 10,000 years (Maenza-Gmelch 1997).

Most of the Moodna Watershed experienced a transition from forest to farm during the era of European settlement beginning in the 17th century. Much of the region reverted to forest during the late 20th century. Therefore the majority of forests in the Watershed are a century old or less. Some forest areas do remain that are up to 150 years old, but there is very little true old growth in the Watershed, despite the fact that trees such as white oak, beech and hemlock can live for 500 years or more.

According to the classic publication characterizing plant communities of New York State (Reschke 1990), there are at least eight different forest community types that occur from the lowest elevations of the Watershed to the tops of the highest ridges. At the very mouth of the Moodna is an area of **freshwater tidal swamp** featuring species such as green ash, black ash, red maple, slippery elm, and American hornbeam and shrubs such as alders and spicebush. In areas prone to seasonal flooding, such as Idlewild Glen and some locations further up the Moodna mainstream, one finds floodplain forest, dominated by species like silver and red maple, sycamore, cottonwood, black willow, and ash. Adjacent mesic forests in lower elevations may also have elm, tulip poplar, and sugar maple. Widely distributed, especially around the Watershed's lower elevations and adjacent slopes are so-called "successional hardwoods". These are typically found on previously cleared sites, characterized by a mixture of species such as gray birch, hawthorn, sassafras, box elder, American elm, slippery elm, red maple, pin oak, silver maple and red cedar mixed with non-native species such as black locust, tree of heaven, Norway maple and buckthorn. Elsewhere in valleys and around population centers are many scattered patches of sugar maple, pine, hemlock and introduced Norway spruce. Higher on the slopes, the proportion of oak increases in the widespread forests that the DEC classifies as either Appalachian oak-hickory forest (red, white, and black oaks, hickories, white ash, red maple, Eastern hop-hornbeam, with dogwood, witch hazel and shadbush), or on drier, rockier areas

chestnut oak forest (chestnut and red oaks, with white oak, red maple, American chestnut, huckleberry, and mountain laurel). Outside of the preserved areas, most stands of these forest types are highly fragmented and young, with a high proportion of early successional and nonnative species. Within the Highlands, the oak forests are typically less fragmented, but tree height growth is often restricted due to shallow bedrock, and the understory is typically dominated by witch hazel, mountain laurel, huckleberry and blueberry. A pitch pine-oak-heath rocky summit community type is sometimes present at higher elevations and on ridgetops, characterized by pitch pine, chestnut oak, and scrub oak. On a restricted number of higherelevation and north-facing slopes are found hemlock-northern hardwood forests which are dominated by eastern hemlock, sugar maple, and sometimes American beech, with associated trees including yellow birch and striped maple. However, the total amount of this forest type in the Watershed is restricted. Finally, forested wetlands occur all around the Watershed at various locations that are generally classified as red maple-hardwood swamp, dominated by red maple with other trees such as black ash, American elm, swamp white oak, and bitternut hickory and generally featuring a dense shrub layer with spicebush, winterberry, black chokeberry, red osier dogwood, and highbush blueberry.

Species Composition and Trophic Structure

In some recently and/or heavily disturbed forest fragments, native biological diversity has been greatly reduced and largely replaced by a suite of invasive non-native species. Invasive species can dramatically impact species diversity and ecosystem function. Two prevalent examples include the introduced brown headed cowbirds, which seriously parasitize the nests of many forest breeding birds and the hemlock woolly adelgid, an introduced insect pest that feeds on and devastates eastern hemlocks, have spread throughout the region.

The trophic structure and food webs of the area have been altered for well more than a century as a result of the widespread eradication of top carnivores. This "decapitation" of food webs has increased populations of many herbivores, especially deer. In these areas excessive browse on seedlings and small trees threatens continued regeneration of the forest (Phelps and Hoppe 2002). Where deer populations are especially high (more than about 40 deer per square mile) regeneration of native shrubs is typically threatened and populations of sensitive wildflower species have been reduced or lost completely.

Fragmentation and Disturbance

As mentioned above, most of the forests in the Moodna Watershed are highly fragmented and/or exist in relatively small parcels, contrasting with a few large, contiguous forest parcels, especially in the Highlands. Large contiguous forests provide important forest interior habitat which permits the survival of populations of many sensitive species including Neotropical songbirds and organisms with large home ranges and/or resource requirements such as bears and bobcats. Smaller forest tracts have a high ratio of edge to interior which can favor generalists and disturbance-adapted species at the expense of native forest interior species (Hoppe 2003). In some small forest fragments native species have been largely displaced by generalist and non-native invasive species.

Moodna forests have their own natural disturbance regimes including fires of varying frequency and intensity, ice storms, windthrow, landslides, and cycles of drought and flood. Human activity has substantially decreased the extent of fires through fire suppression. This has altered forest composition, especially in the upper slope and ridge communities which historically burned more often than the lowlands. Fire suppression has led to an increase in fire sensitive species (e.g. thin-barked trees such as red maple) at the expense of fire tolerant or dependent species such as chestnut oak and pitch pine. Fire suppression can also enhance the buildup of substantial fuel loads, potentially increasing the intensity of the fires that do occur. Fires increase nutrient cycling, unless subsequent storms wash nutrients from the sites, while fire suppression can retard nutrient cycling.

Notable Features of Moodna Watershed Forests

Forest types within the Moodna Watershed that are relatively rare around New York State include the tidal swamp, floodplain forest, and pitch pine-oak-heath rocky summit communities. The Highlands portion of the Watershed contains what the New York Natural Heritage Program considers to be outstanding examples of the state's chestnut oak forests. The only remaining old growth forests around the Watershed occur on scattered high steep ridges and summits of Schunnemunk Mountain, Black Rock Forest, and the adjoining ridges extending to the southern Watershed boundary. Eastern hemlock, pitch pine, and chestnut oak trees up to 300 years old have been found in some areas too steep and/or inaccessible for logging (D'Arrigo et al. 2001)

A notable feature of the Watershed is the high proportion of forest that is permanently protected. This includes most of the Highlands forests as well as the other large, contiguous forest tracts. Large areas of contiguous forest are required to sustain many late-successional and larger organisms and top carnivores whose natural home range may be several square miles or more. Protection of these larger parcels has facilitated the return of coyotes and bears, the persistence of populations of river otters and occasional habitation by bobcats.

Benefits Provided by Moodna Watershed Forests

Forests are much more than trees and associated species. While the components, including humans, are individually important, it is the processes which connect these components that define system functionality and ultimately provide the services and products that humans value. Forests are vital to humans because of these ecosystem services that they provide. In the context of this Watershed Plan, Moodna Watershed's forests are especially important because they not only provide water but also filter pollutants and regulate both water quality and flow.

It is clear from the biomonitoring project recently released by the Orange County Water Authority that forested areas are associated with high water quality scores and that the most impacted sites are located in non-forested (developed or cultivated) areas of the Watershed (OCWA 2008). Some of the best BAP score sites (Idlewild Creek 2489-001, 2489-006, 2489-007, Woodbury Creek 2489-008, 2489-009, Mineral Spring 2489-011, Trout Brook Tributary 4089-007) have significantly forested areas upstream, while some of the worst BAP score sites (Black Meadow Creek 2202-001, Cromline Creek 2089-008, Silver Stream 4800-011, Woodbury Creek 5889-010) had urbanized areas upstream. Forests further protect streams and adjacent low-lying areas by intercepting precipitation, using/retaining/transpiring much of this water, replenishing groundwater through infiltration, and slowly releasing the remainder to streams, thus helping to minimize stormflows. Forest vegetation also releases much of the oxygen that humans and other animals breathe. Forests control local cycling of many nutrients, and function in global cycles of water, carbon, and other chemicals (Dixon et al. 1994). They also filter out many atmospheric pollutants, although some trees release isoprene and terpenes that can result in ozone formation (Benjamin and Winer 1997). The abundant root biomass of forests and forest litter layers protect soils, and reduce stream siltation and sedimentation.

The Moodna's forests serve to support a wide range of biological diversity and are critical to the survival of most of the area's native species. Forests act to control and ameliorate climate, both locally and regionally. Forests enhance human health and provide nature enjoyment, solitude, and recreation. They are valued for their aesthetic beauty, and they enhance property values. They provide commodities including timber, pulp, fuel and a variety of other products. Parking lots and strip malls may have some value but they do not provide any of these services. Humans often take forests for granted. But we do so at our own risk. The natural processes that comprise forest function, if disrupted, can create changes that will not remain unnoticed.

Areas of Concern for Forests

Forests of the Moodna Watershed face challenges to their health which threaten their ability to provide the ecosystem services listed above. Many of these challenges are interrelated and act in concert to pose serious threats to forests of the Moodna Watershed. One major concern is further loss of forest habitat due to increasing development. Many areas are at risk of further land use change away from forest. Some areas that remain in forest cover have experienced recent declines in health and accelerated mortality for a number of native tree species, even some which have proven very resilient to past disturbances. Causes of significant tree die-offs include: hemlock wooly adelgid, beech bark disease, butternut canker, "ash yellows," anthracnose, and "oak decline."

The problems associated with increased tree mortality due to all of these causes are exacerbated by decades of tree regeneration failure around much of the Watershed. In most cases this is largely due to overherbivory by white-tailed deer, whose populations have been unnaturally high for decades, due primarily to a lack of natural predators. Regeneration of native species is further challenged by competition from a variety of non-native, invasive species. The spread of non-native invasives is a world-wide phenomenon and, due to the global scale of human movement, they will likely continue to spread.

Another significant challenge to the forests of the region is changing climate. In the 20th century the Moodna Watershed region experienced an overall warming in air temperature, due primarily to a trend toward warmer winters and summer nights (Warrach et al. 2006). Climate always fluctuates and has changed substantially in the past, but a concern is that the current rate of climate change may be more rapid than the response rate of many species (IPCC 2001). Modeling efforts by the US Forest Service project that, if current rates of climate change continue, within the next century the climate of the Moodna area will be unsuitable to support native tree species such as sugar maple and will be more suitable for species such as southern pines, currently located hundreds of miles to the south (Iverson et al. 2007). Changing climate is already likely responsible for changes in forest community composition, as Black Rock Forest records document that most of the species that were extirpated between 1930 and 2000 were

northern relicts such as black spruce, and most of the species that invaded the forest in that time were southern species with expanding ranges such as red mulberry and catalpa (Schuster et al. 2008). Further warming will almost certainly challenge other native trees that are sensitive to winter temperatures and the absence of winter snowpack (Pederson et al. 2004, Pederson 2005). The Moodna Watershed can probably expect further warming of nights and winters and reduction of winter snowpack, with resulting species movements and probable loss of the remaining patches of northern hardwood forest in the Watershed. It is less clear how precipitation patterns will change. However, it has been predicted that there may be increased incidence of weather extremes, which can include both heavy precipitation events with the potential for heavy runoff and flooding, and droughts which might be accompanied by increased fire incidence, potentially worsened due to high fuel loads resulting from fire suppression (NECIA 2006).

Forests also face continuing biogeochemical challenges through altered atmospheric chemistry and resulting chemical deposition. Precipitation in southeastern New York State continues to be acidic, depositing substantial quantities of nitrogen and sulfate and significant amounts of mercury on the landscape (NADP 2007). Combined with additional deposition in dry and aerosol forms, this leads to changes in soil chemistry over time and increased impacts on many native organisms. Some upper watershed areas in the Highlands have become completely acidified, resulting in strong selection for acid-tolerant species.

Forest fragmentation, tree mortality and disturbances favor generalist and often alien, weedy species, hastening rates of change. These factors, compounded by regeneration failure of many native species, indicate that future forests will be very different. We may expect increased populations of thin-barked, high seed producing species such as red maple and black birch, already abundant in the understory, along with fast-growing non-native species such as tree-of-heaven establishing in canopy gaps (e.g. Knapp and Canham 2000). Altered forest canopies and understories and reductions in diversity may result in future forests which store less carbon and may provide reduced ecosystem services compared to forests of the past.

Land Use

Protected Open Space

The biological and forest resources found in the Watershed and outlined in the previous two sections remain valuable and impressive to this day due in large part to land preservation efforts. One exceptional example of ecologically-valuable open space is Black Rock Forest, owned by the Black Rock Forest Consortium. This Forest includes nearly 4,000 acres of woodlands that have been used for scientific research since the mid-1900s and is still used as a living laboratory for students of all ages and backgrounds, including those performing research in pursuit of an advanced degree. Research has proven that this Forest has high habitat and species diversity. The natural state of Black Rock Forest acts as a safeguard for several reservoirs within its boundaries that serve the Villages of Cornwall-on-Hudson and Highland Falls. Other nature preserves within the Watershed include tracts adjacent to Schunnemunk Mountain State Park (owned by the Open Space Conservancy and The Nature Conservancy), and a portion of the Orange County Land Trust's Hamptonburgh Preserve.



Several agencies, both non-profit and governmental, hold conservation easements on farms or forests. Conservation easements restrict properties in Goshen (Orange County holds two easements in common with the Town of Goshen), Cornwall (Open Space Conservancy, Orange County Land Trust, and Scenic Hudson separately hold easements), Montgomery (Town and State cohold an easement on a farm), and New Windsor (Orange County Land Trust holds an easement on a farm).

The Palisades Interstate Park Commission (PIPC), a bi-state agency, also maintains substantial natural areas within the Watershed. Symbolized as State Parks in Map 9, PIPC's holdings provide nature-based recreation opportunities and also maintain and strengthen ecological communities. Several State Parks are within the Watershed, including the entirety of both Goosepond Mountain and Schunnemunk Mountain State Parks and portions of Harriman and Storm King State Parks. Though managed less for ecology than for historic context, the State Office of Parks, Recreation, and Historic Preservation (OPRHP) owns Knox's headquarters and the New Windsor Cantonment, both within the Town of New Windsor.

At the Federal level, buffer lands for the Appalachian Trail meander through a southern portion of the Watershed in Warwick, Chester, and Monroe, while West Point Military Academy owns forested land in the southeast. West Point, however, is considered to be only temporarily – not permanently – protected since the Department of the Army can choose to sell or lease portions.

The remaining protected natural areas are owned either by the County or by municipalities for water supply or parkland purposes. Over half of the County's reservoir lands at Glenmere Lake & Black Meadow Creek are within the Moodna Watershed (the Black Meadow Creek is a tributary of the Otter Kill which turns into the Moodna Creek when it joins with the Cromline Creek). Though owned by the NYSDEC, the County manages Kowawesee Unique Area, which encompasses the bulk of the valuable habitat at the mouth of the Moodna (i.e where the Moodna Creek meets the Hudson River). The Towns of Goshen and New Windsor each own sizeable tracts of land to protect their reservoirs (Browns Pond & Goshen Reservoir #2, respectively). Municipal parks in the Watershed vary in condition from manicured recreation fields (Goshen's Craigville Park) to forest (the bulk of Woodbury's Earl Reservoir Park) and therefore differ in the ecological services they provide, but the important public recreation they provide improves the quality of life of residents, as discussed in the "Recreation" section of this Plan, and does serve as important open space.



Map 9: Protected Open Space

*Considered as temporarily protected open space since it can be leased or sold at the discretion of the US Military Academy/Dept of the Army.

Local Perspective Watershed Modeling: Estimating Impact of Future Land Use Change on Water Quantity and Quality

Submitted by Molly Ramsey, Doctoral Candidate at SUNY ESF

Computer watershed models can estimate the effects of different land use change scenarios on the water resources of the Moodna Creek watershed. How the rates of simulated streamflow, groundwater, and runoff vary with the location and intensity of urbanization can help inform future economic development and water and land resource management plans. The first phase of the modeling project involves using simple watershed computer models to estimate the effect of development on the hydrology and water quality of the Moodna Creek watershed; this phase includes running the nutrient and sediment component of one of the modeling programs for the four different land use change scenarios. This phase has been completed, although it has not been validated with measured streamflow and water quality monitoring data, and therefore it is important to consider the results from the watershed models as preliminary. The second phase of the project is the installation of a stream gage along the Moodna Creek outlet and the calibration and validation of a physically-distributed, water routing model (surface and subsurface flows). This phase has not been completed, although this more data intensive, spatially-explicit watershed model will better inform water and land resource management for the watershed and will provide important hydrological data for characterizing the watershed and how it may change with increased urbanization, including peak discharge or streamflow that can be used to develop flood frequencies for the watershed.

Watershed Models

Generalized Watershed Loading Function Model

The Generalized Watershed Loading Function model (GWLF) is a hydrologic model that simulates water (including stream water flow, infiltration, runoff, and storage; groundwater will be estimated by difference) and loading of sediments and nutrients to receiving watersheds. The model can be used to represent multiple land uses including forest, wetland, meadow, and urban with varying degrees of imperviousness.

Integrated Watershed Condition Model

The Integrated Watershed Condition Model is a statistical model that predicts how watershed urbanization affects a large suite of water quality and biological variables. The modeled stream water quality is derived from multiple linear regression relationships calculated from stream water quality monitoring data and the land use characteristics of the associated watersheds obtained from the USGS NAWQA (National Water Quality Assessment Program) dataset (Hong et al. 2000). The dataset used in this model is restricted to the NY/NJ/PA area so that sufficient data sets could be analyzed without compromising specific characteristics of the region (Hong and Limburg, in preparation).

Land Use Change Scenarios

Generalized Watershed Loading Function (GWLF) Model Four different land use change scenarios were run in the GWLF model:

- 1) all forested
- 2) all urbanized (i.e. 100% impervious surface)
- 3) current land use pattern, based on 2001 National Land Use Dataset
- 4) 15% increase in urbanization.

These scenarios were applied to the major subwatersheds (also referred to as subcatchments) of the Moodna.

Preliminary Results

Hydrological Component of GWLF

Average annual groundwater rates (averaged over 16 years based on weather record from 1990 – 2006) were slightly lower for the 15% buildout scenario compared to the current land use. The 100% impervious or urban land use had the lowest groundwater rates overall with annual average rates barely above zero. The 100% forested scenario had the highest groundwater rates. The subcatchments varied somewhat with the Silver Stream subcatchment, with the highest percentage of urbanized land, having the lowest groundwater annual average rates and the Mineral Spring Brook with the highest percentage of forested land having the highest groundwater annual average rates. Simulated streamflow rates were consistent between subcatchments and land uses except for the 100% urban. In this land use scenario, streamflow was higher reflecting the higher runoff coefficients used for this land use in the model. Runoff rates were very high relative to other land use scenarios for the 100% urban. The 15% buildout had slightly higher annual average rates versus the current land use. The lowest runoff rates were for the Mineral Spring Brook subcatchment with the highest percentage of forested land and vice versa for the subcatchment with the highest percentage of urbanized land, Silver Stream. The GWLF simulations showed only small differences between the current land use and 15% buildout for all of the subcatchments.

Integrated Watershed Condition

Chloride concentrations in streamwater are highest for the subcatchment with the highest percentage of urbanized land, Silver Stream. While the data does not demonstrate a strong relationship, a few subcatchments with lower urbanized land had higher chloride concentrations. This may be due to a relatively higher percentage of agricultural land. The model was run for the Woodbury subcatchment for four different land use scenarios: current, 100% forested, 100% agriculture, and 100% urban. Chloride concentrations were much higher for the 100% urbanized followed by the current land use and then the 100% agriculture. Dissolved phosphorous and nitrogen concentrations were simulated as highest in the current land use scenario for the Woodbury. Contributions from forested land plus the agriculture and urban may be the reason for the higher concentrations in the current land use versus the single land use type of the 100% urban and 100% agriculture.

The general trends in the water quality conditions for each subcatchment included a higher biological index, lower nutrient concentration, higher dissolved oxygen content, and lower temperature for the subcatchments with the most forested land (for example, Mineral Spring Brook). The subcatchments with a higher proportion of agricultural land (e.g. Otter Kill) had the lowest dissolved oxygen concentrations, while the subcatchments with the highest proportion of urbanized land (e.g. Silver Stream) had the highest proportion of nutrients and heavy metal concentrations.

It will be helpful to compare these individual subcatchments with further analyses and how their water quality changes with different land use scenarios but particularly with water quality data collected from the Moodna Creek and its tributaries. Although the statistical relationships of the model were derived from regional watersheds, a more accurate understanding will only be gained when the modeled results are validated with field data.

Development Trends in the Moodna Watershed⁴

Development in the Moodna Watershed has been steadily increasing for some time, but beginning in 2005, there was a substantial increase in the development of the northeastern portion of the Moodna Watershed, specifically the Towns of Newburgh, New Windsor, Montgomery and Cornwall (Map 10). Development in the Town of Warwick on the southern end of the watershed has also increased; however, only a small portion of the Town of Warwick is located within the Moodna Creek Watershed, and the increased development is occurring primarily outside the watershed boundary. The majority of the proposed developments in the Town of Newburgh, the Town of New Windsor, the Town of Cornwall, and the Village of Cornwall-on-Hudson are within the Watershed boundary. Development in these municipalities is occurring in previously-established corridors; in the Town of Newburgh, several developments are proposed in the Route 300 corridor in close proximity to the City of Newburgh boundary, and in the Town of New Windsor, a new senior-housing development is proposed for Route 32, less than a half-mile from the "Five Corners" intersection (the intersection of Route 94, Route 32, and Route 300). Development in the Town of Cornwall is proposed more frequently in the area immediately surrounding the Village of Cornwall-on-Hudson.

There are many reasons for these increases in development permits. As the real estate market neared its peak, people began to extend the geographical parameters of their searches for relatively affordable homes within commuting distance of the New York metropolitan area. The northeastern area of the Watershed provides close access to both Interstate 87 (the New York State Thruway) and the Palisades Parkway, as well as to direct commuter rail links on the east side of the Hudson (Metro-North train stations in Beacon, Poughkeepsie, and Croton). Others capitalized on this increase in residential population to open businesses to serve the needs of the new residents. The Town of Newburgh, for example, has approved multiple new "big-box" commercial developments along the Route 300 corridor in the last five years; also along Route 300, two residential developments proposing a total of approximately 280 units are currently under consideration.

Primarily, commercial development is occurring in locations near existing similar developments; "big-box" retail developments are located near other big boxes, chain restaurants are near other similar chain restaurants, and so forth. Additionally, residential developments are located near established residential areas. Newer residential developments in the Town of Montgomery are located close to the Villages of Montgomery and Maybrook, while new housing developments have been proposed directly adjacent to the Moodna Creek on the border between the Towns of New Windsor and Cornwall in a moderately-highly-developed area. These particular developments are age-restricted housing, which is a residential category that has also increased substantially in recent years as the Baby Boomer generation reaches retirement age. However, there is at least one example of a proposed larger-scale subdivision in the Town of New Windsor, south and east of the Five Corners intersection, which is not age restricted. This development is located near several established neighborhoods and is in the area of the Town served by the Cornwall School District, which is more highly rated than the Newburgh Enlarged City School District that serves much of the Town of New Windsor.

⁴ This narrative is based on information regarding municipal submittals received by the Orange County Planning Department as per NYS General Municipal Law §239 of the State of New York. This Law requires that certain development activities within 500 feet of municipal boundaries, County or State roads, County or State parkland or recreational facilities, County or State land used for public facilities, or farm operations located within a County Agricultural District must be reviewed by the regional or county planning entity.



Map 10 Development Trends

N 1 0.5 0 1 Miles * Parcels that applied for a site plan or subdivision permit that was then forwarded to the County Planning Dept for review as mandated by NYS General Municipal Law section 239 I, m, or n.

** Developed land includes Residential parcels under 5 acres, commercial parcels under 20 acres, Industrial parcels under 40 acres, Community service parcels under 20acres, office parcels under 20 acres, public service parcels under 20 acres and roads.



Several parcels of land along the Moodna Creek in the Towns of Cornwall and New Windsor are being proposed for subdivision as of the writing of this Plan. The close proximity of these parcels not only to each other but also to the Creek creates the potential for impacts to water quality, scenic resources, and biological resources that exist in and around the stream corridor. The water level of the Creek could potentially become more "flashy" due to stormwater runoff from the site during storm events, while the baseflow of the Creek could possibly be lowered if the proposed developments install wells in the sand and gravel aquifer. Methods such as clustering, conservation subdivision and the incorporation of Low Impact Development techniques into these developments could go a long way in ensuring that water resources are minimally impacted.

Map 10 displays parcels that are already "developed" (see definition at bottom of map), and those that are proposed to be developed. The white areas, therefore, represent land that is developable, at least in theory (environmental constraints or other encumbrances could render some parcels within the white areas unable to be developed). This map also shows Orange County's adopted Priority Growth Areas, which are areas within which the County prefers to have future growth, especially higher-density or significant commercial growth, focused. Although development approvals are largely granted by the municipalities in New York State, it is within these areas that Orange County will give support, incentives, and investments for water and sewer infrastructure improvements/extensions, sidewalk construction, transportation infrastructure, opportunities for transit-oriented development, housing, and commercial development. Areas outside of the PGAs, on the other hand, are high priorities for farmland and open space preservation.

From the previous development proposals, we can generally assume that the following trends will continue:

- Development will be proposed first in areas with existing infrastructure; established travel corridors in or near centers with water and wastewater services
- Development will be proposed in areas with scenic value; many areas within the Moodna Watershed have picturesque characteristics and are likely to appeal to homebuyers and entrepreneurs.
- Development will be proposed near existing community centers or nodes; infill development will be proposed for lots within and adjacent to the Village of Cornwall-on-Hudson and established centers like Vails Gate in the Town of New Windsor and Orange Lake in the Town of Newburgh

Review of Local Codes and Plans

The following text is a summary of a detailed code and plan analysis conducted by the OCPD; the complete code review may be found in Appendix A of this Plan. This review work was completed in order to assess the strengths and opportunities that currently exist in the local codes; the OCPD made no attempt to determine whether ordinances have been effectively implemented.

Upon review of the comprehensive plans, zoning codes, subdivision codes, and other relevant land use codes and policies within each municipality, the OCPD found the following information. Most of the municipalities within the Watershed have comprehensive land-use plans, but not all of those plans include objectives intended to protect the natural resources and open space existing within the municipality. Those that do include those objectives typically protect these resources by endorsing wetland and farmland preservation as well as protection measures for existing natural resources and endangered species.

Municipalities within the Watershed typically encourage good land use practices rather than require them. The subdivision and zoning codes for the municipalities within the Watershed generally allow but do not require new developments to consider "cluster development" or conservation subdivisions, in which new residences or commercial buildings are clustered together on lots smaller than typically permitted by the zoning regulations, while the remaining land in the subdivision is preserved or protected as open space. Ridgelines or viewsheds are protected only in the Towns of Blooming Grove, Chester, and Cornwall, and only the Towns of Blooming Grove and Cornwall include measures of protection for historic resources and biological habitats.

Water resources are generally well protected in the Watershed. Several of the municipalities have established overlay zones, where zoning maps show an overlay zone protecting surface water, water supply, or aquifers in the area of the Moodna. Most of the municipalities are concerned with controlling streambank erosion and limiting development on steep slopes, and many municipalities include buffers for wetlands, floodplains, and waterbodies. The Towns of Blooming Grove, Chester, Cornwall, and Warwick all include a 100-foot building setback as measured from the high-water mark of a flowing watercourse, in which no buildings may be constructed, and the Town of Monroe requires a fifty-foot-wide buffer; the Towns of Blooming Grove, Cornwall, and Monroe require the same building setback from the shoreline of lakes and ponds as well. Although many wetlands in the County are protected by the U.S. Army Corps of Engineers and/or the New York State Department of Environmental Conservation, the Towns of Blooming Grove, Chester, Goshen, Monroe, Newburgh, and Warwick and the Village of Woodbury allow for additional wetland protection measures such as additional buffer area for wetlands, buffers for wetlands not protected by ACOE or DEC, and regulation of activities within wetland areas. All communities in the Moodna Watershed have adopted the Flood Damage Prevention Law as set forth by the DEC. In addition, the Towns of Chester and Goshen have delineated Floodplain and Ponding Area districts on their Official Zoning Maps, and the Village of Woodbury prohibits development in floodways.

This Plan recommends an audit and update of local codes to promote Low Impact Development (LID) techniques, also known as Better Site Design, which would be done through a roundtable process (see Plan Recommendations). This recommendation is an extension of the code review that was done by the OCPD; however the roundtable process directly engages the municipalities in the discussion, recommends a variety of actions that can be taken in order to promote low impact development, and provides an opportunity for municipalities to compare their codes and site design processes to determine what works. LID techniques are a set of design principles and tools for preventing increased flooding and increasing infiltration and natural stormwater treatment. Key goals in this approach are to minimize the creation of new impervious surfaces, reduce the footprint of new development projects, maximize preservation of natural areas,

maximize onsite infiltration of water into the ground, and reduce discharges of stormwater directly to streams or other surface water bodies. In short, LID can dramatically lessen the cumulative impacts of new development when used at a large or landscape scale.

Water Supply

In evaluating the existing state of the water supply within the Moodna Watershed for this Plan, the Orange County Water Authority relied primarily on three sources. James Beaumont of OCWA completed a comprehensive summary of available information about public water supply systems in his draft Report on Present Status of Orange County Water Supply Systems dated June 2002, spurred in part by the drought of 2001-2002. Another source was a survey of municipal leaders conducted by the OCPD and the Water Authority in 2003, which provided additional information about locations where water supply is considered an outstanding issue. The third source is the recent Water Master Plan, commissioned by the OCWA and completed in 2009.

All of these sources concur that water supply is a priority need for most municipalities in the Moodna Watershed. The 2003 survey of municipal leaders yielded the following comments: in Blooming Grove at the time, water was the "greatest issue"; in Woodbury at the time, water was a "huge issue"; and at the time, Washingtonville "needs more wells." Most of this Plan's discussion on water supply concerns can be found in the "Issues" section of the Plan, under Water Supply. Following is a brief portrayal of water supply sources in the Watershed, as well as some specific information about two municipal systems and a discussion about future water needs.

Sources of Water

In Orange County overall, roughly one-third of drinking water supply is from municipal systems using surface sources, one-third is from municipal systems using groundwater sources, and the remaining one-third is from private wells. Rural stretches of the Moodna Watershed are mostly served by individual wells, whereas the bulk of the Villages as well as sizeable portions of the Town of New Windsor are served by a centralized municipal or community water system (see Map 11: Water Supply Sources). These centralized water systems are supplied either exclusively by wells, or by a combination of wells and reservoir water.

It is important to also note that two New York City Aqueducts pass through the County, carrying a combined capacity in excess of 1,500 million gallons per day. Currently, the Village of Cornwall-on-Hudson and the Town of New Windsor tap into the Catskill Aqueduct to supplement their reservoir and/or well production.

Reservoirs

In the below list of reservoirs located in the Moodna Watershed, italics indicate a reservoir that supplies water for a community that is mostly or wholly outside of the Moodna Creek watershed.

- Walton Lake (serves the Village of Chester)
- Goshen's Reservoir #2 (serves the Village of Goshen)
- Silver Stream Reservoir/Brown's Pond (serves as an emergency back-up source for the City of Newburgh)
- Upper Reservoir (serves the Village of Cornwall-on-Hudson)
- Sphagnum Pond (serves the Village of Cornwall-on-Hudson)
- Tamarack Pond (serves the Village of Cornwall-on-Hudson)
- Arthurs Pond (serves the Village of Cornwall-on-Hudson)
- Aleck Meadow Reservoir (serves the Village of Cornwall-on-Hudson)

Note that only one reservoir supplies water to a community that lies entirely within the Watershed; water from the other reservoirs is exported into an adjacent watershed, resulting in what is called an interbasin transfer. The end of the "Water Supply" section has additional detail and recommendations on the topic of interbasin transfer.

Wells

There are approximately 260 municipal and community wells in the Watershed, ranging in production rate from 5 gallons per minutes (gpm) to a few hundred gpm. The majority of these supplies are bedrock wells, while a handful of others are shallow wells that tap into sand and gravel aquifers, including (highlighted in Map 11):

- Washingtonville
- o Cornwall-on-Hudson
- Village of Chester
- o Village of Woodbury
- Lake Hill Farms (Town of Chester)
- Highland Lake Estates (Village of Woodbury)
- Mountain View Estates (Town of Blooming Grove)

See the Water Supply section under "Issues" for further discussion on this topic.

Summary Information ('02) for Selected Municipal Water Districts within the Moodna Watershed The Village of Cornwall-on-Hudson, which is partially in the watershed, has one of the most prolific water supply systems in the County of Orange. They have a tap into the Catskill Aqueduct, a prolific sand and gravel well in the Moodna Creek Aquifer in the western part of the Town of Cornwall, and several small reservoirs in Black Rock Forest, all of which are in the Moodna Watershed. Presently the Village is in the final stages of construction of a new filter plant for the reservoirs in the Black Rock Forest. They are not using the reservoirs at the present time for a water supply; but when they come on line, they will extend an already more-thanadequate supply of water for the Village. The Village water supply system serves much of the Town of Cornwall, as well. The estimated safe yield of the entire Village system is 2.51 mgd (million gallons per day). The reservoir system contributes 0.8 mgd; the well field contributes 0.5 mgd and the Catskill Aqueduct contributes 1.21 mgd. The average production is 1.3 mgd.

In contrast, the Village of Goshen, also partially in the Watershed but served by a reservoir in the Moodna Watershed, has experienced several drought emergencies in the recent past. In 2002, the Village's primary reservoir was at about 44% of capacity, prompting the Village to buy water from the Village of Florida and pipe it from Florida's Glenmere Lake into Goshen's Prospect Reservoir. Goshen also has completed a well in the Wallkill River sand and gravel aquifer at Crystal Run Village in the Town of Wallkill. The Village's water supply problems will not end here. They must obtain a DEC Water Supply Permit for permanent use of the Crystal Run Village well field before they can install the permanent water pipe to bring the water from the well field to the Village. They also are hoping to drill additional wells at that well field. Judging from the Town of Wallkill's experience, they may be able to increase their yield from that well field to perhaps one million gallons per day. The reported safe yield of the Goshen reservoirs is 0.6 mgd. However, that value appears to be several times too high when the volume and drainage area of the Goshen reservoirs are compared to Glenmere Lake and Walton Lake where detailed safe yield analyses have been prepared. The reported safe yield of the Goshen system is 1.175 mgd (including 0.25 mgd from the Crystal Run Village well, 0.145 from the high school well, 0.180 mgd from the Harness Estates well, and 0.6 mgd from the reservoirs). The average production is 0.86 mgd.

Future Water Supply Estimates

To assess the ability of current supplies to meet demand both now and into the future, the Water Master Plan assessed current water supply and demand in addition to forecasting future needs in five and ten year increments; projections were made for 2013 and 2018. This forecast focused on municipal water districts, which account for most of the demand in Orange County and cover much of the area where demand is increasing. Data was evaluated for municipalities based on their supply source; for instance, the Village of Cornwall-on-Hudson supplies water to the Town of Cornwall as well as the Village, so the demands for the Town and the Village are combined and evaluated collectively as the Village of Cornwall-on Hudson. While surpluses and deficits were found throughout the County, the only community in the Moodna Watershed that is projected to have a potential water deficit in 2018 is the Village of Washingtonville (which could have demand increase to 90% of supply, a dangerously high proportion of its available water). The Town of New Windsor water district, on the other hand, shows a surplus in 2018 of more than half its supply, and the Town and Village of Cornwall-on-Hudson all show substantial surpluses both now and projected out to 2018.

The authors of this Plan, however, place a caveat on the above analysis because of the simple fact that, as mentioned in the beginning of the "Water Supply" section, not all communities within the Watershed that are serviced by centralized water get their water from within the Watershed; likewise, communities outside of the Watershed may get their municipal water supply from within the Watershed. An assessment of such interbasin transfers, as such cross-watershed water transports are called, has not been completed for the Moodna Watershed but is a recommendation of this Plan. Such an estimate, which would also include transport of wastewater and other imports/exports of water across watershed boundaries, would create a better understanding of the sustainability of water resources within the Watershed.



Map 11: Water Supply Sources

Wastewater Treatment

In the Orange County Water Master Plan Task 2 Report (OCWA 2009), municipal wastewater treatment plants within Orange County were inventoried to determine the population served and the aggregate permitted wastewater treatment capacity. This data provides an excellent picture of the existing conditions within the Moodna Creek Watershed related to wastewater. Eleven municipalities have sewer districts within the Moodna Creek Watershed and are approved by the State Pollution Discharge Elimination System (SPDES) to discharge wastewater into the watershed. The approved flows are as follows and include:

- Town and Village of Chester: 200,000 Gallons per Day (GPD) into Black Meadow Creek
- Town of Woodbury: 36,000 GPD into Woodbury Creek
- Town of Blooming Grove: 12,000 GPD into Satterly Creek
- Village of Washingtonville: 400,000 GPD into Moodna Creek
- Town of Cornwall: 1,620,000 GPD into Moodna Creek
- Town of New Windsor: 5,000,000 GPD into Moodna Creek
- Village of Maybrook: 400,000 GPD into the Otter Kill

In addition, 6 corporations are permitted to discharge wastewater into the Moodna Watershed:

- Nexans Energy USA, Inc: 60,000 GPD into Black Meadow Creek
- Star Anchors and Fasteners: 248,000 GPD into Woodbury Creek
- Yellow Freight Systems: (unspecified) into the Otter Kill
- Maybrook Travel Center: 5,000 GPD into Beaverdam Brook
- Eastern Alloys, Inc: (unspecified) into the Otter Kill
- Stewart International Airport: (unspecified) into Beaverdam Brook

The total permitted discharge of wastewater into the Moodna Creek Watershed is approximately 7,981,000 GPD. This is the equivalent of 14 Olympic-size swimming pools every day. The population served in sewer districts within this Watershed is at least 44,000 persons (some districts did not include estimates of population served in their responses to OCWA for data). The average per capita sewage generation rate obtained was 124 gallons/day. Therefore an estimated 5,456,000 GPD of wastewater is produced within the Watershed today.

The OCWA Water Master Plan projected wastewater treatment plant flow growth to the year 2018 by calculating the per capita sewage generation rate and applying population growth rate projections to NYSDEC populations reported in 2004 for each Wastewater Treatment Plant (WWTP). This calculation shows that four municipal treatment plants will exceed their design capacities by 2018. These WWTP are:

- Firthcliff WWTP (Cornwall) will exceed its capacity by 7,000 GPD
- Maybrook WWTP will exceed its capacity by 49,000 GPD
- New Windsor #12 WWTP will exceed its capacity by 44,000 GPD
- Washingtonville WWTP will exceed its capacity by 560,000 GPD

The OCWA Water Master Plan recommends that Orange County investigate these possible shortfalls and coordinate planning for wastewater collection and treatment with its water supply planning.



Map 12: Wastewater Treatment in the Moodna

The Water Master Plan cites recent NYSDEC data noting that municipal sanitary sewer districts serve 48% of the population. The remainder of the population, approximately 48,000, is assumed to be served by private sewage disposal systems, in the form of individual septic systems and small privately owned and operated wastewater treatment plants. These are permitted by each municipality and report to NYSDEC.

Recreation and Tourism

Outdoor Activities and Recreation⁵

There are abundant recreational opportunities located in the Moodna Watershed. About 1³/₄ miles of the renowned Appalachian Trail crosses through the southwest portion of the Watershed, where it connects to the Highlands Trail. The Highlands Trail crosses through the greater portion of the Watershed, north over Schunnemunk Mountain, through Black Rock Forest, and to the top of Storm King Mountain. The Long Path travels up from New Jersey and crosses northwest, through the central portion of the Watershed. Black Rock Forest is located in the eastern part of the Watershed, in the Town of Cornwall. The Museum of the Hudson Highlands, also located in Cornwall, offers many activities, including the Outdoor Discovery Center. The more urbanized, paved Heritage Trail passes through the southwest portion of the Watershed and provides access to developed areas of the County in a vegetated, natural setting.

There are many parks and Nature Preserves for recreational activities, bird-watching, horseback riding, and some hunting. Moodna Creek Park in the Town of New Windsor and in the shadow of Storm King Mountain, is available for several activities including creek access to the Hudson River. Hamptonburgh Preserve in the Town of Hamptonburgh is a 130 acre property and is prime nesting habitat for many species of birds. Seventy-four of these acres are wildflower meadow, farmland and riverine forest along the Wallkill River. Stewart State Forest in New Windsor, located at the northeastern tip of the Watershed, is a wildlife management area with semi-paved lanes for biking and walking. Schunnemunk Preserve in Cornwall, located at the northwest edge of Schunnemunk Ridge, contains several trails with rocky summits for Hudson River views. Adjacent is Schunnenunk Mountain in Mountainville, with 6 marked trails and excellent views that include those from the highest point in the Lower Hudson Valley. Goosepond Mountain in the Town of Chester is largely wooded and undeveloped but contains hiking areas and horseback riding by permit. Finally, the Kowawese Unique Area at Plum Point in New Windsor is a 102 acre park directly on the Hudson River with vistas of the Hudson Valley gorge and 2000 feet of sandy beach.

Recreational opportunities such as swimming, fishing, boating and even hiking along a river or lake create public awareness with regards to the health and importance of that resource. If people become attached and care about a resource, they will be more likely to protect it. The Moodna Creek and its tributaries have long suffered from a low public profile as a recreational resource and this should be changed. A few public access points within the watershed today (see Map 13) include:

⁵ The information herein is taken from the Orange County Travel Guide printed in 2008. No guarantee is made about the accuracy of the information listed. The Agricultural activities information is taken from a list of active farms provided by the Orange County branch of the Cornell Cooperative Extension.

Kowawesee Unique Area at Plum Point, New Windsor – This County Park that is open to the public permits many activities including swimming, fishing, boating (car-top boats only), picnicking and grilling, and also has a visitor center and a beach.

Earl Reservoir, Town of Woodbury – This town-owned park (available to residents of Woodbury only) allows swimming and diving, finish and has paddleboats.

NYS Route 32, Town of Cornwall – Along this stretch of road, there are three well known access points for fishing and hiking on the Moodna Creek. This area has been classified by the State of NY as a Class A Trout Stream, which is stocked with fish annually.

Town of New Windsor Water Treatment Facility, New Windsor – There is a small boat launch open to the public at the Town of New Windsor Water Treatment Facility off of Rt. 9W just upstream from the Mouth of the Moodna.

Additionally, the Otter Kill and Moodna and Woodbury Creeks (and possibly others) provide great kayaking opportunities when water levels allow. Unfortunately there are limited designated and legal access points to any of these waterways and therefore this Plan recommends that public access points be increased to allow greater opportunity for enjoying the streams and lakes of the Watershed.

Agricultural-Related Tourism

Within the Moodna Watershed there are numerous active farm operations. They include Blooming Hill Organic Farm in Blooming Grove, Stonefield Farm in Salisbury Mills, Jones Farm and Country Store in Cornwall, and Rock Ridge Alpaca Farm and Roe's Orchards in Chester. Chester is also home to Pine Hill, a u-pick establishment that is popular for tourists and residents. Also located within the Watershed are Rainy Day Farm, Berry Patch and C. Rowe and Sons in Campbell Hall, with the latter two also having the u-pick option. In addition, some farms are open specifically for the Holiday season, sometimes as early as October. They include Farm Sides Acres in Cornwall and Pine View Farm in New Windsor. Finally, Orange County hosts several weekly farmers' markets in various municipalities, one of which is in the Town of Monroe in the southern portion of the Watershed.

Nodes of Tourist Activity

The parks, preserved lands and agricultural activities listed above are important tourist resources and have an direct impact on the health of the Moodna Watershed. All of them are examples of land that is being conserved for open space, wildlife management or recreation, and development is strictly limited or prohibited on them. Another way in which the Moodna Watershed benefits from tourist activity is through the centralization of activity, to reduce automobile use among tourists. There are several village and hamlet-type of locations that host a variety of different tourist attractions. Some are walkable locations but all have activities within a short distance from each other. Encouraging tourists to centralize their activities helps to preserve the Watershed because it reduces the amount of auto-generated pollution both in the air and in storm water runoff. Here we describe some of these communities and their tourist activities.

The Village of Washingtonville is home to several activities all within walkable distance from each other, including the historic Moffat Library, Brotherhood Winery, other retail uses and restaurants, and the 94 Pitch & Putt. Similarly, the historic Village of Chester is home to several tourist attractions including the O & H Bait Shop for fishing enthusiasts, the historic Chester Railroad Station, Bodles Opera House, other retail uses and restaurants, and Hambletonian House Bed & Breakfast. Also located in the Town of Chester and roughly 2 miles from the Village of Chester is the regionally-known Hamlet of Sugar Loaf, a self-proclaimed arts and crafts community that attracts art-loving tourists from all parts of the New York City metropolitan region.

An important node in the Moodna Watershed is Vails Gate, which basically consists of the fivepoint intersection of NYS Routes 32, 300 and 94, and the surrounding area. Along with being a dense commercial and residential area, there are many historic and recreational attractions within a very short distance of the intersection, including trail access to the Moodna itself at Knox's Headquarters State Historic Site. Other attractions include the historic Edmonston House, the Last Encampment of the Continental Army, the National Purple Heart Hall of Honor, and the New Windsor Cantonment State Historic Site. Also nearby is Schunnemunk Shadow Stables, off of Rte 94, and the regionally renowned Storm King Art Center in Mountainville.

Finally, a burgeoning node of activity is the Hamlet of Campbell Hall, in Hamptonburgh, on NYS Rte 207. Aside from the aforementioned nature preserve there, attractions include Dorian Equestrian Center, the historic Bull Stone House, and the Hill-Hold Farm and Museum that hosts special events throughout the year.

Alternative Modes of Transport

Alternatives modes of transportation are of high importance in watershed protection as a means to reduce pollution on many fronts. Here we describe some alternatives to automobile use in the Watershed in the context of tourism. The first is the aforementioned Heritage Trail, which is a paved pathway that connects some major tourist centers. The Village of Chester, already mentioned for its several tourist attractions, sits along the Heritage Trail, giving it access to other communities in the County without need for an automobile. These include the Villages of Monroe and Goshen, and eventually the City of Middletown. All of these locations have sites and amenities within walking distance from each other, including retail uses, eateries, historic sites and parks.

It is also important to mention that two commuter rail stations are located within the Watershed. There is one in Salisbury Mills between Vails Gate and Washingtonville and one in the aforementioned Hamlet of Campbell Hall. Also noteworthy is Hudson Valley Biking, based in Monroe, which gives guided, customized bicycle tours through rural roads to local attractions.



Agriculture

Agriculture has affected nearly every stretch of the Watershed's landscape. The spread of agriculture through the Watershed in the 1800s caused mass clear-cutting of forest, leaving relatively few patches of old growth forest (see "Forest" section of this Plan for more info). Rock walls, evidence of historic farm field boundaries, are found throughout the Watershed, even on remote and steep hillsides of Schunnemunk Mountain.

Farmers first cleared the landscape in the 1840s to allow dairy farms and feed production to support the dairy industry. Dairy-related agriculture was the dominant landscape feature from the mid-1800s well into the 1900s, but federal policy changes in the 1980s and emergence of corporate-sized dairies in the West in the 1990s reduced the profits of dairies on the East Coast – Orange County included. From 1985 to 2000, dairy cow numbers in the County were cut in half and the volumes of hay and corn acreage subsequently dropped dramatically. This decline caused many farmers to sell their land, much of which was then taken out of agricultural production and subdivided into residences. Nevertheless, agriculture is still Orange County's leading industry and farms in the Watershed contribute significantly to the County's agricultural base.

Although much of what was once farmland has since regrown into forest or been developed into urban or suburban uses, agriculture remains a vital component of the economic, scenic, and ecological fabric of the Watershed. Today, farmland is largely clustered in the central, western, and northern reaches of the Watershed where the topography is more inviting for grazing of livestock or cultivation of crops (see Map 14: Agriculture). The appealing farm views within the Towns of Goshen, Hamptonburgh, Blooming Grove, Chester, Cornwall and New Windsor attract many tourists and residents and improve the quality of life. Five of the County's Special Scenic Areas are within the Watershed and two of these are agricultural views: Oxford Depot (Blooming Grove) and Kings Highway (Chester). Farmland can also improve ecosystem health by providing wildlife habitat, cleansing surface water, storing carbon (thus helping to minimize global climate change), and maintaining soil integrity.

Perhaps one of the most critical benefits of having a vibrant agricultural landscape in the Watershed is its proximity to one of the largest markets on the planet: the New York City metropolitan area. The relationship between population centers and farmland will become more essential as fuel prices increase and food supply becomes increasingly global.



III. Issues in the Moodna Creek Watershed

As referenced repeatedly throughout this Plan, there are a range of issues having a negative impact on the Watershed, ranging from flooding and erosion to water quality degradation and loss of ecosystem services. Outlined below are the primary topics of concern that need to be addressed in the Watershed.

Flooding

Areas Damaged by Flooding in the Moodna Creek Watershed

One of the major issues identified by Advisory Committee members is flooding, or more specifically the damage caused by flood events. Certain areas have experienced repeated flood damage, caused by multiple floods during the past few years. Significant rainfall on April 15th, 2007 caused major flooding in Orange County and beyond, damaging property and closing numerous roads and bridges for days at a time. The timing of this flood event gave the creators of this Plan the opportunity to inventory the impacts to road infrastructure, namely bridges and segments of roads that were closed due to inundation or damage caused by floodwaters.(see Map 15 for these locations). Streams that overflowed their banks and flooded roads include at least the following:

- Moodna Creek, which closed multiple roads and bridges within the Village of Washingtonville (see inset of Map 15), including State Route 94 bridge at Orrs Mills Road, Patricia Lane, Beverly Lane, West Main Street, South Street, Democracy Lane, East Ave, Farm Lane, Freedom Drive, Hallock Drive, Lewis Court, Locust Street, Nicoll Street, Park Circle, Cardinal Drive, and Peacock Circle. Flooding of the Moodna also caused sections of Taylor Road and Otter Kill Road (Cornwall) to close.
- *Otter Kill*, which closed extensive portions of Otter Road, McBride Land, and segments of Maybrook Road (all within Hamptonburgh), as well as Twin Arch Road (Hamptonburgh, New Windsor).
- *Cromline Creek*, which closed at least half of Cherry Hill Road and a portion of Tuthill Road (Blooming Grove).
- *Satterly Creek*, which closed most of Gilbert Street (Village of Monroe), a portion of Peddler Hill Road and all of Stone Gate Drive (South Blooming Grove), and Barnes Road (Blooming Grove). An unnamed tributary of the Satterly Creek closed much of Prospect Road (South Blooming Grove).
- *Perry Creek*, which closed an extensive portion of Mountain Lodge Road and all of Perry Creek Road (Blooming Grove).
- Silver Stream, which closed Old Windsor Road (New Windsor).
- An unnamed direct tributary of the Moodna Creek, which flooded Willow Lane (New Windsor).
- Unnamed tributaries of the Black Meadow Creek, which flooded a long stretch of Black Meadow Road and part of Pine Hill Road (Town of Chester).
- Unnamed tributary of Youngs Brook, which flooded a significant portion of Quaker Hill Road (Blooming Grove)

Several stakeholders suggested that releases of water from particular dams caused damaging flooding downstream. A cooperative and coordinated approach is needed to manage water control structures at dams to ensure that detrimental downstream impacts are minimized or eliminated altogether. The intermunicipal watershed group that will be formed as a result of this Plan should inventory ownership and management protocols at all dams that have a water control structure in place and then work with involved parties to resolve existing and potential concerns.

Pinpointing the cause of flooding at each of these locations requires extensive field investigation and is beyond the scope of this watershed planning process; however, further investigation into causes of flooding is a recommendation of this Plan. This Plan does outline common causes of flooding and discusses actions that can be taken to remediate impacts of flooding.

Common Causes of Flooding

Increased risks to public safety and health, and to property, arise when buildings or other infrastructure are located in places that are prone to flooding. Much of the damage – if not the majority of the damage – caused by flooding in the Moodna Watershed occurred within floodplains. Such damage could have therefore been prevented if building or road construction within the floodplain had been avoided. Additionally, flood risks and impacts are exacerbated by several other factors:

- Hydraulic constrictions, including bridges, dams, culverts, and other features that impede the flow of water, effectively choking a stream at a specific point and causing upstream areas to backup and flood;
- Development, clearing and increased impervious surface cover in upstream areas, which causes increased runoff during storm events;
- Filling of floodplains, which in their natural state provide room for water to spread out thus reducing potential for flooding farther downstream;
- Variations in precipitation and snowmelt patterns, including short-term climate and weather effects and longer term climate variations, some of which are believed to be caused by human activities (see "Climate Change" section for more information.)
- Sedimentation of streambeds, which reduces the depth of water in streams and also causes streams to widen. Sedimentation is caused by upstream erosion.



Map 15: Flooded Roads and Bridges: Flood Event of April 2007

In areas where flooding is already a problem, it is clearly a major priority to look for ways to reduce flood risks to human life and property. In the past, reducing and mitigating flood risk largely focused on attempting to improve the flow of water in streams by removing obstacles or by deepening, widening or straightening streams, and in some cases by raising the elevation of buildings or removing them altogether. The latter options are often very costly. Altering stream channels is likewise expensive, but also may not really provide the long-term reduction in risks that are sought.

It's also important to draw a distinction between different kinds of risks related to property damage from flooding and runoff. Flooding from streams and rivers that overflow their banks is one category, and this tends to get the most attention. Another category is increased or redirected runoff from human activities, such as new development projects, that impacts downstream property before it ever reaches a stream. It's not uncommon that wet basements, flooded septic leach fields, and other localized impacts are caused by runoff. Also in this second category, in addition to damage caused by water per se, are erosion and mudslides caused by altered runoff patterns. It seems that much of the focus of state and Federal regulatory agencies is on flooding from overflowing streams and rivers, probably in part because these other impacts are scattered around and not well documented.

Understanding Stream Dynamics

A detailed presentation on the disadvantages of some conventional approaches to stream management and flood control, and on alternative strategies, was given at a 2007 workshop in Cornwall led by Dr. Ann Riley, the watershed and river restoration advisor for the San Francisco Regional Water Quality Control Board, who is also the Executive Director of the Waterways Restoration Institute. The central themes she presented were: 1) that the basic principles affecting stream dynamics relate to the movement (erosion and deposition) of material along stream banks and bottoms, as well as to the basic geometry (path and gradient) of stream channels and 2) that two primary causes of flooding and stream channel alterations are hydraulic constrictions and excessive erosion or deposition of sediment.

A detailed discussion of the underlying concepts presented by Dr. Riley is beyond the scope of this Plan, but one of her primary themes was that the physical processes in streams are inextricably linked to a balance between the volume of water and the amount of sediment the stream is carrying. Depending upon their size and other characteristics, streams naturally need a certain sediment load to be stable. Certain human activities that alter this balance lead to either too much sediment in the stream or too little. Measures that harden or armor streambanks to prevent erosion, for example, can lead to a condition termed "hungry water," in which the stream carries too little sediment, and this tends to cause scouring of sediment from the stream bottom to compensate. The opposite effect, when excessive erosion occurs for various reasons, will lead to deposition of sediment that the stream cannot carry. Erosion and deposition are natural and healthy stream processes, in other words, but when either occurs at an excessive rate it becomes a problem.

Another basic principle that she focused on was that natural streams are not long straight channels, but tend to be sinuous with curves. This means that the actual length of the stream is longer than it would be if it were measured in straight-line distance. When a stream is

straightened in an attempt to increase the flow of water and thereby reduce flood risk, the average grade of the stream necessarily becomes steeper, water moves faster, and this increases erosion and incision, or downcutting of the stream bed. This incision has significant impacts for riparian ecology (see Grieser section.) In general, streams and rivers in a healthy watershed tend to migrate somewhat within the floodplain, and one key principle of sustainable stream management is to preserve the floodplain to allow this migration over time. If a stream channel is widened, the flood plain should also be widened, otherwise excessive deposition is likely and dredging may be required.

Dr. Riley's experience indicates that the most cost effective investments in improving stream conditions to mitigate flood problems is addressing hydraulic constrictions: the dams, culverts and bridges that impact stream flow in ways that can affect erosion and flooding. Hydraulic constrictions not only impede the flow of water but also alter sediment deposition and erosion patterns by slowing water and increasing sediment deposition above dams, which leads to the "hungry water" effect that increases stream channel erosion downstream.

A recent field investigation by the DEC's Hudson River Estuary Program revealed that 210 dams and 846 culverts are potentially⁶ present within the Moodna Creek Watershed (see Map 16: Dams and Culverts). This apparent abundance of hydraulic constrictions has a significant influence on flood levels within the Watershed, though specifics are not known at this time.

Jack Isaacs, the Habitat Protection Manager for DEC Region 3 who is involved in permitting and other aspects of stream management projects, has watched the implementation of various approaches over the years, including some of the newer ones that utilize stream analysis and restoration principles developed by David Rosgen, a leading figure in the field. While the Rosgen methods have been embraced by many, including some agencies implementing stream management projects in the NY City watershed region, Isaacs and others suggest that caution must be used before applying these concepts narrowly without also fully considering the whole suite of issues outlined above.

The field of stream management is still evolving. Some of the more recent innovations in stream management and restoration focus on using soil bioengineering concepts, which involve a combination of structural engineering, plant ecology, and stream management principles and tools. This approach for enhancing stream banks in targeted areas, when combined with preservation of the floodplain and other non-structural methods, seems at this point to provide the best chance for long term, sustainable stream management restoration measures for the stream corridor itself. Experience in streams where these approaches have been implemented includes the finding that while large storms can cause significant impacts in natural and degraded stream channels alike (erosion, etc.), the streams where the more sustainable management and restoration methods were used have recovered much more quickly without human intervention, as compared to other streams where more conventional approaches were used.

⁶ Field work to verify these barriers was done only on the Woodbury Creek. Culverts as potential barriers were mapped simply by identifying where streams intersected roads, using aerial photography. Dams were defined broadly to include any pond that was placed in a mapped stream; such a pond, for example, would not be considered a "dam" by most people but was mapped as such because it was likely created from the damming of a stream.

Federal, State, and Local Roles in Flood Prevention and Mitigation

Many federal, state, and local government agencies play a major role in addressing flooding issues. The Federal Emergency Management Agency, the US Army Corps of Engineers, and the NY State Department of Environmental Conservation are some of the key agencies, and the Natural Resources Conservation Service is also involved in certain programs. Because New York is a home rule state, the local level is also able to affect flooding and its impacts.

Federal Action: FEMA, Army Corps of Engineers, NRCS

National Flood Insurance Program – Tthe Local Municipal Role

A primary agency at the federal level is the Federal Emergency Management Agency (FEMA), which administers the National Flood Insurance Program (NFIP). NFIP is one of the primary existing frameworks aimed at preventing or limiting new building construction and filling in floodplains. The Program also encourages local municipalities to voluntarily adopt and enforce local floodplain management ordinances. To comply with FEMA requirements, these local laws must provide flood loss reduction building standards for new and existing development. In general, the NFIP's provisions apply to geographic areas deemed at significant risk for flooding that are known as Special Flood Hazard Areas.

Municipalities that join the NFIP must adopt and enforce minimum floodplain management standards for areas designated as Special Flood Hazard Areas (SFHAs) on maps issued by FEMA, known as Flood Insurance Rate Maps. The floodplain management requirements within SFHAs are designed to prevent new development from increasing the flood threat and to protect new and existing buildings from anticipated flood events. Local floodplain management ordinances and enforcement procedures must meet certain FEMA requirements, and local regulations must be updated when FEMA issues certain new data or when applicable Federal or State standards are revised.

If a municipality does not participate in the NFIP, there are significant ramifications for property owners. Flood insurance, which is generally not available except through the NFIP, is not available for buildings in these municipalities. Many forms of financial assistance for property owners impacted by floods during a Presidentially-declared disaster are also not available in these communities, unless the municipality applies and is accepted into the NFIP within 6 months of the Presidential disaster declaration.

Flood Insurance Rate Maps

FEMA's National Flood Insurance Program is based in part on Flood Insurance Rate Maps, which delineate a number of different geographic areas that are together deemed Special Flood Hazard Areas (SFHAs). These areas are subject to the local floodplain management standards outlined above, and which SFHA zone a site is located in determines the specific management standards and affects flood insurance rates. New Flood Insurance Rate Maps (FIRMs) and a revised Flood Insurance Study took effect in August of 2009. These new products are based on detailed technical analysis of watershed conditions and hydrology in certain locations in Orange County. The new maps designate certain new areas as SFHAs, which will potentially lead to a requirement that owners of existing buildings in these areas buy new flood insurance, which can

cost several thousand dollars per year. Flood insurance is typically required for any home that has a mortgage. In other locations, areas previously mapped as SFHAs have been taken out of the flood-prone areas in the new maps.

The FEMA Community Rating System – An Opportunity for Municipalities

FEMA's programs include an incentive for local municipalities to adopt floodplain management programs that go beyond the minimum requirements of the national program. This is called the Community Rating System, and in municipalities that implement this approach property owners are eligible for reductions in flood insurance premiums of 5-45%.

Other Flood Studies and Programs

US Army Corps of Engineers: Nationally, the US Army Corps of Engineers is involved in evaluating water resource issues, including flooding risk management. The New York District of the US Army Corps of Engineers is responsible for all waters that drain to the Hudson River and implementing projects that are technically feasible and economically justified to resolve water resource problems. The Corps requires that they are Congressionally authorized to conduct a water resource study and study/project funds must be appropriated prior to any work. Their work generally follows a precise process with a number of steps that can take years to implement. In contrast to FEMA, which provides funding for near-term mitigation of damage after certain storms, the Corps follows a longer-term process for its projects.

In the Moodna Creek Watershed and adjacent areas, the Corps is in the process of preparing an initial assessment of flooding problems in a number of counties, including Orange County, that were affected by the April 2007 storm that was a declared disaster. This project, known as a Comprehensive Response Document (CRD), is the first step towards conducting more detailed studies in one or more watersheds in these counties. This study includes the Moodna Creek Watershed and Army Corps staff have held meetings with county and local municipal officials to collect data. The next step, if it is authorized by the US Congress, will be a more detailed study of the Moodna Creek Watershed called a Reconnaissance Report. The third step in the process is called a Feasibility Study, which then serves as the basis for construction projects to provide flood damage reduction. The current CRD project is expected to be released as a draft for comment in 2010 and after being finalized will be submitted as a report to Congress. For Corps projects, local support is critical at each step along the way. Local involvement includes participating in cost-sharing; while the current CRD project and the potential next step, the Reconnaissance Report, are fully funded by the Federal Government, the Feasibility Study generally requires 50% local funding and construction projects require 35% local funding.

Natural Resources Conservation Service: The Natural Resources Conservation Service (an agency of the US Dept. of Agriculture) is in the process of finalizing a study focusing on one small area along Cardinal Drive in Washingtonville that has a history of significant flood damage. FEMA has previously purchased and demolished several homes in this area.

State Level: NYS Department of Environmental Conservation

New York State, primarily through the Department of Environmental Conservation (DEC), has lead and active oversight in floodplain management. DEC also coordinates with the State Emergency Management Office (SEMO) on flood hazard response and mitigation. In the Moodna Watershed, municipal officials and property owners may be most familiar with flood hazard programs as well as stormwater management. In recent years, DEC has moved strongly to implement such management, particularly within the Urbanized Area of the Moodna Watershed where the "MS4" requirements are now in place. These requirements address a variety of stormwater management elements, notably the necessity to file stormwater management plans for certain new development as well as other requirements on local governments to advance education and other management programs. While stormwater management regulations are primarily driven by water quality protection goals, flood control objectives are also factored into the design guidelines for stormwater management facilities in new development.

Local Level: Municipalities and School Districts

Opportunities for implementing enhanced flood prevention and mitigation strategies at the local or regional scale include using low impact development stormwater management design principles and practices in new development projects, local regulations to limit development in selected upstream areas that may significantly increase risks to locations downstream, local land use planning and zoning mechanisms to control the overall density of development, which could be linked explicitly to flood prevention goals, and enacting local floodplain management regulations that go beyond the minimum required by the National Flood Insurance Program. Local governments are also strongly encouraged to adopt stormwater management regulations modeled from sample codes already prepared by NYSDEC. Local governments are also encouraged to go beyond these model codes if interested.

Local Action: Low Impact Development (LID) to Prevent and Mitigate Flooding

For preventing increased flooding in areas where new development projects are planned, one of the best strategies available is a set of design principles and tools known as low impact development stormwater practices, also termed better site design (this topic is discussed in other sections of the Plan, including "Review of Local Codes"). Key goals in this approach are: 1) to minimize the creation of new impervious surfaces, which block the infiltration of precipitation and runoff into the soil and groundwater, 2) reduce the footprint of new development projects and maximize preservation of natural areas, and 3) use stormwater management practices that maximize infiltration of water into the ground onsite, and reduce discharges of stormwater directly to streams or other surface water bodies.

Obstacles to using low impact development (LID) stormwater practices include existing local regulations, which typically include many specific requirements for roadway width and design, drainage, curbs, and other infrastructure details for new development projects. These specifications very often conflict with the design principles and specific tools used in low impact design. One solution to this problem is to review local codes and ordinances to identify sections that conflict with LID principles, and revise codes where needed to allow or even mandate LID.



Implementation of Low Impact Development/Better Site Design Submitted by Kevin Sumner Orange County Soil and Water Conservation District

Plugging the terms LID and BSD into an internet search engine yields copious results from all over the United States, but measuring where in the country and to what extent these principles are seriously employed can be a challenging proposition. In contrast, we can fairly easily count the number of local municipalities that have adopted a stormwater management local law that has been determined to meet the minimum requirements established by the NYSDEC. BSD does not, however, lend itself as easily to implementation in the form of a regulatory device since it encompasses a *design approach* that would be difficult to define in terms of a local law or ordinance. Yet, in the opinion of many water resource professionals, current stormwater management laws without the addition of BSD principles will not provide for sustainable protection of our water resources.

The Lowes Home Center project, in the Village of Chester, provides a realworld example of how adoption of LID/BSD principles can be seriously implemented. In this case, the Orange County Soil and Water Conservation District (SWCD) was asked by the Village Planning Board to review the Site Plan proposal that had been submitted to them for the Lowes project. The SWCD prepares technical reviews on behalf of local governments with a focus on water resource protection. Ideally, these reviews work in concert with review services provided to these governments by private engineering consultants. The SWCD made extensive comments on the construction-phase erosion and sediment control plan that had been prepared for the Lowes site by Langan Engineering. In terms of postconstruction stormwater management measures, Langan was well aware of the minimum NYS requirements and had already prepared a plan that included 'wet ponds' for stormwater treatment, an option considered acceptable in the NYS Stormwater Design Manual. SWCD reviewed these aspects of the Site Plan as well and asked Langan representatives to consider adding measures to the post-construction SWM plan to augment the pollutant removal expected from the wet ponds, and to 'more closely approximate the predevelopment hydrology' (including less volume of surface runoff and more shallow and deep infiltration). SWCD made several suggestions in this regard, including use of parking lot islands for stormwater treatment.

Langan representatives were very receptive to working with SWCD to improve the Site Plan in this fashion and, as a result of numerous meetings and exchanges of correspondence, at least five additional measures were added to the Site Plan proposal to achieve the desired goals. These practices included: 1) reducing the overall number of parking spaces, 2) designing a number of the parking lot islands as rain gardens, 3) use of grass pavers instead of asphalt of concrete for a portion of the proposed paved areas, re-design of underground detention system to provide for 4) swale. infiltration/recharge, 5) bioretention/infiltration а In combination with the two wet ponds initially designed for the site, this 'suite' of practices is expected attenuate water resource impacts to a much greater extent than the initial SWM plan that met NYSDEC minimum requirements. In addition, these practices are not expected to cause an unreasonable increase in construction costs. Some of the measures, such as
reducing parking spaces, will instead reduce costs. While there will be some maintenance costs associated with some of the BSD measures, these as well are not expected to at all onerous.

Located on a site that will be visited by many people from the local community, unique opportunities will be presented to highlight some of the BSD measures employed in the site design through interpretive signage, tours and related educational functions. In this way, the challenging job of expanding the adoption of BSD measures throughout the region may be furthered. Since, as noted above, legislating BSD may be difficult if not impossible, it seems likely that educational efforts such as this will be crucial to widespread and meaningful adoption of these important water resource protection principles.

A final important point: the inclusion of these measures on this Site Plan proposal required the cooperation and hard work of many partners project applicant, their designers, including the the Village's consultants, the SWCD, and perhaps most importantly, the Planning Board. Their support was crucial to the ability of the SWCD to negotiate Site Plan revisions with the project's designers. Equal hard work and cooperation at the project construction phase will be necessary to bring these measures to fruition. Past experience has demonstrated that good plans on paper do not always translate to proper construction techniques. Like any other successful initiative, long term commitment of human and everyone's best resources will be necessary along with financial intentions.

Dams

The abundance of dams in the Moodna Watershed has a significant influence on stream channel dynamics and creates unnecessary hazards to people, property, and the environment. As mentioned in the previous section and displayed in Map 16, research by the DEC's Hudson River Estuary Program identified 210 potential dams within the Moodna Creek Watershed, using remote sensing techniques. While some of these dams are still performing a public use, such as water supply, recreation, or hydropower, many of dams have outlived their original purpose and may pose safety, liability, and other concerns. Evidence clearly proves that dams can impact streams in at least the following ways:

- Altering water quality by reducing oxygen levels
- Increasing evaporation and temperature in the stream
- Blocking upstream migration by fish and other aquatic species
- Causing accumulation of sediment behind the dam, thus making streams shallower and even wider upstream of the dam
- Prompting erosion downstream of the dam

Additionally, dams can collapse, crack, or be washed away, causing a wide array of impacts from streambank erosion to streamside flooding and associated property damage. Certain dams in the Watershed have water control structures that allow the water to be intentionally released at specific times, but anecdotal evidence suggests that such releases of water, while improving

conditions behind the dam through decreased flooding, can be detrimental to downstream areas by causing unexpected flood surges. Watershed residents and property owners would benefit from increased coordination and awareness of dam management and from a more thorough inventory of dams. Strategic removal of certain dams could improve watershed health and safety and reduce flooding but more study is needed in order to identify and prioritize dams for removal.

Research on stream dynamics and dam removal has already been completed for one dam in the Watershed: a dam on the Moodna Creek behind the Lafayette Paper Mill site in New Windsor. This research was conducted by American Rivers, a national organization that protects and restores rivers, and could lead to reduced erosion and flooding locally if the study's recommendations are implemented (see Appendix D for full report). American Rivers found substantial streambank erosion and streambed sedimentation near the dam; both of these conditions are being perpetuated or exacerbated by the obsolete dam behind the Mill. The organization thus recommended the following actions:

- Removal of the dam, in order to eliminate high flow velocities caused by a breach in the dam that are exacerbating erosion along the stream banks. Dam removal would also improve conditions for fish movement.
- Excavation of the floodplain and vegetative stabilization. The banks of the Creek are steep in this area, leaving little room for the Creek to expand during floods. Stream flow velocities could be reduced if water could more easily spill out onto the floodplain, thereby reducing the erosive power of the water. American River recommends excavating a floodplain "bench" along the creek and aggressively vegetating it in order to reduce stream flow velocities.

Although the dam removal project is fully designed and permitted, funding needs to be secured in order to complete the removal. Complicating this dam removal project is the fact that in 2007 the river established an old river channel and skirted around the northern dam abutment structure. By doing so, the dam no longer serves as a significant barrier to upstream movement of aquatic life, and also curtails the ability to raise dam removal funds. This Plan nonetheless recommends that this dam removal project and associated restoration work be funded in order to remove the unnatural dam structures from the stream channel.

Climate and Water Resources

Observed temperature and precipitation records in and around this region are available back to the early 20th century, and in a few cases in the 19th century. During that time we have seen climatic swings that have occasionally resulted in stressed water supplies. It is possible that 21st century changes in climate will fall out of the range of what has been observed in the past. Hence, long term planning should consider potential future changes in climate that might affect the quantity and quality of water for future generations. In this section we briefly outline some salient points related to historical climate variations, and what we know about the potential impacts of future climatic variations on water supply, with a focus on the question of whether or not this region is at risk for significant droughts on the coming century.

Precipitation and temperature vary year to year, as well as decade to decade and over longer time scales. While our region has experienced a number of periods during which local water supplies were stressed during the last 100 years or so, the early- to mid-1960s stands out as the driest period. During that period, annual precipitation totals reached the lowest levels on record, and these record low levels lasted several years. Streams, and therefore the availability of surface water for consumption, were running significantly below mean values. Groundwater supplies, especially from wells adjacent to streams and rivers, were also affected. This period included the most intense drought, the "drought of record", in Orange County. While the 1970s tended to be relatively wet, since the 1980s a number of years have been relatively dry, but no dry periods have been as dry, or as long-lasting, as the 1960s.

While precipitation is the main driver of water availability, one should not underestimate the impact of temperature. Temperature is the main driver of evaporation rates from land and water surfaces, as well as of transpiration rates from forests. In our region, the fraction of annual precipitation that is lost to evaporation can vary significantly, between perhaps 30% and 60%, depending largely on temperature. Thus, years with the same amount of precipitation, but very different temperatures, can result in very different input to water supply systems. One study has estimated that for every degree F temperature increase, precipitation must increase by 5-7% for the total water input to the system to remain the same. These are just general guidelines, as the actual response in any situation depends on many factors such as the timing of the changes, winds, cloudiness, etc.

Studies of future climatic changes generally fall under one of two categories: 1) Sensitivity studies address questions of "what if." For example, what if precipitation decreases below 1960s levels? What if precipitation remains the same, but temperatures increase? 2) Other studies rely on projections of what might be expected to occur in this region under different "scenarios" of global climate change. Different scenarios refer to different projections of global patterns of energy usage, economic growth, technological advances, and other trends that affect climate. Each of these scenarios is then used as input into climate models to see how the different factors might affect climate across the globe. By considering different scenarios, and by including results from a number of different models, many of the uncertainties inherent in making any future projection can be accounted for, and a range of plausible future changes is obtained. Projections of regional temperature changes are considered more reliable than projections of regional precipitation changes, which are more variable geographically and more difficult to model accurately. The discussion below is based on results of previous studies of this second type of analysis.

Climate modeling studies performed in this manner indicate that the Hudson Valley region is likely to experience a significant warming by the end of the 21^{st} century. The range of temperature changes under a plausible range of scenarios is approximately 3-5 C°, or 5-9 F°. How significant is this change? One major study showed that such a change would result in longer, hotter summers that would be the equivalent of moving New York State down to South Carolina. These same studies indicate the precipitation is likely to increase, perhaps only a few percent, but perhaps by up to 20%. Thus, we do not know if precipitation changes will make up for the additional evaporation if the climate warms, and whether the annual water supply into our local systems will be significantly affected.

A recent study of historical changes in the nearby Catskill Mountains (Burns et. al. 2007), which supply most of New York City's water, indicates that in the last half century the region has experienced increases in temperature, precipitation, and water loss due to evaporation and transpiration. As a result of these changes, the annual supply of water to the basins has not changed significantly (it may have increased slightly), but the timing of streamflow has already shifted earlier by 1-2 weeks.

Another study of potential future changes to the New York City water supply region (Frei et al 2002) shows that, depending on the magnitude of temperatures and precipitation changes, the resulting mean annual input may change anywhere from +10% to -30%; under the driest scenario mean conditions will be similar to conditions during the 1960s drought; the mean annual snow pack will be reduced by at least 50%; and most of the runoff will be shifted to winter rather than spring. The most recent results available from the global climate modeling community corroborate the main point that a great deal of uncertainty exists with regards to the impact of climate change on water supplies in this region.

The two studies mentioned in the previous paragraphs did not address the intensity of precipitation. Climate models predict that heavy rainfall events in the region may become more frequent, a trend that has already become evident in recent weather patterns over many regions. The models also indicate that short, relatively severe dry spells will become more frequent. These trends may mean the region will experience a combination of more flooding and erosion while water shortages also become more common.

The impacts of these changes in precipitation patterns will potentially be exacerbated by landscape alterations from ongoing development. The creation of more impervious surfaces, in particular, generally reduces groundwater recharge and increases surface runoff. In combination with the effects of a changing climate, these trends may further reduce groundwater availability and streamflow levels during dry periods, while also increasing runoff and the risk of flooding and erosion during wet weather. These changes will also affect the ecology of habitat in streams and adjacent floodplains and wetlands.

Another predicted significant impact of climate change is a rise in sea level. In the Moodna Creek Watershed, this will affect water level areas at the mouth of the Creek where it flows into the Hudson River Estuary, because the level of the river is directly influenced by sea level. This area includes significant tidal estuarine wetland habitat that is likely to be significantly affected by sea level rises of even a few inches.

Responses to climate change can be categorized as either adaptation (adjusting to changes once they have occurred) or mitigation (proactively working, such as to reduce greenhouse gas emissions so that the rate of climate change is slowed). Local adaptation responses to the impacts of climate changes should include: enhanced water conservation measures; more widespread use of low impact development stormwater practices for new development, and retrofitting of existing neighborhoods with these practices; protection of streams, wide riparian buffers, and floodplains from development or alteration; careful consideration of appropriate designs for drainage infrastructure, bridges, and other infrastructure that may be affected by changing runoff and stream flow patterns. Local efforts to mitigate climate change include: land use planning efforts that reduce vehicle miles traveled (VMT); increases in energy efficiency in all sectors; increased usage of renewable energy sources; and planting trees. Two notable reports that concur with these responses to climate change are *Potential Impacts of Climate Change on Water Supply in Orange County* (OCWA 2009) and *Potential Impacts of Climate Change on Sustainable Water Use in the Hudson Valley (Frei 2009).*

Threats to Biodiversity

Two of the greatest threats to biodiversity are habitat loss and invasive species (Mack et al. 2000). In particular, land use changes that degrade and destroy natural habitats pose the most significant threats to native biodiversity. Suburban sprawl, for instance, fragments the landscape into smaller and smaller pieces of habitat, and surrounds these fragments with development, often having lethal effects on wildlife species that require large, connected natural areas. Furthermore, the resulting patchwork of land uses creates ideal conditions for invasive species to take hold.

Land-use decisions made at the municipal and regional level will have lasting impacts on the function of natural systems in the Moodna Creek Watershed, and their ability to support its human communities. For example, loss of habitat can lead to a corresponding loss in basic watershed functions, such as water infiltration and purification by forests and grasslands, erosion control along stream banks, and flood attenuation in wetlands. Habitat loss and fragmentation also creates unsuitable conditions for many native plants and animals, and leads to increased populations of more common, nuisance species such as white-tailed deer, Canada geese, mosquitoes, and black-legged tick, which carries Lyme disease.

Additional threats to biodiversity include impacts associated with human development, many of which can be reduced or prevented altogether, such as light pollution, failing septic systems, household pets, and pollution of natural areas from contaminants such as road salt, pesticides, herbicides, fertilizers, and household chemicals and pharmaceuticals. Increasingly, global climate change presents a new array of conservation challenges and variables, such as shifts in habitat availability and timing of natural events.

Water Supply Risks

Based on various sources including OCWA Report June 2002. Key findings include:

- A number of water systems had to add emergency supplies to sustain them during the 2001-2002 drought.
- The drought of 2001-2002 showed that the recorded safe yields are greatly over estimated for many of the water supply systems. Some major systems that depend on surface water supplies, including the City of Newburgh, and systems that depends on groundwater supplies that draw from shallow sand and gravel aquifers adjacent to streams, including Washingtonville, found that their recorded safe yields are not correct.
- The recorded safe yields of all of the water systems should be reevaluated as a first step in a program to assess the future water supply needs of the County.

During this drought, the following systems in or near the Moodna Watershed imported water to supplement their supplies:

- City of Newburgh opened the tap into the Catskill Aqueduct near Brown's Pond. That action was taken as a precaution in case there were lighter that usual spring rains.
- Town of Blooming Grove Water Districts 1 and 6 used their emergency wells.
- Town of Chester, Walton Lakes Estates brought water tank trucks of water and poured the water into the well. The well was used to pump the water into the system. The Town has drilled a new well that is being used on an emergency basis.
- Town of Goshen, Arcadia Hills brought water tank trucks of water and poured the water into the well. The well was used to pump the water into the system.
- Town of Goshen, Hambletonian Park brought water tank trucks of water and poured the water into the well. The well was used to pump the water into the system.
- Village of Goshen pumped water to Prospect Reservoir from Glenmere Lake when the Lake level was above a certain level. They built a temporary pipeline to bring the water to the Village. The Village of Florida asked Goshen not to pump when the Lake level dropped below that level. Goshen also has developed a well at Crystal Run Village near the Wallkill River. The last easement for the Crystal Run Village pipeline was litigated, and was secured in June 2002.
- Village of Kiryas Joel brought in about 420,000 gallons of water in tanker trucks to supplement their supply during Passover.
- Village of Washingtonville used emergency wells at the Spindler facility.

Some of these and other systems have repeatedly experienced real water supply concerns since the drought in 2001-2002. These situations have reinforced the need for all water systems to develop better safe yield estimates as the first step to assess future water supply needs.

The drought risk affecting the Village of Washingtonville was exemplified in 2005 during what was a relatively short but intense dry spell. While this was not considered a real drought, the Village was dangerously close to running out of water. This excerpt from an article in the Times Herald-Record describes the situation they were facing:

October 06, 2005: <u>Washingtonville facing water shortage</u> By Ashley Kelly, Times Herald-Record

Washingtonville - The village is tapping emergency wells in an effort to keep water supplies afloat in the face of drought conditions. "It's very serious. Possibly the village will be running out of water very soon," said Kevin Kropchak, department of public works supervisor. The last significant rainfall the town got was in April when parts of the village flooded. "We had a wet spring with flooding, but no sign of rainfall since then," Kropchak said. The village needs two months of regular rainfall, or the equivalent of 7 to 10 inches over an eight-week period, to meet its daily consumption of 550,000 gallons, said village engineer Jim Farr. Shipping truckloads of water into the village and building a five-mile pipeline from a neighboring area are two options village officials have discussed. Both have been deemed too expensive. It would cost the village \$10,000 a day to truck in only half of its daily water needs. The lack of rainfall has spawned mandatory water restrictions for village residents, such as banning outdoor water uses. Several anecdotal reports indicate that sections of the main stem of the Moodna Creek were totally dry during this short, intense dry spell. Locations that were reported as dry include an area in the Village of Washingtonville and one in the Town of Cornwall near New Windsor. With our future climate predicted to have more frequent and severe droughts and our rate of groundwater recharge likely to decrease, the need for adequate and reliable sources of water will become even more essential in coming years.

Better information about stream flow levels and trends could potentially be used to improve the understanding of safe yield for wells directly influenced by stream flow. Stream gages that monitor and record water levels could be used for this purpose, in addition to providing unique information that would help predict flood levels resulting from heavy precipitation events.

Existing monitoring and data collection systems for precipitation data, stream flow, groundwater levels, and other basic data are very patchy, at best. Groundwater is not currently monitored in Orange County, and neither is monthly production data for municipal water systems. Precipitation data is monitored, but this data is only archived at West Point, outside the Moodna Watershed.

Reservoir Concerns

Based on available information about water quality in the Watershed's reservoirs (listed and described in the "Existing Conditions" section under "Water Supply"), there are no known significant existing impairments that may affect public health, but there are definitely potential risks, and there are intermittent problems with the aesthetic quality of water. Walton Lake is reported in the 2008 NY State DEC Waterbody Inventory as being stressed and needing verification. The Inventory gives the following details on Walton Lake:

Overview: Recreational uses in Walton Lake may experience minor impacts/threats due to excessive aquatic vegetation and/or algal growth. This assessment is based on previously reported concerns and conditions in the lake need to be verified.

Previous Assessment: Concerns that recreational uses and aesthetics in Walton Lake may be restricted by excessive aquatic vegetation were previously reported. Suspected sources of nutrients feeding the lake include inadequate and/or failing onsite septic systems serving residences along the lake and lawn chemical/fertilizer usage. Urban runoff and road salt/sanding activity may also influence water quality in the lake. Grass carp were introduced to control aquatic vegetation growth in the lake. However the lake has been stocked with trout and it is noted as a satisfactory large mouth bass fishery. (Orange County WQCC and DEC/Reg 3, FWMR, 1996)

It is important to note that this information in the 2008 Inventory is focused not on water quality as it relates to drinking water, but on recreational and aesthetic uses and values of the lake. This does not mean, however, that the problems it identifies are not relevant to public health of water consumers. When water is disinfected using chlorination, the same eutrophic conditions that cause these aesthetic problems also contribute directly to formation of disinfection by-products that are considered a significant health risk.

In contrast to the area around Walton Lake, which has been built out with houses for decades, the Silver Stream Reservoir Watershed is currently under development pressure. While detailed information is not currently available about water quality conditions in the reservoir or how these may be changing over time, there are significant indications of actual or potential problems. In 2006, the US Army Corps of Engineers put a stop work order on a large development project immediately adjacent to the reservoir due to unauthorized disturbance of wetlands. An aerial image taken in 2004 clearly indicates turbidity in part of the reservoir, apparently from erosion and sedimentation from the adjacent development site. The City of Newburgh's Water Department has recently raised the issue of the need for better stormwater management and other measures in order to protect this water supply. In recognition of this concern, New Windsor's recently adopted Comprehensive Plan recommends creating a watershed protection law along with an overlay zone. The recommended overlay zone would include the area delineated by the boundary of the drainage area of the Silver Stream Reservoir. The intent of the overlay zone is to restrict the types of development and vegetative clearing activities that could potentially lead to water quality degradation. The Plan proposes requiring special permits for construction, filling, excavating and grading activities that take place within the overlay zones. Until this overlay zone is incorporated into the Town's zoning code, however, such an overlay zone is not in effect. The Town also plans on using available resources to acquire/purchase or otherwise protect the land surrounding Silver Stream Reservoir which is deemed to be the most pertinent to preserving water quality. In addition, New Windsor intends to work jointly with the City of Newburgh to assist in the protection of City owned watershed lands which surround the Silver Stream Reservoir. Regardless of whether such actions are taken at the municipal level, education of homeowners in this Watershed will be important to protecting the reservoir.

Concerns with Wells

Imperiled water sources are not limited to surface waters; the ability of wells to yield adequate supply is also a particular concern in the Watershed. OCWA's 2002 report states that safe yields for many municipal water systems are "greatly overestimated." This assertion, coupled with subsequent research, highlights the fact that this is especially true for systems utilizing wells drawing from sand and gravel aquifers. Washingtonville's wells, for example, are located very close to the Moodna Creek and water levels are directly linked to stream flow in the Creek. In September 2005, after only a fairly short period of low rainfall, the private wells serving the Village of Washingtonville were dangerously low and the Village issued statements warning that they could run out of water. Luckily, heavy rains in October alleviated this situation.

The sand and gravel aquifers that wells tap into are shallower than bedrock aquifers, have less distance between the ground surface and the water table, and typically recharge more quickly than bedrock aquifers. While sand and gravel wells are not necessarily under the influence of surface water, they are more susceptible to being affected by surface water and could therefore experience inconsistent yields resulting from changes in surface water levels. These wells may also be vulnerable to contamination from surface water if the well's cone of influence extends into a surface water body.

However, bedrock wells can also be under the influence of surface water, as demonstrated in Beaver Dam Lake. These community wells are in close proximity to the Lake itself and have

been determined to be hydrologically connected to the lake water, in all likelihood because of a fracture trace underneath the Lake that acts as a "pipe" connecting the well with the Lake.

Users and managers of any water supply that can be so easily connected with surface water should be aware that actions and conditions at the land surface could potentially cause a profound effect on the quality and quantity of their drinking water. Best management practices and wellhead protection zones are just two techniques that can be implemented to help protect these sensitive supplies.

Wastewater Concerns

Protecting and preserving water resources is one of the major challenges we face in the Moodna Watershed and other areas experiencing relatively rapid development. A comprehensive and sustainable approach to watershed planning must integrate water quantity issues – recharging groundwater and maintaining flow in streams – with more effective water quality protection. This section discusses some of the key concepts and goals that should be considered as new infrastructure is planned, with a focus on the fundamental importance of recycling wastewater and stormwater back into the local ecosystem. Systems that are designed to return water to the soil, together with effective management programs to ensure they are operated properly over time, can help to achieve these goals.

While the below text focuses on a "decentralized" approach to wastewater management, it should also be noted that different situations call for different treatment methods; while a decentralized approach may be the wisest option in some instances, traditional treatment methods, such as centralized wastewater systems and individual septic systems, are well-suited to others.

The Problem – "Big Pipe" Sewers and Impervious Surfaces

Conventional approaches to water-related infrastructure rely heavily on engineering but typically ignore some basic underlying principles of watershed hydrology. The result has been that, for many years, engineers have focused on moving water away to try and solve drainage and pollution problems. The first wastewater systems for cities, for example, simply used water to flush wastes downstream to the nearest river. Eventually, rising populations and increased awareness of links between polluted water and disease led to the first sewage treatment systems to cleanse the water before it was discharged. But while treatment standards gradually increased, and huge investments in wastewater collection and treatment infrastructure were made, especially after the 1972 Clean Water Act (which provided large Federal subsidies to local communities), the entire paradigm of moving this water away has remained central. Similarly, stormwater management has focused on building pipes to drain water away from buildings and roads. Regulations require treatment for stormwater from new development projects to remove sediment and other pollutants, but again the central concept of moving the water away remains entrenched. This "Big Pipe" paradigm involves spending a lot of money (the collection network alone for centralized sewage systems can be 60-80% of the total system cost) to move water and, moreover, depletes the water upon which local streams and watersheds depend.

Another major factor affecting groundwater, stream flow, wetlands, and other elements of a healthy watershed is the creation of impervious surfaces. This term refers to buildings, roads, parking lots and other hard surfaces that prevent rain from infiltrating into the soil. In an undeveloped forested watershed, the soil and underlying aquifer acts as a sponge. Rain is absorbed and drains into the ground (only during occasional larger storms is there much surface runoff). Over a period of weeks and months, much of the water flows slowly through the ground and eventually reaches streams. This flow of water moving through the ground and feeding the streams is called interflow and baseflow. In undeveloped areas, a large portion of the water flowing in streams, especially during dry summer weather, is this water that's traveled through the soil and groundwater.



Water Balance

Figure 4: This diagram from the Center for Watershed Protection illustrates how buildings, roads and other impervious surfaces cause more surface runoff and reduce the baseflow and interflow that are essential for healthy streams.

Impervious surfaces, however, cut off the infiltration of water into the ground, leading to reduced baseflow. The other effect of increased impervious cover is higher flows in streams during rainstorms because less water is stored in the soil and more runs off directly to streams. The result is higher peak flows during storms and increased erosion in the stream channel, all of which changes the ecology of the stream. The net effect is higher peak flows but lower flows during dry weather.

When these impacts of impervious surfaces are combined with the effects of centralized sewers, the problems can be magnified. In many areas, drinking water is obtained from municipal or private wells. While some areas are served by septic systems, which return the water to the soil, many areas are sewered. Water that is withdrawn from the ground and then discharged to sewers almost always ends up in a stream and therefore does not recharge the local aquifer. These areas, therefore, experience the combined impact of impervious cover reducing groundwater recharge, as well as groundwater being withdrawn and carried away in sewers.

Another problem with centralized sewers, which has gained little attention, is the so-called French drain effect. Sewer lines are generally installed to flow downhill by gravity, and often placed near or even in existing stream corridors because these follow natural drainage contours. The sewer pipes are laid in trenches with a bed of gravel underneath. The unintended consequence of these trenches however, creates a new conduit to drain groundwater away from local ecosystems. Depending on local soil and geology, this can result in the draining of wetlands and smaller streams. Another, much more widely known problem is called infiltration and inflow. This refers to the fact that sanitary sewer lines very often have cracks and leaks that let groundwater and rain enter the sewers. This means that in wet weather, wastewater collection and treatment systems can be overwhelmed with excess flows they were not designed to handle. In many systems in our region the end result is overflows and discharges of partially-treated sewage during wet weather. Finally, common sense will tell you that the same cracks and leaks that allow rain to get into sewers during wet weather may allow untreated wastewater to leak out during dry weather. This is probably a significant problem in some areas and may be resulting in pollution of groundwater and streams, but the extent of the problems is unknown.

A More Sustainable Approach – Decentralized Management

As outlined above, the conventional paradigm for managing both wastewater and stormwater is to move it away as quickly as possible. This mentality originated in an era before water quality and groundwater recharge were major concerns, but this has changed. Our current understanding of watershed systems now highlights the need for a more sustainable approach.

Alternative technologies and design principles for stormwater management, known as low impact development or better site design, are beginning to be used in the region and are, to a significant extent, being supported as a preferable approach by NYSDEC. For wastewater, decentralized wastewater planning and management principles are being applied in other parts of the US and are increasingly being discussed in this region. Ecologically based treatment systems such as a constructed wetland in the Town of Lloyd (Ulster Co.), a number of systems that use spray irrigation to polish treated wastewater, and others are operating in our region. In addition to recycling water, these systems can provide beneficial reuse opportunities for nutrients in wastewater, which can contribute to a sustainable regional agricultural economy.

Key obstacles to a decentralized approach, however, include a lack of awareness of local officials, developers, and others about what is actually allowed under current regulations. Another obstacle is the poor track record of previous generations of small treatment plants, often called package plants. A more fundamental issue, though, is how to control and guide the use of these decentralized systems appropriately. Steep slopes, smaller wetlands, and other sensitive areas are not protected by state laws, and more widespread use of decentralized wastewater systems will likely lead to development in some of these areas unless local regulations are enacted to manage what is permitted. Paradoxically, however, the very same decentralized technologies that pose a potential threat if they are not regulated and managed properly are absolutely essential for designing compact new developments that follow the neo-urbanist, or old-fashioned village development patterns, which rely on small lot sizes that are incompatible with the large lots needed for individual onsite septic systems.

Another key to effective implementation of a decentralized strategy is better planning and management policies and mechanisms for all wastewater systems. Currently, there is no state requirement for maintenance of private septic systems. Many municipal wastewater systems are aging and need upgrade or replacement, and it is well-known that wet weather overflows and other problems are causing discharge of inadequately treated sewage in many place. The coming years will see large investments in upgraded infrastructure and these systems can potentially incorporate a mix of decentralized systems (both individual onsite systems and small community systems) that are managed at the municipal or even regional level, but this will require better education, technical support, and policy initiatives at the state or county level.

As in most parts of the region, most larger wastewater treatment systems in the Moodna Watershed discharge to streams. There is at least one smaller municipal system that discharges to the ground, a system operated by the Town of Chester that uses a community leach field. From a watershed planning perspective there are some significant benefits available by discharging to the ground. These benefits include nutrient uptake by vegetation and soil particles (particularly if the discharge is in the shallow root zone instead of 2 feet below grade as in a standard leach field), groundwater recharge, and avoidance of adverse impacts to stream ecology from certain constituents in treated effluent, including nutrients. This is an important issue in the Moodna Creek Watershed because available water quality data indicate that nutrient enrichment is the most prevalent water quality problem in streams in the watershed (see the "Water Quality" section for more information).

Nutrient Management – A Critical Issue for the Moodna Creek Watershed

Even when wastewater treatment systems are functioning properly and meeting their permit requirements, unless these requirements include nutrient removal, discharges of treated effluent include significant amounts of nutrients. The nutrients that are most significant for water quality in fresh waters, generally, are nitrogen and phosphorus, with phosphorus being the one that is generally considered the critical factor in driving eutrophication of streams, reservoirs, and lakes. (Note – there is some research indicating that nitrogen, rather than phosphorus may be the limiting nutrient in some freshwater bodies at certain times, but this is deemed to be much less common than the more typical case, where phosphorus is the limiting nutrient. In salt water systems, nitrogen is considered to be the limiting nutrient and is therefore the higher priority for management and removal during treatment).

Based on available water quality data, including findings from the OCWA Stream Biomonitoring project and related NYSDEC studies, nutrient loading is the most widespread water quality problem in streams in the Moodna Creek Watershed. One significant source of nutrients is wastewater discharges. The NYSDEC has recognized this as an issue in the Woodbury Creek and is including phosphorus limits in SPDES permit requirements. These requirements, however, will not necessarily be sufficient to protect water quality in this trout stream, given other existing sources of nutrient inputs and ongoing development in the Woodbury Creek basin.

A number of wastewater treatment systems in the Moodna basin currently have significant problems, including major infiltration and inflow (I&I) conditions and treatment plants that need upgrades. Certain treatment plants are planned to be upgraded or replaced. In some cases, the financing for these upgrades is linked to new development projects that will finance system

improvements or replacements. Other areas are served by onsite septic systems, and in some cases these are viewed as a known or suspected cause of water quality problems. These are some selected examples of significant issues:

- The Town of Chester is moving forward with a plan to construct a new treatment plant that will initially primarily serve areas in and adjacent to the Village of Chester, and will discharge to the Black Meadow Creek. This plant may eventually also serve areas from which wastewater is currently flowing to the Harriman treatment plant, which may raise concerns about water quality in the Black Meadow Creek, but at the same time would mean that water currently being exported from the Moodna basin would be discharged within the Watershed.
- The Orange County Water Authority is currently working with the Town of Blooming Grove on a needs assessment to wastewater management issues in the Mountain Lodge Park community. This neighborhood contains hundreds of homes on small lots served by onsite septic systems. Due to the lot size, generally poor soil conditions, and other factors, many of these onsite systems are not adequate to protect water quality and the town is concerned that groundwater quality may be impacted.
- The Town of Cornwall is currently conducting an initial study of the I&I problems in the sewer system, and the Village of Cornwall-on-Hudson, which is served by the Town's treatment plant, is seeking funding to conduct a similar study. As an indication of the scale of the problems, while the permitted capacity of the town's treatment plant is 1.5 million GPD, in wet weather I&I often increases the discharge significantly above this, and on at least one occasion in recent years it exceeded 10 million GPD during a very heavy rain event, according to monitoring reports filed with the NYSDEC.
- The Valley Forge treatment plant in Woodbury requires major upgrades or replacement due to age, and the Village of Woodbury is planning for a larger replacement plant as part of the overall plan for the proposed Legacy Ridge housing development, which would involve the developer paying for the new plant.
- Also in Woodbury, the relatively new treatment plant built to serve the Brigadoon housing development has experienced major problems with inadequately treated effluent and has been fined by the NYSDEC. This treatment plant is privately owned and operated and the Village and Town of Woodbury therefore have no direct control over plant operations. As the Times Herald-Record reported on March 30, 2007, "The state Department of Environmental Conservation has ordered the Carteret Group of Pearl River, developer of the 240-unit subdivision off Route 32, to settle up following months of illegal sewage discharges from its wastewater plant. The penalties stem from inspections in March and July 2006."
- The Town of New Windsor is currently under a sewer moratorium imposed by the NYSDEC because the system's available permitted capacity has been reached, and no sewer line extensions will be allowed. The average daily flow is approximately 4 million gallons per day, making it the largest system in the Moodna Watershed. The Town's wastewater treatment plant is located on the banks of the Moodna Creek at Rt. 9W, and the discharge is in the tidal portion of the Moodna close to the Hudson River. The Town

has identified I&I as a major problem. The Moodna Development Corporation, at one time, owned an allocation of sewer capacity of approximately 1.2 million gallons per day, and because this corporation has since closed this additional capacity is being divided between the Town of New Windsor and the Town of Cornwall. New Windsor is currently exploring the expansion of its existing plant by 10.75 million GPD, with much of this capacity intended to serve Stewart Airport. In November 2003, Riverkeeper sued the Town of New Windsor over discharges into the Moodna Creek, which was leaking from two manholes. It was settled in 2005 when the town agreed to repair the manholes, remediate the area and provide public access to the water.

Water Export from the Moodna Creek Watershed: Harriman WWTP

The County-run wastewater treatment plant (WWTP) in Harriman provides treatment capacity that serves areas in the Moodna Creek Watershed including parts of Woodbury, Blooming Grove, and Chester. A wastewater management district called the Moodna Basin Joint Operations and Maintenance Commission is responsible for operating the sewer systems in these communities. The Harriman plant also serves areas in the Town and Village of Monroe, the Village of Harriman, and the Village of Kirvas Joel that are in the Ramapo River watershed; Orange County operates the sewer systems in those areas, and the treatment plant itself. This arrangement is significant for watershed planning because the water that's conveyed from areas in the Moodna Watershed to the Harriman treatment plant, together with the rest of the plant's flow, is discharged to the Ramapo River. It is therefore exported out of the Moodna basin and not returned. This is known as an interbasin transfer and constitutes a net reduction in the total flow through certain tributaries to the Moodna Creek. This amount is not necessarily a significant portion of the total water in the Moodna Watershed, but at the local scale this export may have a significant impact on smaller tributaries. Combined with the impact of impervious surfaces in reducing groundwater recharge, this could have a significant cumulative impact on streamflow, especially during summer weather when streams rely largely on base flow.

There are myriad other interbasin transfers involving wastewater, but a thorough inventory of these scenarios was not completed for this Plan due to lack of time and resources. Interbasin transfers involving water supply are discussed in the "Water Supply" section.

IV. Recommendations²

1. PLANNING AND COOPERATION

A. An Intermunicipal or Watershed Group Should be Created to Develop a Long-term Mechanism for Intermunicipal Coordination on Priority Watershed Goals High Priority / Low Cost / Lead – OCWA, OCPD

OCWA and Orange County Planning Dept. should invite watershed municipalities to appoint an official representative and an alternate to participate in the development of an intermunicipal or watershed group/council/committee. This group, referred to here as the Watershed Group, should develop a detailed proposal for forming an official watershed council. The OCWA, the OCPD and other County departments should commit to provide sufficient technical and administrative support to this Group to enable it to become a self-sustaining entity over time.

This Group will outline general goals, solicit questions and priorities, establish an operating structure (chair, subcommittees, etc.), and a regular meeting schedule and other operating procedures. Once these are established, the Group should sponsor a training workshop for members and elected officials in the Moodna Watershed about existing local authority under state law to implement intermunicipal agreements and programs. OCWA, based on input from the Group, should conduct research into various models for implementing and sustaining intermunicipal collaboration, including existing organizations of municipalities in the Long Island Sound, Ramapo River, Cayuga Lake basins, and others.

The Group should review the findings of the Moodna Watershed Conservation and Management Plan to identify priority issues and recommendations and select several major focus areas for project development and implementation and set measurable benchmarks and goals for implementation. A Technical Advisory Group with data sharing should also be formed with invited representatives from scientific, policy, legal, engineering and other sectors, to support ongoing research, development and implementation of priority projects. OCWA, with guidance from the Group, should research Federal and State funding programs, and other funding sources that can support collaborative projects. The Group, with OCWA's support, should develop a proposed strategy for sustainable funding and other mechanisms for maintaining professionally-staffed technical and educational capacity to support ongoing intermunicipal collaboration on watershed protection and enhancement projects and programs. Funding sources to be considered for ongoing operations should include general funds or special districts (water, sewer, or stormwater districts) in watershed municipalities, fee-for-service models, and others.

Although the Group is not listed as a "Lead" in any of the below recommendations, it will likely be involved in implementation of all or most of these recommendations.

⁷ See end of section for list of acronyms used herein.

B. Protect Riparian Buffers from Development

High Priority/Low Cost/Lead - Municipalities

Municipal zoning, site plan, and subdivision regulations should include language that ensures protection of important riparian buffer areas from encroachment and degradation. Perhaps equally as important, local planning boards should be vigilant during the subdivision and site plan review processes to guarantee that the intent of such laws is implemented. Recommended buffer widths vary depending on many factors, including the resource to be buffered, the purpose in buffering the resource, site conditions, etc. A helpful resource called "Conservation Thresholds for Land Use Planners" can be downloaded for free from the Environmental Law Institute's website.

C. Enhance Habitat Protection during Development Approval Process

High Priority/Low Cost/Lead - Municipalities

Municipal boards and planning boards should develop "Habitat Assessment Guidelines" or biodiversity review standards, currently used by some towns in Ulster and Dutchess counties, to identify important resources early in the planning process, and to have preliminary discussions on conservation priorities before serious site planning begins. Such guidelines would serve to make review of ecological impacts more efficient, timely, and predictable.

D. Greenway Compact Program

Low Priority / Medium Cost / Lead – OCPD

The Greenway Program was created by the State of New York to facilitate the development of a voluntary regional strategy for preserving scenic, natural, historic, cultural and recreational resources while encouraging compatible economic development and maintaining the tradition of home rule for land use decision-making. Benefits of becoming a Greenway approved County include technical and financial assistance for community planning efforts, a potential 5% rating advantage over non-compact communities for receiving competitive state funding for Greenway projects, opportunity to offer a streamlined environmental review process for activities, and provided protection from lawsuits brought against communities because of the acquisition of land or the adoption of local land use regulations consistent with a regional Greenway Plan.

2. <u>REGULATORY CHANGE</u>

A. Audit and Update Local Codes to Promote Low Impact Development High Priority / Low Cost / Lead – OCPD, Municipalities

The OCPD should work with willing municipalities to complete the Better Site Design Roundtable process developed by the DEC's Hudson River Estuary Program. See "Review of Local Codes" section for more information.

B. Fund a Regional Stormwater Specialist

High Priority / Medium Cost / Lead – Orange County Soil and Water Conservation District (OCSWCD)

Evidence suggests that there is a widespread need to improve compliance with stormwater pollution prevention plans (SWPPPs) and that water quality would improve if erosion and sedimentation were decreased within the Watershed. One method for enhancing stormwater management would be to have a regional stormwater specialist, who could logically be stationed with the OCSWCD. Such a specialist could coordinate training opportunities and also offer technical assistance to local stormwater management officers, or their equivalent, to implement an effective stormwater and erosion control program, MS4 communities, in particular, could benefit from the technical support this specialist could provide.

C. Draft New or Update Existing Department of Health Watershed Protection Rules and Regulations for All Reservoirs within the Watershed

High Priority / Low Cost / Lead – Municipality, OCPD, OCHD Division of Environmental Health

These state-enabled rules and regulations allow a municipality whose reservoir is outside of their municipal boundaries to enact regulations to control activities in the watershed of their reservoir. This would require working with NYS to lift the apparent moratorium on creating new or updating existing rules and regulations. An alternative to these rules would be to get complimentary language in local codes or to create intermunicipal protection agreements.

D. Support Development of Local Conservation Advisory Councils (CACs) High Priority / Low Cost / Lead – OCPD, OCLT and OCSWCD

Municipalities should create new, or empower existing, conservation advisory councils to develop municipal natural resource inventories and/or open space plans, as set forth in the State of New York General Municipal Law, Article 12-F Section 239-x and 239-y. These councils should serve as important and actively involved advisory bodies to town boards, planning boards, and zoning boards of appeals and contribute substantially to environmental reviews. The OCPD, Orange County Land Trust, and Orange County Soil and Water Conservation District are available to assist CACs in development of Natural Resource Inventories, completion of which is one of the primary tasks of new CACs. Ideally, the municipal board will empower the CAC to become a Conservation Board, which has enhanced authority.

E. County Adoption of Official Map Showing High Priority Resources and Drainages Medium Priority / Low Cost / Lead – Orange County

Section 239-e of NYS General Municipal Law enables Counties to adopt an official map "in order to facilitate the planning and development of roads and drainage systems and sites for public development." These maps can protect drainage systems and sites for public development. Such a county official map "shall serve as a basis for the adoption and administration of regulations for the control of development along or otherwise related to roads, drainage channels and sites for public development." Features that can be shown on the map include: existing and proposed rights-of-way for drainage systems and for county roads rights-of-way; rights-of-way required for any proposed transportation network; and sites for any proposed county, state or federal development facilities, including parks, drainage courses, water courses, and public buildings

3. <u>RESEARCH</u>

A. Research and Inventory of All Hydraulic Constrictions

High Priority / Medium Cost / Lead – TBD

In order to pinpoint structures that cause or exacerbate flooding, the Watershed's bridges, culverts, and dams should be assessed for their capacity to restrict the flow of streams. The extensive work done by HREP, shown in Map 16, can be used as a starting point for this research.

B. Install and Maintain System of River/Stream Gages

High Priority / High Cost / Lead – OCWA, USGS, OCLT

As of the writing of this Plan, there are no river flow gages within the borders of Orange County. Communities in the Watershed have suffered from a series of large scale floods in the past few years. These floods have impacted residential, business and agriculture communities and resulted in significant financial losses. Certainly addressing the primary causes of the increased flood events is a top priority and in order to do that effectively a lot of basic information is needed regarding the hydrology of the Moodna Creek and its tributaries. Real-time streamflow gages can be installed, operated and maintained by the United States Geological Survey (USGS). Gages are installed directly on the river or along side the river and record the stage and discharge, or river depth and volume, at 15-60 minute intervals. The data are then transmitted to USGS offices via satellite and downloaded to the website for public viewing within minutes of arrival.

Current and historic real-time data from streamflow gages are then used by the National Weather Service to forecast, and predict the impact of, floods and droughts thereby reducing the risk of loss of life and property. Gage data are also be used by planners and decision makers to manage ground and surface-water resources for domestic, agricultural, commercial, industrial, recreational, and ecological purposes. In addition, the data can also be used in decisions regarding the design of bridges, culverts and other hydraulic structures that must function safely during floods. Finally, by making current river conditions available online people who want to use the river for recreational purposes, such as kayaking and fishing, can do so in a safe manner. The installation of a gage on the Moodna Creek is recommended just after the confluence of Cromline Creek and the Otter Kill, which is upstream of communities that have been heavily impacted by flooding: Washingtonville, Blooming Grove and Cornwall.

C. Reassess Safe Yields for Public and Community Water Supplies

High Priority / Medium Cost / Lead – OCWA, Municipal Suppliers

In a recent study conducted by the OCWA (Water Master Plan), it was found that additional data collection and analytical work is needed, particularly concerning the determination of the safe-yield for the many water supplies within the County, which included these reservoirs/lakes within this watershed: Brown's Pond\Lake Washington, Goshen's Reservoirs 2, and Black Rock Forest Reservoirs.

D. Continue Stream Biomonitoring Research and Determine Causes of Pollution High Priority / High Cost / Lead – OCWA

Data collected through stream water quality biomonitoring is valuable and should be continued. OCWA has completed sampling every year since 2004 and plans to continue, but there is a need for additional and ongoing data collection in order to determine sources of pollution and identify emerging or future trends. Additional research at problem sites can enhance understanding of causes of water quality impairment and lead to mitigation measures, while sampling at sites where sampling has not yet occurred will create baseline data to which future sampling can be compared to establish trends. Illicit discharges and other point sources of pollution should be identified and rectified so as to help improve water quality.

E. Expand Public Access to Water Related Recreation

High Priority / Medium Cost / Lead – Municipalities, conservation groups

Few opportunities currently exist to legally access the Moodna Creek, its tributaries, and lakes in the Watershed. Potential access points were identified in Map 13; these and other potential water-related recreation sites should be further explored.

F. Continue Biological Research and Restoration

High Priority/Medium Cost/Lead - Various

Additional field research, especially on fish and aquatic communities in the Moodna Creek and its tributaries, should be performed to better understand local biological resources. Areas that are being overrun with invasive species should be identified and restored with native vegetation, particularly in riparian areas and wetlands whose functions are critical to watershed health. Areas with exceptionally rich or unique biodiversity should also be more thoroughly studied and documented so that protection measures can be devised and implemented.

G. Continue and Follow Up on Climate Change Research

Medium Priority / Low Cost / Lead - OCWA

Climate change is a consideration that requires a long term and continuous effort by many stakeholders in order to deal with emerging sciences and the development and implementation of adaptive plans. Some preliminary recommendations are to evaluate the sensitivity of safe yield and dependable yield to project changes in drought frequency and intensity, keep plans flexible in the face of uncertainty, encourage and maintain familiarity with major climate change studies, and continually conduct historical climate analyses. The latter recommendation is especially important for this Watershed because data only goes back about 10 years; for climatological analyses, this period is not enough time to fully understand the effects of climate change.

H. Inventory and Repair Areas Endangered by Erosion

High Priority / Medium Cost / Lead - TBD

Certain streambanks that have been eroded by high velocity streamflow are threatening to undermine infrastructure and property. Such areas include at least Mill Street and Forge Hill Road in the Town of Cornwall, although there are undoubtedly other areas in need of mitigation or restoration to prevent further streambank loss. Research should be conducted to identify badly eroded areas and corrective measures should be identified.

I. Calculate or Otherwise Assess Interbasin Transfers of Water and Wastewater Medium Priority/Medium Cost/Lead – OCWA, Municipal Suppliers

Water is transported across the boundaries of the Watershed both for community water supply reasons and for the transport of wastewater, and therefore a calculation of interbasin transfers would enable a better understanding of the water budget in the Watershed.

J. Maintain a Library of Sample and Model Codes

Medium Priority / Low Cost / Lead - OCPD

Municipalities would be more likely to incorporate model language into their regulations if an inventory of model codes was available.

K. Research Nutrient Loading

Medium Priority / Medium Cost / Lead - OCWA

Water quality sampling has proven that excess nutrients, from various sources but most notably inadequately treated wastewater, is one of the most widespread pollutants in the Watershed. Identifying sources of nutrient loading is a first step in resolving this issue.

L. Community Stream Walk and/or Monitoring

Medium Priority / Low Cost / Lead – TBD

Residents, students, CAC members and other stakeholders should receive support and encouragement to conduct strategic field assessments of streams within the Watershed. The information gleaned from these site visits, which can include water quality sampling, can be used for many purposes, including the identification of: point sources of pollution, riparian areas in need of protection or restoration, water quality status, important habitats, potential public access points, stormwater retrofits, etc.

4. EDUCATION / OUTREACH

A. Promote Understanding and Implementation of this Watershed Plan *High Priority / Low Cost / Lead - OCWA and OCPD*

Planning boards, municipal boards, conservation advisory councils, and other decision makers should be offered training to understand the recommendations of the Watershed Plan, how the Plan fits into their role as land-use decision makers, and how they can be partners in Plan implementation. The OCWA should maintain online Watershed information including an interactive Watershed Atlas.

B. Educate and Foster Public Understanding on the Needs of Biological Resources, Including Forests, Wetlands, and Other Natural Areas

High Priority / Low Cost / Lead –HREP, OCPD, OCMPF

Increase public understanding of important local biological resources, such as protected and declining species to ensure their ability to persist in the watershed. This should be done through outreach and education for residents, students, municipal leaders, decision makers (planning boards etc.), conservation leaders and other stakeholders. Examples include canoe trips, trainings, and educational walks/hikes. These stakeholders should also be offered training on local biodiversity resources, planning considerations, and how the State Environmental Quality Review (SEQR) process can be used most effectively to support conservation-oriented planning.

C. Engage and Support Residential Lake Communities in Lake Management

High Priority /Medium Cost / Lead – Homeowners associations, host municipality and/or OCWA

Lake health and public awareness of contributors to water quality degradation could be improved through outreach to lake communities to encourage enrollment in the Citizen Statewide Lake Assessment Program (CSLAP) or other monitoring program. This would create a sense of ownership and stewardship among lakeshore property owners and ideally result in increased management of lake-side activities.

D. Enhance OCWA Water Conservation Education Program (WCEP) and Develop Adult Curriculum and Training for Watershed Protection Topics

Medium Priority / Low Cost / Lead – OCWA, Orange County Municipal Planning Federation (OCMPF) and OCSWCD

It is recommended that water conservation education programs, such as those that OCWA sponsors, include local Watershed information in the curriculum. It is also recommended to expand and adapt this type of education for the purpose of training adults. Training and technical support on scientific, legal, policy, land use planning and economic matters should be provided to municipalities and other stakeholders, as needed, based on issues identified in this Plan and on priorities developed by the Watershed Group. OCWA should continue to work with outside organizations to leverage existing funding and other resources for delivering this support.

E. Reach Out to Owners of Important Water Resources

Medium Priority / Low Cost / Lead - TBD

Landowners whose property includes an important water resource, such as a stream or riparian area, large or otherwise significant wetland, a lake or pond, groundwater recharge area, public wellhead protection area (especially sand and gravel wells), or other important water resource should be identified and contacted. These landowners should be educated about the importance of land management techniques that enhance and protect water quality. The need for restoration, mitigation, conservation, or further education can then be assessed.

F. Enhance Knowledge and Effectiveness of LID Facilities Through Demonstrations and Training

Medium Priority/Low Cost/Lead – OCSWCD, Cornell Cooperative Extension

Municipal leaders, stormwater professionals, and others should be educated about specific design options for LID stormwater facilities. Training is one avenue for education (Cornell Cooperative Extension was awarded a grant to educate landscapers and others in the construction business), but demonstration sites can be equally as effective in displaying the aesthetics, design, and function of these facilities. Example demonstrations include pervious pavement, rain barrels, riparian plantings, rain gardens and other bioretention facilities and so forth. One demonstration site already exists in the Watershed; a rain garden treats parking lot runoff at Black Rock Forest's headquarters.

5. SAFETY / HAZARD MITIGATION

A. Convene a Moodna Creek Watershed Flood Summit

High Priority / Low Cost / Lead – OCWA and Orange County

OCWA, in partnership with the County, should convene a Flood Summit to provide community leaders in the Moodna Creek Watershed with an opportunity to meet with officials from NYSDEC, the Army Corps of Engineers, and other agencies involved with flood safety and risk mitigation. OCWA should work with municipalities and other agencies to communicate concerns about flooding issues to the Army Corps of Engineers in connection with a current (phase one) study of flooding problems in the Moodna and other parts of the region. This Army Corps study has the potential, after several more steps, to lead to a major commitment of Federal resources to study flooding issues and potential responses in the Watershed. At the same time, municipalities, OCWA and other stakeholders should begin planning funding strategies for providing the required local matching funds for future Federal studies.

B. Inventory Ownership and Management of Dams

High Priority / Low Cost / Lead – TBD

There is currently no coordinated system in place for managing the release of water from dams. A cooperative and coordinated approach is needed to manage water control structures at dams to ensure that detrimental downstream impacts, such as flooding and erosion, are minimized or eliminated.

C. Assess Feasibility of Removing Obsolete Dams and Secure Funding for Dam Removal

High Priority / Medium Cost / Lead – TBD

Approximately 210 dams potentially exist in the Watershed, according to research done by the DEC's Hudson River Estuary Program, and many of these dams are no longer in use. Dams that would help to alleviate flooding and erosion or help improve fish migration in the Watershed should be identified and dam removal studies should be completed for the highest priority dams. A dam removal study has already been completed for a dam on the Moodna Creek behind the Lafayette paper Mill site (see Appendix D); the removal of the dam has already been designed and permitted but funding needs to be secured in order to complete the project.

D. Assess Groundwater Sustainability

Medium Priority / High Cost / Lead - TBD

Need cumulative assessment of water withdrawals and long-term sustainability of groundwater availability in areas experiencing the impacts of increased water withdrawals through wells, new impervious surfaces, and in some cases installation of sewer lines that can also deplete shallow groundwater that provides one source of recharge to deeper aquifers.

6. SITE SPECIFIC

A. Protect and Enhance Lafayette Paper Mill Site (Town of New Windsor) High Priority /High Cost /Lead - TBD

This abandoned mill is bookended by the Moodna Creek on one side and Forge Hill Road/County Route 74 on the other, making it an ideal site for public access to the Creek. However, the site needs remediation in order to be deemed safe for public access, and currently no funding has been secured for remediation. Additionally, work should be performed in and along the Moodna Creek behind this site in order to alleviate flooding and erosion; such work includes removal of the dam and excavation of the floodplain coupled with riparian plantings.

B. Protect and Clean Up Idlewild Glen and Gorge (Town of Cornwall and Village of Cornwall-on-Hudson)

High Priority /High Cost /Lead - TBD

The headwaters of the Idlewild Glen are in Black Rock Forest, and therefore the water quality of the Glen starts out very good. As it makes it way toward the mouth of the Moodna Creek, where it joins the Creek just before the Hudson River, it passes through a more urbanized landscape and ultimately through the Idlewild Gorge, which has documented wastewater pollution.

C. Identify Potential Riparian Restoration and Conservation Projects

High Priority / Low Cost / Lead – TBD

Using information such as aerial photography and the analysis completed by John Mickelson (see Appendix B and the "Local Perspective" box in the "Riparian Areas" section), stakeholders should strategically visit stream-side areas and assess their potential for conservation or restoration.

D. Lower Moodna Erosion Assessment (Towns of New Windsor and Cornwall) High Priority / Medium Cost / Lead - TBD

The Moodna Creek from Rt. 32 downstream almost to Rt. 9W has some significant streambank erosion problems. Near Rt. 32, and farther downstream where the Creek runs along Old Forge Hill Road., there are several very steep areas where the streambank and adjacent hillside are eroding. It's not known how quickly this is progressing but the County and the towns of New Windsor and Cornwall should evaluate the potential near-term risks to buildings and roads at these sites, and begin planning mitigation measures that may be needed at some point in the future.

E. Assign Historic Landscape Protection to the Moodna Viaduct and Valley Area (Towns of Cornwall and Blooming Grove)

High Priority / Medium to High Cost / Lead – Orange County, Municipalities, TBD

Explore potential of a local, state, or federal designation for this landmark landscape, which includes Schunnemunk Mountain, the MetroNorth railroad trestle, and the Moodna Creek valley.

F. Complete a Management Plan for County-Owned Lands at Black Meadow Creek (Towns of Chester and Warwick)

Medium Priority / Medium Cost / Lead – Orange County

As discussed in the "Biological Resources" section, County lands surrounding Glenmere Lake (which is in the Wallkill River Watershed) also encompass part of the Black Meadow Creek and have unique and impressive biological resources. This land was originally purchased for the development of a reservoir that would have been created by damming Black Meadow Creek. This did not occur, and the land has remained vacant, forested, and closed to the public for decades. A management plan could help to protect

the rare biodiversity found on this property and also suggest potential types of public access to the property.

G. Pilot and Demonstrate Decentralized Wastewater Treatment Pojects (Mt. Lodge Park, Town of Blooming Grove and Elsewhere)

Medium Priority / High Cost / Lead - TBD

Mountain (Mt.) Lodge Park, like other communities in the County, was once a seasonal retreat community, but is transforming into a densely developed year-round community. A recent study (Fuss & O'Neill/OCWA, 2008) demonstrated that many individual on-site septic systems in Mt. Lodge Park do not meet current health code separation distances. Further reports of high groundwater, poor road drainage, steep slopes, and poor drinking water increase the likelihood of conditions which have a high potential for public health issues. To further complicate these issues, sufficient area does not exist to repair or replace individual septic systems with conventional ones. It was recommended to replace existing failing and/or insufficient wastewater systems using a Decentralized Wastewater Treatment (DWWT) approach. It would be beneficial to construct and demonstrate DWWT systems in Mt. Lodge Park and show how these systems could be used in a wider application in this and other similar communities in Orange County

H. Remove Steel I-Beams from Moodna Creek Streambed

Medium Priority / Medium Cost / Lead – TBD

Unused and rusted steel I-beams are vertically embedded in the Creek beneath the Forge Hill Road Bridge and should be removed because they pose a hazard to boaters.

7. <u>CONSERVATION</u>

A. Protect and Manage Riparian Areas

High Priority /Variable Cost /Lead - Various

Riparian buffers should be maintained and restored as necessary to protect habitat and preserve channel stability. Approaches that have been used to protect existing buffers include: fee simple acquisition, conservation easements, municipal planning tools, riparian buffer ordinances, and development tools (Alliance for the Chesapeake Bay 2004).

B. Identify, Protect, and Manage Important Habitats

High Priority / Medium Cost / Lead – Municipalities, conservation organizations

Organizations such as Hudsonia, Ltd, the Hudson River Estuary Program, the New York Natural History Council, and others can assist in habitat identification. High priority habitats include: large, unfragmented forests blocks, vernal pools, submerged aquatic vegetation beds in the mouth of the Moodna Creek, any habitat used by a rare species at any point in its life cycle, large contiguous grasslands or meadows, active farmland, forested and shrub wetlands, and riparian buffers/stream corridors (mentioned above). Protection methods include purchase by a conservation organization or municipality, conservation easement, or (for habitats that are found on private land or even public parks) outreach to the landowner on appropriate habitat management, if appropriate. Forest management options include participation in the DEC's Cooperative Forest Management Program and other forest stewardship programs (e.g. 480[a]), outreach to owners of large forest tracts regarding management, reduction in herbivore populations and protection/enhancement of native carnivore species

C. Protect and Manage Important Water Resources

High Priority / Variable cost / Lead – Municipalities, conservation organizations

Land that is critical for protecting drinking water supplies – including reservoir watersheds, wellhead protection areas, and groundwater recharge areas – should be kept in a natural state and managed appropriately in order to maintain the integrity and reliability of drinking water. Protection methods include use of conservation easements or outright purchase by a conservation organization or municipality. Once protected, the land should be managed to maximize its ability to filter pollutants and prevent erosion.

List of acronyms used in the Recommendations Section:

OCHD	Orange County Department of Health
OCLT	Orange County Land Trust
OCPD	Orange County Planning Department
OCSWCD	Orange County Soil and Water Conservation District
OCWA	Orange County Water Authority
TBD	Lead entity to be determined
USGS	United States Geological Survey

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