SECTION 4. 2 MANAGING WATER RESOURCES: STORMWATER AND WASTEWATER

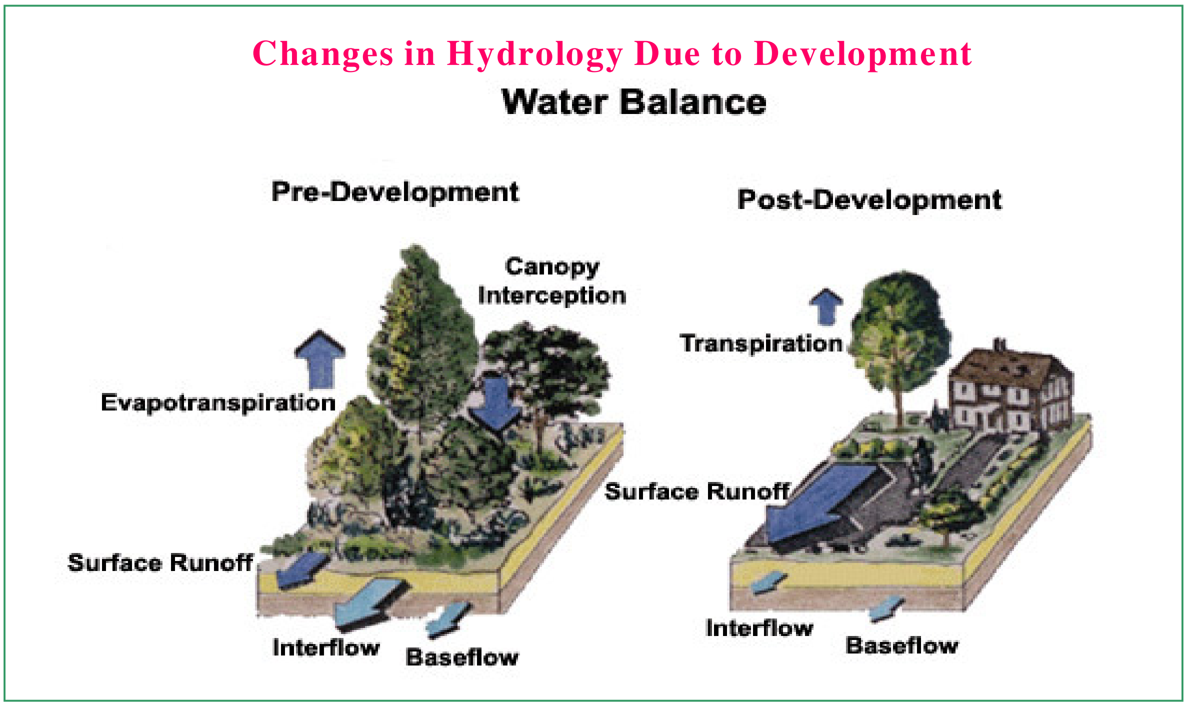
Management of water in communities and on the landscape is an age-old issue. Drainage practices for rainwater and melting snow have evolved for thousands of years. In earlier times, before most communities had sewer systems for wastewater, water draining from streets in cities and other communities would also carry human waste, animal manure and garbage. Over time, sewer systems were developed to carry water away from populated centers, and early systems did not provide any treatment so raw sewage was discharged to water bodies. Treatment standards for wastewater (water carrying human waste and other concentrated waste sources from industry) have gradually become tighter over time as impacts on waterways increase and become more apparent. Meanwhile, the water quality impacts of rain and melting snow flowing into local waterways, which is now called stormwater runoff, did not get as much attention for many years. After the Federal Clean Water Act was enacted in 1972, large amounts of Federal funding were allocated for building and upgrading wastewater treatment plants and collection sewers. But it was not until 1990 that Phase 1 of the Federal regulations was enacted to address stormwater discharges from larger communities. Regulations addressing discharges from smaller communities and from construction sites were first enacted by NY State in 2003 (Phase 2). Since then, stormwater programs have evolved, and newer ideas about using green infrastructure for both stormwater and wastewater management have begun receiving more attention. This section provides background information on these programs and trends and discusses some important next steps for advancing these strategies in the Rondout watershed and surrounding region.

The NYS DEC stormwater programs require all construction sites that meet certain thresholds to obtain a stormwater permit. For smaller sites, this permit requires an erosion and sediment control plan implemented during construction, with site practices that are temporary until the construction is completed. For larger sites, permanent stormwater management practices that follow state guidelines must be designed and installed during construction, and then maintained after that. In addition, the Phase 2 program enacted in 2003 applies to certain municipalities known as MS4s, which stands for municipal separate storm sewer systems (i.e., M and four S's.) MS4 municipalities are designated based on a formula that factors in total population and population density in specific census blocks, and are the same geographic areas that are defined as "urbanized areas" by the US Census. MS4 municipalities are required to implement a local stormwater program that includes six components, which are called "minimum measures." The six minimum measures are described, along with other details on these issues, in Section 4.1.

In addition to local governments that are subject to the MS4 requirements (towns, villages and cities, which are known as traditional MS4s with land use control), other entities are also regulated as MS4s. Counties are termed traditional non-land use control MS4s and must do certain things that are also required of the local MS4s. Non-traditional MS4s are public organizations that have physical facilities located within MS4 designated areas, which are regulated if they exceed certain thresholds regarding the type of facilities they have and how many people work or live on their property (they include state and federal prisons, office complexes, hospitals; state transportation agencies; university campuses, public housing authorities, and schools). Finally, there's an MS4 designation for industrial facilities, and if they meet regulatory thresholds they must comply with New York State's Multi-Sector General Permit (MSGP) for Stormwater Discharges Associated with Industrial Activities [1]. .

<u>The Importance of Impervious Surface</u>: The Phase 2 stormwater program requirements for construction sites originally focused on temporary erosion control measures for most sites, and for larger projects, permanent stormwater management practices that mostly utilized conventional designs (i.e., without much focus on green infrastructure.) More recently, in 2010, NYS DEC released updated permit requirements and design guidelines for stormwater planning and practices in new development. The state's program now includes a greater emphasis on minimizing the impacts of hydrologic changes caused by development. With the goal of preserving the natural functions of watersheds that help keep water clean, supporting healthy ecological systems, and keeping streams and riparian systems relatively stable -- although these are, inevitably, always changing. This newer green infrastructure approach to stormwater permitting and the design of stormwater plans and practices comes out of on an understanding of the impacts of impervious surfaces.

As land use changes in a watershed from undeveloped to developed, the impact of stormwater on water resources also changes. Land that is largely undeveloped, with no roads, parking or buildings, generally produces very little surface runoff. Forests, grasslands and other natural upland areas have a great capacity to absorb precipitation as it falls, or snow as it melts. Much of this water percolates down through the soil and recharges groundwater, and some of this groundwater flows underground and eventually re-emerges as surface water at lower points in the landscape, very often in streams. This flow of groundwater to streams, known as base flow,



<u>Figure 4.2.1:</u> This diagram illustrates the increase in runoff and decrease in groundwater recharge (interflow and baseflow) that results from increased impervious surface.

[1] http://www.dec.ny.gov/docs/water_pdf/gp0601.pdf

provides a large proportion of the total flow in smaller streams, especially in the summer and other dry periods when there's little rainfall. It can, however, take weeks or months for water to percolate through the ground before it reaches a stream.

Compare this scenario to what happens to precipitation in a highly-developed landscape. Roads, parking and other impervious surfaces typically prevent water from reaching the underlying soils, thus blocking the recharge of groundwater. Most water that reaches impervious surfaces simply flows downhill over the surface, relatively rapidly, until it reaches a stormwater collection system, stream, or other waterbody.

Another factor that affects how water moves through the watershed is trees and other vegetation. Trees intercept rainfall by temporarily storing water on their leaves and bark. This water eventually drips to ground or evaporates into the atmosphere. Trees and plants also pull water up through their roots and use it for their growth, and in the process water is released from the leaves as water vapor, a process called transpiration. The combination of plant transpiration and the evaporation of water from soil surfaces is called evapotranspiration. Evapotranspiration and rainfall interception in a vegetated landscape, has a major influence on the storage and movement of water through a watershed, and indeed on the local climate itself, including ambient temperature.

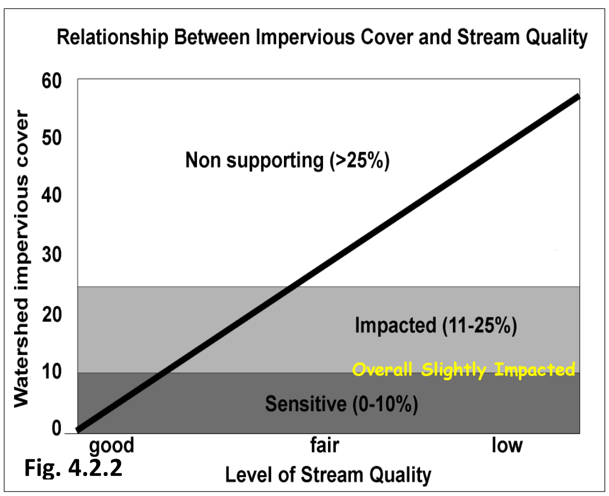


Fig. 4.2.2

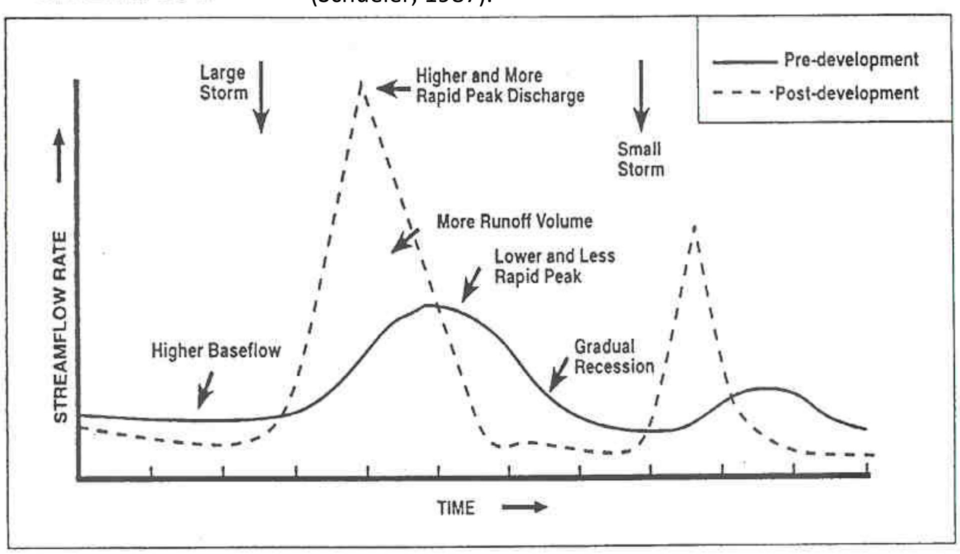
Figure 4.2.1 depicts these concepts, including the fact that surface runoff is higher and base flow is lower in a more highly developed landscape.

As watersheds become more developed and impervious surfaces increase, major impacts occur to the hydrology of streams and other waterbodies, and on water quality itself. In a very lightly developed watershed, where the total impervious cover is well under 10%, there is little surface runoff and healthy groundwater recharge provides a relatively steady flow of water in streams. In more heavily developed watersheds, as the percentage of impervious cover rises above 10% and reaches 20% or higher, there is an increase in surface runoff and a decrease in infiltration resulting in less groundwater recharge. At 25% it is non-supporting of aquatic life. The Rondout watershed at 9.4% average impervious surface is overall only slightly impacted, and more easily protected because it does not also need to be remediated. The increase in volume of water reaching the stream channel causes stream flow to rise rapidly during storms, which often causes new erosion or flooding problems and can exacerbate existing problems. At the same time, the reduced groundwater base flow leads to lower stream

flows during dry periods. Smaller streams that used to run year-round can dry up completely, as has happened in other watersheds.

Figure 4.2.3 illustrates some of these concepts by comparing two different stream flow patterns. The pre-development scenario (solid line in this graph) shows that stream flow rises relatively slowly after a storm begins, and then gradually recedes after the storm. The post-development scenario (dashed line on the graph) represents a more highly developed watershed. The rapid flow of surface runoff to the stream causes a sudden spike in stream flow, followed by a rapid decline. Also, stream flow is lower during dry periods between storms in the post-development scenario, due to reduced base flow from groundwater.

Figure 4.2.3. Change in Hydrograph following development. (Schueler, 1987).



The impervious surfaces and conveyance systems of developed sites result in an earlier and higher peak discharge rate.

Another key impact of impervious surfaces is also related to the fact that they seal off the natural infiltration process in which water percolates down through the soil and groundwater. As water seeps through the soil layer in a relatively intact, vegetated landscape, it comes into contact with the soil, the roots of trees and plants, and the diverse ecosystem of microbes and other life forms that live underground. These natural ecosystems provide tremendous filtering and uptake capacity for removing nutrients and other pollutants from water. Stormwater management systems of various kinds are intended to utilize some of these soil-based processes, as well as processes that occur in surface water bodies such as wetlands, ponds and streams. Green infrastructure, also known as low impact development, is a term describing practices and design concepts for stormwater and wastewater management that emphasizes replicating the processes that are at work in a healthy watershed. These practices purify water and return it to the local ecosystem while helping to maintain groundwater recharge and streamflow as much as possible.

The impact of impervious surfaces, and limiting the percentage of impervious cover in a watershed, is a key aspect of watershed planning, protection and restoration. Along with the effects of non-point source pollutants and point source pollutants on water quality per se, these hydrologic changes from development of the landscape are some of the most fundamental issues and challenges we face. As our understanding of the importance of these issues has grown over the past 10-20 years, watershed planning and restoration methods have emerged to try and limit these changes as new development takes place, and attempt to mitigate some of the impacts to water quality in areas that are already more urbanized.

Green Infrastructure for Stormwater Management: In the environmental planning, design and regulatory sectors, there is a growing focus on the concept of green infrastructure for managing water resources. Green infrastructure, in this context, refers broadly to a set of design principles and specific practices for using the inherent qualities and functions of soils, vegetation, and other components of natural ecosystems to provide a sustainable approach for managing water. US EPA, NYS DEC, and many other agencies and organizations have adopted policies and specific programs that clearly support the benefits and advantages of green infrastructure. The use of these practices are being encouraged over conventional gray infrastructure systems where stormwater treatment practices are usually added at the end of the pipe, to meet basic regulatory requirements. There are significant challenges, however, to fully implementing this approach. These challenges are discussed below in the Green Infrastructure for Wastewater Management section, because the most fundamental issues are common to both sectors.

Applying green infrastructure principles, in the broadest sense, should begin with a regional- and community-scale evaluation of streams and their associated floodplains as well as adjacent wetlands and ponds. The community's master plans should emphasize that preserving these riparian areas as largely or completely undeveloped is the most sustainable way of managing and protecting water resources and should focus new development in other areas. Protecting or restoring streambanks and stream channels, floodplains, wetlands, as well as forests and other uplands, preserves the natural functions of the landscape in areas that are planned to remain largely undeveloped or lightly developed, thus helping to maintain a healthy watershed.

At a site-specific scale, green infrastructure generally means stormwater management practices that are designed to replicate the natural functions and processes that occur in undeveloped landscapes as water is absorbed by the soil and percolates down to groundwater. Green infrastructure, therefore, places a great emphasis on the value of infiltrating water into the ground, instead of sending it over the surface or in underground pipes directly to a stream. Green infrastructure also includes a major focus on using trees and other plants, as part of engineered ecological systems to manage water, utilizing the nutrient uptake, evapotranspiration, and soil filtration functions of vegetated systems to more closely mimic natural watersheds. Some of the key physical, chemical and biological processes that are involved in the function and performance of green infrastructure practices include:

- settling of silt and sediment in ponds and wetlands;
- filtration and removal of solids as water travels through soils or other media;
- adsorption of certain nutrients and other substances to the surface of soil particles (this is one important mechanism for phosphorus removal, and for some other nonpoint pollutants);

- uptake of phosphorus and nitrogen compounds by vegetation as they grow (these materials act as fertilizers);
- evapotranspiration mechanisms (described above); and
- a number of biological and chemical processes involving microbes in the soil and groundwater that break down certain nutrients and other substances.


Photo 4.2.2 Rain Garden

Site-scale GI practices include:

- **Bioretention areas (including rain gardens):** designed to collect and infiltrate much or all of the water flowing into them.
- **Vegetated swales and vegetated filter strips**: designed to convey water, allowing it to flow overland to lower areas while providing some water quality treatment and infiltration along the way.
- **Planting and maintaining trees**: including trees planted in tree pits designed to provide enough available soil volume for trees to be healthy, especially along urban streets and sidewalks where trees typically don't have enough room to grow without damaging sidewalks or other hard infrastructure.
- **Pervious pavement, (including paving bricks, and porous asphalt and concrete:**) allows runoff to infiltrate into the ground.
- **Green roofs and green walls**: vegetated systems that are designed to be integrated with buildings or other structures and can provide substantial energy efficiency benefits in addition to managing stormwater runoff.
- **Rain barrels or cisterns**: capture water for storage and reuse


Photo 4.2.3 Porous asphalt or concrete

See Appendix L for more information about specific GI practices and related technical guidance.


Photo 4.2.4   Green Roof

<u>Green infrastructure in the Hudson River Estuary Region</u>: For several years, the NYS DEC Hudson River Estuary Program has provided education and technical assistance to encourage the use of low impact development (LID), which is in many ways the same as green infrastructure. Another term used for the same general set of ideas is Better Site Design. The Estuary Program has provided grants to support review of local codes to identify areas where existing codes make LID and GI challenging for developers and to recommend code revisions. The program has also supported implementation of a number of demonstration projects. More recently, the Hudson Valley Regional Council has partnered with Hudson River Sloop Clearwater and the Hudson River Watershed Alliance to initiate a regional green infrastructure planning program with Federal funding administered by

the NYS DEC (see http://hudsonvalleyregionalcouncil.com/ for more information.) The Estuary Program has a number of GI demonstration projects in the Hudson Valley listed at this web page http://www.dec.ny.gov/lands/58930.html and more are being planned and implemented across the region.

Green Infrastructure Challenges and Opportunities: Green stormwater infrastructure practices of have great potential to restore water quality due to TMDLs exceedances to impaired waterbodies and to address infrastructure upgrades required to mitigate combined sewer overflows (CSO) or sanitary sewer overflows (SSOs) apply. These projects usually involve major capital expenditures, and the opportunity to invest a larger portion of funds in green infrastructure has proven both cost-effective and environmentally-sound in programs such as Philadelphia's Triple Bottom Line and PlaNYC's *Sustainable Stormwater Management Plan.* Although there are no CSO's in the lower, non-tidal Rondout watershed, there are in adjacent communities, notably Kingston in the tidal Rondout, where investments in GI can have significantly positive impacts on economic revitalization, public health and other benefits. A strong regional commitment to implementation of green infrastructure can also help reduce development pressure in the outlying watershed areas of the upper and lower the non-tidal Rondout. There are many economic and other implications that need to be considered, but GI practices are increasingly playing an integral role in Smart Growth planning.

Measuring Success: One challenge for municipal planners, engineers and regulators has been finding a way to accurately predict the efficacy of GI stormwater management practices, including the difficulty of measuring the ability of green stormwater infrastructure projects to efficiently divert, store and infiltrate adequate quantities of stormwater and to effectively remove key pollutants. The University of New Hampshire Stormwater Center has built an amazing field research site and has carefully measured results from five conventional systems (retention pond, stone rip-rap swale, vegetated swale, filter berm swale and deep sump catch basin), four manufactured treatment devices (MTDs) (ADS infiltration unit, Stormtech, Aquafilter and hydrodynamic separator), and seven Low Impact Development (LID) systems (surface sand filter, biorentention at 48" depth and at 30" depth, gravel wetland, porous asphalt, pervious concrete and tree filters). In addition to measuring quantity and hydraulic performance at peak and lag times, they measured the effectiveness at removing total suspended solids (TSS), petroleum hydrocarbons, dissolved inorganic nitrogen, zinc and total phosphorous. Porous asphalt and pervious concrete performed exceptionally well, with an average of 82% - 93% peak flow reduction and 1,200 minutes (20 hours) lag time.

Photo 4.2.5 Aerial photo of University of New Hampshire Stormwater Center.

The average year-round volume reduction for pervious concrete was 95%. Subsurface gravel wetlands also performed exceptionally well. More information is available at http://ciceet.unh.edu/news/releases/unhsc_report_2009/report.pdf

Green Infrastructure for Wastewater Management:

While using green infrastructure for stormwater management has gained relatively broad acceptance among regulatory agencies and other stakeholders, the same cannot be said for wastewater systems. There is growing support and interest for using certain green infrastructure practices, such as constructed wetlands among regulators and design professionals. A broader, more comprehensive implementation of GI principles for wastewater planning and management, however, raises questions and challenges that remain daunting.

A green infrastructure approach for wastewater utilizes many of the same principles and strategies that underlie a GI strategy for stormwater:

- Manage water onsite or close to the source,
- Minimize the use of gray infrastructure to move water longer distances,
- Use the natural capacity of soils and vegetation to filter and treat water,
- Place a very high priority on dispersing water into soils instead of directly discharging it to a stream or river, and
- Ensure the water recharges groundwater to maintain pre-development hydrology and base flow to streams as much as possible.

If this framework is followed, the resulting treatment infrastructure can protect water quality, maintain groundwater recharge, and provide a relatively energy efficient, sustainable approach for managing wastewater. The existing approach for managing wastewater, by contrast, tends to favor larger, centralized sewer systems that convey wastewater to larger treatment plants serving entire communities, or even regional-scale systems serving a number of municipalities. Regulatory agencies are traditionally much more comfortable with this centralized approach, because it is simpler to maintain regulatory oversight and enforcement on a single discharge point for treated water, rather than monitoring dozens or even hundreds of smaller discharges distributed throughout the community. Yet this distributed (or decentralized) paradigm is basically inherent in a green infrastructure approach to stormwater, and to wastewater.

It is possible to use some elements of green infrastructure concepts and principles even in a larger, more centralized wastewater system. The treatment plant itself, for example, could use reed beds or constructed wetlands for treatment, and the dispersal of treated effluent can be done using land application, such as spray irrigation or drip irrigation systems, to discharge water to soil-based systems that include vegetation. Spray irrigation is widely used for treated wastewater at a number of locations in the US, including some in NY State. Yet many of the benefits of more complete implementation of a green infrastructure approach to wastewater management are not available using this centralized model. The capital costs and other impacts, including energy and chemical usage, of building and maintaining larger networks of sewers in a centralized collection system are high. The cost of the pipe network can be 60% or more of the total system cost. At a time when financial resources for maintaining or restoring infrastructure are very tight, these issues should warrant a serious re-consideration of assumptions that underlie the centralized wastewater management paradigm, which dates from the 19^{th} century or earlier and has basically not been revised in over 100 years.

There are other major impacts of centralized wastewater systems, which tend to go unrecognized. Larger sewer systems, especially as they get older, tend to allow a lot of groundwater and surface runoff to enter the system during wet weather through cracks, joints, manholes, etc., a problem known as infiltration and inflow. Less well known is the tendency for these failures to allow raw sewage to leak out into groundwater. Installation of larger sewer lines also changes the watershed's hydrology in several ways, including moving wastewater longer distances, and also creating preferential flow paths for groundwater along sewer lines and other underground utility corridors that can lower the local water table and drain smaller wetlands and streams. Larger systems may also facilitate land use and development patterns that contradict local or regional planning goals, in part by encouraging sprawl.

In sum, the conventional approach to wastewater planning and infrastructure development that has been followed by most communities in our region for decades has many substantive problems and adverse impacts, which are not widely discussed. The strong and widespread support for a green infrastructure strategy for stormwater that has emerged in recent years provides a new opportunity for dialogue about the same basic set of ideas and goals as they apply to wastewater management.


Photo 4.2.6 Vegeated Bioswale

Meeting the Challenge of State and Local Policies for Green Infrastructure

There are significant challenges to implementing green infrastructure for stormwater and for wastewater. While the new NYS DEC stormwater regulations and design guidance prioritize green infrastructure for new development, DEC has reservations about how effective green infrastructure for stormwater management may be in addressing long-term control plans to meet regulatory goals of combined sewer overflow (CSO) in many area cities. The central challenge seems to be establishing a framework that provides adequate assurance for effective maintenance and quality control for hundreds of smaller, local (decentralized) stormwater practices. The same challenge exists for wastewater planning for unsewered areas, and is also relevant for wastewater infrastructure upgrades in existing sewer systems. Unless state agencies and local government can collaborate to find solutions for this challenge, the full potential of green infrastructure as a more cost-effective, sustainable and beneficial approach for environmental restoration and economic revitalization will not be realized.

There have been some recent policy developments in NY State that are directly relevant to these issues. The NYS Environmental Facilities Corporation (the agency that administers funding for municipal water and sewer infrastructure), NYS Energy Research and Development Authority (NYSERDA), NYS DEC, and the NYS Department of Health co-authored an infrastructure planning and policy memo in 2008, Promoting Smart Growth and Energy Efficiency through the State Revolving Funds[2], and a related document, New York Clean Water State Revolving Fund

[2] http://www.dec.ny.gov/press/43508.html

Sustainability Initiative Advisory Group Recommendations, June 2010.[3] These policies go a long way towards incorporating many of the green infrastructure principles and goals described above, including the linkages to land use planning and avoiding sprawl, and energy efficiency benefits. While the value of decentralized approaches is noted in them, they do not include any focus on the benefits of returning water to local ecosystems for groundwater recharge, avoiding larger pipe networks and their attendant adverse impacts, or the importance of using soils and vegetation as energy efficient, sustainable components of the water treatment process. Further development of these state policies to recognize and include these hydrologic and water quality benefits of green infrastructure for wastewater management is a key next step that can be supported by watershed management programs such as those for the Rondout.

Even more recently, a new state law was enacted in NY, the Smart Growth Public Infrastructure Policy Act[4], which supports some of the same principles and goals. This law requires state agencies to develop policies to integrate land use, environmental, economic, and historic preservation, into funding decisions regarding infrastructure investments.

<u>Integrated Water Management</u>

Integrated water management is an emerging concept that recognizes that decision-making about water infrastructure and water resources planning has traditionally been done in a compartmentalized way. Drinking water supply, stormwater management, and wastewater management have almost always been done separately. As research and experience in the field increases, more sophisticated watershed planning and management perspectives have taken hold. It is becoming clear that a compartmentalized approach is not adequate to implement a sustainable, long-term planning framework for water resources. Managing these sectors separately has major limitations for achieving water resources goals, such as water quality protection and restoration, maintaining adequate quantities of water for human and ecosystem needs, and limiting flooding, erosion and other adverse impacts. In addition, there are significant linkages between water infrastructure and other issues, including energy use and efficiency potentials, energy production, economic development and revitalization, meeting other infrastructure needs (e.g., transportation, solid waste management, food production, etc.), habitat protection and restoration, and recreation. Work is currently taking place to identify opportunities for greater energy efficiency and cost savings and exploring the possibility of creating revenue streams by producing energy from wastewater or solid waste, recapturing nutrients from wastewater, or producing hydropower in municipal drinking water systems where water is flowing downhill and generators can be installed in the system. These ideas have important potential for leveraging available resources to invest in better watershed protection strategies. Another term being used to describe integrated water management is sustainable water infrastructure, and, where other infrastructure components, such as solid waste and energy production potentials are included, integrated resource management.

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[3] http://www.nysefc.org/dotnetnuke/AboutUs/SRFSustainabilityInitiative.aspx
[4] www.assembly.state.ny.us/leg/?default_fld=&bn=A08011%09%09&Summary=Y&Text=Y

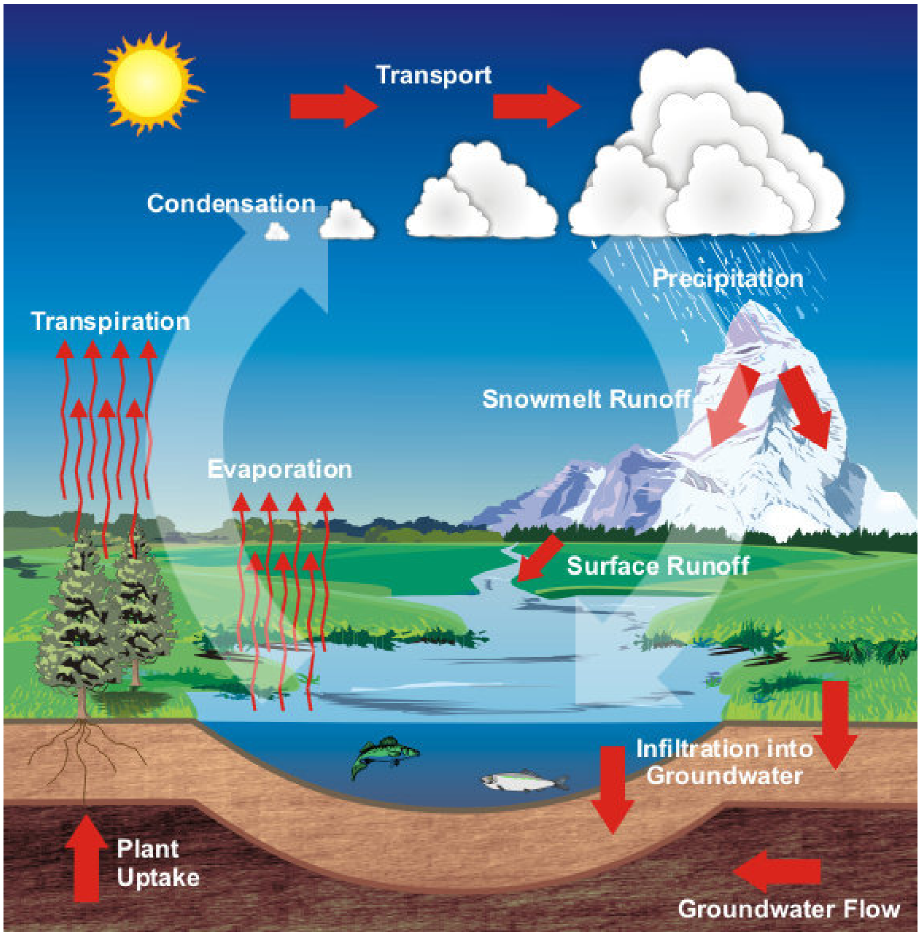

Figure 4.2.4 Green Infrastructure utilizes natural systems and/or incorporates engineered practices that mimic them. Working with the natural water cycle, a variety of GI storm and wastewater systems can be used beneficially to reduce run-off and pollution, as well as beautifying a neighborhood and mitigating climate change impacts.