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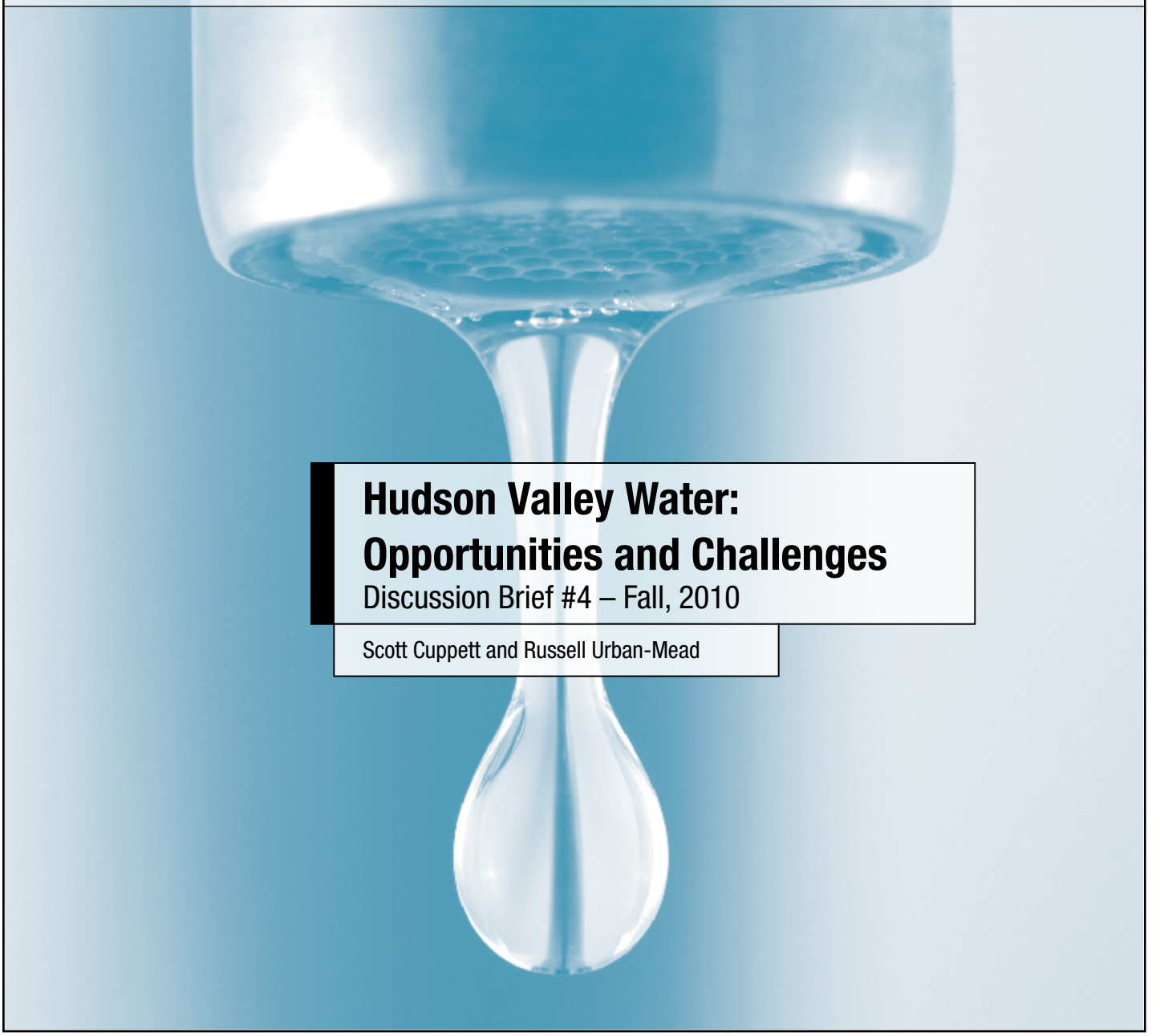
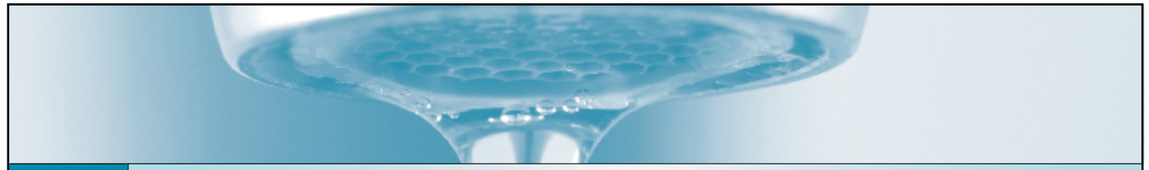


Hudson Valley Water: Opportunities and Challenges

Discussion Brief #4 – Fall, 2010

Scott Cuppett and Russell Urban-Mead



The Hudson Valley could be called the Saudi Arabia of water. We are very rich in a resource that is scarce and expensive in much of the rest of the world.

Hydrogeologist **Russell Urban-Mead** *(above left)*, certified professional geologist and LEED AP®, works at the Chazen Companies where he develops water supplies and provides water resource planning services to private clients, towns and counties. He received his Masters degree from Rensselaer Polytechnic Institute in Troy, has served on Hyde Park's Town Board and is currently a Hudson River Watershed Alliance steering committee member. Recent projects include public water system wells, aquifer recharge rate analysis, sustainable septic system density evaluations, and analysis of regional aquifer systems. Mr. Urban-Mead also focuses on sustainable design and energy conservation projects at The Chazen Companies.

Through a partnership with the New York State Department of Environmental Conservation's Hudson River Estuary Program and the Water Resources Institute at Cornell University, **Scott Cuppett** *(above right)* implements a watershed conservation program in the Hudson River Estuary watershed. Focusing on community-based watershed planning and implementation, Scott provides assistance to municipalities, county agencies, watershed groups, advocacy groups and academic partners to study and understand local water resource issues and develop strategies to protect and restore those resources. A focus of Scott's work is engaging land use decision makers in watershed issues through intermunicipal collaborations. Scott's work is guided by the Hudson River Estuary Action Agenda, which provides measurable objectives for Hudson River tributaries and their watersheds.

EVEN BETTER, UNLIKE OIL, OUR WATER IS RENEWABLE; WITH RARE EXCEPTIONS, PRECIPITATION PREDICTABLY REFRESHES OUR AQUIFERS AND WATERSHED RESERVES EACH YEAR.

Alternative energy sources are being developed as we write. Oil will someday be less important, but there is never going to be an alternative to clean water. It is inevitable that investors and planners from across the nation and even around the world will flock to the Hudson Valley with ideas for a wide range of water-intensive industrial, residential, commercial and agricultural uses. In tandem, our region's population will likely continue to grow, resulting in land use changes that will continue to impact our water availability and quality.

As this happens we should be prepared. There are hard-learned lessons from recent history. We have locally over-tapped some of our aquifers, failed to provide sufficient infrastructure, and contaminated some of our water to the point that human and environmental health is threatened. Part of the challenge is that although water is a regional resource, we govern ourselves in hundreds of localities that, collectively, make the key decisions about our region's future. As we prepare for further uses of our water for a sound regional economy, we need to remember that we have been working hard to restore our streams, aquifers and lakes, and must continue to do so if we are to protect the quality and character of our water resource for the environment, ourselves and our posterity.

Our regional resources include an educated workforce, and interconnected rail and road transportation networks. To these we add water, which can, and should, be utilized within its renewable water cycle envelope to support more industry, more farming and more tourism. Yet, notwithstanding our abundance of water and our past best efforts, our water might be squandered if conservation and protection do not continue to be strongly integrated with our goals for economic development.

The urgent need for pioneering regional water resource planning and protection in the Hudson Valley cannot be overstated. Below we speak of watershed planning initiatives that will prompt a regional conversation integrating best preservation practices with water resource uses that encourage economic growth. We propose approaches and strategies that capitalize on our ecosystem's ability to provide clean and abundant water through better land use decisions, rather than an alternative philosophy that relies heavily on new technological innovation to more effectively treat both wastewater and drinking water. Taking this ecosystem approach is more sustainable, less energy intensive, and ultimately cheaper. We endorse protecting our sources of water as the first of multiple barriers to safeguard water from contamination, as opposed to only investing in water treatment technology at points of delivery or use.

The Source of Our Water Riches

Two reasons for our wealth in water are obvious. We have lots of rain and snow. And we have the Hudson River. A third, less immediately evident factor, is that we could have even more rainfall in the future.

1. *Lots of Precipitation*
   Most Hudson Valley communities receive between 38 and 44 inches of precipitation per year (Randall, 1996). This stands in sharp contrast to the less than 15 inches received in many western American states. This annual precipitation replenishes the Hudson Valley's aquifers, fills its streams and maintains its lakes and ponds.

2. *The Hudson River*
   The Hudson brings to the region fresh water gathered from a 12,000 square mile watershed above Poughkeepsie. The salt front in the Hudson River Estuary typically lies between West Point and Newburgh. This makes the Mid-Hudson Valley the effective outlet of the freshwater Hudson River. The average freshwater discharge between 2002 and 2006 south of Poughkeepsie was approximately 9.3 million gallons per minute (Wall et al, 2008). This is an extraordinary volume of fresh water. For perspective, Poughkeepsie's water plant withdrew about 10 million gallons per day, amounting to just 0.07% of the river's average freshwater outflow in 2008.

3. *More Precipitation in the Future*
   Most climate change models suggest the Hudson Valley lies in one of the few parts of the United States expected to see increases of precipitation in the future (IPCC, 2007). Some models suggest the additional rain may simply wash off in big storms or evaporate due to higher temperatures or that the additional precipitation may come mostly in winter, but so far the above-average regional precipitation we have received since 2002 has provided us with above-average groundwater levels (Chazen, 2010), suggesting that aquifers are benefiting. It is worth noting that climate change is an evolving science, and models can suggest varying future scenarios.

Generally, we seem to be the exception to water shortages experienced both in the United States and abroad. Water levels have been falling in the Great Lakes. Southern states cope with extended droughts and water shortages. Mid-western aquifers primarily recharged thousands of years ago are failing due to over-pumping. And our western states go from one water shortage to the next. Water shortages globally are becoming the subject of intensive international negotiations and sometimes open conflict.

We must assure that we use our good fortune wisely, calling upon the best available science to help us act, invest and plan intelligently. Local and regional decision-making throughout the Hudson Valley regarding water use, groundwater recharge, water quality and land use must proactively identify water allocation goals and provide for watershed and water resource protection. When requests for access to our water resources reach our doorstep, planning documents, scientific data and infrastructure templates must be in place, and institutional arrangements should already be worked out.

In the following pages, we will demonstrate the necessity for a number of important strategies to safeguard and manage our water assets. Briefly, these touch on the following:

- Take a holistic watershed, or

sub-basin, approach to water management.

- Expand planning approaches to balance the competing uses of water: drinking, industrial purposes, recreation, tourism and ecosystem needs.
- Invest in appropriate water supply and wastewater treatment infrastructure and "water-ready" sites.
- Preserve and protect groundwater recharge areas, floodplains, wetlands and forests.
- Develop infrastructure and operational responses for occasional droughts.
- Promote engineering, construction and development practices that foster groundwater recharge at the site level.
- Minimize cumulative negative impacts from land use change on water quality and quantity.
- Establish enforceable programs to assure sufficient stream flows for fish and wildlife.

Sustainable Water Use Principles and the Need for a Plan

There is a triple bottom line definition for sustainable water use. The United States Geological Survey addresses it by calling for the "development and use of ground water in a manner that can be maintained for an indefinite time without causing unacceptable environmental, economic, or social consequences" (Alley et al, 1999). The NYSDEC views it similarly, defining its goal regarding water as "embracing the elements of sustainability - the simultaneous pursuit of environmental quality, public health, economic prosperity and social well-being."

Unfortunately, our regional need for a sustainable water resource strategy is informed more by negative experiences than effective planning. We have seen water shortages caused by excessive localized water withdrawals, polluted groundwater and degraded streams and rivers resulting from the cumulative effect of land use impacts. Water is a regional resource, yet no single agency or entity, local or regional, has been accountable for sustaining our water resources for the public, or for the reliable support of economic and ecosystem benefits dependent on water.

A concept, referred to as "wet growth" also deserves mentioning in this sustainability discussion. Advocates for "wet growth" planning argue that land use, development and growth management policies should give heightened priority to overall watershed health, water quality, water availability and water use (Arnold, 2005). Wet growth planners are concerned that the separate development of land use and water use laws is resulting in insufficient attention to sustainable water policy and practices. This concept, not yet well established among public policy thinkers, would give water policy priority attention in land use decision making, including comprehensive planning and zoning.

What We Are Doing Well

In many ways we have prepared well for the use and allocation of water in the Hudson Valley:

- Federal and state laws and regulations have worked to reduce point sources of water pollution such as discharges from industrial site outfalls, sewage treatment facilities and many large-scale stormwater outfalls. As a result, much of the Hudson River is now swimmable, and many of its streams and rivers today support drinking water uses and provide vital fish populations that drive millions of dollars in annual recreation and tourism expenditures.
- DEC stormwater management requirements, combined with education and outreach, have reduced many of the negative impacts to water quality and water quantity from uncontrolled stormwater flowing off of new developments and urbanized areas.
- DEC aquifer pumping test protocols for new public water system wells ensure significant review of local aquifer capacity at specific sites. Required flow tests nearly always give sufficient data to assure that new community wells will be productive over the long term, and that impacts upon nearby pre-existing wells, wetlands and streams are correctly assessed.
- The DEC's Hudson River Estuary Program and other organizations have worked to advance scientific research, and enhance natural resource management through outreach and education. The Estuary Program focuses on the Hudson River and its tributaries between the Troy Dam and New York City. The Hudson River National Estuarine Research Reserve is one of a number of valuable academic, research, and private or public organizations that provide a wealth of significant research and natural management on water resources.
- Low-impact design (LID), green site design (GSD), better site design (BSD), and green infrastructure principles (GI) – e.g., porous pavement, rain gardens, bio-retention areas and bioswales – have been promoted for new development and as retrofit approaches for older developments. Data collected over time will likely confirm the effectiveness of these techniques towards promoting beneficial recharge of stormwater, preserved stream baseflow volumes and critically necessary flood reduction.
- Some counties and municipalities in the region are advancing and supporting regionally-based water resource plans. Orange County has watershed plans for the Moodna and Wallkill watersheds, a water master plan and aquifer maps, and plans to develop several regional wellfields and community interconnections to support several cooperating municipalities. Dutchess County has watershed management plans for the Wappinger, Fishkill and Fall Kill Creeks. The county maintains a regional aquifer monitoring network and has funded research to define aquifer recharge rates and sustainable septic system densities. Dutchess County has also developed a model aquifer protection ordinance available for municipal adoption and has acquired former USGS stream gages to expand its own monitoring network. In Ulster County, a floodplain corridor plan is being developed for the Lower Esopus and early efforts to develop a watershed plan for the Rondout Creek are underway.
- Taking advantage of our water richness, Dutchess County has already developed significant water treatment and distribution infrastructure to bring Hudson River water to some of its population and industry centers. Most of this water is also appropriately returned to the Hudson River as treated wastewater, within a few miles downstream of where it is extracted.
- Active watershed organizations throughout the Hudson Valley provide a range of citizen monitoring, advocacy and stream conservation activities on Hudson River tributaries. Some receive limited funding for special projects; most rely on citizen volunteers and some municipal involvement. Many have compiled valuable data describing stream flows and watershed resources, advocating for such issues as water quality protection and flood control practices.
- The Hudson River Watershed Alliance and a host of regional environmental advocacy organizations, including Clearwater, Riverkeeper, Scenic Hudson and others gather data, provide training, events and materials, and advocate for, and keep public attention focused on, water quality, quality of life, and environmental considerations.
- To protect drinking water quality for New York City and many lower Hudson Valley communities, the New York City Department of Environmental Protection and DEC have advanced important green infrastructure principles of water protection by capitalizing on ecosystem services provided by vast forested areas as a cost-effective, sustainable alternative to expensive wa-

The authors of this paper offer the personal perspectives of a private sector hydrogeologic consultant working at The Chazen Companies who has spent sixteen years developing water supplies and helping communities develop water resource planning strategies (Urban-Mead), and a watershed coordinator who has spent a similar number of years administering watershed planning and management services for the NYS Water Resources Institute at Cornell University as part of a cooperative project with the NYS Department of Enviromental Conservation (NYSDEC) Hudson River Estuary Program (Cuppett). This review does not represent the perspectives of either of their employers, but does of course reflect their career experience. Urban-Mead can be reached at 845.486.1551 or rum@chazencompanies.com. Cuppet can be reached at 845.256.3029 or swcuppet@gw.dec.state.ny.us.

ter treatment at the point of delivery. The city has sought to proceed with a degree of sensitivity to local economic and social needs of the upstate communities that are hosts for its water resource. There is still a need, however, for continuous assessment of the environmental and social impacts related to the city's inter-watershed/basin transfers.

What We Could Do Better

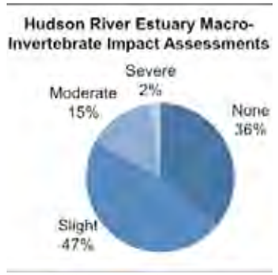
Notwithstanding our achievements, there remain areas in which existing programs do not sufficiently prepare us to meet foreseeable demands and challenges. Moreover, there is little doubt that unanticipated challenges will emerge in the coming decades that will require adaptation and reconsideration of priorities. Below are some particular areas in need of improvement.

Reduce Sources of Non-Point Pollution

Existing federal and state regulations are not yet fully effective at controlling diffuse and scattered pollution sources (non-point pollution). Non-point threats in our region include salt from road de-icing activities, a wide range of pollutants carried to our waters from impervious surfaces, sediments from disturbed landscapes and flood-damaged streambanks, a wide range of personal care chemicals (e.g., pharmaceutical residues in wastewater) and nutrients from septic systems, and herbicide/fertilizer residues. Addressing each individual source is difficult and expensive, yet collectively these non-point source pollutants are now being recognized to seriously taint our ground and surface water supplies.

An example of nonpoint source pollution – stormwater running off a road into a nearby river, carrying with it pollutants and higher water volumes and velocities. Photo credit: Scott Cuppett

A 2002 DEC report including consideration of approximately thirty years of macro invertebrate assessment data from 300 stream stations in the Hudson Estuary watershed identified impacts in roughly two thirds of stream segments, often from non-point pollution. Nearly half the sites were slightly impacted, 15% were moderately impacted and 2% were severely impacted. Similar results were noted during recent intensive bio-monitoring in Orange County streams. These kinds of impacts degrade aquatic habitat and have negative consequences for stream life and drinking water.



Source: NYS Department of Environmental Conservation, Thirty Year Trends in Water Quality of Rivers and Streams in New York State.

Where the point sources originate over aquifers, the impacts detected in streams often pass through our aquifers before they reach the streams. Domestic wells sampled in Dutchess County neighborhoods have more frequently detected nitrates where septic systems are closer together (Chazen, 2010 and 2006). Experience suggests that pharmaceutical and personal care chemical concentrations from wastewater are also likely to also be most concentrated in groundwater where septic systems are closer together.

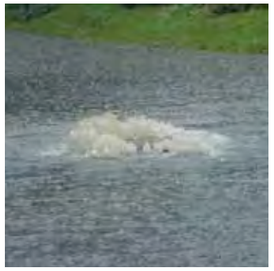
Dutchess County's sampling data also shows that dissolved salt concentrations rise under denser neighborhoods, presumably because of winter de-icing activities associated with greater necessary road density (Chazen, 2010). These sodium chloride data suggest that, especially in densely settled neighborhoods, road runoff should not be recharged into the ground unless salt use is curtailed or effective pre-treatment measures can be developed.

Replace and Expand Failing Water and Wastewater Infrastructure

Many of the Hudson Valley's water and wastewater systems are old, past their prime or do not adequately service new or expanding population centers. Some sewage systems combine wastewater and stormwater collection in ways that overwhelm treatment plant capacity during flood periods. Replacing, upgrading and expanding aging water supply/distribution and wastewater infrastructure is essential for both regional economic development and preserving the health of our communities and water bodies. Updating New York State's municipal wastewater infrastructure over the next twenty years was conservatively estimated in 2008 to cost $36.2 billion. Even without a fiscal crisis, the challenge is daunting. Yet the resources must be found if the region is to both prosper and preserve its quality of life.

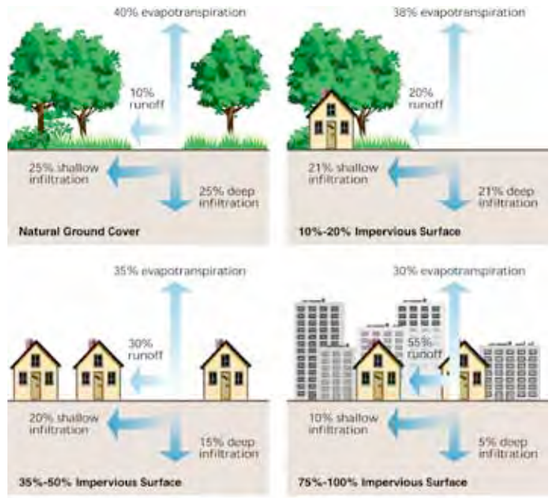
Reduce Use of Impervious Surfaces and Further Strengthen Stormwater Measures to Promote Groundwater Recharge

Until recently, New York State's stormwater program has focused primarily on managing quality and peak flows, with less emphasis on limiting increased overall runoff volume. The cumulative effect of this omission was the possible exacerbation of downstream flooding and little emphasis on preserving local groundwater recharge. Regulations were revised last year to address this concern, including promoting a wide range of infiltration infrastructure options for use on future development sites. In conjunction with the state change, the Hudson Valley town of Pleasant Valley recently adopted zoning measures to reduce off-site storm runoff, requiring that there be no change in runoff volumes on most new development sites except in the case of storms greater than the 10-year peak storm (Pleasant Valley Zoning Code, §98-53). Few other Hudson Valley communities have taken such proactive measures to limit flooding and preserve on-site recharge; they should.



Sewer manhole overflowing in New Paltz, NY due to aging infrastructure that combines both stormwater and sanitary sewer. Photo credit: Scott Cuppett

Increased coverage of land with impervious surfaces without provision for offsets reduces groundwater recharge and therefore threatens the reliability of domestic and public wells. Especially if climate change brings us more storms and intervening dry periods. Lost recharge also reduces



General relationship between impervious surface area, surface runoff, infiltration and evapotranspiration (FISRWG, 1998)

groundwater flows critical to the preservation of streams, wetlands and ecosystem processes. A water resource study conducted by Pleasant Valley as part of its master planning process noted unexplained flow reductions in the Wappinger Creek as it passes through the town (Chazen, 2007). Stream gauging along the Sprout Creek in southern Dutchess County has also identified evidence of stream flow volume reductions over time (Chazen, 2005). New York State continues to develop more specific technical guidance regarding in-stream flow protection which will help highlight the significance of such changes, but the issue of stream depletion should be a critical part of water resource allocation management planning.

In general, the higher the percent of impervious cover and the less forest cover in a watershed, the more degraded a stream will become, particularly when impervious surfaces directly shunt runoff to surface waters. Most streams remain vital and healthy when their watersheds are less than 8-10% covered with impervious surfaces (for reference, 10% impervious cover can be typical for a two acre residential lot). Increasing impacts to stream temperatures, streambed erosion, and water quality arise as impervious surfaces rise to 25%, a level typically reached when housing density reaches quarter acre lots. Summertime baseflow reliability begins to wither significantly once impervious surfaces linked to storm water infrastructure exceeds 30% of a watershed. Above these thresholds, streams tend to become ecologically dysfunctional, and restoration becomes costly and questionable.

Require Well Testing and Develop Water Budgeting Protocols
Applications for new wells typically are not required to show how proposed withdrawals affect the carrying capacity of a local watershed. The result has been piecemeal water takings over time, and possibly the kind of stream reductions described above in the Wappinger Creek and the Sprout Creek.

Source: Stormwater Manager's Resource Center. Relationship between impervious cover and stream quality.

Current water consumption across the Hudson Valley region falls far below aquifer recharge rates. But new withdrawals, particularly if not offset by appropriately-treated wastewater returns or enhanced recharge efforts, may eventually contribute to chronic local stream damage and eventually impose negative impact on water supplies. To both ensure potable water supply reliability and accurately detect local ecosystem impacts during permitting, communities should ensure that pumping tests are conducted at elevated rates. If tests are conducted during wet seasons, potential impacts of pumping tests should be measured in adjacent streams and wetlands, and water budget assessments should be completed that take into account environmental flow needs of adjoining individual streams and drought conditions. The new zoning in Pleasant Valley includes some of these measures. An early collaborative attempt at minimum stream flow preservation was made by six municipalities in eastern Dutchess County, using stream gauging to determine each municipality's groundwater contribution to the Ten Mile River and accordingly assigning groundwater use allocations available to each municipality to avoid dewatering this river (Chazen, 1999).

The transfer of water from one basin to another needs additional attention. Interbasin transfers can occur at many scales. The New York City drinking water supply system, for example, transfers over one billion gallons a day to and from watersheds within the Hudson Valley (e.g., Rondout, Croton and Esopus systems) and the neighboring Delaware basin. Water in "losing" streams or rivers can suffer ecological and economic damage from lack of downstream freshwater flows, with especially acute impacts during dry times of year. The impacts of water transfers on both donor and receiving water bodies must be better integrated into environmental reviews.

Develop More Effective Means to Conserve Wetlands, Floodplains and Streamside Areas
Encroaching upon, filling, excavating and clearing floodplains, wetlands and streamside areas can have profound impacts on water quality and quantity. In certain areas of the Hudson Valley, communities and developers find these sensitive areas among some of the last vacant and undeveloped areas. Structures located in or near these areas are at a higher risk of being in harm's way during flooding. Floodplains, wetlands and streamside spots serve as vital green infrastructure that cleanses and purifies water, and acts to hold water that spills over stream banks, slowly releasing floodwaters to reduce downstream flooding. We should find opportunities and promote, via comprehensive plans and zoning, development towards infill and greater density in already developed parcels before considering developing these areas.

Enforce and Support Existing Regulatory and Planning Programs
Enforcement of regulations remains necessary to preserve water quality and capacity in the Hudson Valley. The impressive results of the Clean Water Act and the Safe Drinking Water Act will be compromised if we do not continue to focus adequate resources on controlling potential pollution point sources. Similarly, planning and education programs, such as those provided by the Hudson River Estuary Program, the Hudson River Watershed Alliance, the Soil & Water Conservation Service, and a host of other non-profit and county efforts must remain active and properly funded.

Strengthen Watershed Organizations
Throughout the Hudson Valley, not-for-profit groups interested in watershed-based approaches have arisen to promote community-based solutions. Inter-municipal agreements are being developed to coordinate the implementation of watershed protection and restoration strategies, such as improved codes to reduce stormwater creation. The joint efforts of citizen groups and participating municipalities have improved public access, planted trees, offered effective public education and advanced water-sensitive land use policies. These groups do valuable work, especially in affecting how people think about our region's water resource.

But watershed organizations often operate on a volunteer basis without sustained funding. Too often they compete with each other for limited available resources. Moreover, their advocacy is hampered by the absence of enforceable flow or water quality standards for individual watersheds. To remain effective, these groups must take a tougher minded approach to their organizational


Lower Esopus Creek at the Tongore Bridge crossing County Route 5, resulting from upstream NYCDEP diversion, during summer low flow conditions. Photo credit: Scott Cuppett

"Water-capacity infrastructure should direct desired economic activity to locations where water is most readily available."

viability and relationships with each other, and find ways to assure a sustainable future, individually and collectively.

Recommendations: the Hudson River, Its Tributaries and Aquifers

The public is often understandably left puzzled by the discussion of community water issues. One week the press features stories about too much water: flooding. The next week, we read of community leader complaints about insufficient water supplies to support growth and development. As we have shown here, there is more than enough groundwater and surface water in the mid-Hudson region for current uses, and more still available from rain, the Hudson River and anticipated climate change benefits. But too many wells have sometimes been installed in concentrated areas or contamination in one area causes fears of widespread contamination. The resulting messages are confusing for both the public and public officials.

It is important to distinguish among three simultaneous challenges: water availability, water distribution and natural resource conservation. The true difficulty for many municipalities is seldom the overall supply, but how to collect water responsibly and how to distribute it cost-effectively to the places where it is needed. Water is abundantly available on a regional scale, but it must be collected from optimal withdrawal locations often separate and distant from the locations of proposed use.

Resolving the availability of sustainable water supplies to population and commercial/industrial centers throughout the Hudson Valley without causing local environmental damage requires planning and investment. It is time to consider the pros and cons of instituting an institutional mechanism to advance watershed-based water systems development and management before further pressure mounts for major water withdrawals from Hudson Valley aquifers or from the Hudson River itself. This could begin with continued planning at county levels, and then perhaps advance over time to inter-county planning and suitable watershed scale coordination. Planning must include avoidance of localized water over use which adversely affects local ecosystem functions. There appears to be growing statewide and regional pressure and interest in implementing regional frameworks to address these types of issues (Negro and Porter, 2009).

Below are some elements that could be included in enhanced intermunicipal and regional water source development, watershed planning and management. Some of these elements are partially being implemented now on a local scale, but they could be bolstered and more widespread.

Identify "Water-Ready" Sites and Create a Recognition Program that Rewards Conservation Site Plans and Development

Taking account of sub-regional carrying capacities and environmental flow and quality requirements, environmental and economic development leaders should collaborate in designating "water-ready" development sites. Governments should support these with necessary infrastructure investments. Some location considerations would include proximity to connections with heavy rail, Hudson River docks, interstate highway links, and urban redevelopment opportunities and smart growth principles. Development should proceed in a manner that supports conservation and water protection goals. Financing for such sites might be found through host-benefit investments made by consortiums or by individual new business ventures. The Greene County Industrial Development Agency provides one good example of economic development and natural resource conservation being pursued collaboratively. That agency builds into their shovel-ready sites a predetermined plan that protects sensitive areas, while also allocating a percentage of funds generated through economic development to buy locally significant sensitive land and fund conservation programs. A reward or recognition program should be created among developers, government and conservation non-profits,

"We can only consider water to be a reusable resource if we return it to our watersheds in a reusable condition."

such as watershed groups, to encourage thoughtfully planned and constructed development in "water-ready" areas. In exchange, conservation groups could identify the sites, and local governments could streamline permitting processes.

Water and Wastewater Capacity and Distribution System Planning

Water-capacity infrastructure should direct desired economic activity to locations where water is most readily available. Private-public partnerships are increasingly common tools to support such efforts. Regional water master plans and local zoning can be used to coordinate primary growth nodes with available water distribution points, while also protecting natural resources and base stream flows. Community water system distribution and interconnection systems, such as those envisioned in Orange County and those being implemented and expanded by the Dutchess County Water and Wastewater Authority, can help ensure reliable water supplies for densely settled community centers from highly reliable water source areas.

We note that critical attention must be given in coming years to the present limits of existing wastewater treatment methods. If we are to withdraw more water from our watersheds for domestic and manufacturing purposes, and commensurately return greater volumes of treated wastewater to our streams and the Hudson River, we must examine the cumulative impacts of wastewater returns. A particular concern is the wide range of pharmaceuticals and chemicals in personal care products that are currently inadequately treated by standard wastewater treatment measures. We can only consider water to be a reusable resource if we return it to our watersheds in a reusable condition. Establishing re-use benchmarks will ultimately define the degree to which we can optimize water use in the Hudson Valley.

Watershed Scale Management and Research

Watershed management must simultaneously occur at the scale of each watershed's tributary streams and on the scale of the Hudson River itself. Individual watershed plans must move beyond compendiums of land use, habitat, natural resource, and stream and pollution data followed by generic recommendations. These plans must also include clear guidelines and implementation priorities and must specify who is responsible for implementation. It is time for plans developed for individual watersheds to prioritize and clearly identify necessary corrections and development objectives. Advances in watershed management plans should:

- Include flow data that precisely identifies losing or gaining stream segments,
- Identify stream tendencies to flooding or extreme loss of flow during dry periods in ways that guide specific steps toward mitigation,
- Include groundwater quality data that identifies specific pollution sources,
- Describe targeted planning or investment steps to, for example, provide shading for specifically vulnerable stream reaches,
- Identify specific losing stream segments and nearby watershed sites specifically needing groundwater recharge BSD/LID investments as mitigation for development or climate change,
- Use water quality information to provide precise land use planning recommendations, and
- Upgrade targeted wastewater plants or areas with densely-scattered septic systems to improve stream quality.

When preparing watershed plans, we should be investing more in research and monitoring, applying the best available science to make decisions and gauge our progress. Both public and private efforts are needed to generate the necessary data. Only when hard data provide the basis for action can watershed improvement and infrastructure investments be successfully promoted, funded and implemented. Researching and gathering such information may cost more than current water-

shed planning initiatives. But as we enter an era of increasingly scarce investment funds, we must defensibly define targeted infrastructure and conservation planning goals if we are to see necessary projects funded and if we are to get the most out of the limited dollars available.

Water Conservation and Local Wastewater Returns
Increased groundwater volumes may be withdrawn from most aquifers throughout the Hudson Valley. Many sand and gravel aquifers are not fully explored and a wide distribution of bedrock wells may still be drilled. But the valley's aquifers are not as deep and porous as those in some other parts of the United States, so as a general rule withdrawals should be balanced by nearby returns of appropriately treated wastewater. It is also generally best to limit water transfers between individual Hudson River tributary watersheds unless flow and aquatic service requirements of the donor stream are well known. Important ways to improve well pumping tests in aquifers to assess stream flow impacts are addressed elsewhere in this paper.

While withdrawals are increased, water conservation measures and sustainable water footprint evaluations must be completed to help minimize water consumption impacts. We must be mindful that excessive consumption, water exports (e.g., bottling), or water transfers can unduly diminish stream and aquifer capacity during dry seasons, resulting in lost ecosystem and economic water capacity. When occasional droughts occur, communities able to limit water consumption will both experience the fewest inconveniences and will impose the lowest consumption impact on their watershed ecosystems.

Low Impact Development (LID), Better Site Design (BSD), and Green Infrastructure (GI)
As earlier noted, we need more research in the Hudson Valley to confirm if low-impact design (LID), better site design (BSD) and stormwater green infrastructure (GI) practices work as hoped to mitigate the effects of groundwater withdrawals and the spread of impervious surfaces. Uses of rain gardens, bioswales, parking median infiltrators and other measures may make it possible to support development, while maintaining water budgets and assuring aquifer recharge. Investments in retrofit LID infiltration methods may be particularly beneficial tools for returning quality baseflow back to urban streams. Roadway runoff should not be recharged to aquifers unless provided with careful and full pre-treatment.

Septic systems remain a practical and low-maintenance alternative suited to long-term use in the Hudson Valley. However, we need more widespread work to identify regional recharge rates, correlate aquifer conditions to seasonal water quality threats and confirm the land's carrying capacity for septic systems. Where testing shows that nitrate concentrations are rising in neighborhoods dense with septic systems, more detailed sampling is warranted. Particular attention should be given to determining if pharmaceutical residues or other personal care chemicals are present in domestic well water.

Local Government Action and Restructuring
Municipalities can also proactively adopt zoning and planning strategies to protect water, for example, law and code changes that focus on aquifers, wetland and watercourses, floodplains, habitats and stormwater. Zoning based on watershed boundaries and the protection of critical areas is an ambitious approach that is undervalued and underutilized. We must begin to protect these and other important natural and environmental features cohesively within the development process if we are to conserve water as a regional asset.

Regionally, at the watershed-level, counties, cities, towns and villages must create formal arrangements to work together on water issues. The Ulster County Planning Department has a guide for municipalities seeking to write their own wetlands law. A model aquifer management ordinance, prepared by Dutchess County, is available on its website for any municipality to adapt and adopt. Response plans and source interconnections are needed in many counties to manage through periodic summer droughts. The use of uniformly-applied local laws and policies is beneficial to both municipalities and investors alike, as it reduces the complexity caused when each municipality has different laws. Institutionalizing watershed cooperation allows municipalities to share resources, address common problems and react to unanticipated issues.

"Reapportionment and redistricting at the state and national levels will soon occur. We recommend aligning state and federal legislative districts as closely as is possible with watershed boundaries."


Esopus Creek riparian (streamside) area and floodplain. The right side of the river is forested and protected, while the left side is disturbed and could use some restoration. Photo credit: Candace Balmer

Reapportionment and redistricting at the state and national levels will soon occur. We recommend aligning state and federal legislative districts as closely as is possible with watershed boundaries. This would naturally result in elected officials responding to constituencies with regionally-aligned needs and priorities to address water policy. Transportation, economic development, cultural, and environmental issue policy matters often also coincide with watershed boundaries, so this recommendation is not as parochial as it might initial appear.

Rural Development Density
Rural parcels that will rely on wells and septic systems must be on large enough lots to avoid negative impacts from septic system discharges into groundwater. Yet the negative social consequences of large parcel development (e.g., sprawl) also need to be avoided. This suggests the desirability of both an overall commitment to sustainable rural density and the use of cluster subdivisions when traditional septic systems and domestic wells are used in rural areas.

Using Water from the Hudson
Dutchess County's Hudson River water source in Hyde Park is being extended almost yearly to serve additional communities. Recently too, a lengthy pipeline extension crossing half a county was constructed to connect Poughkeepsie's intake to East Fishkill's industrial complex, including IBM. Downstream, a principle water supplier in Rockland County is currently proposing a desalination plant to withdrawal brackish Hudson River water. And in Orange County, plans for a regional water system distributing either surface water or groundwater have waxed and waned for several decades. Upriver, there are constant discussions of additional freshwater river withdrawals, including plans for significant industrial use in the Saratoga area.

Work sponsored by New York City's water supply program suggests that if 300 million gallons per day were drawn to New York City from a freshwater Hudson River intake in Dutchess County, the salt front would move up one mile (De Vries & Weiss, 2001). Any proposed new agricultural or comparable consumptive water uses which similarly either transfer water to the atmosphere (transpiration from irrigation or cooling tower uses) or fully remove water from the watershed (e.g. a beverage industry as one example) would also result in direct losses to Hudson River flow. The effects of these types of one-way water withdrawals from the Hudson River ecosystem are unknown. But the coupling of multiple new sets of water supply and

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wastewater plant returns along the freshwater Hudson would be expected to impose far lower impacts since withdrawals would be balanced by nearby returns. That said, with any significant takings from the river improved technologies may be needed to minimize local impacts (pipe intakes) or outfalls (thermal, nutrient or chemical residue discharges).

One could argue that taking water from the Hudson River would alleviate pressure on tributary freshwater ecosystems in the watershed. But the Hudson is a coastal estuary supporting a rich and productive ecosystem. Before tinkering with this ecosystem, whether withdrawing freshwater from north of the salt front, or brackish water from the southern portions of the estuary, we must take great care to understand sustainability equations in estuarine settings so that the delicate coastal balance is not negatively affected. In sum, however reluctant many are to even discuss the matter, it is inescapably true that the region must begin now to consider the cumulative impacts and potential sustainable limits of water withdrawals from the Hudson, or face the consequence of having failed to do so in what may be far more difficult circumstances.

The Opportunity and the Challenge

We know enough to be optimistic about available water capacity in the Hudson Valley: we have ample average annual rainfall, we have freshwater gathered by a very large watershed and we have indications of yet higher precipitation levels in the future. Compared to almost any other part of the world, we are water-rich and in an enviable position.

Current water uses do not appear to come close to exceeding the water carrying capacity of the Hudson Valley. Our overall aquifer water levels are not falling and are in fact flush with groundwater (Chazen, 2010). Moreover, our water is renewing and ultimately renewable, unlike petroleum reserves or mid-west aquifers filled primarily during the last ice age. All this bodes well for community life and water-dependent business in our region.

But examples of local over-use do exist, teaching us also that misuses will occur without planning. Water use which squanders or over-consumes may dewater local steam segments or wetlands or threaten other existing water-dependent activities if more is taken than replenished. Freshwater that is extracted and then discharged far downstream is as potentially damaging as an inter-watershed transfer, potentially causing ecological harm and result in losses of fresh water that might otherwise be available for other economic, human or ecosystem purposes.

Our water quality issues today are often the cumulative result on watersheds of local land use decisions. A single community's storm water treatment practices or wastewater discharges may not have much discrete impact, but together – on a watershed scale – communities' decisions build upon each other to present regional-scale water quality challenges. Well known metaphors – "tragedy of the commons" and "death by 1,000 cuts" – come to mind.

Measured approaches are warranted. To best consider our water resource opportunities and responsibilities, Hudson Valley communities must: identify and protect aquifer source areas, including forests and wetlands that conserve their quality and quantity; invest in or promote new water collection and distribution systems; manage and monitor yield capacity and quality; stimulate withdrawal offsets in the form of treated wastewater returns or aquifer recharge enhancements; and support regional ecological analysis of water uses on the river ecosystem. New water infrastructure investments are likely to attract economic vitality, which may be used to fund equivalent conservation efforts.

And, of course, we need to be ready when others seek us out to tap our "Saudi Arabia of water" resources. We need to be confident in advance that we understand the "safe use" consumption levels of water from both the Hudson River and its tributaries, and have appropriate allocation, protective and "water-ready" site measures in place.

With some smart thinking and collaborative action now, the Hudson River Valley can continue to thrive. We can find a sustainable balance between the development and use of surface and groundwater for an indefinite time, without causing unacceptable environmental, economic or social damage. With 40 inches of yearly rain, a grand freshwater river and likely more rain coming, it is inexcusable if we do not.

Sources

For a complete list of sources for this paper please reference the electronic version on the State University of New York at New Paltz CRREO website: www.newpaltz.edu/crreo

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