Tracking Healthy Waters Protections in the Chesapeake Bay Watershed

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EXECUTIVE SUMMARY

A team of graduate students in the Thomas Jefferson Program in Public Policy at the College of William & Mary surveyed local government staff in 23 Chesapeake Bay Watershed localities in Maryland, Pennsylvania, and Virginia. Four categories of watershed protection tools were tested across all states: watershed management, zoning ordinances, development management, and natural resources protection. On average, localities utilized less than half of the policies categorized as watershed management and development management. Development management and natural resources protection policies were almost universally used. Local policies varied in their level of stringency and enforcement. A number of state regulations mandated the use of certain policies, and localities differed widely in their use of local regulatory authority to have more restrictive policies. The most successful localities blended mandates with incentives and advisory services, while gearing action and awareness specifically toward watershed protection.

Each state differed in a number of ways concerning their approach to protecting healthy watersheds. Maryland, characterized by a high amount of state control, mandates a number of protective regulations regarding watershed health. These state standards and regulations are largely uniform and do not allow sufficient flexibility for individual localities facing divergent pressures. Pennsylvania exercises more decentralized control over the localities. Counties in Pennsylvania do not engage in the same regulatory design process, leaving this to municipalities and engaging in an oversight role. Similar to Maryland, Virginia exercises a high degree of state control over watershed protection, but the state does allow for more flexibility than Maryland, placing different requirements on developed and undeveloped localities.

A basic statistical analysis looking at potential relationships between the various tools and watershed health demonstrated that only two categories appeared to have a significant relationship with watershed health. Development management policies and zoning ordinances showed statistically significant correlations with the proportion of "good" or "excellent" quality samples within a county. Given the intent of this project as a pilot study, the sample size was too small to gain more than a cursory understanding of the interstate and intrastate trends. Future studies should focus on expanding the sample size and modifying the survey methodology to capture a greater level of detail.

INTRODUCTION

Our client, The Nature Conservancy, plays a vital role in environmental issues throughout the Chesapeake Bay Watershed and beyond. As one of the largest environmental non-profit organizations in the world with over one million members, TNC works internationally to protect and restore critical natural resources. Within the Chesapeake Bay Watershed, our client actively works on or supports conservation easements, land acquisition for conservation, biological monitoring and assessments, sustainable forestry and water management, and various restoration efforts. Given our client's focus on Chesapeake Bay restoration, the protection of healthy watersheds within the Chesapeake Bay Watershed parallels TNC's mission and goals.

Our client's relationship with the Chesapeake Bay Program (CBP), a regional partnership coordinating Chesapeake Bay restoration, also enabled us to receive additional guidance and access to information on watershed research and data. CBP contains six goal implementation teams, including the Maintain Healthy Watersheds Goal Implementation Team (GIT4). The GIT4 seeks to protect local watersheds with high levels of water quality from degrading by collaborating to address and improve the various scientific, policy, and management issues associated with watershed protection. Both TNC and CBP's GIT4 have expressed a need for a better understanding of the types of policymaking occurring at the local level to protect healthy watersheds. Specifically, our client requested that our team conduct a pilot study to document what watershed protection policies local governments use and to provide recommendations for tracking the local-level protection of healthy watersheds over time.

While various projects and initiatives designed to restore impaired watersheds provide an array of benefits to private citizens, businesses, and governments, watershed restoration remains costlier compared to healthy watershed protection. Given the preventative nature of protecting healthy watersheds, governments would need to invest in fewer types of public infrastructure, such as water treatment facilities, and can thereby reduce costs. In addition to necessitating fewer public infrastructure expenditures, maintaining healthy watersheds can also minimize the impacts of flooding, reduce sedimentation and erosion issues, and assist with improving groundwater recharge capacity.[1] Furthermore, several studies indicate that proximity to open green space increases the property values of residential homes. Finally, relatively unpolluted and pristine waters must exist in order for successful tourism and recreational activities such as fishing and boating to take root and thrive within a locality or region.

[1] U.S. Environmental Protection Agency, "Healthy Watersheds News," EPA Healthy Watersheds, Summer 2012, water.epa.gov/polwaste/nps/watershed/upload/hwnews12-2.pdf.

LITERATURE REVIEW

A number of survey and research projects have focused on the actions of local communities and governments to restore watershed health. A substantially more limited number of reports have assessed how local-level activities support the protection and maintenance of watersheds with relatively high water quality. Prior to initiating our survey, we reviewed several relevant studies and reports analyzing various components of watershed protection. In particular, we focused on publications that either addressed watershed policy at the local level or recommended certain policy and management strategies for watershed protection.

In 2008 the Center for Watershed Protection published the results of a survey containing questions based on the eight tools of watershed protection. Survey respondents included local government staff in 73 coastal plain communities across Alabama, Delaware, Florida, Georgia, Louisiana, Maryland, Mississippi, North Carolina, New Jersey, Pennsylvania, South Carolina, Texas, and Virginia. Most often, survey respondents indicated a lack of funding and limited staff resources as the primary reasons for the limited adoption of watershed protection tools. Furthermore, the researchers concluded that the local governments were primarily meeting state and federal regulations but not able to gather resources for additional initiatives.[2]

In another report, three non-profit organizations (Friends of the Rappahannock, James River Association, and Potomac Conservancy) based in Virginia received funding from the Chesapeake Bay Stewardship Fund to assess how Low Impact Development (LID) practices impact stormwater runoff.[3] The researchers, in collaboration with graduate students in urban planning and environmental policy programs at three Virginia universities, analyzed the local codes and ordinances of 41 counties and independent cities within the Chesapeake Bay Watershed's non-tidal areas. The researchers modified the Virginia Department of Conservation and Recreation's *Checklist for Advisory Review of Local Ordinances*[4] to uniformly gather data on LID principles.

Ultimately the research team made several findings relevant to our report. First, at least one locality established codes or ordinances for all 76 of the LID principles, thereby indicating that the integration of LID principles into local regulations is possible. Second,

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[2] Karen Cappiella, Lauren Lasher, Neely Law, and Chris Swann, *Watershed Planning Needs Survey of Coastal Plain Communities* (Technical memorandum, Center for Watershed Protection, 2008), 22.
[3] Friends of the Rappahannock, James River Association, Potomac Conservancy, *Promoting Low Impact Development in Virginia: A Review and Assessment of Nontidal County Codes and Ordinances* (2012).
[4] Virginia Department of Conservation and Recreation, *Checklist for Advisory Review of Local Ordinances* (Word document, 2009), http://www.dcr.virginia.gov/stormwater_management/documents/checklist_adv.doc.

the most substantial gap among localities for protecting water quality entailed the protection of trees and vegetation. Third, localities receiving low scores (indicating fewer numbers of LID principles) were typically rural and under less development pressure.[5]

Currently the VDCR's Division of Chesapeake Bay Local Assistance (DCBLA), as part of Phase III of the Chesapeake Bay Preservation Act, provides a checklist of local ordinances to assess whether localities adequately meet the performance criteria. DCBLA then conducts advisory reviews using the checklist to verify that the localities' ordinances comply with the criteria. The compliance evaluations for localities occur approximately every five years. In the "Moving Forward" section of our report, we discuss DCBLA's checklist and its potential utility for future research.

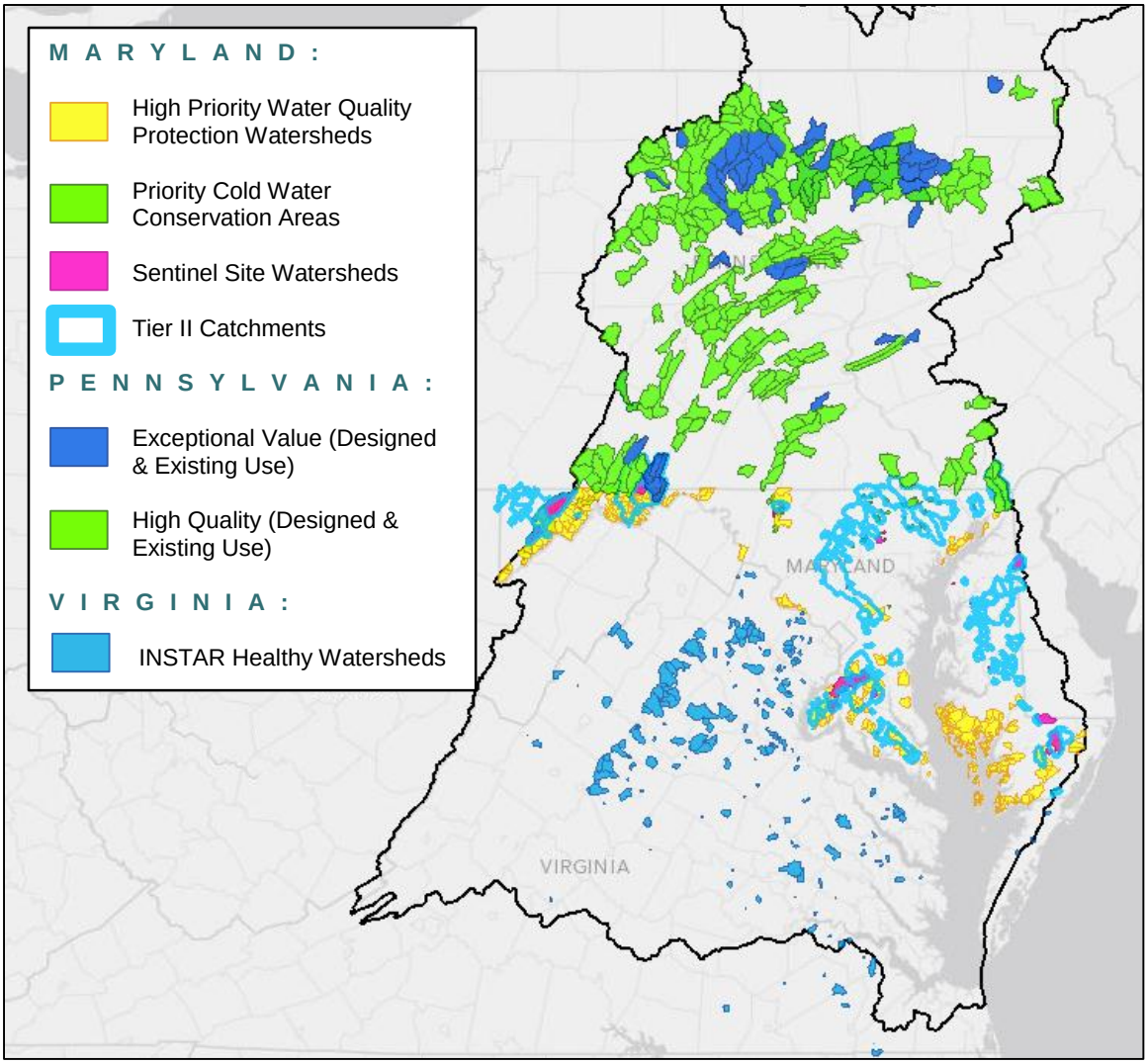
In 2011 the U.S. Environmental Protection Agency released its Healthy Watersheds Initiative, which provided a framework for how the agency plans to protect healthy waters. EPA's framework and action plan contains several focus areas for state involvement, including the development of various healthy watershed assessments, green infrastructure assessments, outreach programs, and healthy watershed protection plans.[6] Ultimately the plan outlines the need for state programs that assess water quality and provide watershed protection but also the need for land use regulations and watershed planning at the local government level. Several state programs (e.g. Maryland's GreenPrint Program, Pennsylvania's Healthy Waters Initiative, and Virginia's Healthy Waters Initiative) have emerged to promote the conservation of ecologically valuable, healthy lands and watersheds. The recent flurry of activity among federal and state governments regarding the protection of healthy watersheds will hopefully induce a "trickle down" effect for local governments in the near future.

[5] Ibid, 16.
[6] U.S. Environmental Protection Agency, *Healthy Watersheds Initiative*: *National Framework and Action Plan*, 2011, water.epa.gov/polwaste/nps/watershed/upload/hwi_action_plan.pdf.

SURVEY METHODOLOGY

We refined a set of survey questions initially developed in July 2012 in order to capture as much detail from respondents as possible. We also requested and received feedback from Chesapeake Bay Program GIT4 members, who had a diverse set of skills and experiences relating to watershed policy. The final list of survey questions consisted of 9 questions, including 2 questions which listed 11 planning and zoning tools and 9 regulatory and management programs to determine which of the listed items each locality had adopted or implemented. **Appendix I** contains the complete list of survey questions used for this report.

Figure 1. Map of Areas Meeting State Definitions for Healthy Watersheds[7]



[7] Chesapeake Bay Program staff provided this data via Chesapeake*Stat*, a website created by CBP that contains spatial data viewers and various data sets. Chesapeake*Stat* can be accessed at http://stat.chesapeakebay.net.

Given the intentional open-endedness of the questions, we conducted the survey via telephone to best extract detailed, comprehensive answers from the respondents. We also anticipated that a telephone survey would induce additional comments from the respondents, given the free-flowing nature of telephone conversations. Typically, respondents spent 30-45 minutes answering the survey, with some respondents spending upwards of 90 minutes.

Due to the time constraints associated with the project and our client's requests, we focused on a sample of 10 localities per state, for a total of 30 localities. Using GIS data provided by the Chesapeake Bay Program, we selected localities with high concentrations of healthy watersheds. Where possible, we attempted to include a mix of localities with rural, suburban, and urban characteristics. The localities surveyed, as well as their general demographic profiles, are listed in **Appendix II**. Each state differs in its use of criteria for defining healthy watersheds, and **Figure 1** shows the CBP data mapping where healthy watersheds exist, according to state definitions.

Though all three states utilize some type of biological health assessment to determine watershed health, Maryland uses the most multifaceted system. Maryland has a number of classifications for healthy watersheds and does not explicitly categorize its watersheds in broad "good" and "excellent" or "high quality" and "exceptional value" terms, as do Virginia and Pennsylvania, respectively. As shown in **Figure 1**, high priority water quality protection watersheds, areas with priority cold water conservation areas, Sentinel Site watersheds, and/or Tier II catchments were chosen as candidates for survey participation.

The Maryland Department of Natural Resources conducts the Maryland Biological Stream Survey (MBSS) annually on a statewide basis. Using data collected from the MBSS, watershed health is assessed and certain watersheds fall into classifications for high quality, such as sentinel site and stronghold watersheds. Used for long-term monitoring, sentinel sites are healthy, non-tidal watersheds that have minimal disturbance. Stronghold watersheds were also factored into the selection of localities but were not included in the map. Stronghold watersheds represent the areas with the highest numbers of rare, threatened, or endangered aquatic species. These watersheds are deemed most important to protecting aquatic biodiversity.[8] Using MBSS data, Maryland classifies high-quality, Tier II waters in order to provide additional protection to Tier II waters, under the state antidegradation policy. States must adopt antidegradation policies to protect and maintain high quality waters, though states have varied in their implementation of these policies.

[8] Maryland Department of Natural Resources, "Watersheds of Greatest Importance for the Preservation of Maryland's Aquatic Biodiversity," www.dnr.state.md.us/streams/pdfs/StrongholdFactSheet.pdf.

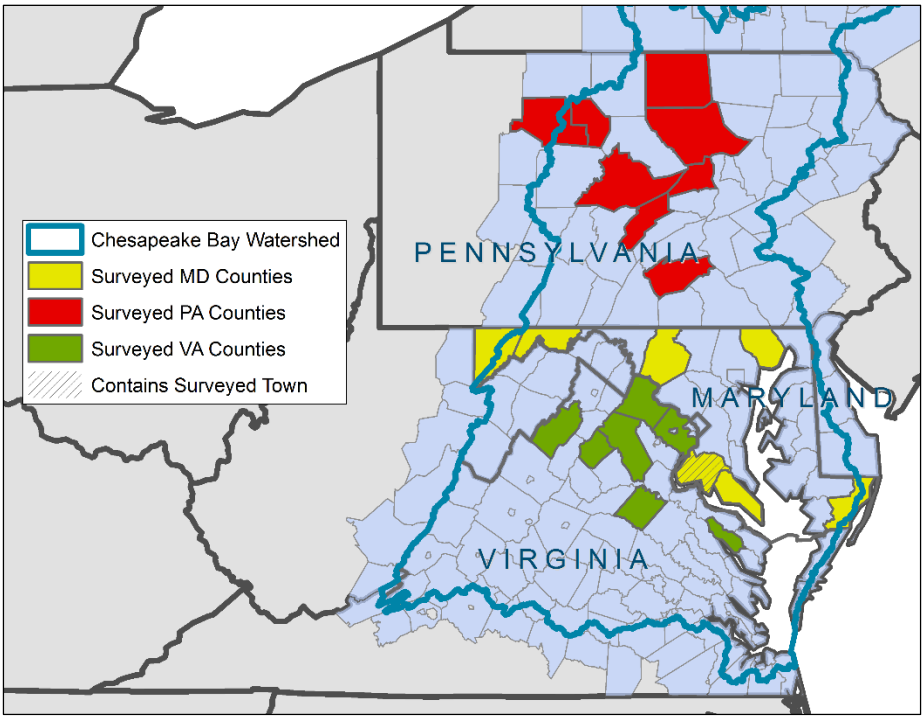
Tier II catchments specifically refer to the catchments of streams that possess biological or chemical traits exceeding the minimal water quality requirements of Tier I catchments.[9]

The Pennsylvania Department of Environmental Protection (PDEP) conducts stream assessments to determine water quality and classify streams of high quality. Within Pennsylvania the state code provides criteria for surface waters to meet in order to become classified as High Quality (HQ) or Exceptional Value (EV). Surface waters are further classified based on existing use and designated use. The term "existing use" refers to the current or past condition of a stream, whereas "designated use" refers to the attainable condition of a stream.[10] If a stream's existing use meets the requirements for High Quality or Exceptional Value classification, municipalities (often with local government support). HQ and EV designated streams receive the highest levels of support and protection from PDEP. Municipalities can petition PDEP to update its designated use in the case of a stream's existing use surpassing its current designated use. In this scenario, a stream is not getting the level of protection it should receive.[11] **Figure 1** shows those waters meeting the HQ or EV classifications.

Similar to the MBSS, the Interactive Stream Assessment Resource (INSTAR) developed by the Center for Environmental Studies at Virginia Commonwealth University, uses biological stream data to provide a modified Index of Biotic Integrity (mIBI) score and Virtual Stream Assessment (VSA) and score for each studied stream.[12] INSTAR compiles water quality data collected by state agencies, local governments, volunteers, and academic institutions, provided the data comply with certain sampling criteria. The INSTAR healthy watersheds, as indicated in **Figure 1**, represent the watershed areas surrounding Healthy Waters INSTAR sites. A small number of surveyed Virginia localities indicated concerns with INSTAR's methodology or were simply unaware of INSTAR.

[9] Maryland Department of the Environment, "Water Quality Standards," www.mde.state.md.us/programs/Water/TMDL/Water%20Quality%20Standards/Pages/programs/waterprograms/tmdl/wqstandards/index.aspx.
[10] Delaware Riverkeeper Network, *Protecting Streams in Pennsylvania: A Resource for Municipal Officials*, 2007, 6.
[11] Citizens for Pennsylvania's Future, *Stream Redesignation Handbook*, 2009, 29.
[12] Jennifer Ciminelli et al. *Healthy Waters*. Report, Virginia Department of Conservation and Recreation, 7.

Figure 2. Map of Surveyed Localities



We began contacting potential localities on October 19, 2012, and continued conducting surveys through November 20, 2012. We concluded our data collection process with 23 participating localities for a response rate of 77%. Although a total of 25 localities agreed to participate in the survey, 1 locality provided incomplete responses via e-mail, due to time constraints; the other locality did not have any regulatory authority, as the county administered regulations for the town. **Figure 2** highlights the eight Maryland localities (seven counties and one town), eight Pennsylvania counties, and seven Virginia counties who participated in and completed the survey.

CATEGORIZATION OF POLICIES

When creating the survey, we divided the list of local policies into two categories: planning and zoning tools and regulatory and management programs. In order to provide a more compelling qualitative and statistical analysis of the individual policies, we placed the policies into four new categories: watershed management, zoning ordinances, development management, and natural resources protection.

Table 1. Categorization of Policies

Watershed Management	Zoning Ordinances	Development Management	Natural Resources Protection
GIS-based Watershed Inventory	Cluster Development Ordinance	Infill and Community Redevelopment	Critical Area or Special Protection of Lands Adjacent to Water Bodies
Needs and Capabilities Assessment	Floating Zones	Low-Impact Development Standards	Landowner Stewardship Programs
Water Quality Monitoring and Assessment	Impervious Cover Limits	Transfer of Development Rights	Long-term Conservation Programs
TMDL Implementation/ Monitoring Plan	Overlay/ Special Use Zoning Districts	Urban Growth Boundaries	Voluntary Best Management Practices
Watershed Management Plan	Riparian Buffer Limits		
Watershed-Based Zoning	Steep Slope Ordinance		

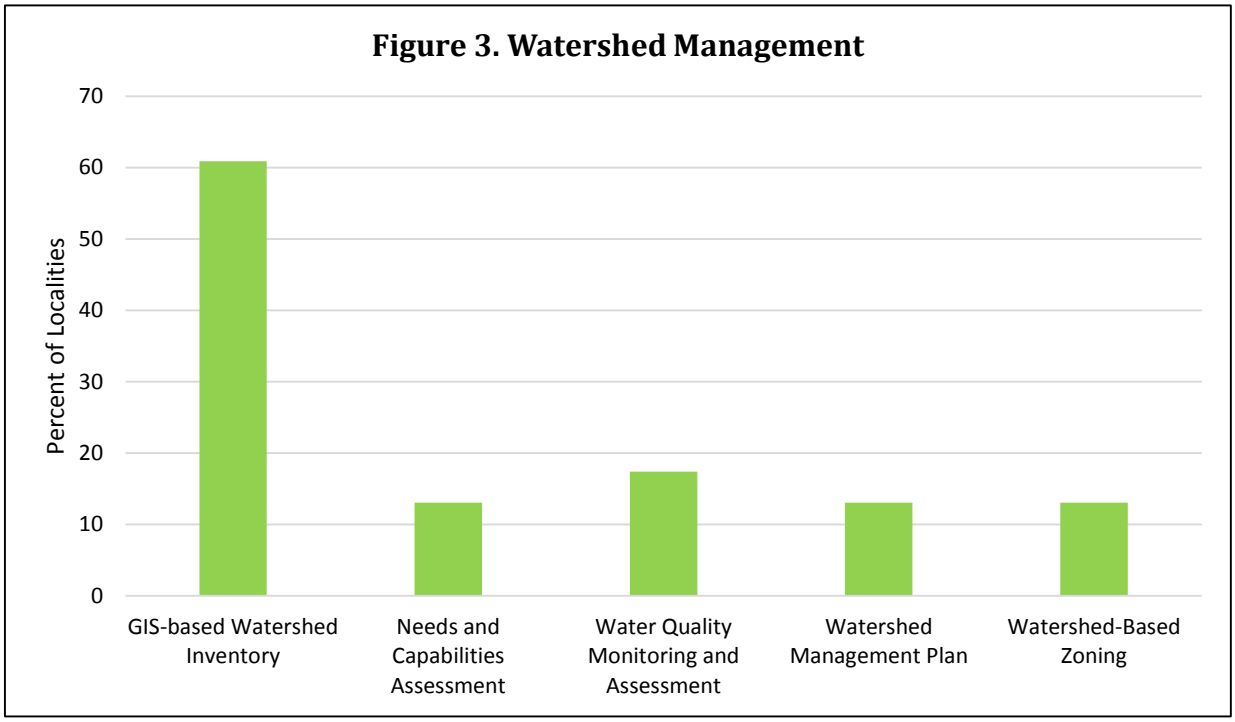
Although the survey addresses whether a locality contains guidance or regulations on pesticide and fertilizer use, or whether it has an emergency spill response plan, we did not include them in the categorization. Given their overwhelming use among localities and loose, redundant ties with watershed protection, we chose to omit these two policies from the overall categorization. Both pesticide and fertilizer use and emergency spills are largely regulated at the state and federal level with minimal to no variation among the surveyed localities. In several instances, survey respondents indicated other governmental

agencies that operate educational and advocacy programs regarding fertilizer or pesticide use. For example, several of Pennsylvania's conservation districts and Virginia's soil and water conservation districts were cited for their work locally to minimize the improper use of fertilizers and pesticides both in residential and agricultural areas.

INTERSTATE TRENDS

WATERSHED MANAGEMENT

Watershed management policies were used by 19 of the 23 responding localities. The town contacted in Maryland did not have the authority to use the watershed management tools as the county claimed that role. The three remaining localities without watershed management tools in place were predominantly rural and decentralized with protected state forests and historic sites. These localities often cited a lack of adequate resources at the local government level which made the complete implementation of state watershed management requirements difficult.



Watershed management plans were in place for 11 counties and took 2 main approaches for watershed management. One approach involved making individual watershed management plans for each watershed within the locality. This approach usually involved one or more watershed management tools which applied specifically to an individual

watershed. The other approach entailed a countywide plan that focused more on general steps the county should take to protect the health of all watersheds. Three of the localities used the first approach, 4 localities used the second approach, 4 localities used both approaches, and the final locality had a watershed management plan in progress with a projected completion date in 2013.

Only 13% of responding localities indicated the use of watershed-based zoning. Watershed-based zoning is essentially a planning process where the local government incorporates numerous factors (e.g. impervious surface area, water quality, and current land use) into land use and development decisions. A local government will designate certain watersheds or subwatersheds as targets for potential development as a way to minimize future development in watersheds deemed more critical.[13]

Surprisingly, 61% of localities indicated the use of a type of GIS-based watershed inventory. The degree to which GIS data was utilized for planning and development predictably varied widely. Similar to the findings of the Center for Watershed Protection's results from a survey of local government staff in coastal plain communities, limited technological capacity does not seem to be the reason local governments are not implementing important watershed protection tools.[14]

The least prevalent tool, Needs and Capabilities Assessments (NCAs) were used by only three localities. As one of the tools listed in the Center for Watershed Protection's *User Guide to Watershed Planning in Maryland*, the NCA consists of five sections[15] which enable local government staff to readily identify existing resources related to watershed management.[16] The NCA is an organizational checklist to guide local government staff in assessing what agencies and departments handle certain facets of watershed protection, whether the locality has adopted specific regulations, and what areas of improvement exist within the locality. While its purpose overlaps with a number of other possible documents and even a county's comprehensive plan, it can help staff to better identify gaps in regulatory protection or even jurisdictional authority. Since it was originally designed for Maryland localities, its limited use is not necessarily surprising.

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[13] Center for Watershed Protection, "Land Use Planning Fact Sheet: Watershed Based Zoning," Stormwater Manager's Resource Center, http://www.stormwatercenter.net/Assorted%20Fact%20Sheets/Tool1_Planning/WatershedBasedZoning.htm.

[14] Karen Cappiella, Lauren Lasher, Neely Law, and Chris Swann, *Watershed Planning Needs Survey of Coastal Plain Communities* (Technical memorandum, Center for Watershed Protection, 2008), 22.

[15] The five sections, as originally described by CWP, include: Regulatory Forces Driving Watershed Planning, Local Agency Capacity, Your Local Agency Restoration Rolodex, Adding Non-Local Government Partners to Your Rolodex, and Community Attitudes.

[16] Karen Cappiella et al, *A User Guide to Watershed Planning in Maryland*, Center for Watershed Protection, 2005, 57-58.

The results from the survey question concerning TMDL implementation/monitoring plans are not reflected in **Figure 3**, largely due to a discrepancy in responses. Some localities provided feedback concerning their degree of involvement in the development of TMDL Phase I and II WIPs. Other localities indicated the presence of an impaired watershed which has a TMDL implementation plan for how to reduce a pollutant exceeding the maximum allowable load. A small number of surveyed localities have produced plans that outline how the county government intends to implement reductions to satisfy TMDL requirements. Frederick County, MD, for example, created a report in July 2012 to analyze more cost-effective measures to meet TMDL requirements than those recommendations set forth in the county's WIP.[17] Several respondents expressed frustration with being forced to comply with TMDL requirements, while not receiving state or federal funding necessarily to do so. For future research, a more detailed question or set of questions concerning a locality's level of involvement in TMDL regulations may prove useful.

Though not captured in **Figure 3**, the first question of our survey asked respondents to list the known healthy watersheds (based on the respective state's definition) within a jurisdiction. Since we only selected localities with at least some portion of a watershed deemed healthy by state criteria, the survey respondents should have been able to list at least one healthy watershed. A few counties in Virginia specifically listed watersheds considered "high quality" based on county-level assessments or some other criteria, other than INSTAR scores. Pennsylvania counties uniformly recognized the distinctions of HQ and EV waters and readily provided the names of watersheds classified as such. The responses varied in Maryland localities, likely due to the variety of possible classifications for healthy waters in the state.

The watershed management tools listed have variable usefulness for watershed preservation. They are valuable tools that should be used to preserve healthy watersheds, but many of the tools could be used without a significant enforcement component. Almost all of these tools could be used merely as a way to gather information, making it a necessary component of any watershed preservation plan, but not sufficient on its own to have a demonstrably positive impact.

[17] Frederick County Government, *Chesapeake Bay TMDL Analysis for Frederick County, Maryland*, 2012.

Policy Recommendations

- *Complete a countywide watershed management plan*. Several counties had watershed management plans for specific watersheds but not necessarily all of their watersheds.

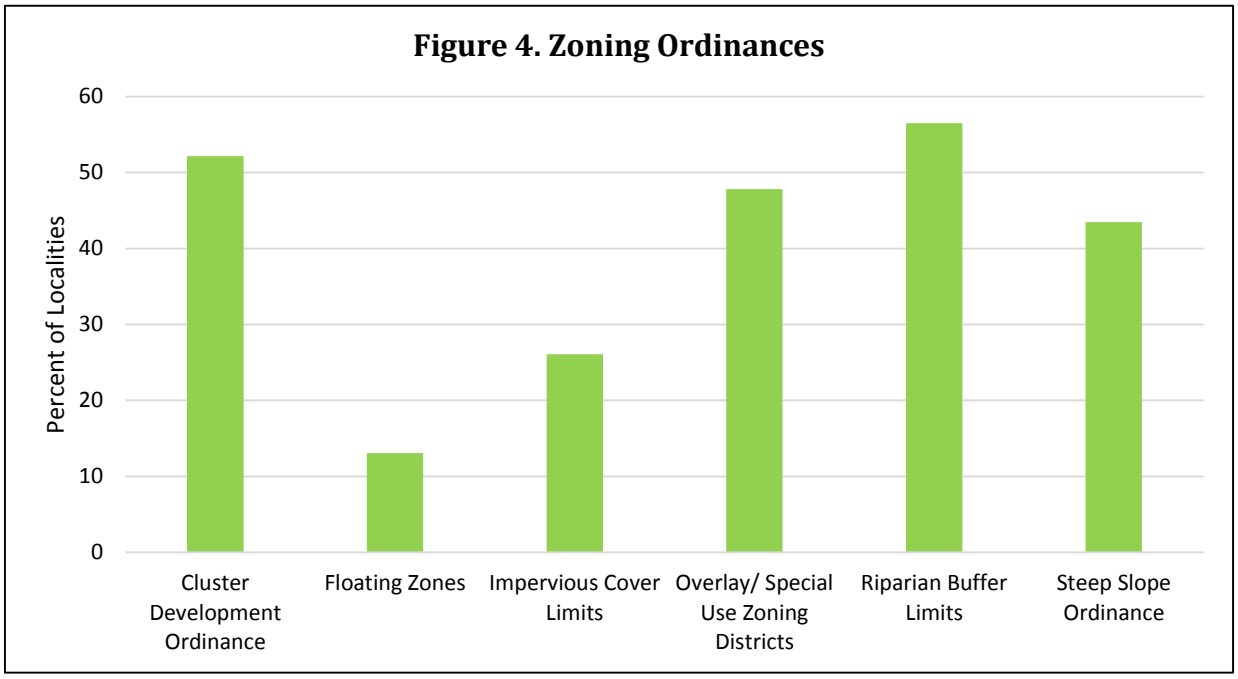
- *Integrate the watershed management plan into the comprehensive plan.* In order to enhance effectiveness, the locality's countywide watershed management plan should be incorporated into the comprehensive plan and contain specific goals and requirements that will give teeth to the locality's watershed protection strategy. The best watershed management plans were completed on a countywide basis and were well incorporated into the comprehensive plan.

- *Utilize community resources.* By coordinating with the instrumental non-profit watershed associations and watershed councils, localities can take advantage of community resources and better inform the development of countywide policies.

- *Implement watershed-based zoning*. There appears to be a need among localities for incorporating watershed-based zoning into the development approval process. Many local governments have a wealth of GIS data on a subwatershed level and could easily transition to steering development away from the most critical subwatersheds.

ZONING ORDINANCES

From our sample, 19 localities indicated the use of at least one of the listed zoning ordinances. The four localities that did not use any of the surveyed zoning ordinances were primarily rural and also contained large areas of land devoted to either federal or state protection as public forests and historic sites.



Of the zoning ordinances, floating zones were by far the least utilized with only 13% of localities indicating their use. Several respondents expressed unfamiliarity with the term and were unsure of their function. A floating zone is a future land use planning tool that enables a local government to include certain conditions for desirable development projects without specifying a geographic area in the official zoning map. Floating zones provide more control to local governments and can be an excellent planning tool to establish more stringent standards for environmental protection. For example, the zoning ordinance for Charles County, MD contains four floating zones (Planned Residential Development Zone, Mixed Use Zone, Planned Employment and Industrial Park Zone, and Planned Manufactured Home Park Zone), each of which outline criteria to be met in order for development to receive approval under the respective zoning district. Each floating zone also contains conditions concerning the preservation of open space.[18]

In contrast with floating zones, overlay zoning districts become attached to certain geographic areas and provide additional conditions for land use within those areas.

[18] Charles County Government, *Charles County Zoning Regulations Chapter 297*, 2008.

Overlay districts are included in a locality's zoning map. Of the surveyed localities, 48% had overlay districts which help protect watersheds and water quality. Several respondents indicated the use of overlay districts to protect drinking water in order to protect watersheds that supply drinking water to citizens. The overlay districts often contained stream or riparian buffer requirements, density limits, and steep slope restrictions.

The majority of localities (52%), particularly in Virginia and Maryland, cited the use of a cluster development ordinance. By adopting a cluster development ordinance, a local government can offer smaller lot sizes (e.g. additional development rights) in exchange for the preservation of a certain percentage of the overall parcel. Despite the clear benefits of cluster development for more sparsely populated localities, some of the most rural counties, such as Richmond County, VA, in our sample did not utilize clustering. As indicated in Richmond's 2011 Comprehensive Plan, however, the County plans to complete a feasibility study to assess potential new zoning that encourages clustering for agricultural land.[19] Should the proposed zoning come to fruition, Richmond County could preserve its vital agricultural operations and maintain large open spaces while also accommodating residential growth.

Impervious cover limits were used by 26% of responding localities. The term "impervious cover" refers to any surface that does not allow for the absorption or filtration of rainfall, and such surfaces include rooftops, parking lots, roads and sidewalks. Most commonly localities cited a 15% impervious cover ordinance, meaning that impervious surface was limited to no more than 15% to the total lot size. Some localities applied this ordinance to only certain zoning areas, such as an overlay district protecting critical area, or to only certain lot sizes. Fairfax County, VA essentially offers a carrot for developers to minimize imperviousness since developers must meet BMP requirements if impervious surface surpasses the county's average land cover condition of 18%.

All three states require some riparian buffer minimums, though not all of the localities implemented or used these requirements. Of the localities that did use riparian buffer minimums, some used only a 50-foot setback in narrow circumstances and others used variable setbacks based on activity and location along the watershed. Some of the localities are subject to the Chesapeake Bay Preservation Act (CBPA) regulations. The CBPA requires 100-foot buffers for land adjacent to tidal waters and tidal wetlands (including non-tidal wetlands contiguous to tidal wetlands), but several localities require vegetation buffers in certain watersheds or zoning districts.[20]

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[19] Richmond County Government, *Comprehensive Plan Update*, 2011.
[20] Virginia Department of Conservation and Recreation, "Riparian Buffers," www.dcr.virginia.gov/stormwater_management/ripbuff.shtml.

Some localities used voluntary versions of these tools with financial incentives to gain compliance from developers. When coupled with adequate incentives these options can prove as successful as mandatory programs and are potentially easier and cheaper to implement than mandatory programs. The continued presence of some of these tools is uncertain in some localities, however. One of the localities noted that they previously used a number of zoning ordinances which served to protect watersheds but that these ordinances were eliminated by the Board of Supervisors after an election in which party control shifted.

Policy Recommendations

- *Expand vegetation buffer requirements.* The majority of surveyed localities either cited use of a local buffer ordinance or adherence to state requirements for state-defined healthy watersheds.

- *Establish risk aversion measures*. Risk aversion measures, such as floodplain ordinances and strong erosion and sediment control regulation, can serve as successful watershed protection measures where public support for watershed protection cannot otherwise be leveraged.

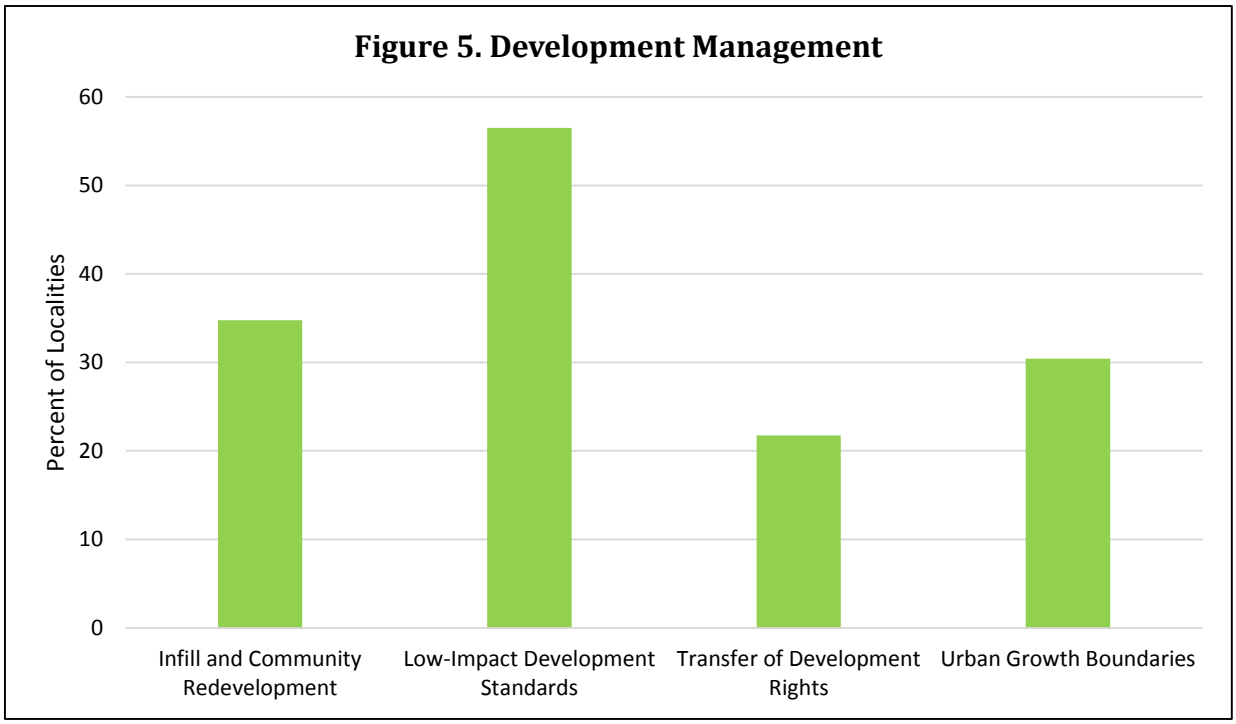
- *Incentivize developers to reduce impervious cover*. Local governments should update local codes to minimize the addition of impervious cover, particularly for parking lots and streets. Sidewalks and roads can be adequately narrowed without sacrificing safety or usefulness. Localities should prioritize the use of tax credits for development that achieves impervious cover reductions beyond the minimum requirements. Alternatively, localities could consider revising stormwater utility user fees to incorporate a fee schedule based on impervious surface.

- *Create educational and outreach programs for the general public and community of developers.* The potential watershed protection benefits of well-designed zoning ordinances do not have to come to the detriment of citizens or businesses.

DEVELOPMENT MANAGEMENT

Of the responding localities, 20 used at least one of the development management tools listed in the survey. Two of the localities that did not use any development management tools did not utilize zoning ordinances either. As seen with the two prior sections, these two localities are predominantly rural with large tracts of protected lands and likely do not face the same development pressures that other localities face.

Figure 5. Development Management



LID standards are being increasingly implemented through the adoption of state-mandated stormwater management plans. All of the states had stormwater management requirements, but only Maryland required low-impact development (LID) standards as part of their stormwater management requirements. Slightly more than half of the responding localities had LID standards, likely due to state stormwater management requirements.

Urban growth boundaries and community infill and redevelopment efforts were common in more developed localities, but virtually nonexistent in more rural localities. Rural localities face fewer development pressures than more urban localities making many of these tools less useful. Urban localities also noted that infill and redevelopment efforts are important because of the provision of sewage and public water. Without infill and community redevelopment efforts urban localities may overload their service provision abilities while rural areas may more readily handle infill without strict regulation.

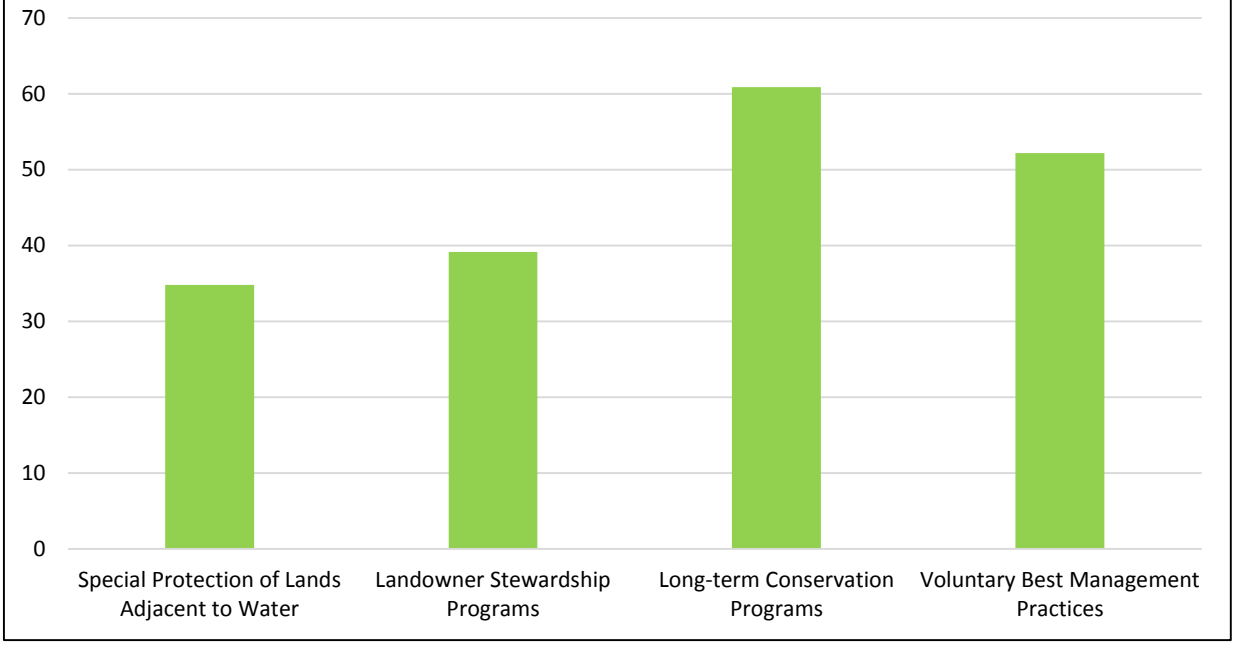
Transfer of Development Rights (TDR) programs were used by 22% of localities and played a significant role in protecting the healthy watersheds. TDR programs are generally regarded as preferable to Purchase of Development Rights (PDR) programs in the sense that development rights with TDR programs are purchased by private citizens and do not require public funds. Typically, however, PDR programs are more successful in rural, agricultural counties, and TDR programs work best in suburban or urban localities with limited open space. Many of the localities that discussed their TDR and PDR programs with us mentioned agricultural interests as a key constituency for the program. This is likely because TDR programs can allow for some agricultural development on land designated for preservation. One Virginia county indicated that a neighboring county recently created a TDR program, and the surveyed county plans to monitor its implementation and level of success.

Policy Recommendations
• *Utilize the county's comprehensive plan to outline development standards which serve as soft regulations for developers.* A few counties found notable success leveraging zoning approval to gain desired concessions from developers in the absence of explicit requirements. In counties facing strong resistance to additional or more restrictive development management ordinances, the comprehensive plan becomes an ideal tool for prescribing new development management standards. If development proposals that fail to meet the new standards do not receive approval, developers will adjust over time to the new standards, provided compliance with the standards is not cost-prohibitive. • *Encourage the use of urban growth boundaries and prioritize infill/redevelopment*. Rural and suburban localities particularly benefit from using urban growth boundaries and limiting sprawl development. Rural localities can achieve success in limiting urban growth simply by limiting their service provision. • *Introduce a TDR program in localities resistant to more stringent forms of land use management.* TDR programs in more suburban counties experiencing increased growth can take advantage of market demand for density credits while also conserving important agricultural or forestal land.

NATURAL RESOURCES PROTECTION

Of the responding localities, 22 used at least one of the natural resource protection tools mentioned. The number of tools in use, while substantial, does not show the whole picture. Not all of the tools utilized were used widely throughout the locality and not all of the tools widely used had teeth. State programs that provide or mandate natural resources protection at the local level also resulted in some localities relying solely on state programs and not developing local programs.

Figure 6. Natural Resources Protection



Long-term conservation programs are a perfect example of the variable effectiveness of a useful tool. The most common long-term conservation program identified was the use of conservation easements, often acquired through federal match programs or state funding. Localities that could not obtain these matched funds noted difficulties in fully funding these programs. Some localities also noted that their conservation programs focused heavily on agricultural lands. In particular, several localities with fairly high levels of agricultural land indicated their use of Purchase of Development Rights (PDR) programs. A PDR program is a land conservation program through which a locality simply purchases the development rights for a parcel, typically retiring the development rights. Several localities also relied on non-profit organizations to fill in gaps in their own conservation programs.

Landowner stewardship programs and voluntary best management practices (BMPs) were predictably most common in localities with large agricultural or forestal districts, and appeared to achieve a significant amount of buy-in from farmers—localities achieved a

great amount of success working with the farmers on voluntary efforts. These programs seemed to be more successful when they offered some kind of property-specific advice, such as soil sampling and analysis. The most effective programs also offered some incentives for environmentally beneficial actions.

The designation of critical areas or special protection of lands adjacent to water bodies, the last policy mentioned, was used by a number of localities. The scope of these critical areas and the extent of protection were variable across localities. Most of the localities stated that flood plains fell within the scope of this tool and consumed the bulk of its attention. Other responses included stormwater ordinances and zoning ordinances for properties with septic tanks. Pennsylvania had some state requirements for critical areas, and some federal programs also required protection of critical areas, especially in some of the more rural areas. Most of the localities used zoning ordinances to implement this specific tool, though one of the localities mentioned a program where landowners would get money from both the federal and state government if they included a buffer on their property.

Policy Recommendations

- *Encourage and support conservation easements and PDR programs in rural counties.* Finding cost-effective ways to protect watersheds by utilizing resources already available is perhaps the most important effort counties can undertake in natural resources protection. Land trusts and other non-profit organizations frequently perform outreach to landowners with property ideal for conservation easements. Rural local governments can collaborate with these organizations to co-hold easements or simply to help ensure that the most important lands for conservation easements receive them.

- *Create a network of green infrastructure.* Connecting open space areas with greenways (i.e. natural, open space corridors) is an excellent way for growing rural, suburban, and urban localities to incorporate land conservation and produce economic benefits for the local government. Aside from increasing land values near the open space corridors and areas, greenways can improve water quality, reduce flood damage, and help manage stormwater runoff and overflow.[21]

- *Ramp up public outreach and education for watershed protection.* Counties with the strongest watershed protection policies also made concerted education efforts, both to the agricultural sector and the general public. This trend suggests the importance of such efforts not only in guiding individual behavior but also in gaining public support for watershed protection.

- *Incentivize voluntary BMPs, particularly for agricultural land*. Counties that gained buy-in from agricultural operators and other landowners or developers seemed to be more successful at protecting the watershed. Buy-in seemed greatest when the county offered advice and incentives for BMPs. Local governments should take full advantage of state and federal financial incentive programs for the installation of BMPs.

[21] Virginia Department of Conservation and Recreation, "Greenways," www.dcr.virginia.gov/recreational_planning/greenway.shtml.

COOPERATIVE RELATIONSHIPS

Surrounding Localities

Partnerships with surrounding localities were not very frequent, but coordination with other localities did show considerable promise where communities sought ways of sharing resources to reduce costs. For example, some localities were probing the viability of sharing the costs of engineers, inspectors, and other experts. Where counties did partner with one another, some collaborated to offer educational programs for the public as well as training for farmers and developers. Given the importance of education efforts, as identified above, these collaborative educational efforts appear to be another imminently viable way of effectively using resources at the counties' disposal. The most frequent coordination, however, was among those localities sharing streams and rivers. Indeed, regional authorities and watershed management efforts facilitated communication and coordination between the localities in many instances. In counties without these ties, however, little communication and coordination with surrounding localities existed. Establishing lines of communication appeared to be an easy way in which localities could ensure that their efforts were not being unnecessarily duplicated.

Active Non-Profit Organizations

Every responding locality benefitted from the activity of non-profit organizations operating within the community. These organizations typically provided the greatest assistance in water quality monitoring but were also very active advocates and educators within the surveyed communities. It was certainly clear that non-profit organizations were an indispensable asset in every locality surveyed. The most common volunteer or non-profit organizations are listed below:

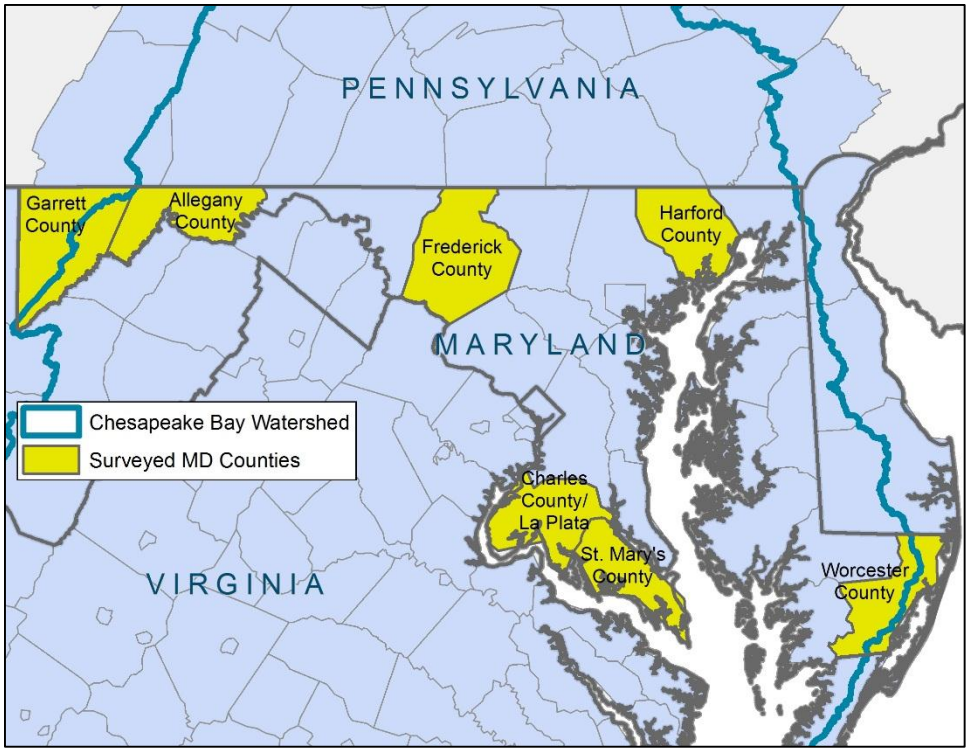
- Watershed- or Locality-Specific planning and protection organizations
- Land trust organizations
- University programs
- Trout Unlimited
- Pennsylvania Senior Environmental Corps
- The Nature Conservancy
- Adopt-A-Stream
- Ducks Unlimited
- League of Women Voters

INTRASTATE TRENDS

In conducting the survey, it swiftly became apparent that each locality's efforts were in part molded by the demographic and legal contours of the state. Accordingly, the following section teases out some of the state-specific trends and offers case studies of localities in each state that were particularly responsive to the survey and particularly active in their watershed protection efforts.

MARYLAND

Figure 7. Map of Surveyed Maryland Counties



Selected Localities

We initially selected 10 localities and added an additional county to replace one of the non-responsive localities. We received responses and completed surveys for 8 of the 11 total localities. Maryland was the only state that we targeted towns for survey participation; we contacted towns because of the fewer number of counties with healthy watersheds (due to Maryland's smaller geographic size). The Maryland sample contained a mix of rural and suburban counties, with some counties containing urbanized areas. The localities differed in the amount of direct control exercised over zoning and regulatory practices, with some exercising a great deal of control and one town exercising almost no control over zoning or regulation. This was also observed in locality concern with the health of the watersheds. A

few localities were very concerned with maintaining their healthy watersheds and rehabilitating their impaired watersheds, while other localities exhibited little if any concern with the overall health of their watersheds. The full list of surveyed localities including demographic information is provided in **Table 2** in **Appendix II**.

Analysis

Maryland exhibits a significant amount of state control over localities. The state imposes a number of requirements related to watershed management and other environmental issues. The state should be commended for taking a strong and central role in protecting its natural lands, but the uniform requirements have been problematic. Maryland encompasses a diverse set of localities, ranging from the urban Baltimore and DC metro localities to the suburban bay and ocean front localities of the eastern shores to the rural mountainous western regions with tracts of federally protected lands. All of these localities have different concerns and resources, and uniform regulations that may work well for some localities prove ineffective or unreasonable for others. Localities in Western Maryland particularly expressed frustration over the application of regulations tailored toward the more developed parts of the state. These regulations often had the particularly undesirable effect of inhibiting maintenance of the western communities rather than simply controlling growth.

Maryland has statewide LID standards and stormwater regulations. Stormwater regulations are specifically designed to maintain water health through the "[reduction of] stream channel erosion, pollution, siltation and sedimentation, and local flooding."[22] The stormwater regulations require environmental site design, through structural design and nonstructural best management practices, to the maximum extent possible. The state offers guidance and tools to help localities effectively implement these environmental site designs. The statute codifying these regulations specifies the use of natural conservation, impervious cover minimization, and runoff slow down. LID standards have been useful in improving stormwater management.

Maryland requires the use of some riparian buffer minimums. These minimums are required for critical areas and forestry harvesting areas, and incentives are offered for private landowners throughout the state. The size of these buffers differs between localities with most being around 100 feet.

The more heavily populated counties, focused mainly in the central and eastern counties, have some form of watershed management plans that are handled at the county level. Most

[22] Maryland General Act § 4-201, http://mlis.state.md.us/asp/web_statutes.asp?gen&4-201.

of these plans have some watershed specific components involved, and a number are incorporated into the localities comprehensive plans. The western most localities either did not have a watershed management plan or did not have one that was effective. The two westernmost localities also had more concerns with damage from coal mining runoff, were more rural, and had a larger amount of protected lands.

Case Study: St. Mary's County

St. Mary's County has taken significant steps in its effort to maintain the healthy watersheds within its borders. Like many other counties, St. Mary's County has a number of river and watershed groups that have developed watershed action strategies. Particularly of note, however, is St. Mary's incorporation of each of these plans into the County's water resources management plan. The County has not paid mere lip service to the goals of the watershed-specific plans but has adopted a number of specific recommendations by ordinance or incorporation into the County's comprehensive plan. St. Mary's County also makes a concerted effort to update the comprehensive plan regularly to ensure consistency with water quality recommendations. In an attempt to mitigate future impacts on its healthy waters, St. Mary's County places a significant emphasis on channeling development as well as educating the public about their impact on the watershed.

In order to determine and assess the health of its watersheds, St. Mary's County relies, in addition to state monitoring, on watershed groups under the Maryland Biological Streams Survey and a robust stream monitoring program operated through St. Mary's College. The Army Corps of Engineers also works with the county on feasibility studies for improving oyster habitat. The County consistently uses the data collected by these groups to help inform their planning efforts. The County also benefits from a very extensive GIS-based watershed inventory that shows the vast network of streams in the county and has lots of information about wetlands, endangered species, and forest cover.

The County's primary planning and zoning efforts are geared toward ensuring focused development of the community. The County places a strong emphasis on infill and community redevelopment as well as on increasing the amount of green space in areas that were not developed with green space in mind. Under the County's comprehensive plan, 70% of all development must occur in the development districts, town centers, and village centers; these are also the only areas where commercial districts are allowed. The County's cluster development ordinance requires 50% of land in rural areas to remain as undeveloped open space. As a result of these policies and that attendant difficulty and expense of building in the rural parts of the County, rural development has come to a virtual halt. In addition to the planning and zoning tools focused on limiting rural

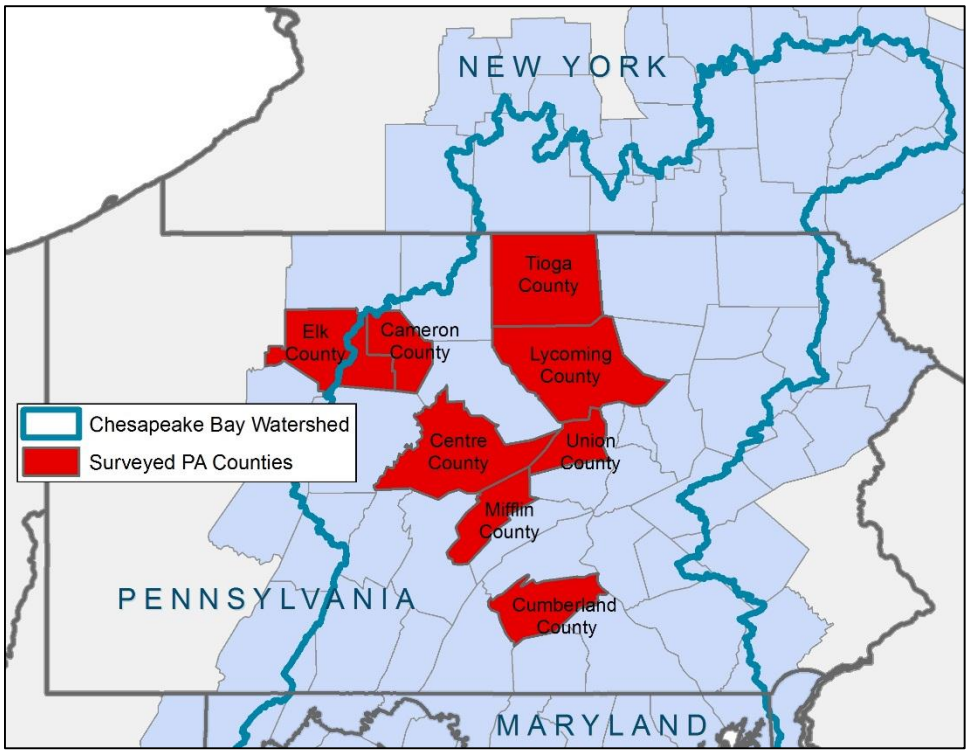
development, the County has a steep slope ordinance that protects any slope of 15% or greater in critical areas and 25% or greater outside critical areas; riparian buffer minimums that account for adjacency to critical areas, non-tidal wetlands, and hydric soils; and critical area protections that limits impervious cover, density, type, and location of development. The County has had particular success in using regulations meant to reduce risk to persons and property as a means of protecting its healthy watersheds.

St. Mary's County also has extensive regulatory and management programs in place. Mostly through the state, but occasionally through local acquisition or mitigation requirements for public works projects, St. Mary's County has established a significant number of conservation easements to protect its healthy watersheds. St. Mary's also has a unique Transfer of Development Rights (TDR) program, through which individuals and commercial developers can purchase TDRs in order to exceed the maximum number of dwelling units or floor area allowed per acre. Finally, the County promotes voluntary BMPs and is currently setting up a neighborhood certification program that individuals can enter BMPs online and the County can be credited under the TMDL.

In its efforts to protect its healthy watersheds, St. Mary's County notably utilizes its relationships with surrounding counties, particularly with respect to common issues relating to the TMDL requirements. Placing a high value on education efforts, the County also does a laudable job of coordinating with and supporting the various private volunteer groups, watershed associations, and schools in its area.

PENNSYLVANIA

Figure 8. Map of Surveyed Pennsylvania Counties



Selected Localities

We initially contacted 10 localities in Pennsylvania but added 2 additional localities to replace unresponsive localities. Of the 12 overall localities contacted we received 9 responses. These localities were overwhelmingly rural in composition. Unique to these localities was the existence of conservation districts to manage environmental concerns. The full list of surveyed localities including demographic information is provided in **Table 3** in **Appendix II**.

Analysis

In Pennsylvania each watershed must receive a stormwater management plan which differs from Virginia and Maryland's approach to locality-level stormwater management programs. Of the surveyed Pennsylvania counties, Cumberland, Elk, Lycoming, and Mifflin had completed Act 167 stormwater management plans for all of its watersheds as of May 12, 2011.[23] Pennsylvania Code requires riparian buffers of 150 feet for land-disturbing

[23] Pennsylvania Department of Environmental Protection, *1978 Stormwater Management Act 167*, 2011.

activities occurring in HQ or EV watersheds.[24] Pennsylvania was also unique in the localities' manifest need to coordinate multiple layers of government.

There is no unincorporated land within the Commonwealth of Pennsylvania, so the counties just extensively coordinate with the municipalities they encompass, in addition to coordinating with conservation districts, non-profits, regional councils of government, and the state. This augmented need for coordination was further complicated by the generally lower population sizes of the counties and fewer community and county resources to facilitate coordination. Many respondents expressed frustration over the inefficiency and duplication of work effort that this coordination challenge created. Increased efforts to coordinate and centralize the watershed protection process within each county has perhaps the greatest potential to yield positive results. The most significant barrier to this effort, aside from limited resources, is the distinct priorities of rural and developed municipalities within many counties in the Commonwealth; rural municipalities commonly being less concerned with watershed protection efforts and placing a greater value on individual autonomy.

Case Study: Centre County

The Centre County Conservation District official who responded to the survey identified a number of healthy streams within the county, but noted that while some parts of the identified streams were healthy, other parts were impaired by acid mine drainage. Although Centre County has a countywide management plan, it does not incorporate the individual watershed assessments for streams within the county. The assessments were very extensive and were all completed within the last 10 years by watershed associations or Pennsylvania State University's Center for Watershed Stewardship. Additionally, water authorities encompassing several municipalities within the county developed source water protection plans in order to protect drinking water. Each of the watershed assessments made recommendations that considered the impact of future growth. A number of entities regularly survey and assess water quality, including the state fish and boat commission, Pennsylvania Senior Environmental Corps, and water resource monitoring teams supported jointly by municipalities.

Of the 35 municipalities in Centre County, only 1 used overlay districts to protect its healthy watershed. Every municipality did, however, incorporate into its land development ordinance impervious cover restrictions for new development. State Act 167 addresses countywide stormwater management and is watershed-based—Centre County has a 167 plan for two stream watersheds. One township attempted to pass a steep slope

[24] Pennsylvania Code § 102.14, www.pacode.com/secure/data/025/chapter102/s102.14.html.

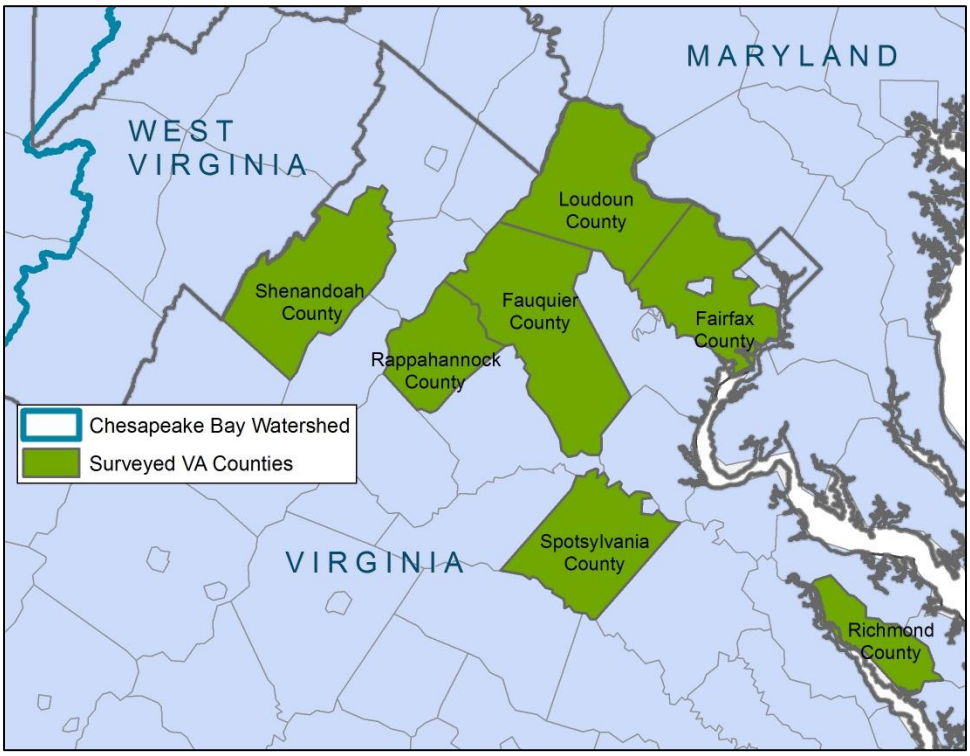
ordinance but faced strong opposition from the public. Each developed township has adopted a riparian buffer minimum, but, outside of complying with the state Chapter 102 requirement of riparian buffers for high quality waters and new developments, no rural municipalities have adopted a riparian buffer minimum. While some municipalities encourage infill, community redevelopment, and cluster development, none had any official requirement; essentially we found lots of layers but no real enforcement. The county has a GIS-based watershed inventory accessible by the public, as well as access to information through Penn State.

With regard to regulatory and management tools, Centre County had agricultural land preservation programs that placed conservation easements on land. A few municipalities have an open space program through which public funds are used to purchase open space. Under the EPA's MS4 requirements, more populated municipalities must adopt low-impact development standards related to stormwater management. A number of landowner stewardship programs through the state that are geared toward farmers required conservation plans and manure and nutrient management plans. These state laws, however, have not moved to enforcement at the county level. Rather, the county focuses on helping farmers become compliant. The erosion and sediment control officials have greater enforcement power. Voluntary BMPs for farmers are encouraged through match programs by which the county will contribute 50% of the cost.

There are many layers of programs and involvement in watershed protection necessitating coordination between localities. For example, watershed group's coordinate across counties and the regional council governments coordinate across municipalities within Centre County. Centre County also coordinates work with Clifford County on the streams that form the counties' shared boundary. The Centre County Conservation District focuses its efforts on seeking federal grants, such as EPA's Healthy Waters program, and PDEP's Healthy Waters program. Finally, the county benefits from the work of a number of watershed groups, an active League of Women Voters chapter, and Penn State.

VIRGINIA

Figure 9. Map of Surveyed Virginia Counties



Selected Localities

We initially contacted ten localities but added one additional locality to replace an unresponsive locality. Of the eleven overall localities contacted, seven ultimately responded. Virginia's response rate was the lowest response rate of any of the three states. The localities chosen were evenly distributed between rural, suburban, and urban localities. Virginia had the most diverse locality selection of the three states, and also had the highest average socioeconomic status. The full list of surveyed localities including demographic information is provided in **Table 4** in **Appendix II**.

Analysis

Virginia engages in statewide monitoring of watershed health.[25] According to the Virginia Department of Environmental Quality, Virginia has the third largest water quality monitoring database of all states. Virginia's recently expanded state stormwater regulations are currently being implemented across the state and are moving localities

[25] Virginia Department of Environmental Quality, "Water Quality Monitoring Programs," http://www.deq.virginia.gov/Programs/Water/WaterQualityInformationTMDLs/WaterQualityMonitoring.aspx.

toward increased utilization of LID standards, though at differing rates of rapidity. Also, VDCR's Healthy Waters Initiative, funded by EPA as part of its Healthy Watersheds program, attempts to increase awareness about the need to protect healthy waters within the state.[26] Although the initiative does not seem well known by local governments in the state, it has the potential to spur watershed protection activities if it can successfully collaborate with local staff.

In surveying the diverse set of localities in Virginia, it became clear that urbanized and rural localities had very distinct priorities relating to watershed protection. The more rural Central Virginia localities placed a high value on maintaining their agricultural character by limiting development, most notably through conservation easement programs. Although the rural localities' desire to cabin development has had the effect of maintaining healthy watersheds, doing so was not a primary motivation for these efforts. Furthermore, these localities were less likely to employ environmentally focused measures via zoning ordinances and watershed management efforts. The more urbanized localities, conversely, sought to facilitate responsible development, but recognized development as an inevitable outcome.

Case Study: Fairfax County

Fairfax County provided great insight into how a rapidly developing county within the Washington, D.C. metropolitan area can actively utilize various policies and programs to protect areas with high water quality. The County's Department of Public Works and Environmental Services developed an internal system to assess ecological health within the county. Wastewater Management's Environmental Laboratory, within Public Works, conducts approximately 100,000 analyses to support the county's various environmental programs. The County also conducts ecosystem monitoring in and around Pohick Creek and Gunston Cove which receive treated wastewater effluent from the Normal M. Cole, Jr. wastewater treatment facility.

The County has also acted aggressively to protect drinking water within the county. For example, in the southern part of the county exist designated special areas which maintain low density zoning in order to protect the water supply. These specially protected areas also tend to be the more pristine watersheds within the county. The Occoquan River watershed is a vital component within the county as the Occoquan Reservoir provides drinking water for approximately 1.7 million residents throughout the Northern Virginia

[26] Jennifer Ciminelli et al. *Healthy Waters*. Report, Virginia Department of Conservation and Recreation, 2-3.

area.[27] As a result, the County undertook comprehensive rezoning of two-thirds of the watershed to be zoned as RC (1 building unit per 5 acres).

Fairfax County is one of the few counties surveyed in Virginia that has completed a watershed management plan. The County began working on the plan in 2003 and completed its 3-watershed plan in 2011. Prior to initiating work on the watershed management plan, the County completed stream physical assessments from 2001-2002. From those 2001-2002 assessments, only 9% of streams were deemed excellent condition, 14% good, 32% fair, 34% poor, and 11% very poor. In each subsequent year the County has completed a similar, but scaled-down (roughly 40 assessments annually) series of stream assessments using probability-based criteria. Using the Stream Quality Index, which incorporates annual data on populations of benthic macroinvertebrates to create an index value ranging from one to five (five indicating excellent water quality), the county received an index score of 2.83 in 2011. Using 2004-2011 monitoring data, the percent of good and excellent quality streams in the county increased from 13% and 0% to 20% and 12.5%, respectively.[28]

By utilizing GIS tools, the County models different assumptions for how land use and development will change in the future. County staff also run various scenarios over existing land use and land cover to estimate impacts on water quality and quantity. Given that only 6.5% of the county's total land remains vacant, infill and redevelopment plays a critical role in future development for the county.[29] Considering the extensive stormwater management requirements for redevelopment, the surveyed county official indicated that more LID principles and techniques are appearing.

Interestingly with Fairfax County, staff indicated that while the County has not adopted a number of the ordinances and regulations highlighted in our survey, the County encourages certain elements in proposed development and developers know to incorporate the encouraged measures into their proposals in order to receive approval. For example, no steep slope ordinance exists within the county, but the County's comprehensive plan addresses the stringent expectations regarding steep slope, and the surveyed county official indicated that developers recognize the need to adhere to the comprehensive plan's guidance in order to receive approval for a proposed development project.

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[27] Prince William Conservation Alliance, "The Occoquan Reservoir," http://www.pwconserve.org/issues/occoquan/quickfacts.htm.

[28] Fairfax County Stormwater Planning Division, *2011 Fairfax County Stormwater Status Report*, Fairfax County Government, 2011.

[29] Molchany, David, "Building a Sustainable Future – Energy Efficient Fairfax County," Presentation, Fairfax County Government, 2012, Slide 3.

Although the county does not have urban growth boundaries per se, the comprehensive plan does identify growth centers and the boundaries of these growth centers. The County also uses environmental quality corridors (EQCs), which are natural corridors that connect areas of open space. The County incentivizes the preservation of EQC land by allowing density transfers to non-EQC areas of the property. The County employed the use of no less than 50% of the surveyed policies in all four categories. Despite being the most densely populated, urban locality in our sample, Fairfax County stuck out as a local government dedicated to preserving as much of its healthy waters as possible.

CORRELATION AND REGRESSION ANALYSIS

Given our client's long-term goals to assess the effectiveness of local policies in protecting healthy watersheds, we used our survey data, along with secondary data, to investigate relationships in our data. We do find statistically significant correlations among our data, and these findings are described below. It is important to indicate, however, that the findings represent correlations and are not evidence of causation. Correlations provide rather helpful insights into whether certain groups of policies are positively or negatively correlated with measures of watershed health, as well as determining the extent to which two sets of data are correlated.

DATA DESCRIPTION

As a measure of water quality, we used data from Chesapeake Bay Program that gathers benthic macroinvertebrate samples data from multiple agencies and partners to uniformly evaluate biotic integrity, a commonly used indicator of water quality. Using the Chesapeake Bay Basin-wide Benthic Index of Biotic Integrity (B-IBI), water quality scores were determined using data from 8,871 randomly sampled sites. The data used was collected between 2000 and 2008 by state and federal government agencies, local governments, non-profit organizations, and academic institutions. Possible score values range from 0-100, with a score of 100 indicating the best possible biotic integrity score. The scores are further categorized into ranges of "very poor" (0-17%), "poor" (17-30%), "fair" (30-50%), "good" (50-67%), and "excellent" (67-100%).[30][31]

Since our team surveyed only counties that contained at least a portion of at least one watershed meeting its respective state's criteria for a healthy watershed, an average B-IBI

[30] Chesapeake Bay Program, "Health of Freshwater Streams in the Chesapeake Bay Watershed," www.chesapeakebay.net/indicators/indicator/health_of_freshwater_streams_in_the_chesapeake_bay_watershed.

[31] Chesapeake Bay Program, "Bay Barometer: A Health and Restoration Assessment of the Chesapeake Bay and Watershed in 2009," 2009, www.chesapeakebay.net/documents/cbp_505131.pdf.

index score of very poor, poor, or fair does not indicate a complete absence of high quality watersheds within the county. In total, our sample included 92 B-IBI scores, with an average of 4.8 scores per county.[32] To create *goodexcbibi*, we calculated the percent of B-IBI index scores within the "good" or "excellent" range from the total B-IBI index scores within a county. Similarly with *fairtoexcbibi*, we calculated the percent of B-IBI index scores falling within the "fair," "good," or "excellent" range in order to capture higher proportions of watersheds within the counties.

Given the lack of water quality data meeting sampling criteria for some of our Pennsylvania counties, Elk County and Mifflin County were removed from the sample. The town of La Plata, MD was also removed from the sample.

We included the three demographic explanatory variables *personssqmi*, *bachelorshghr*, and *medianhhinc* to serve as measures of population density, education attainment, and household wealth, respectively. We gathered information on the number of persons per square mile, our measure of population density, as we expected lower levels of water quality from our watershed health indicators due to more densely populated counties currently experiencing and with a history of experiencing significant development.[33] We hypothesized that higher percentages of the county's population 25 years or older with at least a bachelor's degree would correspond with higher average B-IBI index scores due to an increased public awareness for watershed issues. As with our population density measure, our education measure data came from 2010 U.S. Census Bureau data.[34] Echoing the similar assumptions of former researchers, we anticipated that counties with higher levels of household wealth correspond with higher levels of water quality due to a greater public demand for local policies that focus on watershed protection and restoration.[35] The median household income data came from U.S. Census Bureau's 2006-2010 American Community Survey's five-year estimates.[36] Summary statistics can be found in **Table 5** in **Appendix III**.

DATA ANALYSIS AND FINDINGS

Initially, we conducted a correlation analysis of all of the variables in our data set. A correlation analysis uses statistical software to measure the degree of association between variables. The results of these calculations are shown in **Table 6** in **Appendix III**. When

[32] The total amount is based on 36 scores in Maryland, 22 scores in Pennsylvania, and 34 scores in Virginia.
[33] U.S. Census Bureau, "State & County QuickFacts," 2010, http://quickfacts.census.gov.
[34] Ibid.
[35] James Miller et. al, "Biodiversity Conservation in Local Planning." Conservation Biology 23, no.1 (2008): 56.
[36] U.S. Census Bureau, "2006-2010 American Community Survey 5-Year Estimates," www.factfinder2.census.gov.

investigating correlations between the specific surveyed policies and the three watershed health measures, we found two significant correlations. LID standards and landowner stewardship programs were negatively associated with B-IBI scores and the percent of fair to excellent quality watersheds, respectively.

Some additional correlations stood out when analyzing correlations between the policies. For example, having a watershed management plan was significantly and positively correlated with conducting water quality monitoring. Localities that used overlay districts for watershed protection were positively associated with localities that had long-term conservation programs. Finally, two pairs of variables showed the strongest associations (with correlation coefficients of 0.87), with each pair being positively associated. Having a conservation program was positively correlated with both having a GIS-based and LID standards. The relatively high number of variables correlated with conservation programs isn't too surprising given how many localities had conservation programs.

To build on the correlation coefficients, we also utilized regression models to gain a better sense of the potential correlations between local policies and watershed health. We conducted an ordinary least squares (OLS) regression using our three watershed health measures as dependent variables. The regression models enable us to estimate relationships between our watershed health measures and each of our explanatory variables, while accounting for possible correlations with the other explanatory variables. Based on the results of the regressions, we can identify statistically significant correlations between our selected variables.

As shown in the second column of **Table 7** in **Appendix III**, our OLS regression model using the average B-IBI index score within a locality as our dependent variable does not produce any statistically significant results. Given the small sample size and limited number of B-IBI index scores in some counties, these results are not necessarily surprising. Despite the lack of statistical significance, we can begin to note the presence of positive or negative coefficients. The variables *personssqmi*, *bachelorshghr*, *wtrdsmgmt*, and *devmgmt* have negative coefficients. Interestingly only the variables z*oningords* and *natrsrcsprot* have positive coefficients indicating that an increase in the percent of zoning ordinances and natural resources protection policies, respectively, is positively correlated with the average B-IBI index score within a county. The variable *medianhhinc* has a positive but almost negligible coefficient value.

In the third column, we find a significant and negative correlation between *devmgmt* and *goodexcbibi*. The data indicates that we can estimate a 47%[37] decrease in the proportion of watersheds with good or excellent quality B-IBI scores, given a 51% increase in the percent of development management policies a county uses. In other words, for every 1% increase in a county's development management policies, we can estimate a nearly 1%[38] decrease in the percent of good or excellent quality watersheds within that county. While this finding seems to counterintuitively suggest that counties playing a more active regulatory role in development management also have fewer proportions of high quality watersheds, a number of factors could explain this result. In examining the correlations between specific policies within the Development Management category and our dependent variable, we find that LID standards have the strongest correlation at a coefficient of -0.44[39]. Since LID standards provide improvements to stormwater management by minimizing stormwater runoff, the presence of LID standards within a county likely signifies a high degree of development and stormwater infrastructure.[40]

Lastly, we find two statistically significant correlations in the fourth column which shows the results of an OLS regression using our third dependent variable *fairtoexcbibi*. The variable *bachelorshghr* is statistically significant and negatively correlated with *fairtoexcbibi*. This means that for every percent increase in the proportion of the population with at least a bachelor's degree, we can predict a 1.6% decrease in the percent of fair, good, or excellent watersheds within a county. At first glance this finding may seem counterintuitive assuming more highly educated populations will be more aware of water quality issues. A possible explanation may simply be that areas with higher proportions of college-educated people are also more developed areas. Given the overwhelming link between rural areas and high water quality, this explanation seems very plausible.

Also in the fourth column, we find significant relationships between one of our policy categories and our dependent variable, the percent of a county's water samples deemed "good" or "excellent." The variable z*oningords* is positively correlated with *fairtoexcbibi*. This result suggests that we can predict a 0.5% increase in the proportion of high-quality watersheds within a county given a 1% increase in zoning ordinances. Of course, this finding only indicates a statistically significant correlation and not causation.

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[37] We calculated a 47% decrease by multiplying the coefficient by the sample mean. The calculation occurred as follows: -0.9248*0.5125 = -0.4739. This result is the estimated mean effect.
[38] We multiplied the coefficient by one percent, as follows: -0.9248*0.01 = -0.0093. This is a value of -0.93%.
[39] Correlation coefficients are calculated on a scale of -1 to 1 with -1 and 1 indicating perfectly negative and positive correlations, respectively.
[40] The correlation coefficient between *lidstandards* and *personssqmi* is 0.29, which does not suggest a strong association; however, this result could be skewed by the small sample size.

Development management policies and zoning ordinances may be the two most effective categories of tools for preserving watershed health. The results of our statistical analysis seem to suggest this conclusion, though the regression models do not imply causation. The two categories were the only sets of policies with statistically significant correlations to our watershed health measures. Our findings beg the question of why development management tools are negatively associated with better watershed health but zoning ordinances are positively associated.

Development management is primarily a set of reactive tools designed to reduce the amount of or rate of certain types of development. Zoning ordinances, on the other hand, focus more on a preventative, conservation approach. For example, riparian buffer and steep slope ordinances are specifically intended to provide environmental protection. Development management policies often do not appear in local codes until a locality is fairly suburban. Once a locality becomes relatively urbanized, the use of development management policies seems to diminish.

Certain limitations within our data make it difficult to ascertain how robust the statistically significant correlations are given the amount of unknown data associated with our analysis. We recognize that our analysis is potentially limited by the following factors: small sample size, endogeneity, and omitted variable bias. Furthermore, we attempted to verify and apply uniform assumptions to as much of the data as possible, but we recognize the possibility for potential errors.

As mentioned previously, a sample size of only 20 localities makes it difficult to note statistically significant relationships. In addition to a limited overall sample size, we were also unable to run regression analyses using variables to account for whether a county is located in Maryland, Pennsylvania, or Virginia. Since each state only had seven to eight localities participating in the survey, we would not have generated robust results. Given the variations among state regulations regarding local policies, it could be highly useful and informative to control for these variations.

Since our data does not enable us to analyze how changes in local watershed policies correlate with changes in water quality, our current data provides only a snapshot in time. The cross-sectional data presents the possibility for issues of endogeneity. Our regression models predict the health of a locality's watershed based on local demographics and policies. The relationship could easily be circular, however. It may simply be that more developed counties have additional resources to implement various watershed protection policies but also, as a consequence of their development, have higher portions of poor or very poor quality watersheds. Future research could help avoid this problem of endogeneity by using lagged data for the dependent variables.

As indicated above, the regression analyses also likely suffer from omitted variable bias. Although we included three demographic measures to account for differences in population density, education levels, and income levels, it is highly likely that other factors not incorporated in our analyses also affect the watershed health measures.

MOVING FORWARD

Given the limited sample size and lack of sufficient water quality scores in Pennsylvania, our team could only reasonably analyze correlations between variables. Furthermore, the average water quality scores were extracted from 2000-2010 data, but the survey data concerning local policies only accounts for policies in place as of 2012. As a result, the current data provides only a snapshot of data and does not offer the opportunity to analyze how changes in local policies correlate with changes in water quality. Due to the limited data, our team could not statistically infer any causal relationships between the adoption or presence of certain policies and the maintained or improved percentage of healthy watersheds in a locality. Certainly, given the number and fluctuation of variables affecting water quality, precise effects of specific zoning and regulation efforts will be difficult to isolate, even with improved data.

In order to adequately gather data for a comprehensive analysis, we recommend initiating a project designed to utilize a detailed checklist, similar to VDCR's Checklist for Advisory Review of Local Ordinances, disseminated to relevant staff of local governments within the Chesapeake Bay Watershed either annually or biennially. Given the additional cost constraints associated with conducting an annual survey and the often lengthy process of ordinance adoption, we recommend a biennial survey.

There are variations among Chesapeake Bay states for whether certain watershed protection tools, such as riparian buffer or stormwater management requirements, are regulated at the state or local level (or both). Given this inconsistency, the survey should explicitly address these potential differences. When compiling and analyzing the survey data, future researchers should account for variations in regulatory authority. It is important to capture the possible layers of regulations. A locality may be located in a state with fairly progressive stormwater management requirements but that specific locality may also expand upon the state requirements with additional local restrictions. Alternatively, a locality may not implement an ordinance that addresses certain restrictions, such as buffer requirements, within healthy watersheds but that does not indicate a complete lack of protection. Buffer requirements may exist at the state level for high quality watersheds. Given the numerous recent amendments in state regulations affecting Chesapeake Bay watersheds, the overlap between state and local regulations is a highly useful relationship to track.

In conducting a future survey, we would also emphasize the potential benefits of surveying both planning and zoning officials, as well as conservation district officials. In our pilot survey, these two subsets contributed unique perspectives and insights that would allow the research team to gain the most complete picture possible of localities' watershed

protection efforts. Further, in addition to the technical aspects of the survey, future researchers should attempt to map coordination efforts between the variety of actors involved in watershed protection. Through the pilot survey, it became clear that maximizing coordination between levels of government and with non-profit organizations was the most cost-effective means of protecting watershed health and fully capturing the benefits of the resources available in the face of budget and political expediency limitations.

In conjunction with the biennial survey, the future research team should conduct and compile water quality assessments biennially. Various academic institutions, non-profit organizations, and governmental entities already collect samples of benthic macroinvertebrates and can contribute their sampling results for the purposes of the recommended research project. By using an index score such as the Chesapeake Bay Basin-wide Benthic Index of Biotic Integrity (B-IBI), the research team can gather benthic macroinvertebrate samples collected by various groups. Given the variations in state protocols for how to score and assess the sampling indicators, the research team can uniformly calculate an index score across state lines.

Recognizing the intent of our client to gauge the effectiveness of local policies in protecting its healthy watersheds, we recommend that future survey research maintain a categorization of policies. Within the categories (e.g. Development Management and Natural Resources Protection), model ordinances and model programs should be determined for each policy prior to launching the survey. The researchers could then rate the ordinance or program on a small scale (e.g. 0-3) to account for whether a locality did not have the policy or whether the policy failed to meet, met, or exceeded the model policy. By incorporating this implementation score into the data analysis, researchers can investigate the effectiveness of certain policies on watershed protection, while accounting for differences in stringency.

In addition to VDCR's checklist, EPA created a Water Quality Scorecard in 2009 which lists policy questions and corresponding goals intended for local governments to gauge their level of stormwater management and watershed protection. The scorecard could prove particularly useful when developing a lengthier, more detailed survey. The scorecard lists implementation tools and policies across five categories, and each line item is worth a set number (e.g. 2) or range of possible (e.g. 1-3) points. For example, a responding local government can receive two points in the Support Infill and Redevelopment category if the locality claims the use of "[z]oning and land development regulations [that] implement urban service areas/urban growth boundary policies by restricting development in outlying areas."[41]

[41] U.S. Environmental Protection Agency, *Water Quality Scorecard*, 2009, 25.

In conclusion, the results of our survey suggest that a number of local policies serve to protect and maintain healthy watersheds in the Chesapeake Bay. Additionally, the majority of survey respondents indicated a desire to expand their current watershed protection efforts. While support from state and federal agencies plays a critical role for local governments seeking to preserve healthy waters, local governments can better utilize codes and ordinances to achieve goals of watershed protection. Future research which actively tracks local codes, ordinances, and other regulations affecting watershed health can gauge the effectiveness of these policies to guide local governments.

APPENDICES

I. Healthy Watersheds Survey
II. Demographic Profiles of Localities
III. Survey Response Summaries
IV. Data Output Tables

APPENDIX I: HEALTHY WATERSHEDS SURVEY

1. Based on your state's definition of a "healthy watershed," please identify any known healthy watersheds within your community's jurisdiction. If your state has not defined healthy watersheds are there any watersheds of special designation (trout streams, sensitive species, high quality according to EPA standards, etc.) in your community's jurisdiction?

2. Has your community completed a watershed management plan? If so, when was it implemented and last updated? How does it relate to your comprehensive plan?

3. *If the community has healthy watersheds and a watershed management plan,* does the plan account for how future land use will impact any healthy waters within the community? If so, how?

4. Does your community survey and assess the health of its watersheds? If so, how often?

5. Does your community use any of the following planning or zoning tools to protect healthy watersheds?

    - Overlay or special use zoning districts
    - Impervious cover limits
    - Watershed-based zoning
    - Floating zones
    - Steep slope ordinance
    - Riparian buffer minimums
    - GIS-Based watershed inventory
    - Infill/Community redevelopment
    - Urban growth boundaries
    - Cluster development ordinance
    - Critical area or special protection of lands adjacent to water bodies
    - Other: Please describe.

6. Does your community utilize any of the following regulatory or management programs to protect healthy watersheds?

    - Long-term conservation protection programs
    - Implementation and monitoring plan
    - Transfer of Development Rights (TDRs)

- Low-Impact Development (LID) standards
- Landowner stewardship programs
- Needs and Capabilities Assessment (NCA)
- Voluntary best management practices (BMPs)
- Guidance or restrictions on proper application/use of fertilizers and pesticides
- Emergency spill response plan
- Other: please describe.

7. Do you have any partnerships with surrounding localities to coordinate watershed management responsibilities? If so, which localities?

8. Are there any community stewardship or volunteer monitoring programs (e.g. Adopt-A-Stream) in your community? Are there any non-governmental organizations working to protect watersheds in your community?

9. Aside from the programs and tools already addressed, are there any other ways in which your locality actively protects its healthy watersheds?

APPENDIX II: DEMOGRAPHIC PROFILES OF LOCALITIES

Table 2. Maryland Locality Demographics					
Locality	**Population**	**Area (Sq Mile)**	**Persons per Sq Mile**	**Percent 25 Years or Older with Bachelor's Degree or Higher**	**Median Household Income**
Allegany County	75,087	424	177	15.9%	$37,747
Charles County	149,130	458	320	26.1%	$88,825
Frederick County	236,746	667	354	35.8%	$60,276
Garrett County	30,079	656	47	17.5%	$32,238
Harford County	246,489	526	560	30.5%	$57,234
La Plata	8,753	7	1,250	28.6%	$80,129
St. Mary's County	105,151	357	294	27.4%	$80,053
Worcester County	51,454	695	110	26.1%	$40,650

Table 3. Pennsylvania Locality Demographics					
Locality	**Population**	**Area (Sq Mile)**	**Persons per Sq Mile**	**Percent 25 Years or Older with Bachelor's Degree or Higher**	**Median Household Income**
Cameron County	5,085	399	13	14.9%	$39,773
Centre County	154,722	1,112	139	40.0%	$47,016
Cumberland County	235,406	545	432	32.3%	$60,832
Elk County	31,751	832	39	16.2%	$43,745
Lycoming County	116,747	1,244	95	18.8%	$42,689
Mifflin County	46,682	415	114	11.1%	$37,539
Tioga County	42,419	1,137	37	17.7%	$40,338
Union County	44,847	317	142	22.2%	$45,474

Table 4. Virginia Locality Demographics					
Locality	**Population**	**Area (Sq Mile)**	**Persons per Sq Mile**	**Percent 25 Years or Older with Bachelor's Degree or Higher**	**Median Household Income**
Fairfax County	1,100,692	391	2767	58.0%	$105,416
Fauquier County	66,071	647	101	30.8%	$83,877
Loudoun County	312,311	521	606	57.2%	$115,574
Richmond County	9,220	191	48	9.8%	$42,182
Rappahannock County	7,444	266	28	37.4%	$62,117
Shenandoah County	42,289	509	83	17.5%	$50,171
Spotsylvania County	124,327	402	305	29.9%	$76,574

APPENDIX III: DATA OUTPUT TABLES

Table 5. Summary Statistics				
Variable	***Mean***	***Std. Dev.***	***Min***	***Max***
Average B-IBI Index Score *= avgbibi*	38.37	13.21	16.68	60.62
Percent of Watersheds with Good or Excellent B-IBI Index Scores *= goodexcbibi*	51.77%	37.45%	0.00%	100.00%
Percent of Watersheds with Fair, Good, or Excellent B-IBI Index Scores *= fairtoexcbibi*	84.05%	25.33%	25.00%	100.00%
Persons per Square Mile *= personssqmi*	322.76	599.58	12.80	2,766.80
Percent of Population 25 Years or Older with Bachelor's Degree or Higher *= bachelorshghr*	28.29%	12.94%	9.80%	58.00%
Median Household Income *= medianhhinc*	$63,947	$23,228	$37,747	$115,574
Percent of Watershed Management Policies In Effect *= wtrdsmgmt*	33.75%	24.70%	0.00%	75.00%
Percent of Zoning Ordinances In Effect *= zoningords*	50.83%	25.64%	0.00%	83.33%
Percent of Development Management In Effect *= devmgmt*	51.25%	32.92%	0.00%	100.00%
Percent of Natural Resources Protection Policies In Effect *= natrsrcsprot*	66.25%	28.42%	0.00%	100.00%
Number of observations: 20				

Table 6. Correlation Coefficients				
Policy Category	**Local Policies**	**Average B-IBI Index Score**	**Good or Excellent Watersheds**	**Fair to Excellent Watersheds**
Watershed Management	GIS-based Watershed Inventory	-0.49	-0.33	-0.37
	Needs and Capabilities Assessment	-0.01	0.02	-0.15
	Water Quality Monitoring and Assessment	-0.10	-0.15	-0.12
	Watershed Management Plan	-0.43	-0.42	-0.62*
	Watershed-Based Zoning	0.12	0.04	0.07
Zoning Ordinances	Cluster Development Ordinance	-0.20	-0.16	-0.08
	Floating Zones	0.35	0.38	0.22
	Impervious Cover Limits	-0.17	-0.03	-0.11
	Overlay/ Special Use Zoning Districts	-0.14	-0.02	-0.07
	Riparian Buffer Limits	-0.19	-0.21	0.06
	Steep Slope Ordinance	0.14	0.18	0.28
Development Management	Infill and Community Redevelopment	-0.14	-0.10	-0.19
	Low-Impact Development Standards	-0.60*	-0.44	-0.37
	Transfer of Development Rights	-0.04	0.02	-0.11
	Urban Growth Boundaries	-0.08	-0.13	-0.08
Natural Resources Protection	Special Protection of Lands Adjacent to Water	0.00	-0.16	-0.13
	Landowner Stewardship Programs	-0.41	-0.38	-0.56
	Long-term Conservation Programs	-0.46	-0.36	-0.32
	Voluntary Best Management Practices	0.26	0.38	0.15
* Statistically significant correlation				

Table 7. OLS Regression Results for Watershed Health Measures			
Variable	**Average B-IBI Index Score**	**Good or Excellent Watersheds**	**Fair to Excellent Watersheds**
Persons per Square Mile	-0.007876 (0.31)	-0.000262 (0.21)	-0.000011 (0.93)
Bachelor's Degree or Higher	-39.73856 (0.40	-1.33912 (0.28)	-1.642588 (0.04)**
Median Household Income	0.000119 (0.68)	0.000006 (0.40)	0.000005 (0.26)
Watershed Management	-1.563700 (0.94)	-0.181333 (0.74)	-0.036432 (0.91)
Zoning Ordinances	12.58814 (0.48)	0.543738 (0.26)	0.480166 (0.10)*
Development Management	-26.29020 (0.17)	-0.924759 (0.08)*	-0.288006 (0.33)
Natural Resources Protection	19.27137 (0.33)	0.797206 (0.14)	-0.144837 (0.63)
** Significant at 5% level; * Significant at 10% level			

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