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.

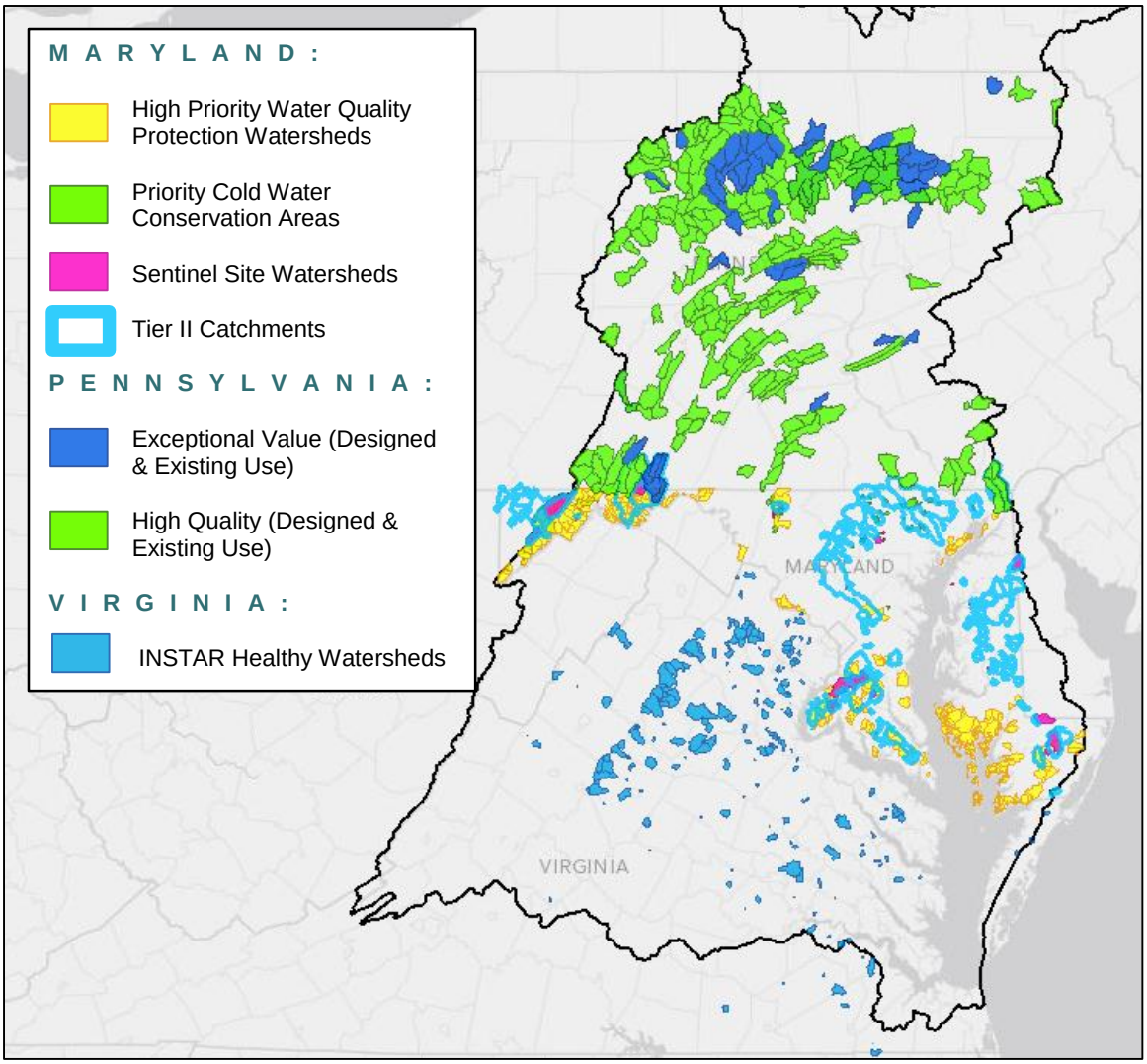
In 2011 the U.S. Environmental Protection Agency released its Healthy Watersheds Initiative, which provided a framework for how the agency plans to protect healthy waters. EPA's framework and action plan contains several focus areas for state involvement, including the development of various healthy 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.

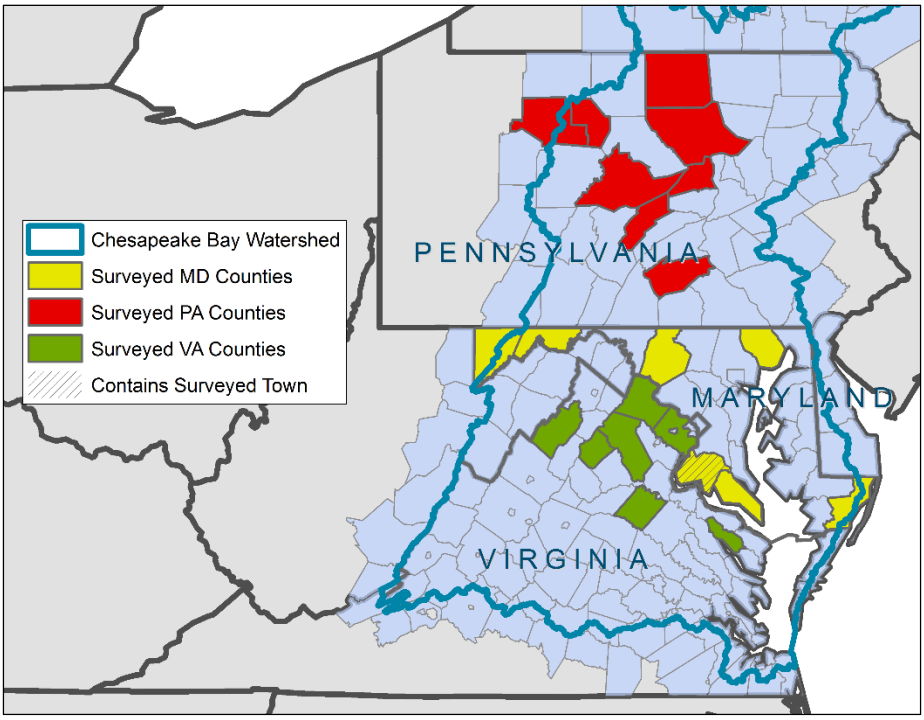
Tier II catchments specfically refer to the catchments of streams that possess biological or chemical traits exceeding the minimal water quality requirements of Tier I catchments.[9]

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		

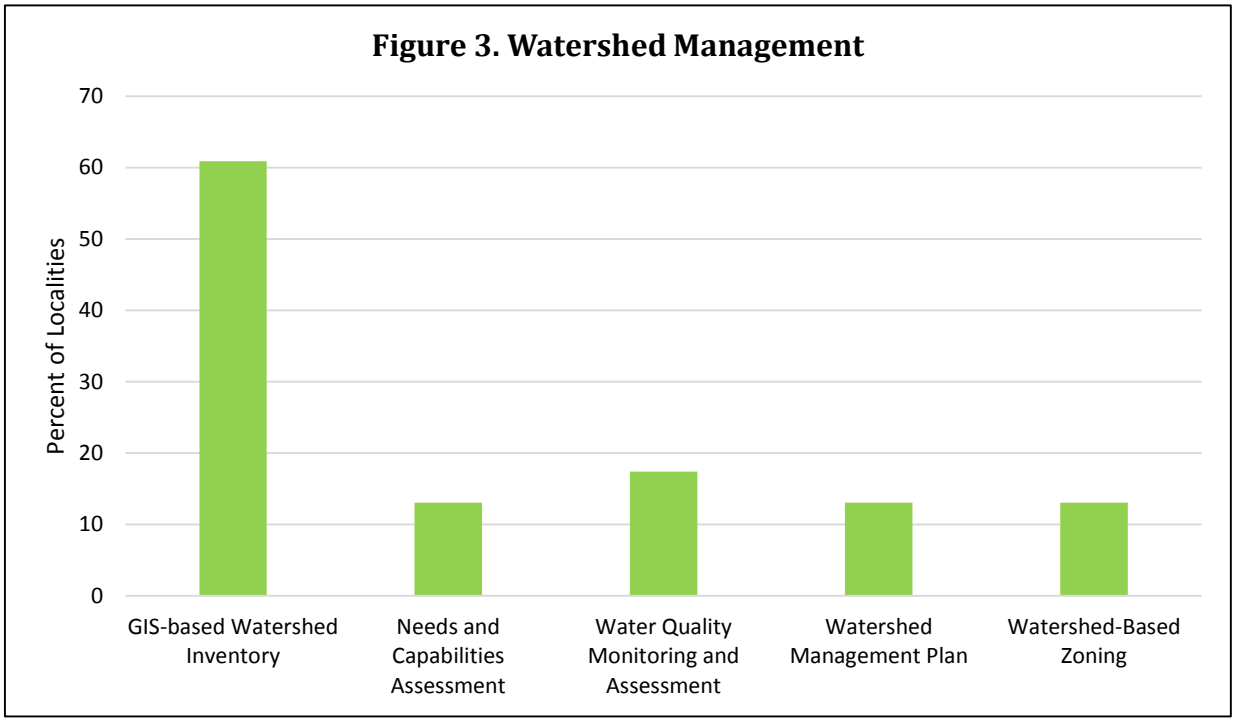
Although the survey addresses whether a locality contains guidance or regulations on pesticide and fertilizer use, or whether it has an emergency spill response plan, we did not include them in the categorization. Given their overwhelming use among localities and loose, redundant ties with watershed 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.

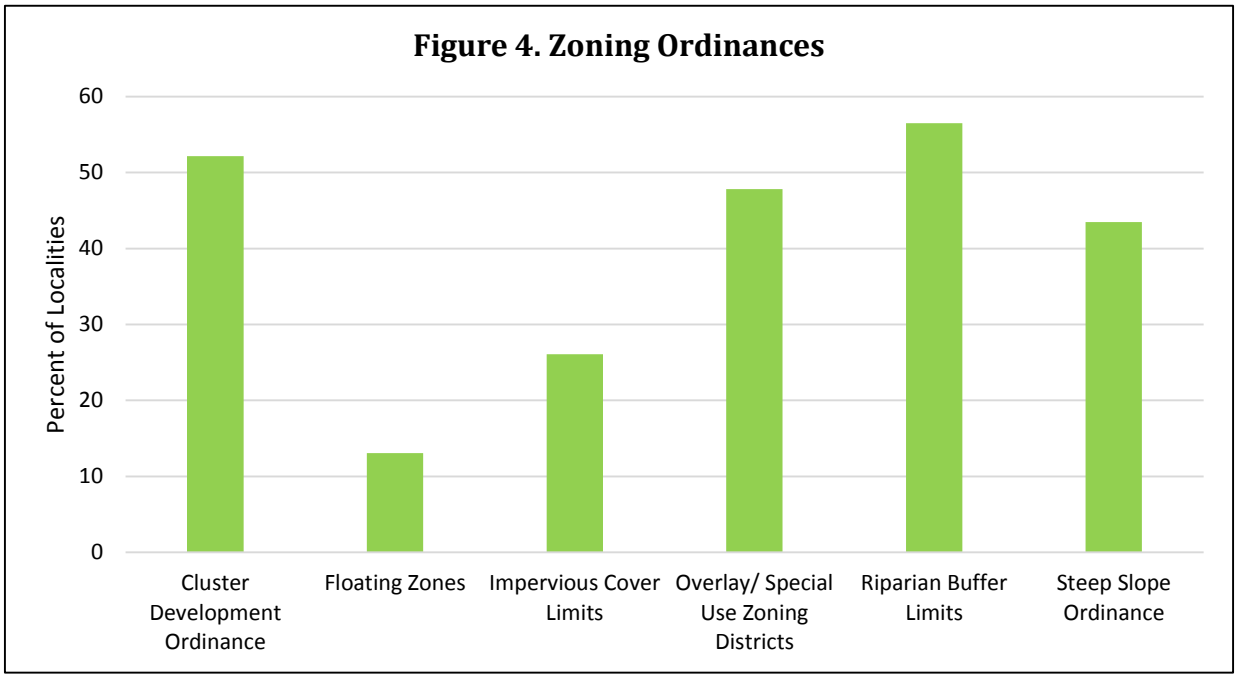
- *Integrate the watershed management plan into the comprehensive plan.* In order to enhance effectiveness, the locality's countywide watershed management plan should be incorporated into the comprehensive plan and contain specific goals and requirements that will give teeth to the locality's watershed 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.

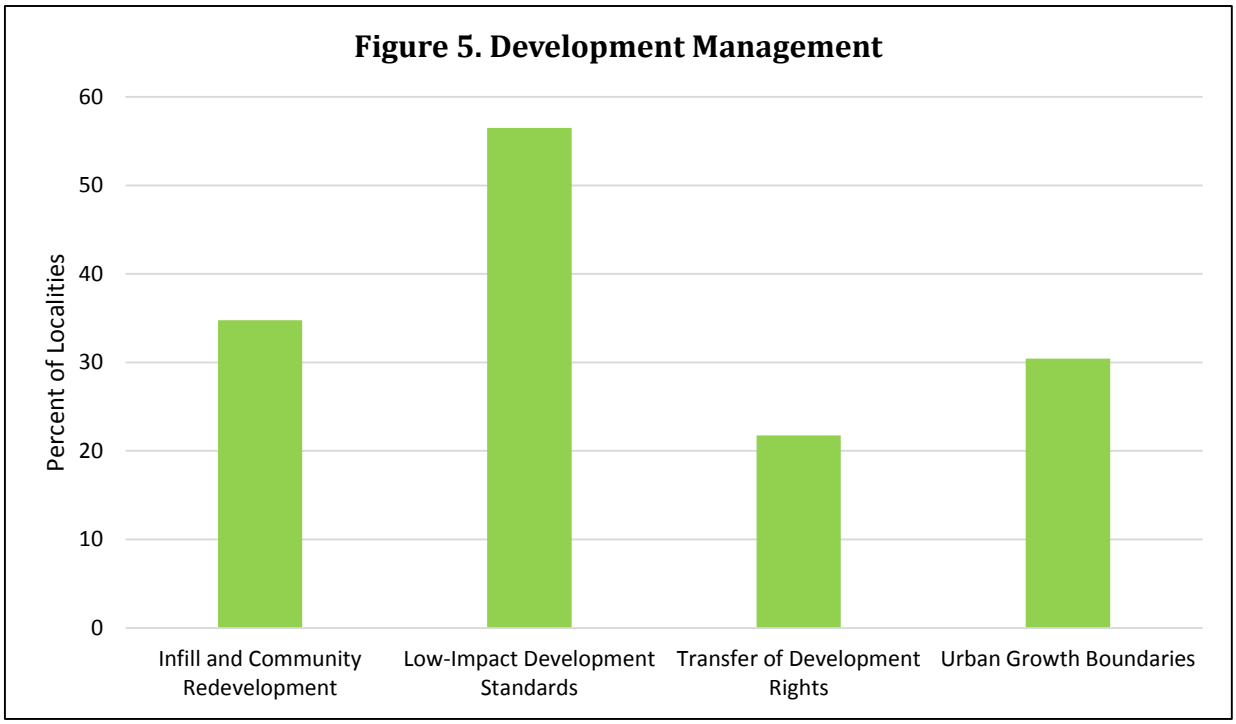
- *Establish risk aversion measures*. Risk aversion measures, such as floodplain ordinances and strong erosion and sediment control regulation, can serve as successful watershed protection measures where public support for watershed protection cannot otherwise be leveraged.

- *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.



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.

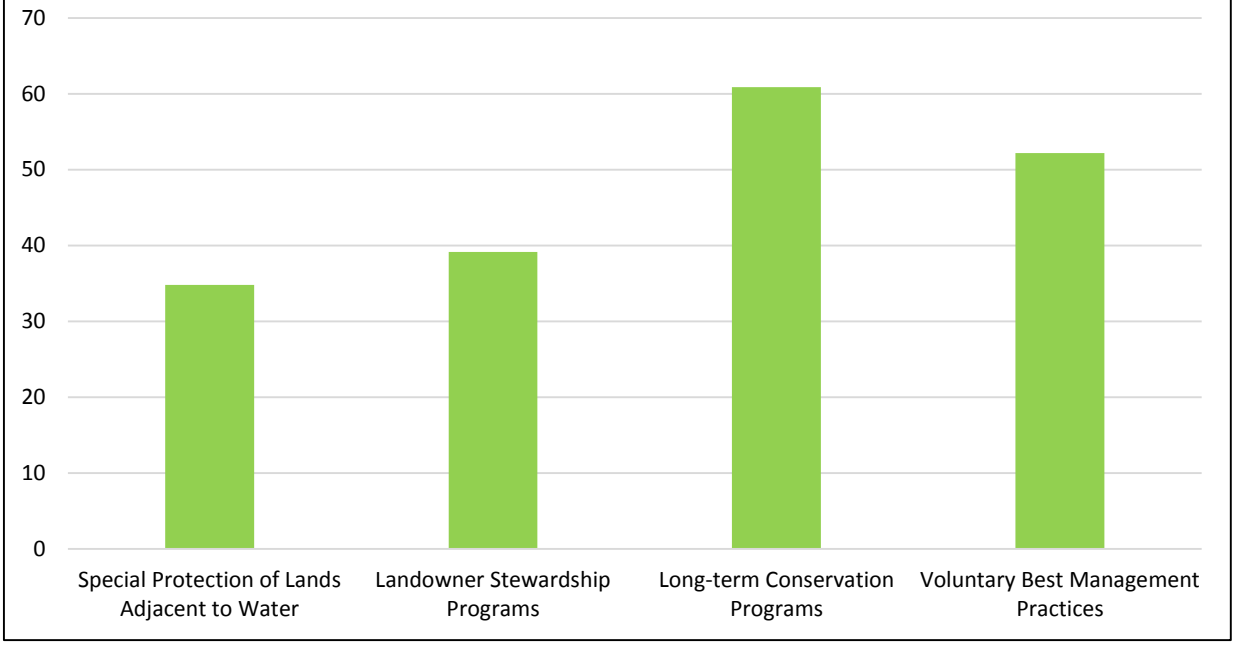
Transfer of Development Rights (TDR) programs were used by 22% of localities and played a significant role in protecting the healthy watersheds. TDR programs are generally regarded as preferable to Purchase of Development Rights (PDR) programs in the sense that development rights with TDR programs are 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:

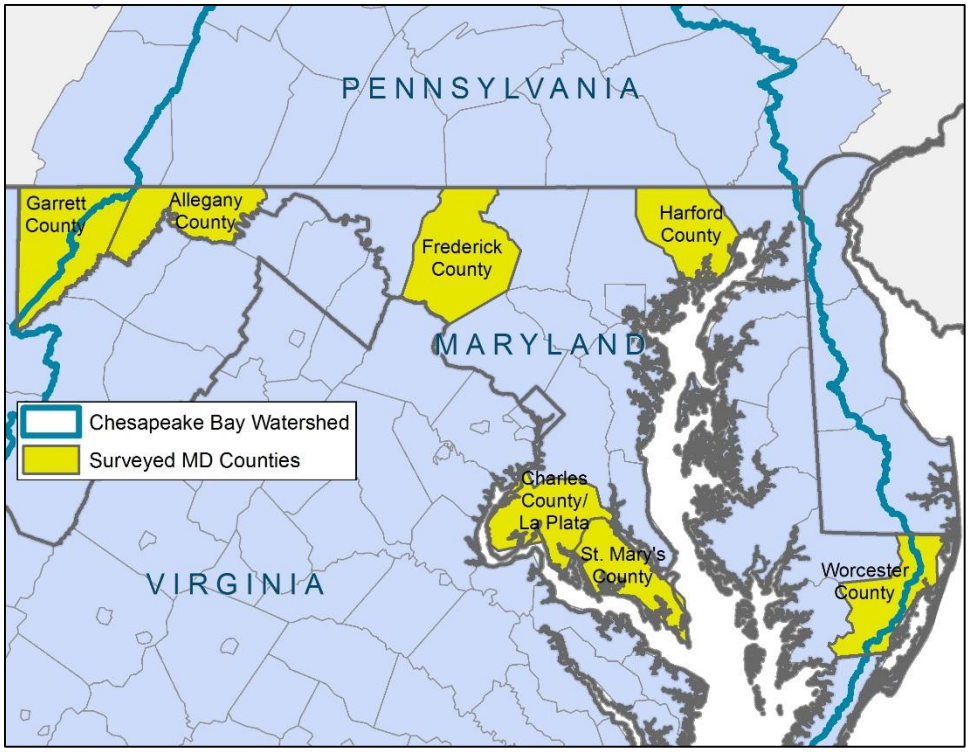
- Watershed- or Locality-Specific planning and protection organizations
- Land trust organizations
- University programs
- Trout Unlimited
- Pennsylvania Senior Environmental Corps
- The Nature Conservancy
- Adopt-A-Stream
- Ducks Unlimited
- League of Women Voters

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

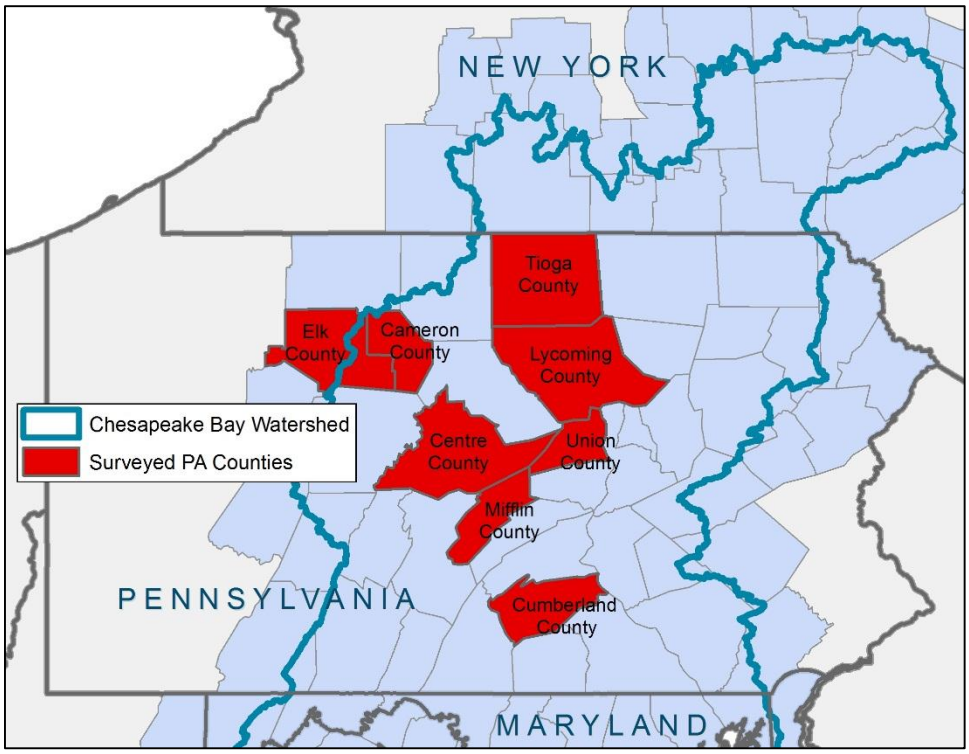
development, the County has a steep slope ordinance that protects any slope of 15% or greater in critical areas and 25% or greater outside critical areas; riparian buffer minimums that account for adjacency to critical areas, non-tidal wetlands, and hydric soils; and critical area protections that limits 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.

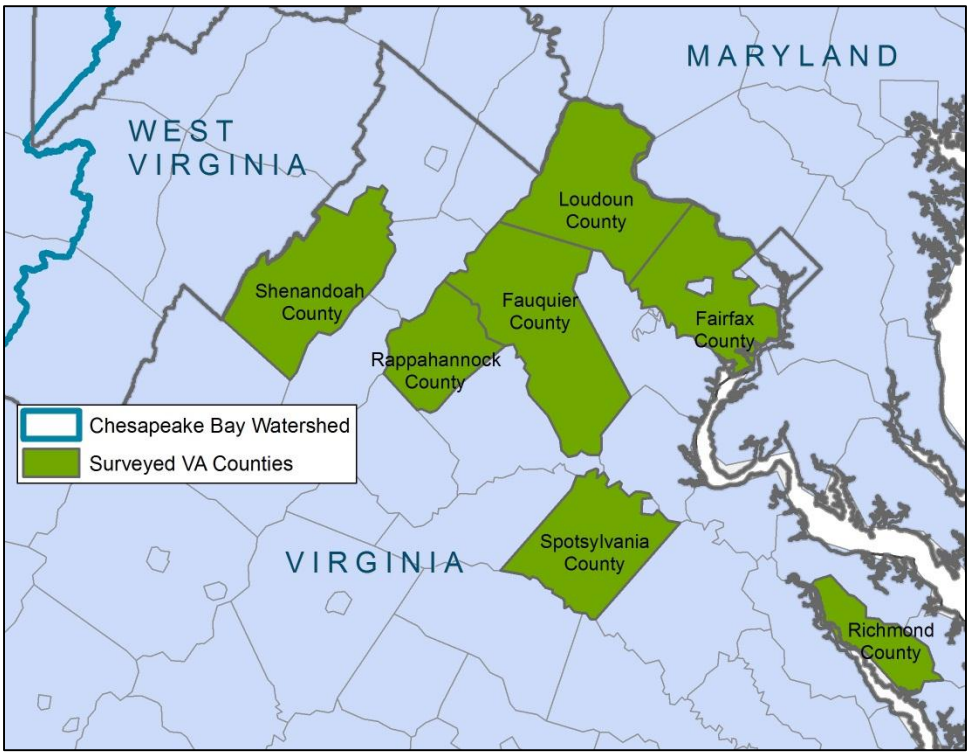
ordinance but faced strong opposition from the public. Each developed township has adopted a riparian buffer minimum, but, outside of complying with the state Chapter 102 requirement of riparian buffers for high quality waters and new developments, no rural municipalities have adopted a riparian buffer 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 IV**.

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 IV**. 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 IV**, 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: SURVEY RESPONSE SUMMARIES

Maryland

Allegany County

The Allegany County Land Use and Planning official who responded to the survey identified three Tier 2 watersheds in the County. The county had twelve different watershed-based comprehensive plans but this did not work and was poorly managed. Perhaps two plans for the Eastern and Western parts of the County would have worked as the Western part of the County has coal mining, but dividing the County into twelve different watershed plans did not make sense because there are not drastically different issues from watershed to watershed. . After six years of unfeasibility, the watershed specific plans were scrapped as the task became insurmountable. The County now has one watershed management plan that accounts for future land use and development, although the healthy watersheds are in areas that will not be developed, such as conservation land or steep slope areas—only 2.5% of the county is populated when you exclude steep slopes and conserved land. The soil conservation district for the county has conducted two stream corridor assessments, but these assessments were for watersheds that were not high quality.

Allegany County uses a number of planning and zoning tools to maintain its healthy watershed. The County has a steep slope ordinance by which any land having a greater than 25% slope is non buildable. The County has riparian buffer minimums written into its land use ordinance and also benefits from a GIS-based watershed inventory. Although there are no explicit urban growth boundaries or infill initiatives, the County's comprehensive plan encourages infill and redevelopment and the water and sewer plan establishes a municipal growth area for each of the municipalities. Limiting growth to protect healthy watersheds, however, is not a priority for the County because the healthy watersheds are in conservation land or steep slope areas that will not ever be developed. Indeed, the respondent expressed that the County was frustrated with all of the Maryland state regulations that are tailored toward the more populated areas in the Eastern part of Maryland, and only have the effect of Allegany County of diverting businesses and individuals to Pennsylvania or West Virginia, thus inhibiting the community's ability to sustain itself.

Allegany County also employs regulatory and management programs to protect its healthy watersheds. The County actively participates in the Maryland Agricultural Land Preservation (MALF) program, an easement program that buys out farmers' development rights. The County also engages in flood buyout acquisitions to remove residential structures from the floodplain. Through its TMDL watershed protection plan committee, the County is currently seeking a tree planting grant and in order to improve the effectiveness of this effort, the County is working on a GIS-based model that identifies the

most ideal places to plant trees. The County's soil conservation district currently works with agricultural landowners to plant trees along streams through the Conservation Resource and Enhancement Program (CREP) and also offers guidance to farmers on the proper application and use of fertilizers and pesticides. Through the state-required stormwater management program, Allegany County administers low-impact development standards.

Through its Watershed Implementation Plan (WIP) committee, the County coordinates with the smaller municipalities to administer regulations. While the County used to have a relationship with surrounding localities through various tributary teams, the County no longer participates in these team projects. There are, however, a number of watershed associations within the County and The Nature Conservancy's Allegany Forests Project Director is also active in the effort to maintain healthy watersheds within the County.

Charles County

Charles County has several high quality waters, totaling to about 15. The county is currently in the process of implementing a watershed management plan, and hopes to complete it in the year 2012. This implementation also comes with an update of the county's comprehensive plan. As such, the surveying and maintenance of watersheds varies, with some watersheds given more precedence than others. Though there is not a watershed plan yet, the county does encourage several tools, which include zoning based on watersheds and special use, floating zones, steep slope ordinances, infill redevelopment, and cluster development ordinances. In addition to this, the county also keeps track of watersheds using GIS. Charles County does have a transfer of development rights program, as well as development standards and best management practices. A landowner stewardship program is available upon application.

Several community groups exist within Charles County and the surrounding area. The majority of them (including the Patuxent River Commission and the Wicomico Scenic River Commission) focus on the health of particular watersheds. These groups often organize assessment and community involvement programs to insure that their respective watersheds are kept healthy. In addition to these groups, Charles County has also partnered with surrounding counties such as St. Mary's in order to promote watershed health of those that may overlap between county lines.

Frederick County

Frederick County has a number of healthy watersheds within its boundaries, including a number of non-degradation areas. Frederick has created a watershed management plan that is driven by the CWA and NPDES requirements, as well as state water standards. This county also participates in the voluntary CWA §319 program for non-point sources, and

was recognized by EPA for the quality of its program. Approximately 60% of the localities in the county have developed a watershed management plan as well. Frederick did indicate that the requirements from the state and the EPA were different, and that the plans of the communities driven by these different criteria were sometimes conflicting. A weakness identified in this plan was its failure to account to future land use impacts on the watershed. The plan does include monitoring of the watersheds. This includes randomly stratifying smaller streams, countywide biological assessments, and a long-term monitoring station. Enough sites are sampled every 5 years to get a statistical perspective of watershed health.

During the interview it was mentioned that much of the community planning is not integrated with watershed management. Frederick County has no impervious cover limits, but has engaged in an impervious cover reduction plan and has stringent restrictions on the effects of impervious cover. A state policy for impervious cover offsets is also being developed. The county also uses substantial GIS information and releases the data for free on its websites. This data also includes the catchments for the watersheds. The specialist I talked to was worried that the recent election was going to negative impacts on the health of the watershed. According to the specialist the board leans towards deregulation politically and has moved to eliminate both the riparian buffer minimums and the steep slope ordinances that were in place. It is also possible that some of the flood plain ordinances will be slashed by the board this year.

Frederick County uses a variety of regulatory tools to protect its watershed. There is a long-term conservation plan in place, though it was designed mostly to protect agricultural land and forestry. This plan has designated 50 acres for planting or protection. There is an implementation and monitoring plan for watershed restoration and progress reports for NPDES. Maryland requires low-impact development standards, which Frederick County has implemented. A landowner stewardship program is in place that provides outreach to homeowners to help maintain the watershed, a watershed stewardship program recognizes individuals that have contributed to projects protecting the watershed, and a program call Green Leaders encourages homeowners to complete environmentally friendly projects. Frederick County has a needs and capabilities assessment plan, but it is implemented on a permit specific basis to get the most limitation possible from the NPDES permit. The county, through the green leader program provides a fertilizer management program with a free soil test and the resources to interpret the results. There used to be a set of voluntary best management practices related to the §319 program, but the ability to use them has since been eliminated so resources could go to regulatory goals. Frederick County has a host of other programs that were not specified, but are available through their website.

Frederick County has a number of informal relationships with municipalities in its county and has regular meetings to help them understand the regulatory requirements. The county also joined the stormwater management association with surrounding counties in order to share data and coordinate programs. There is a volunteer monitoring program in its pilot phase called the "Friends of Frederick County" that provided a smartphone application that allows anyone to take pictures of pollution in the watersheds and report it to the county. In addition to this the county sponsors a non-advocacy group made up of a number of non-governmental organizations and provides this group space in the county offices. Almost all of the collected data and relevant information can be gathered from a quarterly newsletter sent out by the county and an annual report on watershed health. All of this information is also available online with the Frederick County Watershed Alliance.

Garrett County

Garrett County has a few Tier I streams in the county which are mapped out in the comprehensive plan. The county does not have a watershed management plan or a monitoring and implementation plan. The county relies solely on volunteers to monitor the watershed and provide the data to both the county and the state. The county does use a few zoning tools, though these are only used for watershed protection to the extent required by federal protection standards. There are steep slope ordinances for grades of greater than 30%, setbacks of 50 feet for construction and roadways in order to keep the flood plain clear, and buffer for sensitive areas. The county also uses bonuses to incentive cluster development and there are some floating zones in the Deep Creek watershed. Garrett County is very decentralized and does little zoning at the county level.

Garrett County has a few regulatory tools in use, though there does not seem to be anything about the state standard and most of the work is done by municipalities. All of the current conservation plans are geared towards protection of farm lands, and the only real county regulation is focused on the protection of potable water sources. Garrett has a relationship with Allegany County to carry out its emergency spill response. Outside of this there are no relationships for watershed protection. There are a few volunteer organizations that protect specific watersheds or teach monitoring techniques, but that is the extent of the relationship with the county. Overall Garrett County does very little besides the lowest requirements to protect its watershed because much of its land is subject to federal protection and its population is very small.

Harford County

The county contains the Deer Creek watershed which is ranked the 3rd best stronghold watershed by the State of Maryland. While the county does not have a countywide watershed management plan, the County completed a plan for Deer Creek watershed in 2007. Due to the importance of Deer Creek for providing public drinking water, the County

utilizes a Water Source Protection District to protect community ground water systems. The County utilizes two overlay districts, a Natural Resources District (NRD) and Water Source Protection District (WSPD), primarily to protect drinking water. Land contained within the NRD has 75-150 feet stream buffer requirements for streams draining less than or more than 400 acres, respectively. The NRD also establishes a steep slope ordinance for areas with a grade of at least 25% and greater than 40,000 square feet, in addition to protections for non-tidal wetlands. While the county's Critical Areas have restrictions on impervious surface, the WSPD has a more stringent requirement of a 50% limitation on impervious surface.

Although the County does not mandate cluster development through an ordinance, the County does encourage clustering through a couple of means. First, the County's zoning code allows for Conventional with Open Space (COS) development for certain residentially zoned areas of at least 5 acres. Areas eligible for COS can have smaller lot sizes and reduced setback requirements in exchange for providing extra open space. Second, agricultural district land of at least 35 acres may pursue development under the Conservation Development Standards, provided the developed area does not surpass 25% of the total area and that the preserved area does not constitute less than 75% of the total area. The county supports its agricultural land extensively and has a very active agricultural preservation program, along with the Rural Legacy program supported by the State. Furthermore, while the County hopes to expand its TDR program, it currently allows for the transfer of density from one agricultural district parcel to a nearby parcel (within a half mile) located in a rural residential or rural village area.

La Plata

La Plata was one of two towns surveyed. This town was one of the smallest localities surveyed and did not have a full watershed within the township boundaries. Instead there are portions of two separate watersheds, both of which are managed at the county level. La Plata has no watershed management plan and, with the exception of sewage treatment effluent, does not monitor the health of its watersheds, stating that these are handled at the county level.

La Plata uses a range of zoning tools, though none of them are specifically meant to protect the watershed. Instead, tools such as overlay districting and zoning tools are used to increase flexibility in residential planning and encourage mixed use communities. Urban growth boundaries and community redevelopment plans have a connection to stormwater management, a requirement placed on localities by the state. Almost all of the regulatory tools are focused on stormwater management, though the town does have a state required conservation plan in place. However, by the town's admission this plan needs

improvement and is spotty at best.

La Plata has some cooperative relationships with Charles County and Maryland, and also cooperates with the Port Tobacco Conservancy, which is solely focused on the watershed between Port Tobacco and the Potomac. La Plata also established a stormwater management fee to provide for capital improvements to its stormwater program.

St. Mary's County

Please see Page 28 for case study.

Worcester County

As the easternmost county in the state, Worcester County has miles of Atlantic Ocean coastline and includes the well-known Assateague Island. The county is primarily rural with the exception of Ocean City which attracts large numbers of tourists each year. Starting in 2001 with Isle of Wight Bay, the County has completed or is in the process of completing four Watershed Restoration Action Strategies designed to protect and restore the targeted watershed. The County actively participates in TMDL developments and completed a county-level TMDL Phase II WIP in 2011.

Similar to several other surveyed localities, the County largely depends on a non-profit organization, Maryland Coastal, to conduct stream monitoring throughout the county. While the County did not indicate having several of the surveyed ordinances and regulations, the County identified three state programs which strengthen watershed protection at the county level: Rural Legacy Program, Critical Area Program, and Conservation Reserve Enhancement Program. The surveyed County official also indicated that over 80% of the county is in resource protection zoning, and the county's agricultural and resource protection zoning is rather restrictive in terms of development.

The County does coordinate watershed management with surrounding localities and focuses on building and maintaining these relationships. For example, a Rural Legacy Area creek separates Worcester County and Somerset County, and the two counties share grant funds to protect lands within that creek watershed. The surveyed county official also indicated a strong relationship with the Coastal Bays Program, a non-profit partnership consisting of federal, state, and local government entities (Worcester County included). The Coastal Bays watershed makes up roughly one-third of Worcester County. Overall the county has a number of active non-profit organizations and governmental agencies of various levels collaborating to protect the watersheds.

Pennsylvania

Cameron County

Cameron County does not have a watershed management plan, though a conservation plan funded by BCNR was implemented in 2010. The county does assess the health of its watershed because of the interests of private citizens and non-profit organizations. Cameron County did not use any of the listed zoning tools for anything other than the regulation of flood plains. No zoning tools were used for watershed management outside of this specific, state mandated, purpose.

Cameron County does not have a long-term conservation plan, though it does have a stream rehabilitation program and fish habitat enhancement program. The county has engaged in 5 to 10 projects per year for the last 6 years. The county has a land stewardship program and guidance on fertilizers through NRCS. These programs provide money and tax cuts to landowners and farmers to protect wildlife habitats. There is an emergency spill response plan in place that is handled through emergency management services. The county does work with other counties that feed its watersheds in order to protect its watersheds, and works with volunteers and two non-profit organizations: the Bucktail Watershed Association and Trout Unlimited. The interview revealed that much of the work is done through private citizens.

Centre County

Please see Page 31 for case study.

Cumberland County

The Cumberland County Conservation District official who responded to the survey identified two exceptional quality streams and sixteen high quality streams within the county. Cumberland County's stormwater management plan was the closest thing the county had to a countywide watershed management plan. There were, however, conservation plans for three of the larger streams in the county that accompanied watershed assessments. While the countywide stormwater management plan does not account for how future landuse will impact healthy waters, the stream conservation plans did look 5-10 years down the road to the additional impact of tourism and development.

Although the conservation district office does not do any water monitoring on a regular basis, a number of watershed associations and a local college group within the county do monitor stream health. Cumberland County has a planning department that reviews and helps develop model ordinances, but for the most part, ordinances are developed and passed at the municipality level. Each of the planning and zoning tools listed in the survey were in place in at least one of the 33 municipalities, with the sole exception of floating zones. The level of involvement and adoption of ordinances varied with the level of

development in each municipality—more rural municipalities being less likely to pass the ordinances listed. With regard to regulatory and management tools, there are a number of private land trust organization programs that purchase conservation easements, such as the Central Pennsylvania conservancy. The county has done some land acquisitions as well, through federal conservation easement programs under the Farm Bill. The countywide stormwater ordinance mentioned above incorporates low-impact development standards. A number of landowner stewardship and voluntary BMP programs exist within the County. The Pennsylvania Department of Conservation and Natural Resources assists farmers while the conservation district, through cost-share programs or technical assistance, works with both farmers and developers to implement BMPs and develop erosion and sediment control plans for new developments. The conservation district does not overly influence developers, but they effect some revisions to the developers' plans. The Pennsylvania Department of Agriculture oversees the application and use of fertilizers, but delegates responsibility to the conservation district to help farmers develop nutrient management plans and perform inspections. Cumberland County partners with Franklin County to offer programs on stormwater and erosion and sediment control as well as trainings and workshops for contractors and engineers. Franklin County also partners with municipalities to provide workshops for municipal engineers. The County also benefits from the work of a number of watershed associations, fish and game associations, a local college group, and a senior environmental corp.

Elk County

Elk County has no watershed management program, but one may be included in the updated comprehensive plan, which should be coming soon. Monitoring is important to this county and is done through both chemical, biological, and habitat assessment. Macroinvertebrate sampling is being conducted and continuous monitoring is done through satellite telemetry in the largest watersheds. Elk county does not use any of the zoning tools listed for watershed management, though GIS is used for watershed monitoring, and some set back requirements are used for flood plains.

Elk County has an extensive monitoring program and uses some low-impact development standards in the comprehensive plans. The county also engages in quite a bit of education and outreach in order to promote best management practices and fertilizer use guidance. All but one of the municipalities has a source water protection plan, and most of these encompass emergency spill response plans. Elk County does have a number of relationships with watershed groups in the area, most of which are very active. Elk County also works closely with the Western Pennsylvania Conservancy. It is important to note that only a part of the watershed in Elk County belongs to the Chesapeake Bay watershed.

Lycoming County

As the largest county in Pennsylvania in terms of acreage, Lycoming County contains a substantial number of watersheds and subwatersheds which drain into the Chesapeake Bay. The county is predominantly rural and is one of many Pennsylvania counties now facing the natural gas industry's hydraulic fracturing activities. The County adopted a Recreation, Parks, and Open Space/Greenway Plan in 2008 which specifically addressed each of its healthy watersheds and the need to maintain their water quality.[42] Lycoming County also utilizes a growth corridor to target development in certain ideal areas, while preserving the rural character and recreational appeal of other areas.

The County's Conservation District actively interacts with farm operators, especially concentrated animal feeding operations (CAFOs), to assist them with installing riparian buffers and stream bank fencing to minimize the runoff of non-point source pollution. Due to the increasing activity from Marcellus Shale hydraulic fracturing, the surveyed county official indicated a greater level of public awareness and concern for water quality issues has emerged. A number of non-profit organizations exist at both the county and watershed level to focus on advocacy, education, and water quality monitoring initiatives. Overall the county seems well poised to maintain its healthy watersheds, likely due to the limited amount of anticipated development and commitment to environmental quality from county officials.

Mifflin County

The Mifflin County Conservation District Official that responded to the survey stated that two-thirds of the county's streams were high value, though none were exceptional value, as defined by the Commonwealth of Pennsylvania. Mifflin County also had 6 Class A wild trout streams, as identified by the Pennsylvania Fish and Boat Commission. None of the municipalities within Mifflin County had adopted a watershed management plan. Despite being required to adopt an Act 167 stormwater management plan, only 5 of the 15 municipalities had adopted the model 167 plan that the county developed in 2010. The Act 167 plans that were adopted, however, do consider the impacts of future landuse. Little regular assessment of the health of the community watersheds occurs in Mifflin County; Pennsylvania DEP is supposed to regularly monitor watersheds, but they do not have the manpower or money.

Of the 15 municipalities about half use zoning districts and have special conservation zoning areas around streams and wetlands. The more developed municipalities, approximately half, have some kind of impervious cover limits. These municipalities also tend to be more progressive—rural municipalities do not consider watershed

[42] Lycoming County Planning Commission, *Lycoming County Recreation, Parks, and Open Space/Greenway Plan*, Lycoming County Government, 2008.

management an issue. Although no municipalities have explicit steep slope ordinances, most of the subdivision and subdevelopment ordinances put restrictions in the steeper slope areas. The municipalities must also comply with the state riparian buffer minimums. The Mifflin County Conservation District has a GIS inventory of water quality, but it is piecemeal and mostly within the impaired watersheds. While there are no urban growth boundaries or infill efforts, one municipality within the county does have open space requirements akin to a cluster development ordinance. Finally, the stormwater ordinances take into account the location of the watersheds. With regard to regulatory and management programs, Mifflin County participates in farmland preservation programs, placing conservation easements on certain farmland, which are then protected in perpetuity. Generally one farm is selected per year, and two assessments are done—and agriculture value and market value assessment—and the difference between the two becomes the easement value, which is offered to the farmer. Currently, there are 20 farms in the program. The County's Act 167 stormwater plan incorporates low-impact development standards. There are a number of voluntary BMP programs in the agricultural sector, particularly through the U.S.D.A.'s Section 319 program that has funneled a lot of money since the TMDL was imposed. With the exception of the Juniata watershed organization, most work stops at the county line and there is little coordination with surrounding localities. The Juniata Clean Water Partnership and the local Trout Unlimited chapter are the primary community stewardship organizations operating within the county.

Tioga County

As a rural, sparsely populated county, Tioga County shares many of its characteristics with other counties in our sample. The County does not utilize any of the Watershed Management, Zoning Ordinances, or Development Management policies discussed in this report. Within the County's 2005 Comprehensive Plan, employment opportunities constituted the county's top priority for the future, but natural resource protection, farmland/open space preservation, and watershed planning were listed as 3rd, 4th, and 14th priorities, respectively.[43] While the county may not appear to face substantial residential or commercial development which could threaten watershed health, the natural gas industry is quickly becoming a driver for the local economy and could potentially threaten water quality. The surveyed county official did indicate the presence of a source water protection coalition which is working to get drinking water suppliers across county boundaries to work together. This could become particularly important as the natural gas industry continues to expand and place demands on local water supplies.

Union County

[43] Tioga County Government, "Comprehensive Plan," 2005, 4-28.

The Union County Conservation District reports 12 watersheds within the area, of which 5 are considered to be high quality and one is considered to be of exceptional value. Union County has adopted a watershed work plan which is updated annually and generally deals with the rehabilitation and maintenance of unhealthy watersheds. Several plans enacting erosion and sediment control have also been written. Some tools used include zoning districts, impervious cover limits, watershed based zoning, growth boundaries, and protection of land near watersheds. In accordance with their work plan, several of the watersheds within Union County are assessed regularly. Union County offers an agricultural conservation easement program in order to encourage farmers to be conscious of waters surrounding their land. Union county also has both voluntary BMPs and an emergency spill response plan, though the latter is handled by a different department. A no-till conversion program has also been implemented, which compensates landowners for trying a no-till solution to growing crops. As additional help, farmers are offered assistance with improving their facilities and operations to better prevent nutrient runoff which may affect nearby watersheds.

Community involvement within the district is seen as important, with many education outreach programs run by both Union County and the community group Lower Penns Creek Watershed Association. In combination with this group, workshops and events are put on annually in order to promote awareness of issues regarding watershed preservation. The Lower Penns Creek Watershed Association also functions within Snyder County, which shares some watersheds with Union County.

Virginia

Fairfax County

Please see Page 34 for case study.

Fauquier County

The Fauquier County community development official who responded to the survey could identify one stream that met the state's definition of a healthy watershed. The county has never developed a watershed management plan, but is in the process of hiring an environmental planner who will presumably do so. The County primarily looks to the state to assess watershed health, with the exception of Goose Creek, which is assessed by the Goose Creek Watershed Association. With regard to planning and zoning tools, Fauquier County does not permit hardscaping of areas in the floodplain and has an ordinance requiring developers to maintain natural drainage to the extent possible. The County attempted to pass a steep slope ordinance and an overlay district that would protect surface water, but these met with stiff public opposition. The County has also attempted to monitor groundwater flow and quality, but this process halted when the economy soured. The County does, however maintain a GIS-Based watershed

inventory. Furthermore, infill and community redevelopment are encouraged by the boundaries of the utility service districts and the County also has a cluster development ordinance for its rural areas—all development has to be clustered on 15 percent of the site with the remaining left as open space. Finally, the County has an aggressive erosion and sediment control program through its conservation district. Although the County does not have a significant number of planning and zoning tools in place, when evaluating a special exemption or re-zoning exemption, they do attempt to get more than they could from a standard regulatory standpoint. The County generally takes a collaborative rather than regulatory approach, as officials have found this more effective.

The County utilizes a number of regulatory and management programs to protect its healthy watersheds. First, 25 percent of the county is under some kind of conservation easement—the most in the state. The County does not have a TDR program, as it simply purchases the rights rather than transferring them to others. The new state stormwater regulations have moved the County toward LID practices, such as environmental site design, localized capture and treatment of stormwater, rain gardens, and bio retention swales. John Marshall Soil and Water Conservation District, which operates solely in Fauquier County, has an active voluntary BMP program and offers guidance on the use of fertilizers and pesticides. For example, the Conservation District has a cost-share program through which they share in the cost of fencing if the farmers keep their cows out of the streams, reestablishing the riparian buffer. Fauquier County does not partner with surrounding localities but it does participate with the Rappahannock Rapidan Regional Commission.

Loudoun County

Loudoun County offered an interesting comparison to the rapidly urbanizing Fairfax County, given Loudoun's expanding growth but desire to maintain its rural character. Using a grant from the EPA, Loudoun County completed in 2008 a watershed management plan which provides recommendations for how the County will protect and improve its watershed and water resources. As part of developing the watershed management plan, the County used a subwatershed assessment which provided scores of every subwatershed, and those within the lowest quartile (indicating the highest levels of water quality) were categorized in a focus area to maintain its health. The scoring metrics incorporated estimations of future land use. The county's watershed management plan repeatedly references the detrimental effects on watershed health caused by high levels of impervious surface, but the County has not adopted any ordinances to limit impervious surface.

Additionally, the County has an open space easement program which offers tax incentives to landowners who place their property under easement. The County, in collaboration

with academic, consulting, and citizen groups, regularly conducts water quality assessments and stream monitoring. A number of public and private groups also participate in VDCR's Adopt-A-Stream Program which utilizes citizens to collect litter along and in the county's waterways.

Rappahannock County

Rappahannock County offered an intriguing insight into a rather rural county wedged between pockets of development and with only increased development to come. The County largely depends on the non-profit organization Rappahannock Friends and Lovers of Our Watershed (RappFLOW) to conduct a variety of water quality monitoring and evaluation programs. Specifically, the surveyed county official noted that RappFLOW was instrumental in the water supply plan completed in 2011. The County has adopted a stormwater ordinance in order to address lengthy driveways created for residential development on large parcels. Any proposed linear development project (e.g. driveway) exceeding 1,000 feet in length and 10% grade (at any point) must provide engineering and stormwater management plans to minimize erosion and stormwater runoff.[44]

The county began offering a purchase of development rights (PDR) program in 2006, but as of January 6, 2011, the program only protected 449 acres through the program45. The PDR program receives funding from private donations, rollback taxes from use-value taxation, and the state government matching funding46. Despite the lack of participation in incentives for acquiring conservation easements, 93% of county's land area is either in agricultural or conservation zoning which substantially restricts development. Beyond the zoning restrictions, the County uses funding from a private foundation to implement a cost-share program that matches funds for property owners that implement measures to keep cattle out the streams. The county overall does not have a strong need for restrictive development regulations given the overwhelming rural and agricultural character of the county. County officials do seem cognizant of watershed issues and have the benefit of a strong, well-organized non-profit organization contributing to the protection of water quality.

Richmond County

Richmond County, the southernmost county in our sample, is the geographically smallest and second least populated of our Virginia counties. The county also has the lowest median household income ($42,181) of our Virginia counties.[47] The county contains a large portion of the 8,191-acre Rappahannock River Valley National Wildlife Refuge, a refuge

[44] § 145-20 of County Code
[45] http://www.vdacs.virginia.gov/preservation/pdf/rappahannock-pdr.pdf
[46] http://www.vdacs.virginia.gov/preservation/pdf/rappahannock-pdr.pdf
[47] U.S. Census Bureau, 2006-2010 American Community Survey 5-Year Estimates

that seeks to protect a total of 20,000 acres along the Rappahannock River and its primary tributaries. Land use within the county is predominantly agricultural with pockets of conservation areas and development.[48]

Within the 2011 Comprehensive Plan, the County highlighted the classification of four natural corridors. These natural corridors contain high levels of biodiversity and play a critical role in reducing non-point source pollution for the County. As a result of the natural corridor classification, proposed development in these corridors should seek to minimize its environmental impact and provide impact assessments pertaining to any potential degradation from the proposed development. The County overall incorporates a number of fairly standard ordinances and policy recommendations regarding watershed and environmental protection. The surveyed county official indicated that the County requires 100-foot buffers from tidal waters but that the County is fairly generous in approving variances from the requirement. As we've found with other rural counties, the lack of rapidly encroaching development doesn't necessitate a particularly stringent set of environmental protection regulations beyond state and federal requirements.

Shenandoah County

The Shenandoah County Planning and Zoning official who responded to the survey identified two healthy streams under INSTAR's definition. As part of the Chesapeake Bay TMDL requirements, the Northern Shenandoah Valley Regional Commission developed a watershed management plan in February of 2012. The plan provides the basis for programs to come, such as the stormwater management plan the County is in the process of adopting. The comprehensive plan, the goal of which is to remain a rural, agricultural sector county, has a chapter on water, which the watershed management plan follows. The watershed management plan addresses future land use and considers where the County should be, primary focus being to keep the rural areas of the County open and channel development to the towns. Although the local government does not actively survey and assess watershed health, the DEQ regional office does each year and a number of watershed associations and one local school monitor water quality as well.

Shenandoah County implements a number of planning and zoning tools to protect its healthy watersheds. The County has a floodplain ordinance in place and a riparian buffer ordinance, though there is some flexibility for modification intended to protect individual property owners' autonomy. Shenandoah County also employs impervious cover limits in the form of building coverage limits, but not with regard to pavement or other impervious surface coverage. The County also benefits from a GIS-based watershed inventory. The County limits growth by limiting public water and sewer provision and through a cluster

[48] http://www.fws.gov/northeast/rappahannock/

development ordinance in the rural areas. The County also incentivizes clustering by allowing smaller lots for homes if 80 percent of a development remains open space. Finally, the County's erosion and sediment control ordinance contributes to the effort to maintain its healthy watersheds.

With regard to regulatory and management programs, the County implements a conservation easement program through which the easement authority leverages state and federal funding and holds agricultural and other easements as land trusts—currently 5,000 acres are under conservation easement. Through the Chesapeake Bay TMDL, the County is developing an implementation and monitoring plan that they will use to provide deliverables to the state. While there is no TDR on the books, Frederick County to the North has implemented a TDR program and Shenandoah County is waiting to see how well it is used and how useful it proves to be. The County has LID standards in place through its development ordinances. Through the soil and water conservation district, voluntary BMPs are put in place and benefit from a lot of participation, which is a good indicator that farmers in the County are sensitive to their impact—this is particularly important because the County is mostly agricultural land. The conservation district also provides guidance to farmers on the application and use of fertilizer and pesticides. Shenandoah County partners with surrounding counties through the Northern Shenandoah Valley Regional Commission, a planning district that the counties pay into and that plays a big role in the developing grants to help with stormwater management and identify where shared resources can be utilized. Testing efficiency of shared resources—such as inspectors and engineers—is currently a significant priority. There are also a number of community stewardship programs, including the Shenandoah Riverkeeper group, a trout unlimited chapter, Friends of the North Fork, and a Water Resources Advisory Committee (a quasi-governmental group overseen by the planning and zoning office but comprised of members of the planning commission and board of supervisors that plays a significant advisory role).

Spotsylvania County

Spotsylvania County reported two healthy watersheds within the county boundaries. According to their comprehensive plan, Spotsylvania County follows regulations that relate to watershed management that have been in implementation in their current form since 2008. Though not much information was provided, the county regulations within the comprehensive plan include zoning districts, impervious cover limits, watershed-based zoning, a steep slope ordinance, riparian buffer requirements, infill redevelopment, growth boundaries, and cluster ordinances. The county also utilizes GIS software to maintain an inventory of its watersheds.

The county does have a TDR program, as well as LID standards, implementation and monitoring plan, and long-term conservation protection programs. The Friends of the

Rappahannock non-profit organization has assisted the County with watershed assessments, specifically of the Rappahannock River Watershed.

APPENDIX IV: 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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