GROUNDWATER QUALITY CONTROL THROUGH GOOD GOVERNANCE

A Report for the Science, Engineering, and Technology Services Program
Supervised by Dr. Lawrence Agbemabiese

Research supported by the Delaware General Assembly
And the University of Delaware
Groundwater Quality Control Through Good Governance

SET Student Research Team

A.L. Smith, PhD candidate
Michael McCarthy, PhD candidate
Ariella Lewis, PhD student
Melissa Bollman, MEEP student
Christy Bugher, Engineering student
Executive Summary

Society practices a water sustainability ethic when it meets the needs of existing and future populations equitably while simultaneously ensuring that habitats and ecosystems are protected. Integrated governance strategies can create benefits for the environment, equity (including improved public health) and a sustainable economy. This report investigates the current structure and performance of ground water governance systems in the State of Delaware. The report is organized along 5 thematic avenues, the first of which provides background information on groundwater sources and the ways in which these may be contaminated. It also presents a conceptual framework for analyzing government responses to protecting this valuable common pool resource and describes our research methodology. Using our framework as a guide, the next part examines the groundwater governance strategy of Delaware as exhibited by the Delaware Source Water Protection Law of 2001, which was part of the state’s response to the US Safe Drinking Water Act Amendments of 1996. This section also explores the effectiveness of Delaware’s groundwater governance strategy by examining the extent to which source water protection plans developed by the three counties and 15 municipalities follow the Assembly’s recommendations. The report then moves into the third major topic – case studies – and examines how other comparable states have enacted the provisions of the federal directive. After our examination of those states in the Mid-Atlantic Coastal Plain, we offer our suggestion on what the General Assembly can learn most from this research endeavor. We conclude with a list of best practices to protect groundwater quality that we discovered while reviewing the literature from these other states and we offer a couple of areas for further investigation.
Table of Contents

Executive Summary ....................................................................................................................................... 2

1 Introduction - Groundwater Basics ....................................................................................................... 6
  1.1 Contamination ...................................................................................................................................... 7
    1.1.1 Contamination Sources ............................................................................................................... 8
    1.1.2 Contaminants and health consequences ..................................................................................... 9

2 Conceptual Framework ....................................................................................................................... 11
  2.1 Common Pool Resource Institutions .......................................................................................... 13

3 A Brief History and Summary of the Safe Drinking Water Act ............................................................ 16

4 Methodology ....................................................................................................................................... 18

5 Delaware ............................................................................................................................................. 22
  5.1 Delaware’s Source Water Protection Guidance Manual ............................................................ 24
  5.2 Delaware’s Municipal Ordinances .............................................................................................. 25
    5.2.1 Newark ................................................................................................................................ 28
    5.2.2 New Castle .............................................................................................................................. 28
    5.2.3 Middletown .......................................................................................................................... 29
    5.2.4 Smyrna ................................................................................................................................ 29
    5.2.5 Camden ............................................................................................................................... 30
    5.2.6 Dover ................................................................................................................................... 30
    5.2.7 Milford ................................................................................................................................ 30
    5.2.8 Harrington ........................................................................................................................... 31
    5.2.9 Lewes .................................................................................................................................. 31
    5.2.10 Georgetown ........................................................................................................................ 31
    5.2.11 Seaford ................................................................................................................................ 32
    5.2.12 Laurel ................................................................................................................................... 32
    5.2.13 Millsboro ............................................................................................................................. 32
  5.3 Score Meaning & Comparison .................................................................................................... 33
  5.4 Comparison to DE Source Water Protection Rankings ............................................................... 34
  5.5 CPR Institution and Critical Factors ............................................................................................. 35

6 Case Study States ................................................................................................................................ 37

7 Maryland ............................................................................................................................................. 38
  7.1 Maryland Model Wellhead Protection Ordinance ................................................................. 39
  7.2 Maryland’s Municipal Ordinances .......................................................................................... 45
10.3 CPR Institution and the Six Critical Factors ................................................................. 75
11 Results .................................................................................................................................. 76
12 Best Management Practices ............................................................................................... 78
13 Conclusion – issues worthy of further research ............................................................... 81
14 Sources ............................................................................................................................... 83
15 Appendices .......................................................................................................................... 96
15.1 Appendix I: Delaware’s Model Ordinance (minus definitions) ................................. 96
15.2 Appendix II: NC’s Best Management Practices .............................................................. 99
15.3 Appendix II: Virginia’s Wellhead Protection Plan .......................................................... 103
15.4 Appendix III: Virginia’s Best Management Practices ...................................................... 106
15.5 Appendix IV – WRA Ranking Comparison ................................................................. 109
1 Introduction - Groundwater Basics

Over 70% of the earth’s surface is covered with water, however, only 1% of that amount is usable by people and of that amount 99% is groundwater (“Basics”, n.d.). It is contained beneath the surface in geological formations and is not there in isolation from the hydrological cycle, but as an important part of it (Rail, 2000). Most of it starts off as either rain or snow and as it percolated through layers of soil it eventually displaces the air and collects in what is known as a saturated zone or groundwater body. The topmost layer of the groundwater body is the water table (Manahan, 2005). The time it takes a particular water particle to travel from its point of origin to the saturated zone can be anywhere from a few weeks to thousands of years and is dependent upon gravity, friction, and pressure.

Figure 1: Relation of groundwater to surface water [11]

About 77% of US drinking water of community water systems comes from groundwater sources (Tiemann, 2014). Though New Castle County draws most of its water from surface systems (~60%) the rural counties of Sussex and Kent draw 100% of their drinking water from beneath the ground (Water Resource Agency, 2005). Though
this source is used so widely and has such direct impact on human health, it is often relegated to a position of minor concern in the minds of many people. We cannot see it. Surface water, on the other hand, offers spectacular views and a locale for many leisure activities the memory of which we carry with us throughout our lives. We can see the effects even a minor oil spill can have on these water bodies. Oil spilled on sandy ground that seeps into a high water table is not seen. Groundwater hides in a dark hole and only comes to light when we turn on the spigot. It seems to always be there when we need it, but this ubiquity reinforces its banality – we tend to take it for granted. The unseen nature of this resource and its slow replacement rate make contamination a particularly worrisome problem. Leaking industrial containers next to a river may be easily viewed and stopped. Cleaning up after the spill is also easier and more effective because the water of that river is being constantly replaced. An underground industrial container or one behind the locked gate of a private property could leak pollution into the groundwater with no one knowing about it for a long time. Likewise, cleaning up after such a spill is made that much more difficult because the groundwater is not diluted rapidly (on average, it is replaced once every 1,400 years Ponce, 2006) and all the soil might have to be removed, if that is even possible.

1.1 Contamination

Contamination of groundwater sources – by organic and inorganic chemicals, radionuclides, and/or microbiological organisms – has been found in every state of the country and has caused great alarm at various times among our citizens. A September article in the Delaware News Journal (9/2/14) describes the condition of our state’s surface waters: “Nearly all of the state’s rivers and streams – 94 percent, the highest amount in the region – are so bad that fish can't thrive. In 85 percent of them, Delawareans can’t swim” (Montgomery and Murray, 2014). Though the governor’s clean water initiative addresses mainly these surface waters, it is not difficult to believe
that the same source of this contamination could also affect groundwater supplies. In August of this year (2014) it was found that three wells which supply public drinking water in New Castle County were contaminated with perfluorinated chemicals (PFCs) which are used in firefighting foams on airports. A well serving 2,700 residents was shut down. The EPA does not have anything more than a guidance threshold for these chemicals, but it is investigating whether to change that standard (Montgomery, 2014). Incidents like this raise anxiety among our citizens. And though point-source pollution has been addressed by the state and cleaned-up for the most part (Delaware Division of Natural Resources Division of Air and Waste Management & Division of Water Resources and Delaware Health and Social Services Division of Public Health, 2002), non-point source pollution, of which the wells and the surface water problems above mentioned are an example, requires more than just a clean-up, it requires a change in behavior and the establishment of operating procedures that prevent the contamination in the first place.

1.1.1 Contamination Sources

It is common to categorize the sources of groundwater contamination according to various land uses – residential, commercial/industrial, and agricultural – and it is a convention we will follow in this paper because it seems to follow the pattern we have seen in the local regulations and ordinances we are researching. Other options include categorization schemes dependent on discharge system or physical location of the source. Residential sources include things like lawn care treatment runoff or petroleum products from driveway auto repair. Industry might contribute solvents, cleaning fluids, and metals. Commercial businesses like photo shops and dry cleaners might contaminant the groundwater if they do not properly dispose of the chemicals they use. Runoff from large agricultural operations could allow nitrates, pesticides, and biological pollutants to enter the groundwater even if they are obeying animal tending and Ag
product guidelines. The US Office of Technology Assessment comprised the following characterization as a way of describing the how, where, and why of problematic substances in groundwater:

- **Category I**: subsurface percolation, injection well land application of wastewater, wastewater by-products, hazardous wastes
- **Category II**: landfills, open dumps, residential disposal, surface impoundments, waste tailings, waste piles, materials stockpiles, grave yards, animal burial, aboveground storage tanks, underground storage tanks, containers, open burning, detonation sites, radioactive disposal sites
- **Category III**: pipelines, materials transport, transfer operations
- **Category IV**: irrigation practices, pesticide applications, fertilizer applications, animal feeding operations, de-icing salt operations, urban runoff, percolation of atmospheric pollutants, mining and mine drainage
- **Category V**: production wells, including oil, geothermal and heat recovery, water supply, and other wells plus construction excavation
- **Category VI**: groundwater-surface water interactions, natural leaching, and saltwater intrusion

(Rail, 2000, 5)

1.1.2 Contaminants and health consequences

On their website (http://water.epa.gov/drink/contaminants/), the EPA lists 88 substances they consider groundwater contaminants. Their table includes the maximum contaminant level goals and what is allowed (these are the enforceable standards that are as close to the goal as presently feasible). It also indicates the most common source and what the potential health risks are. For illustrative purposes, we will here describe some of the more common contaminants. For the microorganisms, cryptosporidium is found in human and animal waste and if consumed in drinking water (zero MCLG) it can cause diarrhea, vomiting and cramps. Legionella can cause a type of pneumonia so specific it shares the name with the condition -- Legionnaires Disease. No percentage of these microorganisms are permitted, but test if there is any portion in the water they use a threshold of 5% coliforms to indicate that some of these might be present. Disinfectants are normally used to control these microbes, but they
also have to be controlled. So, no more than 4 mg/L of chlorine is allowed or it might cause stomach discomfort and eye/nose irritation. So far the contaminants seem fairly mild, but the inorganic chemical category contains items like arsenic that can cause circulatory problems or cancer at prolonged exposure to levels of less than .01 mg/L. Cadmium, a discharge from metal factories or the result of corroding pipes, can cause kidney damage at prolonged exposure to levels of .005 mg/L. The common inorganic copper which can come from household plumbing can cause gastrointestinal problems with only a short term exposure. Lead, mercury, and nitrate are other common materials found in this category. The organic chemicals have more unusual names and almost all of them are linked to liver problems and/or increased risks of cancer. Some of the more familiar in this category are substances like benzene (MCL of .005 mg/L); dioxin, an emission from waste incineration (MCL of .0000003 mg/L); polychlorinated biphenyls, commonly known as PCBs and could originate from landfill runoff; and toluene, a discharge from petroleum factories, can cause nervous system problems in people continually exposed to no more than 1 mg/L. These examples barely scratch the surface of contaminants, and that is just the ones the EPA regulates. There are 10,000 new chemicals coming into our environment every year (Tjeerdema, 2012) and most of them are not even tested for possible health impacts if they wind up in our air or water. It is a continual battle against the unintended consequences of modernity and the best way to protect ourselves is to develop and share practices which work to keep any and all contaminants from our groundwater. In order to accomplish this task, good governance techniques have to be understood and disseminated. Our team studied a number of reports, theses, books, government documents, and articles in peer-reviewed journals in an attempt to distill the most common attributes of a framework for groundwater governance.
2 Conceptual Framework

A number of terms have evolved in the research regarding various resource types. The chart below, provided in Carpenter (1998), delineates the differences between them all in a convenient 2X2 matrix. Here, “excludability” refers to how easy or difficult it is to prevent others from using the resource and “subtractability” refers to the extent to which one person’s appropriation of the resource limits the ability of others to appropriate it.

<table>
<thead>
<tr>
<th>Difficult Exclusion</th>
<th>Low Subtractability</th>
<th>High Subtractability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Public Goods</td>
<td>Common Pool Resources (CPR)</td>
<td></td>
</tr>
<tr>
<td>Easy Exclusion</td>
<td>Toll or Club Goods</td>
<td>Private Goods</td>
</tr>
</tbody>
</table>

A common pool resource “is a natural or man-made resource from which it is difficult to exclude or limit users once the resource is provided, and one person’s consumption of resource units makes those units unavailable to others” (Ostrom, 1999, p. 497). These characteristics of a common pool resource (CPR) are often referred to as its low excludability and high subtractability (Starkey, 2011). This situation is easy to see in the case of groundwater quantity. Anyone who can drill deep enough can capture the groundwater and once they take it no one else can have it. Also, owing to the slow recharge rate of this resource, the people using the resource can potentially drain it dry if they do not work together to keep their extraction levels within the resource’s ability to recover (Lopez-Gunn, 2009). In the United States, groundwater quantity is more of a primary issue in the western part of the country. The eastern part of the country is
blessed with greater rainfall, and though quantity can sometimes be an issue, residents here are more concerned with issues of groundwater quality.

According to the US Water Resources Council, every state east of the Mississippi has experienced some form of groundwater pollution. Historically, groundwater has been cleaner than surface water since the soil acts as a filtering mechanism. However, the newer synthetic organic chemicals are able to slide through this natural buffer (Bruggink, 1992). The Environmental Protection Agency (EPA) has found synthetic organics in 45% of large community water systems supplied by groundwater affecting between 5 and 10 million residents, and these are conservative estimates (Smith, 2004). An even more troublesome concern has to do with underground storage tanks and different surface waste disposal sites. The EPA states that 95% of all surface impoundment sites are within ¼ of a mile of drinking water sources and that 26,000 of these disposal pits are not even lined. Underground storage tanks containing gasoline are another huge problem. The EPA estimates that there are 75,000 corroded tanks leaking around 11 million gallons of their fuel into the surrounding soil. If one gallon gets into the aquifer, it can contaminate the drinking water for 50,000 people soil (Bruggink, 1992). A review of the literature reveals only a smattering of articles depicting groundwater quality as a common pool resource problem (exceptions include Sarker, et al, 2008; Ostrom, et al, 1999), but in light of the above facts, maybe more should be written to address the issue.

Though water quality is an aspect of water and, in this way, is considered a CPR good, not a CPR in its own right, there is reason to revisit this limitation. Water quality has both low excludability and high subtractability – the defining characteristics of a CPR. It is difficult to keep someone from appropriating water quality. If they contaminate the source they are depriving others of that portion of quality water and it is difficult to keep them from doing this. Discrete points of pollution may not be too
difficult to prevent, but a lot of pollution is from non-discrete sources. The backyard mechanic dumping old oil onto the ground is hard to prevent with any other techniques than education, building trustful relationships, and community awareness. This person has to be brought into the community and instilled with a sense of responsibility for his fellow residents. It is most likely that he is unaware of the harm his actions might cause or that he thinks his appropriation of some small part of the water quality is not too egregious. It is precisely for situations like this that CPR management is necessary, maybe even more so than with quantity. It is easy for the layperson to know when water quantity is low from the strain on the pump or the flow from the pipe. If water quality is low, the layperson may not know until people start getting sick. Further, quantity will be replaced by recharge. If the water quality is affected, it may just be too cost prohibitive to remedy, if it is possible at all. For these reasons, groundwater quality should be considered a common pool resource and should be managed as such.

2.1 Common Pool Resource Institutions

There are three major approaches to managing CPRs which can be classified as historical, third-party, and cooperative. Kaveh Madani and Ariel Dinar wrote an excellent series of papers analyzing these three approaches\(^1\) using mathematical models (2012b, 2013, 2012a respectively) and my treatment here utilizes their insights. Historical CPR institutions are those which reflect a self-centered worldview – everybody is out for themselves with little concern for their neighbors. Though one might think these situations would result in a tragedy, that is not always the case. To the extent the resource users learn from the history of their actions, make long term plans, and consider externalities, they can avoid complete resource deterioration without having to work with any of the other users. The only problem is that enough of these

---

\(^1\) These authors use the term “non-cooperative” to refer to what we here are calling historical. In essence, they are the same, i.e., the governance structure is one based upon a historical learning curve but implies no sense of cooperation with fellow users. People in this institutional approach have learned which governance practices work well from their own objectives, but they do not really consider others in their calculations. What we are calling third-party, the authors refer to as exogenous. These are two different ways of saying that a party outside the common pool resource community is responsible governing the resource.
users have to be of the smart, non-myopic character that the authors describe in order to achieve this balance. If not, then the third-party institution might produce better results.

In this approach, there is a regulator who controls how the resource is exploited. There are a number of methods available to the regulator such as assigning private property rights, or instituting a tax to control use, of leveling fines for overuse, etc. Many common pool resources are managed this way. The participants do not have to work together and the greatest benefits are realized only as long as they follow the rules of the authority who oversees the resource. If that authority is replaced with a community consensus it results in the last type of institution. Elanor Ostrum and her researchers found situations all over the globe where the authority overseeing the resource was the community itself. These are examples of the cooperative institution for CPR management. Ostrum and her colleagues have been able to extract and refine the principles upon which successful cooperative CPR institutions are based (Ostrum, 1990; Cox, et al, 2010; Wilson, et al, 2013). The eight principles are:

1. That the resource and the dependent population be clearly defined by boundaries
2. That the benefits and costs are shared in an equal manner
3. Group members should be allowed to make at least some of the rules and that decisions are reached by consensus
4. Those following the norms of the group have to monitor the resource to protect its exploitation by others who are not following the rules.
5. Rule breakers are subject to graduated sanctions – at first just a polite word but with harsher punishments to follow on repeated offenses or for more severe infractions.
6. There has to be a clear and fair way to resolve conflicts should they arise
7. Groups can organize to oversee their own affairs
8. If a group is part of a larger social system, there has to be coordination between the groups so contained. A CPR issue is related to size and large scale governance relies upon the close cooperation of all the participating groups. A governance area should always be deferred to the lowest representative body, i.e. those closest and most affected by the activity, unless it is adjudicated that such deferral is ineffective.
Successful cooperative CPRs, and in fact most all effective groups (Wilson, et al, 2013), adhere to these principles. In their in-depth analysis of the three types of CPR institutions, Madani and Dinar conclude that the “comparison of the results of [the cooperative CPR] study with previous studies, using [historical] and [third-party] imposed regulations suggests that cooperative management institutions are the most efficient methods in prolonging the CPR’s life and increasing the long-term benefits to its users” (2012a, p.12). Having said this, though, they acknowledge that implementing these institutions can be a challenge. To overcome this challenge, they suggest that there are actions a government can take to help create these beneficial CPR management solutions. Our conceptual framework can be graphically represented in the following way:

Arun Agrarwal, of the University of Michigan, researched the literature on common pool resource management looking for the critical functions which would enable the sustainability of the resource. His work was heavily dependent upon that of Ostrom (EO -1990) and her list of 8 described above as well as the work of Wade (RW - 1994) and Baland & Platteau (B&P - 1996). He was able to categorize the enabling conditions into four categories, of which, for our purposes, the conditions for the institutional
arrangements are most relevant. In whatever institutional arrangement is used at the local level, it must meet the following six conditions:

i. Rules are simple and easy to understand (B&P)
ii. Locally devised access and management rules (RW, EO, B&P)
iii. Ease in enforcement of rules (RW, EO, B&P)
iv. Graduated sanctions (RW, EO)
v. Availability of low-cost adjudication (EO)
vi. Accountability of monitors and other officials to users (EO, B&P)

In following our framework and applying these critical conditions, we present our research in the following way: First we will describe the federal response to groundwater issues since this is the basis for all the state responses. Second, we describe the methodology we used in researching the state and local responses. From here, we turn to the bulk of our report which describes the state and local responses in Delaware, Maryland, North Carolina, Virginia, and New Jersey. Each of the state treatments will include a description of the state level response followed by a description of various local responses following our methodological guidelines. After considering the local approaches, we characterize the institution used and indicate how it meets each of the six critical conditions listed above. At the end of our paper, we discuss the results of our study and how they benefit Delaware, we describe some best management practices we found, and we conclude with some ideas for further research.

3 A Brief History and Summary of the Safe Drinking Water Act

The federal government began regulating drinking water back in 1914 when it set standards for bacteria levels that might cause contagious diseases (Pontius & Clark, 1999). By the late 1960’s it became apparent that the standards which were in place were insufficient to protect the citizens’ drinking water. Advances in industry and agriculture led to many more toxins in the environment and a number of new chemicals
were making their way into the water system. The public concern was increasing and a study done in 1969 by the Public Health Service found that 40% of public systems did not meet the standards that were in place, let alone emerging contaminants. Over half the systems had deficiencies of disinfection, pressure, or clarity (United States Department of Health, Education, and Welfare, 1970). As a result of this study and others that took place in the following years, Congress passed the Safe Drinking Water Act in 1974.

The Safe Drinking Water Act (SDWA) is the primary piece of legislation that covers the protection of public drinking water. The act is administered through programs that set standards for water quality while it also delegates enforcement and implementation authority to the states. In this way it represents a type of shared federalism (Tarlock, 1997). It has undergone two major amendments. In 1986 it was changed to speed up the process by which EPA classified contaminants for regulation requiring that the agency add 25 new contaminants to the list every three years. This amendment proved unworkable for the agency and in 1996 the act was overhauled again, this time it scrapped the mandatory minimum listing and instead created a risk-based assessment model for when to list a new contaminant (Tiemann, 2014). Any new regulation or contaminant listing was subject to a cost-benefit analysis. The agency had to show that the costs of including a new regulation were worth the benefits to public health. The precautionary principle of the ‘74 act was replaced with a “good science” approach which meant to take care not to overestimate a potential hazard (Tarlock, 1997). In another attempt to ease compliance, the ‘96 amendments also allowed for variances and exceptions, mainly for small systems, based upon the use of most appropriate affordable technologies. Variances are granted only if they do not result in a an unreasonable risk to public health and exceptions are mainly for smaller systems, once again assuming no immediate health risk, and are for a maximum of nine years.
Congress also made funds available for the states to help them establish their oversight and enforcement capabilities (Tiemann, 2014). In addition, section 1429 in Part C allows the EPA to make 50% grants to the states to help them develop coordinated groundwater protection programs in the state. Section 1452 created a revolving loan program to help systems make improvements to meet the SDWA standards (Safe Drinking Water Act, 2002). In short, the 1996 amendments made it easier for the states to comply with regulations by limiting new contaminants and regulations through cost-benefit analyses, giving more authority to the states, and allocating funding to the states so they could meet the guidelines. The purpose was to improve compliance and therefore improve the safeguards for our country’s drinking water. The table below presents a chronology of the Safe Drinking Water Act.

Table 1: Safe Drinking Water Act and Amendments [22]

<table>
<thead>
<tr>
<th>Year</th>
<th>Act</th>
<th>Public Law Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>1977</td>
<td>Safe Drinking Water Act Amendments of 1977</td>
<td>P.L. 95-190</td>
</tr>
<tr>
<td>1979</td>
<td>Safe Drinking Water Act Amendments</td>
<td>P.L. 96-61</td>
</tr>
<tr>
<td>1980</td>
<td>Safe Drinking Water Act Amendments</td>
<td>P.L. 96-580</td>
</tr>
<tr>
<td>1988</td>
<td>Lead Contamination Control Act of 1988</td>
<td>P.L. 100-572</td>
</tr>
<tr>
<td>2011</td>
<td>Reduction of Lead in Drinking Water Act</td>
<td>P.L. 111-380</td>
</tr>
<tr>
<td>2013</td>
<td>Community Fire Safety Act of 2013</td>
<td>P.L. 113-64</td>
</tr>
</tbody>
</table>

4 Methodology

In 1996, the US Congress passed an amendment to the 1974 Safe Drinking Water Act requiring all the states to delineate areas of groundwater recharge and demark wellhead areas. The amendment also required the states to draw-up and execute water resource protection plans for these areas. We will begin with Delaware’s response to
this federal mandate and how they rolled it out to the counties and municipalities. Our study will examine the ordinances for Source Water Protection Areas in all three counties and the 15 municipalities for which such plans are required. In theory, the ordinances should cover any of the following land uses that fall within the jurisdiction of the respective governing body:

<table>
<thead>
<tr>
<th>Residential</th>
<th>Recreation</th>
<th>Highway/Parking Lots</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transportation</td>
<td>Combined Urban</td>
<td>Cropland</td>
</tr>
<tr>
<td>Industrial</td>
<td>Confined Animal Feeding Operations (CAFOs)</td>
<td>Commercial</td>
</tr>
<tr>
<td>Extraction</td>
<td>Forest Land</td>
<td>Water/Wetlands</td>
</tr>
<tr>
<td>Airports</td>
<td>Junk/Salvage yards</td>
<td>Railroads</td>
</tr>
<tr>
<td>Rangeland</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Within each land use there are a number of best management practices (BMP) which may be employed to protect the water source area of concern. Our investigations will revolve around three objectives. First, we will determine if there are land uses mentioned above present in the municipality or county for which there are no regulations. Second, we will investigate whether the ordinances on record represent the best management practices available as determined by our review of the model ordinances distributed by the state’s environmental governance body. Third, if there are compliance or practice issues, we will examine where the failure of governance may have occurred. After our treatment of Delaware, we will consider the governance models used by other states that face similar groundwater issues and evaluate them according to the same objectives.

Our selection of comparison states is based upon geological similarities, governance structures, groundwater use in public drinking water, aquifer type, and cultural
In order for us to gain the most from comparing the practices of Delaware we feel it is essential to look at states that have as many similar independent variables as possible. Geological similarities indicate that ground water recharge rates and filtration will be similar and therefore call for similar wellhead delineation practices. For governance structures we are looking for states that, like Delaware, allow local land use to be controlled by local governments. This stipulation is important because states in which local land use rules are dictated by the state level (like our original candidates from the New England states) remove the level of governance we are trying to examine. That the state uses a fair amount of groundwater will help us find comparison municipalities that share the same characteristics as the cities in Delaware. The same observation is true of the aquifer type. The Delaware towns we are looking at use confined, deep aquifers for their drinking water. Water management techniques for this source are different than they would be for open, semipermeable, and/or shallow aquifers let alone the wide range of differences that apply to surface water systems. The cultural parallels are more difficult to delineate, but we are searching for states that have similar attitudes toward environmental regulation and civic participation. These considerations led us to consider states in the Mid-Atlantic Coastal Plain region of our country. These areas use a lot of groundwater for their community systems, the aquifers tend to be confined and deep, the states relinquish a lot of local land use oversight to the local municipalities, and culturally the states are all located in the North/South border area of the east Coast. Our states are Maryland, Virginia, North Carolina and New Jersey.

To determine compliance rates of the various sub-governments within the state we will use whatever model that was developed by the respective environmental agency (or other relevant body), extract the objectives which pertain to groundwater contamination prevention, and then determine how many of these objectives were
adopted by the local government and if they modified any of the parameters. For Delaware we will look at all the communities for which source water protection ordinances were required. For the comparison states, we will assess the local ordinances using the same process we did for Delaware. However, owing to the large number of counties and municipalities contained in this comparison group, we will not be able to examine every local ordinance. To determine general compliance levels we will select a representative sample of ordinances based mainly upon population size, location, aquifer type, and groundwater use. All the cities are in the coastal plain for reasons discussed above. In choosing the size we looked to Delaware to see what they may have done. DE required all municipalities of over 2,000 fulltime residents to complete source water protection plans. Using the EPA’s database of water systems we found that the median population served by DE’s community water systems was 1,995 persons. In determining the city selection for our other states we followed a similar method, we took the median population served by the CWSs and selected cities around that median which fell in the coastal plain and used groundwater for their drinking water source. We at first hoped to use a mean value and then derivations from that mean, but the population centers skewed the results producing a non-normal distribution. For some of the states, the median population was too low to draw a fair comparison owing to the greater population density of De so we used the first median as the lower range on a new scale from which we derived a new median and then conducted a search similar to what is described above. For these states the median populations selected ranged between 2200 and 3500. After this analysis, we will be able to compare Delaware’s groundwater governance to that of the comparable states and draw some conclusions which will lead to our recommendations.
5 Delaware

Delaware has over 500 public water systems with more than 1,000 wells. Though only 40% of the drinking water in New Castle County is supplied from groundwater sources, all of the drinking water in Kent and Sussex Counties comes from this source type (WRA, 2005). As mentioned earlier, groundwater has some particular characteristics which make governance of it difficult – its ever-presence, its ease of capture, its difficulty of measurement, and the ease with which we can claim a right to it. However, groundwater’s importance to our health and livelihood make it very important that we design governance structures which serve to protect this vital resource. In 2001, the state of Delaware did just that, it enacted the Source Water Protection Law (7. Del. C. 6081, 6082, 6083) which requires municipalities with populations of over 2,000 persons to enact measures to protect their drinking water supplies. The Department of Natural Resources and Environmental Control published a guide in 2005 that provided local governments with information to help them craft their water resource protection plans. By 2007 the municipalities were to have finished their plans. This paper represents our attempt to understand the effectiveness of the Source Water Protection Law in changing local land use regulations and practices to protect wellheads and groundwater recharge areas.

The governance model employed by the Delaware General Assembly to address the protection of the state’s groundwater resources utilizes all three directional structures: top-down, outside-in, and bottom-up. The top-down model, which is commonly used by state legislatures, can be seen in the fact that they passed a law which all municipal governments had to follow – The Source Water Protection Law. This law was in response to the US government’s top-down action requiring states to take actions to protect their drinking water as stipulated in the 1996 amendment to the 1974 Safe Drinking Water Act (DEDNREC, 2007). From an outside-in perspective, they asked DNREC to gather information on best practices from other states in determining how to
advise the municipalities. The bottom-up aspect of this process can be seen in how the Assembly asked for two different avenues for citizen participation. The first was in having the DNREC work with a citizen and technical advisory committee and the second was in asking the municipalities to involve local citizens in the formation of their respective protection plans. Starting in 1996, the Delaware Geological Survey (a partnership between the state and the University of Delaware) and the DNREC began a process of mapping Delaware’s groundwater recharge potential that would last approximately ten years and involve thousands of hours of field, laboratory and geographical information systems (GIS) work. These maps indicate wellhead and groundwater recharge Water Resource Protection Areas. They also indicate discrete point contaminant sources. In 2002, DNREC and the Health and Social Services Division of Public Health published the report of a study analyzing the water supplies in danger of contamination from these sources (DEDNREC, DWR, DHSSDPH, 2002). Samples were tested from the most vulnerable or threatened water sources in the state and there were some contaminants found. However, after treatment of the sites, there were no samples that exceeded drinking water standards. Treatment involved installation of permanent controls and the study “confirms the effectiveness of water treatment methods in delivering safe drinking water to the residents of Delaware” (DEDNREC, DWR, DHSSDPH, 2002, xi]. Installing such controls at all the wellheads or recharge areas in the state to protect against non-discrete, i.e. nonpoint source, pollution would be both prohibitively expensive and unnecessary. To combat this threat to drinking water, the state asked every municipality with over 2,000 year-round residents to develop a water resource protection plan and implement it. The basic framework of the project is exhibited below.
5.1 Delaware’s Source Water Protection Guidance Manual

In 2004, the Water Resource Agency produced *The Source Water Protection Guidance Manual for the Local Governments of Delaware* for the Delaware Department of Natural Resources and Environmental Control in fulfillment of obligations under the state’s Source Water Protection Law of 2001. The guide, produced in conjunction with the Source Water Protection Citizens Technical Advisory Committee, describes “desirable land uses within source water assessment areas that promote the long-term protection of public drinking water supplies” (7 Del. C. 6082a). Chapter 3 of the document offers local governments a useful summary of best management practices related to zoning ordinances, building codes, storm water runoff control, infiltration techniques with design requirements, constructed wetlands, detention ponds, preferred agricultural practices, and some non-regulatory approaches. In Chapter 4 the authors offer a
breakdown of specific threats to source water and the local management tools that the
government can use to protect their drinking water against these threats. In Appendix
D, the authors have created a model ordinance which we will use as our guide in
evaluating the effectiveness of the state’s intent in communicating the minimal level of
compliance expected from municipalities in the state with populations over 2,000 year-
round residents. Land use falls under the jurisdiction of local governments so they are
not obliged to enact the measures contained in this model ordinance. It is for this
reason that we find it a useful guide in determining how local governments take the
counsel of state authorities. Using the model ordinance found in Appendix I (except the
section on definitions), we will chart the adherence rate among the municipalities in the
following section.

5.2 Delaware’s Municipal Ordinances

We are focusing in on the local governance mechanism for groundwater protection
as exhibited by municipal water source protection ordinances as opposed to the county
level for a few reasons. First, as noted above, community eater systems (CWS) draw a
vast majority of their drinking water from groundwater sources, predominantly from
dereeper wells tapping the confined aquifer which lies below the unconfined aquifer and
is separated by a layer of clay or similar earth formation. In Delaware, land use – the
primary impact factor on groundwater quality – is controlled by local governments.
Though county governments have control in unconsolidated areas, CWSs are sure to be
found in cities and townships and so the land use around the wellheads and recharge
areas which supply that water is of utmost concern. Second, agriculture land use is
regulated by the state in DE, not local governments. Since a majority of agricultural
sites are most likely found outside of city/town limits and since irrigation water is
usually drawn from unconfined aquifers, we feel county level ordinances are less
directly tied to protecting the groundwater that ends up in most people’s kitchens. This
is, of course, a simplification, but it is one that influences our next reason for choosing municipal level ordinances. Third, for the sake of uniformity in our comparison cases, we find it useful to focus in on the city/town level. In all the states we examine, local land use is primarily under the auspices of the municipal government. The level of county control varies among the states, but in all of them there are guidelines for municipalities which they are encouraged, but not required, to adapt. In this space, the space between encouragement and requirement, is where we can see the effectiveness of a particular governance model. If it was only requirements that we were investigating, we would have to examine conditions on the ground to determine whether the requirements were being met, a task well outside our capabilities.

In choosing the municipalities of Delaware on which to focus, we follow the Water Resource Protection Law of 2001 and select the ones which have a year-round residency of more than 2,000 people. There are other smaller communities which have also created ordinances, which is laudable, but we focus on these because though they were required to create ordinances, they did not have to follow the guide to do so. We will determine where their approach differs from the guide ordinance and quantify that difference in the following section.

As has been noted, we are examining to what extent the municipal ordinances match the model ordinance proposed by the Water Resource Agency and supported by the General Assembly. We are using these ordinances as a way to understand how municipalities protect their groundwater resources. In so doing, we acknowledge that there may be other tools the community may use to accomplish this task. For instance, a particular town may not include a provision in their wellhead protection ordinance that prohibits septic systems in the wellhead area. However, the town may prohibit their use all together by mandating that all new homes and businesses be connected to the town’s sewer system and so do not feel the need to restate it again in the WHPP.
Though this may be the case, it still remains that the ordinance designed to protect the community’s groundwater resource makes no mention of this potential contaminant source and that there may be abandoned or grandfathered septic systems in the area. A citizen inquiring about how the town protects their drinking water would still like to have all this information in one place and it is the reason we still feel it necessary to remark on omissions of this type in the local plans. In addition, there are two local ordinances which we do not consider in our treatment.

The focus of our study is groundwater governance which leads us to examining the efforts of smaller communities as they are the primary users of groundwater for drinking water supplies (Crocket Consulting, 2010). It is for this reason that we do not consider Wilmington’s Source Water Protection Plan or the related ordinance. The city’s drinking water comes from the Brandywine Creek watershed and the protection plan only addresses groundwater as it helps to recharge the surface waters in the watershed [ibid]. The city of Newark’s drinking water is also mainly supplied by surface water, but it does also utilize groundwater for about 37% of its needs (City of Newark Department of Public Works and Water Resources, 2013). Aside from Newark, all the other cities/towns in our report derive their drinking water from groundwater. We also wish to note here that although the town of Elsmere was initially required to develop a source water protection plan under the 2001 law, it was later determined after completing the source water assessment that the town did not have any wellheads or excellent recharge areas and so did not have to complete a plan. One last note we wish to make before we describe the municipal responses is that the model ordinance first distributed to the municipalities is less strict than a later publication. The first one was included as an appendix in the Source Water Protection Guidebook in 2004. The second one was distributed in 2008 as the Draft Model Ordinance for Smaller Municipalities of Kent and Sussex Counties. It includes most of the more stringent requirements of the initial
guide ordinance, but also allows that communities may option for the less stringent requirements imposed by the state’s Department of Natural Resources and Environmental Control. We score opting for the less stringent guidelines with a percentage value indicating that the community could require more but for historical or political reasons has chosen not to do so. Whether stricter guidelines result in better water quality is a topic we will pick up later in our paper.

5.2.1 Newark

As noted above, Newark draws its drinking water from both surface and groundwater and their drinking water supply protection ordinance (DEDNREC, 2007) reflects this distinction. Newark adopts the more stringent guidelines on storage tanks in the wellhead area, not permitting them, and even draws a stricter low-end limit on the amount of impervious surface it will allow in the WHPA at 10% whereas the model ordinance only indicates a minimum level at 20%. Though these are definitely strong points, the ordinance does not mention other suggested provisions such as diverting storm water runoff away from the wellhead and mandating that storm water discharge be by way of sheet through grasslands or from a treatment facility. There is also no mention that new construction should have no roof drainage to impervious surfaces. The ordinance makes reference to the presence of Water Resource Protection Maps in the City offices, but does not explicitly state that new development has to delineate such areas on their plans before permit approval. That is not to say they are not required to do so, just that it is not indicated in their ordinance. These omissions resulted in a lower compliance score than expected. 57

5.2.2 New Castle

New Castle scores well on the compliance scale with a score of 81. The city is one of the few to maintain a protected zone of 300 feet in the primary WHPA, though it does allow that it can be reduced to 150 feet if a hydrologist can certify that the minimum
travel time of water in the zone is 60 days from the furthest point and that the well
draws from a confined aquifer (New Castle, 2007). The city also abides by the stricter of
the underground storage tank rules. The ordinance does not mention the lot areas for
the two types of aquifers nor does it describe how stormwater should be discharged in
the WHPA. It does, however, list the land uses that are not permitted in its Class A and
Class C wellhead protection zones (corresponding to Zone 1 and 2 of the model
ordinance). Some towns have such a list while others do not. The difference may rest
in whether the ordinance was composed before 2008. The 2008 guidance ordinance
includes a list of 22 prohibited uses broken down into the two zones with some
allowance for conditional uses. The original model ordinance does not list these land
use prohibitions, but they are listed in the body of the original guidance manual.

5.2.3 Middletown

Middletown represents a case where their low score may just be a result of some
unintended omissions in their ordinance. We say this because the ordinance makes no
mention of preventing hazardous storage, septic storage, or underground storage in the
Class A WHPA; yet, it follows the more stringent guidelines on stormwater diversion,
open space in a WHPA, and lot areas for wellheads. It also uses acceptable (though not
the more stringent) goals for recharge areas. The ordinance is also one of the more
sparse covering just over three pages after definitions. The town might possibly have
protective language elsewhere, but it is not present in this ordinance and this is the one
a citizen would likely look to find out about her town’s drinking water protection
activities. The score is a 53.

5.2.4 Smyrna

Smyrna, by contrast, received one of our highest marks, a 92. The town deviated
from the model ordinance in three respects. It opted for the less stringent wellhead
protection zone 1 radius of 150 feet instead of the 300. It only provided for a $\frac{1}{2}$ acre lot
size for wellheads for both confined and unconfined aquifers. The last way it deviated from the model is that it chose the less stringent requirements for underground storage tanks in zone 2. Otherwise, the ordinance could have been written by the Water Resource Agency itself.

5.2.5 Camden
The Town of Camden ranked second best in our method of assessing local ordinance parallels to the state model ordinance with a score of 88. It followed the path of Smyrna with regard to open space in zone 1, did not include any lot size requirements for wellheads, and allowed Hazardous storage tanks in Zone 2, though not underground storage tanks within 1,500 feet of the wellhead. The town also not only had the 22 restricted land uses, but it added one more – concentrated animal feeding operations (CAFOs).

5.2.6 Dover
The city of Dover’s ordinance may suffer from not covering provisions found elsewhere in the city codes for there are a few areas not covered, but other areas are demonstrably lenient. The ordinance does protect the primary wellhead areas (which it calls tier 2, reserving tier 1 for secondary WHPAs confusingly), but makes no statements about impervious surfaces, lot areas, septic tanks or hazardous waste storage (though it does prohibit those hazardous waste generating activities found in the prohibited land usage section of the model ordinance for 15 of 22 uses). The city also allows impervious cover in tier 1 areas of up to 75% which is higher than any of the municipalities we examined. Our team speculated that these exceptions may be due, in part at least, to the presence of a large Air Force base in the city. Score: 53.

5.2.7 Milford
The city of Milford has some detailed descriptions in their plan, but it is lacking in stormwater protection mechanisms for zone 1 and weaker standards are adopted for
zone 2 where impervious cover can reach 60%. They do have a list of prohibited land uses in the three zones, but it is a little confusing in that it cites as conditional many land uses in zone 3, excellent recharge areas, that it prohibits in zone 2. The town ordinances we examined normally classify zone 3 as an overlay of zone 2 that demarks the excellent recharge areas. Maybe they are just considering any recharge area even if it is not in a wellhead protection area, but it is unclear. Score: 69.

5.2.8 Harrington

The ordinance for the city of Harrington was adopted in August of 2008, but it has the look and feel of an older document that was reused to meet the requirements of the General Assembly. This is only an impression, but we base it on the fact that the ordinance does not consider a number of topics raised by the model ordinance. It only asks for a 100 ft radius around the wellhead to be left in a natural state, it does not address storm water discharge or wellhead lot sizes, it does not mention septic or hazardous material storage tanks in tier 1 (different from Dover, tier 1 here actually means the primary protection zone), it allows 75% more impervious cover in tier 2, and it only lists 5 of the 22 suggested prohibited land uses. Score: 57.

5.2.9 Lewes

Lewes received our highest score, a 96. It only did not follow the model ordinance in adopting the weaker standards for natural space around a wellhead and weaker standards for underground storage tanks in excellent recharge areas. It does not list the prohibited uses, but it refers to them in a separate document as being the exact same as those in the model ordinance. Good job Lewes!

5.2.10 Georgetown

Georgetown comes in with a fairly high score at 84. The town uses the weaker standard for its underground storage tanks (UST) and uses 35% as the lowest threshold for impervious surfaces in zone 2. New re-developments are asked to reduce
impervious surfaces as feasible, but there is nothing more specific stated. The ordinance does include a list of prohibited uses within the WHPA that exceeds the model by including 3 more prohibitions. Only 3 municipalities scored better.

5.2.11 Seaford

The Seaford ordinance is relatively sparse and it refers often to what is permitted in the underlying zone. This paucity of information in the ordinance is why it scores so low on the compliance spectrum 52.

5.2.12 Laurel

Laurel scores better than average on our compliance scale with a 76. The ordinance does not address minimum lot sizes in the WHPA and it uses the weaker standard for underground storage tanks in zone 2. It also allows 10% impervious cover in zone 2 and only asks that redevelopment reduce such cover as feasible. Aside from these variances, the town follows the state model.

5.2.13 Millsboro

Though the town of Millsboro scored low on our scale, we feel that might be more due to the age of their ordinance rather than any specific attempt to undermine state attempts to dictate guidelines. The ordinance has an appearance and content which suggest it predates the requirement to produce such an ordinance. So, for example, it does not specify how much open space there should be around a wellhead, but it does indicate that such a space requirement exists on maps in the town hall if a citizen wished to view them. Though the ordinance does not contain some provisions of the state model, in a couple of areas it far exceeds the model. The lot size in the immediate recharge area (read zone 1) is almost 3 times what the requirement for a confined aquifer and the primary area is almost twice the requirement. Our team was particularly impressed by the town’s list of prohibited uses in the WHPA which is 3 times longer than the state list. That being said, the ordinance does not discuss specific
stormwater runoff control features (it does mention the need for development to have plans, it just does not specify the parameter of those plans) and it allows 30% impervious surface in zone 1. 56

5.3 Score Meaning & Comparison

The case of Millsboro above brings up an illustrative point regarding the significance of these compliance scores. A low score does not necessarily mean that a town has disregard for the quality of their groundwater. It simply means that the particular ordinance which is designed to regulate land use in the WHPA does not closely follow the state model ordinance. It could be the case that a town does not include septic tank regulations in the ordinance because they have a separate zoning regulation which does not allow any septic tanks. The town may mandate water/sewer connections for every business and residence and so felt no need to include septic tank provisions in their SWP ordinance. However, the point of having a SWP ordinance (or a WHP ordinance) is that it indicates the measures a town takes to protect the drinking water of its citizens. Such an ordinance shows how concerned the town is about the quality of this resource and it allows a citizen or potential developer to see, in one place, what rules have to be followed.

In future studies, we hope to investigate (1) whether the quality of the ordinance has any effect on the quality of the groundwater and (2) judge the effectiveness of these ordinances in controlling land use by investigating the number of violations and the number of variances granted. If a town has a really strong ordinance to protect groundwater but grants an excessive number of variances, is it really doing what it can to protect the resource? Conversely, a town with a weaker ordinance but a more restrictive variance approval record may be doing more to protect the resource. Our present study, however, is an important and necessary first step in determining the effectiveness of the state’s groundwater governance. Using the best science available,
the state has followed the federal initiative and communicated the importance of certain management methods to protect groundwater. The resulting municipal level ordinances reflect the state’s effectiveness in communicating those management methods and the transparency within which the process operates. Research agendas 1 and 2 above will provide on-the-ground evaluation of the effectiveness of this process. With these caveats in mind, we present the following graph depicting the compliance ranking of each town in our study. The state average is 70.

**Municipal Ordinance Compliance Scores**

![Figure 2: DE Municipal Compliance Scores](image)

5.4 Comparison to DE Source Water Protection Rankings

Many readers of this Delaware section are no doubt familiar with the Source Water Protection Program’s Community Water System Ranking that was employed during the Source Water Assessment process. Though it may be natural to try and compare the results of both evaluations, we urge against doing that. The two systems measure two entirely different phenomena – ours looks at the state government’s ability to communicate the importance of its water quality protection standards while the Water Resource Agency was evaluating the threat level to community water systems from
various sources of contamination. It is a natural assumption to think these systems are linked, we even thought so at first, but once we looked closer at the two systems it became clear that the dependent variables in the analyses were entirely different. We converted the WRA rankings to a 100 point score and tried to see if there was any correlation. There was not. It is important to remember that the assessments were completed before many communities upgraded their ordinances and that some communities did not upgrade their ordinance because there were not many problems indicated in the assessments. Smyrna is a good case in point here. They scored rather low on the WRA assessments (see Appendix IV -- number 8 out of 13 with a transposed score of 48), but rather high on our (#1 out of 13 with a score of 95). There is a clear reason why this could happen. After the assessment phase, the municipality wanted to prevent further contamination so they accepted the most stringent requirements. On the other hand, Dover, who scored highest on the WRA scale and next to last on ours, probably felt no need to update their ordinance since their present process was doing a pretty good job. There are of course many more factors to consider and what appears to be the case is not necessarily so. Future research will be able to explain the differences much more accurately than just referring to different sets of numbers. The different ranking systems are juxtaposed in Appendix IV.

5.5 CPR Institution and Critical Factors

Groundwater quality management in Delaware most closely resembles the Third-Party Common Pool Resource Institution described in section 2.1. The protection measures were designed at the state level and disseminated to local municipalities through the use of a guide book and a model ordinance. Though these resources were designed with the input of a Citizen and Technical Advisory Committee, it was still at the state level and not at the local one. The municipal ordinances themselves, for the most part, follow the model ordinance framework and just adjust the specifics to their
own standards which happen to be less stringent in most cases. The towns which vary most from the model ordinance – Harrington, Dover, Middletown, and Seaford – seem to do so by lacking information which may be contained elsewhere or may be absent due to the age of the ordinance. There does not appear to be much input at the local level construction of these ordinances more than announcing their formation in the local press. The institutional arrangement between the state and local governments does meet most of the 6 critical factors for common pool resource management.

The rules devised by the state and implemented at the local level are relatively simple and easy to understand (i). The local governments do not devise the access rules to the CPR (ii), that task is done through state level approval of well permits. However, from a practical point of view, these rules are followed by local, certified well drilling companies and they are accustomed enough to the standards to serve as practical arbitrators of how these standards are met. Most of the rules are easy to enforce (iii). They apply to conditions which are easy to see – impervious cover, above ground storage tanks, open space around the wellhead, etc. The condition of underground storage tanks can be determined from soil testing, which is a bit more difficult, and illegal dumping rules can only be enforced through surveillance or citizen reporting. These activities are more difficult to enforce and require citizen education and vigilance. The local ordinances do not generally list any graduated sanctions (iv) for ordinance violations, but if violations do occur they are probably handled in the same manner that they are with surface water contamination – through voluntary compliance with the standards once the perpetrator is informed of his or her violation (Association of State Wetland Managers, 2011). Over 90% of incidents have been resolved in this manner. Further actions would have to be settled in civil or criminal court (ibid). However, as stated, most of the time there is a low-cost form of adjudication (v) and a property owner has recourse to dispute wellhead boundaries and/or certain land use practices if
they want to challenge the ordinance or be granted a variance. On the last critical factor, accountability of monitors and other officials to users (vi), there is no mention in the ordinances and we presume the only way to do this is through the court system or the ballot box. That being said, for the most part, Delaware meets the 6 critical factors of a common pool resource institution, which in this case is that of third-party regulation.

6 Case Study States

Delaware’s method of groundwater governance relies on an application of the framework we described in section 1.3. Now we will look at how the other comparable states. All these states are on the coastal plain which means all have heavy groundwater use probably from deep, confined aquifers; they all have similar government structures; they all rely on local land use policy to protect GW; all have a fair amount of agriculture; all are similar culturally and demographically; and all subject to salt water intrusion from rising sea levels. The half of the frame work covered by the capacity and knowledge base descriptions are fairly consistent throughout our study region. All states conduct a thorough hydrological study and they all describe, to slightly varying degrees, the socioeconomic situation within their borders and in relation to the nation as a whole. All the states also identify the management measures most appropriate to protect groundwater quality through the production and dissemination of a guide book and on-call technical assistance. Where the state level approaches differ is in their respective management instruments and their implementation procedures. We will examine these categories of the framework as exhibited by our comparison states to determine if there is information of value for Delaware in how these states protect their GW resources. [initial observations in this respect: NJ relies on private contractors working at district levels – i.e. many communities at once – MD and NC rely on community level response in conjunction
with state agencies; NC plans are more thorough and involve a lot of local buy-in while MD plans are thorough but exhibit less participation in number and quality of community involvement, MD also uses a contractor for communities with threatening contamination prospects; open question whether this is the better way to go b/c our initial investigations appear to suggest otherwise; VA uses a similar method to that of NC and MD but with much less evident production of quality plans]. We will bring out areas where DE is doing well in comparison (information mgmt., overall compliance levels) and areas where they could learn from their peer states (quality of plans, citizen participation)

7 Maryland2

Part of Maryland’s response to the Safe Drinking Water Act Amendment of 1996, the part that concerns our study, was to adopt their already existing program to the new requirements. In 1985, the state senate directed the Maryland Department of the Environment (MDE, though at that time it was the DHMH) to develop a Comprehensive Groundwater Protection Strategy. The MDE coordinated with the Department of Agriculture and the Department of Natural Resources to create statewide policies, programs, and strategies. One of these programs is the Wellhead Protection Program (WPP) and it is the one most similar to Delaware’s Source Water Protection Program. Though the state seems to have greater control of water resources in Maryland, the WPP is meant to protect drinking water derived from groundwater sources and the MDE states that “implementing protection plans … must be a local effort involving citizens, the regulated community, and elected officials (Maryland Water Supply Program, 2013, 26) In this way it is just like the DE plan – local control of local resources, local responsibility to protect local resources.

2 The information in this section is adapted from the state’s Groundwater Protection Program’s report to the Maryland General Assembly in 2013 [25].
The largest water systems in Maryland are the ones serving Baltimore and Washington, DC. Both of these use surface water -- Baltimore from surface reservoirs and DC from the Potomac. The western part of the state also uses surface water. The Coastal Plain region, the Eastern Shore, and the small and medium towns in the Piedmont all rely on groundwater sources. There are 473 community drinking water systems in the state and 423 of them use groundwater and they serve over 700,000 residents. The following figure represents this distribution.

![Figure 3: Percentage of MD pop. served by public water systems or private wells and percentage of water systems using surface or groundwater](image)

7.1 **Maryland Model Wellhead Protection Ordinance**

In accordance with federal guidelines, Maryland first drafted its *Model Wellhead Protection Ordinance* for its community water systems. The original ordinance was revised twice. The first time in 2005, in response to updates in the federal drinking water law. The second time in 2007 for similar reasons. It is duly noted that the ordinance, as entitled, acts as a mere guideline of what state regulators in Annapolis would like to see implemented at the local scale. Since implementation depends completely and totally on local authorities, the state’s role on groundwater governance and wellhead protection, as that of the federal government to states in general, is normally to set standards or guidelines for state and local authorities to adhere to in their deliberations. An official at the Maryland Water Management Administration confirmed that municipalities within the state have never been expected to enact any of
the recommendations, but the state provides these guidelines, just the same, for their consideration in the decision-making process.

Section 1.0 details the purpose and intent of the ordinance. Groundwater in community wellhead protection areas provides the primary source of drinking water and also future water supply. Therefore, a safe, secure and adequate drinking water source is of great benefit to local communities and the future sustainability of Maryland’s overall supply. The contamination threat from accidental spills and discharges of toxic and hazardous materials can be mitigated through adoption of preventive measures in wellhead protection zones. Proper siting, installation and operation of septic systems in agricultural and residential areas would complement and enhance wellhead protection by preventing excess nitrogen from leaving those areas. Overall, the ordinance seeks to protect public health and safety through an integrated approach to community groundwater protection.

Section 2.0 provides definitions for key terms throughout the ordinance. Of special note, the Wellhead Protection District becomes defined as

that land area overlying the aquifer which contributes water to a public water supply well under the permitted withdrawal rate (average annual) and average annual recharge conditions that can be anticipated based on historical data. It is bounded and may be influenced by the ground water divides which result from pumping the well and by the contact of the aquifer with less permeable geologic boundaries. In all cases, the Wellhead Protection District shall extend upgradient to its point of intersection with prevailing hydrogeologic boundaries (a ground water flow divide, a contact with geologic formations, or a recharge boundary), or be limited by time-of-travel. The Wellhead Protection District shall be reviewed and approved by MDE.

The Wellhead Protection District may include two (2) zones of protection, with Zone 1 being the most restrictive. Zone 1 is based on a 1 year time of travel, fixed radius or other assessment of an area most closely connected
to the water supply. Zone 2 is based on a 10-year time of travel or by hydrogeologic boundaries. The boundary of Zone 3, when delineated, encompasses the total land area that is determined to provide recharge to a public water supply well. (Maryland Department of the Environment, 2007, 4)

While the other terms defined in section 2.0 all relate to wellhead protection, the definition for the protection district itself is the most extensive. In this way, each time the wellhead protection district appears in the text, the above definition clarifies exactly what it entails.

Section 3.0 states the authority and enabling statute for use by jurisdiction empowerment under the Annotated Code of Maryland. These include certain non-charter (including home rule) counties, Baltimore City and other incorporated municipalities throughout the state. Basically, these authorities can insert their name and authority over matters of wellhead protection within their respective, local jurisdictions.

Section 4.0 consists of two points on Applicability. The first point states that the Ordinance applies to all land uses within the proposed area within the Wellhead Protection District (WHPD). Maps are available for inspection at the local or county office depending on how the WHPD was defined. Moreover, the second point notes that the Ordinance supplements other laws and regulations. If the Ordinance in whole or in part imposes tighter restrictions than the already established laws and regulations, the provisions of the Ordinance take precedence.

Section 5.0 offers the Extent and Designations for the zones of each WHPD as recommended by the Maryland Department of the Environment (MDE). In Maryland, districts may include 1, 2 or 3 protection zones. Note, “…for each community this section will need to be customized….” (MDE, 2007, 8) The text for each WHPD needs to include what method was used in the area’s delineation. Several possibilities are listed
withdrawal rates.

If two zones of protection

Zone 1 represents area bounded by a ground water travel time of 1 year to supply source and location as determined by a modular semi-analytical ground water flow model.
Zone 2 represents an area bounded by a ground water travel time of 10 years to supply source and location as determined by a modular semi-analytical ground water flow model.

WHPA Code Version 2.2 shows the Huyakorn and Blandford water model flow as one such example.

If third zone of protection

Zone 3 represents that area between the 10-year time of travel boundary and the boundary of the ultimate recharge area to supply source and location.
Area determined by numerical ground water flow model and particle tracking routine (provide model reference).
Model grid size, boundary locations, input parameters and calibration results all described in detail (in report with author, title and date).
MDE has indicated its approval of all areas (zones 1, 1 and 2, 1,2 and 3) consistent with requirements of Section 1428 of the Safe Drinking Water Act. The delineation maps for the WHPD and Zones. Maps are held on file and maintained by the appropriate authority involved, plus accurate copies of maps are made available for review by the public.

Properties located within one or more of the WHPD or Zones are reflected on the maps, and should the boundary of the District or individual zones be modified, additional information or analysis that represents the new boundary lines must be reported. Procedures for modification of boundaries beyond those already established begin by providing evidence to the Zoning Commissioner (ZC). The burden of proof lies with the applicant to show current boundaries no longer represent the criterion upon which they purport to represent. Once the ZC has received written advice from the community’s planning team and/or technical advisors, all property owners potentially affected by the changes are sent notification indicating the proposed changes. Public has the opportunity to comment on the proposed changes for a period of 60 days after notices have been provided.

Section 6.0 on Use Regulations divides into seven subsections summarized here. Permitted Uses include

…conservation of soil, water, plants, and wildlife; Outdoor recreation, nature study, boating, fishing and hunting where otherwise legally permitted; Foot, bicycle, and/or horse paths, and bridges; Normal operation and maintenance of existing water bodies and dams, splash boards, and other water control, supply and conservation devices; Maintenance, repair, and enlargement of any existing structure, Residential development, Farming, gardening, nursery, conservation, forestry, harvesting, and grazing, subject to Prohibited Uses; Construction, maintenance, repair, and enlargement of drinking water supply related facilities such as, but not limited to, wells, pipelines, aqueducts, and
tunnels. Underground storage tanks related to these activities are not categorically permitted.

Prohibited Uses include

...bulk storage of hazardous materials, dry cleaning establishments, coin or commercial laundries, garages/service stations, heavy manufacturing uses, junk yards, yarding areas, manure piles, animal waste, sewage storage....

In section 6.2, the ordinance lists more along with conditional uses (6.3), nonconforming uses (6.4), variances (6.5), and exemptions (6.6).

Performance Plan Standards (6.7), here merit a more complete listing as appears in the table below. The areas as listed in the Ordinance are listed.

<table>
<thead>
<tr>
<th>Containment of Hazardous Materials</th>
<th>Liquid Fertilizer Tanks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stormwater Runoff Infiltration</td>
<td>Underground Injection Wells</td>
</tr>
<tr>
<td>Sewage Sludge and Animal Waste</td>
<td>Underground Hazardous Material Pipelines</td>
</tr>
<tr>
<td>Agricultural Operations with yarding areas</td>
<td>Hazardous Construction Materials</td>
</tr>
<tr>
<td>Wastewater Disposal</td>
<td>Stormwater Infiltration Design</td>
</tr>
<tr>
<td>De-icing Chemicals</td>
<td>Reporting of Spills</td>
</tr>
<tr>
<td>Pesticides Bulk Storage</td>
<td>Monitoring Hazardous Groundwater Materials</td>
</tr>
<tr>
<td>Alterations and Expansion</td>
<td></td>
</tr>
</tbody>
</table>

Section 7.0 on Administrative Requirements comprises subdivision and land development review, notice of violation, stop work orders, and penalties, which may be levied up to $1,000 for any violation of the Ordinance.
The final section, 8.0 on Fees, briefly covers fees established by resolution. The entire section consists of the following statement, “...All fees for review of Subdivision and Land Development Plans shall be established by resolution of the appropriate local governing body. Fees established shall be reviewed annually and adjusted as required. The fees shall include reasonable costs involved with the implementation of this ordinance and may include Administrative and professional staff review costs....” (MDE, 2007, 20) On that note, the Water Supply Program of the Water Management Administration within the MDE concludes its model ordinance for wellhead protection in Maryland. Following suit, counties and municipalities have responded in whole or in part to MDE zone delineation and performance plan standards for wellhead protection.

7.2 Maryland’s Municipal Ordinances

Moving onto the municipalities and counties of Maryland, references back to the State’s Model Ordinance or the elements contained therein. Delineation Zones where appropriate, Permitted, Prohibited and other Uses, as well as Performance Plan Standards become indicators that the local authorities followed the words of the MDE. The sampling of municipalities included the following: Fruitland, Chestertown, Chesapeake Beach, North Beach, Indian Head, Pocomoke City, Centreville, and Berlin. Given the jurisdiction of some of these municipalities within counties named in the Ordinance, Calvert County includes the assessments for Chesapeake Beach and North Beach, Charles County for Indian Head, Worcester County for Pocomoke City, and Queen Anne’s County for Centreville. The Wellhead Protection Plans (WHPP) for remaining municipalities were carried out either by the MDE or ALWI. All Source Water Assessments presently completed are available on the MDE’s website, and organized by county.

One private consulting firm, Advanced Land and Water, Inc. (ALWI) compiled many of the county reports for their community water systems. ALWI is a hydrological
and environmental protection consulting firm with headquarters in Sykesville, Maryland. According to the company’s website, services include water supply exploration, testing, permitting and protection plans, among many others. Additionally, the company had years of experience with both public and private sector clients. In Maryland, the public sector clients consist of the MDE, several counties, and educational institutions. ALWI county Water Assessment Reports looked at for this study include Charles, Queen Anne’s, Worcester, and Calvert. While the municipalities of Berlin, and Chestertown also contracted ALWI to conduct and compile its Water Assessment Report. Before reviewing these reports, the study reviews the selected municipalities that incorporated their own groundwater assessment and wellhead protection plans.

7.2.1 Fruitland

Fruitland’s Source Water Assessment dates the year 2000, several years before the MDE Model Ordinance first appeared. However, the 2008 City of Fruitland Comprehensive Plan includes an entire chapter entitled “Water Resources Element” that reflects the overall language of the 2006 Maryland Resources Element. To the point, the City of Fruitland’s chapter opens with the following introduction:

In 2006, the Maryland Legislature required all counties and municipalities to examine their water resources when predicting future growth. The Water Resources Element requires municipalities to analyze current water supplies, wastewater treatment plant capacity, and point source and non-point source loadings. When looking at future growth needs, the City must address any shortcomings of water resources and either change future land use scenarios to eliminate problem areas or provide options to address any limitations. The following section examines Fruitland’s existing water resources in conjunction with the City’s current development and projected future growth. Where necessary, improvements and alternatives to solve any water resource problems are discussed.
Thus, all counties and municipalities must at least examine their water resources for future planning. In Fruitland, “…the City currently uses four different wells to supply water in a 500,000 GPD elevated water tower. All four wells pump high quality water, with the exception of some iron contamination….“ (Fruitland 2008, 49) As such, the MD Legislature’s requirements have been found for practically each municipality or county selected.

Reflecting language in the Model Ordinance, Fruitland has required 2 zones around its wells with zone 1 allowing for 1 year TOT and zone 2 for 10 years. A land-use summary for the area within the 183-acre extension of zone 2 lists cropland (40%), forest (22%) and residential (21%). While there are no commercial activities on the land, two past poultry operations and a corn field had been disclosed in the contamination inventory under the requirements of the original Ordinance (1994). Furthermore, the City of Fruitland was issued MDE Ground Water Discharge permits for an average 60,000 gallons per week of filter backwash water containing iron. Several commercial facilities located near the WHPA were also inspected with one Notice of Violation (NoV) being issued to a manufacturing company for an open floor drain. The drain was closed, sealed and re-inspected the next day. An underground storage tank located at the Fruitland Water Treatment Plant was removed with no further concern.

Management recommendations for Fruitland’s WHPA consist of forming a local planning committee, public awareness and outreach, aquifer protection, monitoring, planning for new development, land acquisition, contingency planning with changes in uses, as well as contaminant sources inventory updates and well inspections.

7.2.2 Chestertown

Following suit, and under MDE recommendations to assist certain counties and municipalities in the state, ALWI conducted and drafted its ground water assessment and wellhead protection report on behalf of Chestertown. In the Chestertown report,
ALWI states that their regulatory framework is the MDE’s source water assessment and wellhead protection guidelines. The town’s participation in the SWPP was voluntary and not a regulatory requirement under the SDWA.

Several contaminants were found in Chestertown’s wells. PCE, MTBE, Radionuclides, in addition to other pollutants from the well samples. ALWI presented its findings and recommendations to the town Steering Committee. In light of the observations, analysis and findings, ALWI recommended the following to improve overall protection practices: adopt a Source Water Protection Ordinance, increase frequency of monitoring for select contaminants (the former three listed, plus three more), improve site security, community outreach and public education, create a spill notification system, post “No Dumping” signs within SWPA, abandon unused wells, and plan for future town wells (consider Magothy Aquifer).

7.2.3 Chesapeake Beach and North Beach, Calvert County

The towns of both Chesapeake Beach and North Beach are located in Calvert County, which is one such county that the Model Ordinance lists as being free to use outside expertise in its assistance. Here again, ALWI conducted the source water assessment report. After conducting a similar analytical study under a MDE regulatory framework, the management practices for the community water systems and WHPA comprising Chesapeake Beach and North Beach included the following: Forming a local planning committee, public awareness and outreach, increased monitoring, contingency plan, contaminant source inventory updates, inspections and maintenance, plus a detail of changes in use, increases or additions of new wells. Indian Head in Charles County’s ALWI report contains similar advice from the consulting firm.
7.2.4 Centreville, Queen Anne County and Pocomoke City, Worcester County
Likewise, ALWI’s management practice advisement for Centreville in Queen Anne County and Pocomoke City in Worcester County contained the same elements as those advised in other county-level reports.

7.2.5 Berlin
ALWI’s report for Berlin contained some unique advisement given the former presence of large, agricultural and food production firms in the area. In the concluding section, “Protective Recommendations,” the consulting firm recommends the town to reconsider its decision not to request the County “…to embrace and adopt an ordinance throughout the SWPA….” (Berlin, p. 12) A supplemental investigation of certain “unexplained” contaminant sources, conduct agricultural outreach, acquire (or ease) specific properties, extend service areas to extended properties, and post “no dumping” signs within the SWPA.

Here concludes the summary review of selected Maryland county- and municipality-level implementation of state standards. All reports and the Model Ordinance can be found on the Water Programs page of the Maryland Department of the Environment’s website.

7.3 CPR Institution and the Six Critical Factors
Maryland uses the Third Person Common Pool Resource Institution. We can see this in the fact that they issue a model ordinance to their municipalities and that they mandated the formation of WHPPs for 20 communities as a result of the source water assessments. These 20 towns, in their turn, relied upon the expertise of private contractors to develop their plans. In both cases, at the state and local levels, creation and evaluation of groundwater protection plans are left to third parties.

Walking through the six critical factors for common pool resources, Maryland’s Model Ordinance falls in-line with the general practice recommended in them. The rules outlined in the Ordinance maintain a brief, yet easily adaptable and understandable
format. The language of the document is simple and easy to understand, thus in line with the first factor (i). The state government has placed an electronic copy of the document on its water supply program webpage. In doing so, it has made the rules available for easy public access (ii). Enforcement of the rules is left to local authorities to determine (iii). In Maryland, the sanctions are graduated and range from simple, oral warnings of violation to fines to even more formal legal action in the case of largest violators (iv). Municipalities or their water committees provide a low-cost adjudication for the public to resolve violation issues (v). By delineating authority to local control, the monitors have greater accountability to members of the community, since many monitors belong to the community itself (vi).

8 North Carolina

As already noted, the Federal Safe Drinking Water Act (SDWA) Amendments of 1996 placed an emphasis on pollution prevention and asked each state to specify drinking water sources and investigate potential contamination around the areas of these sources. Because North Carolina already had an extensive wellhead protection program as a result of the 1986 amendments to the SDWA, it just had to update the reports it already maintained on the 11,000 wells and 225 surface water intakes within the state. It did so in short order and these upgraded records, compiled along with citizen input, were deemed sufficient for the state to gain approval from the EPA in November of 1999 (NCDENR, n.d.).

North Carolina’s Wellhead Protection Plan is intended to regulate the land uses in specified recharge areas around wells or a wellfields. These wellhead protection areas are defined as “the surface and subsurface area surrounding a water well or wellfield supplying a public water system, through which contaminants are likely to move toward and reach such well water or wellfield” (NCDENR, n.d.). The state’s intention is to eliminate the threat to drinking water sources through locally implemented
Groundwater Quality Control Through Good Governance

It hopes that local governments will expand control of these areas through zoning, easements, and even outright purchase and has provided information to local governments on how to finance these operations. In addition it developed a guidebook to help local communities develop a wellhead protection program.

8.1 NC’s Wellhead Protection Guidebook

The guidebook (North Carolina State University, 2003) was made available to NC communities in their effort to design an effective wellhead protection plan. The document has six chapters. The first describes how to form a planning team and the last two describe how to develop contingency plans and methods for maintaining and updating the plan. For our purposes, the middle chapters are of most interest. Chapter two discusses how to delineate a wellhead protection area. It lists what information should be included and provides specific formulas on how to determine the protection area given the aquifer type, the yield, pumping rate, and pumping period. Since planning departments should have this information, inclusion of how to determine the protection areas from available documents is an effective tool for empowering local participation in the details of the process. Chapter three details how to conduct an inventory of possible contamination sources. An interesting aspect of this chapter is that it includes a way to rank these contamination sources once found, and this ranking plays an important role in what is for our purposes the most relevant chapter – Chapter four on developing management strategies. Here the guide goes into best management practices for managing the possible sources of contamination. For each step in the guide there is an attachment of what a plan should look like using the fictitious “Clearwater, NC” as the example. We will use the model of Clearwater in assessing the submitted municipal wellhead protection plans.
8.2 North Carolina’s Municipal Ordinances

There are 540 municipalities in North Carolina (North Carolina League of Municipalities, n.d.) and of these, 144 have approved WHPPs serving a little over 900,000 residents [58] – or just about 1/10th the state’s population (US Census). These plans are in the office of the Public Water Supply Section of the Department of Environment and Natural Resources. Mr. Gale Johnson [we need his permission to print his name in this document] is the Wellhead Protection Program manager and he worked with us and scanned into PDF format a representative selection of WHPPs in the coastal plain region of the state. He admitted that these were a sampling of the better plans from the region and that in the process of pulling plans and reviewing them he had set aside a number that he thought needed updating. Since we are investigating possible ways Delaware might improve its groundwater governance, it is good that we have such a selection. However, our team would also have liked to review some of the less sufficient plans to evaluate the range of adherence to the state’s model plan. In addition, these plans include some source water assessment information. It is great to have all this information in one place, but when comparing these plans to those of Delaware it is important to remember that Delaware cities too have extensive source water assessments the details of which are just not included in their source water protection plans. In NC, they are all together. This fact helps to explain the greater bulk of these plans which range from roughly 40 to 90 pages.

8.2.1 Chinquapin

Chinquapin is a small town (unincorporated) in a rural area of Duplin County, NC, with a population just over 3,300. Back in 1969, concerned residents got together and formed the Chinquapin Water Association in an effort to ensure the protection of their drinking water supplies [60, same source for entire section]. The Association takes a non-regulatory approach in protecting their groundwater supply. Though they do not have an ordinance, they compensate through direct inspection, assessment, education
dissemination, and networking with state agencies and the Rural Water Association – a nonprofit organization who’s Board of Directors represent community and non-community water systems throughout the state. The local Association provides information to every residence, business, farm, and industry located within the WHPA regarding waste disposal, best management practices, and standard operating procedures. They also inspect wells and underground storage tanks for compliance to state regulations. They even make a special effort to work with anyone using pesticides to make sure they are aware of their obligations under the law to prevent contamination and to ensure their licenses are current. Every year they conduct a survey of possible contamination sources just like they did in the original assessment.

8.2.2 Beaufort

Beaufort is located in Carteret County and their CWS of three wells serves a population of about 4,500 people. The town does not have a water association like Chinquapin. Instead, the Town Council is the responsible party and they directed the water plant operator and the public works director as the main contacts and the parties responsible for implementation. The management section of their plan reads very similar to that of Chinquapin, in many places word-for-word. The primary difference is that their plan addresses auto repair shops more directly (there are no auto repair shops in the WHPA of Chinquapin) and they have a section on their hazardous waste disposal day (only one day a year). Their contingency plan is much less detailed than that of Chinquapin (Beaufort, 2008).

8.2.3 Lake Waccamaw

The Town of Lake Waccamaw is located in Columbus County along the shores of the 9,000 acre lake. The WHPP is remarkably similar to those above except that it has one more day of hazardous disposal than Beaufort and its contingency plan is more extensive than either of the two above, possibly owing to the proximity of the town to
the lake which contains many rare and endangered species of animals, including a few found nowhere else in the world (Lake Waccamaw, 2011).

8.2.4 Carolina Beach

Carolina Beach is the largest of the towns in our NC study with a population of around 12,000. There are 14 wells in the Carolina Beach CWS. Like the previous two towns on our list, the Town Council is responsible for the WHPP. Owing to the size of the community, there is one more person the council authorizes to implement the WHPP, the waste water treatment officer. The town also has an additional section in their management practices that refers to the wastewater lift station. Upon the initial assessment in 1999, one of the wells was closed and is now abandoned (under NCDENR guidelines) because it was located too close to where a landfill once was. Otherwise the management section is very similar to the other three already mentioned (Carolina Beach, 2010).

8.2.5 Pine Knolls Shore

Pine Knolls Shores is a planned residential community serving less than 2,000 people and they have strict zoning laws that do not allow any industry or auto repair shop within their borders. Their planning team does consist of more people than our previous examples, but otherwise, the management plan is identical to that of Beaufort (Pine Knolls Shores, 2010).

8.2.6 Topsail Beach

Topsail Beach is a small community for most of the year with a population less than two thousand. During the summer tourist season, however, the population will grow to over 9,000. This fluctuation puts a strain on their water system in much the same way as it does for Carolina Beach above. The WHPP does not do much to recognize how this fluctuation makes the town different from others in its management practices except to say that they use a book published by the Drinking Water Academy. There is
also little concern with disposing of hazardous wastes as they claim it can all be handled by a service station a couple of miles from town (Topsail Beach, 2007).

8.3 CPR Institution and Critical Factors

Though there are similarities between all these WHPPs, likely owing to the participation of the Rural Water Resource Association, there are also enough differences to give each its own distinct stamp. The state appears to be using a form of the Cooperative Common Pool Resource Institution in that it casts its guidance to municipalities in the form of non-regulatory information and education instead of regulatory ordinances or timetables. The state shows the municipalities how to develop a good WHPP and then leaves it up to them to follow their suggestions. Since so much is delegated to the local municipalities, it is to here that we look to determine how the critical factors for common pool resources are met.

Municipal level compliance to the six critical functions of a common pool resource institution is high. The rules are simple and easy to understand (i) and the local water resource association, the water department, or the city council issue an annual brochure regarding water quality and what customers can do to protect it. The rules for access to the CPR, i.e. well drilling, are devised at the county level (ii) and their oversight is maintained by the local department of health who enlists the aid of certified well drillers to enact day-to-day compliance. Because the rules are local and there are a few different levels of control, they are easy to enforce (iii). Municipal level sanctions amount to helping a violator achieve compliance, but if that proves unsuccessful, the county level health director can pursue graduated actions from misdemeanor charges to more serious court proceedings (iv). As just mentioned, low-cost adjudication (v) is available to citizens through their local water association. Citizens can hold the local health department official accountable (vi) through an appeals process overseen by the
Board of Health. North Carolina municipalities utilize all six critical factors in the management of their groundwater common pool resource institutions.

9 Virginia

Groundwater supplies over ninety percent of Virginia’s public water systems (2,300 of 2,500). It is the sole water source for 38 of the Commonwealth’s 95 counties and accounts for upwards of fifty percent of the water supply in an additional 55 counties (Register & Lloyd, 1997). The substantial usage of groundwater in the Commonwealth has contributed to public unease about Virginia’s groundwater quality and quantity. Concerns encompass both the potentially rapidly dwindling water supply, as well as the heightened likelihood of pollution.

Geology can reveal and predict the likelihood of groundwater contamination based on factors such as soil density and drainage. Virginia’s 40,767 square miles of area (Citydata.com) is segmented into five distinct geologic or physiographic provinces based on homologous geologic characteristics. (Virginia Department of Environmental Quality, n.d.) According to a Virginia Department of Environmental Quality publication, the five geological provinces in Virginia have differing risks of groundwater contamination, with the Valley & Ridge, Blue Ridge, and Coastal Plain provinces all possessing a high risk, as illustrated in the table below.

<table>
<thead>
<tr>
<th>Province</th>
<th>Geology</th>
<th>Pollution Prevention</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cumberland Plateau (PI)</td>
<td>Sedimentary rock yielding ground water of varying quality</td>
<td>Moderate</td>
</tr>
<tr>
<td>Valley &amp; Ridge (VR)</td>
<td>Sedimentary rocks including limestone, dolomite, and shale</td>
<td>High in limestone areas, where ground moves rapidly</td>
</tr>
<tr>
<td>Blue Ridge (BR)</td>
<td>Impervious rock. Well yields are low</td>
<td>High, because of rapid movement of water in cracks and fissures</td>
</tr>
<tr>
<td>Piedmont (P)</td>
<td>Diverse geology with a wide range of ground water quality and availability</td>
<td>low to moderate</td>
</tr>
<tr>
<td>Coastal Plain (CP)</td>
<td>Unconsolidated sand, clay, marl, and shell strata. Groundwater is abundant and use is high.</td>
<td>High, due to geology and population density.</td>
</tr>
</tbody>
</table>

Aside from geological characteristics that cause some aquifers to be more prone to contamination than others, human activity also has increased the potential for the
poisoning of groundwater supplies. Urban runoff is a problem in Virginia’s cities, where effective and natural drainage is sacrificed for architecture and other engineered creations. “These surfaces do not allow rain and snow melt to soak into the ground which greatly increases the volume and velocity of stormwater runoff” (EPA, 2014)

Outside of the urban areas, runoff that derives from agriculture-related activities has the potential for contaminating groundwater. The leaking of septic tanks and petroleum underground storage tanks, which can occur in urban as well as rural areas, poses an additional risk to the quality of groundwater supply (EPA, 2014)

Virginia first implemented the Virginia Groundwater Act of 1973 (Code of Virginia, Title 62.1, Chapter 3.4) to counteract concerns of groundwater pollution and supply in the Commonwealth. This Act aimed to thwart the unsustainable exploitation of groundwater through the issuance of permits; however, the two entities with the majority of the groundwater demand, municipalities and farmlands, were exempt from acquiring permits. The Ground Water Management Act of 1992 (Code of Virginia, Title 62.1, Chapter 25) revised the previous groundwater mandates by requiring users to obtain a permit to extract more than 300,000 gallons of groundwater within a one-month period from zones with overdrawn groundwater reservoirs known as Groundwater Management Areas (GWMA). Along with the permit, groundwater users in GWMA must possess a Water Conservation and Management Plan detailing the land preparation method, water saving irrigation techniques, a water use education program and emergency procedures (Reavis, 1986).

Aside from these state-level regulations, the federal government imposed groundwater directives upon Virginia as part of the 1986 amendments to the Safe Drinking Water Act (SWDA). The 1986 Amendments required each state to submit a plan for Wellhead Protection, defined as a process of: “firstly, identifying the area’s public water supply wells; secondly, assessing the potential risks to ground water in areas around these
wells; and thirdly, implementing measures to manage these risks and prevent groundwater problems.” In 2005, the US Environmental Protection Agency ratified the Virginia Department of Environmental Quality’s Wellhead Protection Plan for the Commonwealth. The first two processes of Virginia’s Wellhead Protection Plan were completed under the Source Water Assessment Program (SWAP) of the Virginia Department of Health and described in the Source Water Assessment Report. To fulfill the SWAP requirement under the SDWA, the Virginia Department of Health conducted assessments on potable water supply sources to determine their vulnerability to pollution by considering source water delineation, potential sources of contamination, land use activities, and potential conduits’ inventory development, with each source being assigned a susceptibility rating. SWAP analyses were completed on drinking water sources serving all public water supply systems by the Virginia Department of Health, and statewide standings are maintained by a Geographic Information System (GIS) database (Commonwealth of Virginia, 1991).

9.1 Source Water Protection Plan Development

Virginia’s Ad Hoc Wellhead Protection Advisory Committee was established in response to the aforementioned SDWA 1986 amendment to represent the welfare of the local governments. In 1991, the committee determined that implementing a mandatory wellhead protection program for local governments was not feasible. At that time, while the committee recognized the benefits of such a regulation statewide, its concerns was stymied by the lack of public awareness and support, important data availability, technical capabilities, and necessary funding (VADEQ, 1991).

The Virginia Department of Health (VDH), with the support of a VDH contractor, outlined six steps to assist local governments with the creation of wellhead protection

---

3 The DEQ, VDH, and its contractors use the terms “Source Water Protection Plan” and “Wellhead Protection Plan” interchangeably to meet Virginia’s Protection Strategy In-Place (SIP).
Groundwater Quality Control Through Good Governance

plans. Three VDH contractors, including Golder Associates based in the capital city of Richmond, are available to assist community water systems serving less than 10,000 population in developing or implementing protection plans. Based on the Virginia Wellhead Protection Plan (2004), the six general steps to develop the plan include:

1: The creation of a Local Advisory Committee (LAC)

The LAC is comprised of waterworks employees, town or local government officials, county or regional government representatives, board members, and/or water customers.

2: Building LAC and VDH Contractor Rapport

At this initial meeting, the VDH Contractor disseminates information to the LAC on the wellhead protection program; and the contractor learns about the local water system.

3: Review of the Source Water Protection Assessment

This assessment would have been previously accomplished by the VDH (as mentioned in the last paragraph of the preceding section), thus this step solely entails a review.

4: Implementation of Wellhead Protection Measures

Several wellhead protection methods are available to the LAC, and the VDH contractor assists the committee in the selection of the most suitable implementation strategy for their water system. This strategy is a key component of the program, and thus the Virginia Department of Environmental Quality (DEQ) released a detailed publication to assist local governments with the development of the recommended wellhead protection measures in 1998. This document entitled Implementing Wellhead Protection: Model Components for Local

CEEP Page 59
**Groundwater Quality Control Through Good Governance**

*Government in Virginia*, provided local governments with all the potential strategies for wellhead protection. The document provided model text for (1) planning and policy governance (the local Comprehensive Plan, Capital Improvement Program, and Emergency Response Plan), (2) the provisions for regulatory techniques (zoning and septic tank related ordinances), (3) non-regulatory techniques and (4) an approach to effective local leadership and oversight.

**5: The Development of the Source Water Protection Plan**

In 2004, the Virginia Department of Health (VDH) issued a sample Wellhead Protection Plan. The purpose of the Wellhead Protection Plan is “to protect ground water which serves, or may serve in the future, as a source of public water supply [...] from the threat of contamination as a result of accidents or unwise practices from nearby residential, industrial, commercial, agricultural, waste management, or transportation activities.” Reflective of the VDH’s initial SWAP, the sample document contained the four key areas: (1) the delineation of the source water protection area; (2) an inventory of potential sources of contamination; (3) a susceptibility analysis; and (4) source water protection plan. The VDH contractors recommend the plan be reviewed and updated annually at a minimum.

**6: Wellhead Protection Implementation**

The local waterworks company is charged with the implementation of the completed plan. Implementation incorporates the education of the community on the protection measures and their significance.

The Environmental Protection Agency (EPA) requires all states to submit a Substantial Implementation (SI) report every year. This report is intended to provide
the EPA with a snapshot of each of the state’s approaches to source water protection as well as the status of their progress towards meeting their implementation targets. The EPA’s leniency on source water protection gives each state the responsibility to design its own governance and set goals valuable and reflective of its unique demands. In October 2014, Virginia amended its approach to source water protection by broadening the Protection Strategy In-Place (SIP). Virginia’s SIP expanded from a VDH-drafted source water protection plan to include all source water protection activities. Newly acceptable SIP activities include the distribution of educational material, the installation of signs and the hiring of an employee dedicated to source water protection. All source water protection strategies remained voluntary but must be maintained appropriately.

9.2 Wellhead Protection Adoption at the Local Government Level

Step four of Virginia’s source water protection plan’s development provided optional strategies for local governments to implement wellhead measures, such as the inclusion of wellhead protection measures within local comprehensive plans. A combination of 10 cities and counties were examined and while the recommended model text was not adopted by all ten entities, their comprehensive plans addressed groundwater IAW Virginia Code 15.2-2224.

Under step five of Virginia’s source water protection plan development, an intricate Wellhead Protection Plan (WHPP) was recommended. Of the ten coastal cities analyzed, only one had drafted a WHPP: The Town of Chincoteague. Other coastal cities met the SI status due to Virginia’s SI Scenario 1. SI Scenario 1 states, “CWS wells in the coastal plain may be deemed as having a SIP and SI status when the well is constructed pursuant to the Virginia Waterworks Regulations and supporting documentation exists.” For this reason, VDH source water protection plans are not completed for coastal cities; however, they meet Virginia’s implementation goals in its SI progress report to EPA (VADEQ Office of Water Supply, 2014).
Of the eight Virginia municipalities and counties we examined, localities on the Eastern shore of Virginia (Arromack and Northampton counties) had the most substantial and detailed groundwater protection plans and regulations that most closely resemble the Source Water Protection Plans for cities in the state of Delaware, with multiple zones delineating wellhead protection and recommended best practices for regulating land use in these areas. Instead of creating their own individual plans based on a state-drafted model ordinance, however, these municipalities had their groundwater protection plans prepared by the same Virginia Department of Health-funded contracted firm. As a result, the Source Water Protection Plans and Best Management Practices for these Virginian towns are nearly identical.

Other towns we examined in Virginia take a less regulated approach to groundwater management. Barring a few municipal and county-level ordinances that mention groundwater protection in the context of Chesapeake Bay Preservation, storm water management, and sewer management, very few wellhead or source water regulations exist, although the need for increased groundwater protection is often discussed in the local Comprehensive Plans. Our research suggests that groundwater management is a more nascent, yet burgeoning, concern for Virginian municipal governments. As wellhead and source water protection plans are not legally required in most VA towns, several have only recently finished or are in the process of drafting groundwater regulations, in contrast to Delaware where municipal water resource protection ordinances for towns of more than 2,000 people were made a requirement in 2001.

9.2.1 Chincoteague

The town of Chincoteague located on the Eastern shore of Virginia relies solely on groundwater from the Yorktown-Eastover aquifer to supply drinking water for its 3,500 residents and 15,000 summer visitors (Golder Associates, 2014). The water is drawn from seven active wells located on the mainland of Accomack County and delivered
through five miles of transmission lines to Chincoteague Island. As the wells are not located within the town’s jurisdiction but on private property owned by NASA, the town of Chincoteague has limited authority to regulate land use activities nearby (Ibid).

In 1992, Accomack and Northampton counties created the *Ground Water Supply Protection and Management Plan for the Eastern Shore of Virginia* that established three Zones for groundwater protection. Zone 1 represents a fixed radius of 200 feet around each wellhead, Zone 2, or the Spine Recharge Area of the aquifer, comprises the center of the Accomack-Northampton peninsula, and Zone 3, the Source Water Protection Area based on “groundwater divides created by the superpositions of pumping patterns upon the ambient potentiometric surface”, includes virtually the entire peninsula (Horsely Witten Hegemann, 1992). The Plan recommended that any potentially harmful activities and dangerous materials should be banned in Zone 1 as a precaution against accidental spills. It was further recommended that any future major polluting activities be prohibited and any activities involving toxic waste, underground fuel storage tanks, etc. be restricted by a permit system in Zone 2, and that Zone 3 should “be managed with protection of ground water in mind”. The Plan also recommended restricting New Mass Drain fields in Zone 2, requiring a county registration program for underground storage tanks storing less than 1,100 gallons, and using above-ground storage tanks in place of underground tanks when possible, along with other zoning and site plan review recommendations designed to protect groundwater from contamination.

In 1999, Arromack County developed zoning ordinances for new developments to minimize the transport of pollutants into groundwater. The 2008 *Accomack County Comprehensive Plan* provided several recommendations for managing groundwater withdrawal, including reducing the threat of saltwater intrusion, minimizing pumping
rates, revise zoning regulations, developing a public education program on groundwater, and pursuing water conservation measures with major industrial users.

In October 2014, a Richmond-based contractor, Golder Associates Inc., prepared a Source Water Protection Plan (SWPP) for the town of Chincoteague with funding from the Virginia Department of Health. The SWPP provided recommended groundwater management strategies including increased public education and outreach, meeting with NASA personnel to promote best management practices (see Appendix 3) for site activities in the Zone 2 (Recharge area), and developing an emergency response plan for hazardous materials released in the Zone 1 protection area.

9.2.2 West Point

The King William County 2003 Comprehensive Plan states that the centrally administered waterworks system serving residential and commercial developments in the town of West Point derives mainly from groundwater sources: a locally drilled well and two elevated storage tanks (King William County, 2003). The Division 20: Chesapeake Bay Preservation Area Overlay District of the Zoning Ordinance of King William County helps regulate septic tank system in the town, a potential conduit for groundwater contaminates, by requiring a back-up drain field (Ibid). The Virginia DEQ has a lengthy permitting process for new wells or increased groundwater withdrawal in the County in an effort to reserve deep aquifers for domestic use(King William County, 2008).

9.2.3 Southampton

Southampton County, Virginia draws most of its public water supply from wells. The largest groundwater water users in the county include a paper mill and chemical plant (Southampton County, 2014). Groundwater is mentioned in the County Code in ordinances related to storm water management, environmental resource impact analyses, and manufactured home park construction (Ibid). The connection of
downspouts and drains to sewers is prohibited in Sec. 16-128 in an effort to avoid pollution.

9.2.4 Colonial Downs

Colonial Downs, part of New Kent county, is instructed to abide by wellhead setback requirements set by the Virginia Department of Health (100 feet) (Commonwealth of Virginia State Board of Health, 1992). There are currently no written wellhead or source water protection plans for the town. Groundwater protection is cited several times in the New Kent County code concerning zoning for motor vehicle sources and parking lot construction, as well as Chesapeake Bay preservation (New Kent County, 2014). Sec. 38-113 also prohibits the construction of new wells within designated groundwater service areas unless the lot in the service area does not have public water facilities available.

9.2.5 Windsor

The town of Windsor is located within the Isle of Wight County and operates its own water system with five wells. Groundwater is the sole source of potable water for the area, with water demands being driven by domestic, commercial, and agricultural users (Windsor, 2008). Windsor’s groundwater use is partially regulated through the Chesapeake Bay Preservation Act and the Department of Conservation and Recreation – Division of Chesapeake Bay Local Assistance (DCBLA) that seeks to limit development in floodplain areas that affect the recharge of groundwater aquifers. Windsor participates in regional programs designed to manage groundwater, including the Cooperative Regional Ground Water Management Program and the Hampton Roads Planning District Commission’s (HRPDC) Source Water Assessment Program (SWAP).
9.2.6 Cape Charles

Cape Charles relies solely on groundwater sources for public drinking water, serving approximately 1,000 people (Golder Associates, 2014). Like Chincoteague, the town is located in Northampton County on the Eastern shore of Virginia and governed by the *Ground Water Supply Protection and Management Plan for the Eastern Shore of Virginia*. Northampton County’s Comprehensive Plan of 2008 aimed to protect groundwater recharge areas (Zone 2) through increased zoning and stormwater management, as well as promote groundwater conservation and protection through education and collaboration. Unlike Chincoteague, all public water supply wells in Cape Charles are located on town property and owned by the town. The SWPP for the town of Cape Charles is in the process of finalization by the contractor Golder Associates, who also prepared the SWPP for Chincoteague. The 2014 draft SWPP for Cape Charles discusses increased public education as part of its recommended groundwater management strategies, as well as the discussion of best management practices with property owners in Zone 2 and the development of emergency response plan for hazardous waste spills.

9.2.7 Tappahannock

While Tappahannock’s central water system is drawn from groundwater, the town’s management of the resource has been an incremental process, according to the 2007 *Comprehensive Plan* (Tappahannock, 2007). In the Plan, Tappahannock recognizes the importance of community leadership will have for groundwater conservation and is looking to the Middle Peninsula Planning District Commission’s Water Resource Program (MPPDC) for guidance. With support from MPPDC, the town seeks to implement a Groundwater Guardian Program to involve local citizens and communities in protecting groundwater and creating a local wellhead/source water protection plan. The town’s Comprehensive Plan also emphasizes the importance vegetative buffers along streams can have on preventing pollutants from runoff contaminating groundwater.
9.2.8 Exmore

Like the town of Cape Charles, Exmore is located in Northampton County on the Eastern Shore of Virginia. Groundwater management is subject to the regulations made in the *Ground Water Supply Protection and Management Plan for the Eastern Shore of Virginia* as discussed in the section on Cape Charles. Golder Associates are in the process of drafting a SWPP for the town.

9.3 CPR Institution and Critical Factors

Similar to North Carolina, Virginia’s groundwater governance most closely follows the Cooperative Common Pool Resource Institution. Virginia established regulations at the state-level but disseminated direct responsibility to local municipalities. At the local level, governments adopted various groundwater management techniques. Despite the decentralized approach, the Virginia Department of Health (VDH) support municipal efforts through two important resources: the accessibility to knowledgeable staff and, the availability of state-funded grants. Aside from technical and financial assistance, helpful tools were circulated to recommend courses of action to groundwater management. Two examples include *Wellhead Protection: A Handbook for Local Governments in Virginia (1991)* and the *Wellhead Protection Plan (2005)* published by the Virginia Groundwater Steering Committee and the Virginia Department of Environmental Quality (DEQ), respectively. When measured by the 6 critical factors for common pool resource management, many of the critical factors are actualized in the relationship between Virginia and its local governments in the protection of communal groundwater systems.

Virginia’s groundwater protection rules are simple but may not be completely comprehensible to citizens. The relaxed nature of the municipalities’ responsibilities is convenient as its simplicity and flexibility allow local governments to adopt governance that is pertinent to the local condition and involvement of citizens. Municipalities therefore have different strategies to engineer effective groundwater management. Unfortunately, this variance can cloud citizens’ ability to acquire knowledge on their groundwater supply. For example, a citizen in Chincoteague would
depend on their Source Water Protection Plan (SWPP) while a West Point citizen would access their Comprehensive Plan. Citizen migration between municipalities may inhibit individuals’ ability to access and understand groundwater management. Despite the variation in local approaches, local governments do not devise the access rules entirely.

(ii) The Virginia DEQ plays a predominant role in the establishment of circumstances that would require permits; one such circumstance is groundwater extraction. Despite the leniency in local governance, municipalities are required, at a minimum, to abide by state access rules.

While discrepancies are likely, the enforcement of groundwater rules tends to be easy (iii) due to the decentralized management structure. This structure gives local governments the ability to tailor governance that is more adoptable and adaptable to their municipality’s attributes. These two features, combined, thereby ease enforcement. In the event enforcement of rules is ineffective, local governance tend not to detail graduated sanctions (iv). Despite the absence of graduated sanctions, discrepant parties are liable, typically by state agencies. Although subjective, adjudication costs are comparably low (v) but can vary depending on the severity of the violation. For example, Del Monte was found to have withdrawn ground water in excess of 300,000 gallons without a permit and was charged approximately $10,000. As stated, groundwater protection directives at the local level do not specify monetary accountability; similarly the accountability of monitors and other officials to users (vi) are also undefined.

Based on the above evaluation, Virginia incorporates the critical factors of a common pool resource institution for the most part.
10 New Jersey

The State of New Jersey, like its immediate neighbor to the south and across the Bay, Delaware, lies almost completely on the Mid-Atlantic Coastal Plain. Extreme weather events in recent years such as higher levels of snowfall and Hurricane Sandy, in particular, have affected the Garden State’s groundwater in ways similar to the First State. New Jersey tops the list of most densely populated states with Delaware a mere 6 places behind on the list. Elevations, especially in coastal areas mimic those of Delaware. Of note, the shallow, Kirkwood-Cohansey Aquifer provides over 90 percent of New Jersey surface streams, wetlands and drinking water needs (Pineland Preservation Alliance, 2015). The aquifer lies on approximately 3,000 ft$^2$ of the Atlantic Coastal Plain from east-central through the far southwest. Moreover, the New Jersey Pine Barrens, the country’s first National Preserve (1978) and a U.S. and International Biosphere Reserve by UNESCO since the 1980s (New Jersey Geological Survey, 2009). Due to preservation efforts, the aquifer has maintained sustainable water table levels over the past 30 years.

10.1 Guidelines for Delineation of Well Head Protection Areas in New Jersey

The New Jersey Department of Environmental Protection (NJDEP) of the New Jersey Geological Survey (NJGS) offers the open-file report (OFR 03-1), Guidelines for Delineation of Well Head Protection Areas in New Jersey. The opening of the document states the mission statements of the two state authorities, respectively. The NJDEP’s mission is “…to assist the residents of New Jersey in preserving, sustaining, protecting and enhancing the environment to ensure the integration of high environmental quality, public health, and economic vitality….” While the NJGS mission is “…to map, research, interpret and provide scientific information regarding the State’s geology and ground-water resources. This information supports the regulatory and planning functions of the Department and other governmental agencies and provides the business community and public with the information necessary to address
environmental concerns and make economic decisions....” (New Jersey Department of Environmental Protection 2003, ii) Accordingly, the two contributing State authorities place their organization’s respective mission statements first and foremost, even before the first page of the Guidelines’ body.

According to the Guideline’s Glossary of terms, a Well Head Protection Area (WHPA) in New Jersey is “…an aquifer area described in plain view around a well, from within which ground water is reasonably likely to flow to the well and through which ground-water pollution, if it occurs, is reasonably likely to pose a significant threat to the water quality of the well. It is delimited by the use of a time-to-travel, and hydrologic boundaries, and is further subdivided by multiple times of travel....” (NJDEP, 2003, 27) Interestingly, each state defines the WHPA in a way that is unique to the state. In the case of New Jersey, the use of time-to-travel (TOT) and more complex methods for determining boundaries is reflected in its Guidelines for Well Head Protection. Following suit, in the Introduction, the stated purpose of the Guidelines is simply to establish approved methods for delineation and submission of Well Head Protection Areas (WHPA) in New Jersey. Meanwhile, the focus of the report is “…to establish the Department’s approved methods for conducting delineations, detailing the minimum data requirements, delineation method selection, preferred hydro-geologic parameter and model selection....” More importantly, and in contrast to other states, the WHP Guidelines clarify that “…use of the prescribed methods will allow interested parties to submit a WHPA delineation for Department review and approval. The report also contains requirements for outside parties interested in submitting WHPA delineations to the Department....” (NJDEP, 2003, 2) As in the case of Maryland, the final statement for interested, outside parties opens the door for private companies to contribute reports, as contracted and on behalf of public authorities in New Jersey.
Under Delineation Impacts, the Guidelines state that costs of remediation or developing alternative water resources is “…burdensome and in some case prohibitive for local governments and utilities….” The text continues that implementing measures to prevent ground-water pollution, therefore, becomes the most cost-effective approach. (NJDEP, 2003, 2).

General Delineation Requirements follow here in three zones, or “tiers” as they are called in New Jersey’s Guidelines where

<table>
<thead>
<tr>
<th>Tier 1</th>
<th>2 years or 730 days</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tier 2</td>
<td>5 years or 1,826 days</td>
</tr>
<tr>
<td>Tier 3</td>
<td>12 years or 4,383 days</td>
</tr>
</tbody>
</table>

On the Tiers, the portion of the zone delineated as the WHPA depends on the time of travel (TOT) of ground water to the pumping well. For Tier 1, the TOT represents an average of different contaminants, such as bacteria and viruses that also have different travel times. Two years provides a reasonable margin of safety beyond even 6 month and 1 year figures, according to the report.

Tier 2 represents a TOT of five years. The Department remains “reasonably” uncertain as to whether it can guarantee containment from a known pollution source to an aquifer between two and five years. That is why Tier 2’s TOT delineation is established at five years.

Tier 3 delineation, if necessary, has been placed at 12 years average TOT of known pollutants to ground water resources. The Guidelines note that a preliminary study analysis in seven New Jersey counties found that 10 to 15 years actually indicates the full TOT of pollution plumes. Thus, 12 years was considered sufficient.
Delineation Methods are detailed in the report through several attachments. The United States Geological Survey (USGS) conducted studies for the NJDEP and found that, as in the case of other Atlantic coastal plain states, New Jersey wells drawing on coastal plain aquifers, “…the specific location of the well screen and its relation to underlying confining units must be evaluated to determine if water recharging the aquifer reaches the well within 12 years…” (NJDEP, 2003, 4). Parties interested in carrying out advanced delineation methods, as such, are strongly encouraged to file a pre-application conference, if the methods fall outside those set in the Guidelines. It is duly note that ultimate approval or denial will be sent in writing the applicants by the Department itself. Finally, the Calculated Fixed Radius (CFR) matrix method becomes the modus operandi for wellhead distance per tier and pumping rate.

Submission of Delineations and Maps following the Delineation Requirements must be sent to the New Jersey Bureau of Safe Drinking Water in Trenton. The complete methodological and mathematical tables followed by mapping requirements to the NJDEP can found in the appendix.

10.2 New Jersey Municipalities

The approach to analysis of New Jersey’s municipal water governance deviates somewhat from approaches that other states have taken. In the Garden State, adherence indictors to the Guidelines included references to the Three Tiers (where applicable), use of CFR methods, and a map submission to the Trenton Water Bureau. Municipalities selected for this research agenda comprise eight. They include Atlantic Highlands, Mt. Olive Township, Pinelands, Greenwich Township, Allamuchy Township, Stanhope, Woodstown and Pemberton Township.

The search for formal, NJDEP Guidelines utilizing WHPP within the selected municipalities became quite a challenge in New Jersey, since information was not so readily available as it was in other states. Many borough codes contained references to
wellhead and groundwater protection with only one, Mt. Olive Township having a full
Wellhead Protection Program Ordinance. Furthermore, an Allamuchy Township
Engineer responded to a project inquiry offering insight into how the NJDEP may
handle wellhead protection in some areas of the state.

10.2.1 Mt. Olive Township

Mt. Olive Township’s WHPP is located in the township code available on the
website ecode360 (See Sec. 400-76.1). The municipality cites the provisions under the
New Jersey Municipal Land Use Law, “…which authorizes each municipality to plan
and regulate land use to secure a safe and adequate drinking water supply for its
residents….” (Mt. Olive Township, Sec. 400-76.1.C). In Definitions (See D), Best
Management Practices (BMP) are defined as “Performance or design standards
established to minimize the risk of contaminating groundwater or surface waters while
managing the use, manufacture, handling or storage of hazardous substances or
hazardous wastes.”

The Three Tiers are the same as those stipulated in the NJDEP Guidelines at 2, 5
and 12 years, respectively. Time of Travel (TOT) also corresponds to the Guidelines
definition. Likewise, the Well Head Protection Area (WHPA) appears in the same
wording as the state document mapping of WHPA in accordance with NJGS standards.

Best Management Practice Performance Standards (See H) following delineation
of WHPA entail several elements. A summary of these include: permitting process and
procedures for any change in land use that may involve potential pollutant sources
(PPS), proper implementation and preventative measures for any change to former or
new activities falling partially in the WHPA that involve or may involve PPS, proper
containment or diversionary structures for PPS within the WHPA, and storm water
management to prevent contamination of groundwater resources.
Mt. Olive Township’s WHPP finishes with an extensive Operations and Contingency Plan, Enforcement and Nonconforming Regulated Activities, all in accordance with NJ State regulatory frameworks.

10.2.2 Allamuchy Township

To finish the section on New Jersey municipalities, a township engineer from Allamuchy responded directly by email to SET project questions on wellhead and groundwater protection in the Northern New Jersey Township. His response follows below:

A Township Clerk/ Administrator forwarded me your email regarding local groundwater protection plans and/ or ordinances that the Township may have with respect to its public water supply wells. As you may be aware, the Township supplies potable water to residents and businesses in the Township of Allamuchy. The Township uses a groundwater diversion under NJDEP Water Allocation Permit 5281 to supply residents and businesses with potable water.

Please be advised that the Township does not have any ordinances or groundwater protection plans in place for public water supply wells. There really is no need for such plans given the fact that the Township’s diversion is so closely regulated by the NJDEP. In addition, the area immediately around the wells is sparsely developed and there is little chance that said areas will be developed in the future due to previous open space acquisitions and the fact that the wells are situated in the Highlands Preservation Area where significant development restrictions apply.

The Township did conduct an extensive hydrologic study of its wells in the time period between 2006 and 2008 in connection with an amendment to its Water Allocation Permit to allow for the instantaneous pumping rate in each water supply well to be increased from 600 gallons per minute to 700 gallons per minute to serve further development in the Township (personal correspondence, 2014)
10.3 CPR Institution and the Six Critical Factors

New Jersey’s Department of Environmental Protection took a much more heavy hand in implementation of the Federal Drinking Water Act and its corresponding stipulations for wellhead protection. Of the states we studied, New Jersey most strongly emulates the Third-Party Common Pool Resource Institution. Almost all issues of groundwater quality control are referred to the state environmental office for clarification or enforcement. While the state guidelines for groundwater protection were easily accessible on the NJDEP website, similar documents at the municipal level were not. New Jersey would receive mixed reviews on information availability to the public on these matters (i). Violation fines in New Jersey are assessed either by local authorities or the NJDEP itself. Again, this enforcement policy would receive moderate approval according to the six critical factors (ii). Due to the vast geographic area of the Mid-Atlantic Coastal plain in New Jersey, federally-protected lands such as the Pine Barrens, and isolated aquifers, the NJDEP assumed much of the responsibility for groundwater and wellhead protection where other states rested regulatory decisions on municipal authorities. Given the vast resources and expertise of the NJDEP, the accountability of monitors and other officials to the public, while not necessarily local, nonetheless exists on the premise of maintaining public safety. In this case, that means the state’s groundwater protection (vi). The deferral of authority to the lowest representative body, at least in a large part of the Garden State was not evident under the municipalities reviewed. However, Mt. Olive Township’s Wellhead Protection Plan adheres closely to the language of federal and NJDEP guidelines. The township lays in the geographic border area between Coastal Plain and inland mountains of Northern New Jersey, so it may have been permitted to draft its own plan given its location. Overall, New Jersey combined the responsibility for groundwater protection between its DEP (especially in the Mid-Atlantic Coastal Plain) and municipalities elsewhere in the state.
11 Results

It was interesting to see how different states approached the issue of groundwater quality control. Delaware’s approach differed from the other states in a number of respects. First and foremost, Delaware was the only state that required a source water protection ordinance from its municipalities (those with a population greater than 2,000). Maryland, North Carolina, New Jersey and Virginia all left the creation of SWP ordinances to the discretion of the local government. From reviewing the plans in these other coastal plain states, it is clear that many of them, with the exception of those in New Jersey where state control seems more prevalent, produced more thorough and detailed documents than those of our own state. **We found that to the extent a local municipality recruited community support from the initial stages, the more detailed were their protection plans.** Though this is the case, it is also true that a far smaller percentage of municipalities in these respective states participated in the creation of local plans. North Carolina, for instance, had the best protection plans, but only about 10% of municipalities actually produced such plans. We also feel that Delaware did the best job making information available to the public in one easy to use website ([www.delawaresourcewater.org](http://www.delawaresourcewater.org)). All the other states had similar websites, but the information on local level activities was not as easy to find and was often less complete. So, Delaware was the best at instituting a broad approach to ensuring that local communities had a groundwater protection plan, however, the plans thus formed were lacking in much of the detail and scope of plans in other states where public participation was included at the earliest of stages in the development. **This observation leads to our primary conclusion and recommendation to the General Assembly: Mandate the creation of Water Resource Citizen Advisory Committees for every municipality in the state for which you required a SWPP.** These could be modeled on the Citizen and

---

4 For the purposes of our research a Water Resource Citizen Advisory Committee makes sense, however, it could be broadened to a Natural Resource or Common Pool Resource Citizen Advisory Committee.
Technical Advisory Committee that was created in state’s response to the SDWA amendment of 1996. The creation of such volunteer groups will bridge the gap between what is best in our state with what is best in the other states of our region. These citizen organizations will have the responsibility of augmenting their community’s SWPP and could advise their respective city councils on how to improve the protection of their drinking water sources. We suggest that these committees be composed of a council person, the water (or public works) supervisor, and at least three volunteers from the community. This process could bring about what is best from the third-party CPR institutions and the cooperative CPR institutions, facilitating the creation of the latter using the strengths of the former. It would put Delaware at the forefront of effective groundwater management and make her a model for other states to follow – once again validating her claim as The First State.

In our research, we did find a number of other best management practices we wish to share with the Assembly. These are also the types of suggestions which could come from a local advisory committee after they reviewed some of the most current science on the matter and researched the work of other communities. We compile them below for your consideration.
## 12 Best Management Practices

<table>
<thead>
<tr>
<th>Recommended practice</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Educate local businesses and industry personnel working at potential polluting sources</td>
<td>Improve education and outreach</td>
</tr>
<tr>
<td>2. Educate elementary and middle school children on the importance of groundwater protection through presentations by local water quality enforcers</td>
<td></td>
</tr>
<tr>
<td>3. Update SWPPs on a regular basis and include specific management measures related to each potential polluting source in the municipality</td>
<td>Tailor governance to local conditions</td>
</tr>
<tr>
<td>4. Enact harsher punishments and require more signage on illegal dumping</td>
<td>Ensure greater compliance with rules</td>
</tr>
<tr>
<td>5. Level impact fees on enterprises for enacting groundwater protection safeguards</td>
<td></td>
</tr>
<tr>
<td>6. Create citizen hotline for reporting pollution</td>
<td>Increase transparency, accountability, and community involvement</td>
</tr>
<tr>
<td>7. Conduct regular testing of raw water samples at every well and report results</td>
<td></td>
</tr>
<tr>
<td>8. Include agricultural land use in source water protection ordinances</td>
<td>Improve efforts at preventing future groundwater contamination</td>
</tr>
<tr>
<td>9. Add more days for hazardous waste collection</td>
<td></td>
</tr>
<tr>
<td>10. Conduct benefit-cost-analyses on expanding use of semipermeable surfaces for parking lots/walkways</td>
<td></td>
</tr>
<tr>
<td>11. Partner with university and private labs to evaluate contamination threats from currently unlisted substances</td>
<td></td>
</tr>
</tbody>
</table>
In the table above we list 11 suggested best groundwater management practices inspired by the municipal regulations we reviewed in states outside of Delaware. These 11 best management practices apply to several different aspects of groundwater governance, organized into strategies of improving education and outreach, tailoring governance to local conditions, ensuring greater compliance with rules, increasing transparency, accountability, and community involvement, and finally improving efforts at preventing future groundwater contamination. While we think all 11 BMP have the potential to strengthen groundwater governance in the state, we also acknowledge that adopting some of them may require a greater amount of time and resources than some city governments currently have available. As stressed throughout the report, the final decision of which practices to implement is best left to local officials and the communities they represent.

Our first two suggestions fall under the general category of strengthening education and outreach efforts. We recommend educating local business and industry personnel who work at potential polluting sources about groundwater rules, thereby targeting the group whose actions can have one of the most negative impacts on groundwater quality, as well as educating elementary and middle school children on the importance of protecting groundwater resources through class presentations made by local water quality officials. To help ensure the rules governing Delaware’s groundwater are up to date and locally devised, we also suggest that cities update their SWPPs on a regular basis and include specific management measures related to each potential polluting source in the municipality. We realize that this may have already been done during the assessment process, but it would be good to include it in the town’s plan/ordinance as well, so that it is more obviously accessible to concerned citizens in a less technical format.

Following the example of other states, Delaware could do more to ensure the rules designed to prevent contamination are followed. For example, our cities could
enact harsher punishments and require more signage regarding illegal dumping. Governments could also consider leveling impact fees on businesses in Zone 2 areas as compensation for enacting groundwater protection safeguards and to pay for more frequent testing. Moreover, we believe creating a hotline for citizens to report pollution activities would increase community involvement in the management of the resource, facilitate rule enforcement, and improve the accountability of officials to users. Officials could conduct regular testing of raw water samples at every well (at least once a year, more so in WHPAs where there is a greater threat of contamination) and record the information in a central database to monitor the progress of the state’s efforts to protect local groundwater resources.

The remaining four recommended best management practices seek to improve upon and expand Delaware’s existing measures for protecting groundwater quality using a precautionary approach. First we suggest that municipalities in Delaware include agricultural land use in source water protection ordinances, instead of relying solely on state regulation. Agricultural practices pose a great potential threat to groundwater through the overuse or misuse of pesticides, herbicides, fertilizers, and the large amount of animal waste produced in some operations. Local agencies are in a better position to monitor agricultural practices and it is easier for them to conduct soil and water tests as needed. Maryland, Virginia, and North Carolina all include some level of local oversight over agriculture practices that might affect groundwater quality, and our state, which contains a large amount of farmland, may want to consider doing the same.

Secondly, we recommend that Delaware bolster its measures to ensure contaminates do not end up in the groundwater. Municipalities could consider adding more hazardous waste collection days to the calendar, perhaps scheduling quarterly pickups and/or having specific sites available for collection. Officials could also conduct benefit-
cost-analyses on expanding the use of semipermeable surfaces for parking lots and walkways, taking into consideration the full societal costs of pollution from storm water runoff.

Finally, Delaware could partner with university and private labs to evaluate threats from substances not currently listed by the EPA as potential groundwater contaminants. Thousands of new substances are introduced to the environment every year and the EPA process for listing these as potential contaminants is lengthy and incomplete. Rather than wait for the EPA to issue new guidelines, this is another area in which the First State could take a proactive leadership role.

13 Conclusion – issues worthy of further research

As we conducted our research, we realized that there were a number of other avenues down which we needed to explore. For instance, how do WHPPs or SWPPs affect the actual quality of the groundwater? To determine the answer to this question would require field tests of raw water data. Some of this is likely available, but not in the water quality reports issued to consumers every year or in information readily available on the internet. These reports are based upon water after it has undergone treatment to meet drinking water quality standards. We would need raw water data from the wellheads themselves. Some water systems collect this data other do not, none of it is readily available on-line. A further consideration is that we would have to determine the subsurface water travel time to particular wellheads (not overly difficult) and only select sites for which the travel time is less than the time since SWPPs were enacted – not generally before 2009. Some wellheads measure their water travel time in decades, if not centuries, but most measure no more than 10-15 years with a fair number occurring in the 1 – 5 year range. Another related question is how does the thoroughness of the plan affect the GW quality?

Another possible project would look at on-the-ground compliance to WHPPs. This involves two avenues of research: (1) Are town councils’ granting variances to
businesses/homeowners in a manner incongruent with the plans’ intentions? Since all
the ordinances allow for dispute resolution and the granting of exceptions (a variance),
what percentage of variance applications do they approve? If it is inordinately high,
how effective is the ordinance at preventing possible GW contamination (possibly
proved or disproved in the above research project – e.g. quality is same both before and
after plan inception, but that is because of the exceptions granted). (2) Are ordinances
being enforced? This would entail looking at permits granted since plans were
instituted and seeing if they meet the ordinance guidelines. These would be permittees
who did not even apply for a variance. A possible variation on this theme would
include doing a “windshield” survey and seeing if there were noncompliant land uses
in place that did not have the requisite permit or variance.

Ladies and gentleman of the Assembly, thank you for granting us the opportunity to
contribute to the process of improving our state’s groundwater protection. We hope
you find this report useful in your deliberations.
14 Sources


DNREC Division of Air and Waste Management & Division of Water Resources and Delaware Health and Social Services Division of Public Health. (September, 2002). The impact of known and suspected contaminant sources on select public drinking water supplies in Delaware. Retrieved from:


Harrington, City of. August 4, 2008. An ordinance to adopt source water protection
regulations. Ordinance No. 08-03. Retrieved from:
http://delawaresourcewater.org/wp-

Horsely Witten Hegemann, Inc. (1992). Ground Water Supply Protection and
Management Plan for the Eastern Shore of Virginia. Retrieved from:
http://www.gpo.gov/fdsys/pkg/CZIC-td224-v8-g76-1992/html/CZIC-td224-v8-
g76-1992.htm

King William County. (2003). Comprehensive plan update 2003: King William County,
Virginia. Retrieved from: http://ghost.kingwilliamcounty.us/wp-
content/uploads/2014/02/KW-Comp-Plan.pdf

King William County. (2008). King William County master utility plan. Retrieved from:
http://resourceintl.com/doc/KING_WILLIAM_COUNTY_MASTER UTILITY_PL-
AN.pdf


Lake Waccamaw, Town of. (March, 2011). Wellhead Protection Plan for the Town of
Lake Waccamaw, PWS ID# 04-24-045. Revised. Not Published.

Lewes, City of. N.D. Source water overlay district. Retrieved from:
http://delawaresourcewater.org/wp-


resource management: Application to groundwater. *Water Resources Research,*
48(9), 1 - 15.


New Kent County, Virginia. (2014). Code of ordinances, Sec 38-90; 82-1; 91-75; 91-5. Retrieved from:
Groundwater Quality Control Through Good Governance


15 Appendices

15.1 Appendix I: Delaware’s Model Ordinance (minus definitions)

Draft Model Ordinance for Smaller Municipalities (DE)

WATER RESOURCE PROTECTION AREA AND
ENVIRONMENTAL PROTECTION REGULATIONS
(DRAFT March 2004)

Section 1100 Intent.
The intent of this section is to provide clarification on the environmental constraints and requirements for
development in environmentally sensitive areas.

Section 1101 Definitions.
(Specific definitions omitted – the document contains a list of 11 terms it uses in this model ordinance)

Section 1102 Water Resources Protection Areas (WRPA).
Water resource protection areas are Wellhead and Recharge Areas. All such areas are as depicted on Water
Resource Protection Area maps located in Town Hall. These areas shall be protected as required by the following
sections to protect the Town's public drinking water resources from contamination and pollution.

Section 1103 Wellheads Class A.
A) Areas within three hundred (300) feet of the well shall be one hundred (100) percent open space.
B) The natural runoff flowing into wellhead areas shall be allowed and all new stormwater run-off shall be
diverted around the wellhead protection areas wherever practical.
C) The stormwater system’s discharge to wellhead WRPA’s shall be by sheet through a grassland or discharge
from a stormwater management facility having a wetland or aquatic bench. Stormwater runoff from all
parking areas shall be directed to a stormwater management facility before it is discharged into a wellhead
WRPA.
D) Within the wellhead area, impervious surfaces shall be limited to the buildings and access associated with
the well and distribution and treatment facilities and their maintenance
E) The minimum lot area for a proposed public water supply well and related facility drawing from a confined
aquifer shall be 1 acre and the minimum lot area for a public well drawing from an unconfined aquifer shall
be 2 acres.
F) Underground storage tanks containing petroleum or any hazardous substances listed in 40 CFR 116 in an
aggregate quantity equal to or greater than a reportable quantity as defined in 40 CFR 117 shall not be
permitted in a designated wellhead area.

Or

Underground storage tanks containing petroleum or any hazardous substances listed in 40 CFR 116 in an
aggregate quantity equal to or greater than a reportable quantity as defined in 40 CFR 117 may be
constructed in a designated wellhead area provided the UST’s are constructed with double containment in
accordance with the Delaware Standards for Underground Storage Tanks.

G) Septic systems may be permitted in wellhead areas provided:
   1) The minimum residential lot density is 2 acres per dwelling.
   2) The minimum soil permeability is 1 inch per hour.
   3) The depth to seasonal high groundwater table is more than 5 feet.

H) Hazardous Waste Storage, Treatment, and Disposal Facilities, and Sanitary and Industrial Facilities as
defined in the Delaware Regulations Governing Hazardous Waste shall not be permitted in wellhead areas.
Section 1104 Recharge Areas.
Recharge Areas are those areas with high percentages of sand and gravel that have "excellent" potential for recharge as determined through a Stack Unit Mapping Analysis performed originally by the Delaware Geological Survey.

A) Within Multifamily Residential, Office, Commercial, Industrial, Transportation/Utility, Institutional Uses - Development of these uses within the Town of ______ may occur provided the impervious cover of the parcel within the recharge area is 20% or less unless an environmental impact assessment report certified by a state registered professional geologist or professional engineer with a background in hydrogeology indicates that additional development would not endanger the public or the environment. In situations where the existing impervious cover of a property is over 50% and the applicant desires to re-develop the property, the gross impervious cover shall be equal to or less than the original impervious cover percentage of the original site. In areas zoned as either Commercial (C) or Industrial (I) within the Town of ______ the applicant can seek relief by submitting an environmental study and report certified by a state registered professional geologist or professional engineer with a background in hydrogeology that indicates that additional development would not endanger the public or the environment.

B) Single Family Residential Uses - New development within the Town of ______ may occur provided the impervious cover of the entire parcel within the recharge area is 20% or less unless an environmental impact assessment report certified by a state registered professional geologist or professional engineer with a background in hydrogeology indicates that additional development would not endanger the public or the environment.

C) Underground storage tanks containing petroleum products or any hazardous substances listed in 40 CFR 116 in an aggregate quantity equal to or greater than a reportable quantity as defined in 40 CFR 117 shall not be permitted in a designated recharge area.

Or

Underground storage tanks containing petroleum or any hazardous substances listed in 40 CFR 116 in an aggregate quantity equal to or greater than a reportable quantity as defined in 40 CFR 117 may be constructed in a designated recharge area provided the UST are constructed with double containment in accordance with the Delaware Standards for Underground Storage Tanks.

D) For all new construction, all structures shall be required to discharge roof drains into underground recharge systems or permeable surfaces. No discharge by roof drains to impervious surfaces is permitted in recharge areas.

E) Septic systems may be permitted in recharge areas provided:
   1) The minimum residential lot density is 2 acres per dwelling.
   2) The minimum soil permeability is 1 inch per hour.
   3) The depth to seasonal high groundwater table is more than 5 feet.

F) Hazardous Waste Storage, Treatment, and Disposal Facilities, and Sanitary and Industrial Facilities as defined in the Delaware Regulations Governing Hazardous Waste shall not be permitted in wellhead areas.

Section 1105 Boundary Determination for WRPA.
A) All subdivision and land development plans depicting development or land disturbance submitted for Town review shall be evaluated for the existence of water resource protection areas by scaling for distances shown on the Town of _______________ Water Resource Protection Area Map. If existing, the boundaries of the areas shall be delineated on the plan by the applicant's engineer.

B) When there appears to be a conflict between the mapped boundary and actual site conditions, the applicant may engage the services of professional practitioners set forth in this section to prepare a report intended to determine more accurately the precise boundary of the water resource protection area, which report shall be submitted to the Town with the detailed findings necessary to indicate the location of the boundary.

C) The plan showing the boundary conflict should indicate the following:
   1) A detailed topographic layout of the subdivision and/or area to be developed prepared by a land surveyor or engineer.
   2) For wellhead and recharge boundary determinations, a site-specific geological and hydro-geological analysis shall be performed by a state-registered professional geologist or engineer with a background in hydro-geology and shall be based upon thorough site investigation and testing; and
   3) Evidence derived from a site-specific investigation which may include aquifer testing, test borings, test pits, observation wells, groundwater elevations and topography surveys as appropriate for the
type of water resource protection area to clearly demonstrate that the area in question does not meet the definition of a water resource protection area as defined in Section 1101.

D) The applicant is permitted to make a submission to the Town with the written approval of the Delaware Geological Survey, the University of Delaware Water Resources Agency, and the Department of Natural Resources and Environmental Control, to adjust the boundary or area designation based thereon. Such adjustments shall have the effect of exempting the subject parcel from the use regulations of this section and shall have the effect of amending the limits of the water resource protection area. The applicant will then be required to provide a notification sent to the Town indicating that they concur with the amended boundary location in order to be exempted from the requirements of this section.

**Section 1106 Uniform Standards and Criteria.**
A) The following standards and criteria shall be applicable to any limited use, special use or other use requiring an environmental impact assessment permitted pursuant to this Division:

1) Stormwater management facilities shall be designed and constructed in accordance with DNREC "Delaware Sediment and Stormwater Regulations," dated January 23, 1991 or as later revised.

**Section 1107 Environmental Impact Assessment Report.**
New development in WRPAs may exceed the 20% impervious cover threshold within recharge WRPAs, but be no more than 50% impervious, provided the applicant submits an environmental assessment recommending a climatic water budget and facilities to augment recharge. The environmental assessment must document that post-development recharge will be no less than predevelopment recharge when computed on an annual basis. Commonly, the applicant offsets the loss of recharge due to impervious cover by constructing recharge basins that convey relatively pure rooftop runoff for infiltration to ground water. Refer to Supplement 1 entitled “Ground-Water Recharge Design Methodology” for the details of how to design recharge facilities in Delaware water resource protection areas.

A) If a proposed use requires an environmental impact assessment report, the applicant shall have such a report certified by a professional engineer, geologist or other certified professional in the applicable environmental discipline. Mitigation cannot be used where the conflict can be avoided or minimized. The report shall contain the following criteria, given in order of preference:

1) Site character. The report shall identify all potential on-site sensitive environmental concerns.

2) Avoidance. Alternative sites or routes shall be identified that would not damage the resource or result in less resource damage. Reasons shall be provided explaining why using these sites is impossible or infeasible versus that proposed.

3) Minimization. The applicant shall demonstrate that the plan minimizes the impact of the activity, route, or use on the resource. The applicant shall also demonstrate that the areas impacted shall be lowest quality and result in the least damage to the resource.

4) Mitigation. A mitigation plan shall be submitted indicating mitigation activities. On-site replacement is the most acceptable form of mitigation. However, mitigation can include restoration and enhancement after the use is abandoned. Mitigation by replacement on another site shall be at a ratio of two to one (2:1). Mitigation may also include enhancement; this ratio shall be four to one (4:1). Final Town approval is required for all other forms of mitigation not consistent with this section.
## 15.2 Appendix II: NC’s Best Management Practices

<table>
<thead>
<tr>
<th>Activity</th>
<th>Source</th>
<th>Local Tools</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Construction</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Residential/Commercial</td>
<td>Runoff from disturbed land; Runoff from impervious surfaces</td>
<td>• Zoning codes: Critical area zoning, floodplain management</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Impact fees</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Buffers and setbacks</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Development agreements</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Subdivision regulations: Site design, sediment and erosion control</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Building codes: Porous pavement, impervious surfaces</td>
</tr>
<tr>
<td></td>
<td></td>
<td>•Limits, excavation, grading and seeding, phased development</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• BMPs: Grass swales, infiltration basins, runoff ponds</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Pollution Prevention: Source reduction and management, education</td>
</tr>
<tr>
<td>Industrial/Transportation</td>
<td>Runoff from disturbed land; Runoff from impervious surfaces</td>
<td>• Zoning codes: Critical area zoning, floodplain management</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Impact fees</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Buffers and setbacks</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Development agreements</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Building codes: Porous pavement, impervious surfaces</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Limits, excavation, grading and seeding, phased development</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• BMPs: Grass swales, infiltration basins, runoff ponds</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Pollution prevention: Source reduction and management</td>
</tr>
<tr>
<td><strong>Industry</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Storage tanks (above and below ground)</td>
<td>Hazardous and nonhazardous materials and waste</td>
<td>• Zoning codes: Critical area zoning, floodplain management</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Buffer and setback zones</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Restoration: Re-siting and remediation</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Pollution prevention: Source reduction, management and disposal, education</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Emergency response planning</td>
</tr>
<tr>
<td>Injection wells</td>
<td>Hazardous and nonhazardous waste, industrial process water disposal</td>
<td>• Zoning codes: Critical area zoning, floodplain management</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Buffer and setback zones</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Restoration: Remediation</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Pollution prevention: Source reduction, management and disposal, education</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Emergency response planning</td>
</tr>
<tr>
<td>Land application</td>
<td>Industrial waste, Industrial sludge, Petroleum refining waste</td>
<td>• Zoning codes: Critical area zoning, floodplain management</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Buffer and setback zones</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• BMPs: Runoff ponds, constructed wetlands</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Pollution prevention: Source reduction and disposal, education</td>
</tr>
</tbody>
</table>

30 adapted from Kundell and DeMeeo, 2000
<table>
<thead>
<tr>
<th>Activity</th>
<th>Source</th>
<th>Local Tools</th>
</tr>
</thead>
<tbody>
<tr>
<td>Industry</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Material transfer operations</td>
<td>Hazardous and nonhazardous material and waste</td>
<td>• Zoning codes: Siting, critical area zoning, floodplain management</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Buffer and setback zones</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• BMPs: Runoff ponds</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Pollution prevention: Source management and disposal, education</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Emergency response planning</td>
</tr>
<tr>
<td>Pipelines</td>
<td>Hazardous and nonhazardous material and waste</td>
<td>• Utility requirements</td>
</tr>
<tr>
<td>Surface impoundment</td>
<td>Waste lagoons and storage ponds</td>
<td>• Zoning codes: Siting, overlay districts, critical area zoning, floodplain management</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Buffer and setback zones</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Restoration: Re-siting</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Pollution prevention: Source reduction, management and disposal, education</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Emergency response planning</td>
</tr>
<tr>
<td>Superfund sites</td>
<td>Hazardous waste; petroleum releases</td>
<td>• Buffer and setback zones</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Restoration: Remediation</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Pollution Prevention: Source reduction and management</td>
</tr>
<tr>
<td>Radioactive storage and disposal</td>
<td>Hazardous wastes from hospitals and laboratories, transportation spills</td>
<td>• Buffer and setback zones</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Restoration: Remediation</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Pollution Prevention: Source reduction and management</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Emergency response planning</td>
</tr>
<tr>
<td>Permitted discharges</td>
<td>Toxic releases: Air emissions; Water discharges; Hazardous waste disposal</td>
<td>• Pollution Prevention: Source reduction, management, disposal and education</td>
</tr>
<tr>
<td>Permitted facilities</td>
<td>Solid waste disposal</td>
<td>• Zoning codes: Siting</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Solid waste ordinance</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Buffer and setback zones</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• BMPs: Grass swales, runoff ponds and wetlands</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Pollution Prevention: Source reduction, management and education</td>
</tr>
<tr>
<td>Activity</td>
<td>Source</td>
<td>Local Tools</td>
</tr>
<tr>
<td>--------------------------------</td>
<td>---------------------------------------------</td>
<td>----------------------------------------------------------------------------</td>
</tr>
<tr>
<td><strong>Mining</strong></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
| Injection wells                | Oil and gas activity disposal, Mineral extraction disposal | • Pollution Prevention: Source reduction, management and education  
• Restoration: Re-siting and remediation  
• Emergency response planning |
| Hydrocarbon releases           |                                             | • Restoration: Re-siting and remediation  
• Pollution Prevention: Source reduction, management, disposal and education  
• Emergency response planning |
| Pipelines                      | Hydrocarbon releases                        | • Pollution Prevention: Source management and education                     |
| Stockpiles/Waste piles         | Mining and mine drainage, Quarrying, Mineral extraction, Tailing piles | • Buffer and setback zones  
• BMPs: Runoff ponds and wetlands  
• Pollution Prevention: Source reduction, management, disposal and education |
| **Urban (commercial and residential)** |                                             |                                                                            |
| Storage tanks (above and below ground) | Hazardous and Nonhazardous materials and waste | • Zoning codes: Siting, critical area zoning, floodplain management  
• Buffer and setback zones  
• Restoration: Re-siting and remediation  
• Pollution prevention: Source reduction, management and disposal, education  
• Emergency response planning |
| Stockpiles/Waste piles         | De-icing salts storage                      | • Buffer and setback zones  
• Pollution Prevention: Source reduction, management and education  
• Restoration: Re-siting and remediation |
| Cemeteries/Graveyards          | Chemical and pathogenic contamination      | • Zoning codes: Siting  
• Buffer and setback zones  
• Restoration: Re-siting and remediation |
| Ground water / Surface water cross connection | Unused wells; Abandoned wells; Broken sewer and storm water drains | • Stormwater management: Intergovernmental coordination and consistency, stormwater infiltration facilities  
• Restoration: Remediation |
| Land application               | Fertilizer, Pesticides/Herbicides, Wastewater | • Zoning codes: Siting, overlay districts, critical area zoning, floodplain management  
• Buffer and setback zones  
• BMPs: Nutrient loading standards, fertilizer limits  
• Pollution prevention: Source management and disposal, education |
| Landfills                      | Municipal Landfills; Open dumps, Scrap tire piles | • Zoning codes: Siting  
• Solid waste ordinance  
• Buffer and setback zones  
• BMPs: Grass swales, runoff ponds and wetlands  
• Pollution Prevention: Source reduction, management and education  
• Restoration: Re-siting and remediation |
## Groundwater Quality Control Through Good Governance

| Impervious surfaces | Runoff from streets, roads and parking lots | • Subdivision requirements: Site design  
• Building codes: Impervious surface limits, porous pavement  
• BMPs: Grass swales, infiltration basins  
• Stormwater management: Intergovernmental coordination, stormwater infiltration facilities |
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Permitted Discharges</td>
<td>Air emissions; Water discharges; Solid and hazardous waste disposal</td>
<td>• Pollution prevention: Source reduction, management and education</td>
</tr>
</tbody>
</table>
| Septic tanks | Individual houses, multi-family units, small businesses | • Zoning codes: Siting, overlay districts, floodplain management, critical area zoning  
• Building limitations  
• Subdivision regulations: Site design, on-site wastewater controls  
• Restoration, Remediation |

### Activity Source Local Tools

#### Urban (commercial and residential)

| Disposal wells | Stormwater drainage; Automobile service station disposal | • Zoning codes: Siting, overlay districts, floodplain management, critical area zoning  
• Stormwater management: Intergovernmental coordination, infiltration facilities  
• Pollution Prevention: Source reduction, management and education  
• Emergency response planning |
| Surface impoundment | Cesspools, Waste lagoons | • Zoning codes: Siting, overlay districts, floodplain management, critical area zoning  
• Subdivision regulations: Site design, on-site wastewater controls  
• Pollution Prevention: Source reduction, management and education  
• Emergency response planning |

#### Other

| Saltwater Intrusion | Saltwater | • Conservation and reuse  
• Awareness and education |
| Transportation corridors | Runoff from disturbed sites and impervious surfaces; Herbicide application: Hazardous and Nonhazardous materials and waste spills | • Zoning: Siting of highway and road location, critical area zoning, overlay districts, floodplain management  
• Buffers and setbacks  
• Subdivision regulations: Site design, sediment and erosion control  
• BMPs: Grass swales, excavation, grading and seeding, runoff ponds  
• Stormwater management: Intergovernmental coordination and agreements, infiltration facilities  
• Emergency response planning |
15.3 Appendix II: Virginia’s Wellhead Protection Plan

The Wellhead Protection Program Requirements and Virginia’s Implementation

I. Program Summary and Purpose

- The SDWA goal: To protect State ground water resources from contaminants through ongoing regulatory/non regulatory State programs and through voluntary participation by local governments.
- Funding: Establishment of an EPA approved State Wellhead Protection Program in Virginia may result in the allocation of funds within the Drinking Water State Revolving Fund Program and DEQ’s Clean Water Act grant will fund implementation of local protection programs as they lack funding for protection measures.
- DEQ does not intend to create a schedule for revisiting the components of this voluntary plan.
- Maintaining the document on the GWPSC web site provides an avenue for updates on new initiatives.

II. Duties of State agencies, local governments and public water supply systems (Roles & Responsibilities)

- DEQ will serve as the lead agency for coordination of this voluntary protection program.
- VDH will continue as the Commonwealth’s regulatory authority for public water supplies, including ongoing oversight of the Drinking Water State Revolving Fund Program.
- Local governments will have the primary responsibility for protection program implementation.
- Local protection plans will not be approved by the Commonwealth however there will be minimum program elements required for dispersal of State or Federal funds for wellhead protection activities.

III. Delineation (Define Protection Areas)

- Zone 1 Ground Water Source Assessment Areas, defined in the Virginia Source Water Assessment Program and approved by EPA as 1000 foot fixed radius, will be accepted as an initial delineation. The Commonwealth does not intend to revisit or revise the method established in the SWAP nor does the Commonwealth intend to approve more technical delineations as being more protective of the resource.
• The Commonwealth will encourage localities to explore tools for managing contaminants within protection areas that are best suited to local hydrogeologic and political conditions.

IV. Source Identification

• The VDH completed contaminant source inventories for all public water supplies wells as outlined in the Virginia Source Water Assessment Program. The VDH will continue to meet their regulatory commitment by completing contaminant source inventories for all new public water supply systems.

• Agencies will make electronic data relating to permit issuance available upon request by VDH for updates to their Zone 2 information (Zone 2 Ground Water Source Assessment Areas are defined in the Virginia Source Water Assessment Program and approved by EPA as 1 one mile fixed radius).

V. Management Approaches

• §15.2-2223 and §15.2-2283 of the Code of Virginia include ground water protection provisions for local governments to consider when developing Comprehensive Plans and/or zoning ordinances.

• Because local governments have the authority for land use decisions, selection of management methods to protect ground water will be determined at the local level.

• The Commonwealth will encourage local governments to select a management method that will be supported by their constituents and protective of the resource.

VI. Contingency Plan (Contingency Planning)

• The Virginia Emergency Response Council (VERC) designated the Virginia Department of Emergency Management (VDEM) to serve as the contact for facility immediate/emergency notification in the event of a release, spill, etc.

• The VDEM also serves as the lead agency in facilitating communication among local emergency planning committees and providing technical assistance.

• Because of this activity businesses have reassessed their chemical inventories and their manufacturing processes.

• In addition, more businesses are working cooperatively with local governments to plan for and try to prevent an accidental chemical release.
Water purveyors and local government officials will be the lead in establishing cooperative relationships with local emergency planning committees for protection program preparation.

### VII. New Wells

- VDH will maintain regulatory authority in the development, contaminant source inventory/assessment, and permitting of new public water supplies.
- VDH ensures new wells meet the quantity demands placed on the system by the consumer. VDH copies DEQ on well site authorization letters when the well is within a Ground Water Management Area.
- DEQ issues ground water withdrawal permits in Ground Water Management areas to minimize adverse impacts to the ground water resource.

### VIII. Conduct Ongoing Public Education and Outreach (Public Participation)

- To meet EPA demands for public input, DEQ will post a public notice on www.deq.virginia.gov concurrent with the April 15, 2005 submittal of this revised plan for approval. The notice will request written comments by May 13, 2005.
- The public notice will be published in six newspapers throughout the Commonwealth as well. Any comments received will be addressed and copies of comments and DEQ responses will be provided to EPA within one week of the close of comments (no later than May 20, 2005).
15.4 Appendix III: Virginia’s Best Management Practices

<table>
<thead>
<tr>
<th>Potential Source</th>
<th>Structural</th>
<th>Non-Structural</th>
<th>Education/Outreach</th>
</tr>
</thead>
</table>
| Abandoned wells                   | 1. Abandoned wells should be properly plugged by landowners or abandoned well program. | 1. Conduct frequent inventories to locate any abandoned wells that have been overlooked.  
2. Enact and enforce ordinances requiring well plugging. | 1. Develop education materials explaining the potential impact of abandoned wells.  
2. Encouraging citizens to have them plugged or to notify jurisdictional entities. |
| Above Ground Storage Tanks (AST)  | 1. Above ground storage tanks should be constructed of noncorrodible materials and be placed on impermeable surfaces or raised above the ground.  
2. Containment structures should be constructed around the facilities to contain spills. | 1. Require that AST operators immediately notify water system officials in the event of a leak or spill.  
2. Periodic inventory of contents to detect loss. | 1. Disseminate information on the proper construction and maintenance of AST’s to appropriate parties.  
2. Include operators in spill response and contingency planning. |
| Accidental Spills                 | 1. Contain, cleanup, remove, remediate. Accidental spills should be immediately contained using the appropriate methods to prevent migration of chemicals into water bodies and groundwater. | 1. Hazardous material carriers should be routed around source water protection areas if possible. | 1. Designate one local authority to oversee and coordinate emergency response activities.  
2. Include accidental spills in spill response and contingency planning |
| Agricultural Waste Pesticide Dumping | 1. Contain, cleanup, remove, remediate. | 1. Work with County and extension agents to develop pesticide disposal program. | 1. Educate pesticide users and citizens on the proper handling and disposal of pesticides. |
| Animal Feedlots                   | 1. Animal feedlots should follow the VA regulations and EPA guidelines for best management practices for construction standards. | 1. Work with local agencies and extension agents to create manure management programs  
2. Limit or prohibit feedlots inside source | 1. Disseminate information on the proper handling of feedlot wastes to appropriate parties and citizens.  
2. Develop education materials explaining |
<table>
<thead>
<tr>
<th>Groundwater Quality Control Through Good Governance</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Artificial Recharge</strong></td>
</tr>
<tr>
<td>1. Plug any dry or abandoned wells not used for artificial recharge in the area to avoid cross contamination of drinking water sources.</td>
</tr>
<tr>
<td>2. Notify citizens in area concerning this practice.</td>
</tr>
<tr>
<td>1. Ensure that appropriate UIC permits are on file with DEQ Groundwater Program.</td>
</tr>
<tr>
<td>1. Obtain copies of required permits and review water quality to be injected into aquifer.</td>
</tr>
<tr>
<td><strong>Auto Repair Shops</strong></td>
</tr>
<tr>
<td>1. Ensure that appropriate permits are on file with DEQ to conduct this type of activity.</td>
</tr>
<tr>
<td>2. Ask state and local inspectors to verify appropriate handling of hazardous wastes, hydrocarbons, and solvents.</td>
</tr>
<tr>
<td>3. Verify the disposal procedure for chemical wastes from these types of businesses.</td>
</tr>
<tr>
<td>1. Disseminate information on the proper handling of automotive wastes to appropriate parties and citizens.</td>
</tr>
<tr>
<td>2. Develop education materials explaining the potential impact to source waters.</td>
</tr>
<tr>
<td>3. Encourage citizen involvement and reporting of illegal dumping of automotive wastes to jurisdictional entities.</td>
</tr>
<tr>
<td><strong>Illegal Dumping</strong></td>
</tr>
<tr>
<td>1. Install remote surveillance equipment at dump sites.</td>
</tr>
<tr>
<td>2. Install fencing or other controls such as tire deflators to inhibit dumping.</td>
</tr>
<tr>
<td>3. Work with local agencies and citizens</td>
</tr>
<tr>
<td>1. Provide necessary support to local law enforcement to prosecute dumpers.</td>
</tr>
<tr>
<td>2. Establish a hotline or online center for citizens to report violations.</td>
</tr>
<tr>
<td>3. Work with local agencies to establish a program that allows</td>
</tr>
<tr>
<td>1. Establish an outreach and education program for all citizens informing them of the dangers of these types of activities to source waters.</td>
</tr>
<tr>
<td>2. Work with local agencies to educate</td>
</tr>
<tr>
<td><strong>Underground Storage Tank (UST’s)</strong></td>
</tr>
<tr>
<td>-------------------------------------</td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>
### 15.5 Appendix IV – WRA Ranking Comparison

<table>
<thead>
<tr>
<th>WRA City</th>
<th>WRA Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dover</td>
<td>1</td>
</tr>
<tr>
<td>Millsboro</td>
<td>2</td>
</tr>
<tr>
<td>Millford</td>
<td>3</td>
</tr>
<tr>
<td>New Castle</td>
<td>4</td>
</tr>
<tr>
<td>Seaford</td>
<td>5</td>
</tr>
<tr>
<td>Georgetown</td>
<td>6</td>
</tr>
<tr>
<td>Laurel</td>
<td>7</td>
</tr>
<tr>
<td>Smyrna</td>
<td>8</td>
</tr>
<tr>
<td>Newark</td>
<td>9</td>
</tr>
<tr>
<td>Middletown</td>
<td>10</td>
</tr>
<tr>
<td>Camden</td>
<td>11</td>
</tr>
<tr>
<td>Harrington</td>
<td>12</td>
</tr>
<tr>
<td>Lewes</td>
<td>13</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>CEEP City</th>
<th>CEEP Score</th>
<th>CEEP Rank</th>
<th>Difference b/w CEEP and WRA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Smyrna</td>
<td>95</td>
<td>1</td>
<td>-7</td>
</tr>
<tr>
<td>Camden</td>
<td>85</td>
<td>2</td>
<td>-9</td>
</tr>
<tr>
<td>Lewes</td>
<td>85</td>
<td>3</td>
<td>-10</td>
</tr>
<tr>
<td>Georgetown</td>
<td>84</td>
<td>4</td>
<td>-2</td>
</tr>
<tr>
<td>New Castle</td>
<td>81</td>
<td>5</td>
<td>1</td>
</tr>
<tr>
<td>Laurel</td>
<td>76</td>
<td>6</td>
<td>-1</td>
</tr>
<tr>
<td>Newark</td>
<td>57</td>
<td>7</td>
<td>-2</td>
</tr>
<tr>
<td>Millsboro</td>
<td>56</td>
<td>8</td>
<td>6</td>
</tr>
<tr>
<td>Millford</td>
<td>54</td>
<td>9</td>
<td>6</td>
</tr>
<tr>
<td>Middletown</td>
<td>53</td>
<td>10</td>
<td>0</td>
</tr>
<tr>
<td>Seaford</td>
<td>52</td>
<td>11</td>
<td>6</td>
</tr>
<tr>
<td>Dover</td>
<td>47</td>
<td>12</td>
<td>11</td>
</tr>
<tr>
<td>Harrington</td>
<td>42</td>
<td>13</td>
<td>1</td>
</tr>
</tbody>
</table>