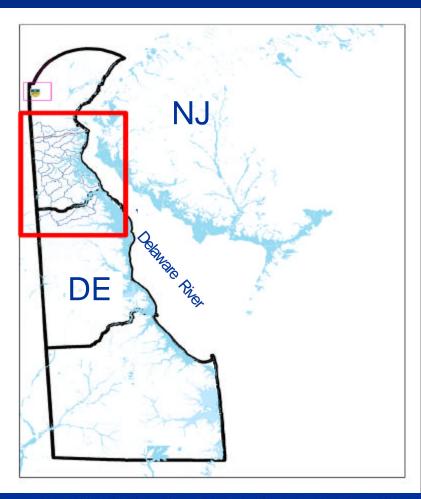
### Watershed Based Wetlands and Water Resource Protection

Using Natural Resource Protection to Limit Impervious Cover within Sub-watersheds of Southern New Castle County Delaware







This project was funded through a United States Environmental Protection Agency (US EPA) Wetland Program Grant to protect and enhance riparian corridors in Southern New Castle County, Delaware. The County retained the University of Delaware, Institute for Public Administration, Water Resources Agency to assist with the watershedbased approach to protecting natural resources



### **Objectives of this Project**

**1)** Evaluate the adequacy of the \*New Castle County Unified Development Code (NCCUDC) natural resource protection standards in limiting impervious cover at full-buildout under current zoning

**2)** To create a method using GIS for determining priority waters heds that need greater protection from development in order to protect water resources and limit impervious cover

**3)** Provide a watershed framework to assist planners when reviewing sub-division plans to minimize impacts on water resources.

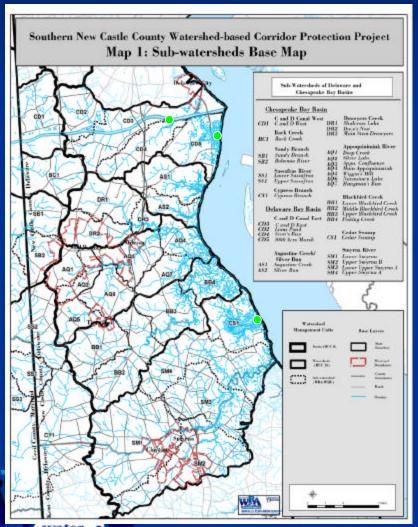
\* The New Castle County Unified Development Code (NCCUDC) under Article 10 sets Resource Protection Standards aimed at protecting Natural resources by requiring the preservation of a minimum amount of the resource as open space.

### Methods

- Create sub-watersheds of manageable size to be used for water quality studies
- Conduct analysis, using GIS raster data, to review the UDC in order to determine its adequacy in limiting impervious cover
- Create a map series that paints a picture of the present and future "health" of each sub-watershed that will aid in planning development locations
- Determine if the UDC environmental standards limit impervious cover at full-buildout with current zoning
- Make recommendations about augmenting the UDC to best protect water resources



MAP 1. Sub-Watersheds 10 sq. miles or less were delineated from gauging station locations using 10 meter resolution digital elevation data.

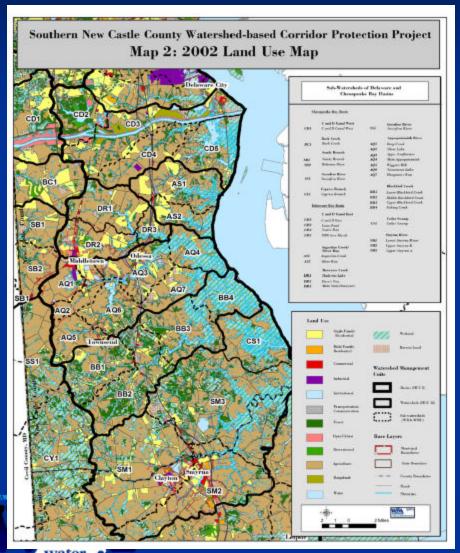


The sub-watersheds were edited to conform to the USGS Hydrologic Unit Codes

These became known as Water Resources Agency Watershed Management Urits

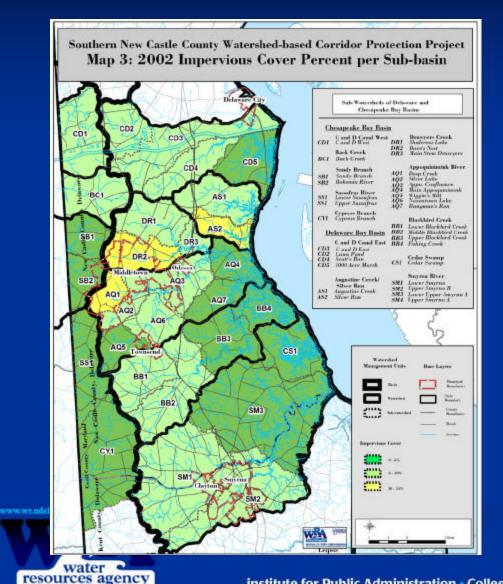
resources agency

## MAP 2. A land use map is in the map series to get a feel for the distribution of land use within each sub-watershed.



resources agency

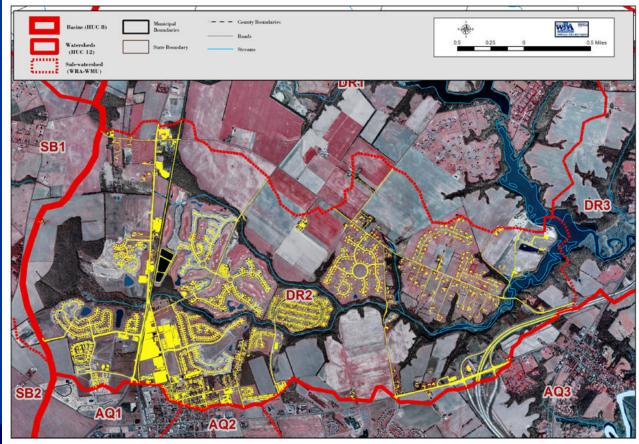
### MAP 3. 2002 Impervious Cover for each sub-watershed





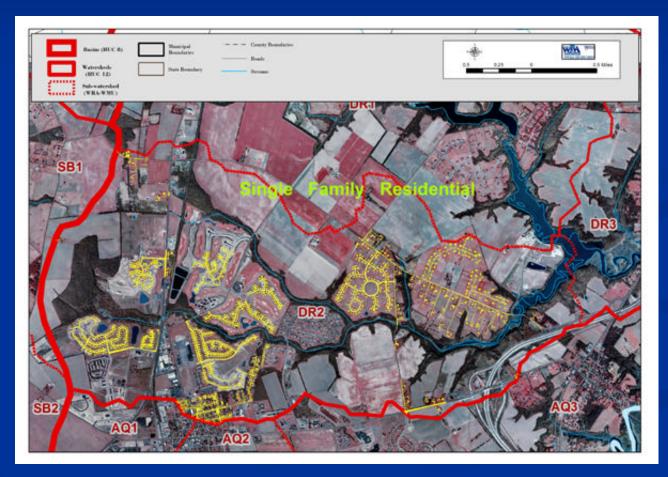
#### Method for Acquiring Impervious Cover Proxy Values

Impervious surfaces (sidewalks, driveways, rooftops and roads were hand digitized from .25 meter aerial photography at 1:2500 scale in order to derive percent values for each land use class.





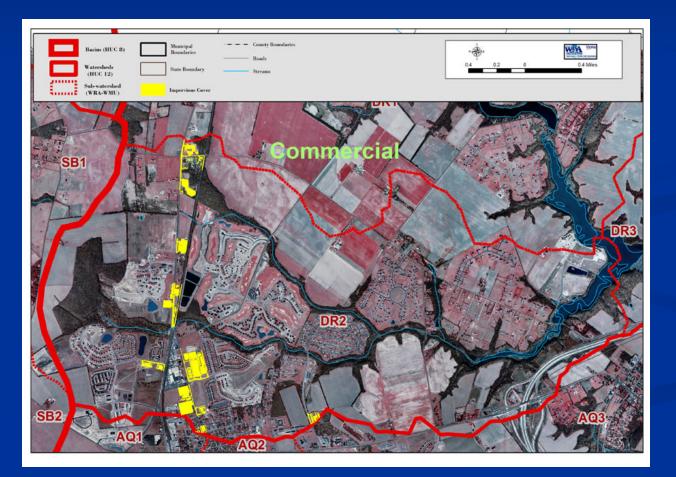
Method for Acquiring Impervious Cover Proxy Values Individual Land use classes were extracted to obtain average values for each class. Single Family Residential is shown below.





Method for Acquiring Impervious Cover Proxy Values

Individual land use classes were extracted to obtain average values for each class. Commercial land is shown below.





Impervious cover values cross checked using the following methods:

- Automatic delineation from aerial photography using feature extraction software called Feature Analyst ©
- New Castle County Planning Department cross checked values with site plans and knowledge of building densities



## **Final Impervious Cover Values**

Land Use	Impervious Cover %
Single Family Residential	20
Multi-Family Residential	45
Commercial	70
Transportation	75
Institutional	30
Industrial	85
Agriculture	3

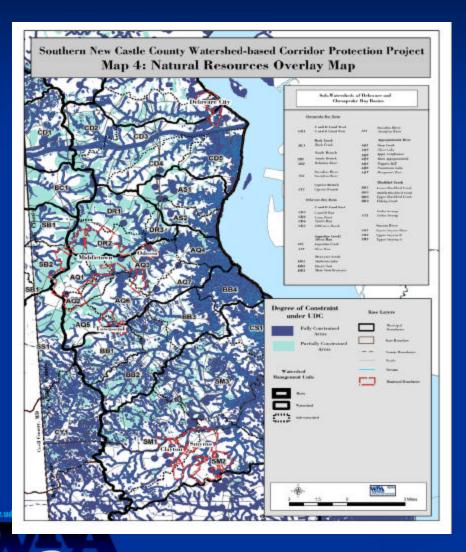


Obtaining impervious cover percents for each land use class allowed the modeling of future impervious cover scenarios. Using the impervious cover proxy values the Water Resources Agency's GIS researcher:

- 1. Modeled impervious cover at full-buildout without the Unified Development Code enforced, but with consideration of federal and state restriction already imposed on certain Natural Resources
- Modeled impervious cover at full-buildout taking into account the Unified Development Code restrictions on impervious Cover for certain Natural Resources, as well as those restrictions already imposed.



## MAP 4. The New Castle County Unified Development Code Restricts impervious cover on selected Natural Resources



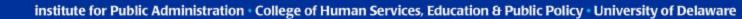
resources agency

#### 100% Protection

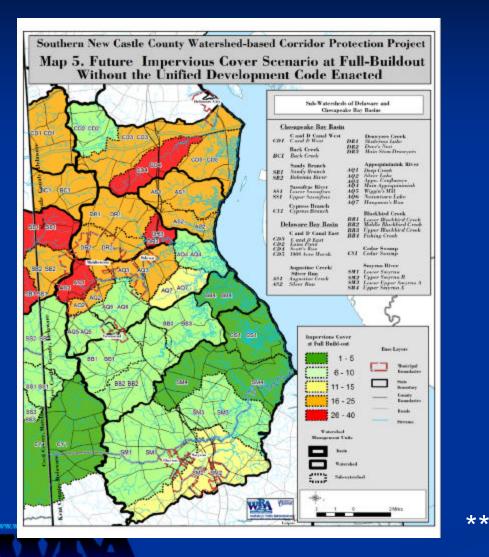
- Wetlands
- 100 year floodplains
- Riparian Buffers
- Slopes >25%
- Class A Wellheads

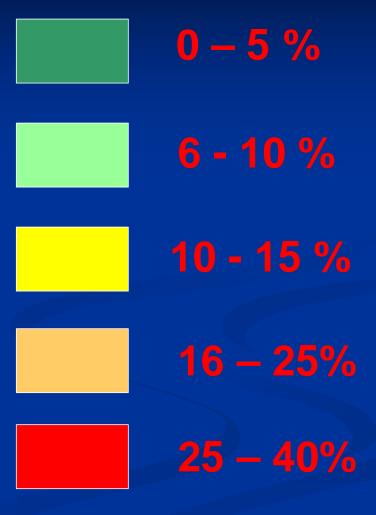
### **Partially Protected**

- Forest
- Recharge Areas
- Slopes 15-25%
- Critical Natural Areas



# MAP 5. Future Impervious Cover Estimates *Without* the Unified Development Code Enforced at Full-Buildout

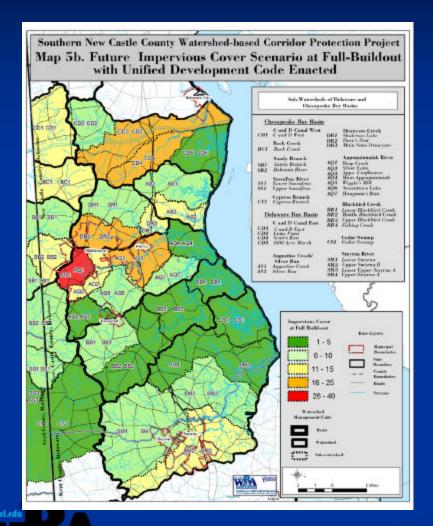


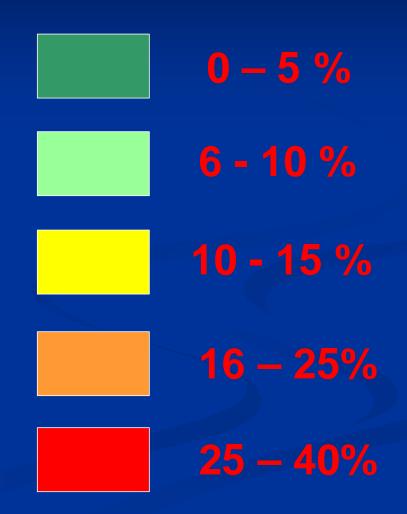


Natural Resources that are protected under Federal or other local ordinances were considered in calculations



# **MAP 5b.** Future Impervious Cover Estimates with the Unified Development Code Enforced at Full-buildout





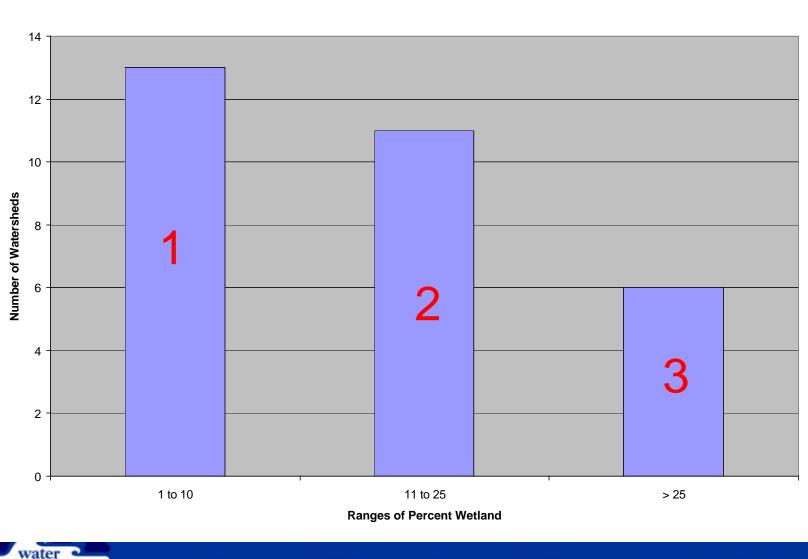


# Sub-watersheds were scored based on percent of:

- Wetlands
- Forest
- % of Riparian Buffer Forest or Wetland
- Public/Private Open Space
- Impervious Cover



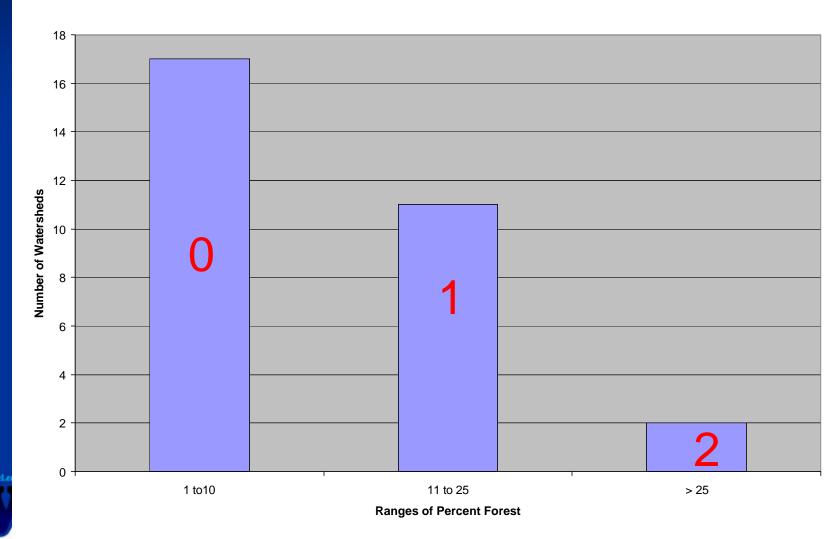
### Percent Wetland per Sub-watershed and Appropriate Score. The higher the score the healthier the watershed (theoretically.)



resources agency

Distibution of Percent Wetland within each Sub-watershed

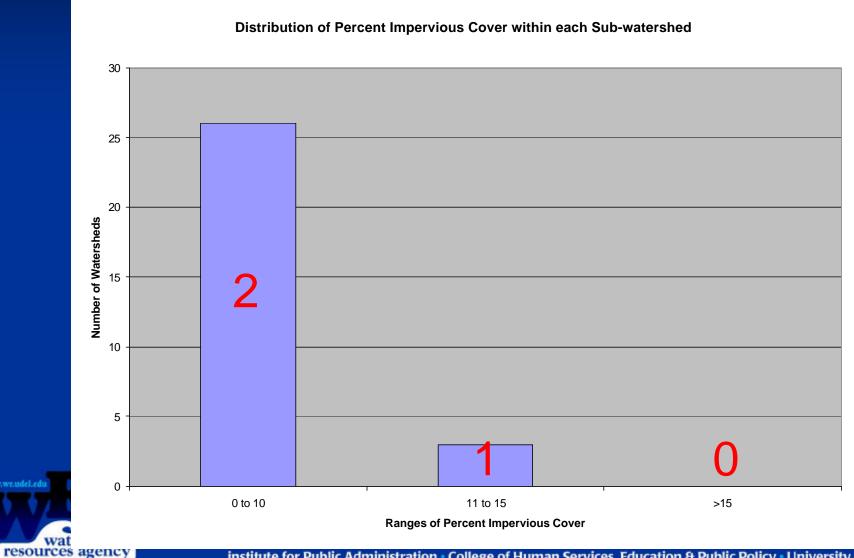
### Percent Forest per Sub-watershed and Appropriate Score. The higher the score the healthier the watershed (theoretically.)



Distribution of Percent of Forest within each Sub-watersheds

resources agency

Percent Impervious Cover per Sub-watershed and appropriate Score. The lower the score the healthier the watershed (theoretically.)



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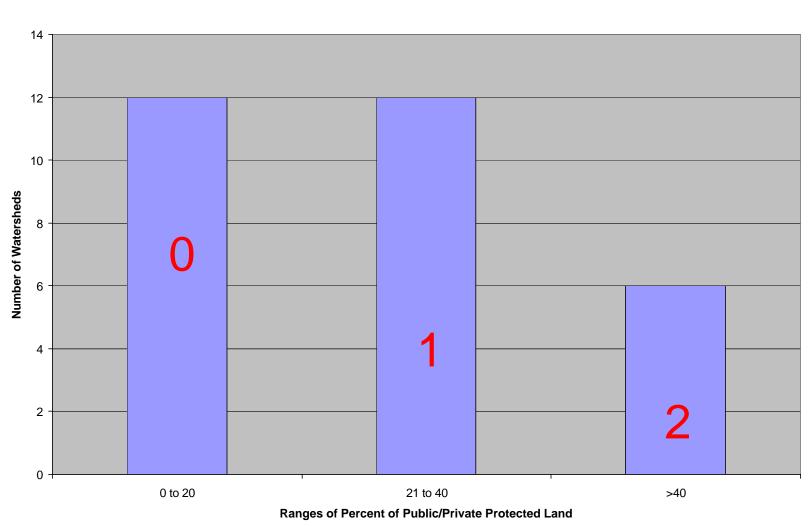
Percent of Riparian Buffer Composed of Forest or Wetland per Subwatershed and Appropriate Score. The higher the score the healthier the watershed (theoretically.)



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Percent Public/Private Protected Land per Sub-watershed and appropriate score. The higher the score the healthier the watershed.



Distribution of Percent Public/Private Protected Land within each Sub-watershed

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## Scores were given to each sub-watershed in each of the 5 natural resource categories and a final score was given.

No.     Drainage Extent     Subwatershed     Drainage Area     Wetland     Forest     Buffer     Public/Pri       Image: Subwatershed     Image: Subwatershed     Image: Subwatershed     Image: Subwatershed     Image: Subwatershed     Image: Subwatershed		NATURAL RESOURCES PERCENT (SCORE)										
Image: Constraint of the sector of		i	Percent Public/Pri		Forest	Wetland	Area	Drainage	Subwatershed	Drainage Extent	No.	
Image: Note of the second se		Impervio				-						
C and D Canal         1         CD1         C and D Canal West         615019         9.61         18(0)         20(1)         66(1)         33(2)         7(2)           Back Creek         2         BC1         Back Creek         48128         7.53         6(0)         4(0)         37(0)         1000         8(1)           Sandy Branch         3         BB1         Bohemi Kivr         3050.04         4.35         4(0)         7(0)         7(0)         4(0)         4(0)         4(0)         4(1)         8(1)           Sassafras River         5         SS1         Sassafras River         104721         8.30         452.         16(1)         430         3(0)         1(2)           Cypress Branch         7         CY1         Cypress Branch         1029.00         1597         46(2)         17(1)         78(2)         32(	SCORE			Wetland			(Sq.Mi.)	(Acres)				
Back Creek         2         BC1         Back Creek         4821.85         7.53         6(0)         4(0)         37(0)         1000         8(1)           Sandy Branch         3         SB1         Bohemia River         3056.04         4.78         7(0)         7(0)         44(0)         1(0)         8(1)           Sassafras River         5         SS1         Sassafras River         107.21         8.30         45(2)         1(4)         43(0)         3(0)         1(2)           Cypress Branch         7         CY1         Cypress Branch         1597         46(2)         17(1)         78(2)         32(2)         3(2)           C         Canal East         8         CD2         Lums Pond         3817.66         5.97         13(1)         30(2)         59(1)         72(2)         6(2)           C &D Canal East         8         CD2         Lums Pond         3817.66         5.97         13(1)         30(2)         59(1)         72(2)         6(2)           C AD Canal East         8         CD2         Lums Pond         3817.66         5.97         13(1)         30(2)         59(1)         72(2)         6(2)           C AD Canal East         8         CD2         Lum										Chesapeake		
Sandy Branch         3         SB1         Bohemia River         3056.04         4.78         7.00         7.00         44.00         100         8(1)           Sassafras River         5         SS1         Sassafras River         1047.21         8.30         452         16(1)         43(0)         3(0)         1(2)           Cypress Branch         7         CY1         Cypress Branch         7         CY1         Cypress Branch         1021989         1597         46(2)         17(1)         78(2)         32(2)         3(2)           C&D Canal East         8         CD2         Lums Pond         3817.66         5197         13(1)         30(2)         59(1)         72(2)         6(2)           C&D Canal East         8         CD2         Lums Pond         3817.66         5197         13(1)         30(2)         59(1)         72(2)         6(2)           10         CD4         Scott's Run         4188.14         651         8(0)         11(1)         6(1)         500         7(2)         6(2)         7(2)         7(2)         7(2)         7(2)         7(2)         7(2)         7(2)         7(2)         7(2)         7(2)         7(2)         7(2)         7(2)         7(2)	7	7 (2)	33(2)	65 (1)	20(1)	18 (1)	9.61	6150.19	C and D Canal West	-		C and D Canal
Johnson Dollar         4         SB2         Sandy Branch         2785.70         4.35         4 (0)         7 (0)         49 (0)         0 (0)         4 (2)           Sassafras River         5         S51         Sassafras River         1047.21         8.30         45(2)         16(1)         43(0)         3(0)         1(2)           Cypress Branch         7         CY1         Cypress Branch         7         CY1         Cypress Branch         100         8(0)         16(0)         2(0)         2(2)         2(2)           C&D Canal East         8         CD2         Lums Pond         3817.66         5.97         13(1)         30(2)         59(1)         72(2)         6(2)           Oblaware         C         Ca and Canal East         7939.01         124.00         19(1)         11(0)         60(1)         500         7(2)         6(2)           11         CD5         1000 Acre Marsh         4788.19         7.48         49(2)         9(0)         74(1)         22(1)         7(2)         6(2)           Augustine /silver Run         12         AS1         Augustine Creek         5051.46         7.89         23(1)         9(0)         74(1)         22(1)         7(2) <th< th=""><th>1</th><th>8(1)</th><th>10(0)</th><th>37 (0)</th><th>4 (0)</th><th>6 (0)</th><th>7.53</th><th>4821.85</th><th>Back Creek</th><th>-</th><th></th><th>Back Creek</th></th<>	1	8(1)	10(0)	37 (0)	4 (0)	6 (0)	7.53	4821.85	Back Creek	-		Back Creek
Sassafras River         5         SS1         Sassafras River         1047         100         200         220         620         200         220         620         200         220         620         220         620         220         620         220         620         220         220         220         220         220         220         220         220 </td <td>1</td> <td>8(1)</td> <td>1(0)</td> <td>44 (0)</td> <td>7 (0)</td> <td>7 (0)</td> <td>4.78</td> <td>3056.04</td> <td>Bohemia River</td> <td>SB1</td> <td>3</td> <td>Sandy Branch</td>	1	8(1)	1(0)	44 (0)	7 (0)	7 (0)	4.78	3056.04	Bohemia River	SB1	3	Sandy Branch
Barrools Drove         6         SS2         Upper Sassafras River         4265.33         100         100         800         1600         200         202           Cypress Branch         7         CY1         Cypress Branch         1021989         1597         46(2)         17(0)         78(2)         32(2)         3(2)         3(2)           C&D Canal East         8         CD2         Lums Pond         3817.66         5.97         13(1)         30(2)         90(1)         72(2)         6(2)           C&D Canal East         8         CD2         Lums Pond         3817.66         5.97         13(1)         6(1)         5(0)         7(2)         6(2)           C         CD3         Cand D Canal East         7939.01         12.40         19(1)         11(0)         6(1)         5(0)         7(2)         6(2)           Augustine /Silver Run         12         AS1         Augustine Creek         501.46         7.89         23(1)         9(0)         74(1)         25(1)         7(2)           Maugustine /Silver Run         12         AS1         Augustine Creek         501.45         7.89         23(1)         9(0)         74(1)         25(1)         7(2)         7(2) <th< th=""><th>2</th><th>4 (2)</th><th>0(0)</th><th>49 (0)</th><th>7 (0)</th><th>4 (0)</th><th>4.35</th><th>2785.70</th><th>Sandy Branch</th><th>SB2</th><th>4</th><th></th></th<>	2	4 (2)	0(0)	49 (0)	7 (0)	4 (0)	4.35	2785.70	Sandy Branch	SB2	4	
Cypress Branch         7         CY1         Cypress Branch         1021989         15.07         46(2)         17(1)         78(2)         32(2)         3(2)           Delaware         Delaware         Example         Example <th>5</th> <th>1(2)</th> <th>3(0)</th> <th>43(0)</th> <th>16(1)</th> <th>45(2)</th> <th>8.30</th> <th>1047.21</th> <th>Sassafras River</th> <th>SS1</th> <th>5</th> <th>Sassafras River</th>	5	1(2)	3(0)	43(0)	16(1)	45(2)	8.30	1047.21	Sassafras River	SS1	5	Sassafras River
Openation         Delaware         Openation         Data         Data <thdata< th=""> <thdata< th=""> <thdata< th=""></thdata<></thdata<></thdata<>	3	2(2)	2(0)	16(0)	8(0)	11(1)		4265.33	Upper Sassafras River		-	
C&D Canal East         8         CD2         Lums Pond         3817.66         5.97         13(1)         30(2)         59(1)         72(2)         6(2)           Image: Second S	9	3 (2)	32(2)	78 (2)	17 (1)	46 (2)	15.97	10219.89	Cypress Branch	CY1	7	Cypress Branch
Open Charlenan         9         CD3         C and D Canal East         7930.01         12.00         10.00         60.01         39(2)         6(2)           10         CD4         Scott's Run         4468.14         6.51         8.00         11.00         60.01         39(2)         6(2)           Augustine /Silver Run         12         AS1         Augustine Creek         5051.46         7.89         23(1)         9(0)         74(1)         25(1)         7(2)           Augustine /Silver Run         12         AS1         Augustine Creek         5051.46         7.89         23(1)         9(0)         74(1)         25(1)         7(2)           Toravjers Creek         14         DR1         Shallcross Lake         4658.41         7.28         10(1)         9(0)         6(1)         15(0)         9(1)           16         DR2         Dove's Nest         3902.13         610         10(1)         6(0)         15(0)         7(2)         14(1)           16         DR3         Main Stem Drawyer's         1313.76         2.05         19(1)         13(1)         66(1)         15(0)         7(2)         14(1)           16         DR3         Main Stem Drawyer's         1313.76         2.05 <th></th> <th></th> <th></th> <th></th> <th></th> <th></th> <th></th> <th></th> <th></th> <th>Delaware</th> <th></th> <th></th>										Delaware		
Image: Second	8	6 (2)	72(2)	59 (1)	30 (2)	13 (1)	5.97	3817.66	Lums Pond	CD2	8	C&D Canal East
Index         Index <th< td=""><td>7</td><td>6 (2)</td><td>39(2)</td><td>60(1)</td><td>11 (1)</td><td>19 (1)</td><td>12.40</td><td>7939.01</td><td>C and D Canal East</td><td>CD3</td><td>9</td><td></td></th<>	7	6 (2)	39(2)	60(1)	11 (1)	19 (1)	12.40	7939.01	C and D Canal East	CD3	9	
Image: Second	4	7 (2)	5(0)	61 (1)	11 (1)	8 (0)	6.51	4168.14	Scott's Run	CD4	10	
B         AS2         Silver Run         2370.03         3.70         30.2         5.00         73.01         42.20         11.01           Drawyers Creek         14         DR1         Shallcross Lake         4658.41         7.28         10(1)         9 (0)         65 (1)         15(0)         9 (1)           Image: Creek         14         DR1         Shallcross Lake         4658.41         7.28         10(1)         9 (0)         65 (1)         15(0)         9 (1)           Image: Creek         15         DR2         Dove's Nest         3902.13         610         10(1)         6 (0)         59 (1)         13(0)         13 (1)         66 (1)         15(0)         7 (2)           Appoquinimink Creek         17         AQ1         Deep Creek         2170.47         3.39         5 (0)         3 (0)         48 (0)         2 (0)         14 (1)           AQ2         Silver Lake         2009.3         314         5 (0)         6 (0)         49 (0)         7 (0)         8 (1)           Q         AQ3         Appo_Confluence         4277.63         6.68         18 (1)         11 (1)         68 (1)         23 (1)         10 (1)           Q         AQ5         Wiggin's Mill         2	7		26(1)			49 (2)	7.48	4788.19	1000 Acre Marsh	CD5	11	
Image: Second	5		25(1)		. ,		7.89	5051.46	Augustine Creek	AS1	12	Augustine /Silver Run
Drawyers Creek         14         DR1         Shallcross Lake         4658.41         7.28         10(1)         9 (0)         65 (1)         15 (0)         9 (1)           15         DR2         Dove's Nest         3902.13         6.10         10(1)         6 (0)         59 (1)         13(0)         13 (1)         13 (1)           Appoquinimink Creek         17         AQ1         Deep Creek         2170.47         3.39         5 (0)         3 (0)         48 (0)         2 (0)         14 (1)           19         AQ2         Silver Lake         2009.3         3.14         5 (0)         6 (0)         49 (0)         7 (0)         8 (1)           19         AQ3         Appo. Confluence         4277.63         6.68         18 (1)         11 (1)         68 (1)         23 (1)         10 (1)           20         AQ4         Main Appoquinimink         3016.41         4.71         58 (2)         1 (0)         77 (2)         50 (2)         2 (2)           21         AQ5         Wiggin's Mill         2688.31         4.20         5 (0)         9 (1)         5 (1)         14 (0)         5 (2)           22         AQ6         Noxontown Lake         3511.53         5.49         15 (1)         <	6	11 (1)	42(2)	73 (1)	5 (0)	30 (2)	3.70	2370.03	Silver Run	AS2	13	
Image: Second	3						7.28	4658.41	Shallcross Lake	DR1	14	Drawyers Creek
Image: Section of the system of the	3			1						DR2	15	
Appoquinimink Creek         17         AQ1         Deep Creek         2170.47         3.39         5 (0)         3 (0)         48 (0)         2 (0)         14 (1)           18         AQ2         Silver Lake         2009.3         3.14         5 (0)         6 (0)         49 (0)         7 (0)         8 (1)           19         AQ3         Appo. Confluence         4277.63         6.68         18 (1)         11 (1)         68 (1)         23 (1)         10 (1)           10         AQ4         Main Appoquinimik         3016.41         4.71         58 (2)         1 (0)         77 (2)         50 (2)         2 (2)         1           10         AQ5         Wiggin's Mill         2688.31         4.20         5 (0)         9 (1)         50 (1)         14 (0)         6 (2)         1           10         22         AQ6         Noxontown Lake         3511.53         5.49         15 (1)         18 (1)         68 (1)         4 (2)         6 (2)         1           10         Blackbird Creek         24         BB1         Lower Blackbird Creek         4749.72         7.42         21 (1)         15 (1)         69 (1)         20 (1)         26 (1)         7 (2)         1           10	5		15(0)	66 (1)	13(1)	19(1)	2.05	1313.76	Main Stem Drawyer's	DR3	16	
Image: Silver Lake         Silver Lake         2009.3         3.14         5 (0)         6 (0)         49 (0)         7 (0)         8 (1)           19         AQ3         Appo. Confluence         4277.63         6.68         18 (1)         11 (1)         68 (1)         23 (1)         10 (1)           20         AQ4         Main Appoquinimik         3016.41         4.71         58 (2)         1 (0)         77 (2)         50 (2)         2 (2)           21         AQ5         Wiggin's Mill         2688.31         4.20         5 (0)         9 (1)         50 (1)         14 (0)         5 (2)           22         AQ6         Noxontown Lake         3511.53         5.49         15 (1)         18 (1)         4 (1)         6 (2)           23         AQ7         Hangman's Run         2695.22         4.21         24 (1)         4 (0)         63 (1)         18 (1)         4 (2)           Blackbird Creek         24         BB1         Lower Blackbird Creek         479.72         7.42         21 (1)         15 (1)         69 (1)         20 (1)         6 (2)           Blackbird Creek         24         BB2         Middle Blackbird Creek         5343.18         8.35         26 (2)         14 (1)         26 (0)	1	14(1)	2(0)	48 (0)	3 (0)	5 (0)	3.39	2170.47	Deep Creek	AQ1	17	Appoquinimink Creek
Image: Section of the section of th	1		7(0)	49 (0)	6 (0)	5 (0)	3.14	2009.3	Silver Lake	AQ2	18	
Image: Note of the system         Image: Note of the system	5	10(1)	23(1)	68 (1)		18 (1)	6.68	4277.63	Appo, Confluence	AQ3	19	
21       AQ5       Wiggin's Mill       2688.31       4.20       5 (0)       9 (1)       50 (1)       14(0)       5 (2)         22       AQ6       Noxontown Lake       3511.53       5.49       15 (1)       18 (1)       68 (1)       <1(0)	8								**			
22       AQ6       Noxontown Lake       3511.53       5.49       15(1)       18(1)       68(1)       <1(0)	4								· · · ·		21	
23       AQ7       Hangman's Run       2695.22       4.21       24(1)       4(0)       63(1)       18(1)       4(2)         Blackbird Creek       24       BB1       Lower Blackbird Creek       4749.72       7.42       21(1)       15(1)       69(1)       20(1)       6(2)         25       BB2       Middle Blackbird Creek       7098.01       11.09       20(1)       28(2)       70(1)       26(1)       7(2)         26       BB3       Upper Blackbird Creek       5343.18       8.35       26(2)       14(1)       26(0)       48(2)       3(2)         40       Cedar Swamp       28       CS1       Cedar Swamp       5248.13       8.20       56(2)       5(0)       81(2)       93(2)       1(2)         Smyrna River       29       SM1       Lower Smyrna       13631.39       21.30       11(1)       5(0)       46(0)       12(0)       7(2)	5				. ,				00	AQ6		
Blackbird Creek         24         BB1         Lower Blackbird Creek         4749.72         7.42         21 (1)         15 (1)         69 (1)         20 (1)         6 (2)           25         BB2         Middle Blackbird Creek         7098.01         11.09         20 (1)         28 (2)         70 (1)         26 (1)         7 (2)           26         BB3         Upper Blackbird Creek         5343.18         8.35         26 (2)         14 (1)         26 (0)         48 (2)         3 (2)           27         BB4         Fishing Creek         3445.87         5.38         75 (2)         2 (0)         85 (2)         89(2)         1 (2)           Cedar Swamp         28         CS1         Cedar Swamp         5248.13         8.20         56 (2)         5 (0)         81 (2)         93 (2)         1 (2)           Smyrna River         29         SM1         Lower Smyrna         13631.39         21.30         11 (1)         5 (0)         46 (0)         12 (0)         7 (2)	5											
25       BB2       Middle Blackbird Creek       7098.01       11.09       20(1)       28(2)       70(1)       26(1)       7(2)         26       BB3       Upper Blackbird Creek       5343.18       8.35       26(2)       14(1)       26(0)       48(2)       3(2)         27       BB4       Fishing Creek       3445.87       5.38       75(2)       2(0)       85(2)       89(2)       1(2)         Cedar Swamp       28       CS1       Cedar Swamp       5248.13       8.20       56(2)       5(0)       81(2)       93(2)       1(2)         Smyrna River       29       SM1       Lower Smyrna       13631.39       21.30       11(1)       5(0)       46(0)       12(0)       7(2)	6									BB1	24	Blackbird Creek
1       26       BB3       Upper Blackbird Creek       5343.18       8.35       26 (2)       14 (1)       26 (0)       48(2)       3 (2)         1       27       BB4       Fishing Creek       3445.87       5.38       75 (2)       2 (0)       85 (2)       89(2)       1 (2)         1       Cedar Swamp       28       CS1       Cedar Swamp       5248.13       8.20       56 (2)       5 (0)       81 (2)       93(2)       1 (2)         Smyrna River       29       SM1       Lower Smyrna       13631.39       21.30       11 (1)       5 (0)       46 (0)       12(0)       7 (2)	7									BB2		
Image: Non-State index       I	7											
Cedar Swamp         28         CS1         Cedar Swamp         5248.13         8.20         56 (2)         5 (0)         81 (2)         93 (2)         1 (2)           Smyrna River         29         SM1         Lower Smyrna         13631.39         21.30         11 (1)         5 (0)         46 (0)         12 (0)         7 (2)	8											
Smyrna River         29         SM1         Lower Smyrna         13631.39         21.30         11 (1)         5 (0)         46 (0)         12 (0)         7 (2)	8				. ,				0	CS1	28	Cedar Swamp
	3										-	
$\begin{array}{cccccccccccccccccccccccccccccccccccc$	4		, ,						,	_		
31         SM3         Lower Upper Smyrna A         7568.01         11.83         26(2)         12(1)         32(0)         26(1)         4(2)	7				~ ~ ~					-		
SO         32         SM4         Upper Smyrna A         10008.68         15.64         38(2)         19(1)         45(0)         37(2)         2(2)	7								· · · · ·			

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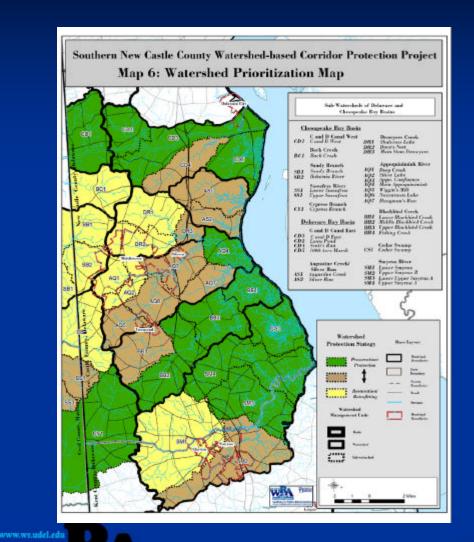
In keeping with the 0,1,2 scoring system sub-watersheds that scored a 1, 2 or 3 received a final score of 0. Sub-watersheds that scored 4, 5, or 6 received a final score of 1. Sub-watersheds that scored a 7, 8 or 9 received a final score of 2.

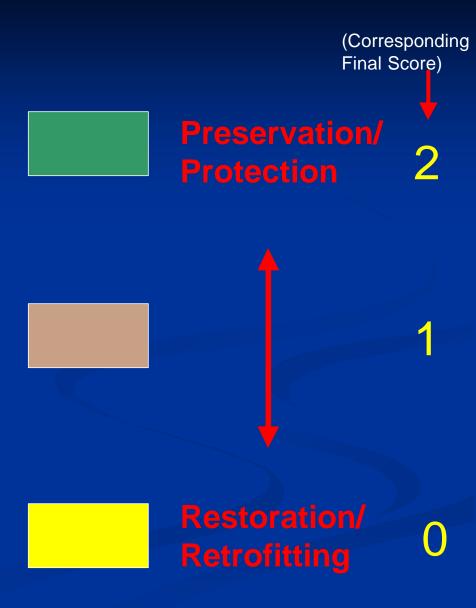


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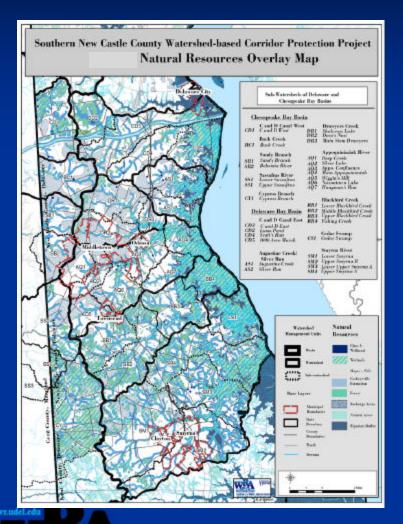
#### **MAP 6.** Watershed Preservation/Restoration Strategy







Map of Natural Resources Per Sub-watershed. The Natural Resources depicted in the map are those protected under the Unified Development Code.

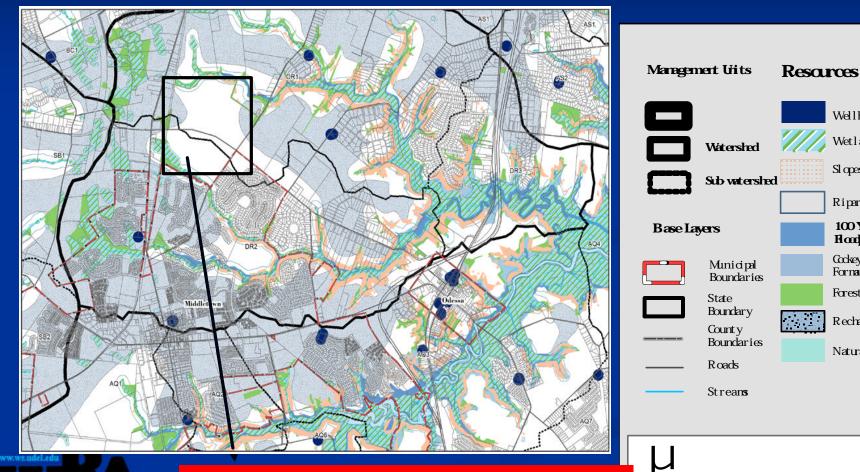


White areas on the map show locations with no restrictions on amount of impervious surface allowed.

Areas of Natural Resources have varying degrees of protection in the form of restrictions on percent of Impervious cover allowed.



Overlying parcels on Natural Resource map allows planners to view where to redirect impervious surface to protect water resources and to protect watershed from exceeding impervious cover thresholds.





Potential relocation of large Sub-division project outside of Middletown, DE. This location would best protect water resources.

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Wellhead Wetlands

Sl opes > 25%

RiparianBuffer 100 Year

Hoodain Cockeysville

Formation

Recharge Areas

Natural Areas

2 Miles

Forest

## **Strengths**

- Can be replicated with limited data needs, so that departments with limited research capabilities can duplicate
- Can test the adequacy of various natural resource regulations to see if the restrictions maintain impervious cover within a watershed below threshold
- Once sub-watersheds are created, various analysis and modeling can be conducted on these units



### Limitations

- The results are limited by the accuracy of the land use data
- Impervious cover proxy values must be calibrated for the study area
   (general values such as documented by the USDA may not work for all locations since building densities vary between municipalities)



## **Contact Information**

For information regarding this project and the methodology please contact:

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