Annual Water Budget for the Cockeysville Formation

"For the Hockessin Village Plan"

June 30, 2004

Prepared for:

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Introduction

The New Castle County Department of Land Use has retained a committee to prepare the Hockessin Village Plan, a plan designed to encourage the preservation of the town center as a compact, historic, pedestrian-oriented, and economically thriving community. The Village of Hockessin is situated over the Cockeysville Limestone Formation, an aquifer protected by the New Castle County Unified Development Code (UDC), which limits the amount of impervious cover to 20% to 50% during new development to protect the quality and quantity of recharge. The University of Delaware, Institute for Public Administration, Water Resources Agency (UDWRA) has agreed to prepare an annual water budget report for the Cockeysville Formation in the vicinity of Hockessin.

Recharge Ordinance

Since 1990, New Castle County code has included criteria to protect water resource protection areas (WRPA) such as the Cockeysville Formation during new development. The Cockeysville is a productive aquifer, the source of 1.5 mgd of public drinking water (principally to Artesian Water Company wells), yet is highly vulnerable to contamination due to the cracks and patterns of its limestone geology. The New Castle County WRPA ordinance limits the amount of impervious cover (such as roof and pavement) to 20% by right for new development in the Cockeysville Formation and Cockeysville Drainage Areas. The purpose of an impervious cover threshold is to minimize loss of recharge and protect the quality and quantity of ground and surface water supplies in the WRPAs.

New development in the Cockeysville WRPA may exceed the 20% impervious cover threshold, but be no more than 50% impervious, provided the applicant submits an environmental assessment report 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. A 2004 UDWRA report, *Delaware Ground-Water Recharge Design Manual*, recommends details on how to design recharge facilities in Delaware water resource protection areas (see www.wr.udel.edu).

Objective

The objective of this report is to prepare an annual water budget for the 1) Cockeysville Formation Outcrop and 2) the Cockeysville Formation Drainage Area to estimate groundwater recharge for existing 2004 land use conditions. This report recommends methods to augment and preserve groundwater recharge in accordance with the water budget and the water resource protection area provisions of the UDC while implementing the Hockessin Village Plan.

Prior Studies

In October 1991, the Delaware Geological Survey (DGS) issued a *Summary Report Geology and Hydrology of the Cockeysville Formation, New Castle County, Delaware*. The DGS determined the 1990 recharge from the 1.3 square mile area of the Cockeysville Formation in Hockessin to be 1.25 mgd or 456 million gallons annually. Annual precipitation measured in 1990 was above normal at 47.04 inches compared to normal precipitation measured at the University of Delaware Farm as 42.61 inches. Therefore recharge as measured in 1990 was higher than normal.

Methods

The UDWRA developed the water budget in accordance with he following methods:

1) ***Study Area*** – Delineate the study area as the Cockeysville Formation Outcrop and the Cockeysville Drainage Area situated in and near the Village of Hockessin.

2) ***GIS Data*** – Derive the following GIS data layers necessary to conduct the water budget analysis:

- Boundaries of the Cockeysville Formation Outcrop and the Cockeysville Drainage Area (Figure 1).
- 2002 Land Use/Land Cover obtained from the Delaware DNREC (Figure 2).
- 1970 New Castle County Soil Classifications and Hydrologic Soil Groups (Figures 3 and 4).

3) ***Land Use Calculations*** – Using GIS techniques, map and calculate the area (acres and percent of area) of each of 14 land uses within the study areas. Compute the overall impervious cover for existing land uses in the study area.

4) ***Infiltration Rates*** – Using the Mather/Thornthwaite water budget approach and USDA Soil Conservation Service runoff curve number techniques, compute the annual infiltration (inches and gallons) for Hydrologic Soil Groups A, B, C, and D for the pervious land covers in the study area:

- Crops
- Grass
- Meadow/Pasture
- Woods

The following steps are used to determine infiltration rates:

- *Precipitation (P)*: Use mean monthly precipitation data (1971 – 2000) for the University of Delaware weather stations in Newark, Delaware obtained from the Office of the State Climatologist at the University of Delaware, Department of Geography.

- *Runoff Coefficient (RC)*: Estimate using the USDA-NRCS Curve Number method. Consult the USDA –SCS Soil Surveys for New Castle County, Kent County, or Sussex County, Delaware to determine Hydrologic Soil Groups A, B, C, or D which underlay the various land cover types.

- *Runoff (RO)*: Multiply Precipitation (P) by Runoff Coefficient (RC)

- *Infiltration (I)*: Precipitation (P) minus Runoff (RO)

- *Potential Evapotranspiration (PET)*: Use recommended monthly PET values for the State of Delaware provided by the State Climatologist.

- *Infiltration Minus Potential Evapotranspiration (I-PET*): Subtract PET from I.

- *Cumulative Water Loss (CWL)*: Calculate CWL by adding the current month's I-PET value to the previous month's CWL, starting in the month with the first negative I-PET value and ending in the last month with a negative I-PET value. Use zero for months that have a positive I-PET value.

- *Soil Moisture Storage Capacity (ST)*: Table 1 summarizes ST for various land covers depending on hydrologic soil group. In months where P – PET is negative, estimates of ST may be obtained from Thornthwaite and Mather, Tables 11 through 22 for a given PET. Where P – PET is positive, use the Thornthwaite and Mather tabular ST values for each month found below in Table 1.

Table 1. Recommended Soil Moisture Storage Capacity for Land Covers in Delaware.

Land Cover	HSG A	HSG B	HSG C	HSG D
Crops	10 in	8 in	5 in	3 in
Grass	12	10	8	5
Meadow/Pasture	14	12	10	8
Woods	16	16	14	12

- *Cumulative Change in ST*: Beginning in months where negative I – PET occurs, subtract Soil Moisture Storage Capacity from the ST of the preceding month.

- *Actual Evapotranspiration (AET)*: Where Precipitation (P) is greater than the Potential Evapotranspiration (PET), the soil remains full of water and the AET will equal the PET. When the precipitation drops below the Potential Evapotranspiration, the soil begins to dry out and the AET equals the P minus RO minus the change in ST.

- *Percolation*: Equals the I – PET minus the change in ST. In months where I – PET is negative, the Percolation is zero.

5) ***Recharge Volume*** – Compute the annual recharge volume (acre-inches and gallons) and composite % impervious cover for the existing 2004 land use scenario.

6) ***Recharge Best Management Practices*** – Recommend BMPs that would enable the Hockessin Village Plan to preserve existing recharge and comply with the provisions of the 2004 water budget and the New Castle County Unified Development Code.

Figure 1. Study Area Delineating Cockeysville Formation (light blue) and Cockeysville Formation Drainage Area (red).

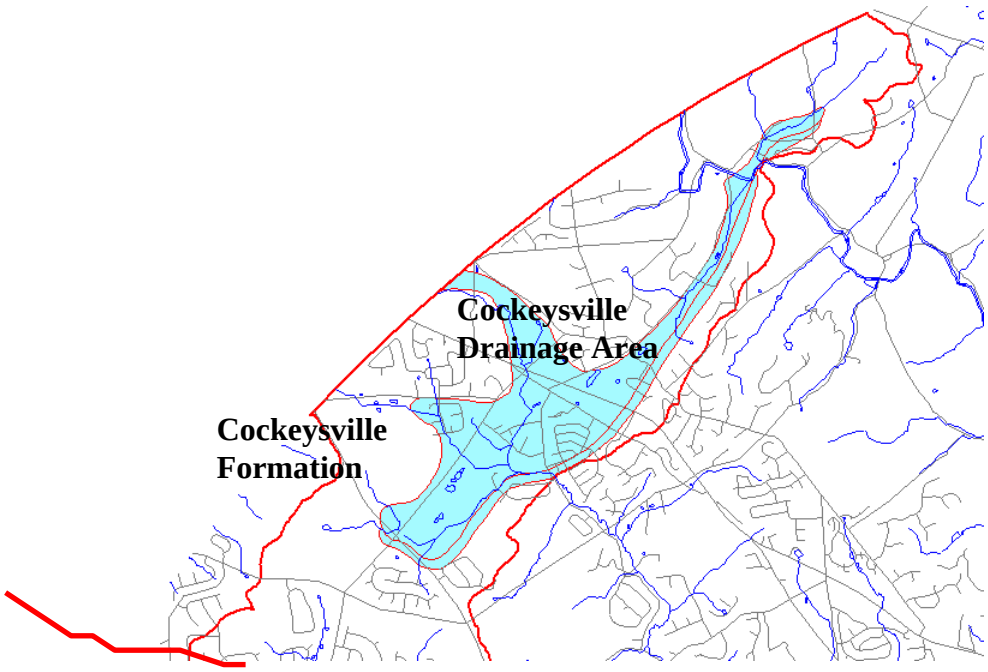


Figure 2. Land Use in the Vicinity of the Cockeysville Formation in Hockessin, Delaware.

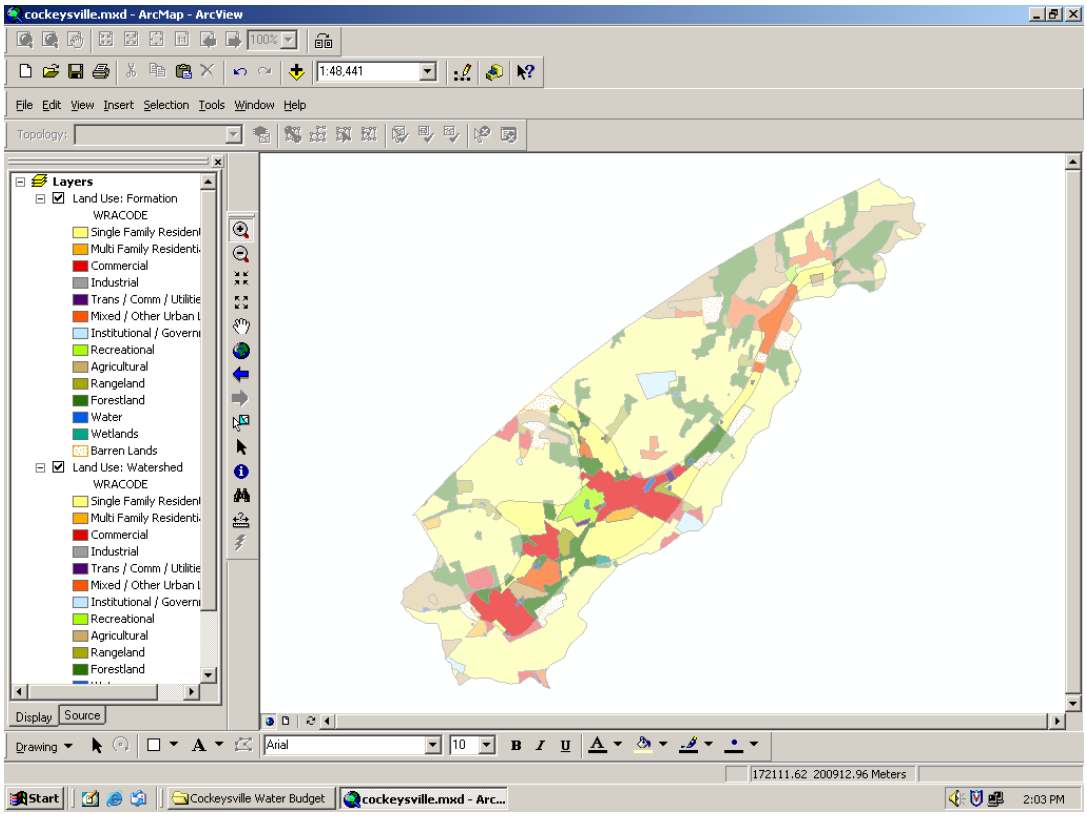


Figure 3. Hydrologic Soil Groups in the Cockeysville Formation in Hockessin, Delaware.

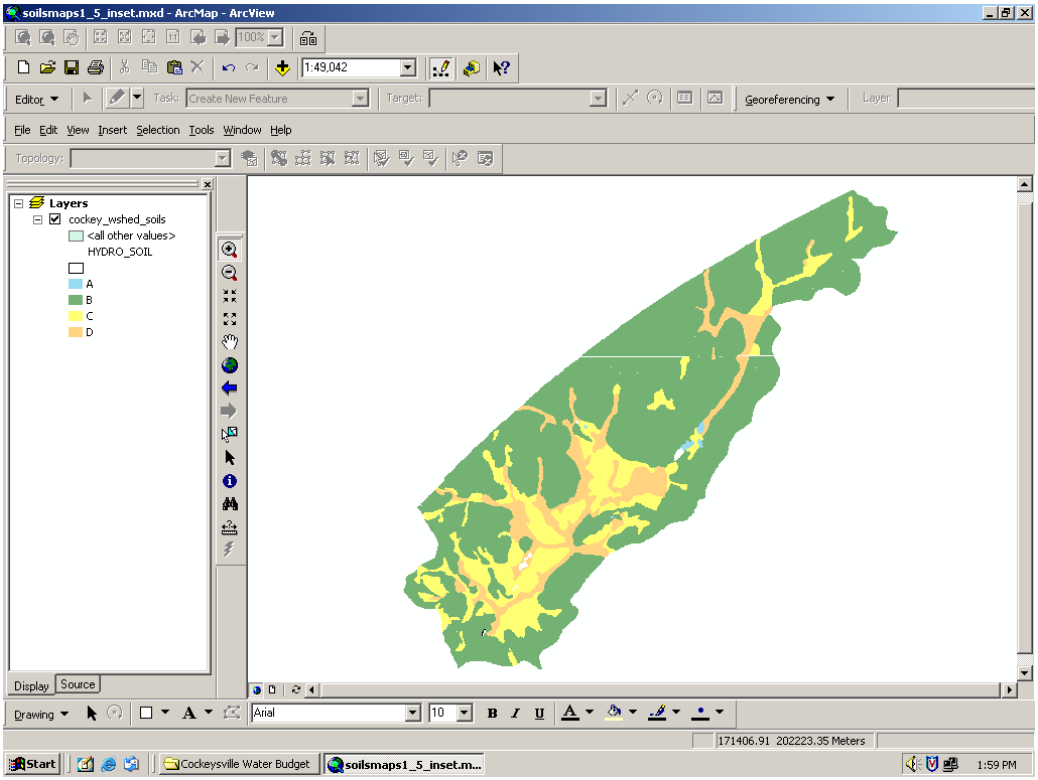
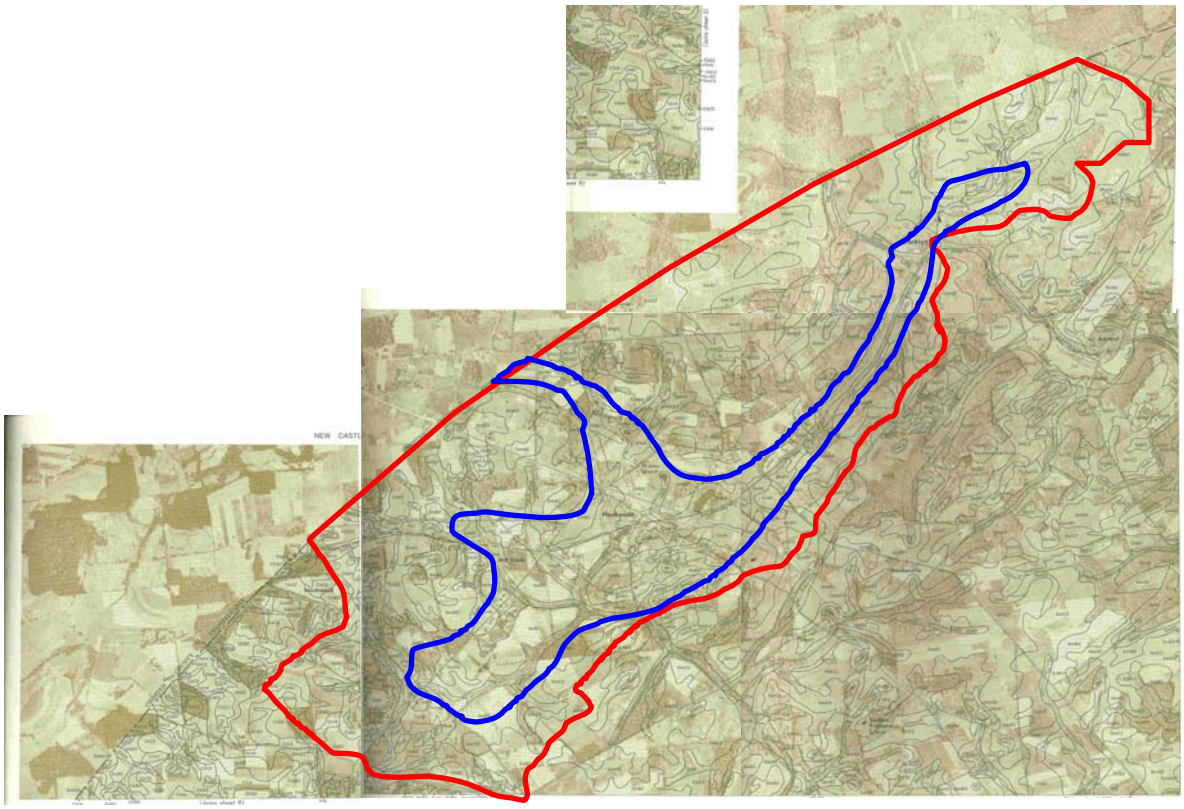


Figure 4. Soil Classification Mapping in the Cockeysville Formation in Hockessin, Delaware



Results

1) ***Land Use Calculations*** – Based on GIS calculations using 2002 land use data, the area of the Cockeysville Formation is 802 acres or 1.25 square miles with an impervious cover ratio of 41.3 %. The Cockeysville Drainage Area is 3516 acres or 5.5 square miles with an impervious cover of 29.1 %. Appendix A includes the tabulation of land use area and impervious cover for the Cockeysville Formation and Cockeysville Drainage Area.

2) ***Infiltration*** – Table 2 summarizes the annual infiltration volume for pervious land cover groups. Appendix B contains the annual water budget calculations of infiltration volume.

Table 2. Infiltration Volume for Pervious Land Cover Based on Hydrologic Soil Groups.

Land Cover	HSG A	HSG B	HSG C	HSG D
Crops	14.43 in	14.79 in	14.33 in	13. 38 in
Grass	12.56	15.33	11.76	11.76
Meadow/Pasture	17.18	16.92	16.65	16.39
Woods	13.57	13.37	13.17	12.97

3) ***Annual Recharge Volume*** – The annual recharge volume for the Cockeysville Formation is 6,207 ac-in or 169 million gallons. The annual recharge volume for the Cockeysville Drainage Area is 36,180 ac-in or 982 million gallons. Appendix C contains the calculations of the annual recharge volume. Table 3 summarizes the land use and recharge volume statistics for the Cockeysville Formation and Cockeysville Drainage Area.

Table 3. Land Use and Recharge Volume Statistics for the Cockeysville Formation and the Cockeysville Formation Drainage Area.

Cockeysville	Area Acres/sq mi	Impervious Cover	Annual Recharge (mg)	Daily Recharge (mgd)	Recharge per Area (mgd/sq. mi)
Formation	802/1.25	41.3 %	169	0.46	0.37
Drainage Area	3516/5.5	29.1 %	982	2.69	0.49

Conclusions/Recommendations

1) ***Impervious cover*** – The existing (2004) impervious cover ratios of the Cockeysville Formation and Cockeysville Drainage Areas are 41.3% and 29.1%, respectively. These ratios exceed the New Castle County UDC threshold of 20% impervious cover by right for new development in the Cockeysville WRPAs. But the ratios are less than the 50% impervious threshold permitted by the UDC provided the new development incorporates recharge facilities.

2) ***Recharge Volume*** – The existing annual recharge to the Cockeysville Formation and Cockeysville Drainage Area are 169 mg and 982 mg, respectively. Existing recharge to the Cockeysville should be preserved at these levels by following a recharge philosophy and incorporating recharge best management practices as described below.

3) ***Recharge Philosophy*** – The Hockessin Village Plan should strive to protect the quality and quality of ground and surface waters in the Cockeysville Formation and Drainage Area WRPAs through the following water resource protection area hierarchy (ranked in order of preference):

a) Preserve WRPAs as open space and parks by acquisition or conservation easement.

b) Limit impervious cover of new development to 20 % by right within WRPAs.

c) Allow impervious cover of new development to exceed 20% within WRPAs (but no more than 50%) provided the applicant develops recharge facilities that directly infiltrate rooftop runoff.

d) Allow impervious cover of new development to exceed 20% within WRPAs (but no more than 50% impervious) provided the applicant develops recharge facilities that infiltrate stormwater runoff from forested and/or grassed surfaces.

4) ***Recharge BMPs*** – The following Recharge BMPSs are recommended to infiltrate runoff from rooftop areas during the implementation of the Hockessin Village Plan.

a) *Rain barrels* – Connected to downspouts. Can hold 50 to 60 gallons of rainwater for irrigation of gardens and landscaping.

b) *Disconnect downspouts* – By disconnecting downspouts to splash rainwater to pervious lawn surfaces, up to 30% of runoff from a building site can be recharged.

c) *Infiltration basins* – Open air, usually to collect runoff from a larger regional network.

d) *Bioretention swale* – Known as rain gardens, these are permeable, sand filled landscaped areas that are planted with native shrubs and trees.

e) *Infiltration trenches* – Underground, usually to collect runoff from a smaller, constrained site.

f) *Dry wells or galleries* – Underground, usually to infiltrate runoff from individual buildings.

g) *Infiltration swales* – Grass lined swales used to convey and infiltrate runoff along the perimeter of properties and pavement edges.

h) *Porous pavement* – Suitable for low traffic areas. Types are permeable asphalt, paver blocks, and hybrid grass-concrete blocks

The following types of pretreatment facilities are recommended to cleanse runoff from non-rooftop areas such a pavements and lawns into recharge facilities:

a) *Forebays* – Excavated areas along swales that store and treat runoff.

b) *Vegetative Filter Strips* – Turf lined areas designed to treat overland runoff.

c) *Water Quality Inlets* – Traps in stormwater inlets designed to remove grease, oil, and sediment.

d) Wet Extended Detention Ponds/Stormwater Wetlands

5) ***Recharge Design Criteria*** –Ground-water recharge facilities are designed to augment infiltration and offset increased impervious cover from new development in recharge and wellhead areas. Recharge basin design should be based on the following criteria:

a) *Soil Permeability* – Underlying soils shall have sufficient permeability to infiltrate the runoff volume from a 2- year storm within 48 hours. This is to allow drying of soils and empty the facility before the next precipitation event, which in Delaware occurs once every five days on the average. Soil permeability tests shall be conducted at locations of the recharge facilities.

b) *Volume* – Recharge facilities shall have sufficient volume to infiltrate runoff from a 2-year, 24-hour storm (3.2 inches in Delaware).

c) *Depth to ground water* – The bottom of the recharge facility should be at least three feet above the seasonal high ground-water table to prevent ground-water mounding.

d) *Side slopes* – Maximum sideslopes of recharge basins should be 4 ft horizontal to 1 ft vertical.

Further guidance on the design of recharge facilities can be sought from the references listed herein.

6) ***Design Calculations –*** The following methodology is recommended for the design of ground-water recharge facilities:

a) Assume an underlying infiltration rate for design that is greater than or equal to 1.0 in./hr. (2 ft/day). This assumed infiltration rate would drain a 4 feet deep recharge facility within the recommended 48 hours. The soil infiltration rate should be based on the results of field permeability testing conducted at the site of the proposed recharge facility.

b) Determine the rooftop area required to collect enough rainfall to offset the annual loss of recharge due to development. Therefore, the Required Rooftop Area (RFA) = Net Recharge Loss/Annual Precipitation (% Annual Precipitation not Evaporated). Approximately 90% of the annual precipitation is assumed not to be evaporated.

c) Determine the dimensions of the recharge system required to store the 2 –year storm runoff volume. For a rooftop runoff system the 2-year runoff volume is equal to the rooftop area multiplied by the 2-year, 24 –hour storm runoff depth which is 3.2 inches in Delaware. Once the 2-year storm runoff volume is determined, calculate the required dimensions of the recharge facility as the: length, width and depth for an open air recharge facility, or length, width and depth multiplied by the void ratio for a stone trench system, or combination of pipe volume and stone volume for a perforated pipe trench system.

d) Check the time required top drain the system based on the assumed infiltration design rate and the 2-year ponding depth in the system. The recharge facility should be designed to drain within 48 hours after a 2-year storm.

e) Design an overflow or bypass system so that storm events larger than the 2-year storm can be safely passed by the recharge facility.

Figure 5. Typical Infiltration Basin

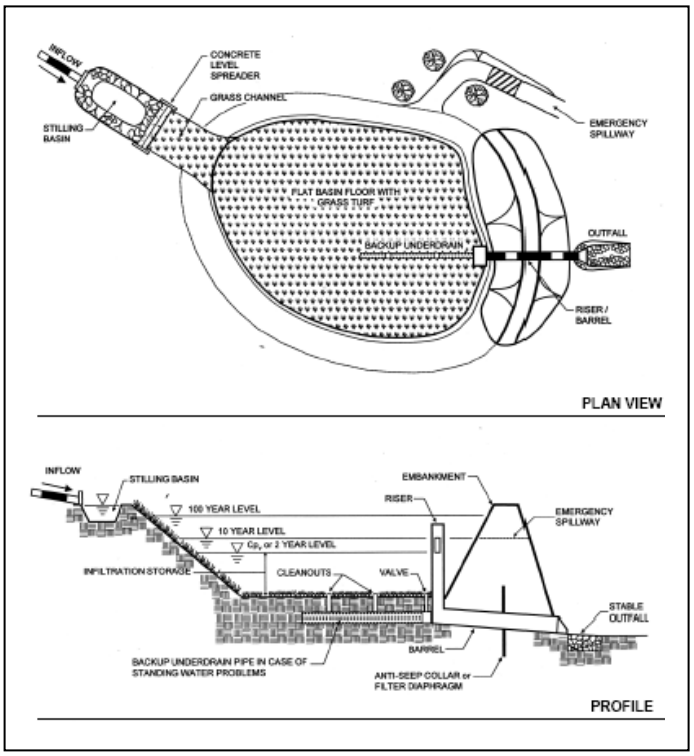


Figure 6. Typical Infiltration Trench.

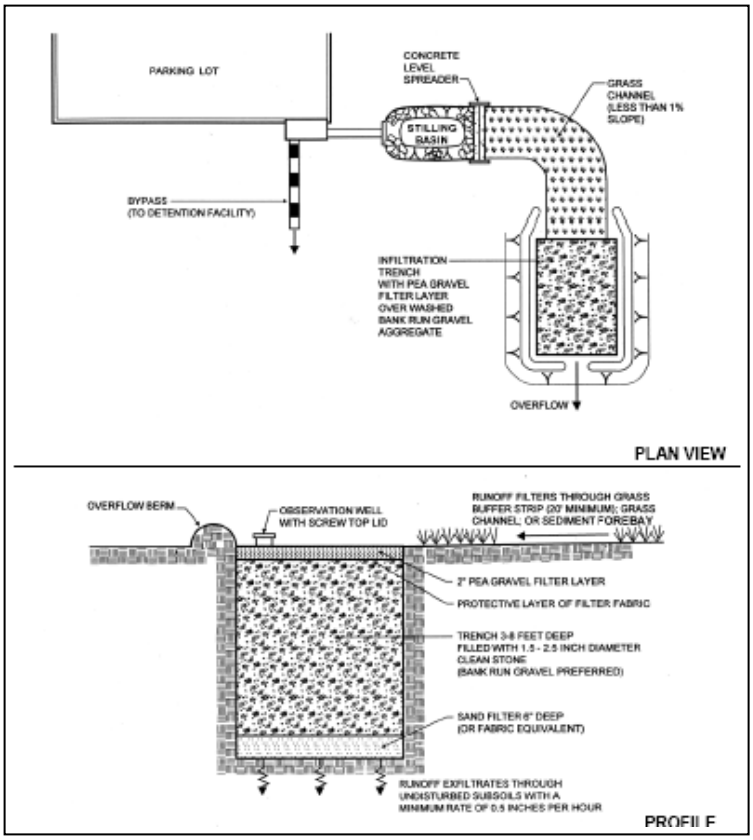


Figure 7. Typical Stormwater Wetland.

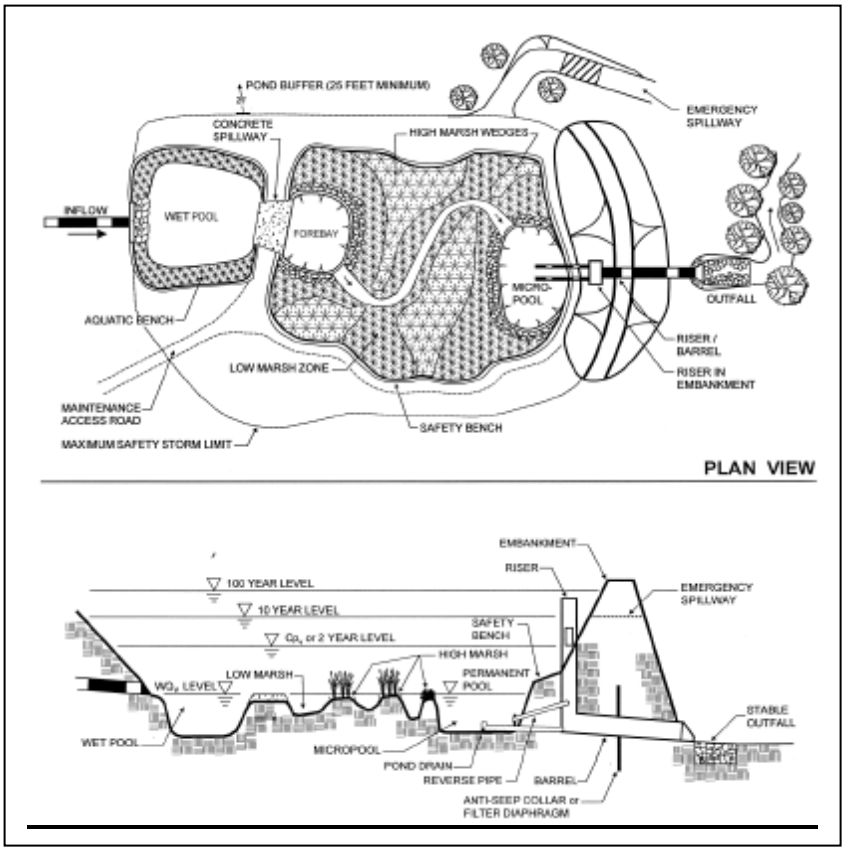
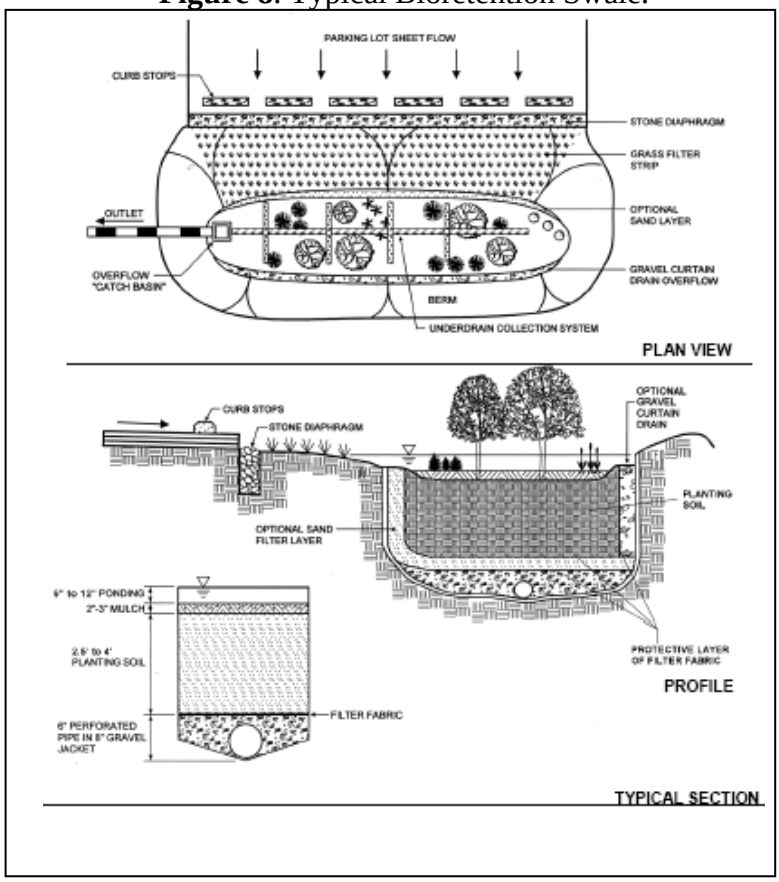


Figure 8. Typical Bioretention Swale.



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Appendix A-1. Cockeysville Formation Land Use and Impervious Cover Tabulation**.**

Cockeysville Formation			**801.81**	**41.3%**	**331.15**
#	***Percent of Area***	***Land Use Classification***	***Land Use Area (ac)***	***Impervious Coefficient***	***Impervious Area (ac)***
1	37.5%	Single Family Residential	300.63	30%	90.19
2	1.4%	Multi Family Residential	10.98	65%	7.13
3	24.4%	Commercial	195.28	85%	165.98
4	0.0%	Industrial	0.00	72%	0.00
5	0.6%	Transp., Comm., and Utilities	4.88	90%	4.39
6	8.7%	Mixed / Other Urban Land	69.74	85%	59.28
7	0.0%	Institutional / Governmental	0.00	55%	0.00
8	4.4%	Recreational	35.16	5%	1.76
9	2.5%	Agriculture	20.44	5%	1.02
10	2.2%	Rangeland	17.96	0%	0.00
11	13.1%	Forestland	105.29	0%	0.00
12	1.1%	Water	8.64	0%	0.00
13	0.6%	Wetlands	5.00	0%	0.00
14	3.5%	Barren Lands	27.82	5%	1.39

Appendix A-2. Cockeysville Drainage Area Land Use and Impervious Cover Tabulation**.**

Cockeysville Drainage Area			**3,514.60**	**29.1%**	**1,022.24**
#	***Percent of Watershed Area***	***Land Use Classification***	***Land Use Area (ac)***	***Impervious Coefficient***	***Impervious Area (ac)***
1	55.6%	Single Family Residential	1,955.35	30%	586.60
2	0.7%	Multi Family Residential	26.10	65%	16.97
3	7.7%	Commercial	270.77	85%	230.16
4	0.0%	Industrial	0.00	72%	0.00
5	0.2%	Transp., Comm., and Utilities	6.97	90%	6.27
6	4.5%	Mixed / Other Urban Land	156.67	85%	133.17
7	1.3%	Institutional / Governmental	45.24	55%	24.88
8	1.2%	Recreational	42.34	5%	2.12
9	9.4%	Agriculture	328.77	5%	16.44
10	1.6%	Rangeland	56.42	0%	0.00
11	14.1%	Forestland	494.42	0%	0.00
12	0.4%	Water	12.75	0%	0.00
13	0.2%	Wetlands	5.93	0%	0.00
14	3.2%	Barren Lands	112.87	5%	5.64

Appendix B. Calculation of Infiltration Volume for Pervious Land Uses.

04-Jun-04

Climatic Water Balance for Meadow in Soil Group A

Soil Moisture Storage = 14 in

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Precip (P) *Table 1*	2.98	2.73	3.26	3.49	4.15	3.85	4.52	4.00	3.68	3.17	3.28	3.50	42.61
Runoff Coeff. (RC) *Table 2*	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	
Runoff (RO) (RC x P)	0.03	0.03	0.03	0.03	0.04	0.04	0.05	0.04	0.04	0.03	0.03	0.04	
Infiltration (I) (= P - RO)	2.95	2.70	3.23	3.46	4.11	3.81	4.47	3.96	3.64	3.14	3.25	3.47	
PET *Table 5*	0.00	0.00	0.62	2.00	3.72	5.25	6.10	5.31	3.74	2.02	0.75	0.00	
I-PET	2.95	2.70	2.61	1.46	0.39	-1.44	-1.63	-1.35	-0.10	1.12	2.50	3.47	
CWL	0.00	0.00	0.00	0.00	0.00	-1.44	-3.06	-4.41	-4.51	0.00	0.00	0.00	
ST (T & M table 19)	14.00	14.00	14.00	14.00	14.00	9.62	9.05	9.57	10.71	14.00	14.00	14.00	
Ch ST	0.00	0.00	0.00	0.00	0.00	-4.38	-0.57	0.52	1.14	0.00	0.00	0.00	
AET	0.00	0.00	0.62	2.00	3.72	8.19	5.04	3.44	2.50	2.02	0.75	0.00	28.29
PERC	2.95	2.70	2.61	1.46	0.39	0.00	0.00	0.00	0.00	1.12	2.50	3.47	17.18

Climatic Water Balance for Woods in Soil Group A

Soil Moisture Storage = 16 in

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Precip (P) *Table 1*	2.98	2.73	3.26	3.49	4.15	3.85	4.52	4.00	3.68	3.17	3.28	3.50	42.61
Runoff Coeff. (RC) *Table 2*	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	
Runoff (RO) (RC x P)	0.03	0.03	0.03	0.03	0.04	0.04	0.05	0.04	0.04	0.03	0.03	0.04	
Infiltration (I) (= P - RO)	2.95	2.70	3.23	3.46	4.11	3.81	4.47	3.96	3.64	3.14	3.25	3.47	
PET *Table 5*	0.00	0.00	0.62	2.00	3.72	5.25	6.10	5.31	3.74	2.02	0.75	0.00	
I-PET	2.95	2.70	2.61	1.46	0.39	-1.44	-1.63	-1.35	-0.10	1.12	2.50	3.47	
CWL	0.00	0.00	0.00	0.00	0.00	-1.44	-3.06	-4.41	-4.51	0.00	0.00	0.00	
ST (T & M table 18)	16.00	16.00	16.00	16.00	16.00	11.52	10.92	11.47	12.65	16.00	16.00	16.00	
Ch ST	0.00	0.00	0.00	0.00	0.00	-4.48	-0.60	0.55	1.18	3.35	0.00	0.00	
AET	0.00	0.00	0.62	2.00	3.72	8.29	5.07	3.41	2.46	2.02	0.75	0.00	28.35
PERC	2.95	2.70	2.61	1.46	0.39	0.00	0.00	0.00	0.00	0.00	0.00	3.47	13.57

AET: Where P > PET, AET = PET

Where P< PET, AET = P - RO minus Ch ST

PERC: If I - PET < 0, than PERC = O

If I - PET > 0, than PERC = I - PET - Ch ST

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Climatic Water Balance for Crops in Soil Group B

Soil Moisture Storage = 8 in

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Precip (P) *Table 1*	2.98	2.73	3.26	3.49	4.15	3.85	4.52	4.00	3.68	3.17	3.28	3.50	42.61
Runoff Coeff. (RC) *Table 2*	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	
Runoff (RO) (RC x P)	0.30	0.27	0.33	0.35	0.42	0.39	0.45	0.40	0.37	0.32	0.33	0.35	
Infiltration (I) (= P - RO)	2.68	2.46	2.93	3.14	3.74	3.47	4.07	3.60	3.31	2.85	2.95	3.15	
PET *Table 5*	0.00	0.00	0.62	2.00	3.72	5.25	6.10	5.31	3.74	2.02	0.75	0.00	
I-PET	2.68	2.46	2.31	1.14	0.02	-1.79	-2.03	-1.71	-0.43	0.83	2.20	3.15	
CWL	0.00	0.00	0.00	0.00	0.00	-1.79	-3.82	-5.53	-5.96	0.00	0.00	0.00	
ST (T & M table 19)	8.00	8.00	8.00	8.00	8.00	4.14	3.72	4.11	5.00	8.00	8.00	8.00	
Ch ST	0.00	0.00	0.00	0.00	0.00	-3.86	-0.42	0.39	0.89	0.00	0.00	0.00	
AET	0.00	0.00	0.62	2.00	3.72	7.33	4.49	3.21	2.42	2.02	0.75	0.00	26.56
PERC	2.68	2.46	2.31	1.14	0.02	0.00	0.00	0.00	0.00	0.83	2.20	3.15	14.79

Climatic Water Balance for Grass in Soil Group B

Soil Moisture Storage = 10 in

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Precip (P) *Table 1*	2.98	2.73	3.26	3.49	4.15	3.85	4.52	4.00	3.68	3.17	3.28	3.50	42.61
Runoff Coeff. (RC) *Table 2*	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	
Runoff (RO) (RC x P)	0.24	0.22	0.26	0.28	0.33	0.31	0.36	0.32	0.29	0.25	0.26	0.28	
Infiltration (I) (= P - RO)	2.74	2.51	3.00	3.21	3.82	3.54	4.16	3.68	3.39	2.92	3.02	3.22	
PET *Table 5*	0.00	0.00	0.62	2.00	3.72	5.25	6.10	5.31	3.74	2.02	0.75	0.00	
I-PET	2.74	2.51	2.38	1.21	0.10	-1.71	-1.94	-1.63	-0.35	0.90	2.27	3.22	
CWL	0.00	0.00	0.00	0.00	0.00	-1.71	-3.65	-5.28	-5.63	0.00	0.00	0.00	
ST (T & M table 18)	10.00	10.00	10.00	10.00	10.00	5.94	5.46	5.91	6.91	10.00	10.00	10.00	
Ch ST	0.00	0.00	0.00	0.00	0.00	-4.06	-0.48	0.45	1.00	0.00	0.00	0.00	
AET	0.00	0.00	0.62	2.00	3.72	7.60	4.64	3.23	2.39	2.02	0.75	0.00	26.97
PERC	2.74	2.51	2.38	1.21	0.10	0.00	0.00	0.00	0.00	0.90	2.27	3.22	15.33

AET: Where P > PET, AET = PET

Where P< PET, AET = P - RO minus Ch ST

PERC: If I - PET < 0, than PERC = O

If I - PET > 0, than PERC = I - PET - Ch ST

Hockessin Village Plan

4-Jun-04

Climatic Water Balance for Meadow in Soil Group B

Soil Moisture Storage = 12in

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Precip (P) *Table 1*	2.98	2.73	3.26	3.49	4.15	3.85	4.52	4.00	3.68	3.17	3.28	3.50	42.61
Runoff Coeff. (RC) *Table 2*	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	
Runoff (RO) (RC x P)	0.06	0.05	0.07	0.07	0.08	0.08	0.09	0.08	0.07	0.06	0.07	0.07	
Infiltration (I) (= P - RO)	2.92	2.68	3.19	3.42	4.07	3.77	4.43	3.92	3.61	3.11	3.21	3.43	
PET *Table 5*	0.00	0.00	0.62	2.00	3.72	5.25	6.10	5.31	3.74	2.02	0.75	0.00	
I-PET	2.92	2.68	2.57	1.42	0.35	-1.48	-1.67	-1.39	-0.13	1.09	2.46	3.43	
CWL	0.00	0.00	0.00	0.00	0.00	-1.48	-3.15	-4.54	-4.67	0.00	0.00	0.00	
ST (T & M table 19)	12.00	12.00	12.00	12.00	12.00	7.74	7.21	7.71	8.78	12.00	12.00	12.00	
Ch ST	0.00	0.00	0.00	0.00	0.00	-4.26	-0.53	0.50	1.07	0.00	0.00	0.00	
AET	0.00	0.00	0.62	2.00	3.72	8.03	4.96	3.42	2.54	2.02	0.75	0.00	28.06
PERC	2.92	2.68	2.57	1.42	0.35	0.00	0.00	0.00	0.00	1.09	2.46	3.43	16.92

Climatic Water Balance for Woods in Soil Group B

Soil Moisture Storage = 16 in

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Precip (P) *Table 1*	2.98	2.73	3.26	3.49	4.15	3.85	4.52	4.00	3.68	3.17	3.28	3.50	42.61
Runoff Coeff. (RC) *Table 2*	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	
Runoff (RO) (RC x P)	0.06	0.05	0.07	0.07	0.08	0.08	0.09	0.08	0.07	0.06	0.07	0.07	
Infiltration (I) (= P - RO)	2.92	2.68	3.19	3.42	4.07	3.77	4.43	3.92	3.61	3.11	3.21	3.43	
PET *Table 5*	0.00	0.00	0.62	2.00	3.72	5.25	6.10	5.31	3.74	2.02	0.75	0.00	
I-PET	2.92	2.68	2.57	1.42	0.35	-1.48	-1.67	-1.39	-0.13	1.09	2.46	3.43	
CWL	0.00	0.00	0.00	0.00	0.00	-1.48	-3.15	-4.54	-4.67	0.00	0.00	0.00	
ST (T & M table 18)	16.00	16.00	16.00	16.00	16.00	11.52	10.92	11.47	12.65	16.00	16.00	16.00	
Ch ST	0.00	0.00	0.00	0.00	0.00	-4.48	-0.60	0.55	1.18	3.35	0.00	0.00	
AET	0.00	0.00	0.62	2.00	3.72	8.25	5.03	3.37	2.43	2.02	0.75	0.00	28.19
PERC	2.92	2.68	2.57	1.42	0.35	0.00	0.00	0.00	0.00	0.00	0.00	3.43	13.37

AET: Where P > PET, AET = PET

Where P< PET, AET = P - RO minus Ch ST

PERC: If I - PET < 0, than PERC = O

If I - PET > 0, than PERC = I - PET - Ch ST

Hockessin Village Plan

4-Jun-04

Climatic Water Balance for Crops in Soil Group C

Soil Moisture Storage = 5 in

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Precip (P) *Table 1*	2.98	2.73	3.26	3.49	4.15	3.85	4.52	4.00	3.68	3.17	3.28	3.50	42.61
Runoff Coeff. (RC) *Table 2*	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	
Runoff (RO) (RC x P)	0.36	0.33	0.39	0.42	0.50	0.46	0.54	0.48	0.44	0.38	0.39	0.42	
Infiltration (I) (= P - RO)	2.62	2.40	2.87	3.07	3.65	3.39	3.98	3.52	3.24	2.79	2.89	3.08	
PET *Table 5*	0.00	0.00	0.62	2.00	3.72	5.25	6.10	5.31	3.74	2.02	0.75	0.00	
I-PET	2.62	2.40	2.25	1.07	-0.07	-1.86	-2.12	-1.79	-0.50	0.77	2.14	3.08	
CWL	0.00	0.00	0.00	0.00	0.00	-1.86	-3.98	-5.77	-6.28	0.00	0.00	0.00	
ST (T & M table 19)	5.00	5.00	5.00	5.00	5.00	1.72	1.44	1.70	2.33	5.00	5.00	5.00	
Ch ST	0.00	0.00	0.00	0.00	0.00	-3.28	-0.28	0.26	0.63	0.00	0.00	0.00	
AET	0.00	0.00	0.62	2.00	3.72	6.67	4.26	3.26	2.61	2.02	0.75	0.00	25.90
PERC	2.62	2.40	2.25	1.07	0.00	0.00	0.00	0.00	0.00	0.77	2.14	3.08	14.33

Climatic Water Balance for Grass in Soil Group C

Soil Moisture Storage = 8 in

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Precip (P) *Table 1*	2.98	2.73	3.26	3.49	4.15	3.85	4.52	4.00	3.68	3.17	3.28	3.50	42.61
Runoff Coeff. (RC) *Table 2*	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	
Runoff (RO) (RC x P)	0.30	0.27	0.33	0.35	0.42	0.39	0.45	0.40	0.37	0.32	0.33	0.35	
Infiltration (I) (= P - RO)	2.68	2.46	2.93	3.14	3.74	3.47	4.07	3.60	3.31	2.85	2.95	3.15	
PET *Table 5*	0.00	0.00	0.62	2.00	3.72	5.25	6.10	5.31	3.74	2.02	0.75	0.00	
I-PET	2.68	2.46	2.31	1.14	0.02	-1.79	-2.03	-1.71	-0.43	0.83	2.20	3.15	
CWL	0.00	0.00	0.00	0.00	0.00	-1.79	-3.82	-5.53	-5.96	0.00	0.00	0.00	
ST (T & M table 18)	8.00	8.00	8.00	8.00	8.00	4.14	3.72	4.11	5.00	8.00	8.00	8.00	
Ch ST	0.00	0.00	0.00	0.00	0.00	-3.86	-0.42	0.39	0.89	3.00	0.00	0.00	
AET	0.00	0.00	0.62	2.00	3.72	7.33	4.49	3.21	2.42	2.02	0.75	0.00	26.56
PERC	2.68	2.46	2.31	1.14	0.02	0.00	0.00	0.00	0.00	0.00	0.00	3.15	11.76

AET: Where P > PET, AET = PET

Where P< PET, AET = P - RO minus Ch ST

PERC: If I - PET < 0, than PERC = O

If I - PET > 0, than PERC = I - PET - Ch ST

Hockessin Village Plan

4-Jun-04

Climatic Water Balance for Meadow in Soil Group C

Soil Moisture Storage = 10 in

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Precip (P) *Table 1*	2.98	2.73	3.26	3.49	4.15	3.85	4.52	4.00	3.68	3.17	3.28	3.50	42.61
Runoff Coeff. (RC) *Table 2*	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	
Runoff (RO) (RC x P)	0.09	0.08	0.10	0.10	0.12	0.12	0.14	0.12	0.11	0.10	0.10	0.11	
Infiltration (I) (= P - RO)	2.89	2.65	3.16	3.39	4.03	3.73	4.38	3.88	3.57	3.07	3.18	3.40	
PET *Table 5*	0.00	0.00	0.62	2.00	3.72	5.25	6.10	5.31	3.74	2.02	0.75	0.00	
I-PET	2.89	2.65	2.54	1.39	0.31	-1.52	-1.72	-1.43	-0.17	1.05	2.43	3.40	
CWL	0.00	0.00	0.00	0.00	0.00	-1.52	-3.23	-4.66	-4.83	0.00	0.00	0.00	
ST (T & M table 19)	10.00	10.00	10.00	10.00	10.00	5.94	5.46	5.91	6.91	10.00	10.00	10.00	
Ch ST	0.00	0.00	0.00	0.00	0.00	-4.06	-0.48	0.45	1.00	0.00	0.00	0.00	
AET	0.00	0.00	0.62	2.00	3.72	7.79	4.86	3.43	2.57	2.02	0.75	0.00	27.77
PERC	2.89	2.65	2.54	1.39	0.31	0.00	0.00	0.00	0.00	1.05	2.43	3.40	16.65

Climatic Water Balance for Woods in Soil Group C

Soil Moisture Storage = 14 in

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Precip (P) *Table 1*	2.98	2.73	3.26	3.49	4.15	3.85	4.52	4.00	3.68	3.17	3.28	3.50	42.61
Runoff Coeff. (RC) *Table 2*	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	
Runoff (RO) (RC x P)	0.09	0.08	0.10	0.10	0.12	0.12	0.14	0.12	0.11	0.10	0.10	0.11	
Infiltration (I) (= P - RO)	2.89	2.65	3.16	3.39	4.03	3.73	4.38	3.88	3.57	3.07	3.18	3.40	
PET *Table 5*	0.00	0.00	0.62	2.00	3.72	5.25	6.10	5.31	3.74	2.02	0.75	0.00	
I-PET	2.89	2.65	2.54	1.39	0.31	-1.52	-1.72	-1.43	-0.17	1.05	2.43	3.40	
CWL	0.00	0.00	0.00	0.00	0.00	-1.52	-3.23	-4.66	-4.83	0.00	0.00	0.00	
ST (T & M table 18)	14.00	14.00	14.00	14.00	14.00	9.62	9.05	9.57	10.71	14.00	14.00	14.00	
Ch ST	0.00	0.00	0.00	0.00	0.00	-4.38	-0.57	0.52	1.14	3.29	0.00	0.00	
AET	0.00	0.00	0.62	2.00	3.72	8.11	4.95	3.36	2.43	2.02	0.75	0.00	27.97
PERC	2.89	2.65	2.54	1.39	0.31	0.00	0.00	0.00	0.00	0.00	0.00	3.40	13.17

AET: Where P > PET, AET = PET

Where P< PET, AET = P - RO minus Ch ST

PERC: If I - PET < 0, than PERC = O

If I - PET > 0, than PERC = I - PET - Ch ST

Hockessin Village Plan

4-Jun-04

Climatic Water Balance for Crops in Soil Group D

Soil Moisture Storage = 3 in

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Precip (P) *Table 1*	2.98	2.73	3.26	3.49	4.15	3.85	4.52	4.00	3.68	3.17	3.28	3.50	42.61
Runoff Coeff. (RC) *Table 2*	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	
Runoff (RO) (RC x P)	0.42	0.38	0.46	0.49	0.58	0.54	0.63	0.56	0.52	0.44	0.46	0.49	
Infiltration (I) (= P - RO)	2.56	2.35	2.80	3.00	3.57	3.31	3.89	3.44	3.16	2.73	2.82	3.01	
PET *Table 5*	0.00	0.00	0.62	2.00	3.72	5.25	6.10	5.31	3.74	2.02	0.75	0.00	
I-PET	2.56	2.35	2.18	1.00	-0.15	-1.94	-2.21	-1.87	-0.58	0.71	2.07	3.01	
CWL	0.00	0.00	0.00	0.00	0.00	-1.94	-4.15	-6.02	-6.60	0.00	0.00	0.00	
ST (T & M table 19)	3.00	3.00	3.00	3.00	3.00	0.49	0.36	0.48	0.83	3.00	3.00	3.00	
Ch ST	0.00	0.00	0.00	0.00	0.00	-2.51	-0.13	0.12	0.35	0.00	0.00	0.00	
AET	0.00	0.00	0.62	2.00	3.72	5.82	4.02	3.32	2.81	2.02	0.75	0.00	25.08
PERC	2.56	2.35	2.18	1.00	0.00	0.00	0.00	0.00	0.00	0.71	2.07	3.01	13.88

Climatic Water Balance for Grass in Soil Group D

Soil Moisture Storage = 5 in

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Precip (P) *Table 1*	2.98	2.73	3.26	3.49	4.15	3.85	4.52	4.00	3.68	3.17	3.28	3.50	42.61
Runoff Coeff. (RC) *Table 2*	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	
Runoff (RO) (RC x P)	0.30	0.27	0.33	0.35	0.42	0.39	0.45	0.40	0.37	0.32	0.33	0.35	
Infiltration (I) (= P - RO)	2.68	2.46	2.93	3.14	3.74	3.47	4.07	3.60	3.31	2.85	2.95	3.15	
PET *Table 5*	0.00	0.00	0.62	2.00	3.72	5.25	6.10	5.31	3.74	2.02	0.75	0.00	
I-PET	2.68	2.46	2.31	1.14	0.02	-1.79	-2.03	-1.71	-0.43	0.83	2.20	3.15	
CWL	0.00	0.00	0.00	0.00	0.00	-1.79	-3.82	-5.53	-5.96	0.00	0.00	0.00	
ST (T & M table 18)	5.00	5.00	5.00	5.00	5.00	1.72	1.44	1.70	2.33	5.00	5.00	5.00	
Ch ST	0.00	0.00	0.00	0.00	0.00	-3.28	-0.28	0.26	0.63	2.67	0.00	0.00	
AET	0.00	0.00	0.62	2.00	3.72	6.75	4.35	3.34	2.68	2.02	0.75	0.00	26.23
PERC	2.68	2.46	2.31	1.14	0.02	0.00	0.00	0.00	0.00	0.00	0.00	3.15	11.76

AET: Where P > PET, AET = PET

Where P< PET, AET = P - RO minus Ch ST

PERC: If I - PET < 0, than PERC = O

If I - PET > 0, than PERC = I - PET - Ch ST

Hockessin Village Plan

4-Jun-04

Climatic Water Balance for Meadow in Soil Group D

Soil Moisture Storage = 8 in

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Precip (P) *Table 1*	2.98	2.73	3.26	3.49	4.15	3.85	4.52	4.00	3.68	3.17	3.28	3.50	42.61
Runoff Coeff. (RC) *Table 2*	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	
Runoff (RO) (RC x P)	0.12	0.11	0.13	0.14	0.17	0.15	0.18	0.16	0.15	0.13	0.13	0.14	
Infiltration (I) (= P - RO)	2.86	2.62	3.13	3.35	3.98	3.70	4.34	3.84	3.53	3.04	3.15	3.36	
PET *Table 5*	0.00	0.00	0.62	2.00	3.72	5.25	6.10	5.31	3.74	2.02	0.75	0.00	
I-PET	2.86	2.62	2.51	1.35	0.26	-1.55	-1.76	-1.47	-0.21	1.02	2.40	3.36	
CWL	0.00	0.00	0.00	0.00	0.00	-1.55	-3.31	-4.78	-4.99	0.00	0.00	0.00	
ST (T & M table 19)	8.00	8.00	8.00	8.00	8.00	4.14	3.72	4.11	5.00	8.00	8.00	8.00	
Ch ST	0.00	0.00	0.00	0.00	0.00	-3.86	-0.42	0.39	0.89	0.00	0.00	0.00	
AET	0.00	0.00	0.62	2.00	3.72	7.56	4.76	3.45	2.64	2.02	0.75	0.00	27.52
PERC	2.86	2.62	2.51	1.35	0.26	0.00	0.00	0.00	0.00	1.02	2.40	3.36	16.39

Climatic Water Balance for Woods in Soil Group D

Soil Moisture Storage = 12 in

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Precip (P) *Table 1*	2.98	2.73	3.26	3.49	4.15	3.85	4.52	4.00	3.68	3.17	3.28	3.50	42.61
Runoff Coeff. (RC) *Table 2*	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	
Runoff (RO) (RC x P)	0.12	0.11	0.13	0.14	0.17	0.15	0.18	0.16	0.15	0.13	0.13	0.14	
Infiltration (I) (= P - RO)	2.86	2.62	3.13	3.35	3.98	3.70	4.34	3.84	3.53	3.04	3.15	3.36	
PET *Table 5*	0.00	0.00	0.62	2.00	3.72	5.25	6.10	5.31	3.74	2.02	0.75	0.00	
I-PET	2.86	2.62	2.51	1.35	0.26	-1.55	-1.76	-1.47	-0.21	1.02	2.40	3.36	
CWL	0.00	0.00	0.00	0.00	0.00	-1.55	-3.31	-4.78	-4.99	0.00	0.00	0.00	
ST (T & M table 18)	12.00	12.00	12.00	12.00	12.00	7.74	7.21	7.71	8.78	12.00	12.00	12.00	
Ch ST	0.00	0.00	0.00	0.00	0.00	-4.26	-0.53	0.50	1.07	3.22	0.00	0.00	
AET	0.00	0.00	0.62	2.00	3.72	7.96	4.87	3.34	2.46	2.02	0.75	0.00	27.74
PERC	2.86	2.62	2.51	1.35	0.26	0.00	0.00	0.00	0.00	0.00	0.00	3.36	12.97

AET: Where P > PET, AET = PET

Where P< PET, AET = P - RO minus Ch ST

PERC: If I - PET < 0, than PERC = O

If I - PET > 0, than PERC = I - PET - Ch ST

Hockessin Village Plan

04-Jun-04

Climatic Water Balance for Crops in Soil Group A

Soil Moisture Storage = 10 in

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Precip (P) *Table 1*	2.98	2.73	3.26	3.49	4.15	3.85	4.52	4.00	3.68	3.17	3.28	3.50	42.61
Runoff Coeff. (RC) *Table 2*	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	
Runoff (RO) (RC x P)	0.24	0.22	0.26	0.28	0.33	0.31	0.36	0.32	0.29	0.25	0.26	0.28	
Infiltration (I) (= P - RO)	2.74	2.51	3.00	3.21	3.82	3.54	4.16	3.68	3.39	2.92	3.02	3.22	
PET *Table 5*	0.00	0.00	0.62	2.00	3.72	5.25	6.10	5.31	3.74	2.02	0.75	0.00	
I-PET	2.74	2.51	2.38	1.21	0.10	-1.71	-1.94	-1.63	-0.35	0.90	2.27	3.22	
CWL	0.00	0.00	0.00	0.00	0.00	-1.71	-3.65	-5.28	-5.63	0.00	0.00	0.00	
ST (T & M table 19)	10.00	10.00	10.00	10.00	10.00	5.94	5.46	5.91	6.91	10.00	10.00	10.00	
Ch ST	0.00	0.00	0.00	0.00	0.00	-4.06	-0.48	0.45	1.00	3.09	0.00	0.00	
AET	0.00	0.00	0.62	2.00	3.72	7.60	4.64	3.23	2.39	2.02	0.75	0.00	26.97
PERC	2.74	2.51	2.38	1.21	0.10	0.00	0.00	0.00	0.00	0.00	2.27	3.22	14.43

Climatic Water Balance for Grass in Soil Group A

Soil Moisture Storage = 12 in

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Precip (P) *Table 1*	2.98	2.73	3.26	3.49	4.15	3.85	4.52	4.00	3.68	3.17	3.28	3.50	42.61
Runoff Coeff. (RC) *Table 2*	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	
Runoff (RO) (RC x P)	0.18	0.16	0.20	0.21	0.25	0.23	0.27	0.24	0.22	0.19	0.20	0.21	
Infiltration (I) (= P - RO)	2.80	2.57	3.06	3.28	3.90	3.62	4.25	3.76	3.46	2.98	3.08	3.29	
PET *Table 5*	0.00	0.00	0.62	2.00	3.72	5.25	6.10	5.31	3.74	2.02	0.75	0.00	
I-PET	2.80	2.57	2.44	1.28	0.18	-1.63	-1.85	-1.55	-0.28	0.96	2.33	3.29	
CWL	0.00	0.00	0.00	0.00	0.00	-1.63	-3.48	-5.03	-5.31	0.00	0.00	0.00	
ST (T & M table 18)	12.00	12.00	12.00	12.00	12.00	7.74	7.21	7.71	8.78	12.00	12.00	12.00	
Ch ST	0.00	0.00	0.00	0.00	0.00	-4.26	-0.53	0.50	1.07	3.22	0.00	0.00	
AET	0.00	0.00	0.62	2.00	3.72	7.88	4.78	3.26	2.39	2.02	0.75	0.00	27.42
PERC	2.80	2.57	2.44	1.28	0.18	0.00	0.00	0.00	0.00	0.00	0.00	3.29	12.56

AET: Where P > PET, AET = PET

Where P< PET, AET = P - RO minus Ch ST

PERC: If I - PET < 0, than PERC = O

If I - PET > 0, than PERC = I - PET - Ch ST

Appendix C-1. Water Budget for the Cockeysville Formation.

Cover Type	*Impervious Cover (%)*	*Area (acres)*	*Soil Group Area (acres)*				*Recharge (inches)*				*Recharge (ac-in)*	*Recharge (gallons)*
			HSG A	HSG B	HSG C	HSG D	HSG A	HSG B	HSG C	HSG D		
Single Family Residential	30%	300.79	0.92	111.21	114.70	73.71						
Impervious		90.24	0.28	33.36	34.41	22.11						
Pervious		210.55	0.64	77.85	80.29	51.60	12.56	15.33	11.76	11.76	2,752	74,735,663
Multi Family Residential	65%	10.98	0.00	1.47	6.62	2.94						
Impervious		7.14	0.00	0.96	4.30	1.91						
Pervious		3.84	0.00	0.51	2.32	1.03	12.56	15.33	11.76	11.76	47	1,282,473
Commercial	85%	195.38	0.00	26.65	102.57	66.72						
Impervious		166.07	0.00	22.66	87.18	56.72						
Pervious		29.31	0.00	4.00	15.39	10.01	12.56	15.33	11.76	11.76	360	9,772,781
Industrial	72%	0.00	0.00	0.00	0.00	0.00						
Impervious		0.00	0.00	0.00	0.00	0.00						
Pervious		0.00	0.00	0.00	0.00	0.00	12.56	15.33	11.76	11.76	0	0
Transp., Comm., and Utilities	90%	4.88	0.00	0.37	2.94	1.84						
Impervious		4.39	0.00	0.33	2.65	1.65						
Pervious		0.49	0.00	0.04	0.29	0.18	12.56	15.33	11.76	11.76	6	167,908
Mixed / Other Urban Land	85%	69.78	0.00	4.41	28.86	32.90						
Impervious		59.31	0.00	3.75	24.53	27.97						
Pervious		10.47	0.00	0.66	4.33	4.94	12.56	15.33	11.76	11.76	119	3,233,644
Institutional / Governmental	55%	0.00	0.00	0.00	0.00	0.00						
Impervious		0.00	0.00	0.00	0.00	0.00						
Pervious		0.00	0.00	0.00	0.00	0.00	12.56	15.33	11.76	11.76	0	0
Recreational	5%	35.18	0.00	9.93	10.85	14.71						
Impervious		1.76	0.00	0.50	0.54	0.74						
Pervious		33.42	0.00	9.43	10.30	13.97	17.18	16.92	16.65	16.39	560	15,206,993
Agriculture	5%	20.45	0.00	3.31	15.07	2.21						
Impervious		1.02	0.00	0.17	0.75	0.11						
Pervious		19.43	0.00	3.14	14.32	2.10	14.43	14.79	14.33	13.88	281	7,623,529
Rangeland	0%	17.97	0.00	0.18	7.72	10.48						
Impervious		0.00	0.00	0.00	0.00	0.00						
Pervious		17.97	0.00	0.18	7.72	10.48	17.18	16.92	16.65	16.39	303	8,237,435
Forestland	0%	105.34	6.43	13.42	27.02	56.06						
Impervious		0.00	0.00	0.00	0.00	0.00						
Pervious		105.34	6.43	13.42	27.02	56.06	13.57	13.37	13.17	12.97	1,350	36,648,088
Water	0%	8.65	0.18	0.37	1.10	4.96						
Impervious		0.00	0.00	0.00	0.00	0.00						
Pervious		8.65	0.18	0.37	1.10	4.96					0	
Wetlands	0%	5.00	0.00	0.00	0.37	4.23						
Impervious		0.00	0.00	0.00	0.00	0.00						
Pervious		5.00	0.00	0.00	0.37	4.23	17.18	16.92	16.65	16.39	75	2,047,667
Barren Lands	5%	27.84	0.00	17.46	3.31	5.51						
Impervious		1.39	0.00	0.87	0.17	0.28						
Pervious		26.44	0.00	16.59	3.14	5.24	12.56	15.33	11.76	11.76	353	9,581,710
Cockeysville Formation		802.23	7.54	188.78	321.13	276.27						
Impervious		331.32	0.28	62.59	154.53	111.48						
Pervious		470.91	7.26	126.19	166.59	164.79					6,207	168,537,892

Appendix C-2. Water Budget for the Cockeysville Drainage Area.

Cover Type	*Impervious Cover (%)*	*Area (acres)*	*Soil Group Area (acres)*				*Recharge (inches)*				*Recharge (ac-in)*	*Recharge (gallons)*
			HSG A	HSG B	HSG C	HSG D	HSB A	HSG B	HSG C	HSG D		
Single Family Residential	30%	1956.39	0.92	1601.03	245.39	131.98						
Impervious		586.92	0.28	480.31	73.62	39.59						
Pervious		1369.47	0.64	1120.72	171.78	92.39	12.56	15.33	11.76	11.76	20,295	551,065,239
Multi Family Residential	65%	26.11	0.00	10.11	13.60	2.94						
Impervious		16.97	0.00	6.57	8.84	1.91						
Pervious		9.14	0.00	3.54	4.76	1.03	12.56	15.33	11.76	11.76	122	3,321,738
Commercial	85%	270.92	0.00	70.59	130.51	68.38						
Impervious		230.28	0.00	60.00	110.93	58.12						
Pervious		40.64	0.00	10.59	19.58	10.26	12.56	15.33	11.76	11.76	513	13,933,103
Industrial	72%	0.00	0.00	0.00	0.00	0.00						
Impervious		0.00	0.00	0.00	0.00	0.00						
Pervious		0.00	0.00	0.00	0.00	0.00	12.56	15.33	11.76	11.76	0	0
Transp., Comm., & Utilities	90%	6.97	0.00	2.57	2.94	1.84						
Impervious		6.27	0.00	2.32	2.65	1.65						
Pervious		0.70	0.00	0.26	0.29	0.18	12.56	15.33	11.76	11.76	10	259,723
Mixed / Other Urban Land	85%	156.75	0.00	67.64	36.95	49.63						
Impervious		133.24	0.00	57.50	31.40	42.19						
Pervious		23.51	0.00	10.15	5.54	7.44	12.56	15.33	11.76	11.76	308	8,370,246
Institutional / Governmental	55%	45.26	0.00	45.03	0.92	0.00						
Impervious		24.89	0.00	24.77	0.51	0.00						
Pervious		20.37	0.00	20.27	0.41	0.00	12.56	15.33	11.76	11.76	316	8,567,554
Recreational	5%	42.37	0.00	15.44	12.87	14.71						
Impervious		2.12	0.00	0.77	0.64	0.74						
Pervious		40.25	0.00	14.67	12.22	13.97	17.18	16.92	16.65	16.39	681	18,482,165
Agriculture	5%	328.94	0.00	270.76	62.50	9.74						
Impervious		16.45	0.00	13.54	3.12	0.49						
Pervious		312.49	0.00	257.22	59.37	9.26	14.43	14.79	14.33	13.88	4,784	129,885,573
Rangeland	0%	56.45	0.00	23.71	10.85	20.77						
Impervious		0.00	0.00	0.00	0.00	0.00						
Pervious		56.45	0.00	23.71	10.85	20.77	17.18	16.92	16.65	16.39	922	25,040,465
Forestland	0%	494.69	7.17	324.99	64.34	101.47						
Impervious		0.00	0.00	0.00	0.00	0.00						
Pervious		494.69	7.17	324.99	64.34	101.47	13.57	13.37	13.17	12.97	6,606	179,359,133
Water	0%	12.76	0.18	1.29	3.31	5.33						
Impervious		12.76	0.18	1.29	3.31	5.33						
Pervious											0	
Wetlands	0%	5.93	0.00	0.00	0.37	5.33						
Impervious		0.00	0.00	0.00	0.00	0.00						
Pervious		5.93	0.00	0.00	0.37	5.33	17.18	16.92	16.65	16.39	93	2,538,484
Barren Lands	5%	112.93	0.18	88.42	11.58	9.93						
Impervious		5.65	0.01	4.42	0.58	0.50						
Pervious		107.28	0.17	83.99	11.00	9.43	12.56	15.33	11.76	11.76	1,530	41,545,777
Cockeysville Drainage Area - Annual Recharge Volume		3516.46	8.46	2521.58	596.11	422.04						
Impervious		#REF!	0.28	650.19	232.29	145.19						
Pervious		2493.68	8.17	1871.39	363.82	276.85					36,180	982,369,202