APPENDIX A

A1: Municipal Map of Stormwater Release Rates*

A2: Release Rate Summary Table

APPENDIX B

B1: Map of Storm Drainage Problem Areas*

B2: Description of Storm Drainage Problem Areas

APPENDIX C

C1: NRCS Type II 24-Hour Rainfall Distribution (Graphic and Tabular)

C2: Precipitation Intensity and Depth Charts

C3: Runoff Curve Numbers and Percent Imperviousness Values

C4: Runoff Coefficients for the Rational Method

C5: Manning 'n' Values

C6: Percent Direct Recharge per Fraction Impervious versus Storage Curve

C7: Percent Direct Recharge per Fraction Impervious versus Storage Curve Usage Instructions

C8: Percent Annual Rainfall versus Vegetated/Surface BMP Design Runoff Chart

APPENDIX D

D1: Recommendation Chart for Infiltration Stormwater Management BMPs in Carbonate Bedrock

APPENDIX E

E1-3: Stormwater Best Management Practices Operations and Maintenance Agreement

APPENDIX F

F1-2: Low Impact Development Practices

APPENDIX G

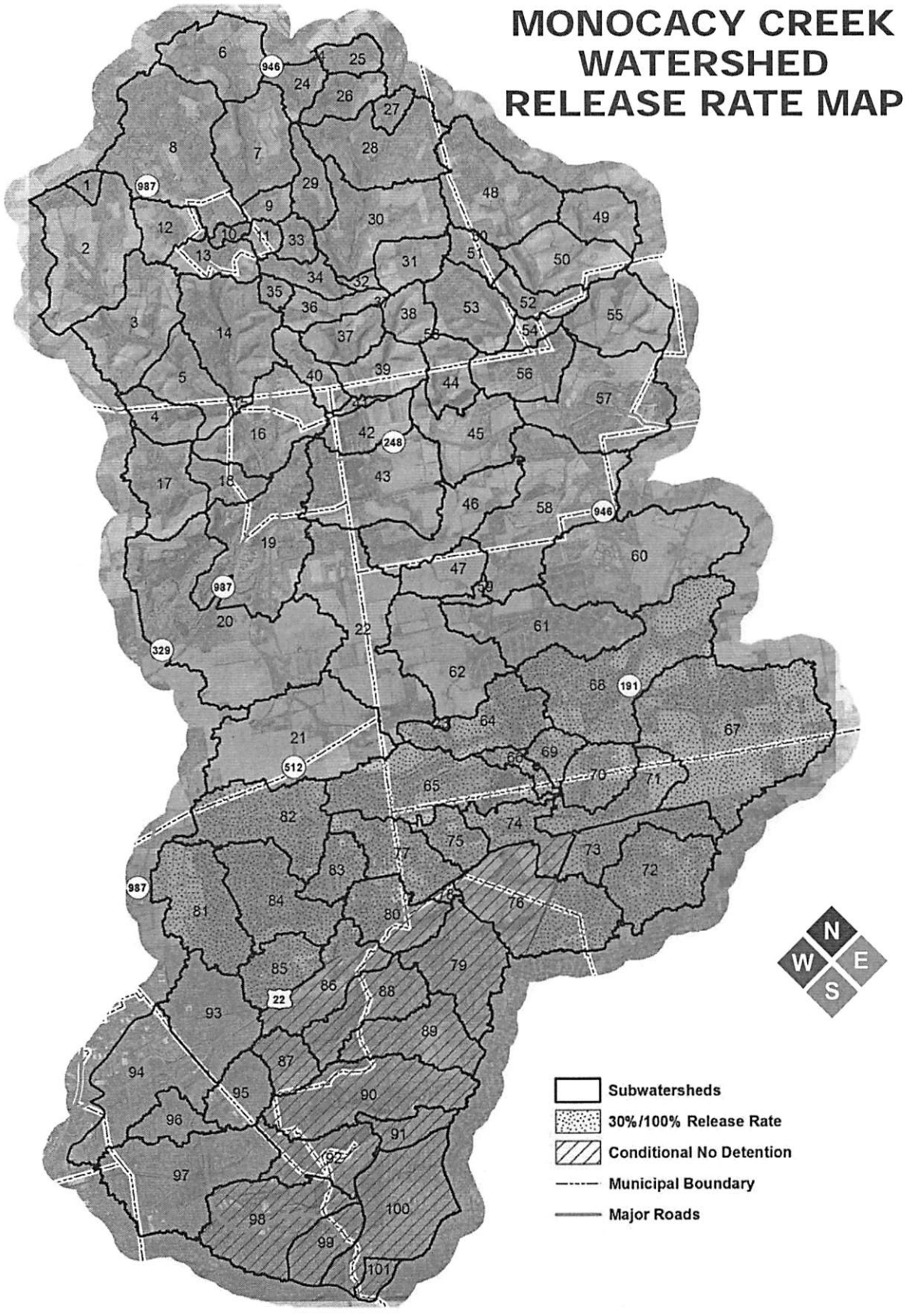
G1-3: Preliminary Site Investigation and Testing Requirements

APPENDIX H

H1-3: List of Acceptable BMPs

* Individual Municipal maps available from the Lehigh Valley Planning Commission upon request

MONOCACY CREEK WATERSHED RELEASE RATE MAP



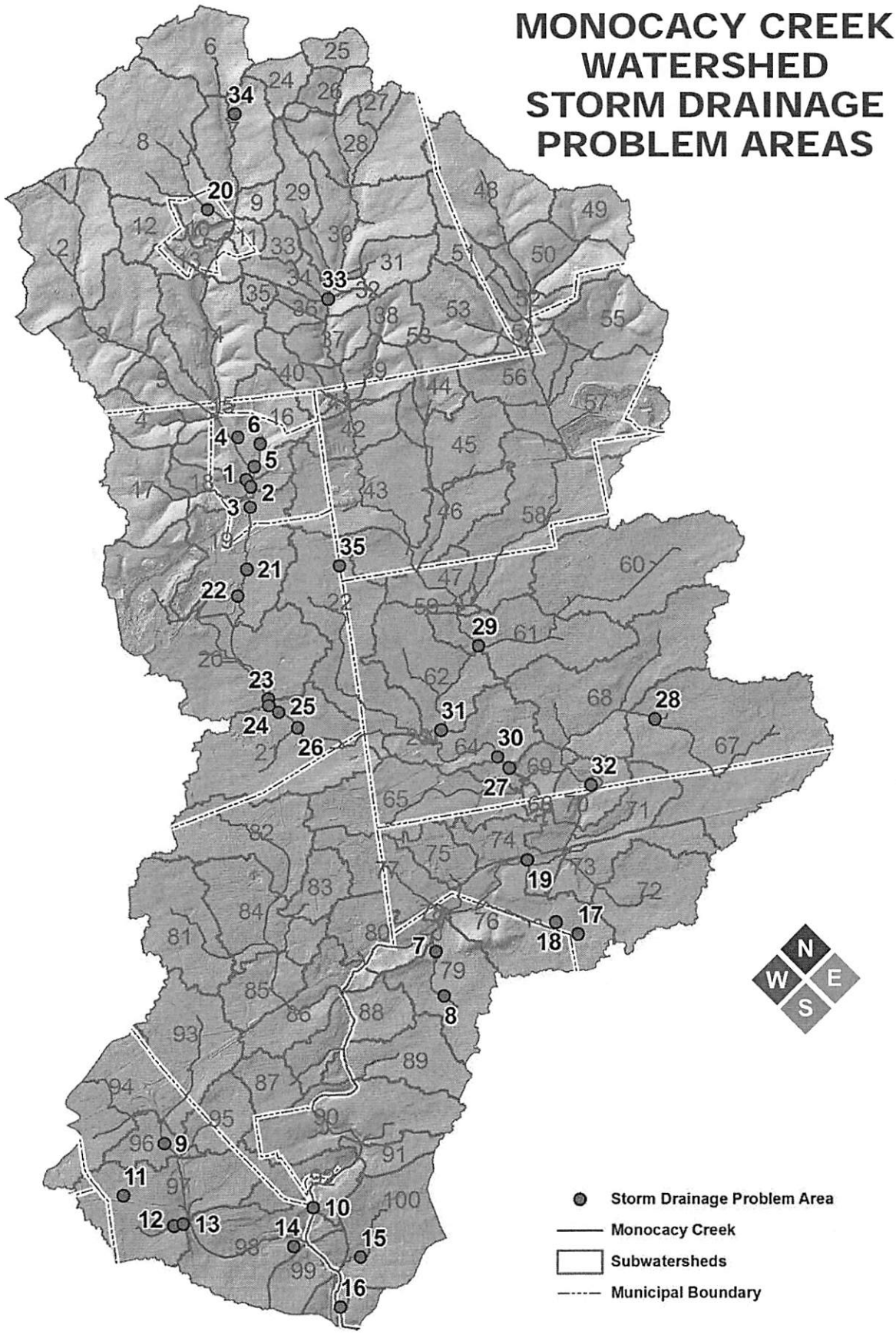
RELEASE RATE SUMMARY TABLE

10-year through 100-year return periods

Subarea	Release Rate %	Subarea	Release Rate %	Subarea	Release Rate %
1	90	34	80	67	30/100*
2	90	35	80	68	30/100*
3	90	36	80	69	30/100*
4	80	37	70	70	30/100*
5	70	38	80	71	30/100*
6	100	39	70	72	30/100*
7	80	40	70	73	See Map
8	90	41	70	74	See Map
9	80	42	70	75	30/100*
10	80	43	50	76	See Map
11	80	44	80	77	30/100*
12	90	45	50	78	CND**
13	70	46	50	79	CND**
14	70	47	50	80	See Map
15	70	48	100	81	30/100*
16	70	49	90	82	30/100*
17	80	50	70	83	30/100*
18	50	51	80	84	30/100*
19	50	52	70	85	30/100*
20	50	53	80	86	See Map
21	50	54	60	87	CND**
22	50	55	80	88	CND**
23	100	56	60	89	CND**
24	100	57	50	90	CND**
25	100	58	50	91	CND**
26	90	59	50	92	CND**
27	90	60	50	93	50
28	90	61	50	94	100
29	80	62	50	95	90
30	80	63	100	96	90
31	80	64	30/100*	97	80
32	80	65	30/100*	98	CND**
33	80	66	30/100*	99	CND**
				100	CND**
				101	CND**

*The 30% release rate applies to the 10-year return period event, and the 100% release rate applies to the 25-year and higher events.

** Conditional No Detention


MONOCACY CREEK
WATERSHED
STORM DRAINAGE
PROBLEM AREAS
N
W
E
S
Storm Drainage Problem Area
Monocacy Creek
Subwatersheds
Municipal Boundary

Storm Drainage Problem Areas

1. Northampton St. Bridge (#117)
Municipality: Borough of Bath
Problem: Street and Property Flooding
Subarea: 16
Reach Number: 15
Proposed Solution: Creek dredging/restoration

2. Main Street
Municipality: Borough of Bath
Problem: Street and Property Flooding
Subarea: 18
Reach Number: 16
Proposed Solution: Creek dredging/restoration

3. Mill Street
Municipality: Borough of Bath
Problem: Street and Property Flooding
Subarea: 19
Reach Number: 18
Proposed Solution: Creek dredging/restoration

4. Creek Road at North Chestnut Street
Municipality: Borough of Bath
Problem: Street and Property Flooding
Subarea: 16
Reach Number: 15
Proposed Solution: Completed creek restoration/water pipe replacement (fall 2016)

5. 151 N. Chestnut Street
Municipality: Borough of Bath
Problem: Street and Property Flooding
Subarea: 16
Reach Number: N/A
Proposed Solution: Attempting underground pipe repairs (spring 2017)

6. 100 Block on Sleepy Hollow Road
Municipality: Borough of Bath
Problem: Street and Property Flooding
Subarea: 16
Reach Number: N/A
Proposed Solution: Replace existing drain tile from 12" to 36" or greater

7. Pine Top Trail/Fox Drive/Bierys Bridge Road
Municipality: City of Bethlehem
Problem: Property Flooding
Subarea: 79
Reach Number: N/A
Proposed Solution: Improve channel capacity

8. Johnston Drive
Municipality: City of Bethlehem
Problem: Street Flooding
Subarea: 79
Reach Number: N/A
Proposed Solution: None proposed

9. Valley Park South Apartments
Municipality: City of Bethlehem
Problem: Property Flooding
Subarea: 96
Reach Number: 94
Proposed Solution: Additional detention upstream

10. Schoenersville Road
Municipality: City of Bethlehem
Problem: Street Flooding
Subarea: 98
Reach Number: 92
Proposed Solution: None proposed

11. Pinehurst Road
Municipality: City of Bethlehem
Problem: Street and Property Flooding
Subarea: 97
Reach Number: N/A
Proposed Solution: Detention facility

12. Homestead Avenue
Municipality: City of Bethlehem
Problem: Street and Rear Yard Flooding
Subarea: 97
Reach Number: N/A
Proposed Solution: None proposed

13. Highland and Eaton Avenues
Municipality: City of Bethlehem
Problem: Street and Property Flooding
Subarea: 97
Reach Number: N/A
Proposed Solution: None proposed

14. 5th Avenue at Route 378
Municipality: City of Bethlehem
Problem: Property Flooding
Subarea: 98
Reach Number: N/A
Proposed Solution: Diversion of runoff to Route 378

15. Goepp Street
Municipality: City of Bethlehem
Problem: Street Flooding
Subarea: 100
Reach Number: N/A
Proposed Solution: Additional inlets and relief pipe system

16. Historical Bethlehem Tannery Building
Municipality: City of Bethlehem
Problem: Property Flooding
Subarea: 100
Reach Number: 99
Proposed Solution: None proposed

17. Oakland Road
Municipality: Bethlehem Township
Problem: Street Flooding
Subarea: 76
Reach Number: N/A
Proposed Solution: None proposed

18. Nijaro Road and Fornance Road
Municipality: Bethlehem Township
Problem: Street flooding
Subarea: 76
Reach Number: N/A
Proposed Solution: None proposed

19. Christian Spring Road
Municipality: Bethlehem Township
Problem: Street Flooding
Subarea: 74
Reach Number: 73
Proposed Solution: None proposed

20. Yost Road and 5th Street
Municipality: Borough of Chapman
Problem: Street and Property Flooding
Subarea: 8
Reach Number: N/A
Proposed Solution: None proposed

21. Railroad Bridge
Municipality: East Allen Township
Problem: Property Flooding
Subarea: 19
Reach Number: 18
Proposed Solution: None proposed

22. Private Road
Municipality: East Allen Township
Problem: Street Flooding
Subarea: 19
Reach Number: 18
Proposed Solution: None proposed

23. Railroad Bridge
Municipality: East Allen Township
Problem: Property Flooding
Subarea: 20
Reach Number: 19
Proposed Solution: None proposed

24. Route 512
Municipality: East Allen Township
Problem: Street Flooding
Subarea: 20, 21
Reach Number: 20
Proposed Solution: None proposed

25. Railroad Bridge
Municipality: East Allen Township
Problem: Property Flooding
Subarea: 21
Reach Number: 20
Proposed Solution: None proposed

26. Railroad Bridge
Municipality: East Allen Township
Problem: Property Flooding
Subarea: 21
Reach Number: 20
Proposed Solution: None proposed

27. Hanoverville Road
Municipality: Lower Nazareth Township
Problem: Street Flooding
Subarea: 66
Reach Number: 64
Proposed Solution: None proposed

28. Hecktown Road
Municipality: Lower Nazareth Township
Problem: Street Flooding
Subarea: 67
Reach Number: N/A
Proposed Solution: Culvert installation

29. Georgetown Road at Ash Drive
Municipality: Lower Nazareth Township
Problem: Street Flooding
Subarea: 61
Reach Number: 60
Proposed Solution: None proposed

30. Georgetown Road
Municipality: Lower Nazareth Township
Problem: Street Flooding
Subarea: 64
Reach Number: 63
Proposed Solution: Bridge replacement on Georgetown Road in progress

31. Steuben Road
Municipality: Lower Nazareth Township
Problem: Street Flooding
Subarea: 62, 64
Reach Number: 61
Proposed Solution: Both bridges replaced in 2016

32. PA Route 191
Municipality: Lower Nazareth Township
Problem: Property Flooding
Subarea: 70
Reach Number: 69
Proposed Solution: Bridges along Route 191 replaced several years ago

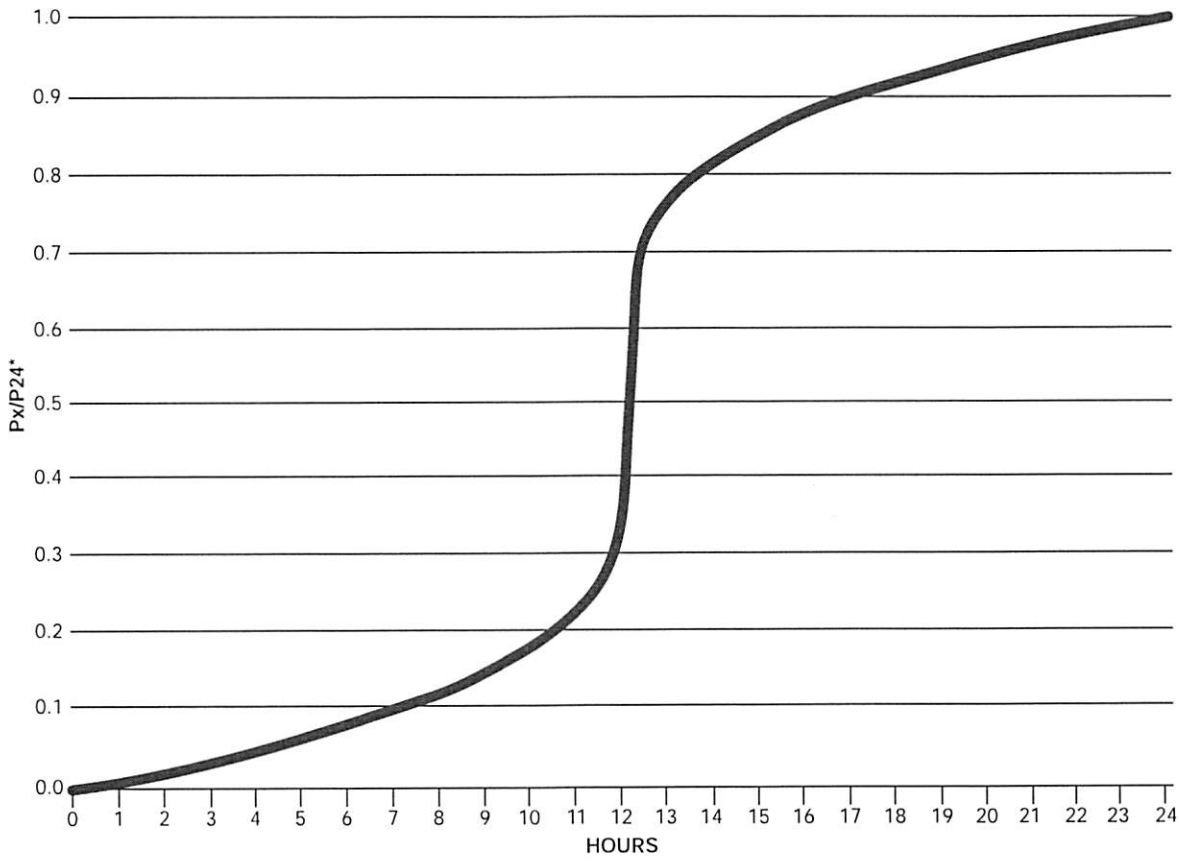
33. Keeler Road
Municipality: Moore Township
Problem: Localized Flooding
Subarea: 36
Reach Number: 34
Proposed Solution: Install new pipe. Permit received

34. Trach Road at South Summit Road
Municipality: Moore Township
Problem: Street Flooding
Subarea: 7
Reach Number: 6
Proposed Solution: Rebuild Trach Road, install storm pipe crossing on South Summit Road

35. Township Line Road at White Fence Lane
Municipality: Upper Nazareth Township
Problem: Street Flooding
Subarea: 22
Reach Number: N/A
Proposed Solution: Minor regrading/clean-up, continued monitoring and maintenance

APPENDIX C

NRCS TYPE II RAINFALL DISTRIBUTION



* Px/P24 equals cumulative percentage rainfall as a fraction of the total 24 hour rainfall

Hour/Min	Px/P24	Hour/Min	Px/P24
1 00	.0107	8 20	.1270
2 00	.0222	8 40	.1356
3 00	.0345	9 00	.1449
4 00	.0479	9 20	.1549
5 00	.0626	9 40	.1659
6 00	.0790	10 00	.1781
6 20	.0849	10 20	.1918
6 40	.0910	10 40	.2077
7 00	.0975	11 00	.2266
7 20	.1043	11 20	.2506
7 40	.1114	11 40	.2843
8 00	.1190	12 00	.3773

Hour/Min	Px/P24	Hour/Min	Px/P24
12 20	.6925	16 20	.8866
12 40	.7361	16 40	.8940
13 00	.7639	17 00	.9009
13 20	.7850	17 20	.9075
13 40	.8023	17 40	.9138
14 00	.8170	18 00	.9199
14 20	.8299	19 00	.9365
14 40	.8415	20 00	.9515
15 00	.8520	21 00	.9651
15 20	.8616	22 00	.9776
15 40	.8705	23 00	.9892
16 00	.8788	24 00	1.0000

PRECIPITATION INTENSITY AND DEPTH CHARTS*

Partial duration series-based point precipitation intensity frequency estimates (in inches/hour)
Average recurrence interval (years)

Duration	1	2	5	10	25	50	100
5-min	3.85	4.57	5.38	5.99	6.76	7.32	7.88
10-min	3.07	3.66	4.31	4.79	5.36	5.80	6.23
15-min	2.55	3.06	3.62	4.02	4.52	4.89	5.24
30-min	1.75	2.11	2.56	2.91	3.34	3.66	4.00
60-min	1.09	1.32	1.64	1.89	2.22	2.48	2.75
2-hr	0.650	0.785	0.984	1.14	1.36	1.54	1.74
3-hr	0.476	0.575	0.716	0.829	0.988	1.12	1.26
6-hr	0.303	0.364	0.451	0.523	0.627	0.715	0.812
12-hr	0.186	0.224	0.278	0.325	0.393	0.453	0.519
24-hr	0.109	0.131	0.164	0.191	0.232	0.266	0.304

Partial duration series-based point precipitation depth frequency estimates (in inches)
Average recurrence interval (years)

Duration	1	2	5	10	25	50	100
5-min	0.321	0.381	0.448	0.499	0.563	0.610	0.657
10-min	0.511	0.610	0.718	0.798	0.894	0.966	1.04
15-min	0.638	0.764	0.905	1.00	1.13	1.22	1.31
30-min	0.873	1.05	1.28	1.45	1.67	1.83	2.00
60-min	1.09	1.32	1.64	1.89	2.22	2.48	2.75
2-hr	1.30	1.57	1.97	2.28	2.72	3.09	3.48
3-hr	1.43	1.73	2.15	2.49	2.97	3.36	3.79
6-hr	1.82	2.18	2.70	3.13	3.75	4.28	4.86
12-hr	2.24	2.70	3.35	3.91	4.74	5.46	6.26
24-hr	2.62	3.14	3.93	4.59	5.56	6.39	7.30

*Source: NOAA Atlas 14, Volume 2, Version 3

RUNOFF CURVE NUMBERS AND PERCENT IMPERVIOUSNESS VALUES*

Cover Description		Curve numbers for hydrologic soil group**			
Land Use/Cover Type	Average Percent Impervious Area	A	B	C	D
Open space (lawns, parks, golf courses, cemeteries, etc.): Good condition (grass cover greater than 75%		39	61	74	80
Impervious areas: Paved parking lots, roofs, driveways, etc. (excluding right-of-way)		98	98	98	98
Streets and roads:					
Paved; curbs and storm sewers (excluding right-of-way)		98	98	98	98
Paved; open ditches (including right-of-way)		83	89	92	93
Gravel (including right-of-way)		76	85	89	91
Urban districts:					
Commercial and business	85%	89	92	94	95
Industrial	72%	81	88	91	93
Residential districts by average lot size:					
1/8 acre or less (townhouses)	65%	77	85	90	92
1/4 acre	38%	61	75	83	87
1/3 acre	30%	57	72	81	86
1/2 acre	25%	54	70	80	85
1 acre	20%	51	68	79	84
2 acre	12%	46	65	77	82
Woods		30	55	70	77
Agriculture		Refer to Table 2-2b in source document (TR55) by crop type and treatment			
Meadow: Continuous grass, protected from grazing and generally mowed for hay		30	58	71	78

*Source: Natural Resources Conservation Service Technical Release No. 55, Second Edition, June 1986

**Hydrologic Soil Group based on the USDA Soil Survey

RUNOFF COEFFICIENTS FOR THE RATIONAL METHOD*
HYDROLOGIC SOIL GROUP AND SLOPE RANGE**

	A			B			C			D		
Land Use	**0-2%**	**2-6%**	**6%+**	**0-2%**	**2-6%**	**6%+**	**0-2%**	**2-6%**	**6%+**	**0-2%**	**2-6%**	**6%+**
Cultivated[A]	0.18[a]	0.23	0.28	0.24	0.29	0.33	0.30	0.34	0.38	0.33	0.37	0.41
	0.23[b]	0.29	0.34	0.30	0.36	0.40	0.36	0.41	0.45	0.39	0.44	0.48
Pasture[B]	0.09	0.13	0.17	0.19	0.24	0.29	0.27	0.31	0.36	0.31	0.35	0.39
	0.12	0.17	0.23	0.24	0.30	0.36	0.33	0.38	0.43	0.37	0.42	0.46
Meadow, Lawn[C]	0.05	0.08	0.12	0.15	0.20	0.24	0.23	0.28	0.32	0.28	0.32	0.36
	0.07	0.12	0.17	0.19	0.25	0.30	0.28	0.34	0.39	0.33	0.39	0.43
Forest, Woods	0.03	0.05	0.08	0.11	0.16	0.20	0.20	0.25	0.29	0.25	0.30	0.34
	0.04	0.08	0.12	0.15	0.21	0.26	0.25	0.31	0.36	0.31	0.37	0.41
Gravel	0.24	0.29	0.33	0.32	0.36	0.40	0.35	0.39	0.43	0.37	0.41	0.44
	0.30	0.36	0.40	0.38	0.43	0.47	0.42	0.46	0.50	0.44	0.48	0.51
Parking, other Impervious	0.85	0.86	0.87	0.85	0.86	0.87	0.85	0.86	0.87	0.85	0.86	0.87
	0.95	0.96	0.97	0.95	0.96	0.97	0.95	0.96	0.97	0.95	0.96	0.97
Residential, Commercial, Industrial and Other "Developed"	Runoff coefficients should be calculated based upon weighted average of impervious area coefficients and pervious area coefficients from above based upon soil type, slope and the particular development proposal.											

*Coefficients for all land uses except parking and other impervious cover are based on the Rossmiller Equation for translating NRCS curve numbers into Rational Method 'c' values. The source for the parking and other impervious cover coefficients is RAWLS, W.J., S.L. WONG and R.H. McCUEN, 1981. Comparison of urban flood frequency procedures. Preliminary draft report prepared for the Soil Conservation Service, Beltsville, M.D.

**Hydrologic Soil Group based on the USDA Soil Survey.

[a] Runoff coefficients for storm recurrence intervals less than 25 years.

[b] Runoff coefficients for storm recurrence intervals of 25 years or more.

[A] Represents average of cultivated land with and without conservation treatment from TR-55, January 1975. These values are consistent with several categories of cultivated lands from TR-55, June 1986.

[B] Represents grasslands in fair condition with 50% to 75% grass cover.

[C] Represents grasslands in good condition with greater than 75% grass cover.

MANNING 'n' VALUES BY TYPICAL REACH DESCRIPTION

Reach Description	Manning 'n'
Natural stream, clean, straight, no rifts or pools	0.030
Natural stream, clean, winding, some pools and shoals	0.040
Natural stream, winding, pools, shoals stony with some weeds	0.050
Natural stream, sluggish with deep pools and weeds	0.070
Natural stream, or swale, very weedy or with timber under brush	0.100
Concrete pipe, culvert or channel	0.012
Corrugated metal pipe	0.012-0.027*

*Depending upon type and diameter

ROUGHNESS COEFFICIENTS (MANNING 'n') FOR SHEET FLOW

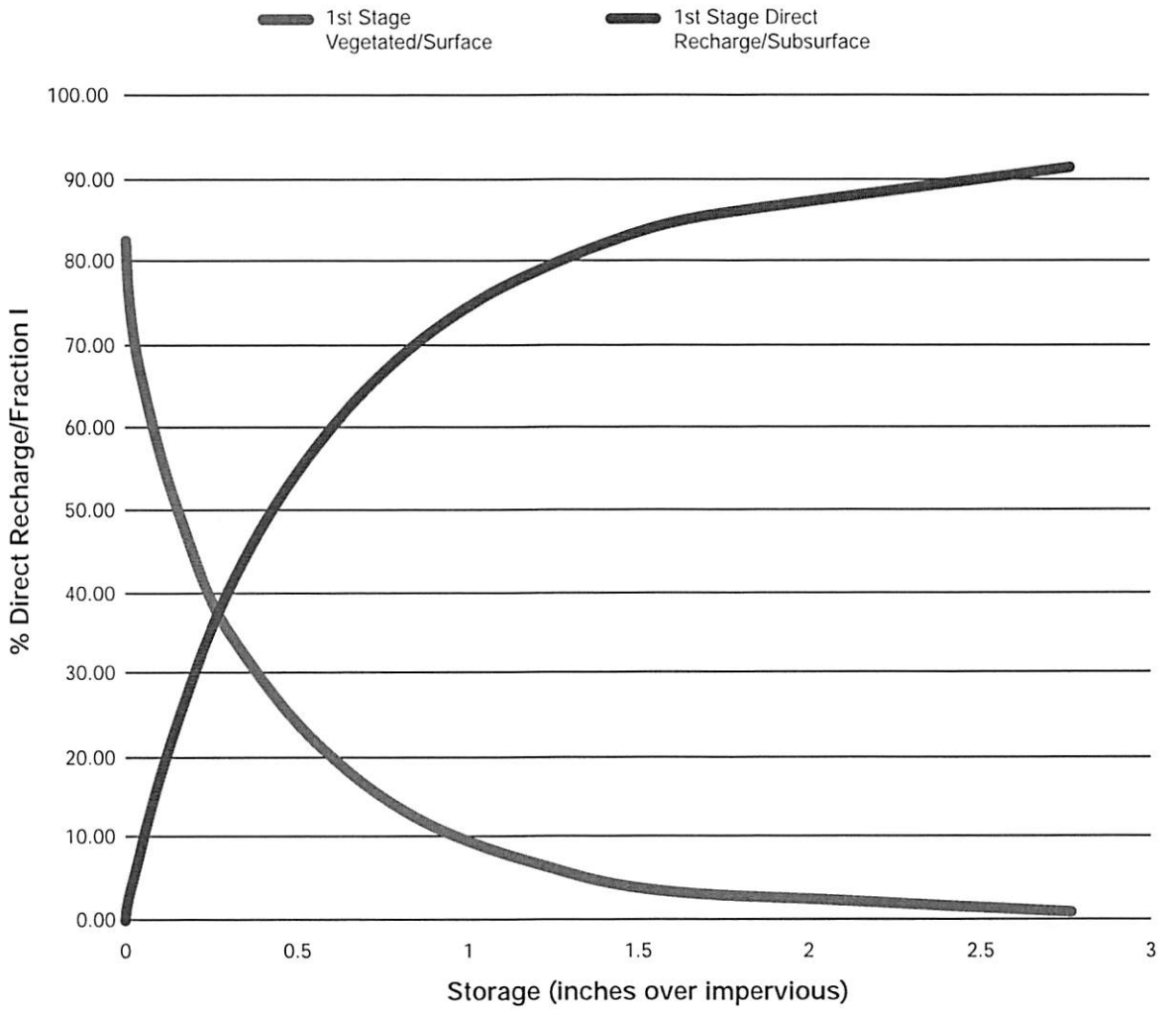
Surface Description	Manning 'n'[1]
Smooth surfaces (concrete, asphalt, gravel, or bare soil)	0.011
Fallow (no residue)	0.050
Cultivated soils:	
Residue cover <= 20%	0.060
Residue cover > 20%	0.170
Grass:	
Short grass prairie	0.150
Dense grasses[2]	0.240
Bermuda grass	0.410
Range (natural)	0.130
Woods:[3]	
Light underbrush	0.400
Dense underbrush	0.800

[1] The 'n' values are a composite of information compiled by Engman (1986).

[2] Includes species such as weeping lovegrass, bluegrass, bufffalo grass, blue grama grass and native grass mixtures.

[3] When selecting 'n', consider cover to a height of about 0.1 ft. This is the only part of the plant cover that will obstruct sheet flow.

PERCENT DIRECT RECHARGE PER FRACTION IMPERVIOUS VS. STORAGE



Note: See C7 for instruction on how to use the chart

PERCENT DIRECT RECHARGE PER FRACTION IMPERVIOUS VERSUS STORAGE CURVE USAGE INSTRUCTIONS

The "1st Stage Direct Recharge" curve is based on impervious areas being diverted first to a Direct Recharge/Subsurface BMP designed to capture less than the 2-year event, with the remaining 2-year runoff overflowing into a Vegetated/Surface BMP. The "1st stage Vegetated/Surface" curve is based on reversing the above. The curves may be used for the whole site, or for pieces of a site to achieve successful designs as follows:

A. If used for whole site designs, the "fraction I" used is the proposed impervious as a fraction of the entire site. As an example, for a 60% impervious site with all impervious directed to a first stage Direct Recharge/Subsurface BMP, use 30% Direct Recharge with 0.60 fraction I to yield 50% Direct Recharge/fraction I and translate into 0.42 inches of storage over impervious areas. The total first stage Direct Recharge maximum BMP storage is 0.42 inches of depth times the surface area of the impervious cover. Similarly, if a first stage Vegetated/Surface BMP followed by a second stage Direct Recharge/Subsurface BMP was used, the minimum Vegetated/Surface storage is 0.15 inches over the impervious cover.

B. If used for pieces of the site smaller than the whole site, the fraction I used is the impervious cover of the part of the site in question as a fraction of the area of the same piece. Each piece may be designed for 30% Direct Recharge if desired, but individual pieces may exceed 30% Direct Recharge provided all BMPs on site are providing less than 30% Direct Recharge in aggregate. In this case, the BMP storage for each piece is used in the chart with the fraction I using the whole site area to determine the contribution of each piece to the 30% Direct Recharge allowable. As an example, still using the 60% impervious site, a piece of the site uses a Direct Recharge/Subsurface BMP first. The piece is half of the total area of the site and is 80% impervious. The BMP is designed for 0.6 inches of runoff from the impervious surfaces. Using 0.6 inches of storage and a fraction I of 0.80, the piece is designed for (%Direct Recharge/fraction I = 60) 48% Direct Recharge. The impervious cover in this piece has fraction I of 0.4 of the overall site acreage and, therefore, using 0.6 inches of storage and a fraction I of 0.4 yields a Direct Recharge/fraction I of 60% using the graph which solves to a Direct Recharge of 24%. This means that this piece uses 24% of the allowable 30% Direct Recharge. The remaining piece(s) will need to be designed for 6% or less Direct Recharge. The remaining piece in this example has a fraction I of the overall site of 0.2. Using 6% Direct Recharge and a fraction I of 0.2 yields a Direct Recharge/fraction I of 30%. Entering the graph at that value, the maximum storage for the piece in a first stage Direct Recharge/Subsurface BMP is 0.2 inches over the impervious portion of its tributary area.

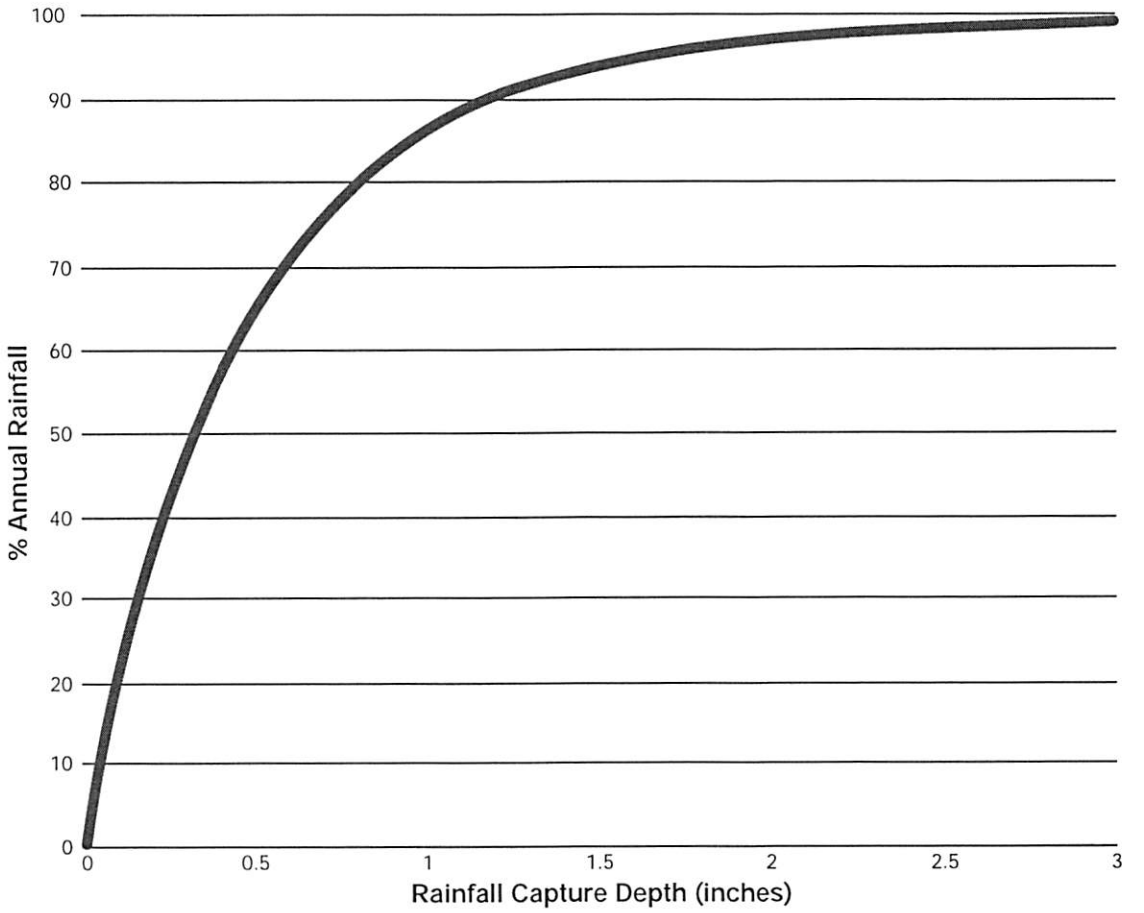
C. If more than two stages of Vegetated/Surface and Direct Recharge/Subsurface BMPs are used to control the WQv, the design considerations are as follows:

1. If the design has a first stage Vegetated/Surface BMP draining to additional stage Vegetated/Surface BMPs and subsequent Direct Recharge/Subsurface BMP, add the storage volumes of the Vegetated/Surface BMPs and use this volume as the first stage Vegetated/Surface storage volume.
2. Similarly, if two or more Direct Recharge/Subsurface BMPs are used first followed by a Vegetated/Surface BMP, add the storage volumes of the Direct Recharge/Subsurface BMPs and use this volume as the first stage Direct Recharge BMP storage volume.
3. In designs with more than two Vegetated/Surface or Direct Recharge/Subsurface BMPs used in series to control the WQv and rules C.1 and C.2 don't apply, the chart shall be applied conservatively to assure the Direct Recharge standard is not violated. For example, with proposed use of a first stage Direct Recharge/Subsurface BMP, second stage Vegetated/Surface BMP, and third stage Direct Recharge/Subsurface BMP, all storage provided shall be assumed to be Direct Recharge for use in the chart.

Essentially, any Vegetated/Surface BMP applied beyond the first stage will be ignored for purposes of determining compliance with the Direct Recharge standard.

PERCENT ANNUAL RAINFALL VERSUS VEGETATED/SURFACE BMP DESIGN RUNOFF CHART

To use this chart, for a given fraction of site impervious directed to a Vegetated/Surface BMP, calculate the runoff capture depth over the impervious in inches, use the curve to find % annual rainfall. The weighted average of % annual rainfall considering all impervious cover to all BMPs must be a minimum of 56%.



APPENDIX D

Recommendation Chart for Infiltration Stormwater Management BMPs in Carbonate Bedrock*

SITE RISK FACTORS	Geology Type	CARBONATE BEDROCK																													
	Effective Soil Thickness	Less than 2 Feet	2 to 4 Feet									Over 4 Feet to 8 Feet									Over 8 Feet										
	Special Geologic Features**	Low/Med/High Buffer	Low Buffer			Medium Buffer			High Buffer			Low Buffer			Medium Buffer			High Buffer			Low Buffer			Medium Buffer			High Buffer			
SITE INVESTIGATION RECOMMENDED		(Unacceptable)	Preliminary			Preliminary			Preliminary			Preliminary			Preliminary			Preliminary			Preliminary			Preliminary			Preliminary			
DESIGN FACTORS	Infiltration Loading Rates (% Increase) ***	(Unacceptable)	0-100%	100-300%	300 - 500%	0-100%	100-300%	300 - 500%	0-100%	100-300%	300 - 500%	0-100%	100-300%	300 - 500%	0-100%	100-300%	300 - 500%	0-100%	100-300%	300 - 500%	0-100%	100-300%	300 - 500%	0-100%	100-300%	300 - 500%	0-100%	100-300%	300 - 500%		
PROGRAM SUMMARY GUIDANCE ****						1	1				1	2								1	2					1					

RECOMMENDED

NOT RECOMMENDED

* Source: Developed by Cahill Associates based on information in "Technical Best Management Practice Manual & Infiltration Feasibility Report", November 2002 and input from the LVPC, 2003.

** Special Geologic Feature Buffer widths are as follows:

Low Buffer is less than 50 feet
Medium Buffer is 50 feet to 100 feet
High Buffer is greater than 100 feet

*** Rates greater than 500% not recommended.

**** Assumes adequately permeable soils and lack of natural constraints as required for all infiltration systems.

1 Infiltration systems may be allowed at the determination of the Engineer and/or Geologist, provided that a Detailed Site Investigation is undertaken which confirms nature of rock, location of Special Geologic Features, and adequacy of the buffer between the SGF and the proposed stormwater system(s).

2 In these Special Geologic Features: Low Buffer situations, infiltration systems may be allowed at the determination of the Engineer and/or Geologist, provided that a Detailed Site Investigation is undertaken and a 25 foot buffer from SGFs is maintained.

APPENDIX E

STORMWATER BEST MANAGEMENT PRACTICES OPERATIONS AND MAINTENANCE AGREEMENT

THIS AGREEMENT, made and entered into this _____ day of _____, 20___, by and between _____, (hereinafter the "Landowner"), and _____, _____ County, Pennsylvania, (hereinafter "municipality");

WITNESSETH

WHEREAS, the Landowner is the owner of certain real property as recorded by deed in the land records of _____ County, Pennsylvania, Deed Book _____ at Page _____, (hereinafter "Property").

WHEREAS, the Landowner is proceeding to build and develop the Property; and

WHEREAS, the stormwater management BMP Operations and Maintenance Plan approved by the municipality (hereinafter referred to as the "Plan") for the property identified herein, which is attached hereto as Appendix A and made part hereof, as approved by the municipality, provides for management of stormwater within the confines of the Property through the use of Best Management Practices (BMP's); and

WHEREAS, the municipality, and the Landowner, his successors and assigns, agree that the health, safety, and welfare of the residents of the municipality and the protection and maintenance of water quality require that on-site stormwater Best Management Practices be constructed and maintained on the Property; and

WHEREAS, for the purposes of this agreement, the following definitions shall apply:

- BMP – "Best Management Practice;" activities, facilities, designs, measures or procedures used to manage stormwater impacts from land development, to protect and maintain water quality and groundwater recharge and to otherwise meet the purposes of the Municipal Stormwater Management Ordinance, including but not limited to infiltration trenches, seepage pits, filter strips, bioretention, wet ponds, permeable paving, rain gardens, grassed swales, forested buffers, sand filters and detention basins.
- Infiltration Trench – A BMP surface structure designed, constructed, and maintained for the purpose of providing infiltration or recharge of stormwater into the soil and/or groundwater aquifer,
- Seepage Pit – An underground BMP structure designed, constructed, and maintained for the purpose of providing infiltration or recharge of stormwater into the soil and/or groundwater aquifer,
- Rain Garden – A BMP overlain with appropriate mulch and suitable vegetation designed, constructed, and maintained for the purpose of providing infiltration or recharge of stormwater into the soil and/or underground aquifer; and

WHEREAS, the municipality requires, through the implementation of the Plan, that stormwater management BMPs as required by said Plan and the Municipal Stormwater Management Ordinance be constructed and adequately operated and maintained by the Landowner, his successors and assigns; and

NOW, THEREFORE, in consideration of the foregoing promises, the mutual covenants contained herein, and the following terms and conditions, the parties hereto agree as follows:

1. The BMPs shall be constructed by the Landowner in accordance with the plans and specifications identified in the Plan.
2. The Landowner shall operate and maintain the BMP(s) as shown on the Plan in good working order acceptable to the municipality and in accordance with the specific maintenance requirements noted on the Plan.
3. The Landowner hereby grants permission to the municipality, its authorized agents and employees, to enter upon the property, at reasonable times and upon presentation of proper identification, to inspect the BMP(s) whenever it deems necessary. Whenever possible, the municipality shall notify the Landowner prior to entering the property.
4. In the event the Landowner fails to operate and maintain the BMP(s) as shown on the Plan in good working order acceptable to the municipality, the municipality or its representatives may enter upon the Property and take whatever action is deemed necessary to maintain said BMP(s). This provision shall not be construed to allow the municipality to erect any permanent structure on the land of the Landowner. It is expressly understood and agreed that the municipality is under no obligation to maintain or repair said facilities, and in no event shall this Agreement be construed to impose any such obligation on the municipality.
5. In the event the municipality, pursuant to this Agreement, performs work of any nature, or expends any funds in performance of said work for labor, use of equipment, supplies, materials, and the like, the Landowner shall reimburse the municipality for all expenses (direct and indirect) incurred within 10 days of receipt of invoice from the municipality *and if not timely paid, a municipal lien shall be placed upon the premises for 110% of the invoice amount, plus statutorily allowed fees, expenses and costs*.
6. The intent and purpose of this Agreement is to ensure the proper maintenance of the on-site BMP(s) by the Landowner; provided, however, that this Agreement shall not be deemed to create or effect any additional liability of any party for damage alleged to result from or be caused by stormwater runoff.
7. The Landowner, its executors, administrators, assigns, and other successors in interests, *hereby* release *and hold harmless* the municipality's employees and designated representatives from all damages, accidents, casualties, occurrences or claims which might arise or be asserted against said employees and representatives from the construction, presence, existence, or maintenance of the BMP(s) by the Landowner or municipality. In the event that a claim is asserted against the municipality, its designated representatives or employees, the municipality shall promptly notify the Landowner and the Landowner shall defend, at his own expense, any suit based on the claim. If any judgment or claims against the municipality's employees or designated representatives shall be allowed, the Landowner shall pay all costs and expenses regarding said judgment or claim.
8. The municipality shall inspect the BMP(s) *as necessary* to ensure their continued functioning.

This Agreement shall be recorded at the Office of the Recorder of Deeds of _____ County, Pennsylvania, and shall constitute a covenant running with the Property and/or equitable servitude, and shall be binding on the Landowner, his administrators, executors, assigns, heirs and any other successors in interests, in perpetuity.

ATTEST:

WITNESS the following signatures and seals:

(SEAL) For the municipality:

_____

(SEAL) For the Landowner:

_____

ATTEST:

_____ (City, Borough, Township)

County of _____, Pennsylvania

I, _____, a Notary Public in and for the County and State aforesaid, whose commission expires on the _____ day of _____, 20__, do hereby certify that _____ whose name(s) is/are signed to the foregoing Agreement bearing date of the _____ day of _____, 20__, has acknowledged the same before me in my said County and State.

GIVEN UNDER MY HAND THIS _____ day of _____, 20__.

_____ _____

NOTARY PUBLIC **(SEAL)**

APPENDIX F

LOW IMPACT DEVELOPMENT PRACTICES

ALTERNATIVE APPROACH FOR MANAGING STORMWATER RUNOFF

Natural hydrologic conditions may be altered radically by poorly planned development practices, such as introducing unneeded impervious surfaces, destroying existing drainage swales, constructing unnecessary storm sewers, and changing local topography. A traditional drainage approach of development has been to remove runoff from a site as quickly as possible and capture it in a detention basin. This approach may lead ultimately to the degradation of water quality as well as expenditure of additional resources for detaining and managing concentrated runoff at some downstream location.

The recommended alternative approach is to promote practices that will minimize post-development runoff rates and volumes, which will minimize needs for artificial conveyance and storage facilities. To simulate pre-development hydrologic conditions, forced infiltration is often necessary to offset the loss of infiltration by creation of impervious surfaces. The ability of the ground to infiltrate depends upon the soil types and its conditions.

Preserving natural hydrologic conditions requires careful alternative site design considerations. Site design practices include preserving natural drainage features, minimizing impervious surface area, reducing the hydraulic connectivity of impervious surfaces, and protecting natural depression storage. A well-designed site will contain a mix of all those features. The following describes various techniques to achieve the alternative approach:

- **Preserving Natural Drainage Features**. Protecting natural drainage features, particularly vegetated drainage swales and channels, is desirable because of their ability to infiltrate and attenuate flows and to filter pollutants. However, this objective is often not accomplished in land development. In fact, commonly held drainage philosophy encourages just the opposite pattern—streets and adjacent storm sewers typically are located in the natural headwater valleys and swales, thereby replacing natural drainage functions with a completely impervious system. As a result, runoff and pollutants generated from impervious surfaces flow directly into storm sewers with no opportunity for attenuation, infiltration, or filtration. Developments designed to fit site topography also minimize the amount of grading on site.

- **Protecting Natural Depression Storage Areas**. Depression storage areas have no surface outlet, or drain very slowly following a storm event. They can be commonly seen as ponded areas in farm fields during the wet season or after large runoff events. Traditional development practices eliminate these depressions by filling or draining, thereby obliterating their ability to reduce surface runoff volumes and trap pollutants. The volume and release rate characteristics of depressions should be protected in the design of the development site. The depressions can be protected by simply avoiding the depression or by incorporating its storage as additional capacity in required detention facilities.

- **Avoiding Introduction of Impervious Areas**. Careful site planning should consider reducing impervious coverage to the maximum extent possible. Building footprints, sidewalks, driveways and other features producing impervious surfaces should be evaluated to minimize impacts on runoff.

- **Reducing the Hydraulic Connectivity of Impervious Surfaces**. Impervious surfaces are significantly less of a problem if they are not directly connected to an impervious conveyance system (such as storm sewer). Two basic ways to reduce hydraulic connectivity are routing of roof runoff over lawns and reducing the use of storm sewers. Site grading should promote

increasing travel time of stormwater runoff, and should help reduce concentration of runoff to a single point in the development.

- **Routing Roof Runoff over Lawns**. Roof runoff can be easily routed over lawns in most site designs. The practice discourages direct connections of downspouts to storm sewers or parking lots. The practice also discourages sloping driveways and parking lots to the street. By routing roof drains and crowning the driveway to run off to the lawn, the lawn is essentially used as a filter strip.

- **Reducing the Use of Storm Sewers**. By reducing use of storm sewers for draining streets, parking lots, and back yards, the potential for accelerating runoff from the development can be greatly reduced. The practice requires greater use of swales and may not be practical for some development sites, especially if there are concerns for areas that do not drain in a "reasonable" time. The practice requires educating local citizens and public works officials, who expect runoff to disappear shortly after a rainfall event.

- **Reducing Street Widths**. Street widths can be reduced by either eliminating on-street parking or by reducing roadway widths. Municipal planners and traffic designers should encourage narrower neighborhood streets which ultimately could lower maintenance.

- **Limiting Sidewalks to One Side of the Street**. A sidewalk on one side of the street may suffice in low-traffic neighborhoods. The lost sidewalk could be replaced with bicycle/recreational trails that follow back-of-lot lines. Where appropriate, backyard trails should be constructed using pervious materials.

- **Using Permeable Paving Materials**. These materials include permeable interlocking concrete paving blocks or porous bituminous concrete. Such materials should be considered as alternatives to conventional pavement surfaces, especially for low use surfaces such as driveways, overflow parking lots, and emergency access roads.

- **Reducing Building Setbacks**. Reducing building setbacks reduces driveway and entry walks and is most readily accomplished along low-traffic streets where traffic noise is not a problem.

- **Constructing Cluster Developments**. Cluster developments can also reduce the amount of impervious area for a given number of lots. The biggest savings is in street length, which also will reduce costs of the development. Cluster development clusters the construction activity onto less-sensitive areas without substantially affecting the gross density of development.

APPENDIX G

PRELIMINARY SITE INVESTIGATION AND TESTING REQUIRMENTS

Required Data and Site Information: The following data shall be gathered utilizing standard testing procedures as part of a Preliminary Site Investigation:

- Bedrock composition – Any apparent boundaries between carbonate and non-carbonate bedrock must be verified by a qualified geotechnical professional.
- Bedrock structural geology – This includes the possible presence of faults and mapping of conspicuous fracture traces or lineaments.
- Overburden and soil mantle composition and thickness.
- Permeability of the soil.
- Depth to the seasonal high water table.
- Presence of special geologic features – This includes sinkholes, closed depressions, fracture traces, lineaments, joints, faults, caves, pinnacles and geologic contacts between carbonate and non-carbonate bedrock.

Preliminary Site Investigation Required for Sites Intending to Use Infiltration

Review of Available Data, Maps and Reports: Some of the required information, as listed above, can be found in existing published data. Suggested resources include the following:

- Geologic maps and references for the development area.
- The Little Lehigh Creek Basin Carbonate Prototype Area Closed Depression Map – available at the LVPC.
- USGS topographic maps.
- Lehigh and Northampton County soil survey maps.
- Aerial photographs from the LVPC or other sources.
- Relevant Pennsylvania Geologic Survey Open File Reports that provide maps of sinkholes and Karst features for Lehigh County (OF 87-01) and Northampton County (OF 87-02).
- Kochanov and Reese (2003). Density of Mapped Karst Feature in South-Central and Southeastern Pennsylvania (Map 68).
- DCNR Online Sinkhole Inventory - (http://www.dcnr.state.pa.us/topogeo/hazards/sinkhole/default.asp).

Field Inspections: In addition to gathering data from published sources, a field inspection of the proposed site is required. A field inspection can provide additional information relating to site features such as carbonate bedrock features, indicators of seasonal high stream-level or water table levels, streams, springs, etc.

Soil Test Pit and Percolation Test Requirements: A minimum of one test pit and a minimum of 2 percolation tests are required for every site. A test pit is a 2-3 foot wide, 8 foot deep trench excavated with a backhoe for observing subsurface conditions. The test pits will be used to describe soil depth and quality, including soil horizons, and testing of permeability or percolation rates and can be conducted by a certified Sewage Enforcement Officer.

Percolation tests are to be conducted as follows (adapted from § 73.15. "Percolation Tests" of the Pennsylvania Code):

1. The percolation tests shall be made in separate holes uniformly spaced over the possible infiltration area.

2. An "Initial Presoak" should not be performed.

3. Percolation holes located within the possible infiltration area shall be used in the calculation of the average percolation rate.

4. Holes having a uniform diameter of 6 to 10-inches shall be bored or dug as follows:

a. To the depth of the bottom of the possible infiltration BMP.
b. Alternate depths if the test pits/auger holes indicate that the soils are more suitable at a different depth (i.e. if a clay horizon is identified and more suitable soils are located beneath the horizon, an infiltration test should be performed in the suitable horizon).

5. The bottom and sides of the hole shall be scarified with a knife blade or sharp-pointed instrument to completely remove any smeared soil surfaces and to provide a natural soil interface into which water may percolate. Loose material shall be removed from the hole. Two inches of coarse sand or fine gravel shall be placed in the bottom of the hole to protect the soil from scouring and clogging of the pores.

6. Immediately before the percolation test, as a final presoak, water shall be placed in the hole to a minimum depth of 6-inches over the gravel and readjusted every 30 minutes for 1 hour.

7. The drop in the water level during the last 30 minutes of the final presoaking period shall be applied to the following standard to determine the time interval between readings for each percolation hole:
   a. If water remains in the hole, the interval for readings during the percolation test shall be 30 minutes.
   b. If no water remains in the hole, the interval for readings during the percolation test may be reduced to 10 minutes.

8. After the final presoaking period, water in the hole shall again be adjusted to approximately 6-inches over the gravel and readjusted when necessary after each reading.
   a. Measurement to the water level in the individual percolation holes shall be made from a fixed reference point and shall continue at the interval determined from step No. 7 (above) for each individual percolation hole until a minimum of eight readings are completed or until a stabilized rate of drop is obtained, whichever occurs first. A stabilized rate of drop means a difference of ¼-inch or less of drop between the highest and lowest readings of four consecutive readings.
   b. The drop that occurs in the final period in percolation test holes, expressed as inches per hour, shall be used to calculate the average percolation rate.
   c. When the rate of drop in a percolation test is too slow to obtain a measurable rate, the rate of 0.25 inches per hour shall be assigned to that hole for use in calculating the average percolation rate. The infiltration area may be placed over holes with no measurable rate when the average percolation rate for the possible infiltration area is within the acceptable range.

When a percolation test hole yields a percolation rate of greater than 12-inches per hour, the proposed infiltration area may not be designed or installed within 25-feet of this hole unless the municipality determines that a testing anomaly caused the fast percolation rate and a retest of the area yields acceptable percolation rates. This percolation rate limit is established to protect groundwater quality and to minimize the risk of subsidence.

Additional Site Investigation and Testing Required if Infiltration is Proposed

Soil Test Pit Requirements: The required number of test pits varies with Effective Soil Thickness. As risk factors increase, the number of test pits increases. A minimum of 2 test pits, uniformly spaced within the proposed infiltration area (e.g., the 2 pits should be centered on each half of the proposed infiltration area), are required for any site proposing infiltration unless the applicant can demonstrate that one test pit is adequately representative of the area proposed for infiltration. For larger infiltration areas, multiple test pits shall be developed at the densities as listed below:

Effective Soil Thickness (ft.)	Test Pit Density (per acre of proposed infiltration area)*	Percolation Tests (per acre of proposed infiltration area)**	Auger Grid Spacing (Feet On-Center)***
8	4	8	50
4 to 8	6	12	35
2 to 4	8	16	25

*No. of Test Pits required = Infiltration sq. ft./43,560 sq. ft. x test pit density from chart rounded up to the nearest whole number

** No. of Percolation Tests required = Infiltration sq. ft./43,560 sq. ft. x percolation tests from chart rounded up to the nearest whole number

***Auger testing is only required on Carbonate sites.

Soil Auger Testing Requirements for Carbonate Areas: Because soil depth is not uniform in many carbonate areas, test pits will not be sufficient to accurately determine the depth to bedrock. Augering provides this essential data as inexpensively as possible. Track-rig rotary soil auger test drilling allows relatively inexpensive, qualitative determination of the presence of overburden voids and will generally penetrate to the top-of-bedrock. Augers typically extend to depths of 20 feet. Special augers extend to as much as 50 feet. Augers do not extend into the bedrock. Auger testing should be performed in a grid pattern across the proposed infiltration area, spaced as indicated in the above table.

Percolation Testing Requirements: For each proposed infiltration area, a minimum of six percolation tests shall be conducted with a vertical component permeability test unless the applicant can demonstrate that fewer tests accurately represent the percolation rate of the proposed infiltration area. Additional testing shall be required if the initial test results show significant variability in the vertical component percolation rate. For larger infiltration areas, percolation tests shall be conducted at the densities listed in the table above.

APPENDIX H

LIST OF ACCEPTABLE BMPs

Best Management Practice	Design Reference Number[B]
Bioretention[A]	4,5,11,16
Capture/Reuse	4,14
Constructed Wetlands	4, 5, 8, 10, 16
Dry Extended Dentention Ponds	4, 5, 8, 12, 18
Minimum Disturbance/Minimum Maintenance Practices	1, 9
Significant Reduction of Existing Impervious Cover	N/A
Stormwater Filters[A] (Sand, Peat, Compost, etc.)	4, 5, 10, 16
Vegetated Buffers/Filter Strips	2, 3, 5, 11, 16, 17
Vegetated Roofs	4, 13
Vegetated Swales[A]	2, 3, 5, 11, 16, 17
Water Quality Inlets[C]	4, 7, 15, 16, 19
Wet Detention Ponds	4, 5, 6, 8

[A] This BMP could be designed with or without an infiltration component. If infiltration is proposed, the site and BMP will be subject to the testing and other infiltration requirements in this Ordinance.

[B] See table below.

[C] Water Quality Inlets include such BMPs as Oil/Water Separators, Sediment Traps/Catch Basin Sumps and Trash/Debris Collectors in Catch Basins.

LIST OF ACCEPTABLE BMPs

Number	Design Reference Title
1	"Conservation Design For Stormwater Management – A Design Approach to Reduce Stormwater Impacts from Land Development and Achieve Multiple Objectives Related to Land Use," Delaware Department of Natural Resources and Environmental Control, The Environmental Management Center of the Brandywine Conservancy, September 1997.
2	"A Current Assessment of Urban Best Management Practices: Techniques for Reducing Nonpoint Source Pollution in the Coastal Zone," Schueler, T.R., Kumble, P. and Heraty, M., Metropolitan Washington Council of Governments, 1992.
3	"Design of Roadside Channels with Flexible Linings," Federal Highway Administration, Chen, Y.H. and Cotton, G. K., Hydraulic Engineering Circular 15, FHWA-IP-87-7, McLean Virginia, 1988.
4	"Stormwater Best Management Practices Manual," Pennsylvania Department of Environmental Protection, January 2005 or current version.
5	"Evaluation and Management of Highway Runoff Water Quality," Federal Highway Administration, FHWA-PD-96-032, Washington, D.C., 1996.
6	"Evaporation Maps of the United States," U.S. Weather Bureau (now NOAA/National Weather Service) Technical Paper 37, Published by Department of Commerce, Washington D.C., 1959.
7	"Georgia Stormwater Manual," AMEC Earth and Environmental, Center for Watershed Protection, Debo and Associates, Jordan Jones and Goulding, Atlanta Regional Commission, Atlanta, Georgia, 2001.
8	"Hydraulic Design of Highway Culverts," Federal Highway Administration, FHWA HDS 5, Washington, D.C., 1985 (revised May 2005).
9	"Low Impact Development Design Strategies *An Integrated Design Approach*," Prince Georges County, Maryland Department of Environmental Resources, June 1999.
10	"Maryland Stormwater Design Manual," Maryland Department of the Environment, Baltimore, Maryland, 2000.
11	"Pennsylvania Handbook of Best Management Practices for Developing Areas," Pennsylvania Department of Environmental Protection, 1998.
12	"Recommended Procedures for Act 167 Drainage Plan Design," LVPC, Revised 1997.
13	"Roof Gardens History, Design and Construction," Osmundson, Theodore. New York: W.W. Norton & Company, 1999.
14	"The Texas Manual on Rainwater Harvesting," Texas Water Development Board, Austin, Texas, Third Edition, 2005.
15	"VDOT Manual of Practice for Stormwater Management," Virginia Transportation Research Council, Charlottesville, Virginia, 2004.
16	"Virginia Stormwater Management Handbook," Virginia Department of Conservation and Recreation, Richmond, Virginia, 1999.
17	"Water Resources Engineering," Mays, L. W., John Wiley & Sons, Inc., 2005.
18	"Urban Hydrology for Small Watersheds," Technical Report 55, U.S. Department of Agriculture, Natural Resources Conservation Service, 1986.
19	U.S. EPA, Region 1 New England web site (as of August 2005) http://www.epa.gov/NE/assistance/ceitts/stormwater/techs/html.

LIST OF ACCEPTABLE BMPs
PRE-TREATMENT METHODS FOR "HOT SPOT" LAND USES

Hot Spot Land Use	Pre-treatment Method(s)
Vehicle Maintenance and Repair Facilities including Auto Parts Stores	- Water Quality Inlets - Use of Drip Pans and/or Dry Sweep Material Under Vehicles/Equipment - Use of Absorbent Devices to Reduce Liquid Releases - Spill Prevention and Response Program
Vehicle Fueling Stations	- Water Quality Inlets - Spill Prevention and Response Program
Storage Areas for Public Works	- Water Quality Inlets - Use of Drip Pans and/or Dry Sweep Material Under Vehicles/Equipment - Use of Absorbent Devices to Reduce Liquid Releases - Spill Prevention and Response Program - Diversion of Stormwater away from Potential Contamination Areas
Outdoor Storage of Liquids	- Spill Prevention and Response Program
Commercial Nursery Operations	- Vegetated Swales/Filter Strips - Constructed Wetlands - Stormwater Collection and Reuse
Salvage Yards and Recycling Facilities*	- BMPs that are a part of a Stormwater Pollution Prevention Plan under an NPDES Permit
Fleet Storage Yards and Vehicle Cleaning Facilities*	- BMPs that are a part of a Stormwater Pollution Prevention Plan under an NPDES Permit
Facilities that Store or Generate Regulated Substances*	- BMPs that are a part of a Stormwater Pollution Prevention Plan under an NPDES Permit
Marinas*	- BMPs that are a part of a Stormwater Pollution Prevention Plan under an NPDES Permit
Certain Industrial Uses (listed under NPDES)*	- BMPs that are a part of a Stormwater Pollution Prevention Plan under an NPDES Permit

*Regulated under the NPDES Stormwater Program

Design references for the pre-treatment methods, as necessary, are listed below. If the applicant can demonstrate to the satisfaction of the municipality that the proposed land use is not a Hot Spot, then the pre-treatment requirement would not apply.

Pre-treatment Method	Design Reference[A]
Constructed Wetlands	5, 6, 10, 12, 18
Diversion of Stormwater Away from Potential Contamination Areas	5, 13
Stormwater Collection and Reuse (especially for irrigation)	5, 16
Stormwater Filters (Sand, Peat, Compost, etc.)	5, 6, 12, 18
Vegetated Swales	2, 4, 6, 13, 18, 19
Water Quality Inlets	5, 9, 17, 18, 21

[A] These numbers refer to the Design Reference Title Chart beginning on H2.